General assumption: Beech forests do not burn. Evidence from recent years: Yes they do!

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[1]Swiss Federal Institut for Forest, Snow and Landscape Research
[2]University of Turin, Italy

Fire in beech forests

Beech forests rarely burn due to …
… compact litter layer with low oxygen content
… a lack of understory vegetation
… typical forest structure („Hallenwälder“)

Beech fire-adaptive traits

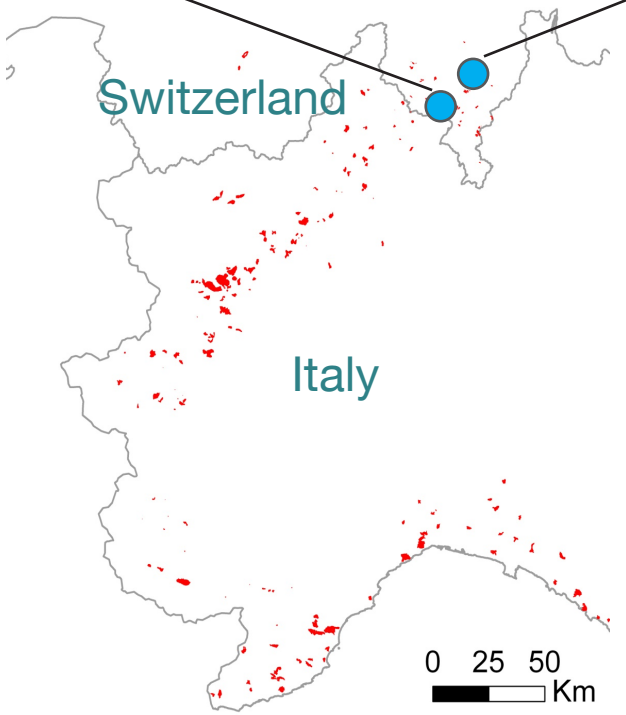
thin bark

limited resprouting

irregular masting seeder

But ...

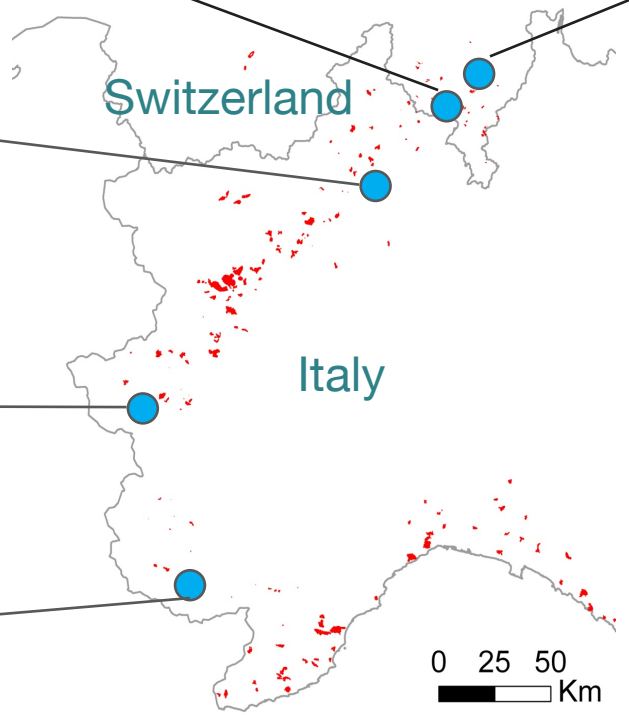
2003 summer fires in beech stands



Forest fires (> 100 ha) 1980-2013

summer fires in beech 2003

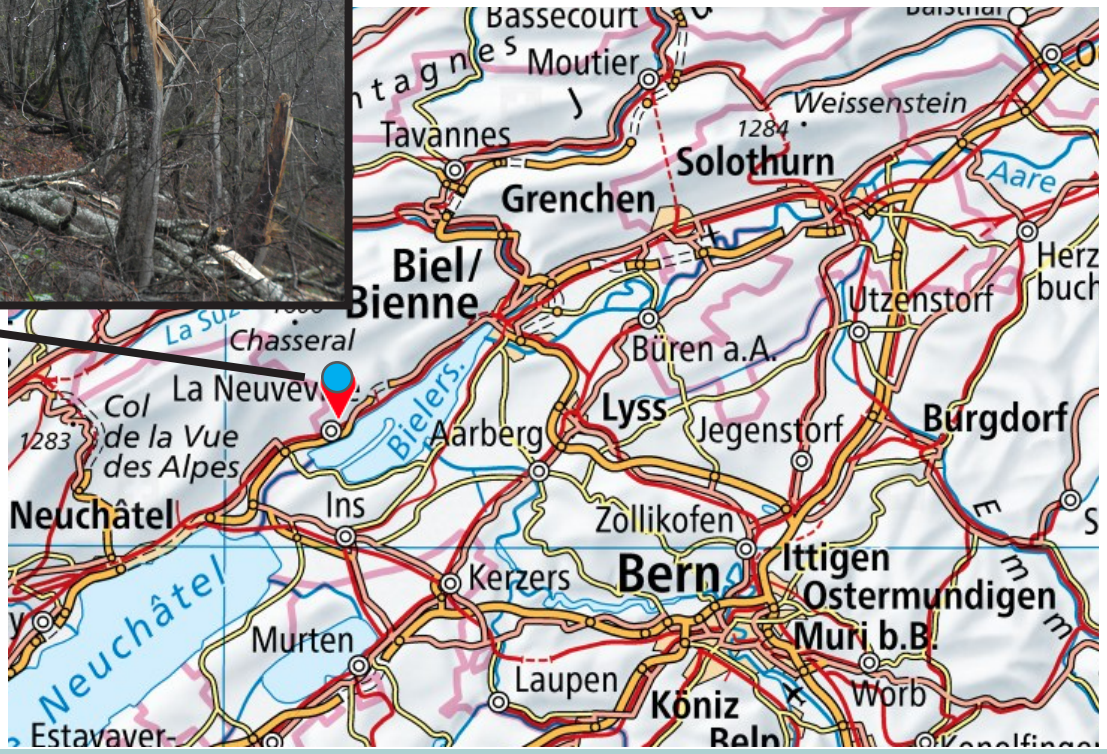
2003 summer fires in beech stands



Forest fires (> 100 ha) 1980-2013

summer fires in beech 2003

2018 spring fire in beech stands



Research questions

How resistant and resilient are beech forests to fire?

Do fires change ecosystem services - protection functions in particular?

Are post-fire measures needed?

Salvage logging?

