Mountain forest ecosystem services: maintaining resilience in the face of disturbances

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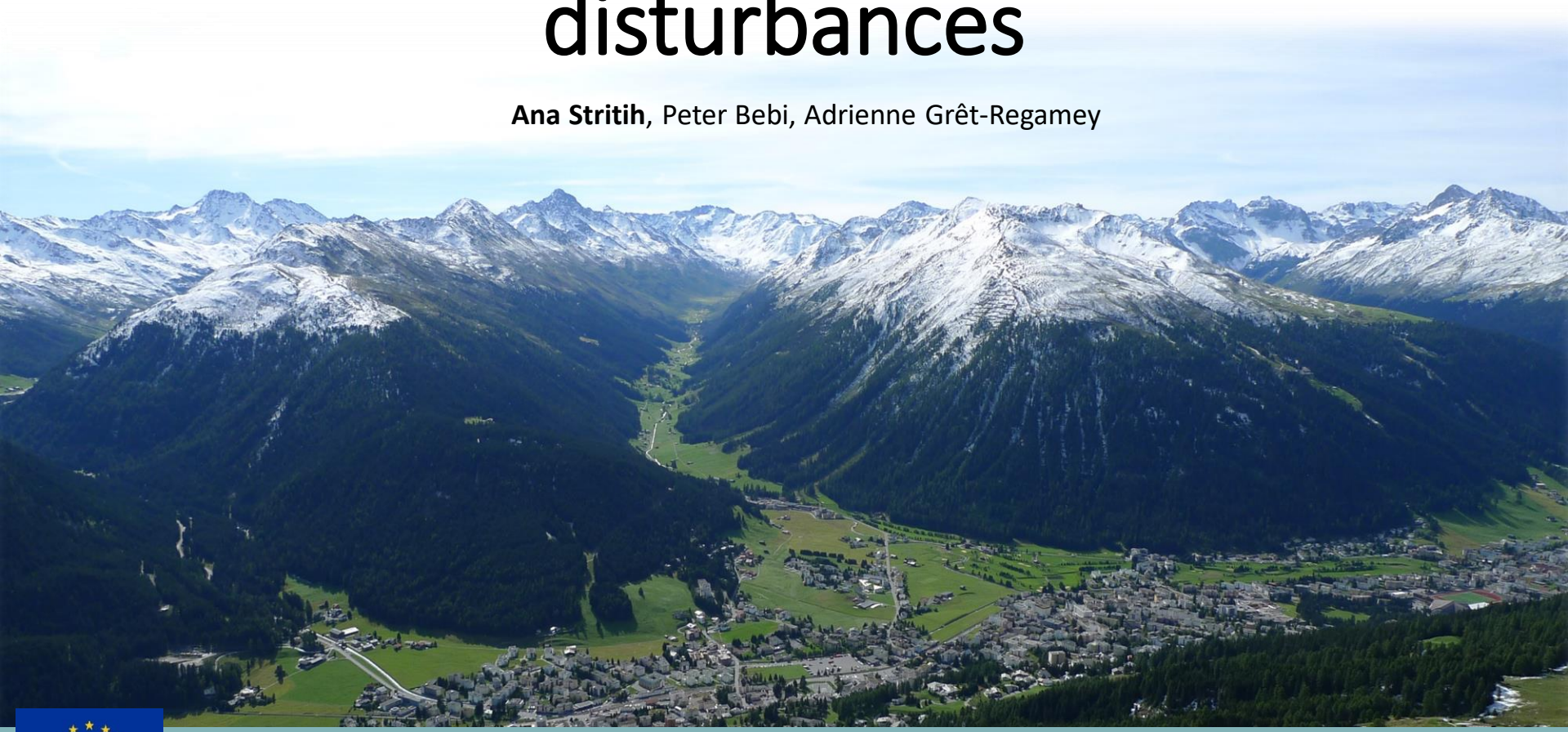

