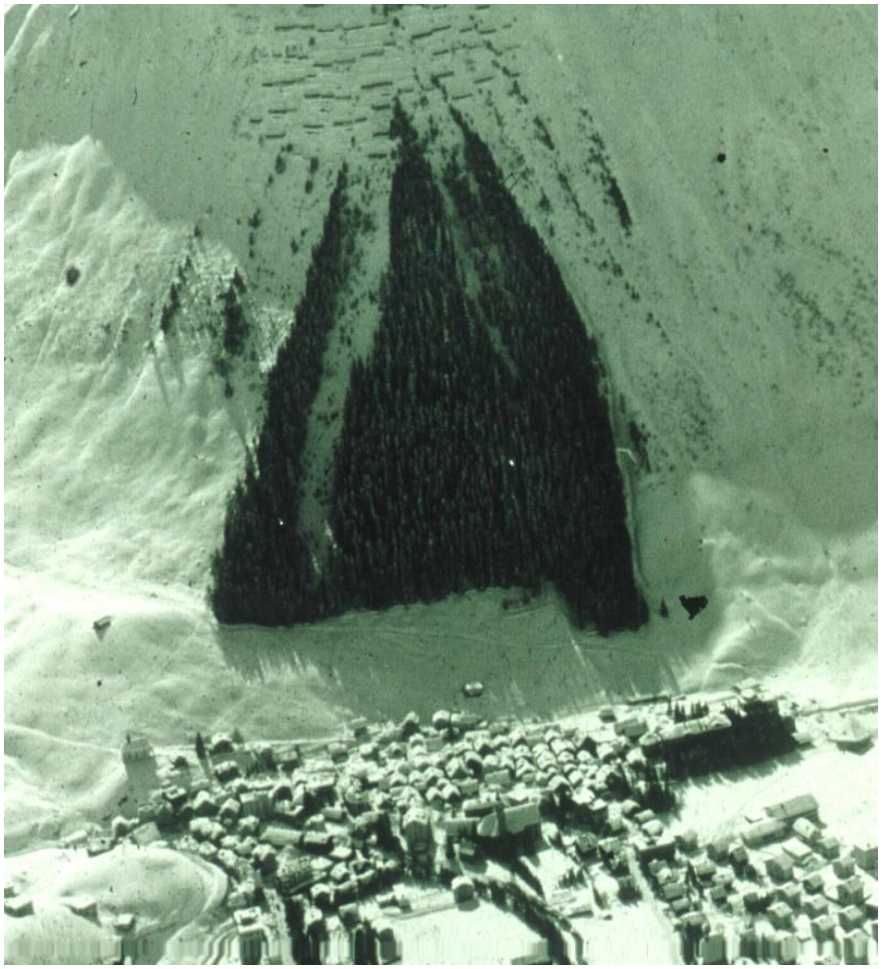
Avalanches: forest interactions and risk management



Frank Krumm[1] and Peter Bebi [1,2]

1. WSL-Institute for Snow and Avalanche Research, SLF
2. Swiss Federal Institute for Forest, Snow and Landscape Research

Overview

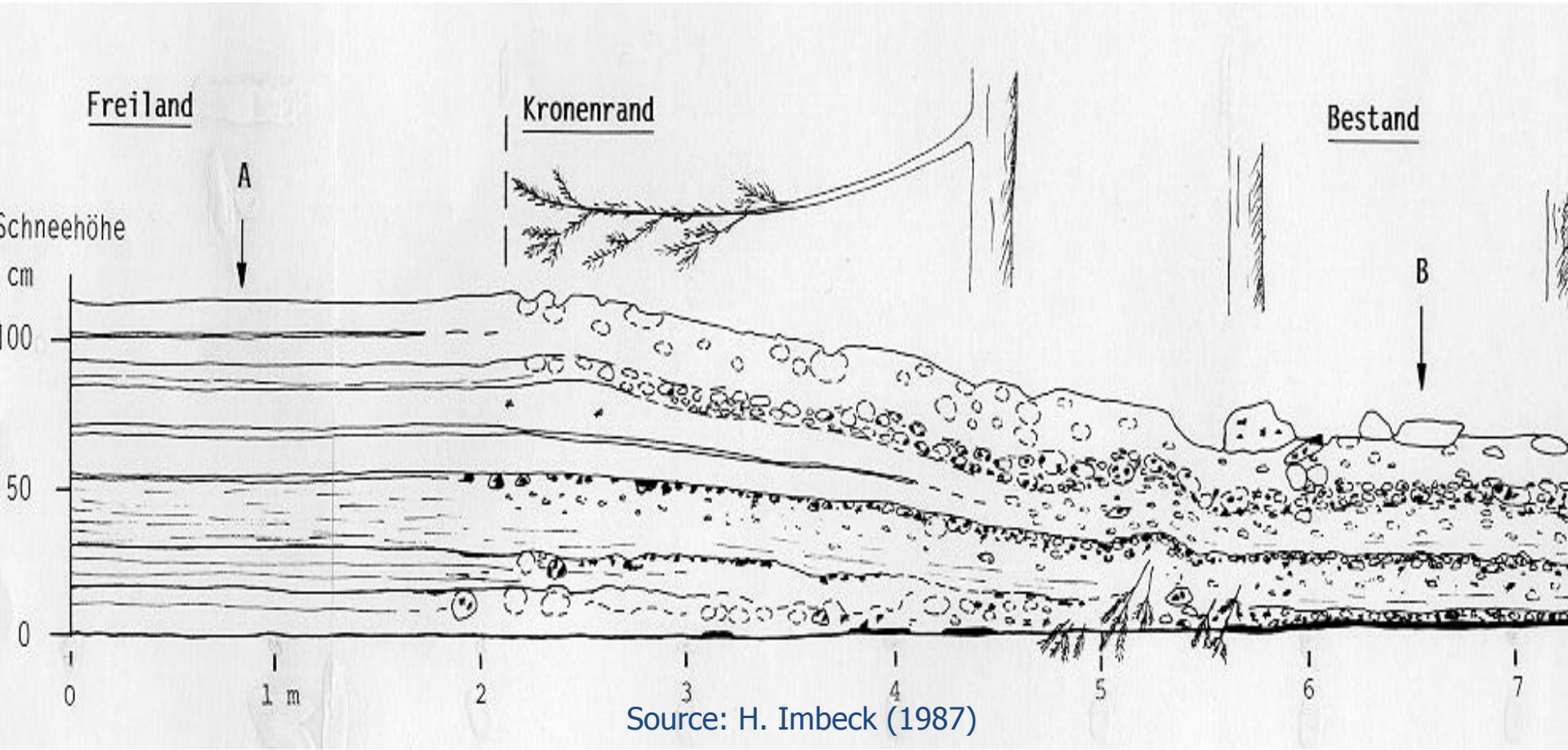
1. Avalanche protection: The role of mounain forests
2. History of Avalanche Protection
3. Interactions with other natural hazards
4. Avalanche-forest interactions in a warmer Climate
5. Conclusions