Afforestation
vs.
natural regeneration

Chapter 1 | Beech mortality

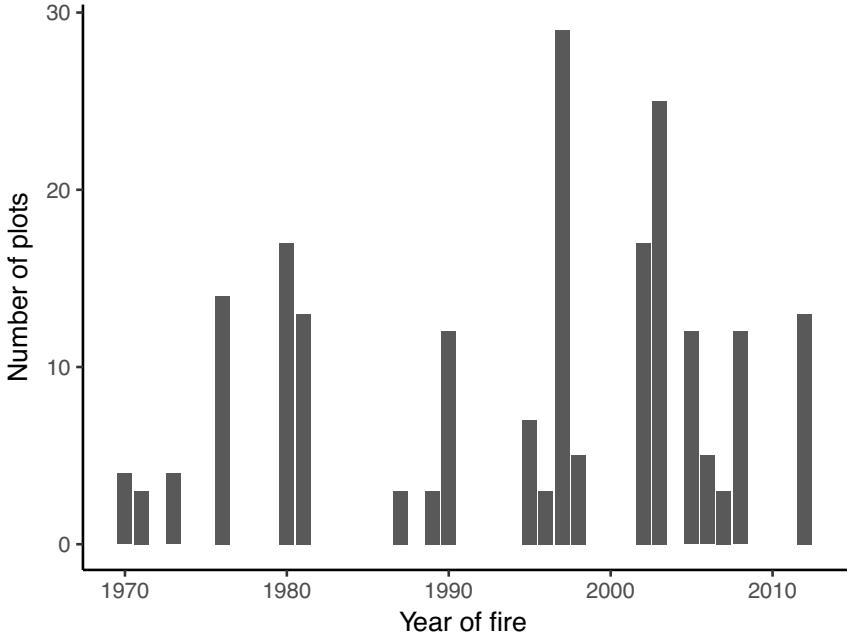
Chapter 2 | Beech regeneration

Chapter 3 | Protection capacity

Study region

Study region Ticino,
Glarus
Solothurn
Piemont

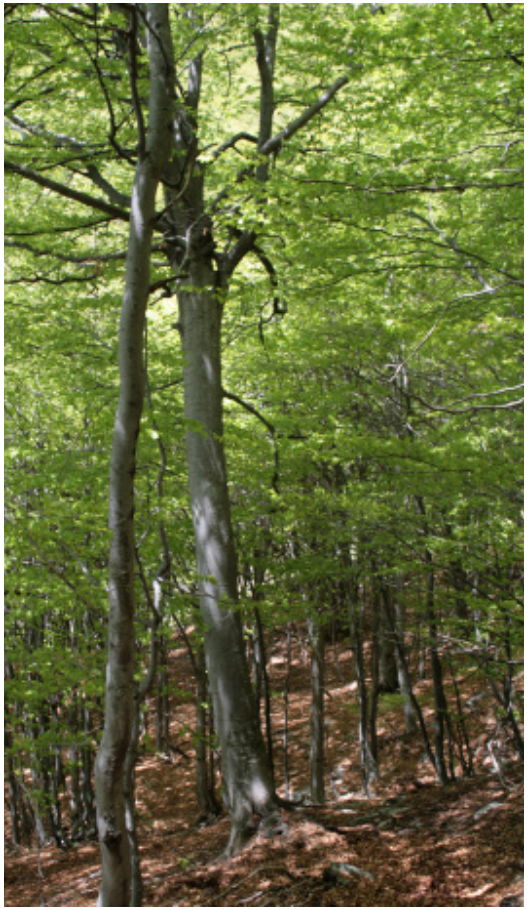
Space-for-time approach



Heterogeneity in fire behaviour

Burn severity

Burn severity



low severity

moderate severity

high severity

Chapter I Beech mortality

Chapter 1 | Beech mortality

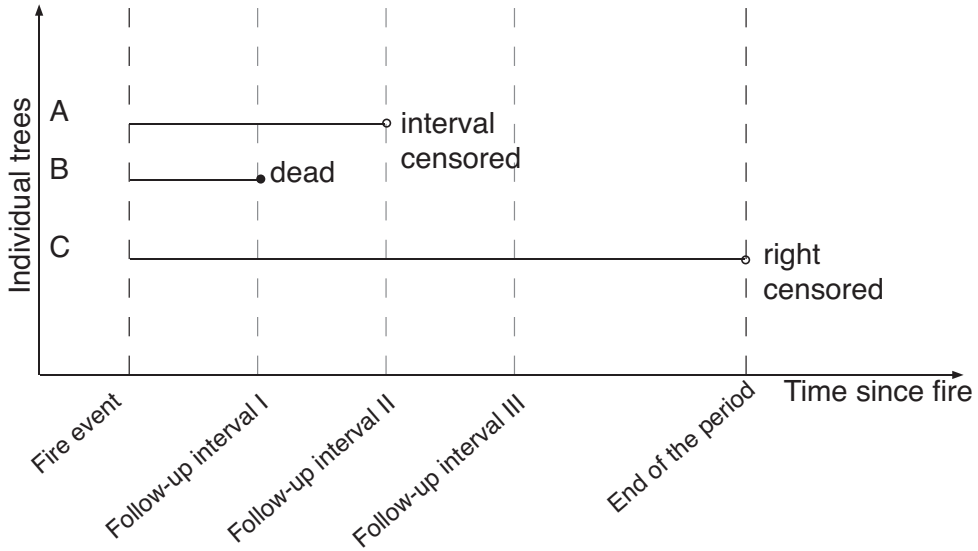
How resistant are beeches to single fires?
What drives the post-fire mortality process?

Chapter 1 | Beech mortality

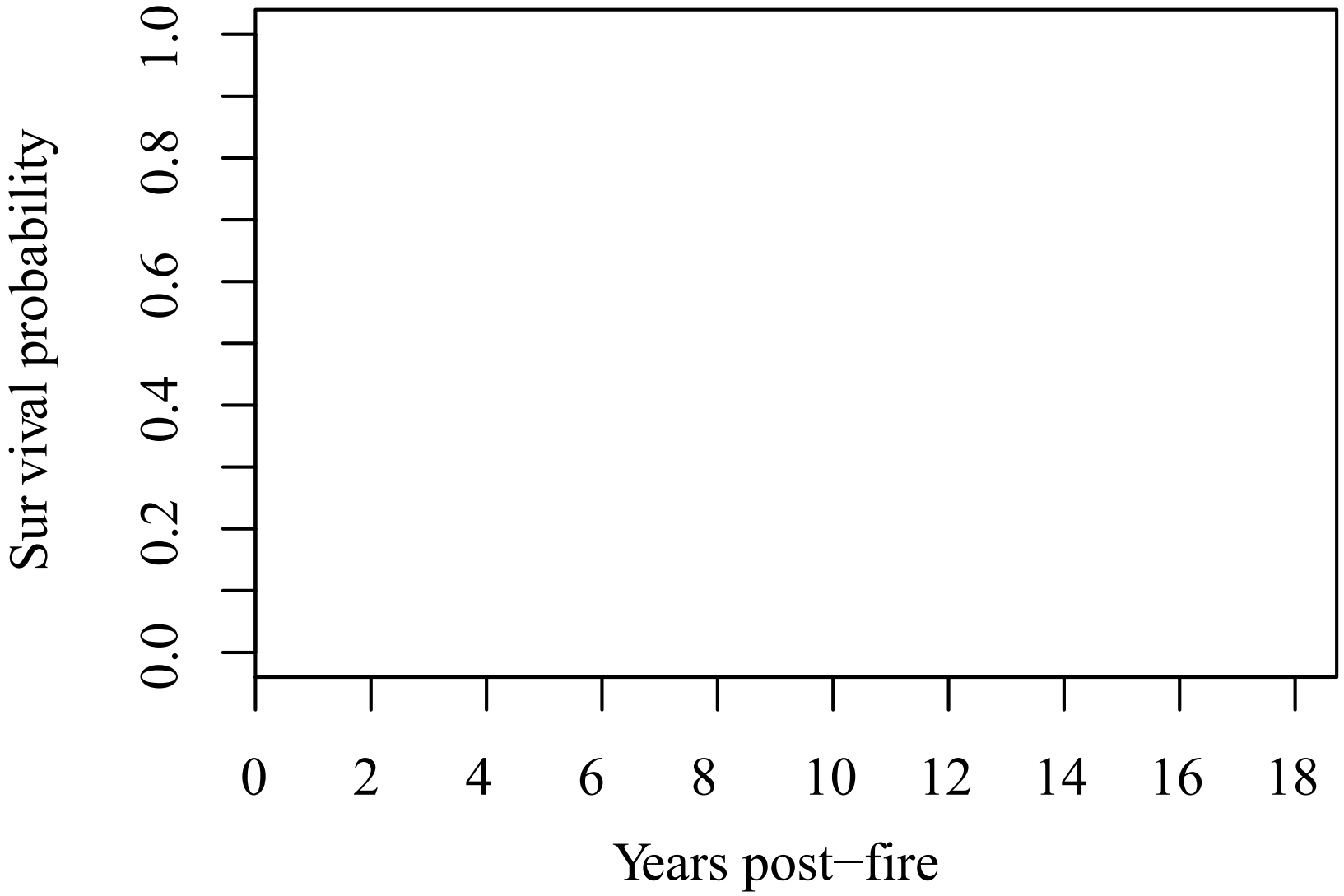
How resistant are beeches to single fires?
What drives the post-fire mortality process?