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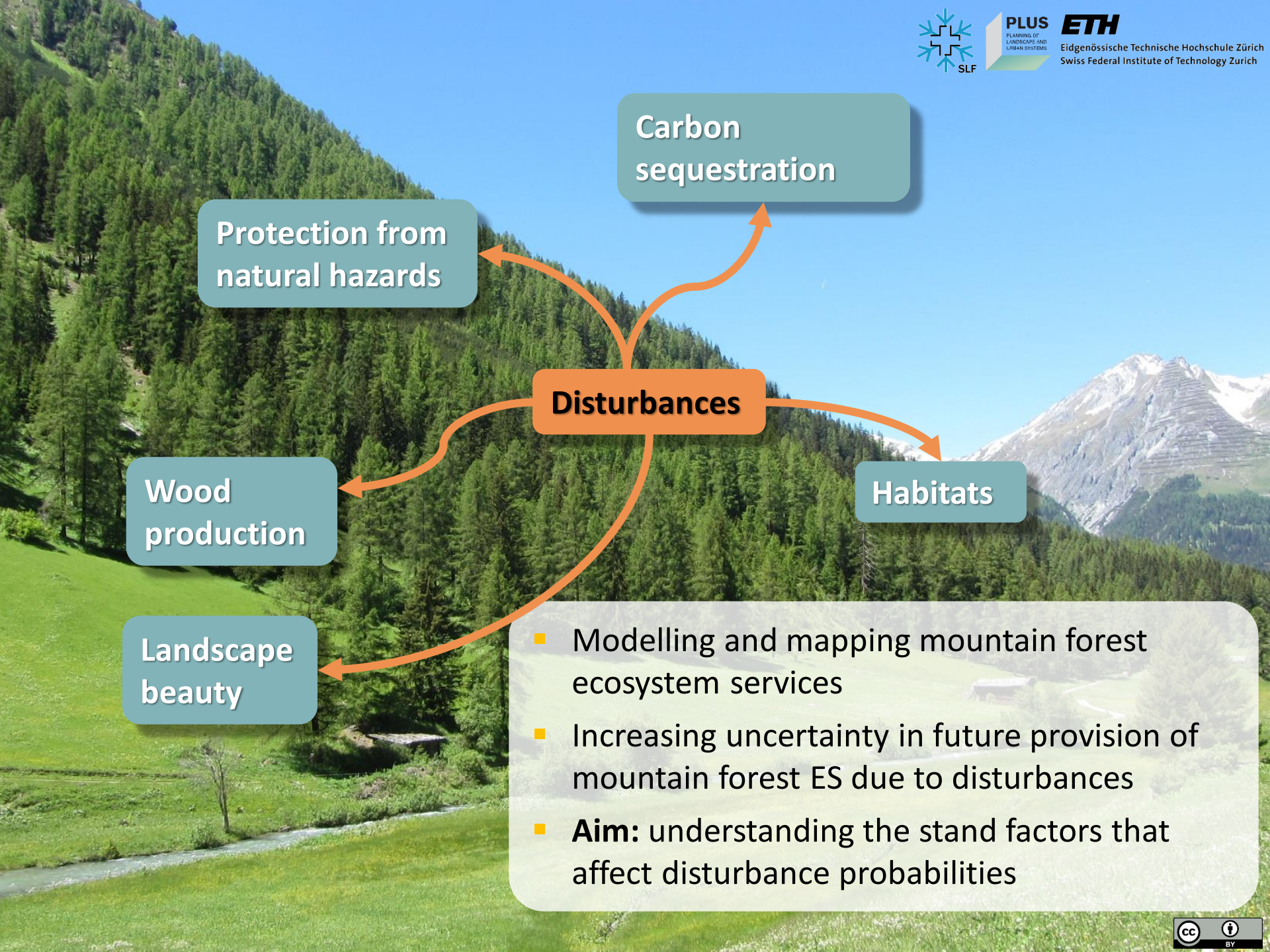


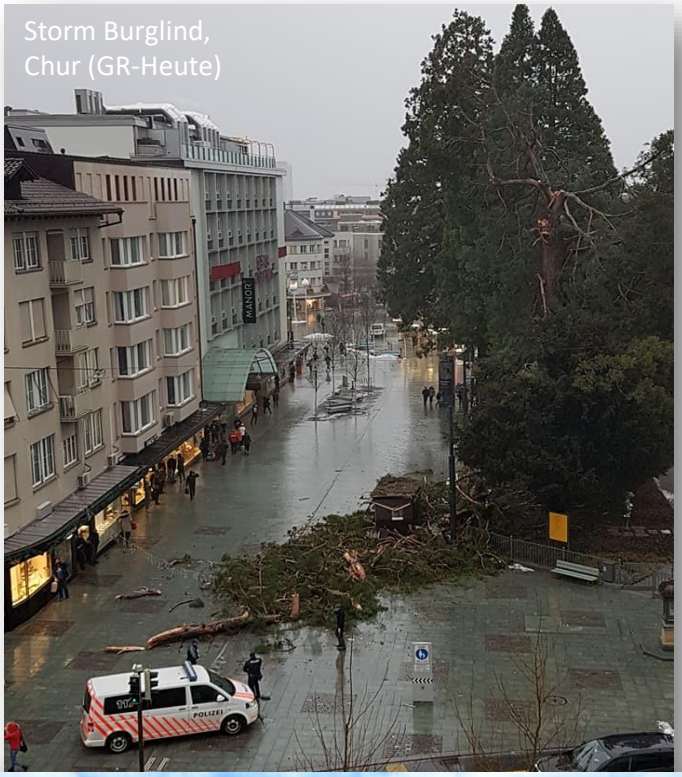
- Modelling and mapping mountain forest ecosystem services
- Increasing uncertainty in future provision of mountain forest ES due to disturbances
- **Aim:** understanding the stand factors that affect disturbance probabilities