Avalanche protection – The role of mountain forests

Main effect: Avalanche releases do generally not occur in closed forested terrain

Small avalanches may be stopped in the forest (detrainment of snow behind trees)

Avalanche protection – The role of mountain forests



Source: H. Imbeck (1987)

→ **More irregular snow cover around trees and in forests and decrease of snow depth.**

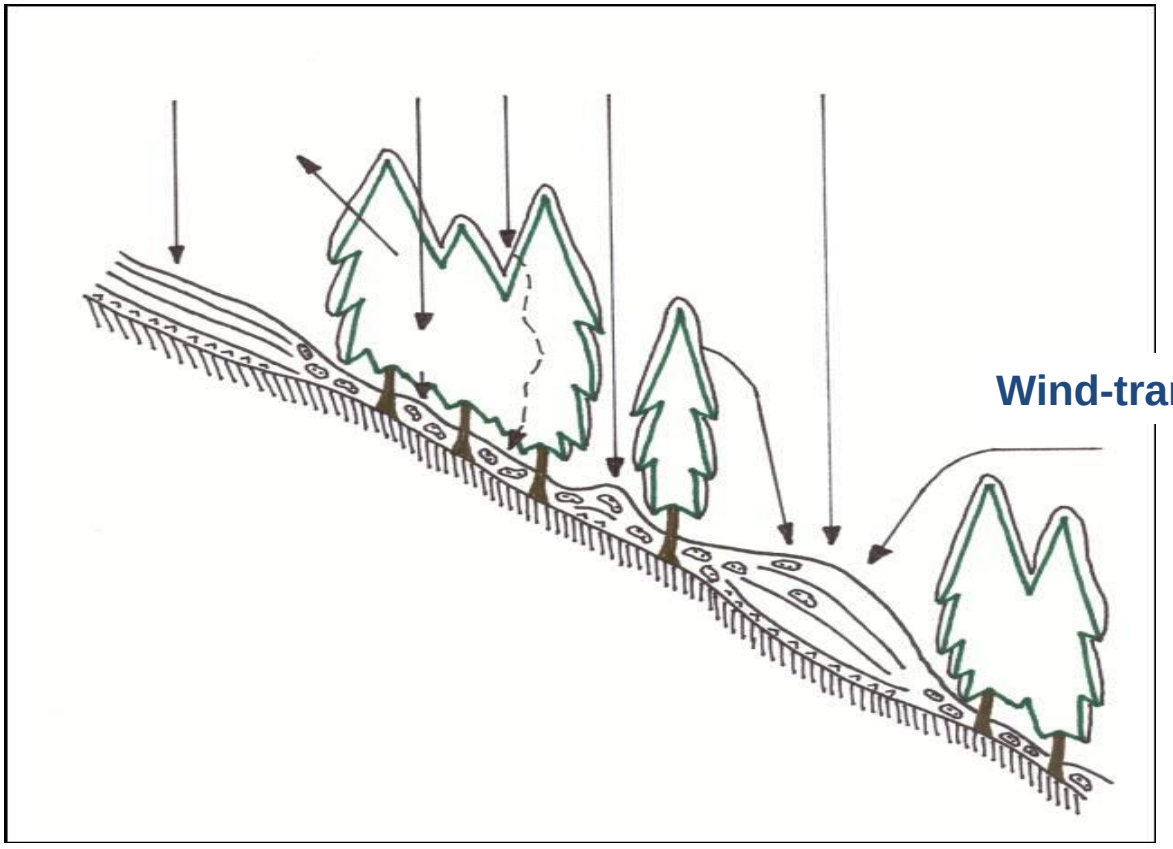
Avalanche protection – The role of mountain forests

Amount and duration of incoming solar radiation are reduced in the forest.

Outgoing long-wave radiation reduced

→ Surface hoar is less probable in forests

Avalanche protection – The role of mountain forests



Source: M. Frehner (from Meyer 1987 and Cemagref)

→ Reduction of wind speeds in the forest compared to open areas and large gaps.

