Adapting to climate change in European mountain forests

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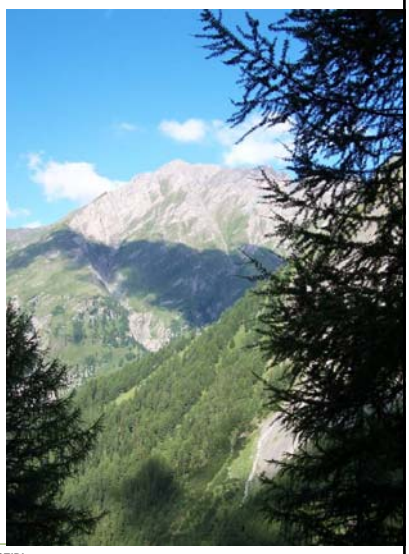
Education and Culture
TEMPUS

content

- a primer on European mountain forests
- observed climate change impacts
- expected future developments
- vulnerability and adaptation: an example
- conclusion

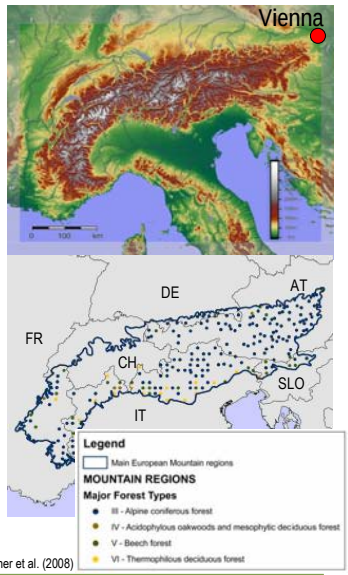
why mountain forests are special…

- environmental gradients
  - temperature ↓ with elevation
  - precipitation ↑ with elevation
- spatial heterogeneity
  - climate (e.g., foehn)
  - soil
- gravitational processes
  - water, snow
  - erosion



forests in the European Alps

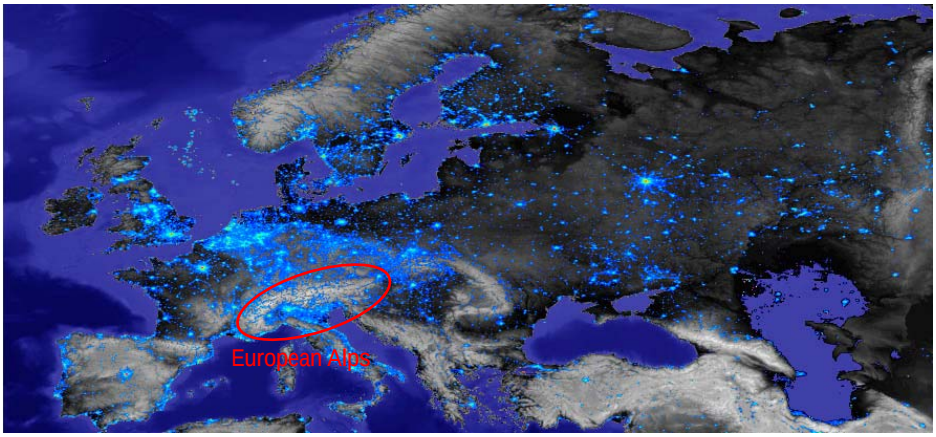
- ecology
  - mainly coniferous-dominated forests
  - tree line approx. between 1600m to 2200m
  - high naturalness
  - specific patterns of post-glacial re-vegetation from refugia
- society
  - intesive historic land use
    - high pastures
    - litter raking
    - clear-cut forestry
  - high population density
  - multiple land-use demands



source: Lindner et al. (2008)

