Importance of physical and biotic factors for liability of forests to pest insects

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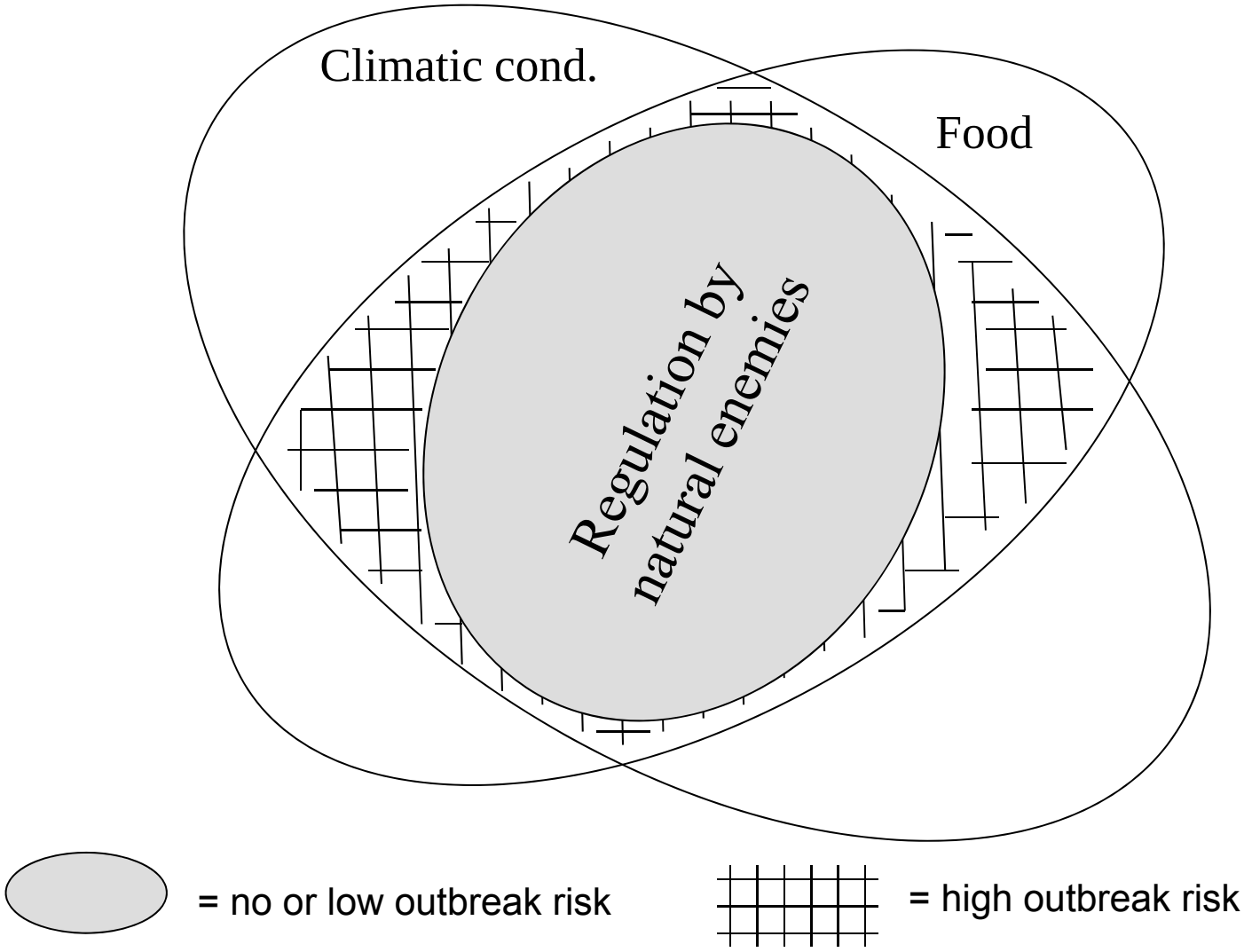
Forests and pest insects

Factors of influence:

- Abiotic (physical) factors
  - climatic conditions, e.g. temperature, rainfall, humidity, snow/ice, wind/storm, day-length, …
- Biotic factors
  - herbivorous species spectrum,
  - nutritional factors – “quality” (tree species) and “quantity” (number of trees in a certain quality)! – competition (intraspecific, interspecific),
  - spatial and temporal coincidence of herbivores with food and of copulation partners,
  - natural enemies (predators, parasitoids, pathogens).