Avalanche protection – The role of mountain forests

Terrain roughness of standing and laying stems

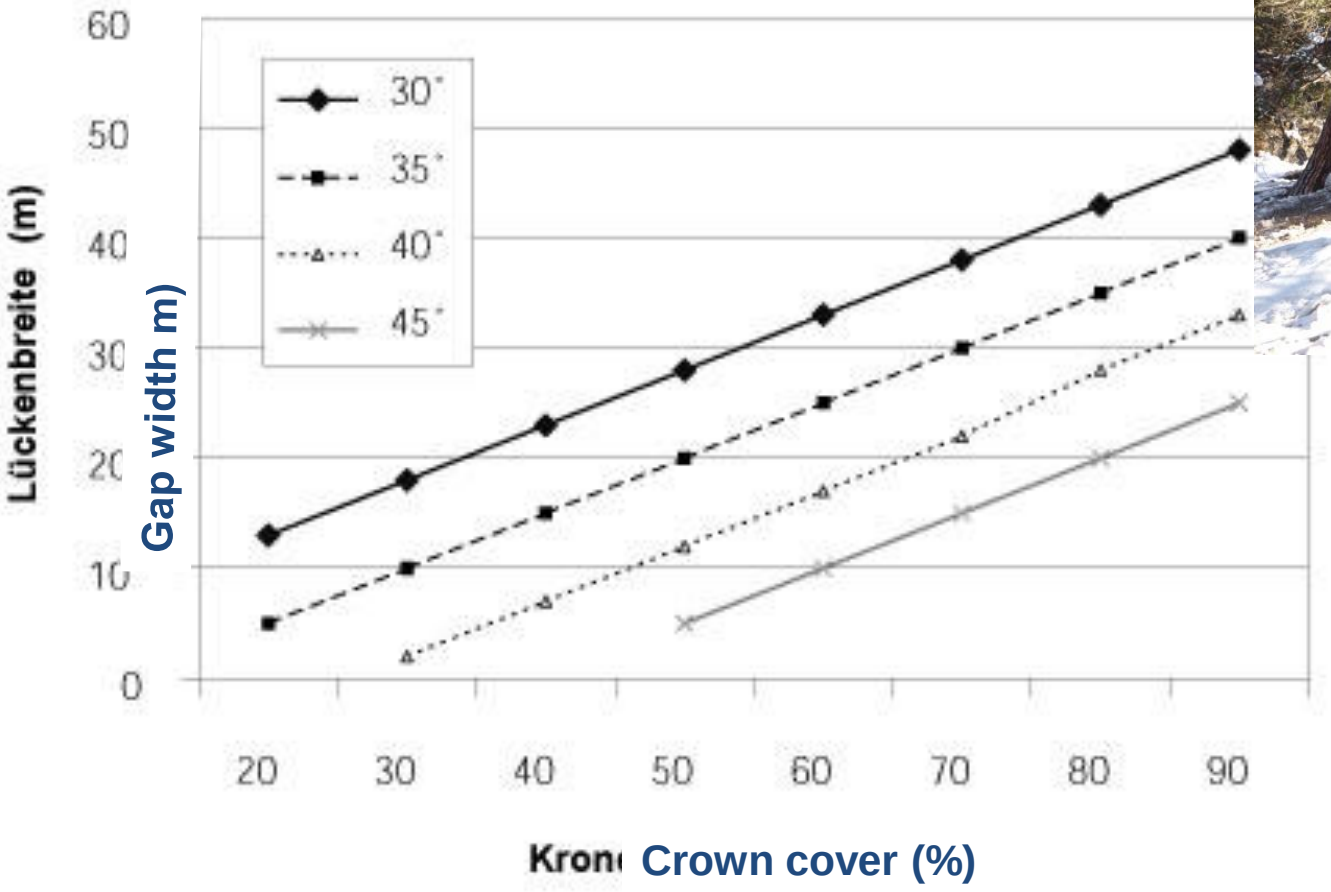
But critical stem densities would be very high only with this effect:

~ 500 stems 30°

~ 1000 stems 40°

(Saeki & Matsuoka 1970, Salm 1978)

Avalanche protection – The role of mountain forests



Relationship between critical gap widths and crown cover densities for triggering of avalanches for different categories of slope steepness