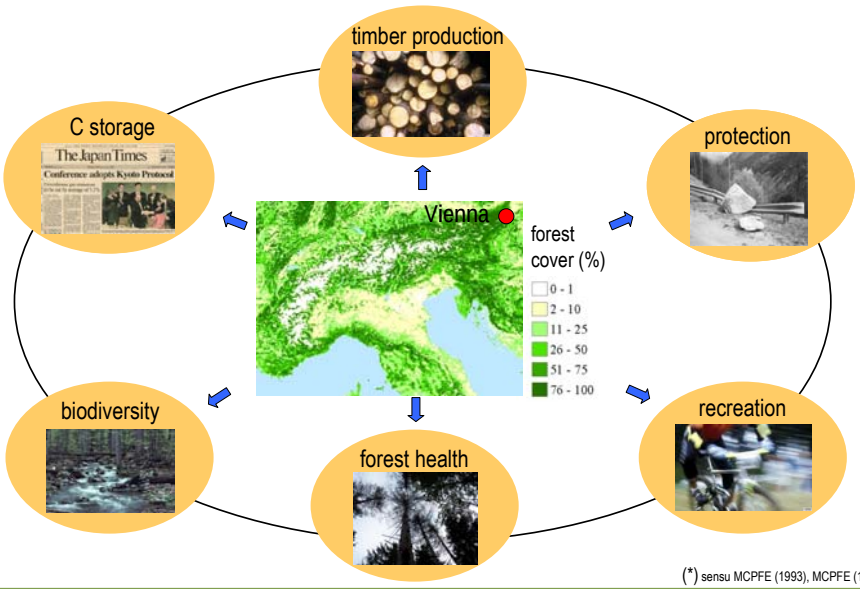
population density

…displayed by city lights as seen from a NASA satellite



source: NASA

sustainable forest management (*)



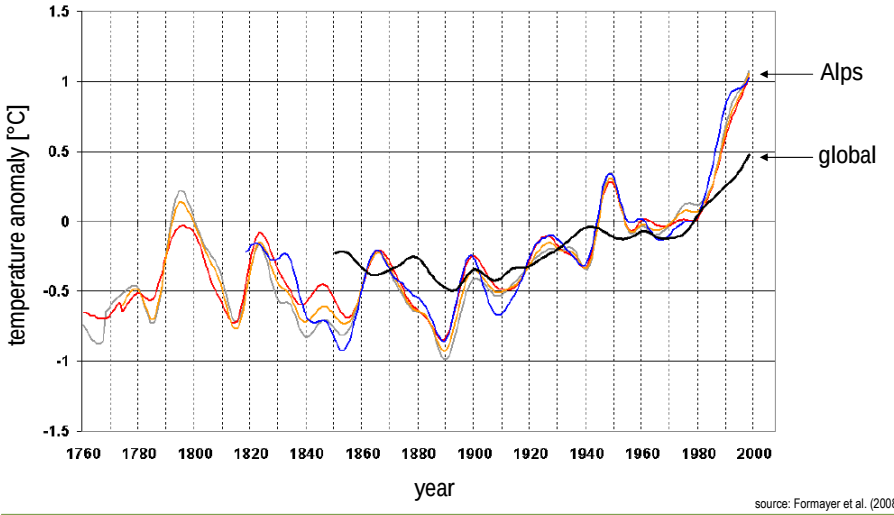
(*) sensu MCPFE (1993), MCPFE (1998)

why worrying about climate change?

- changes are going to be drastic
  - altering major ecosystem processes
- changes are going to happen rapidly
  - within the lifetime of one tree generation
- consequence: forests might not be able to adapt naturally
  - longevity
  - slow migration speed
- bottom line: thread to ecosystem services

the Alps are particularily affected

twofold magnitude of observed warming in the Alps compared to global average



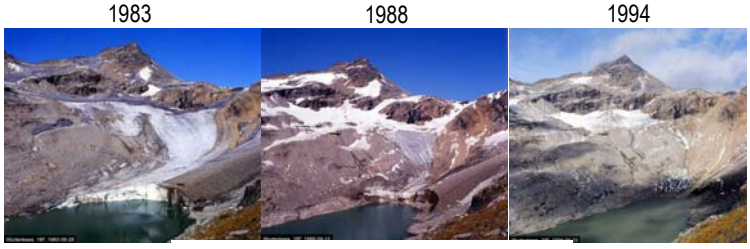
source: Formayer et al. (2008)

diminishing glaciers

what we're already observing (1)

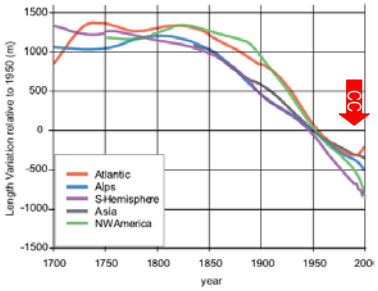
1983 1988 1994

Wurtenkees, Eastern Alps



source: Böhm (2006)

global trend glaciation



source: Oerlemans (2005)