new approach

Modeling delayed (1 – 20 years post-fire) tree mortality
Survival analysis (Kaplan-Meier estimator, Cox-PH model)



Chapter 1 | Kaplan-Meier estimator



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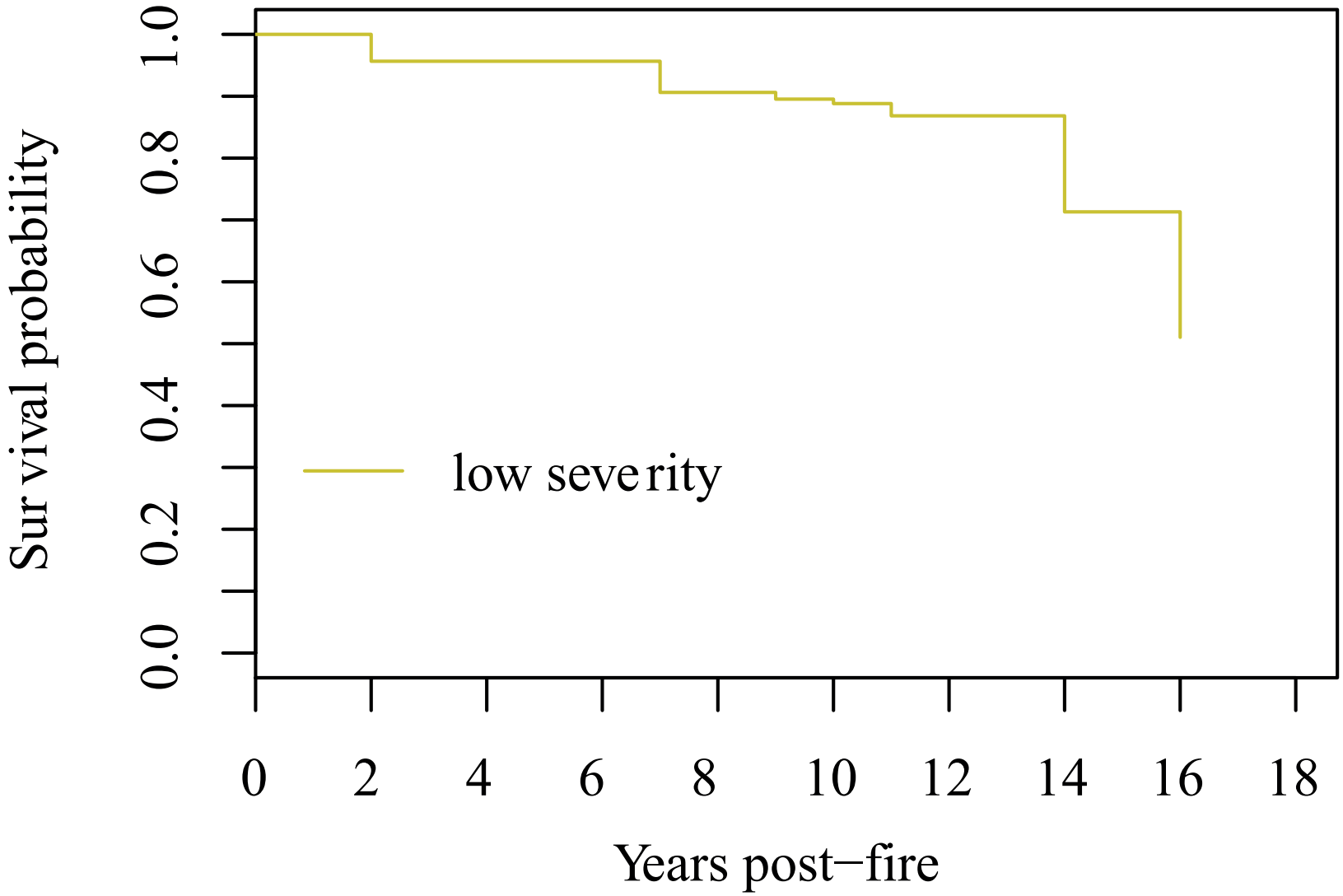

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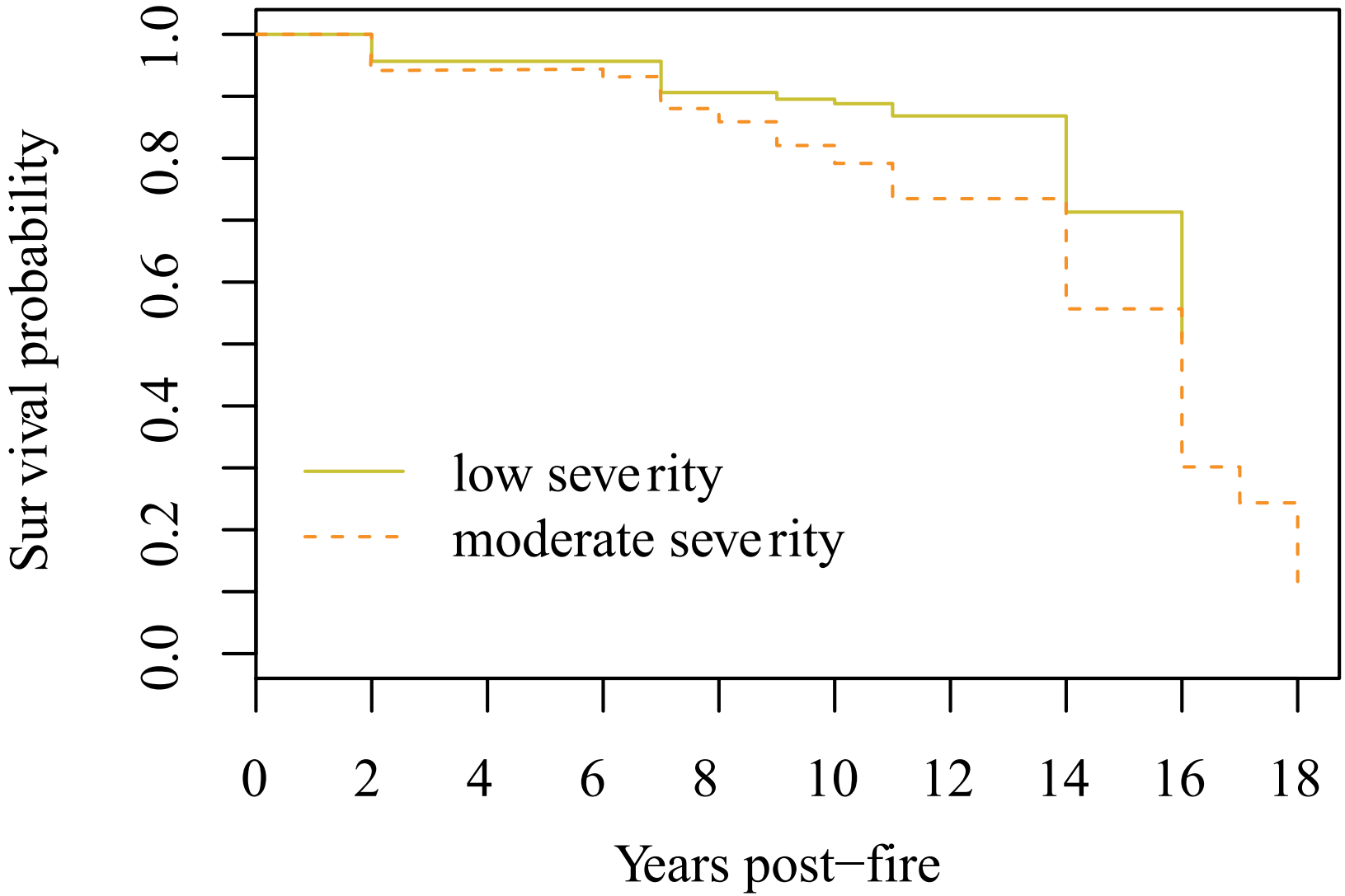

