

Vegetation dynamics in unmanaged mountain forests following bark beetle induced spruce dieback

Vegetation databases
and inference of ecological processes

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Berchtesgaden National Park

Germany

15 National Parks



Quelle: BfN, 2014

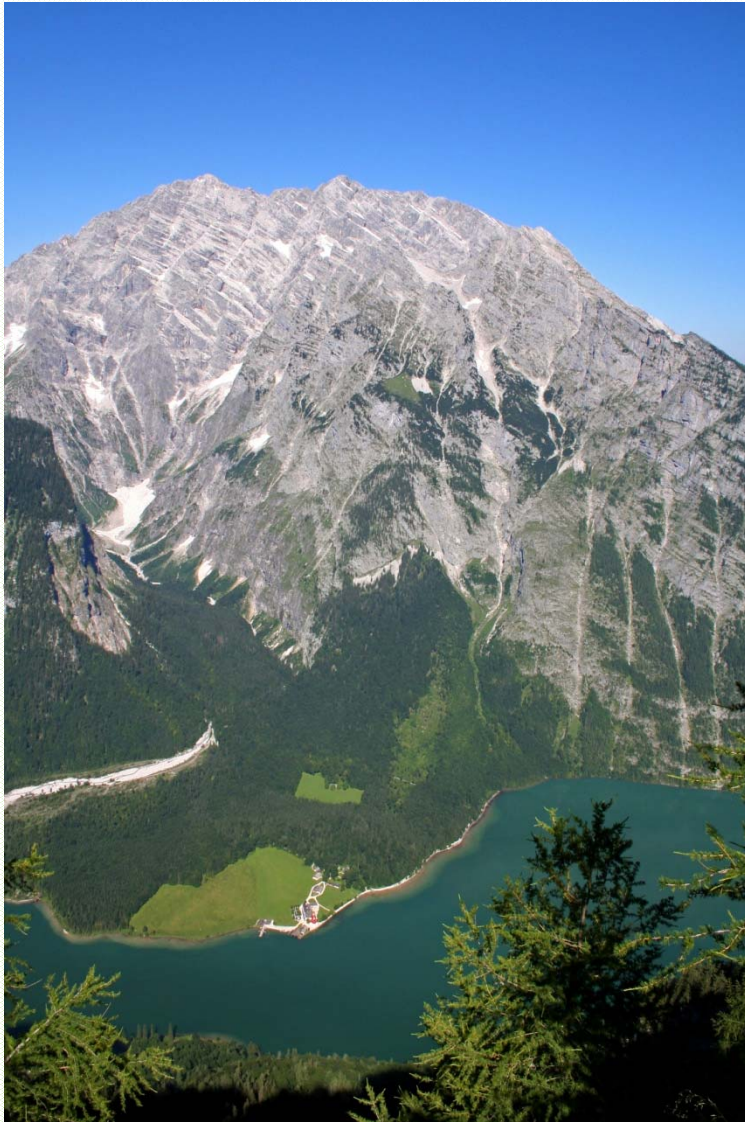
IZ

50 100 km

Berchtesgaden



Berchtesgaden National Park



Foundation