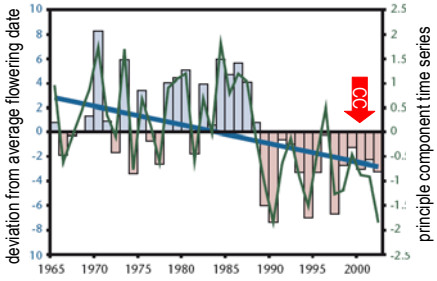
changes in plant phenology

what we're already observing (2)

1988: 22. April 1998: 16. April

flowering of cherry trees experimental station Raumberg

flowering of cherry trees Switzerland

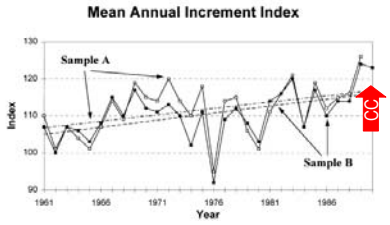


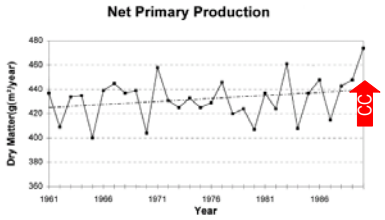
source: Kutishauser und Studer (2007)

growth changes

what we're already observing (3)

- growth trends in the Austrian forest inventory 1961 to 1990





- forest growth in large parts of the Alps is increasing due to
  - change in management
  - nitrogen deposition
  - climate change

source: Hasenauer et al. (1999)

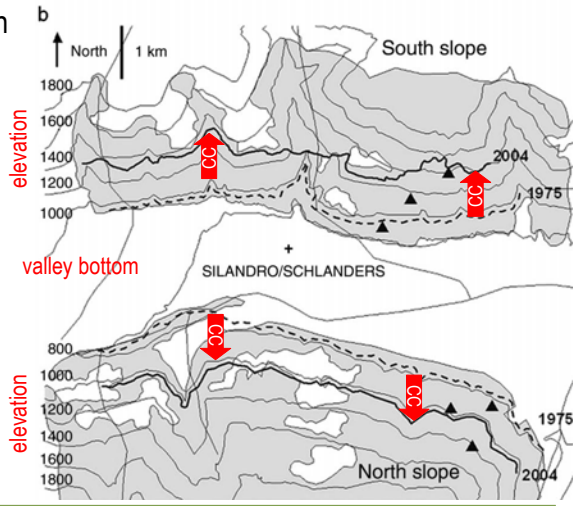
changes in the range of pest species

what we're already observing (4)

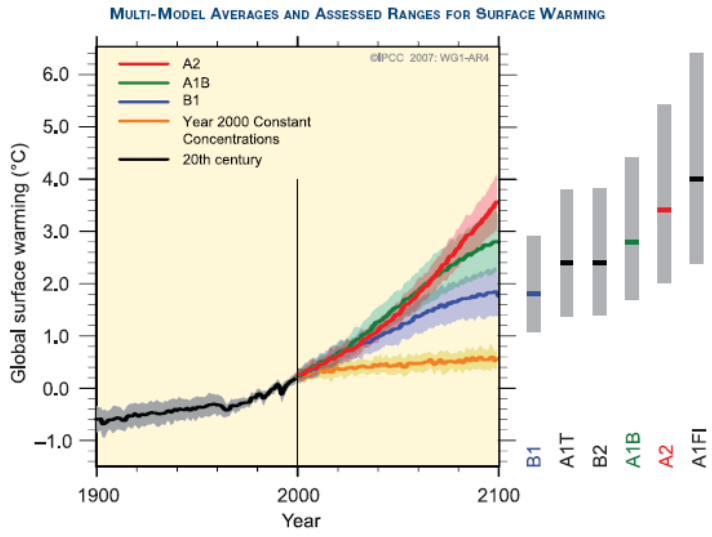
pine processionary moth, Vinschgau, Italy
Thaumetopoea pityocampa