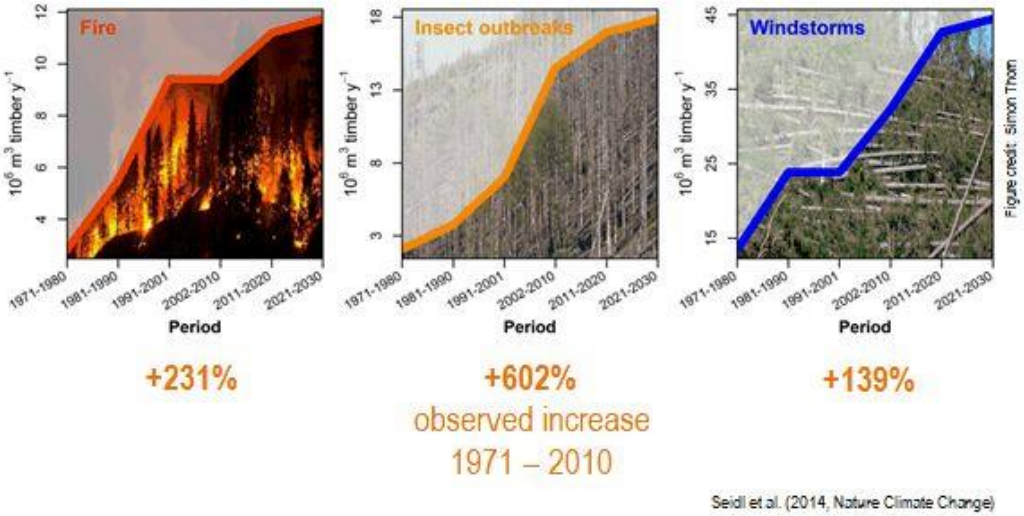
Disturbances

2018 – an extreme year in Canton Graubünden

- January: Storm Burglind
- Driest summer since 1864
- October 27th: Wet snowfall
- October 29th: Storm Vaia

... Forest management increasingly driven by extreme events

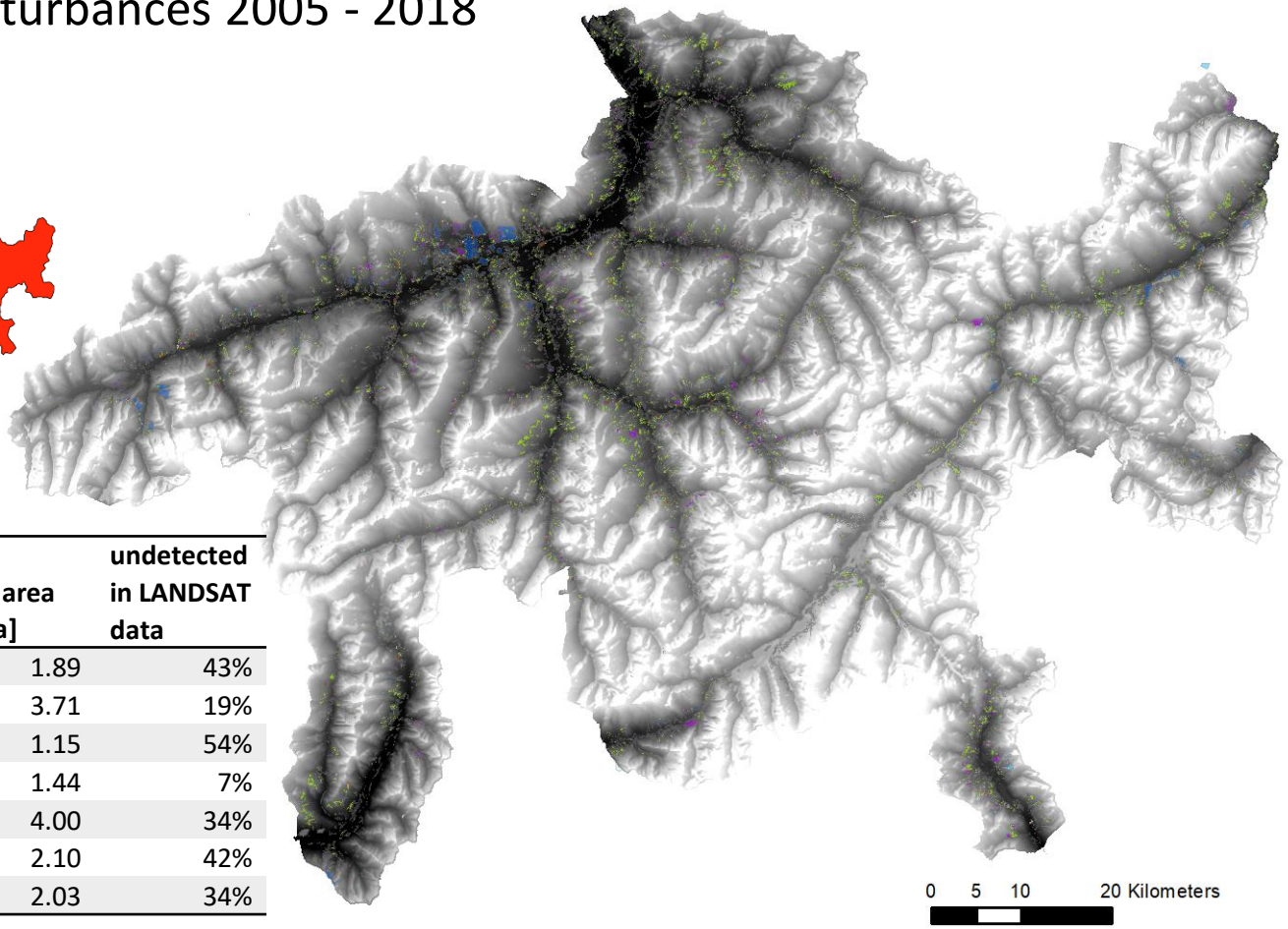




Disturbances – data

Combining LANDSAT-derived disturbance data (Senf et al., in revision) and information on forest management (Canton Graubünden), avalanche data and swissfire database