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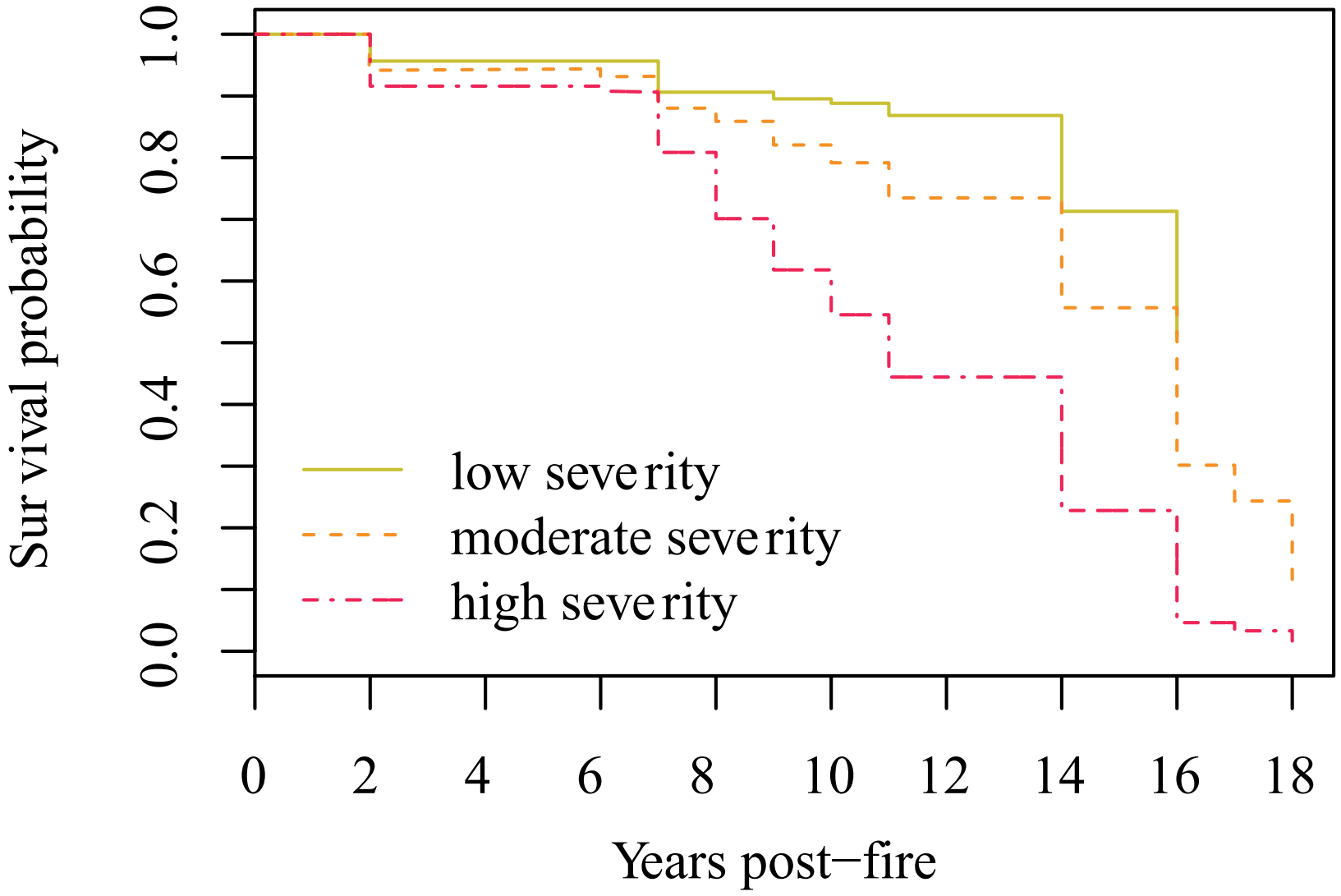

Chapter 1 | Cox-proportional hazards models

Explanatory variables

- Site characteristics (elevation, aspect, slope, ...)
- Tree characteristics (DBH, fungi investation, growth habit, ...)
- Climate (temperature, precipitation, SPEI, ...)

Chapter 1 | Cox-proportional hazards models

Variable	low-model	moderate-model	high-model
DBH	0.9*	0.9***	0.45***
Fungi	1.1**	3.6***	3.6***
growth habit	n.s.	0.9***	n.s.
precipitation	0.9***	0.9*	n.s.
temperature	n.s.	0.3***	0.4*
aspect	n.s.	n.s.	4***
altitude	0.9**	1	1.01***