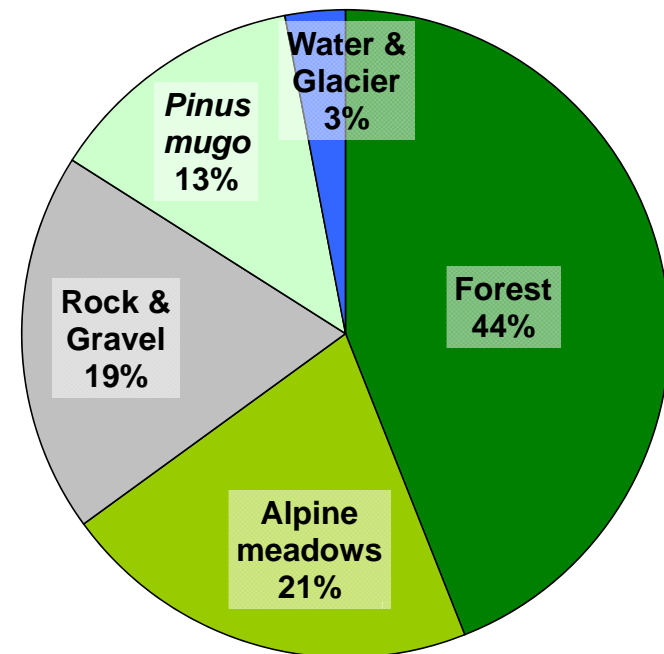
National Park since 1978

Size

20.808 ha

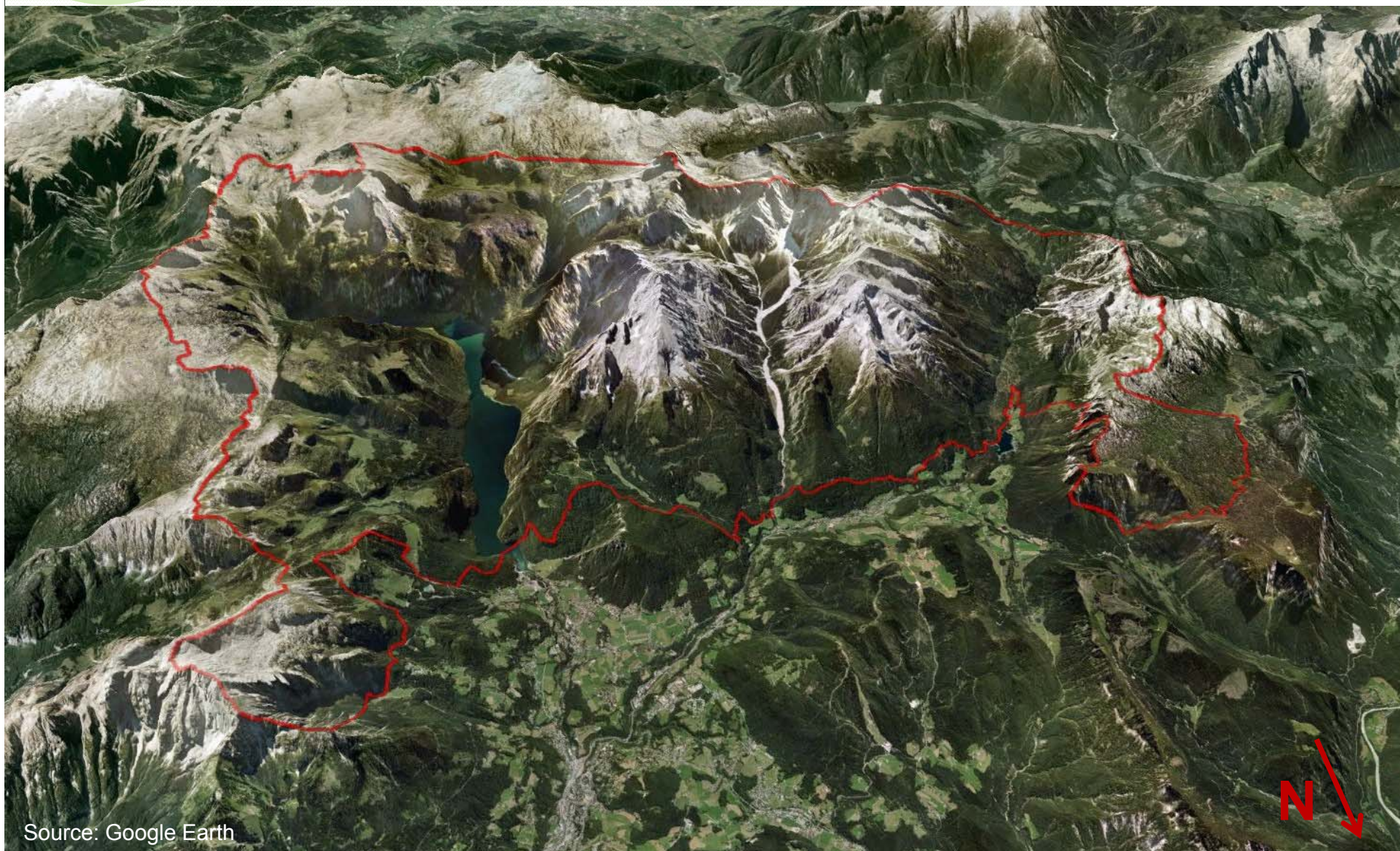
Elevation gradient

Königssee 603 m → Watzmann 2.713 m





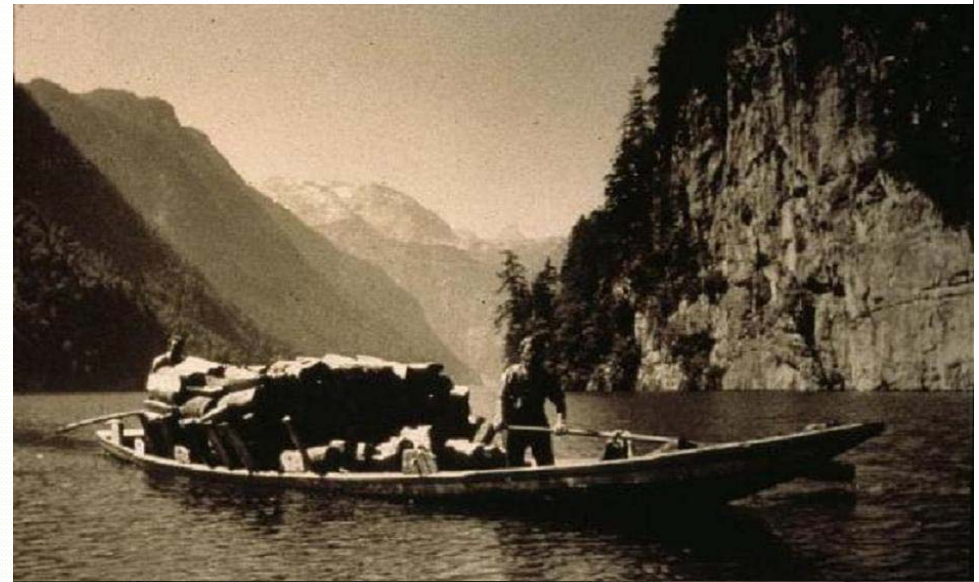
Berchtesgaden National Park



Source: Google Earth



Berchtesgaden National Park



17. – 19. century

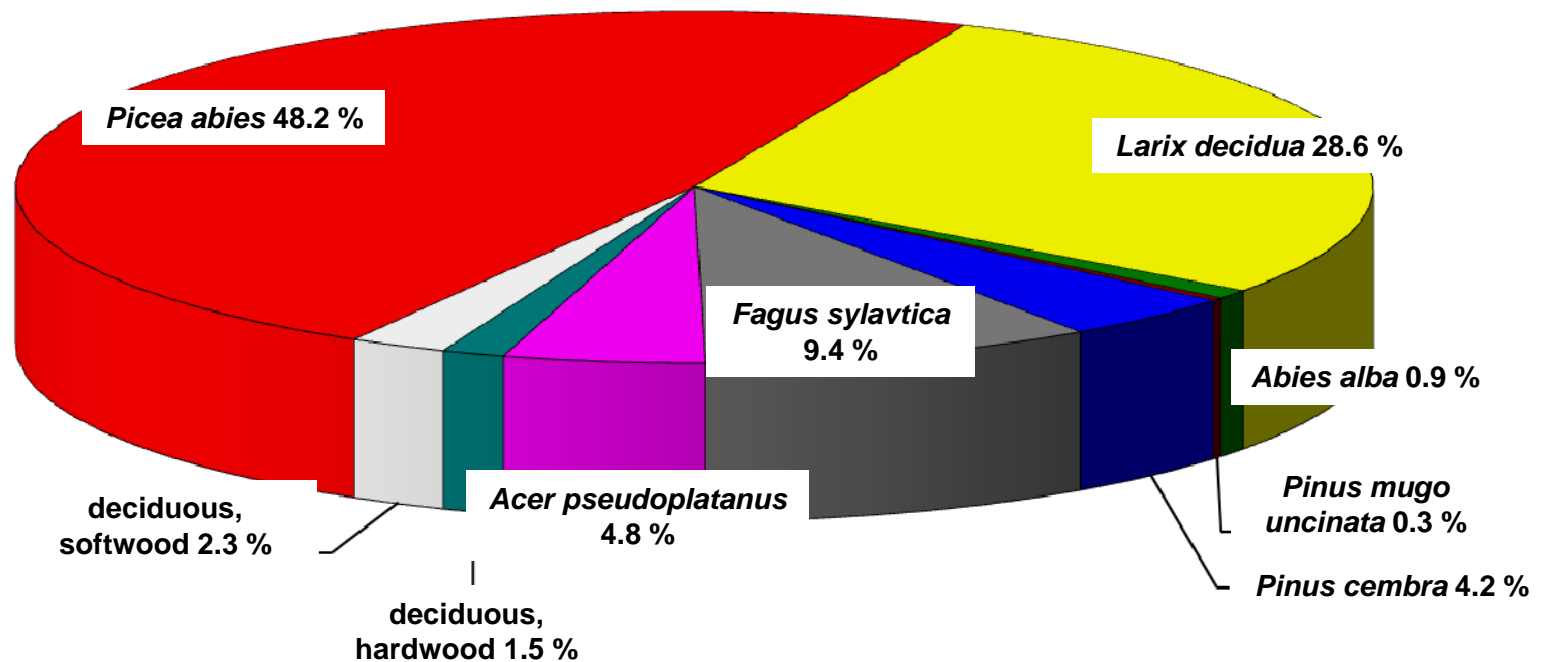
Tremendous wood demand
for salt mining industry