- range increases in elevation
- range expansion in latitude

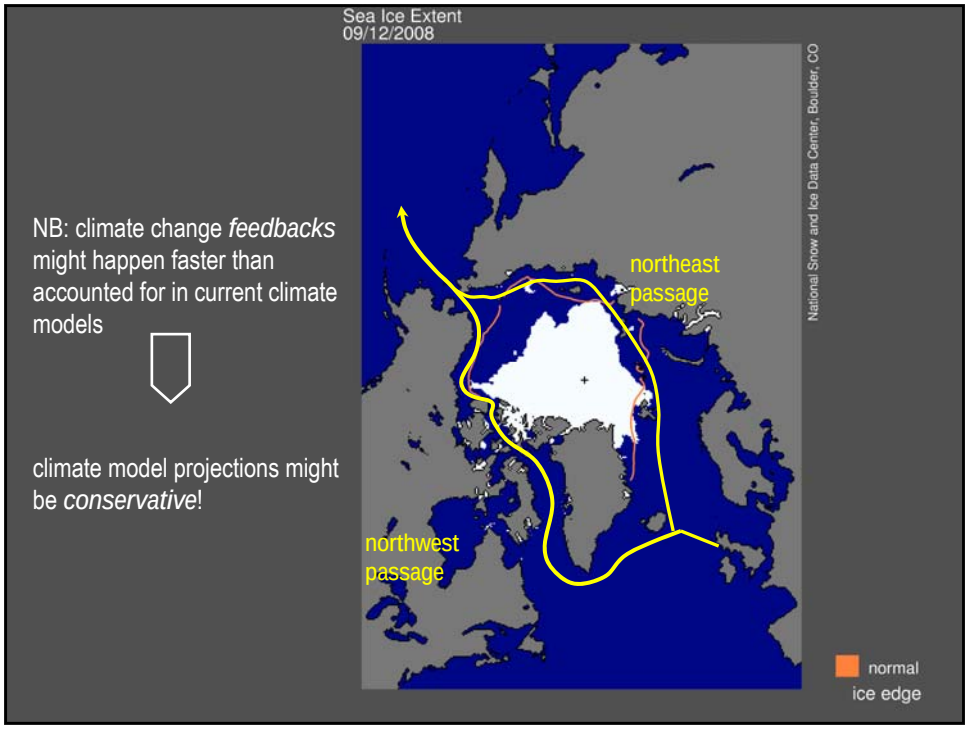
source: Battisti et al. (2005)



expected climate changes – global



source: IPCC (2007)



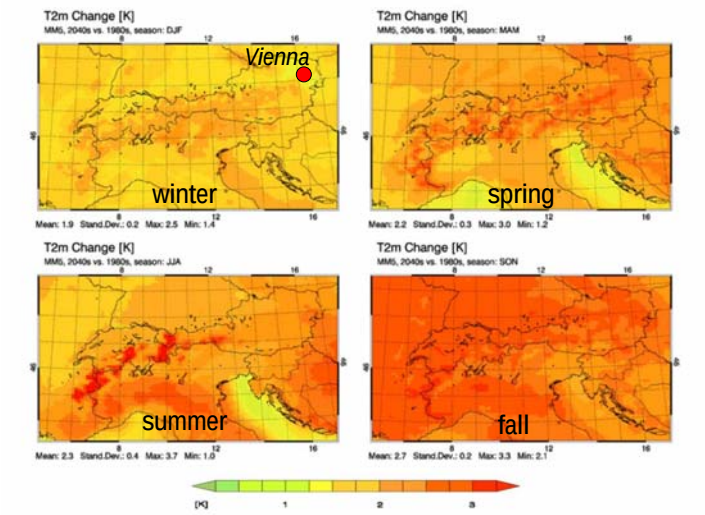
NB: climate change *feedbacks* might happen faster than accounted for in current climate models

climate model projections might be *conservative*!