Climatic cond.
Food
Regulation by natural enemies
= no or low outbreak risk
= high outbreak risk

Density independence and dependence

- Density independent factors:
  - quality and quantity of host material (supply of food sources),
  - climate.
- Density dependent factors:
  - competition for food (within and between species),
  - species composition and abundance of natural enemies.

Outbreak-predisposing factors: site and stand …

- **Site** specific factors:
  - climatic region,
  - longitude/latitude,
  - altitude,
  - exposition,
  - inclination (fall of ground),
  - land morphology,
  - soil type,
  - ground water level,
  - …
- **Stand** specific factors:
  - tree species,
  - tree species origin (provenience),
  - composition of tree species,
  - stocking level,
  - age of trees (even-aged?),
  - stand structure,
  - health status of trees,
  - …

Outbreak-Inciting factors:

“Disturbances” like:

- human activities,
- wind – storm – hurricane ⇨ partly damage of trees, wind breakage, …,
- excess precipitation,
- prolonged drought, combined with high temperature,
- wildfire (forest fire),
- …

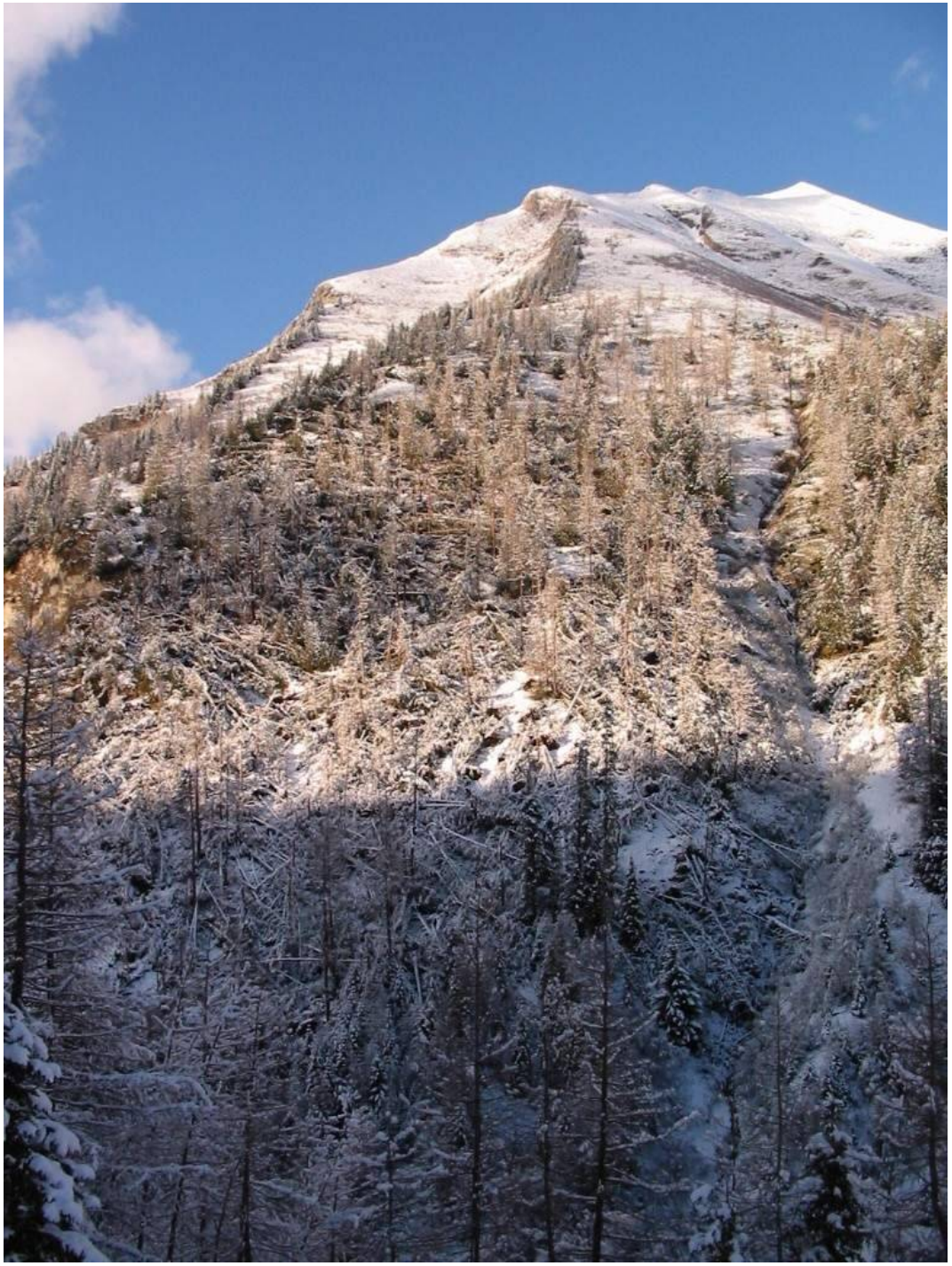
Abiotic factors:

- temperature
- humidity and/or precipitation (e.g. rain, snow, ice, hail)
- sun radiation
- wind or storm
- lightning strikes
- day-length (diapause)
- …

Storm damage

Białowieża


Luxkogel/Dorfgastein

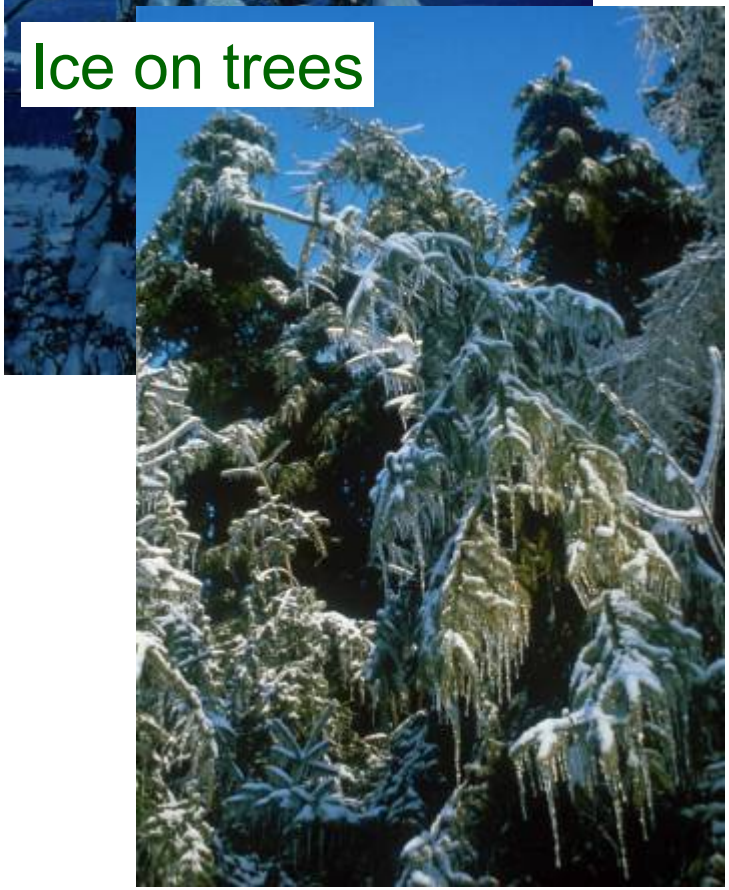


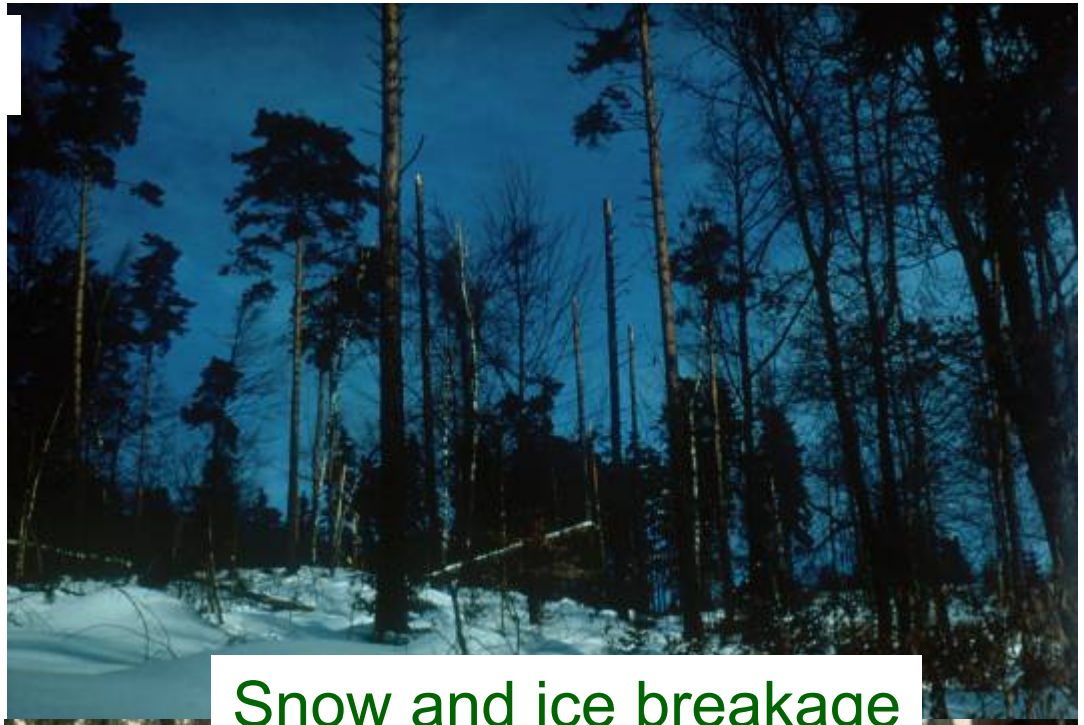
Bad Hofgastein


Donnersbachwald

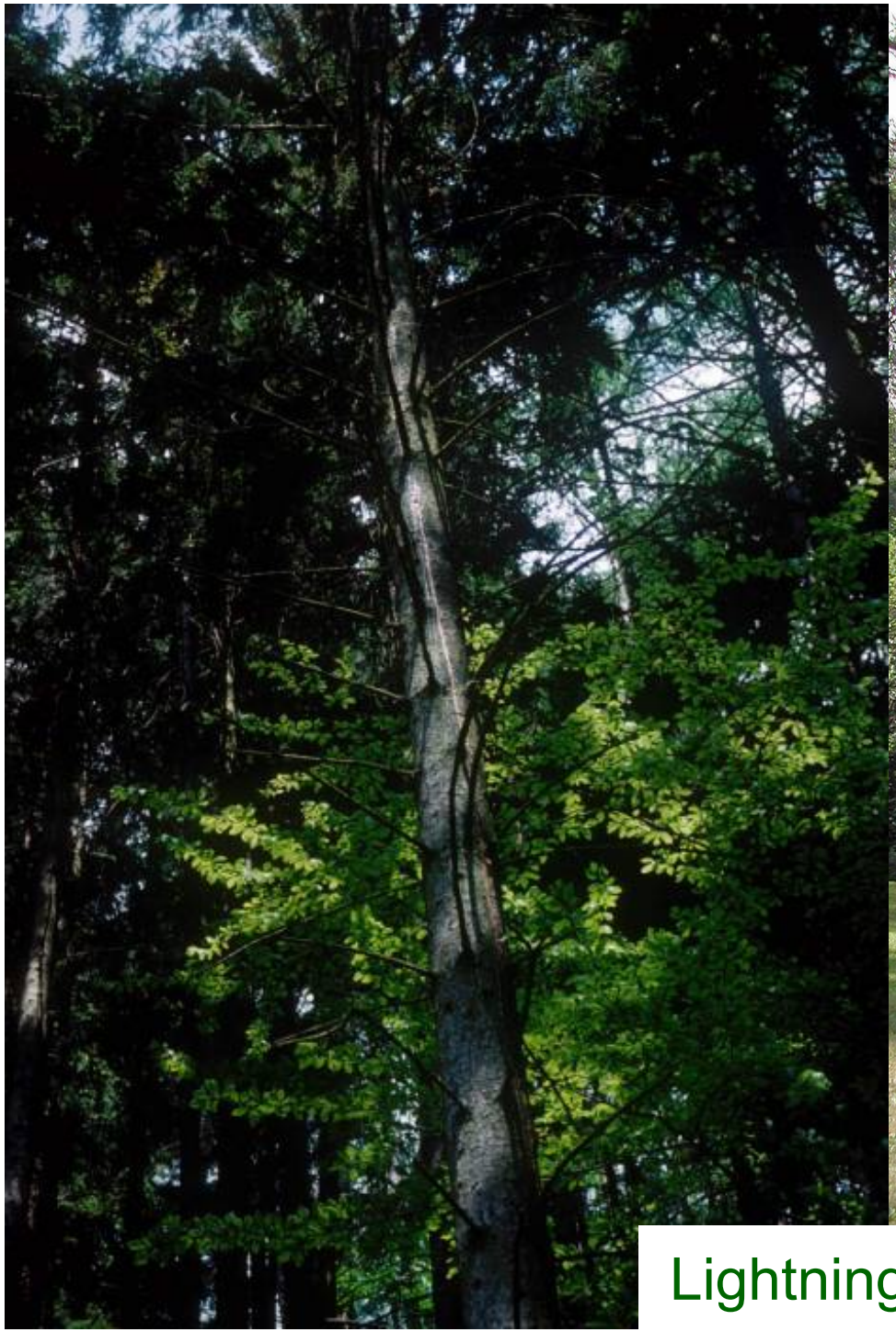
Wet snow

Ice on trees





Snow and ice breakage



Lightning strike

Lightning strike

Damage by hail

Biotic factors – **insect nutrition:**

- Stands with **one tree species** on large area, even aged (e.g. in plantations), may provide an **unlimited food** supply for herbivorous insects with a **high risk** to develop an **outbreak**.

- **Mixed stands**, uneven-aged, may provide **limited food** supply for herbivorous insects with **low risk** for an **outbreak**.

Forest monocultures or plantations can be damaged by insects:

- indigenous insects in plantations of native trees
- indigenous insects that have adapted to exotic trees
- introduced insects in plantations of native trees
- introduced insects in plantations of exotic trees

Biotic factors:

- Insects (reducing tree fitness, or killing trees):
  - Lepidoptera
  - Hymenoptera
  - Coleoptera (e.g. Scolytinae, Curculioninae, Cerambycidae, Buprestidae, …)
  - Hymenoptera (Siricidae)
  - …
- Phytopathogenic fungi
- Blue-stain fungi

➢ **Natural enemies?**

Forest insects outbreaks …

- some insect species can produce high offspring numbers and alternating low numbers (“fluctuation”)
- species that undergo high population levels can become damaging … ⇨