Berchtesgaden National Park

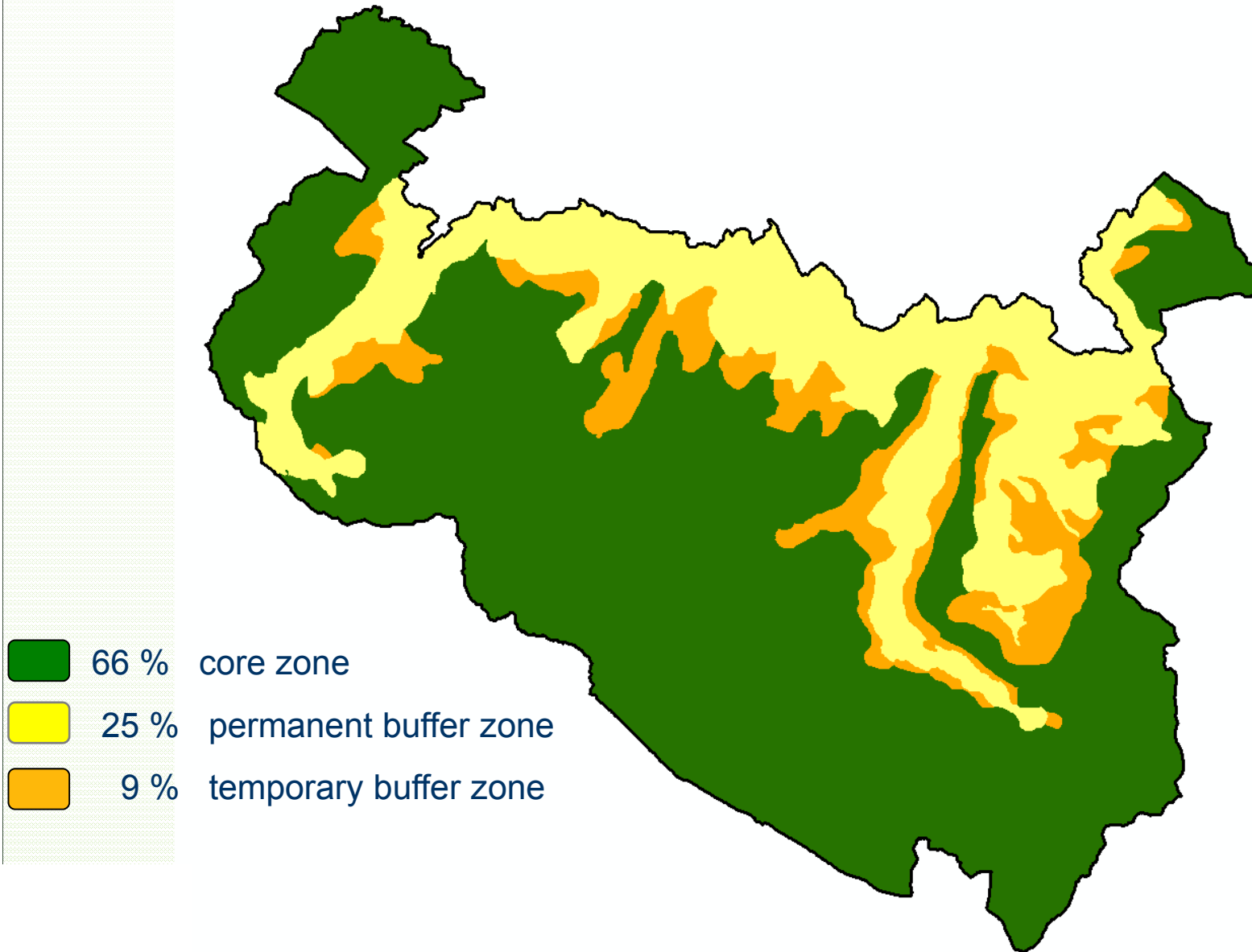


Baumartenverteilung 2010/12
- Nationalpark gesamt -



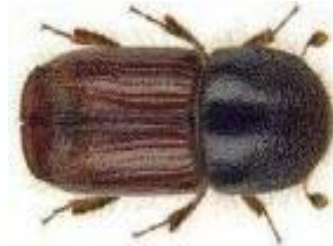


Berchtesgaden National Park





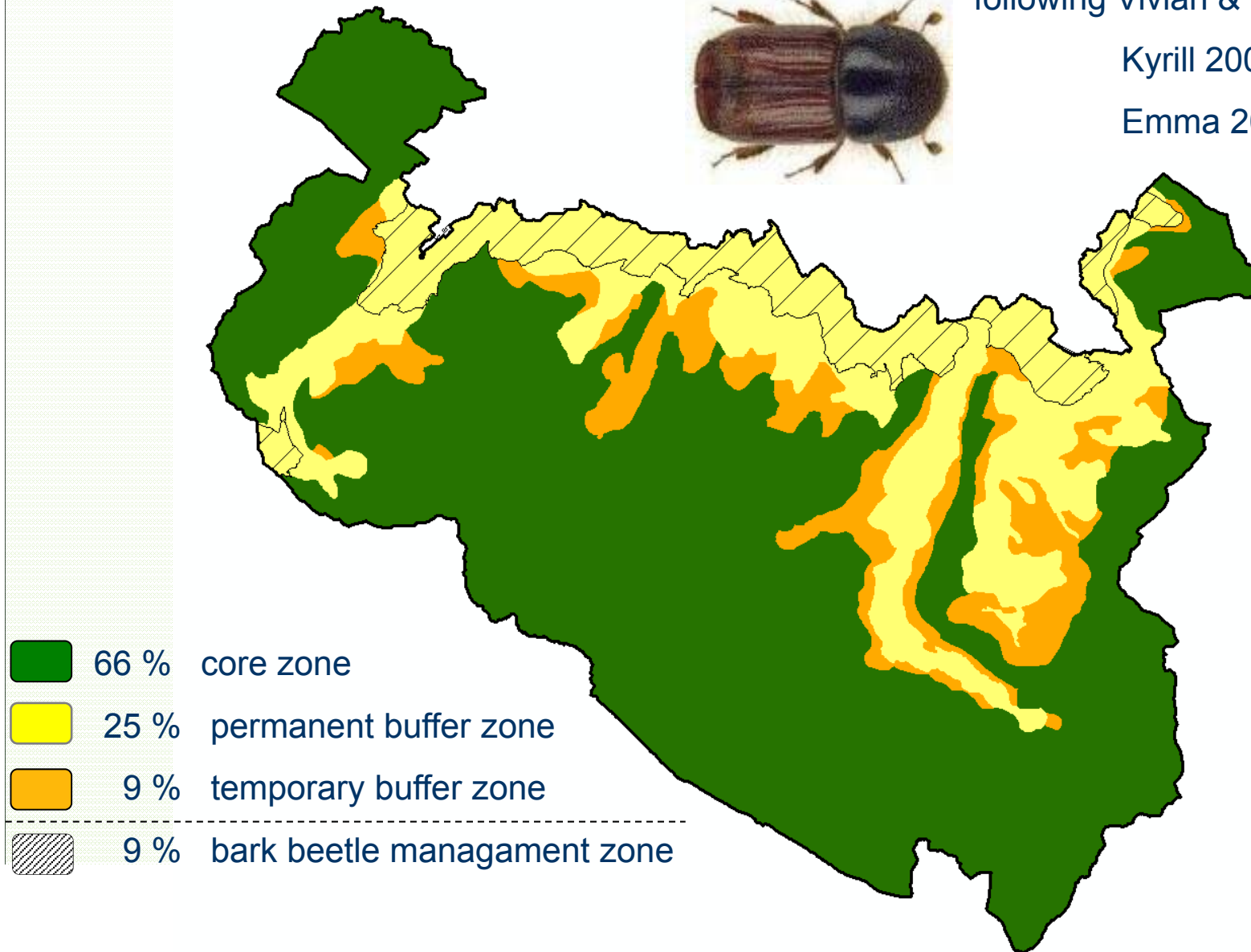
Berchtesgaden National Park



following Vivian & Wiebke 1990

Kyrill 2007

Emma 2008

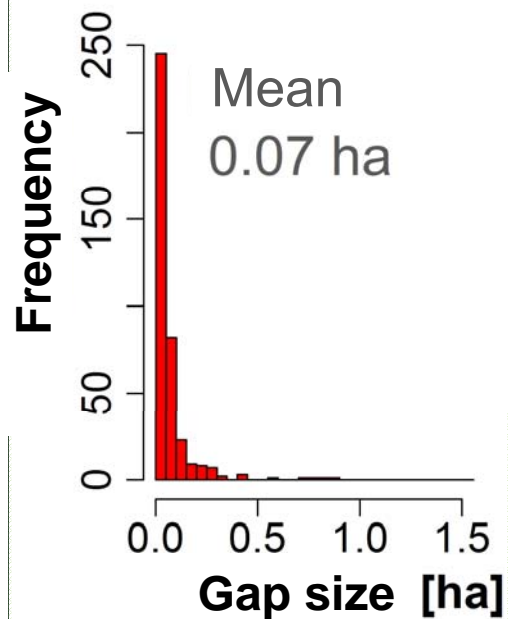


- 66 % core zone
- 25 % permanent buffer zone
- 9 % temporary buffer zone
- 9 % bark beetle management zone

Bark beetle development in the NP



ca. 100 ha



Nationalpark Berchtesgaden

Borkenkäferbefall 1990 - 1997

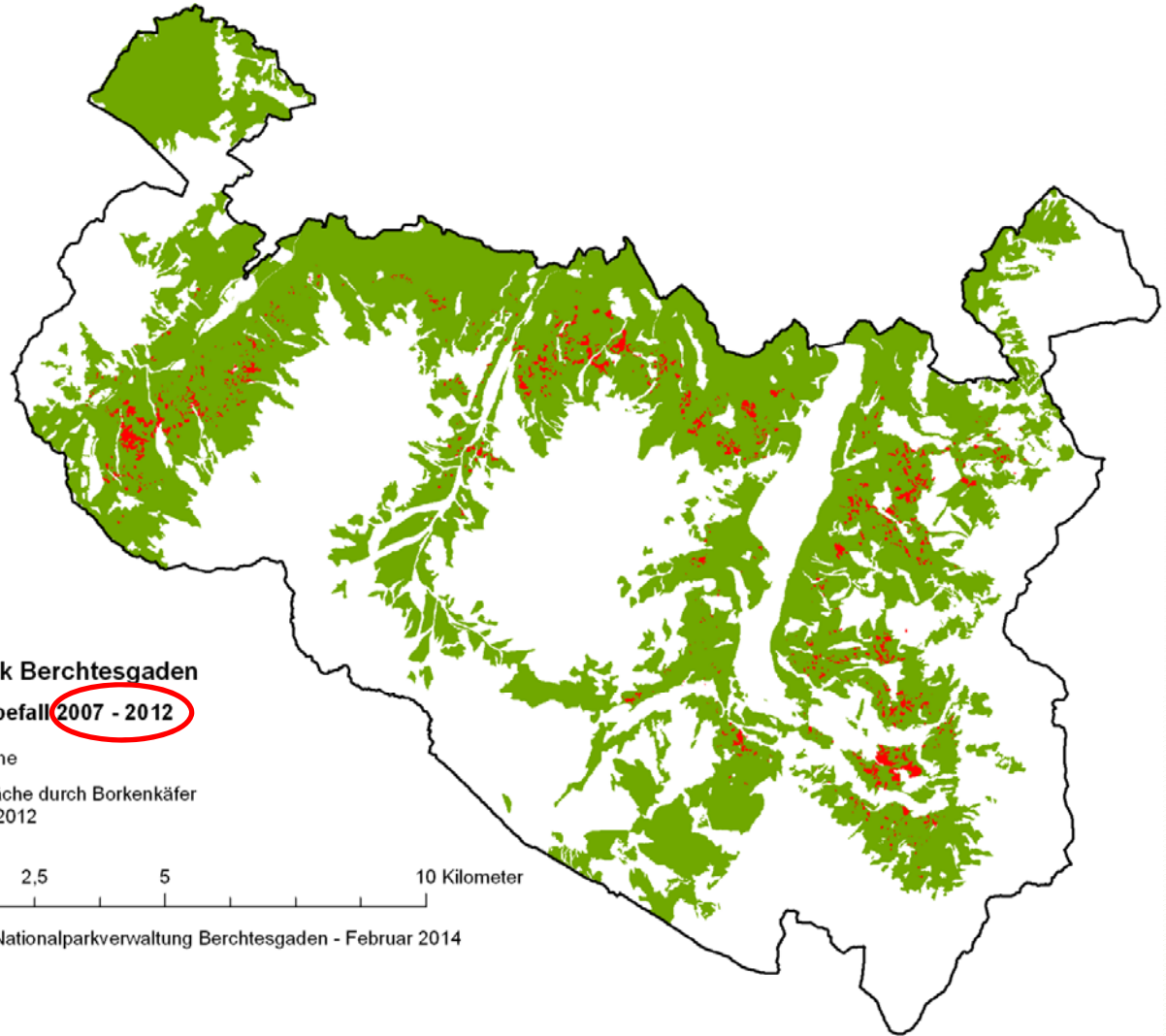
- Waldfläche
- Befallsfläche durch Borkenkäfer auf CIR 1997