Alps – spatial pattern for 2040-2050

expected climate changes

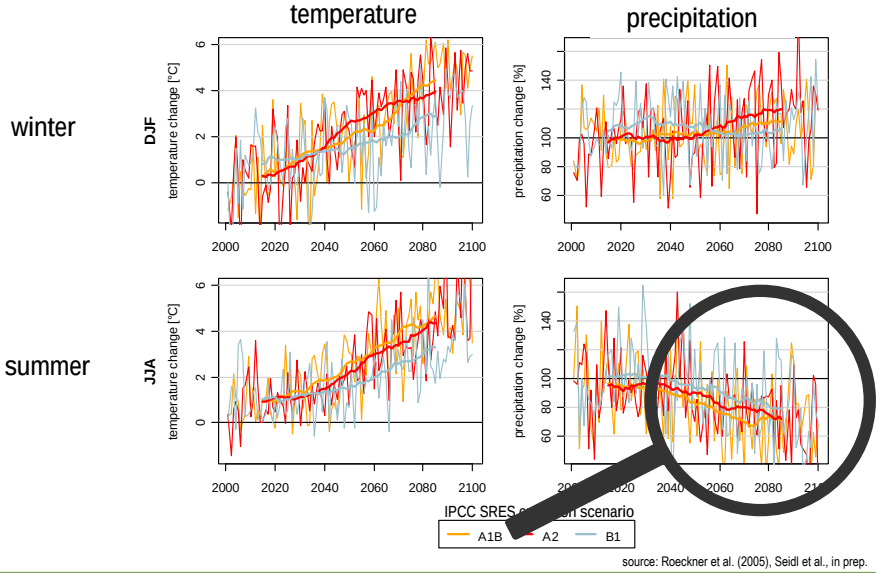
projected temperatur changes



source: Loibl et al. (2007)

Alps – scenarios for the 21st century

expected climate changes

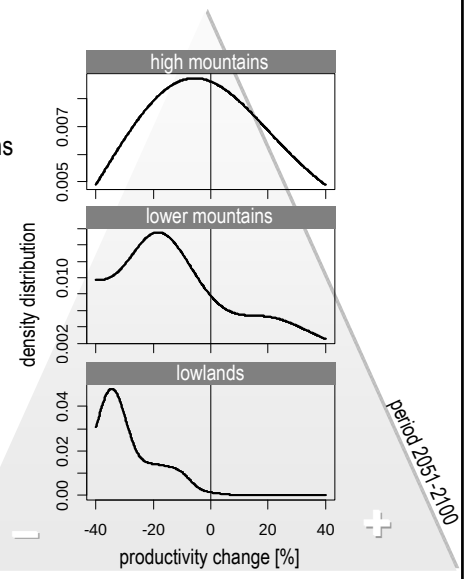


source: Roeckner et al. (2005), Seidl et al., in prep.

growth changes

projected climate change impacts (1)

- commercial forests in Austria
  - growth losses in lowlands
  - increase in subst. parts of high mountains
  - variability high (site, species,…)

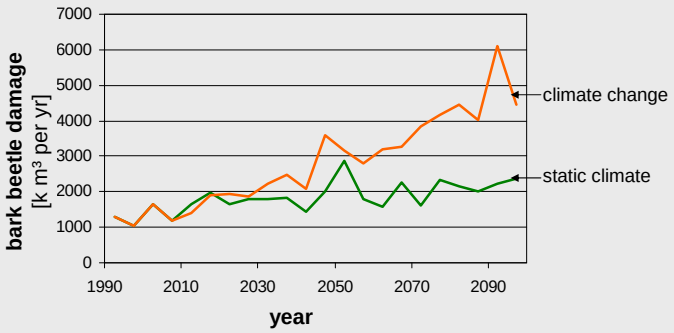


source: Seidl et al., in prep.

changes in the disturbance regime

projected climate change impacts (2)

the spruce bark beetle *Ips typographus* in Austria



source: Seidl et al. (2008)

changes in the disturbance regime

projected climate change impacts (2)

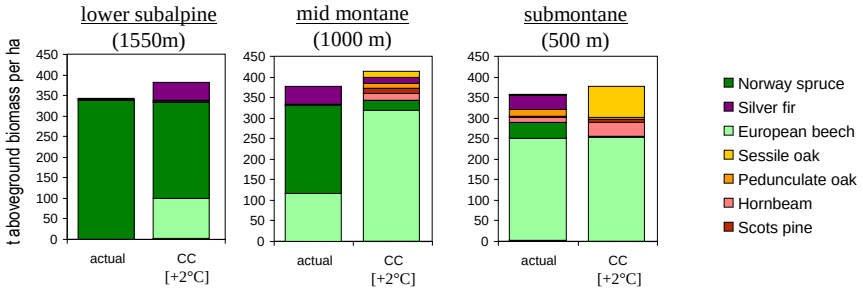
the spruce bark beetle *Ips typographus* in Austria

- historically
  - host distribution > pest distribution
  - bark beetle development limited by temperature
- under climate change
  - beetle development also in high elevation areas possible
  - higher success in overwintering
  - voltinism: from uni- to multivoltine cycles
  - host susceptability increases (drought)

source: Seidl et al. (2008)

changes in vegetation dynamics

projected climate change impacts (3)