HR < 1 reduce the hazard to die
HR > 1 increase hazard to die
HR = 1 no changes

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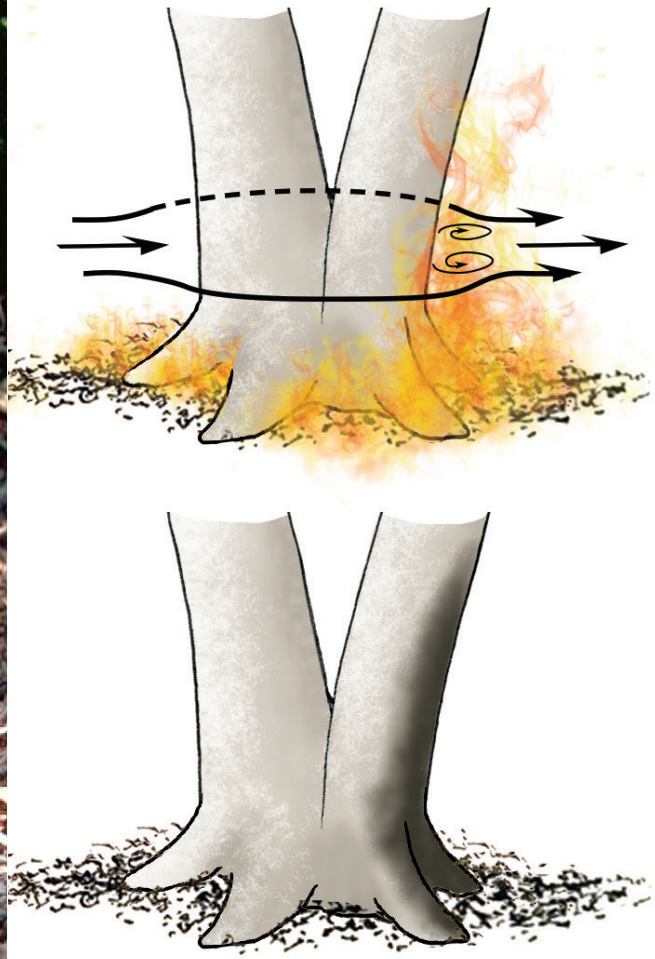

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Post-fire fungi infestation

Daldinia spec.

Cerrena unicolor

Stereum hirsutum

Schizophyllum commune

Irpex lacteus

In moderate and high severity burns trees getting infested by fungi have a 3.6-times higer probability to die.

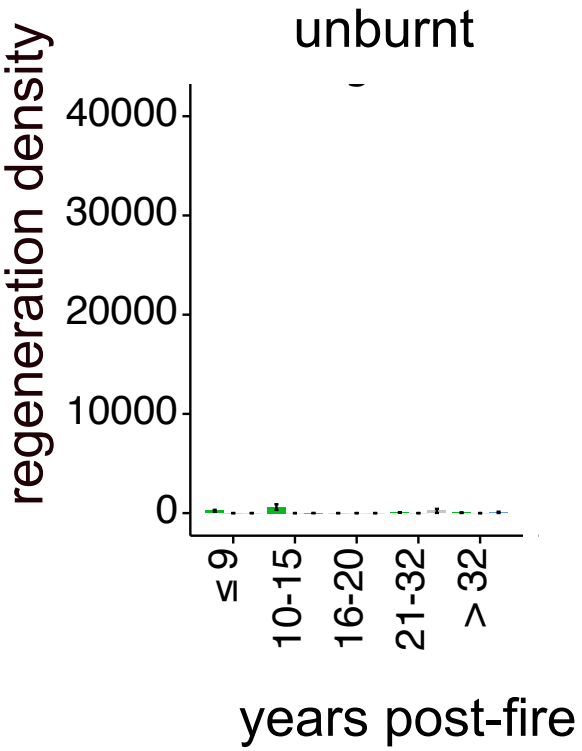
Chapter II Beech regeneration

Chapter 2 | Beech regeneration

What grows after fire?
What drives the regeneration process?

Chapter 2 |Beech regeneration

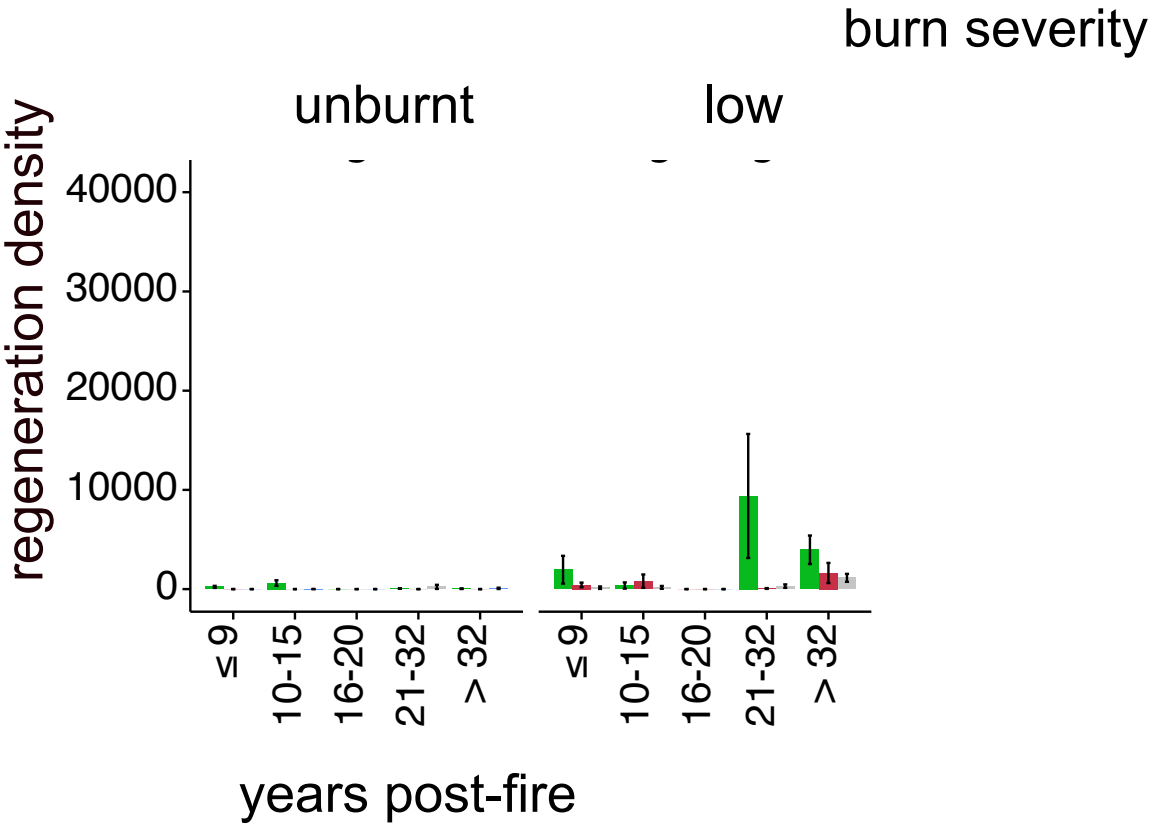
What grows after fire?



beech
pioneer
other

Chapter 2 |Beech regeneration

What grows after fire?