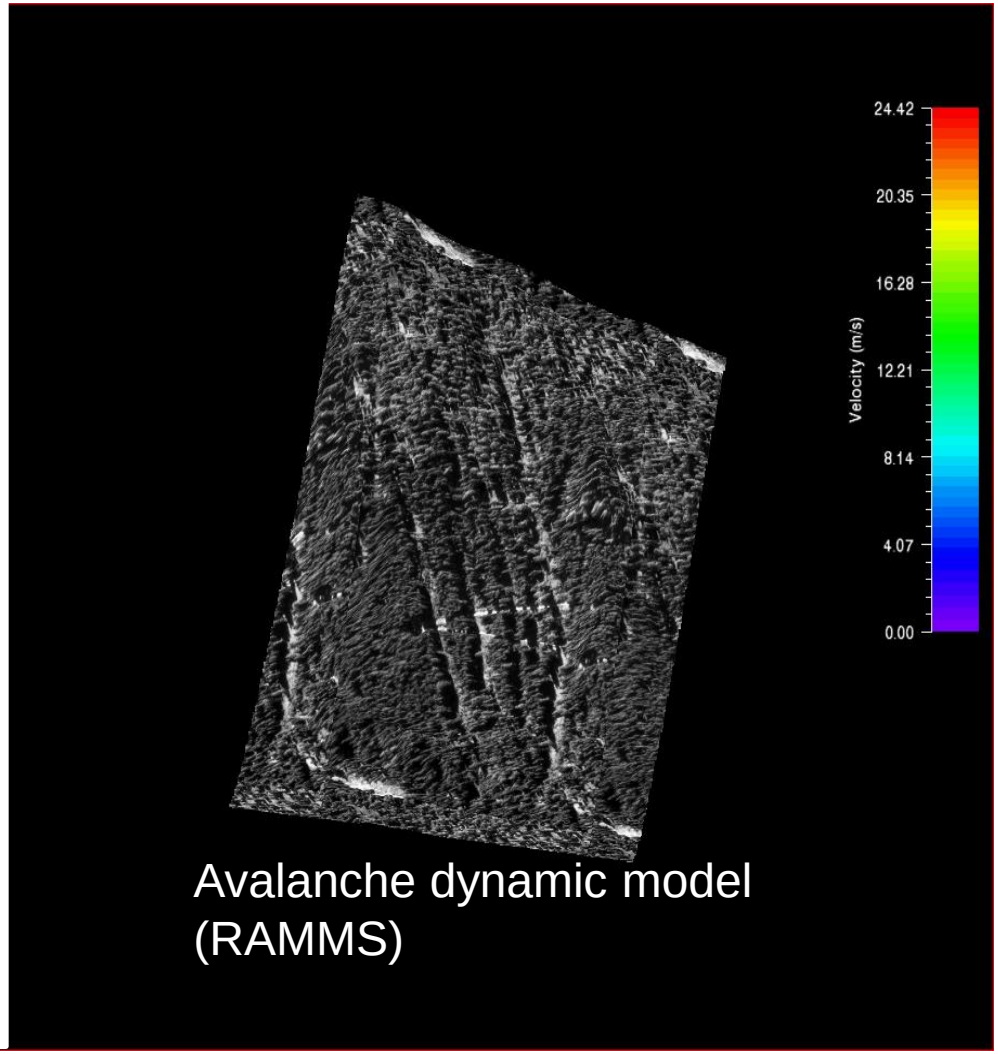
Source: Schneebeli und Bebi, 2004

Limits of avalache protection

➡ Large avalanches from above the treeline can generally not be stopped by the forest

New tols for regional scale avalanche hazard mapping

Newly available
remote sensing data



Avalanche dynamic model
(RAMMS)

->Improved decicion support for management of protection forests

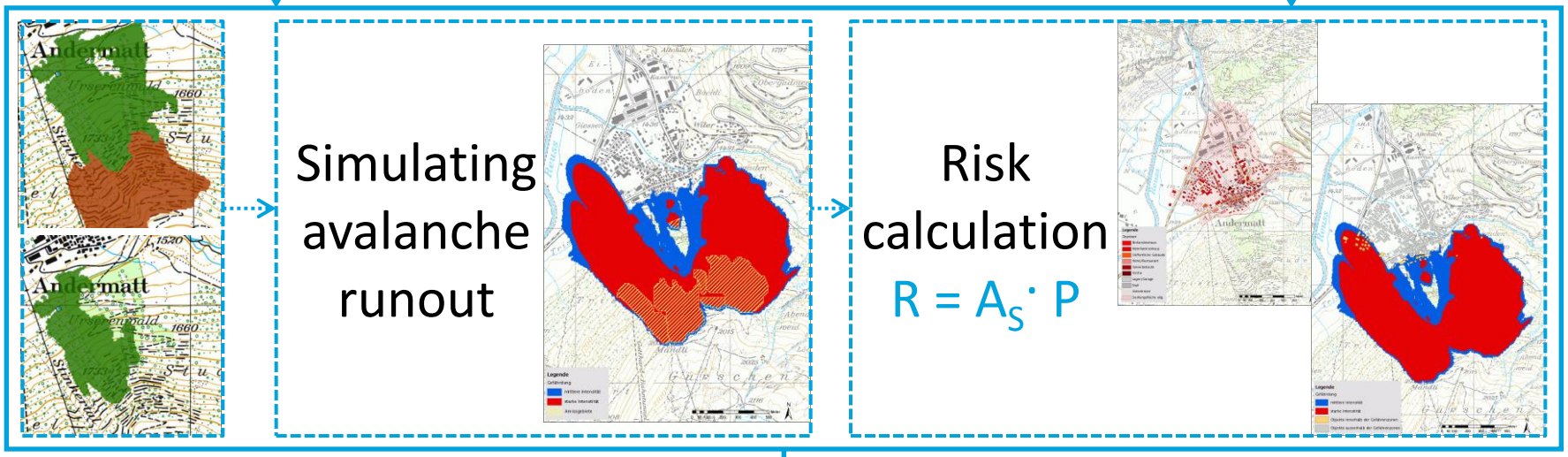
Evaluating protective effects against avalanches:

GIS-based risk analysis: $R = A_S \cdot P$

Mapping of forest structures

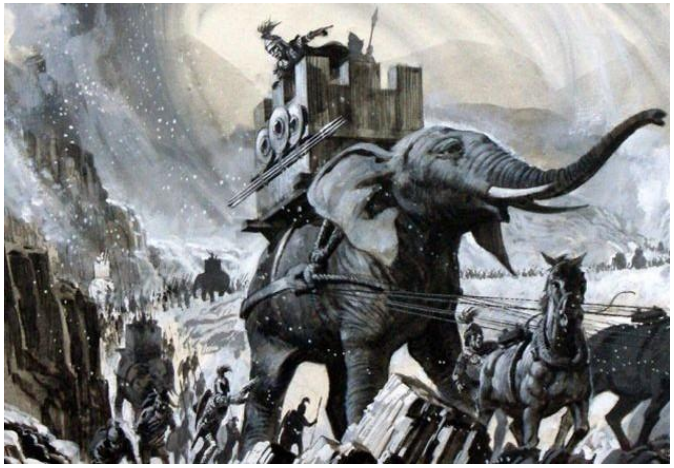
Developing forest cover scenarios

Probability of avalanche releases

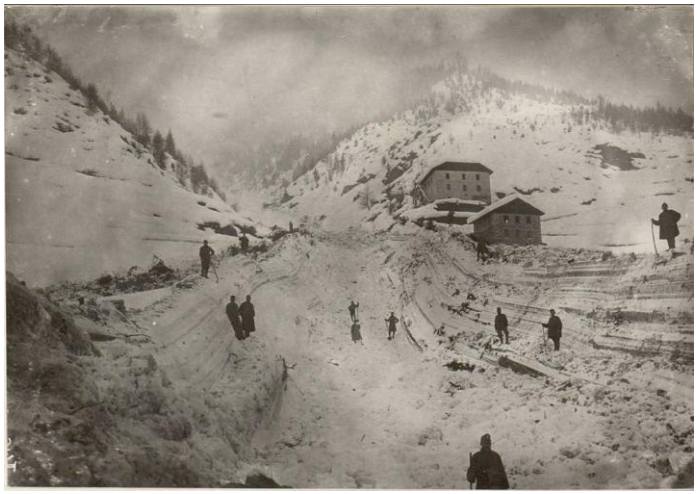


- Comparison of risks depending on forest cover scenarios.
- Determination of the value of the forest for avalanche protection (up to 150’000 Euro /ha and year in this case study