→ dataset of natural disturbances 2005 - 2018



Type	number	mean area [ha]	sd area [ha]	undetected in LANDSAT data
Management	16226	1.03	1.89	43%
Avalanche	163	1.25	3.71	19%
Bark beetle	1628	0.49	1.15	54%
Fire	86	0.86	1.44	7%
Snow breakage	1647	0.85	4.00	34%
Windthrow	2232	0.77	2.10	42%
Other	446	0.88	2.03	34%
Unknown - not recorded in management data	5574	0.40	0.48	25%

Disturbances - data

Combining LANDSAT-derived disturbance data (Senf et al., 2017) and information on forest management (Canton Graubünden), avalanche data and swissfire database

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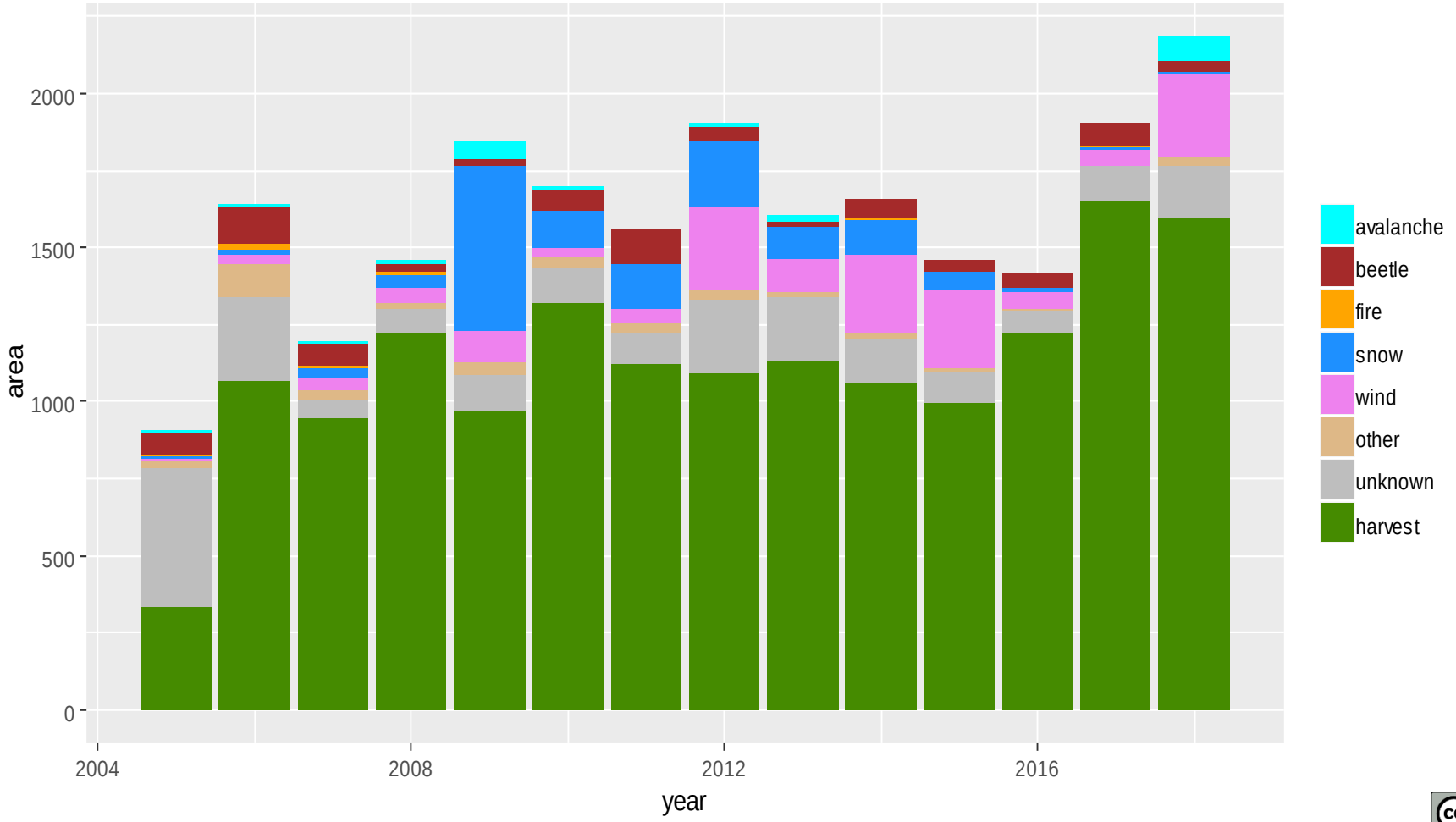
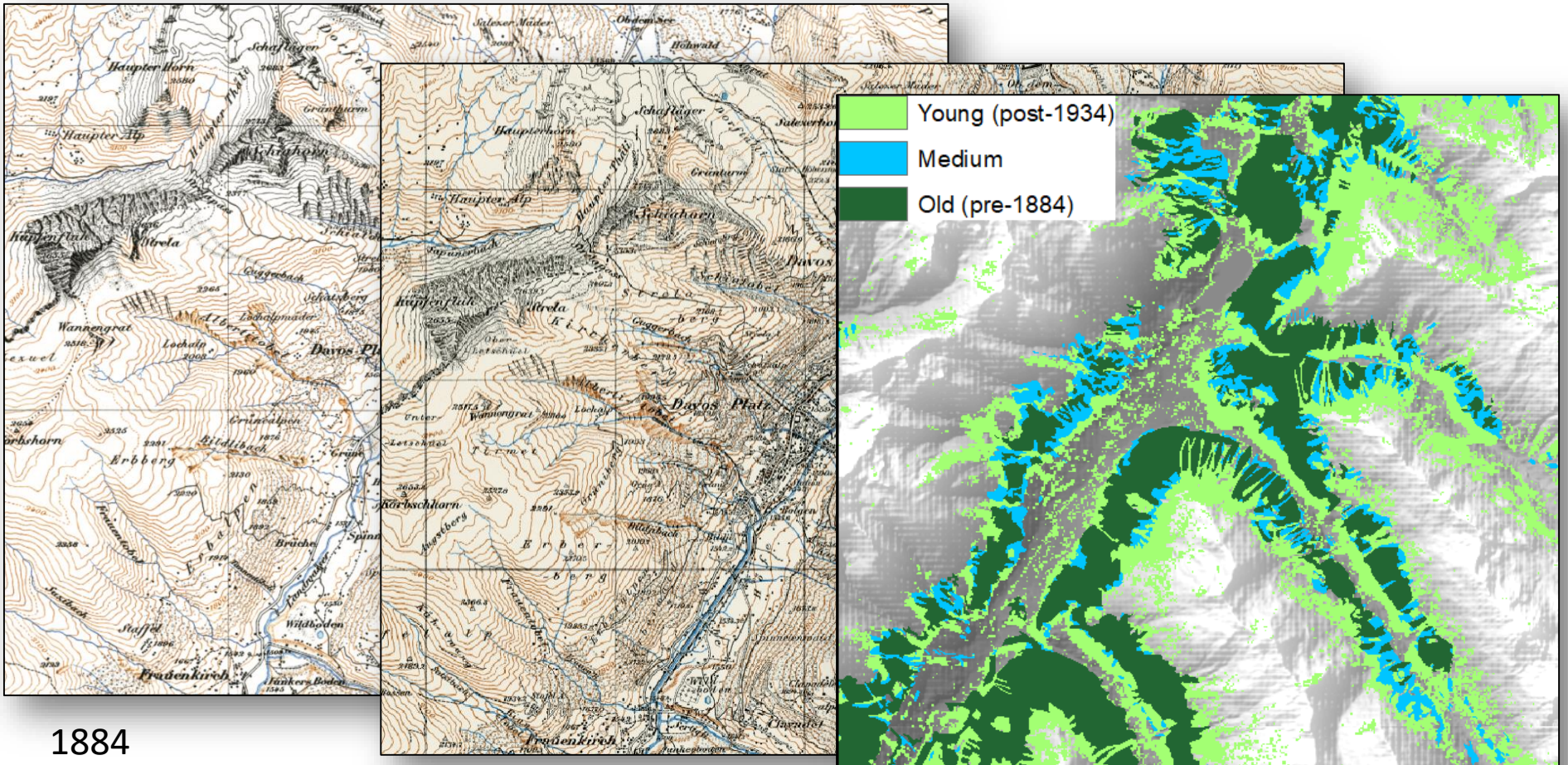