Bark beetle development in the NP



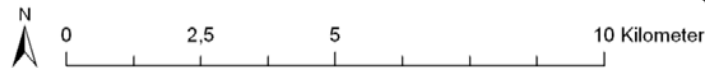
ca. 400 ha



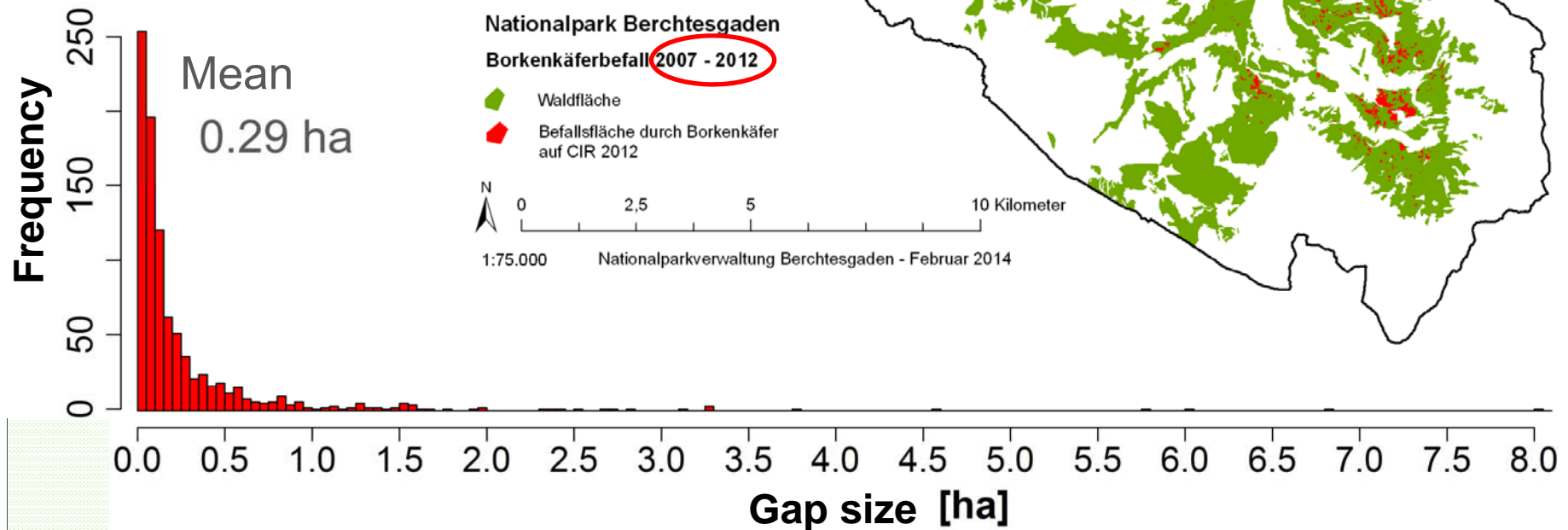
Nationalpark Berchtesgaden

Borkenkäferbefall **2007 - 2012**

- Waldfläche
- Befallsfläche durch Borkenkäfer auf CIR 2012

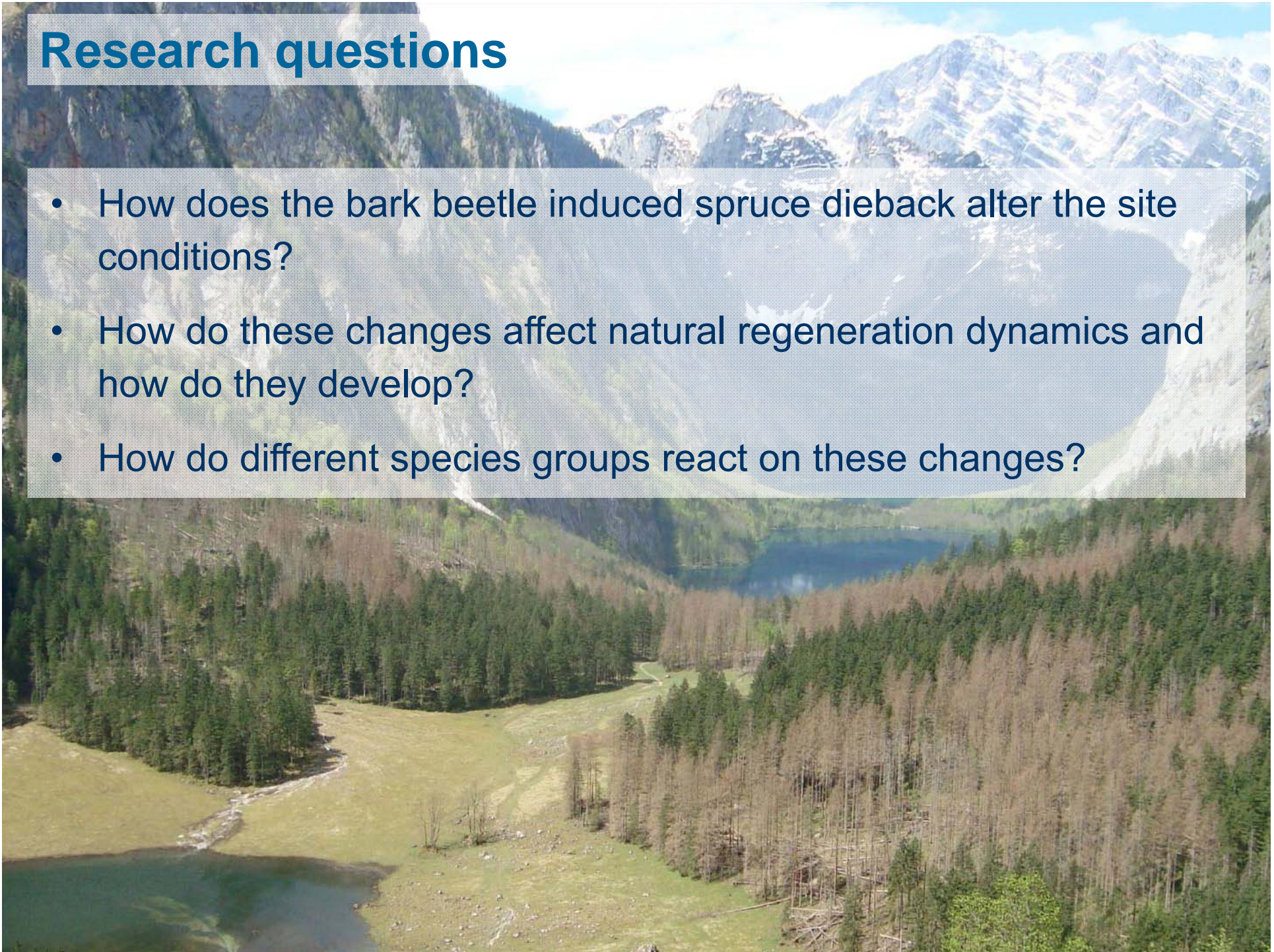


1:75.000 Nationalparkverwaltung Berchtesgaden - Februar 2014

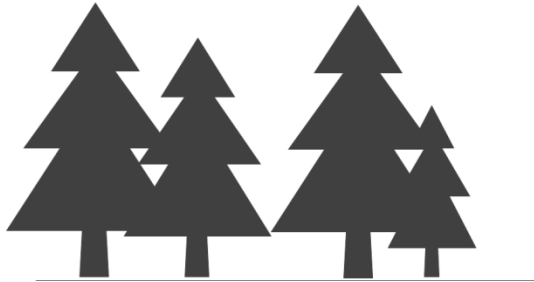


Research questions

- How does the bark beetle induced spruce dieback alter the site conditions?
- How do these changes affect natural regeneration dynamics and how do they develop?
- How do different species groups react on these changes?