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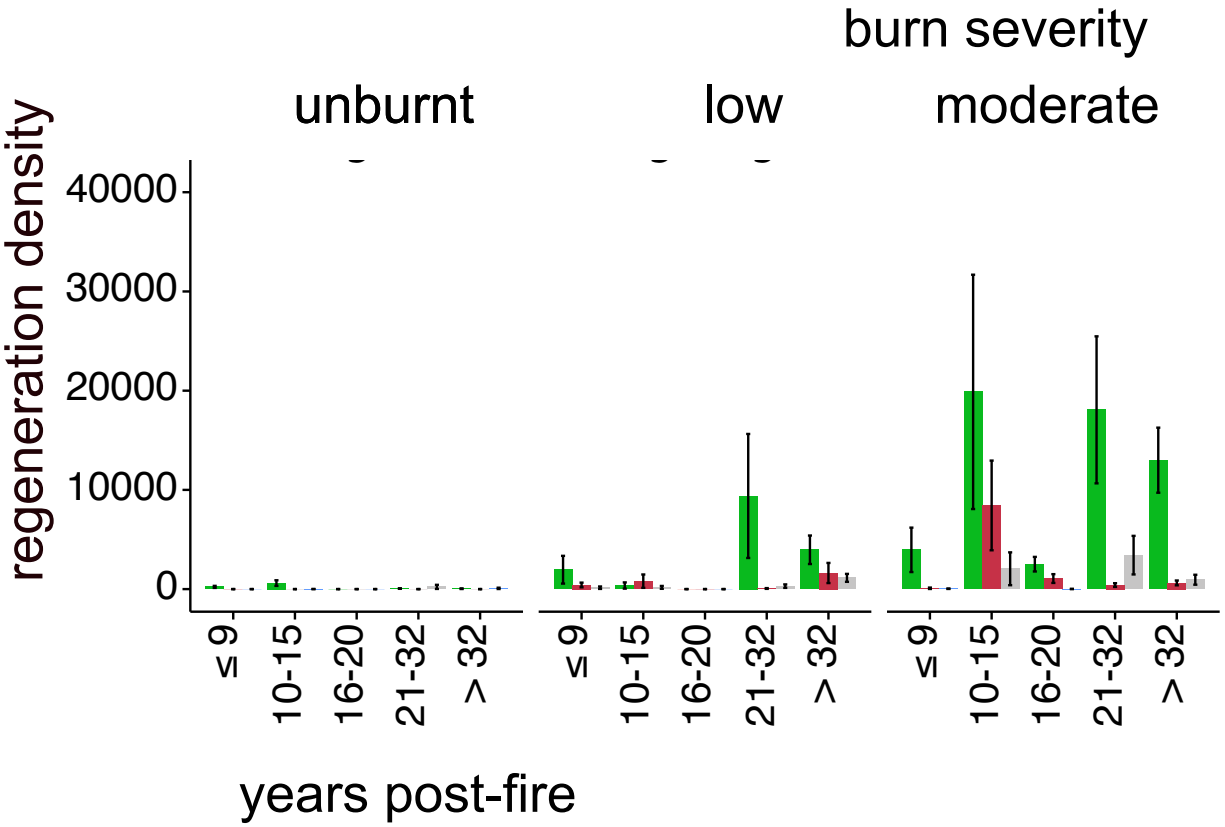

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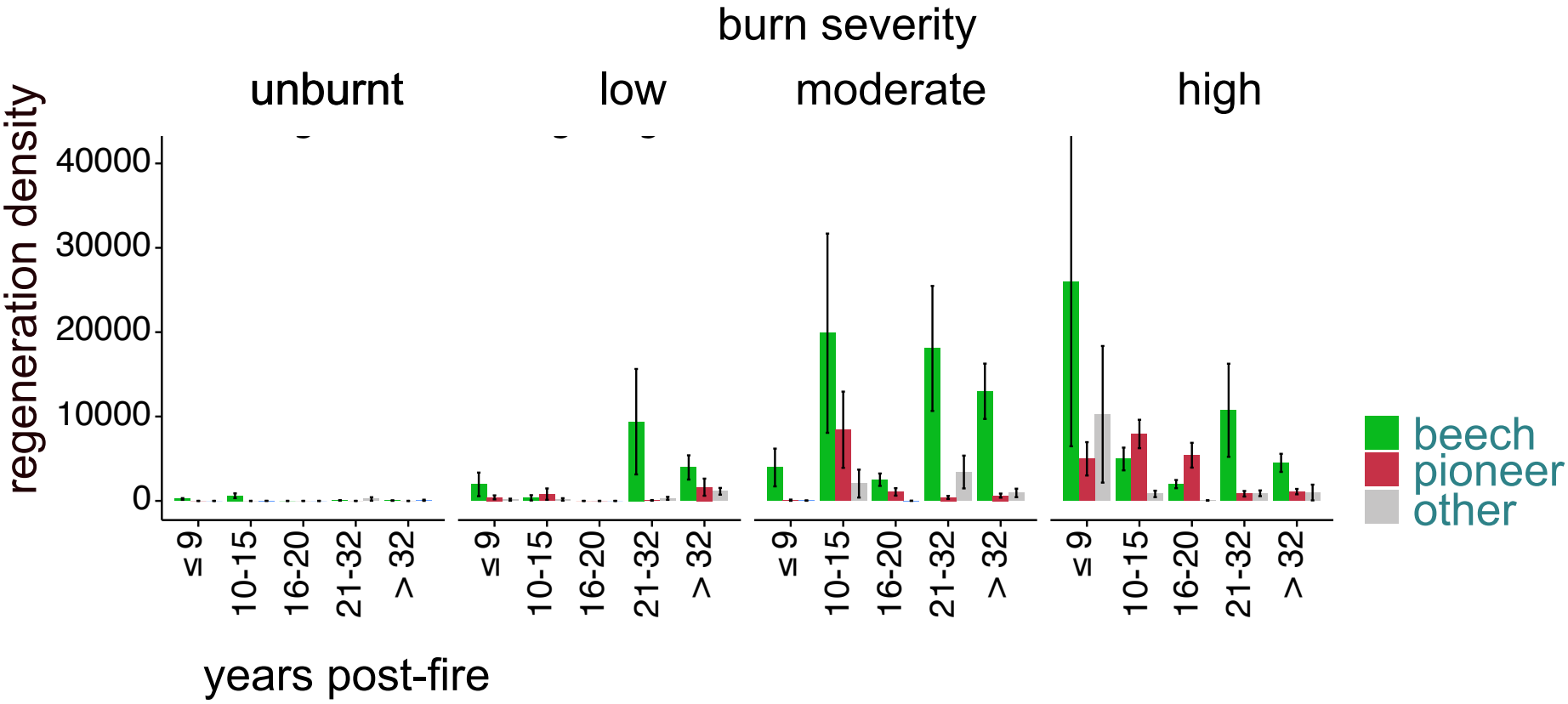

Chapter 2 | Beech regeneration

What drives beech regeneration processes?

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What drives beech regeneration processes?

Mixed-effect-model

Variables	seedlings (height < 20 cm)		saplings (height ≥ 20 cm)	
	Estimate	sig.level	Estimate	sig.level
Intercept	12.7	***	18.4	***
mother trees	2.1	***	-2.3	***
cover ground vegetation	-2.0	***	-2.1	**
years post-fire	-3.1	***	3.0	*
exposition	n.s		-1.1	*
coarse woody debris	n.s		2.3 ***	
R^2	0.54		0.47	

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Chapter 2 | Beech regeneration

What drives beech regeneration processes?

seedlings need
close-by mother trees

Chapter 2 | Beech regeneration

What drives beech regeneration processes?