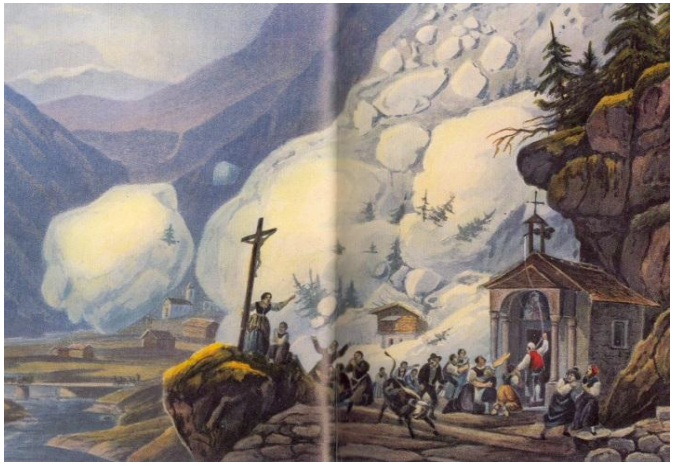
Historic view on snow avalanche catastrophies



218 BC Hannibal crossing the Alps
Loss of ca. 18’000 peoble by avalanches



Trento, December 13th 1916 (White Friday):
Ca 9000 killed people

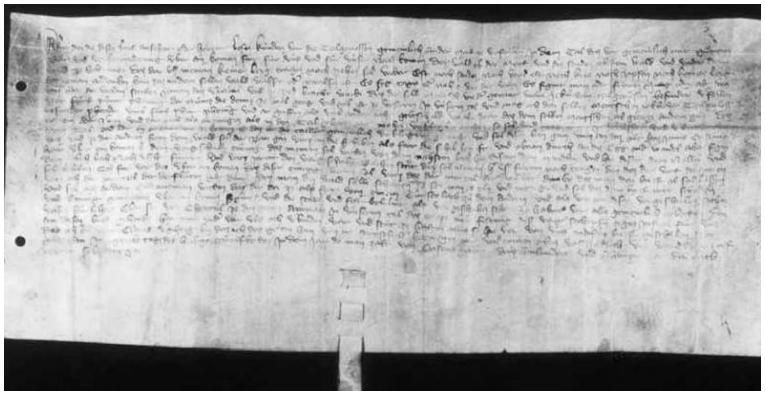


Guides caught by avalanches at Gd St. Bernard, as they started while pilgrims were praying (Rudolf de St. Trout, 1228)

18. Jan. 2017, Rigopiano, Abruzzo
19 people death

History of avalanche protection: Example Andermatt

Early deforestation and overview of the valley (c. 10th-14th century)



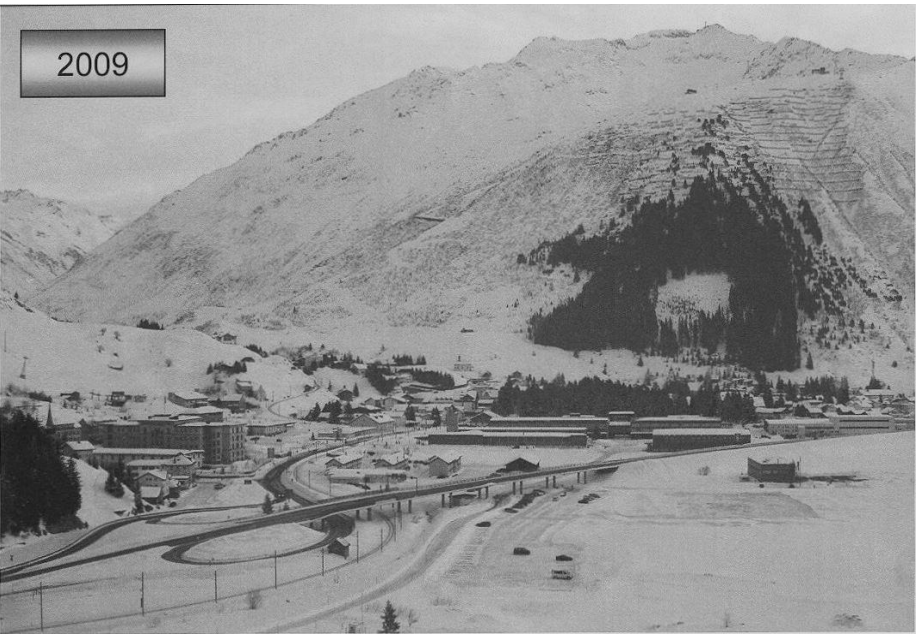
Bannbrief (written order) 1397: **Any use of forest product in remaining forest is not allowed.**

Situation in the beginning of 19th century:

„Only few old trees are standing in the forest, they look sadly down - like Noah once did with his sons from the mountain Ararat (Kasthofer 1822)»