- potential natural vegetation composition in the Eastern Alps
  - drought-tolerant species gain competitiveness in alpine foothills and dry valleys
  - deciduous forest types potentially viable at higher elevations
  - conifers, particularily Norway spruce, loose (relative) competitiveness

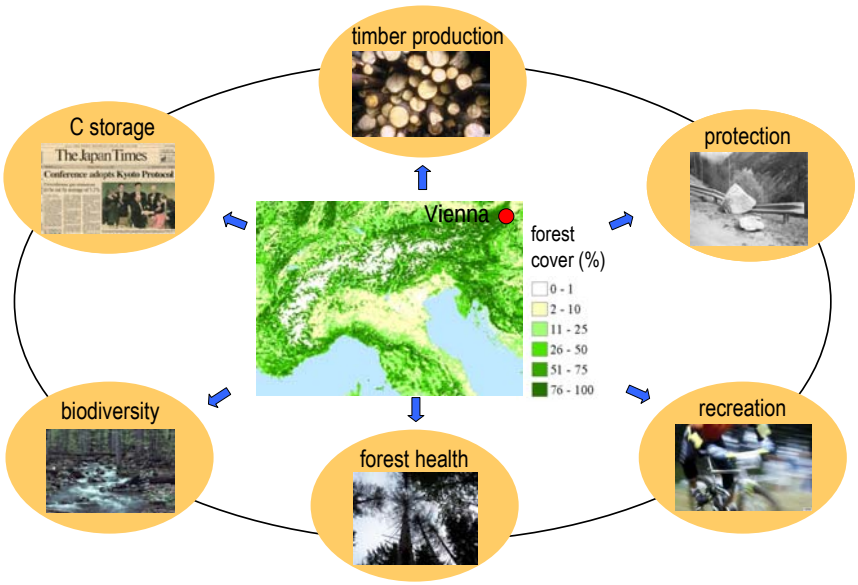
source: Lexer und Hönninger (2001)

timber line shifts

projected climate change impacts (4)

- potential timber line
  - mainly temperature-limited
- actual timber line
  - often lower due to past land-use practices (e.g. high alpine pastures)
- climate change might shift timberlines upwards…
  - …where local site conditions are favourable (soil formation processes very slow!)
  - …where land-use activities are not counteracting this trend

implications for forest goods & services



vulnerability of the SFM system to climate change

- vulnerability is a function of
  - *exposure:* the degree climate change affects a system
  - *sensitivity:* the degree a system is sensitive to changes
  - *adaptive capacity:* the level a system is able to adapt to changes
- vulnerability as prerequisite for (operational) adaptation
  - which forests will be adversely affected? where will be hotspots?
  - when will negative climate effects occur? (cc is a transient phenomenon)
  - which objectives of SFM are particularily affected? (centered on forest functions)

vulnerability assessment Austrian Federal Forests

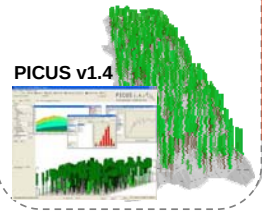
vulnerability and adaptation: an example

- Austrian Federal Forests ÖBf
  - ca. 590,000 ha
  - ~15% of Austrias forest area
  - predominantly mountain forests
  - timber production main mgmt objective on ~368,000 ha

study design

vulnerability and adaptation: an example

- ecosystem model
  - clim. change scenarios
  - evaluate impacts



- indicators of SFM
  - productivity
  - timber stock level
  - C storage
  - biodiversity
  - disturbances
  - ecophys. suitability
  - silvicultural flexibility
  - management cost

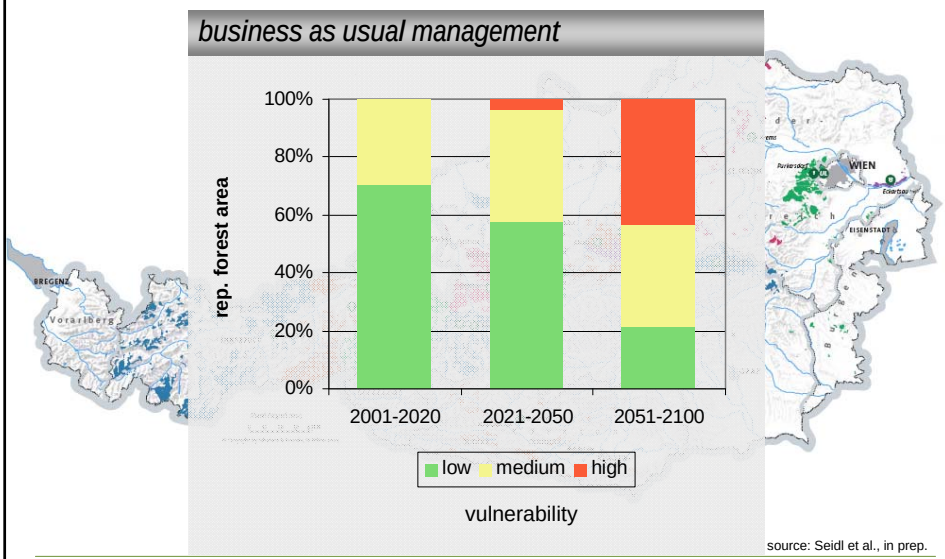
- stakeholders
  - select indicators
  - define thresholds
  - weight indicators