Disturbances – spatial predictors?

- Topography
- Forest structure from stand maps (vertical structure, species composition)
- Tree height (remote sensing, from 2016)
- Forest age (historical maps)
- Recent management interventions (from 2016: was there management in 2005-2015)



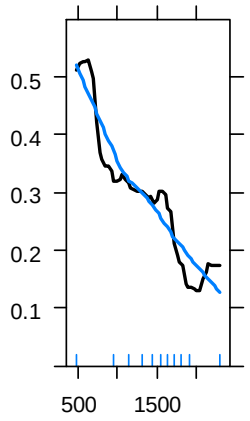
Disturbances – spatial predictors *Preliminary results*

Random Forest model predicting the probability of natural disturbances

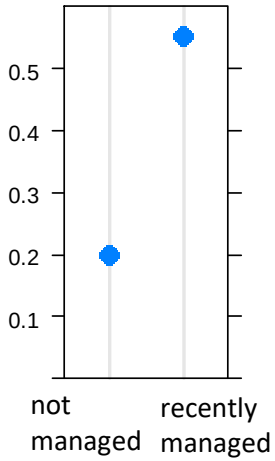
- 850 natural disturbances (2016 – 2018)
- 84 % accuracy

Partial dependence plots (smoothed)

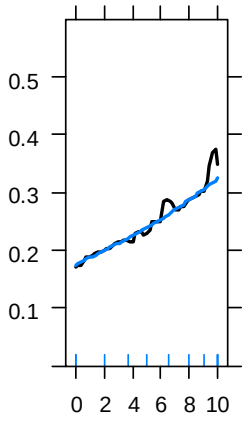
Elevation



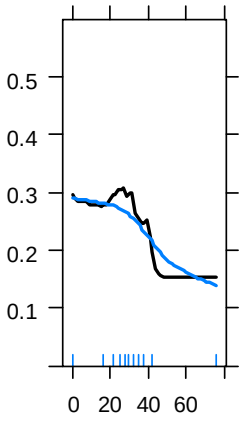
Management



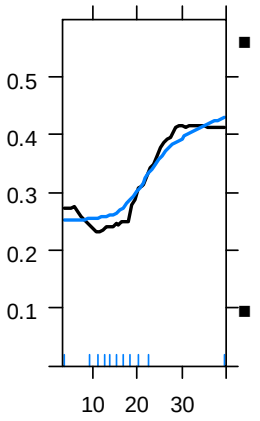
Spruce



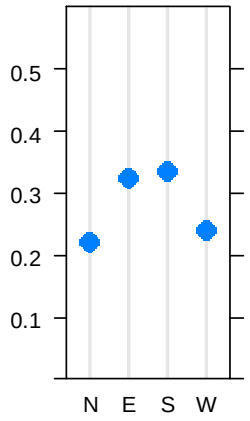
Slope



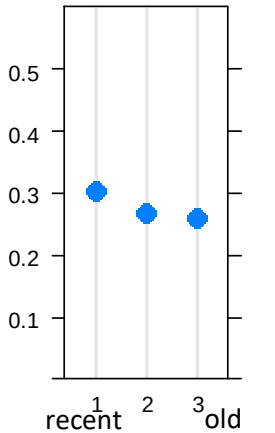
Mean canopy height



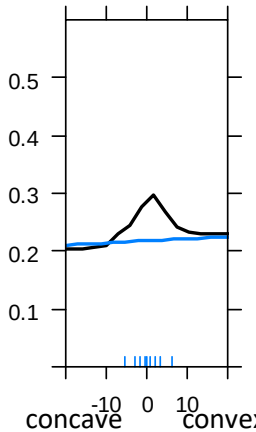
Aspect



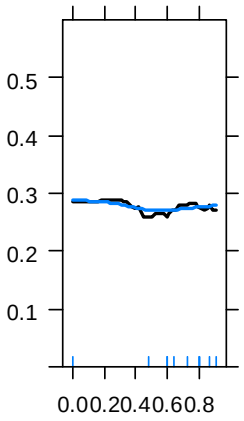
Age



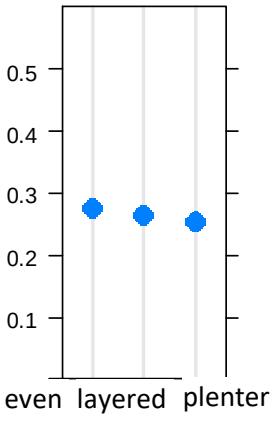
Topographic exposure



Cover



Structure



- Spruce-dominated, even-aged stands at low elevations and gentle, south-facing slopes are more exposed
- Disturbances less likely in old forests (forested before 1884)
- Recent management interventions increase the probability of a disturbance