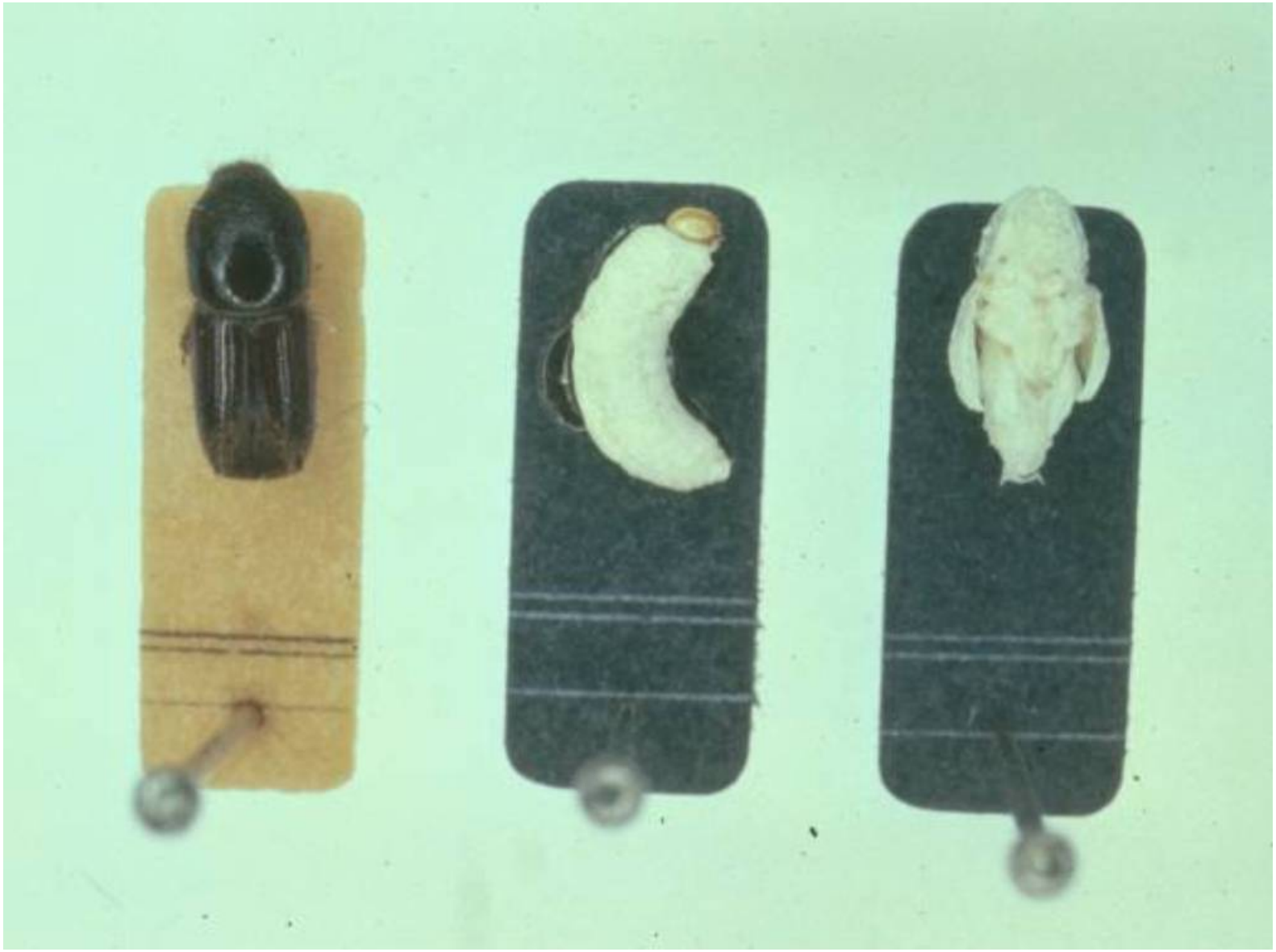
⇨ economical and/or ecological damage or endangering the tree function (depending on forest functions)

In spruce forests (*P. abies*) in Austria:

- major problems with spruce **bark beetles**:
  - ***Ips typographus***,
  - *Pityogenes chalcographus*,
  - *Trypodendron lineatum*,
  - … etc.