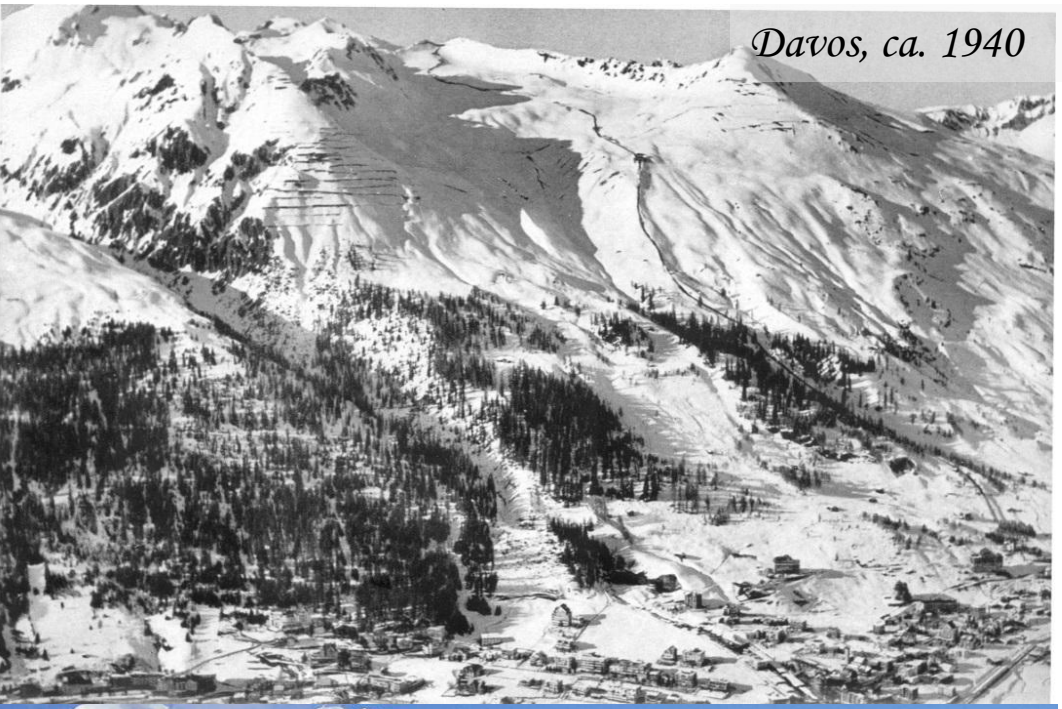
How effective was the Bannbrief?

History of avalanche protection: Example Andermatt



- Increase of settlement and infrastructure in the 20th century
- Increased afforestation and forest density, increasae of forest area from 4 to 24 ha
- Windthrow „Vivian“ 1990

Photos: Photoarchiv Xaver Bühlmann, Andermatt



- **Increase of avalanche protection since the 19th century**

- **Passive and active afforestation**

Management of avalanche protection forests in the Alps

- Increasing concerns about protection against natural hazards during 19th century
  -> new forest laws, afforestations

- Decreasing values of wood in the 20th century

- Development from «afforestation» to «resilence maintenance»

- Small-medium scale interventions (mainly with cable lines)

- Wood production and provision of other ecosystem services as side product of protection forest management

Other measures against avalanches

Frauenkirche Davos: A protection-wedge has bin built after an avalanche destroyed the church in 1602

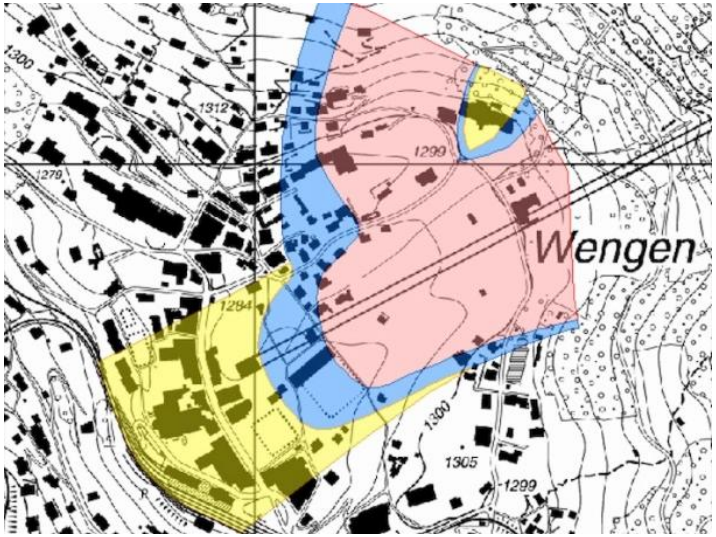
Avalanche barriers made of steel (after ca. 1950)