saplings need light

years post-fire

Chapter 2 | Beech regeneration

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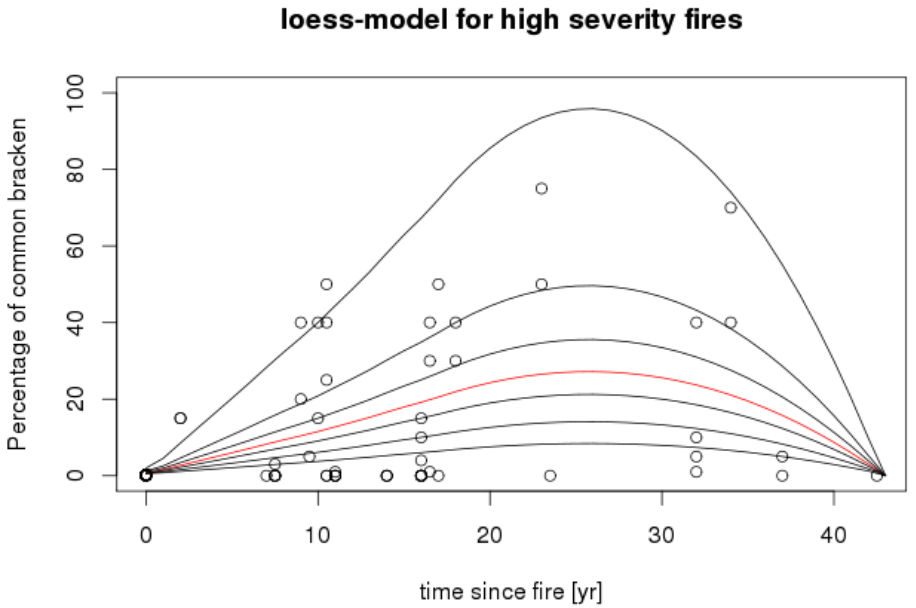

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Chapter 2 | Beech regeneration

What drives the regeneration process?

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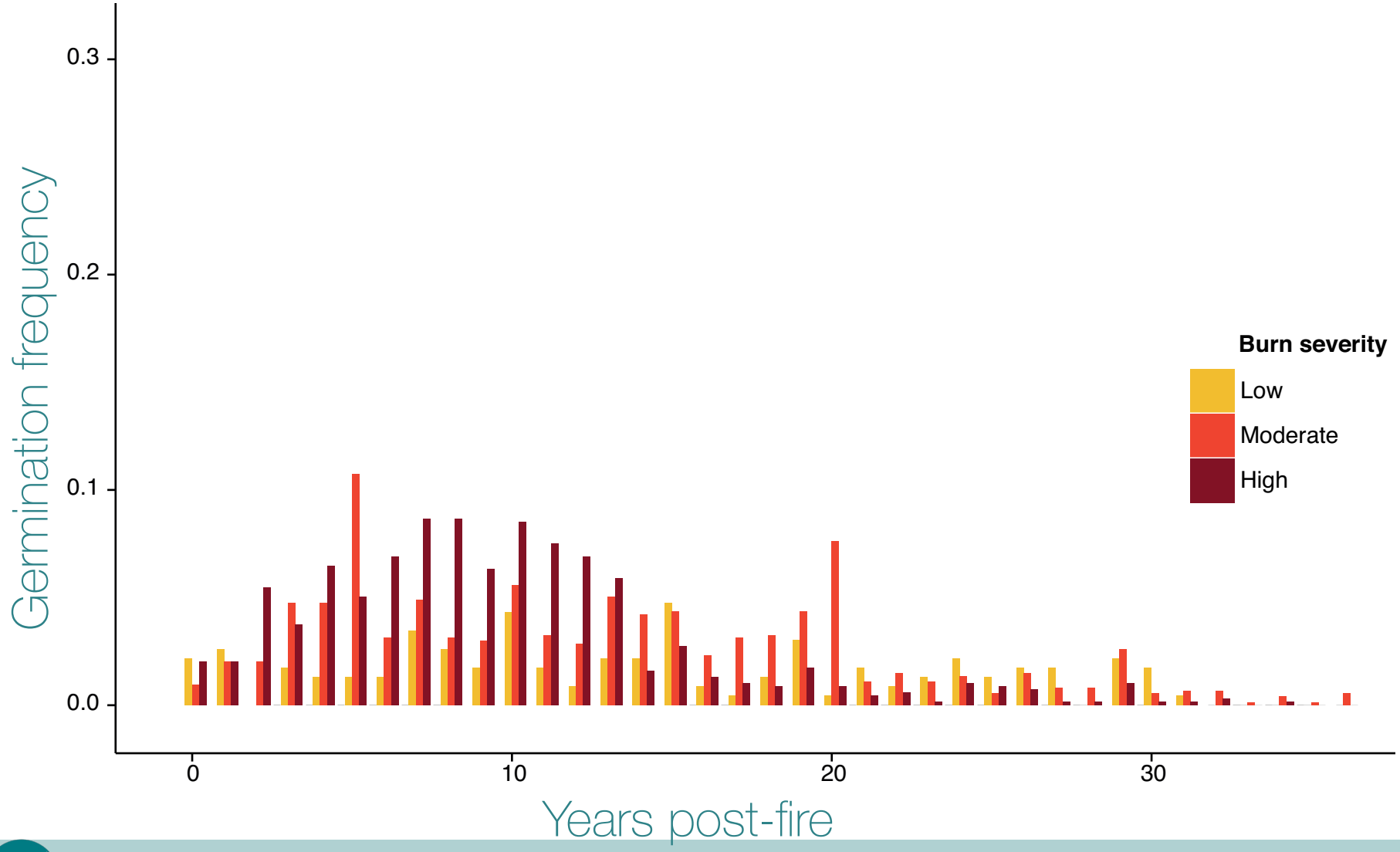
What drives the regeneration process?

- close-by mother trees
- absence of competing ground vegetation
- coarse woody debris

How long is the regeneration window open?

Chapter 2 | Beech regeneration

How long is the regeneration window open?



Chapter 2 | Beech regeneration

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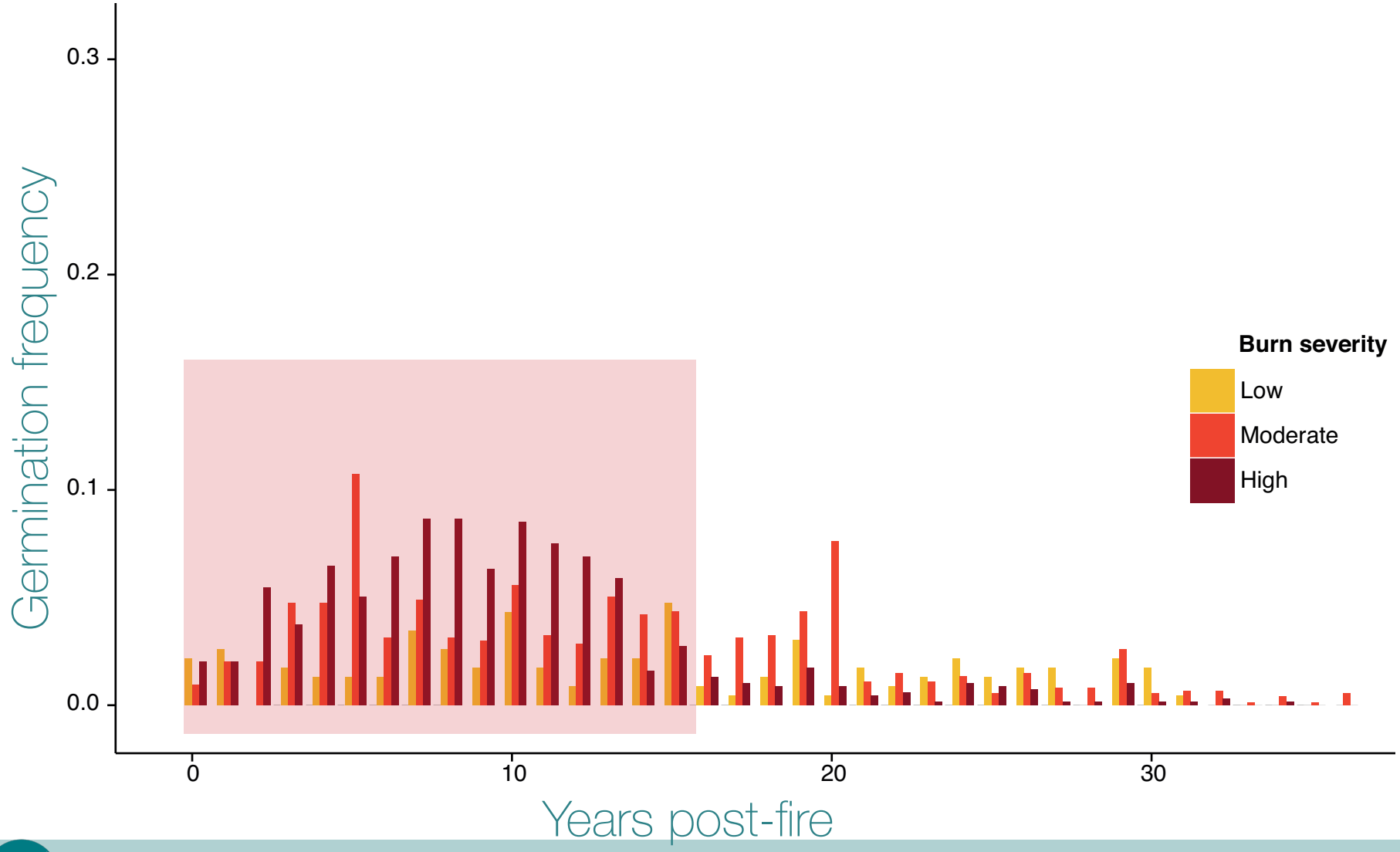