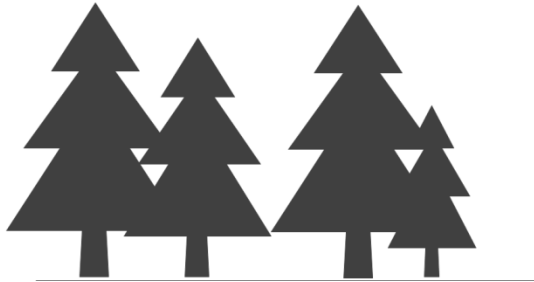
Methods – chronosequence



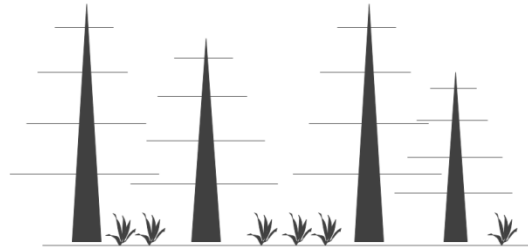
Mature spruce forest



Methods – chronosequence



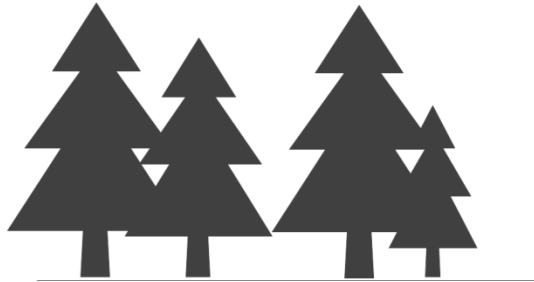
Mature spruce forest



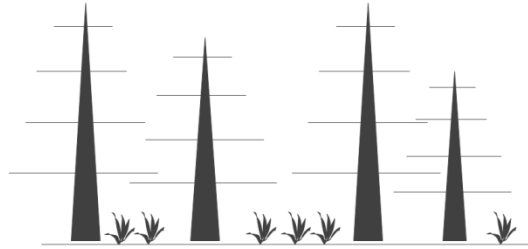
Initial early-seral stage



Methods – chronosequence



Mature spruce forest



Initial early-seral stage



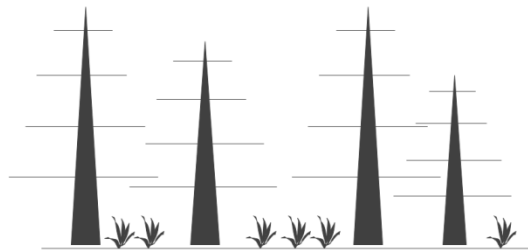
Advanced early-seral stage



Methods – chronosequence



Mature spruce forest



Initial early-seral stage



Advanced early-seral stage



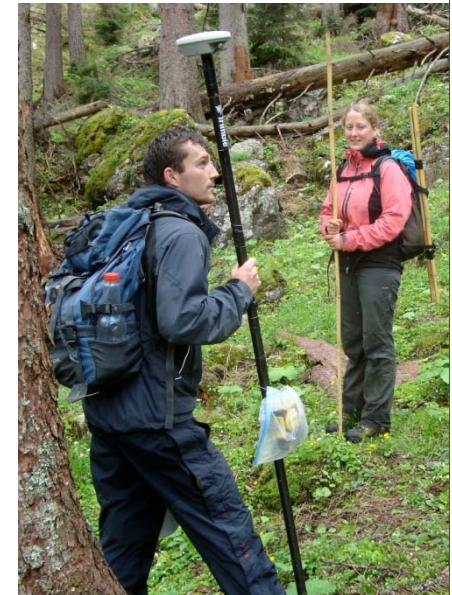
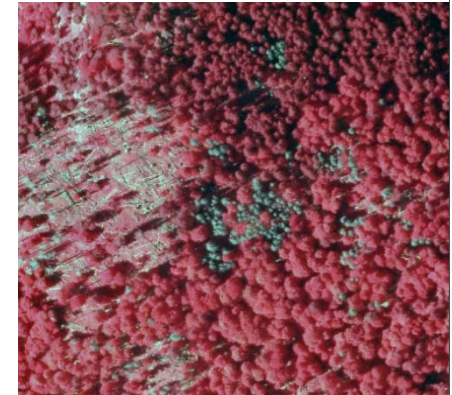
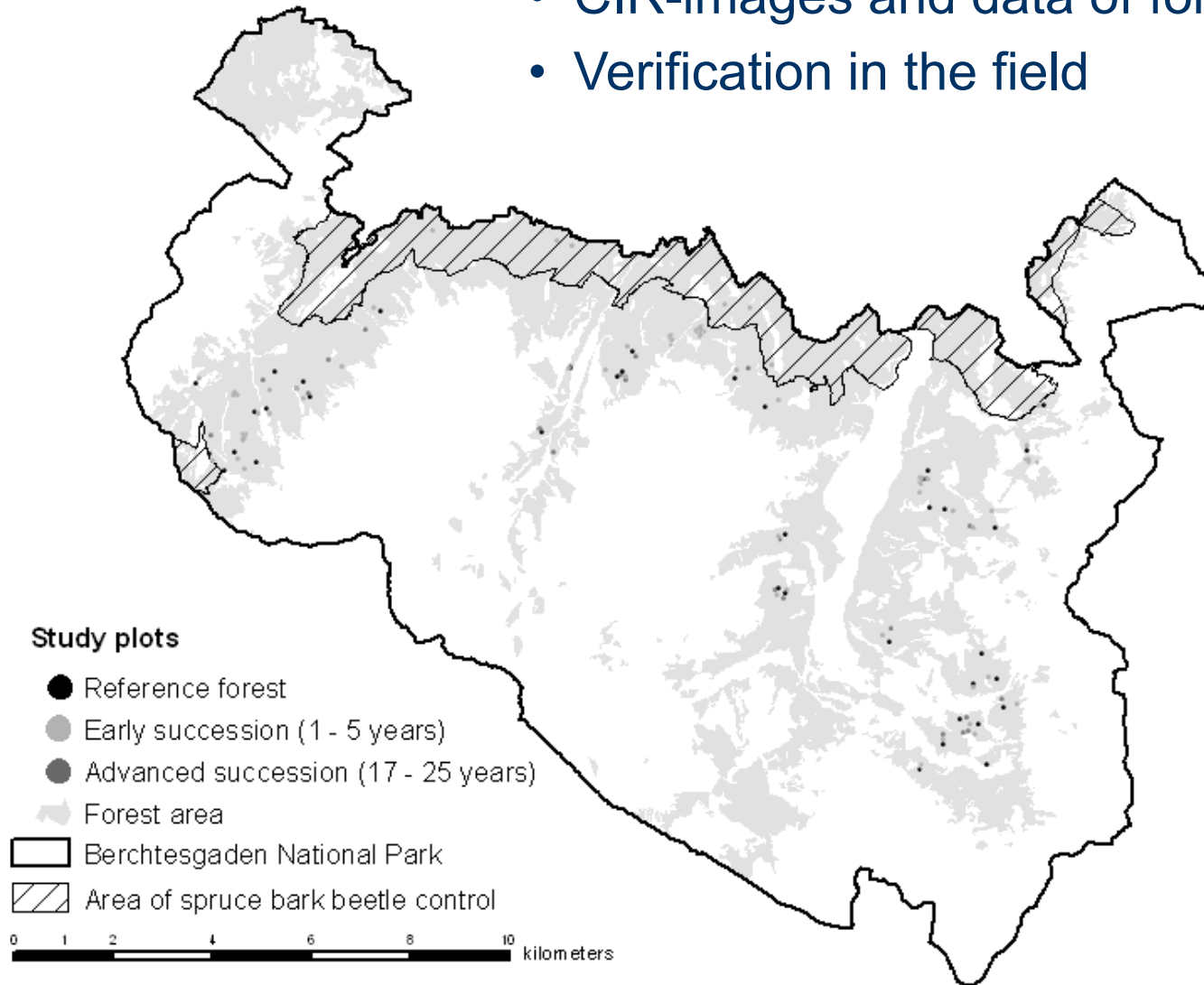
Elevation montane, high montane, subalpine

Aspect north-facing, south-facing

→ 16 types with 6 study plots each → 96 study plots

Methods – study sites

- CIR-images and data of forest inventory
- Verification in the field



Methods - parameters

Site

- temperature (air and soil)
- radiation
- humus & soil



Stand

- living stand
- deadwood
- regeneration



Flora, Fauna & Fungi

- vascular plants
- insects
- mollusks
- saproxylic fungi









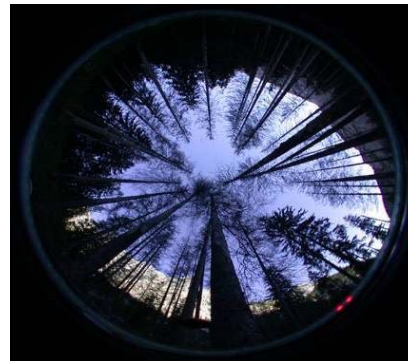






Forest succession – site conditons

	Crown cover	Relative direct radiation
	[%]	[%]
Montane		
Mature	62 (8.8) a	29 (5.3) a
Initial early-seral	18 (11.3) c	41 (6.1) b
Advanced early seral	37 (22.0) ac	41 (8.6) b
High montane		
Mature	62 (8.3) a	27 (3.9) a
Initial early-seral	13 (10.6) c	42 (5.5) b
Advanced early seral	23 (13.7) bc	44 (9.3) b
Subalpine		
Mature	50 (5.9) ab	28 (6.6) a
Initial early-seral	18 (10.3) c	42 (9.0) b