First technical measures, built around 1900

Stone wall (Galtür, Austria), build after Avalanche catastrophy in 1999

Integral risk management against avalanches

Avalanche galleries



Avalanche hazard maps

Protection forest and avalanche barriers

Organisational measures

Interactions with other natural disturabances

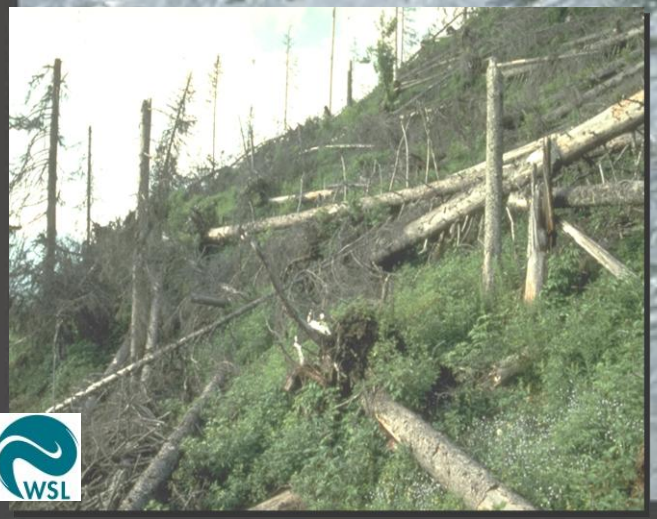
Windthrow

Fire

Bark beetle

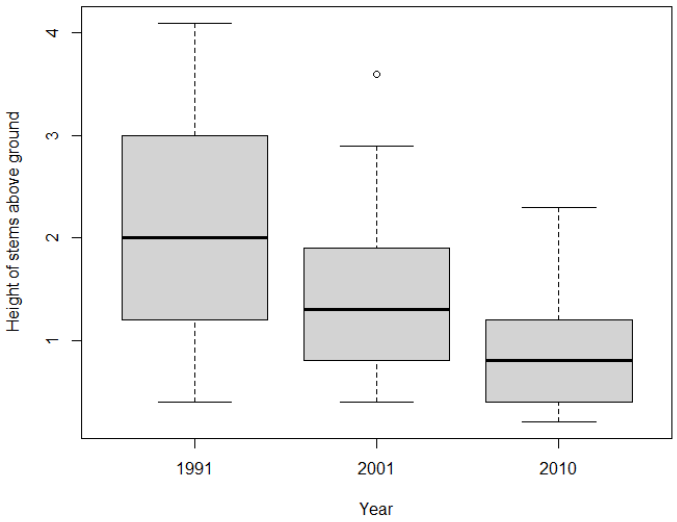
Avalanches

Avalanches after windthrow: only very few releases



Considerable effect of laying trees

Avalanches after windthrow: long term effect



- Decreasing avalanche protection with time.
- Is development of post windthrow regeneration fast enough or are addition afforestations/technical measures necessary?

How good is avalanche protection of post-fire stands?

Examples from Utah (USA)

Avalanche release on not cleared forest fire area

Forest damage from cleared post-disturbance area.

Fotos: M. Jenkins, Utah State University

Interactions between Avalanches and fire

Avalanches contribute to the diversity of the landscape and may act as fire-breaks !

But fine fuel after avalanches
may create new fires

Bark beetle-avalanche interactions

-> Avalanches may act also as breaks for bark beetle autbreaks

-> But new release areas may occur after bark beetle disturbances

Avalanches and floods

➡ Remaining wood in avalanche tracks along torrents may lead to floods

Effects of climate warming on avalanche protection forests

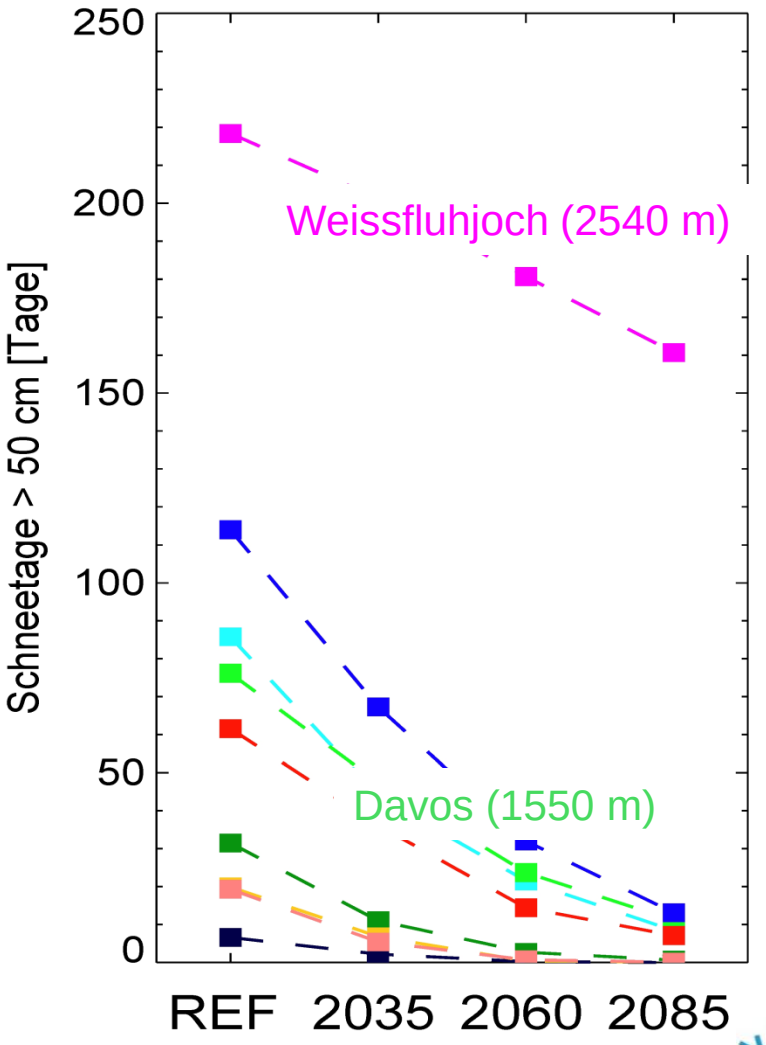
Cold limited sites near treeline:
Increase of treeline and forest density may lead to further increase of avalanche protection

Other Sites :
Increase of drought problems and natural disturbances (forest fire, insects....)
-> new avalanche release areas may occur

New species arriving……

But is there enough snow for avalanches in forested terrain?

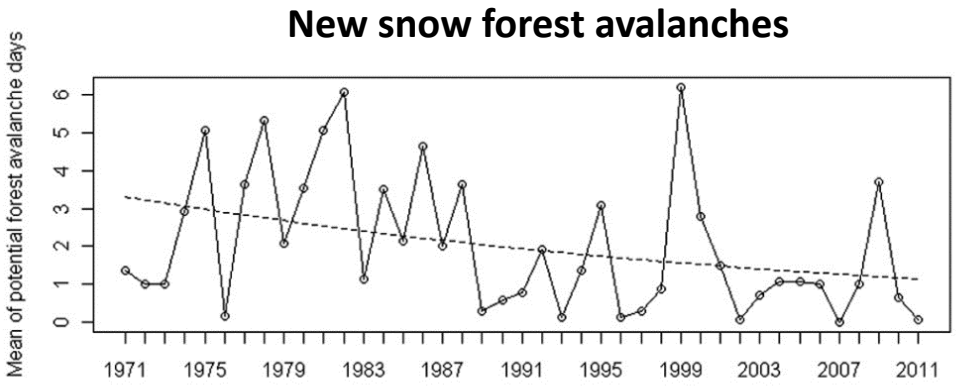
- ➡ The number of days with a snow depth > 50 cm will strongly decrease
- ➡ Avalanches in forested terrrain will generally have a decreasing relevance compared with other natural hazards
- ➡ But : Relevance of wet snow-gliding avalanches may increase in future