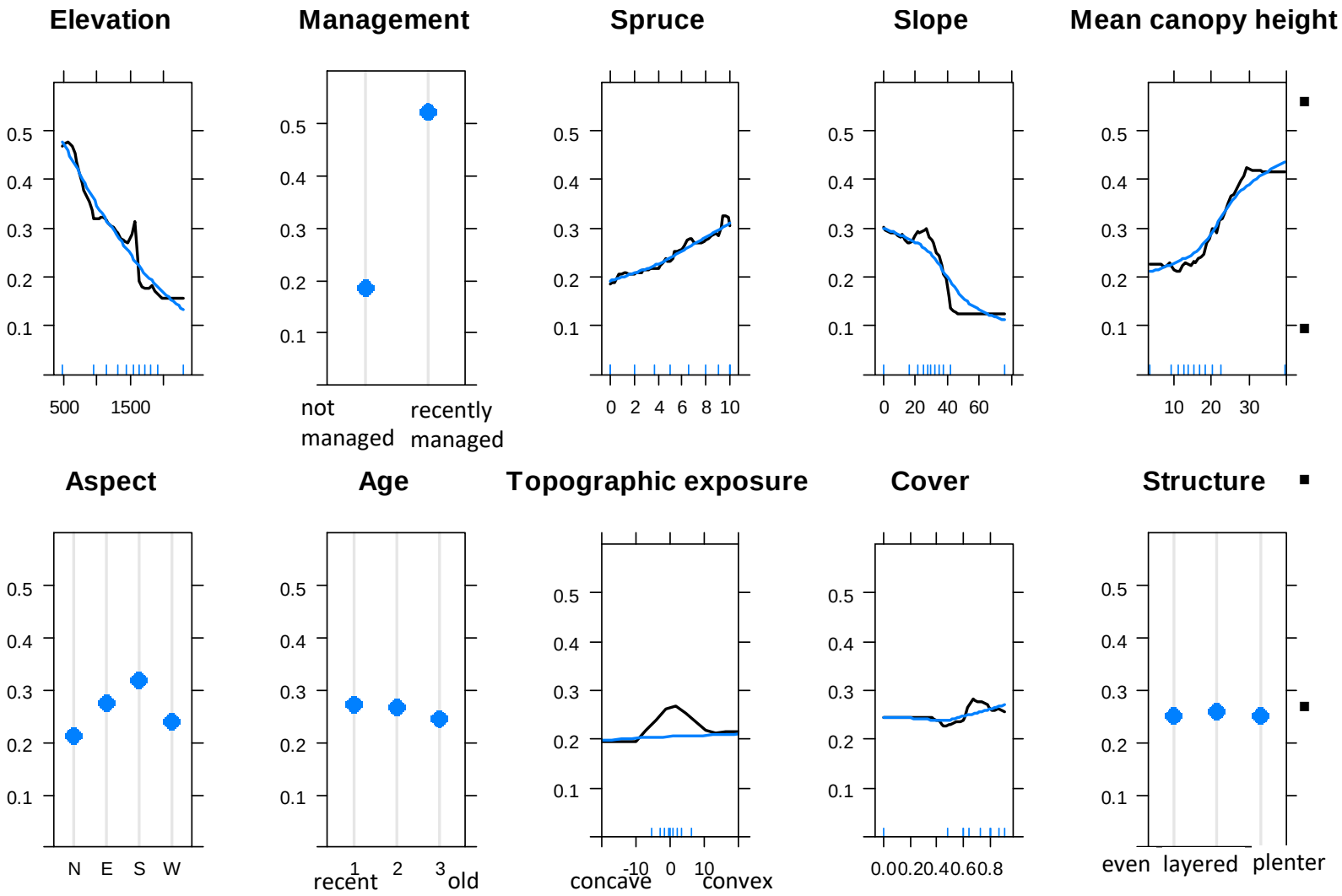
Windthrow – spatial predictors

Preliminary results

Random Forest model predicting the probability of windthrow

- 397 windthrow events (2016-2018)
- 85 % accuracy

Partial dependence plots (smoothed)



- Spruce-dominated stands at low elevations and gentle, south-facing slopes are more exposed
- Disturbances less likely in old forests (forested before 1884)
- Recent management interventions increase the probability of a disturbance
- Vertical structure less important