Forest succession – site conditons

	Crown cover	Relative direct radiation	Snow cover Winter 2012/13	Vegetation period 2013	Litter cover	Ground vegetation cover	Ground vegetation height	Humus depth	Deadwood decay stage
	[%]	[%]	[days]	[days]	[%]	[%]	[cm]	[cm]	(6 classes)
Montane									
Mature	62 (8.8) a	29 (5.3) a	92 (43) a	208 (11) a	24 (16.6) ab	50 (14.1) ac	13 (3.1) a	7 (3.7) a	3 (1.0) ab
Initial early-seral	18 (11.3) c	41 (6.1) b	110 (25) ab	202 (5) ac	21 (20.6) a	56 (18.7) ab	16 (7.5) ab	8 (8.2) a	2 (0.4) c
Advanced early seral	37 (11.7) ac						29 (11.7) bc	5 (3.8) a	3 (0.6) a
High montane									
Mature	62 (8.8) a						10 (3.1) a	11 (6.8) a	3 (0.9) a
Initial early-seral	13 (11.3) c						23 (12.2) bc	13 (9.1) a	2 (0.4) c
Advanced early seral	23 (11.7) bc						30 (14.4) b	10 (6.3) a	3 (0.2) a
Subalpine									
Mature	50 (8.8) ab						13 (3.7) ac	11 (4.8) a	3 (1.2) ac
Initial early-seral	18 (11.3) c						25 (7.8) b	13 (10.4) a	2 (0.3) bc





Forest succession – site conditions

Montane

Mature

Initial early-seral

Advanced early seral

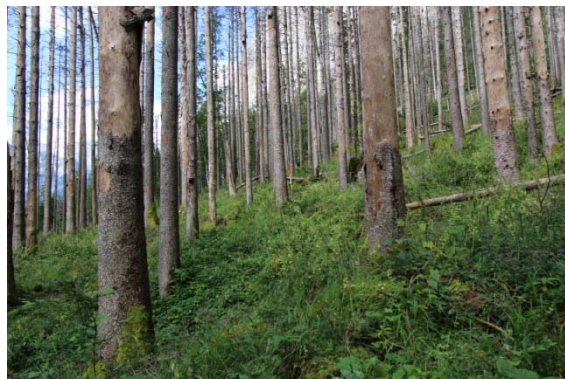


High montane

Mature

Initial early-seral

Advanced early seral



Subalpine

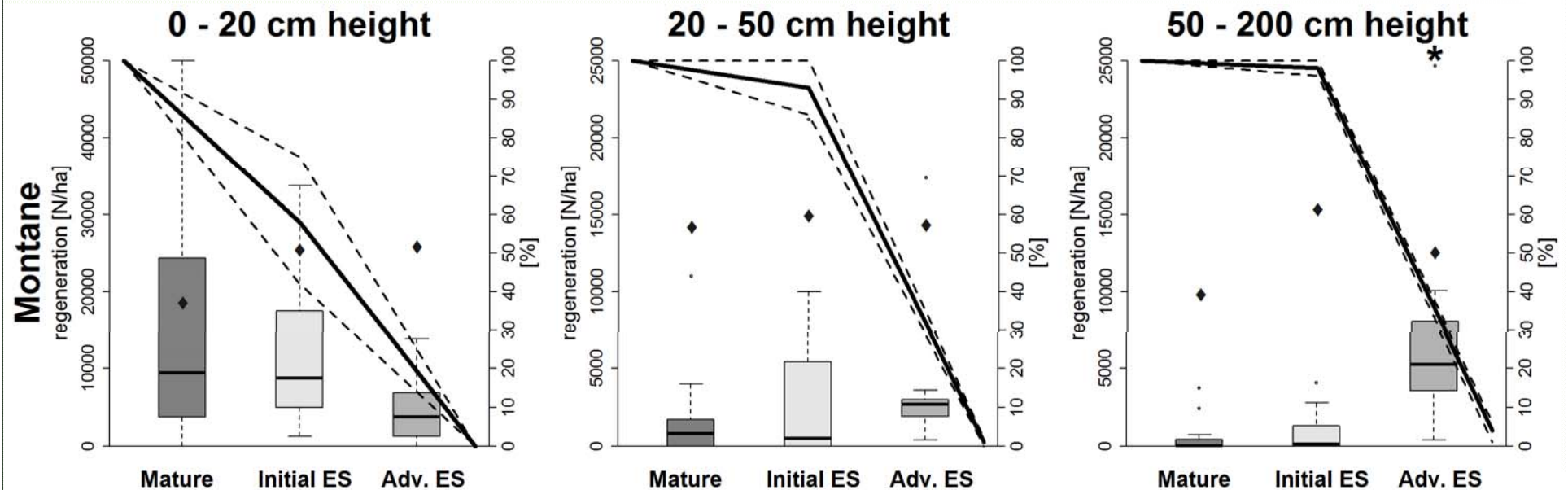
Mature

Initial early-seral



Ground vegetation cover [%]	Ground vegetation height [cm]	Humus depth [cm]	Deadwood decay stage (6 classes)
50 (14.1) <i>ac</i>	13 (3.1) <i>a</i>	7 (3.7) <i>a</i>	3 (1.0) <i>ab</i>
56 (18.7) <i>ab</i>	16 (7.5) <i>ab</i>	8 (8.2) <i>a</i>	2 (0.4) <i>c</i>
61 (14.9) <i>ab</i>	29 (11.7) <i>bc</i>	5 (3.8) <i>a</i>	3 (0.6) <i>a</i>
42 (14.7) <i>a</i>	10 (3.1) <i>a</i>	11 (6.8) <i>a</i>	3 (0.9) <i>a</i>
66 (11.3) <i>bc</i>	23 (12.2) <i>bc</i>	13 (9.1) <i>a</i>	2 (0.4) <i>c</i>
71 (5.1) <i>b</i>	30 (14.4) <i>b</i>	10 (6.3) <i>a</i>	3 (0.2) <i>a</i>
56 (13.1) <i>ab</i>	13 (3.7) <i>ac</i>	11 (4.8) <i>a</i>	3 (1.2) <i>ac</i>
74 (11.3) <i>b</i>	25 (7.8) <i>b</i>	13 (10.4) <i>a</i>	2 (0.3) <i>bc</i>

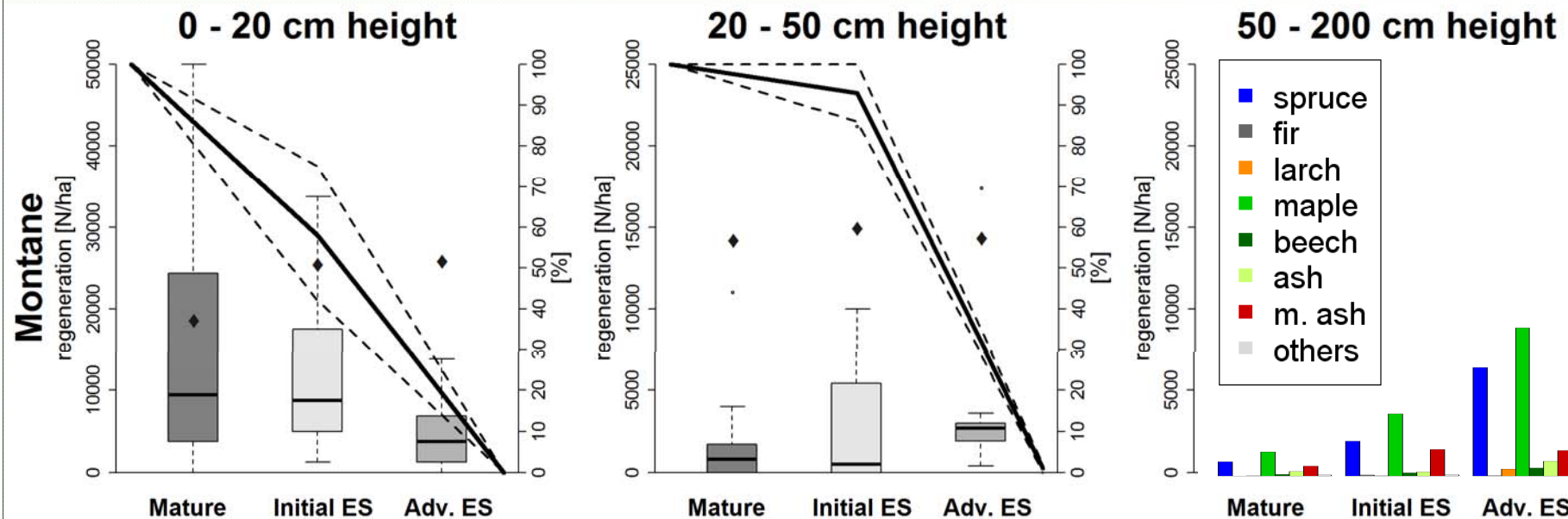
Forest succession – regeneration



Regeneration densities [N/ha] (boxplots), ratio [%] of advance regeneration (lines) and mean ratio [%] of regeneration individuals with **terminal browsing** (rhombi).