VULNERABILITY

source: Seidl et al., in prep.

vulnerability under current management

vulnerability and adaptation: an example



source: Seidl et al., in prep.

developing adaptation strategies

vulnerability and adaptation: an example

- analyse vulnerability
  - adaptation necessary?
  - which indicators/ forest functions affected
  - temporal development of adverse effects
- options for developing management alternatives
  - species composition: adapted species, mixed stands, etc.
  - silvicultural regime: increase diversity, small structured regeneration, etc.
  - management intenisty: increase thinning intensity, decrease rotation period, etc.
- evaluation of alternatives
  - implementation in simulation
  - evaluation in vulnerability framework

adaptation for the Austrian Federal Forests

vulnerability and adaptation: an example

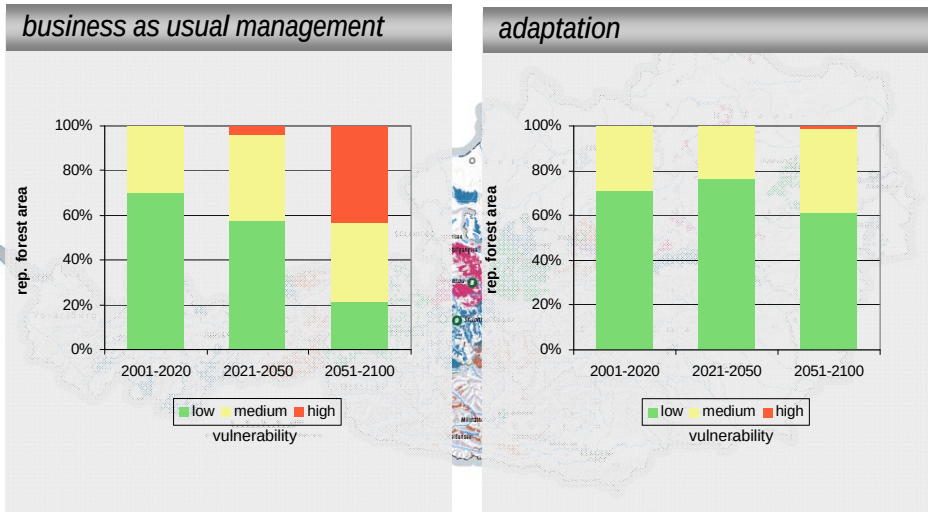
- combining adaptation options according to vulnerability clusters to derive an adaptation strategy for the Austrian Federal Forests

impacts	species	silviculture	mgmt intensity
acute cluster 1 (36%)	X	X	X
severe cluster 2 (36%)	X	X	
mixed cluster 3 (6%)		X	X

source: Seidl et al., in prep.

adaptation success & residual vulnerability

vulnerability and adaptation: an example



source: Seidl et al., in prep.

conclusion

- climate change is a considerable challenge for SFM
  - the pace will be high compared to ecosystem processes in mountain regions
  - changes in ecosystem dynamics will be severe
  - to fulfill forest functions sustainably, adaptation will be necessary
- adapting management towards „climate-smart“ strategies
  - based on a thorough (scientific) analysis of vulnerabilities
  - timely → long lead times of silvicultural measures
  - integrating stakeholders, decision makers
  - operational & context-oriented
  - robust (no regrets, win-win)
  - account for and communicate uncertainties
  - foster learning, capacity building and adaptive cycles

more info:
http://www.wabo.boku.ac.at/waldbau.html
http://www.wabo.boku.ac.at/picus.html
http://www.wabo.boku.ac.at/seidl.html

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