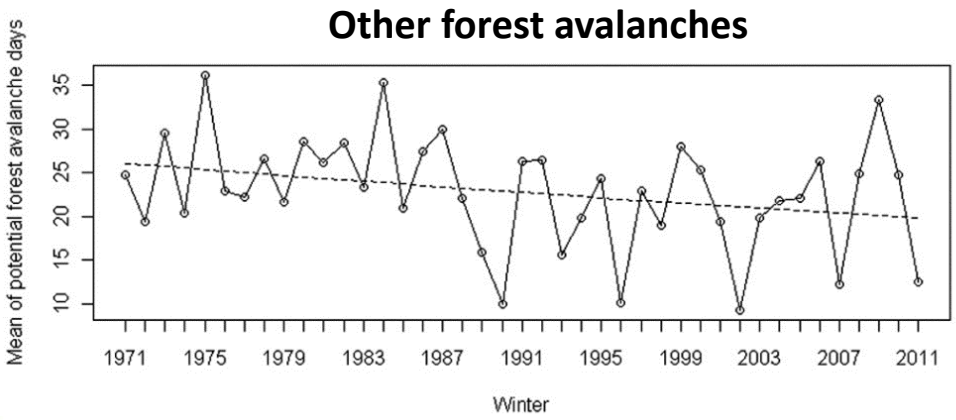


Source: Schmucki et al. 2015 / SLF

Avalanche-forest interactions in a warmer climate

Trends in favorable snow and weather conditions for Avalanches in forested terrain (Source: Teich et al. 2012):





Already negative trends!

Avalanche-forest interactions in a warmer climate

1. Dry and cold avalanches

- After cold snowfall periods
- Mainly subalpine and more often on N-facing slopes

➡ **Decreasing trends in all elevations**

2. Wet snow avalanches

- After warming and or rain
- Low terrain roughness
- Often in broadleaved forests, often as glide snow avalanches on S-exp

➡ **Shift of problem zones to higher elevations**

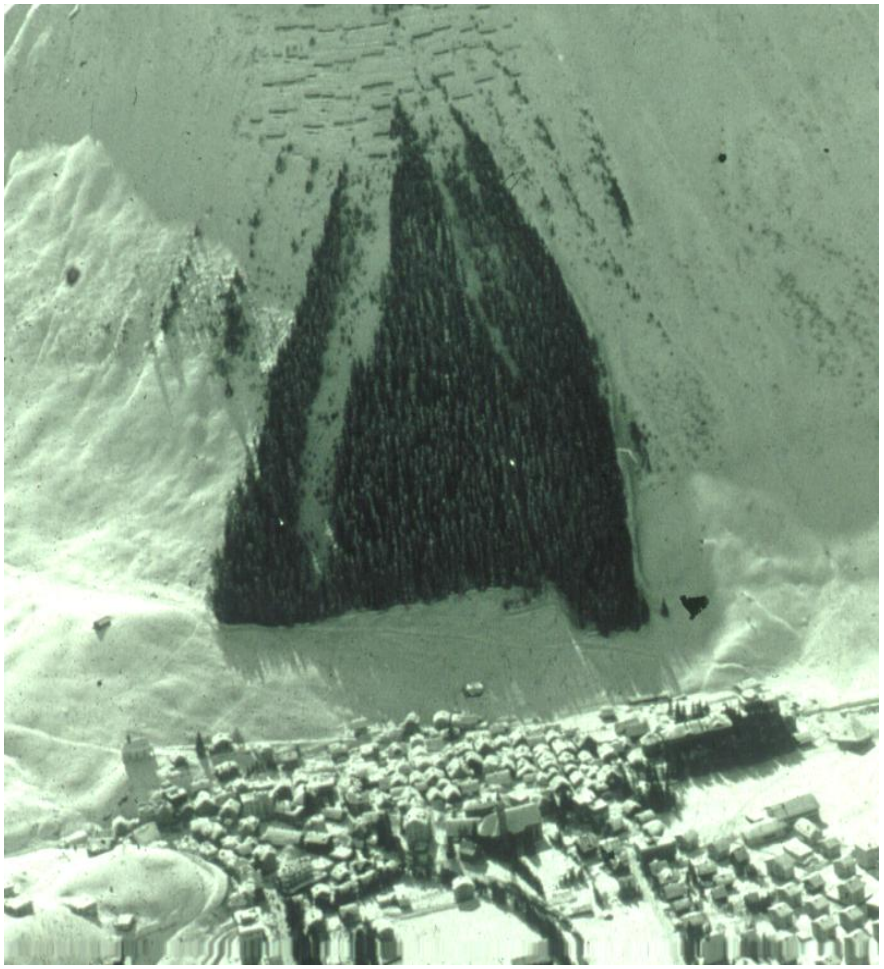
Conclusions

- **Forest management has always been an important part of integral avalanche risk management. But focus is shifting towards increasing resilience and disturbance management.**

- **New possibilities to evaluate the value of protection forests -> important for priorizing the management.**

- **Avalanches will decrease in importance compared to other natural hazards, but wet snow problems and interactions with other disturbances become more important.**

Avalanches: forest interactions and risk management



Thank you for your attention !

VDLS_1_klein.mp4

Frank Krumm[1] and Peter Bebi [1,2]

1. WSL-Institute for Snow and Avalanche Research, SLF
2. Swiss Federal Institute for Forest, Snow and Landscape Research