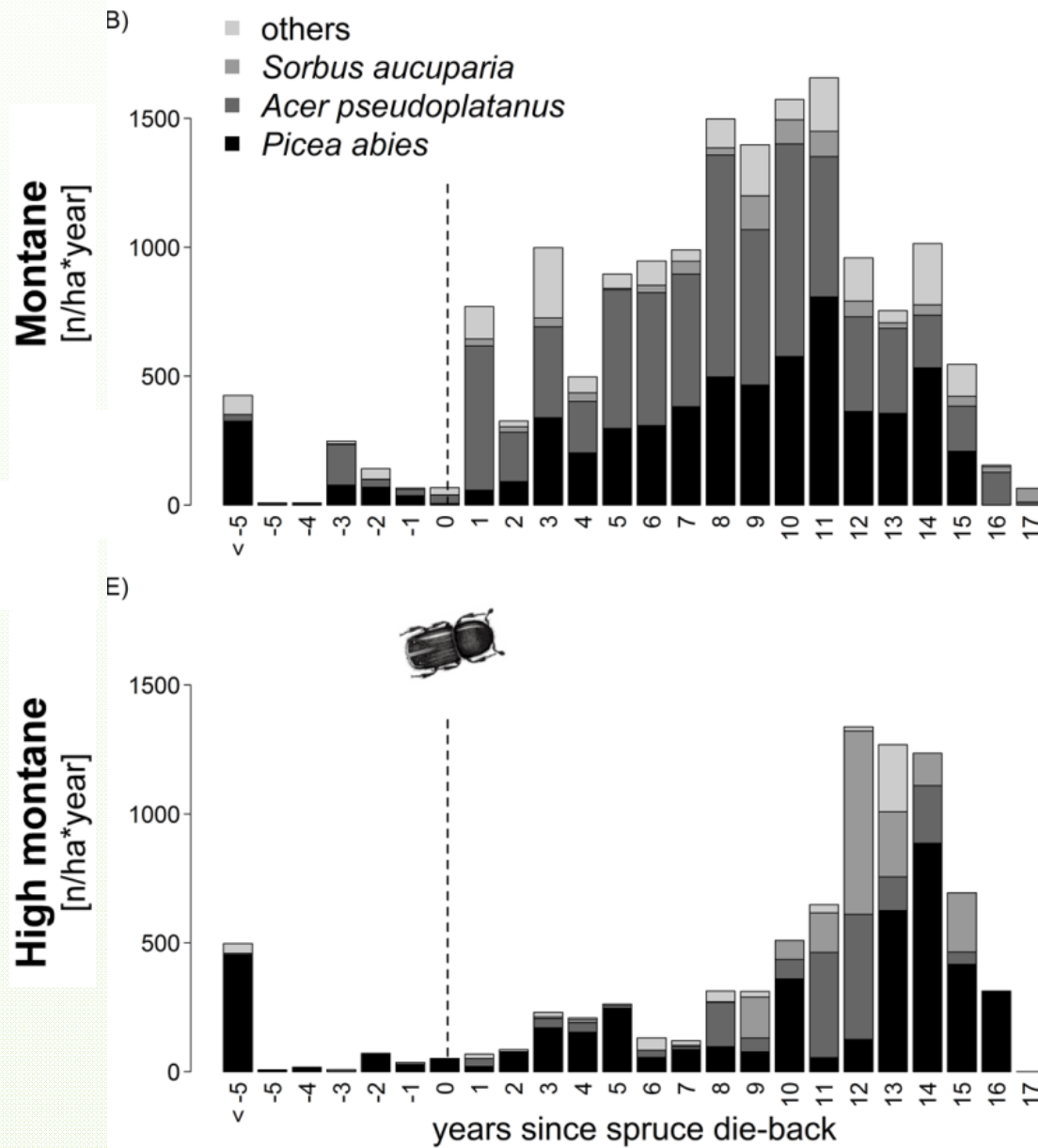
Forest succession – regeneration



Regeneration densities [N/ha] (boxplots), ratio [%] of advance regeneration (lines) and mean ratio [%] of regeneration individuals with **terminal browsing** (rhombi).

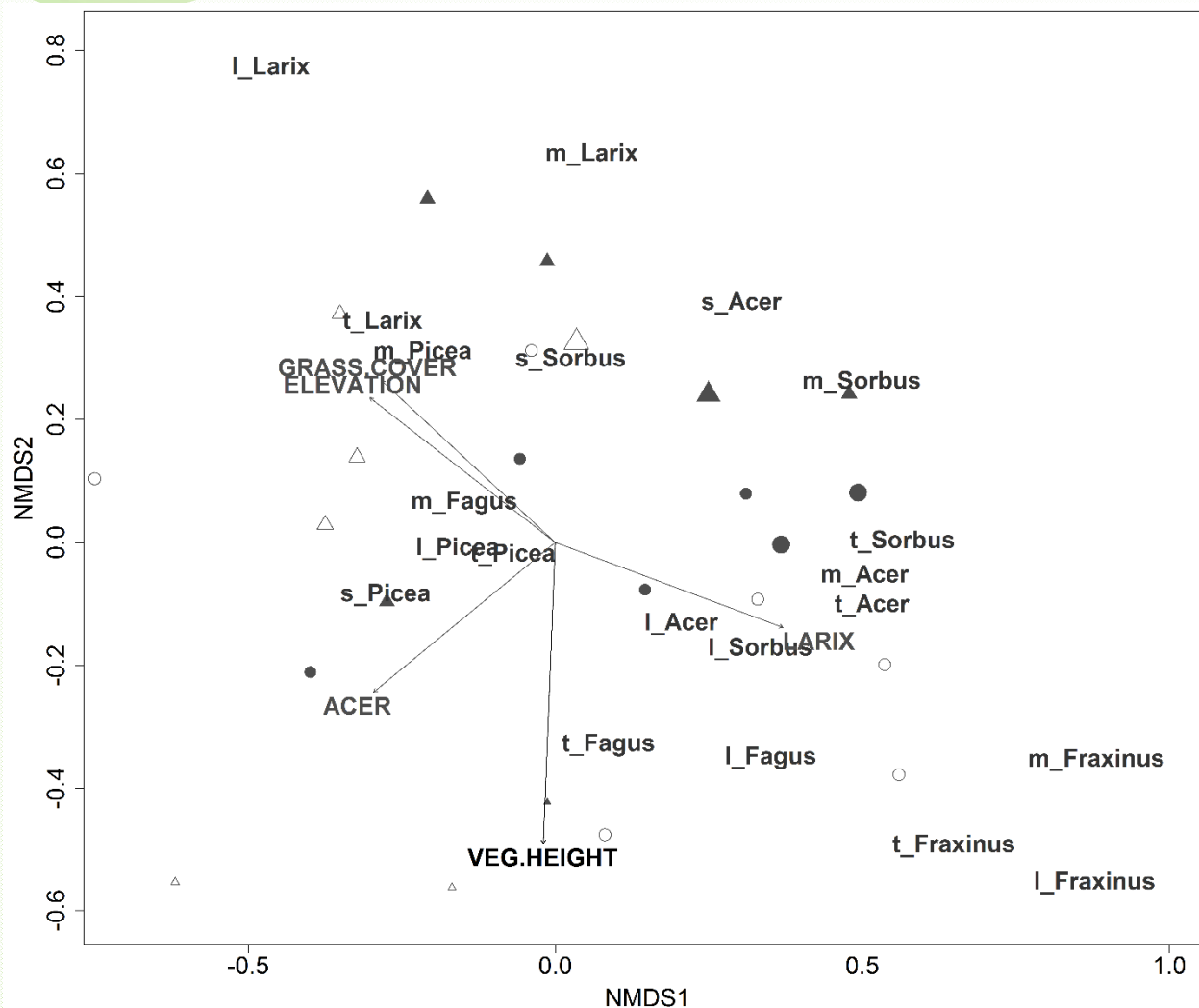


Forest succession – regeneration





Forest succession – regeneration



non-metric fit 0.95
 linear fit 0.72
 stress 0.22

Study plots	Regeneration density on study plots [n/ha]	Regeneration height class
● montane north-facing	○ < 4,000	s small 0 - 20 cm
○ montane south-facing	○ 4,000 - 20,000	m medium 20 - 50 cm
▲ high montane north-facing	○ > 20,000	l large 50 - 200 cm
△ high montane south-facing		t tree > 200 cm