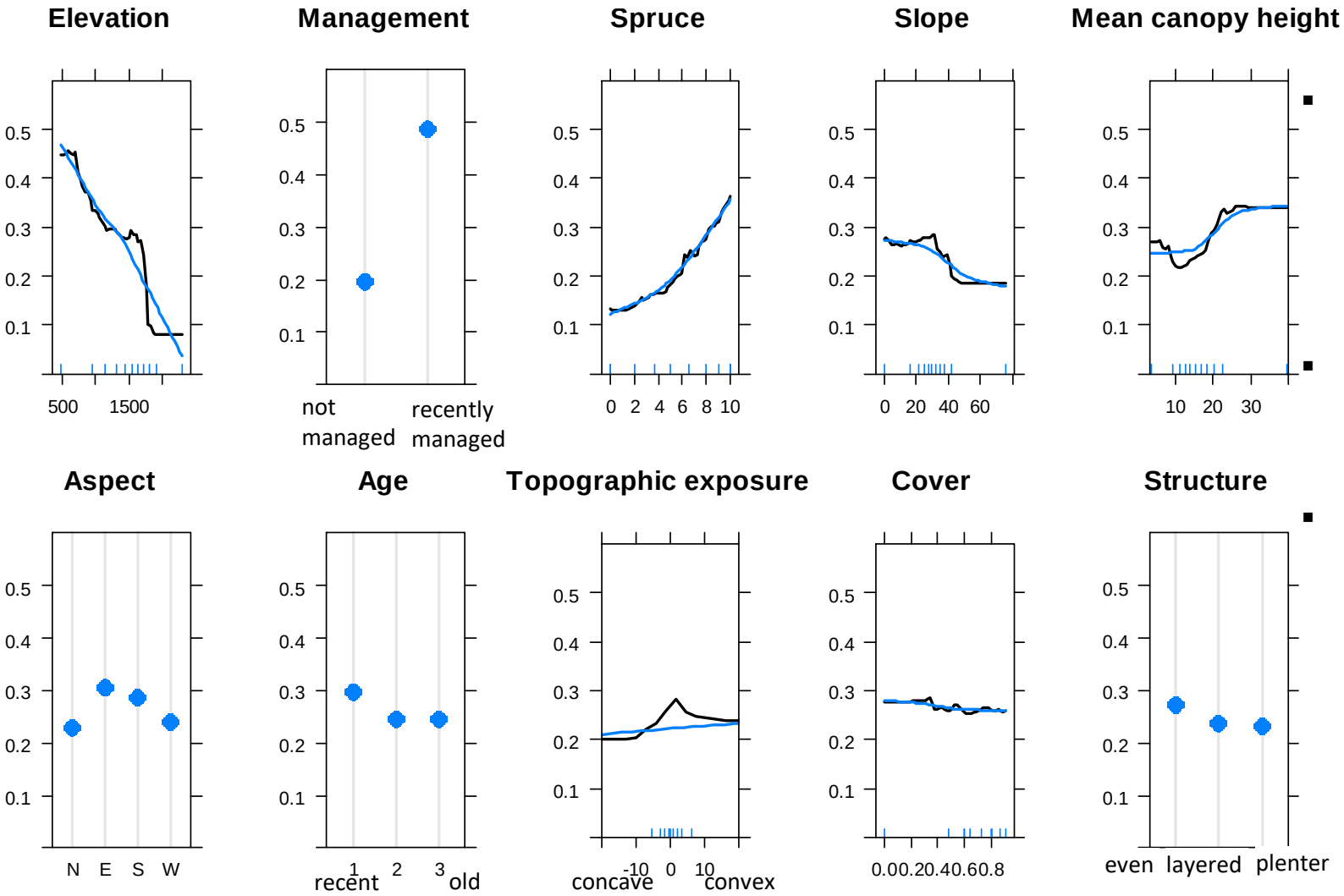
Bark beetle – spatial predictors

Preliminary results

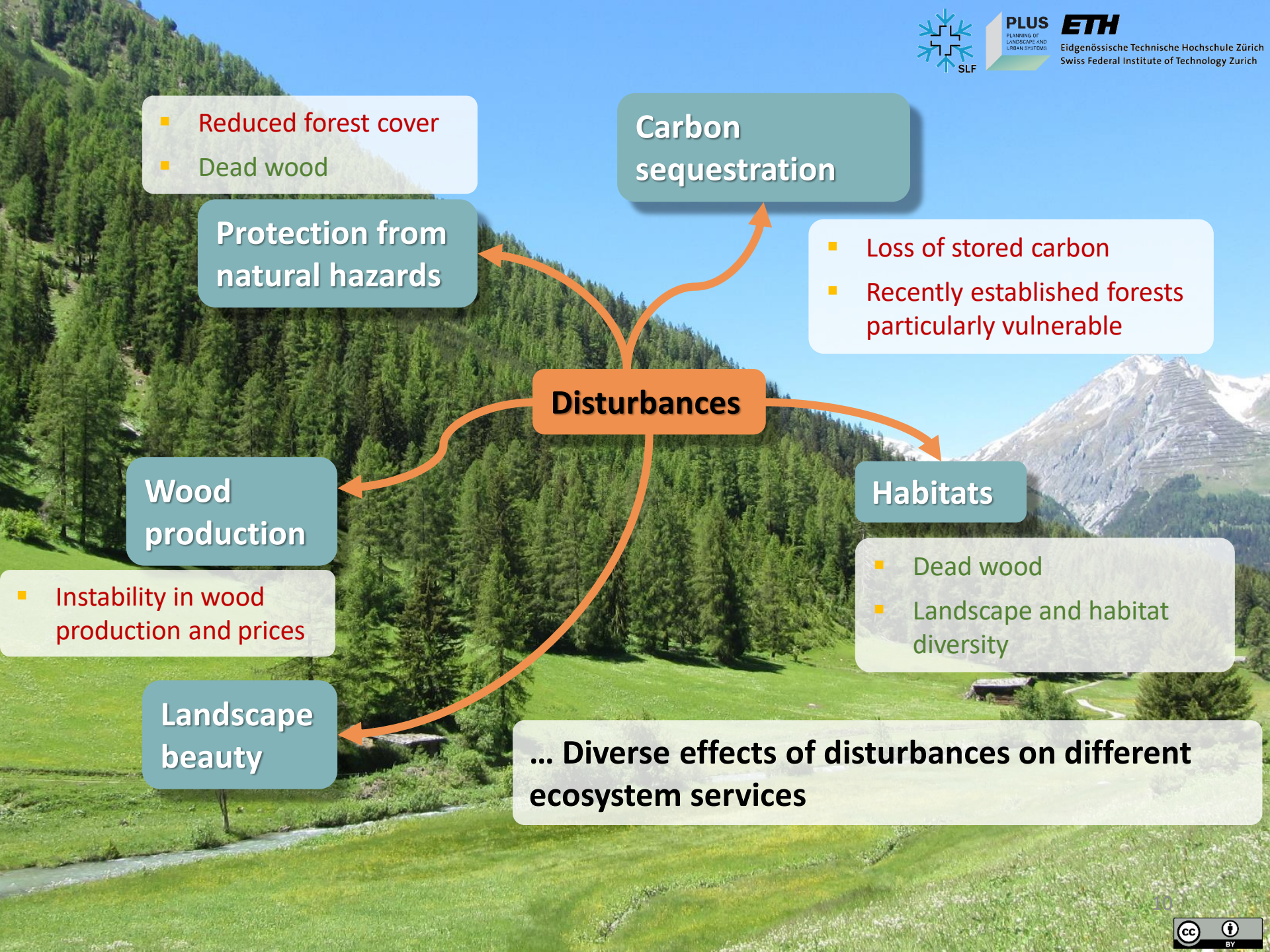
Random Forest model predicting the occurrence of bark beetle outbreaks

- 359 bark beetle events (2016-2018)
- 84 % accuracy

Partial dependence plots (smoothed)



- Spruce-dominated, even-aged stands at low elevations and gentle, east- and south-facing slopes are more exposed
- Disturbances less likely in old forests (forested before 1884)
- Recent management interventions increase the probability of a disturbance


Reduced forest cover
Dead wood
Protection from natural hazards
Carbon sequestration
Loss of stored carbon
Recently established forests particularly vulnerable
Disturbances
Wood production
Instability in wood production and prices
Habitats
Dead wood
Landscape and habitat diversity
Landscape beauty
… Diverse effects of disturbances on different ecosystem services

Conclusions

- Disturbances in mountain forests increase the uncertainty about future provision of ecosystem services
- Spruce-dominated, even-aged stands and recently established forests are more at risk
- Older forests with a heterogeneous vertical structure are more resilient
- On the short term, management interventions increase the susceptibility of forests to disturbances
- Forest management should aim at increasing species- and structural diversity to ensure a resilient provision of ecosystem services

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