Chapter 2 | Beech regeneration

How long is the regeneration window open
Zero-inflated-model with random effect

Variables	Estimate
Intercept	-3.3 ***
mast years	
full	0.7***
half	0.5***
local	0.3 **
canopy cover (caco)	-0.17*
Caco : mast year	-0.3 *
observation intervals	-0.5***
Standardised Precipitation Evapotranspiration I	0.09*
Vegetation competition	-0.26**
Zero-infalted part	
canopy cover	0.4**

Chapter 2 | Beech regeneration

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Chapter 2 | Beech regeneration

years post-fire

Chapter III Protection capacity

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Change fires ecosystem services - especially protection functions?

rockfall

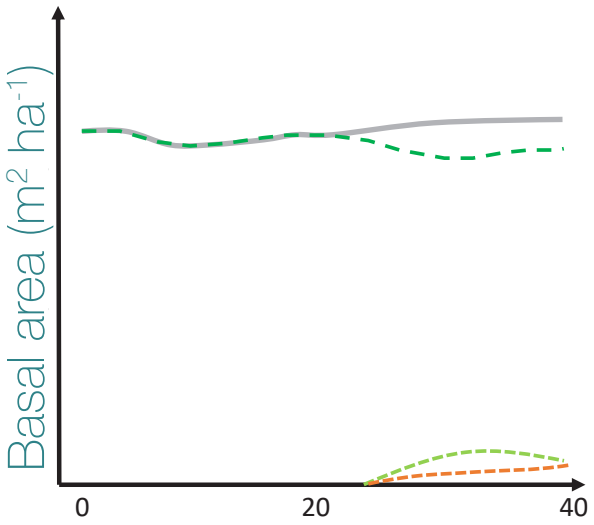
soil erosion

landslide

Chapter III Protection capacity against rockfall

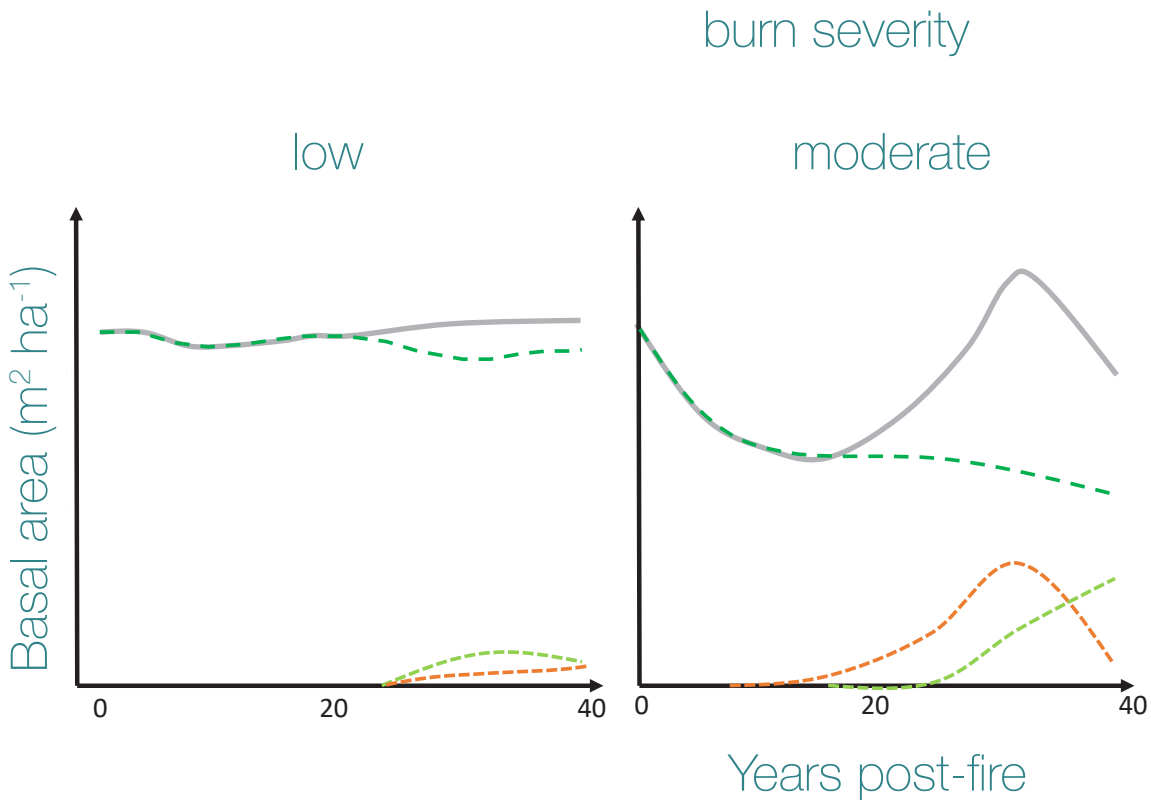
burn severity

low



low protection capacity
sum of basal area
pre-fire beeches
regenerion other tree species
beech regeneration

Chapter III Protection capacity against rockfall



Chapter III Protection capacity against rockfall

Chapter III Protection capacity against rockfall

What do we learn for the practice?

Depending on the ecosystem service ...

... single tree removal for public safty
... be aware of fire severity in protection forests
... always keep in mind the interaction between mast years and tree cover

If it is no protection forest...
... leave dead wood
... leave dying trees
Just assist natur!

What do we learn for the practice?

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Feuerökologie montaner Buchenwälder

Waldleistungen und waldbauliche Massnahmen nach Waldbrand

Janet Maringer, Davide Ascoli, Eric Gehring, Thomas Wohlgemuth, Massimiliano Schwarz, Marco Conedera

Youtube video

Thank you for your attention!

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