Forest succession – plant diversity



Indicator species

Corallorhiza trifida

Homogyne alpina

Melampyrum sylvaticum

Neottia nidus-avis

Rubus saxatilis

Epilobium montanum

Fragaria vesca

Galeopsis speciosa

Moehringia trinervia

Mycelis muralis

Chaerophyllum hirsutum

Circaea alpina

Eupatorium cannabinum

Hypericum perforatum

Lysimachia nemorum

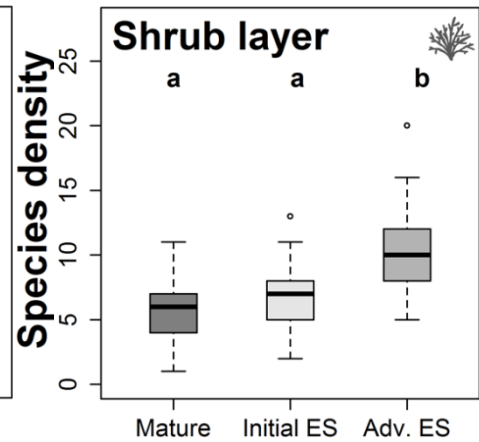
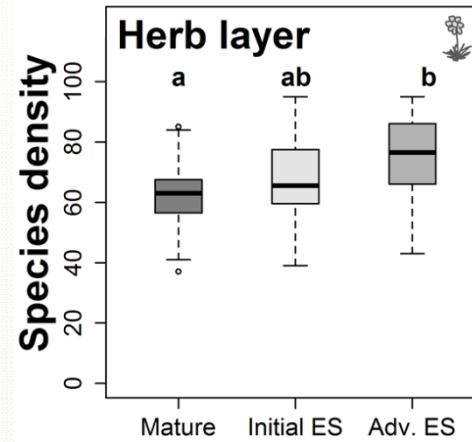
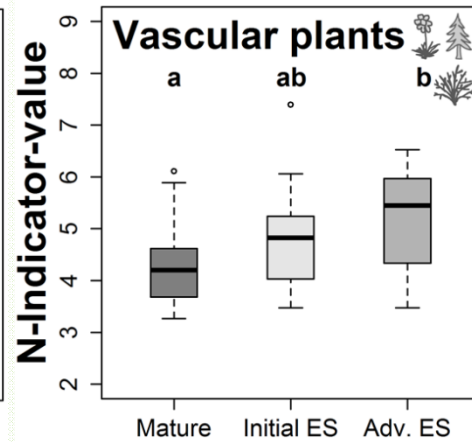
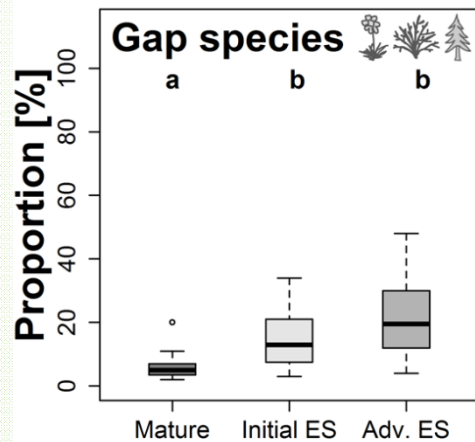
Molinia arundinacea

Senecio ovatus

Urtica dioica

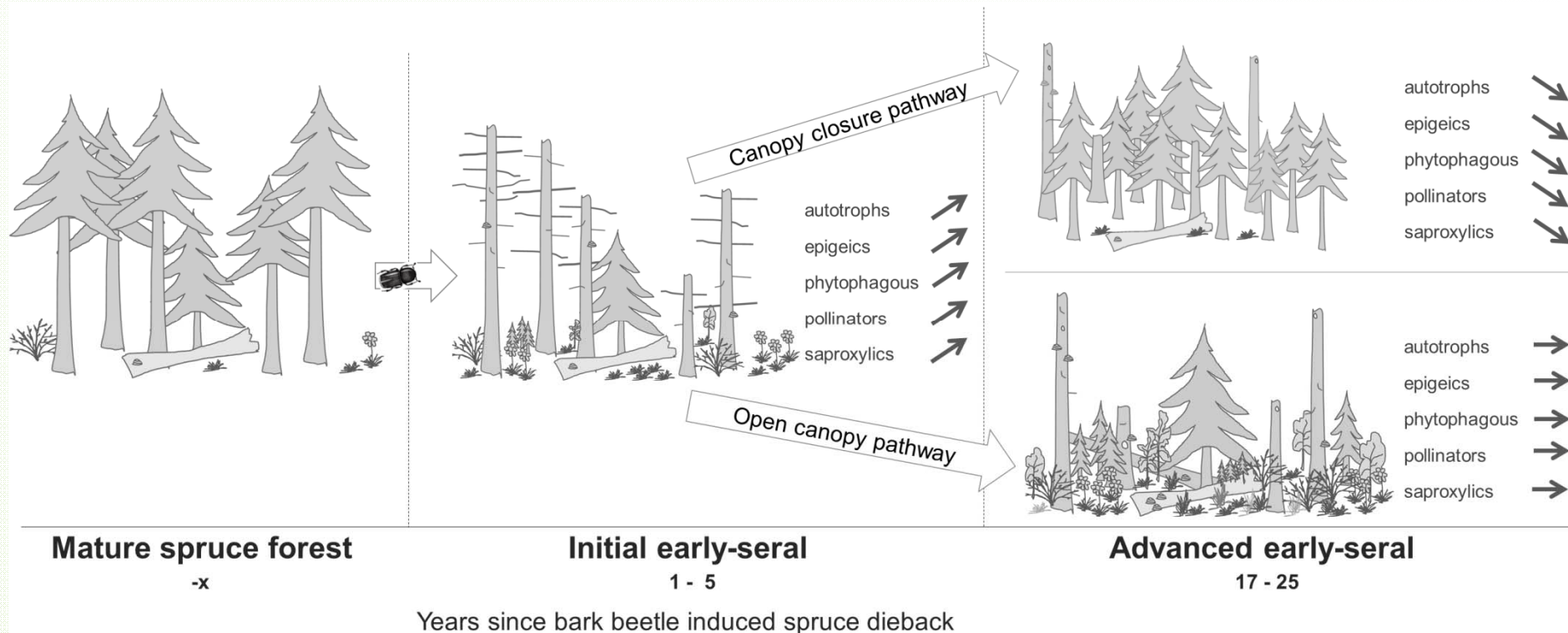
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Forest succession – plant diversity





Forest succession – biodiversity



Expected key structural elements and effects on alpha-diversity of different functional groups at three stages of forest succession before and after bark beetle induced spruce die-back.

Forest succession – biodiversity



Increase of species diversity

- Herb layer
- Shrub layer
- Beetles
- True bugs
- Aculeata (bees & wasps)

→ Especially light-, nutrient & deadwood demanding species do profit



Alosterna tabacicolor
Foto: Guntram Hüfler

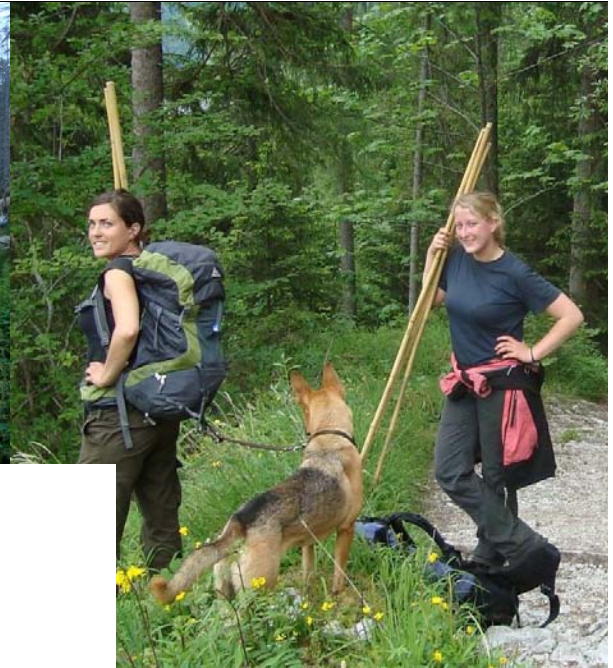


Bombus pratorum
Foto: Otto Schreiber



Conclusion

- Increasing radiation & ground vegetation layer
- Fast regeneration in montane zone, dominated by spruce and maple
- Temporary increase of light-, nutrient & deadwood demanding species
- Increase of spatial heterogeneity on landscape scale
- Planting of beech and fir, where mixed mountain forest is targeted
- Gap management



**T
H
A
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Thank you for your interest!