↳indigenous insect species in a native tree species

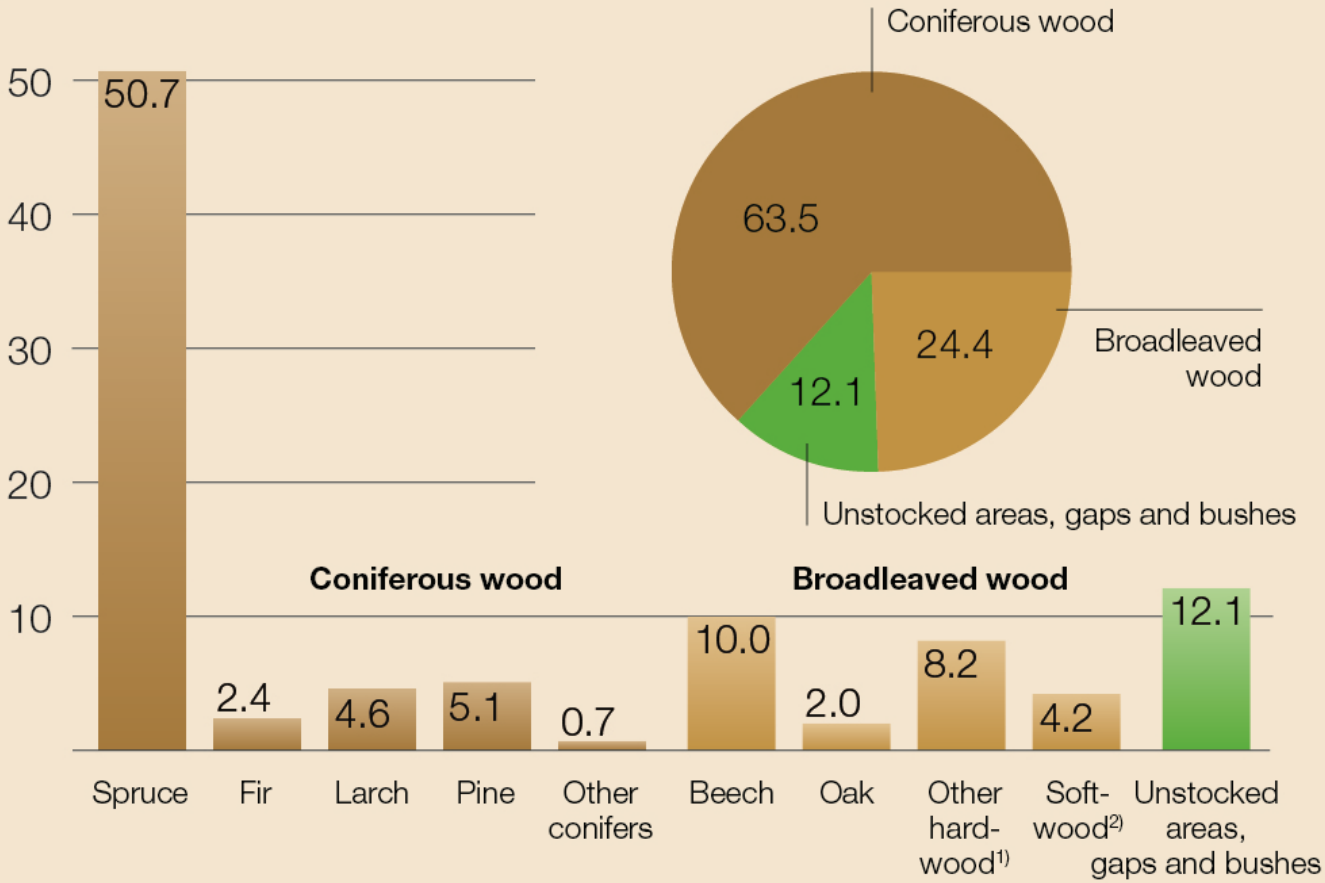
Ips typographus



Ips typographus

Distribution of tree species

in percent area



1) Common hornbeam, ash, maple, elm, Spanish chestnut, black locust, etc.
2) Birch, common alder, grey alder, linden, aspen, white, grey, black and hybrid poplar, willow, etc.

lebensministerium.at

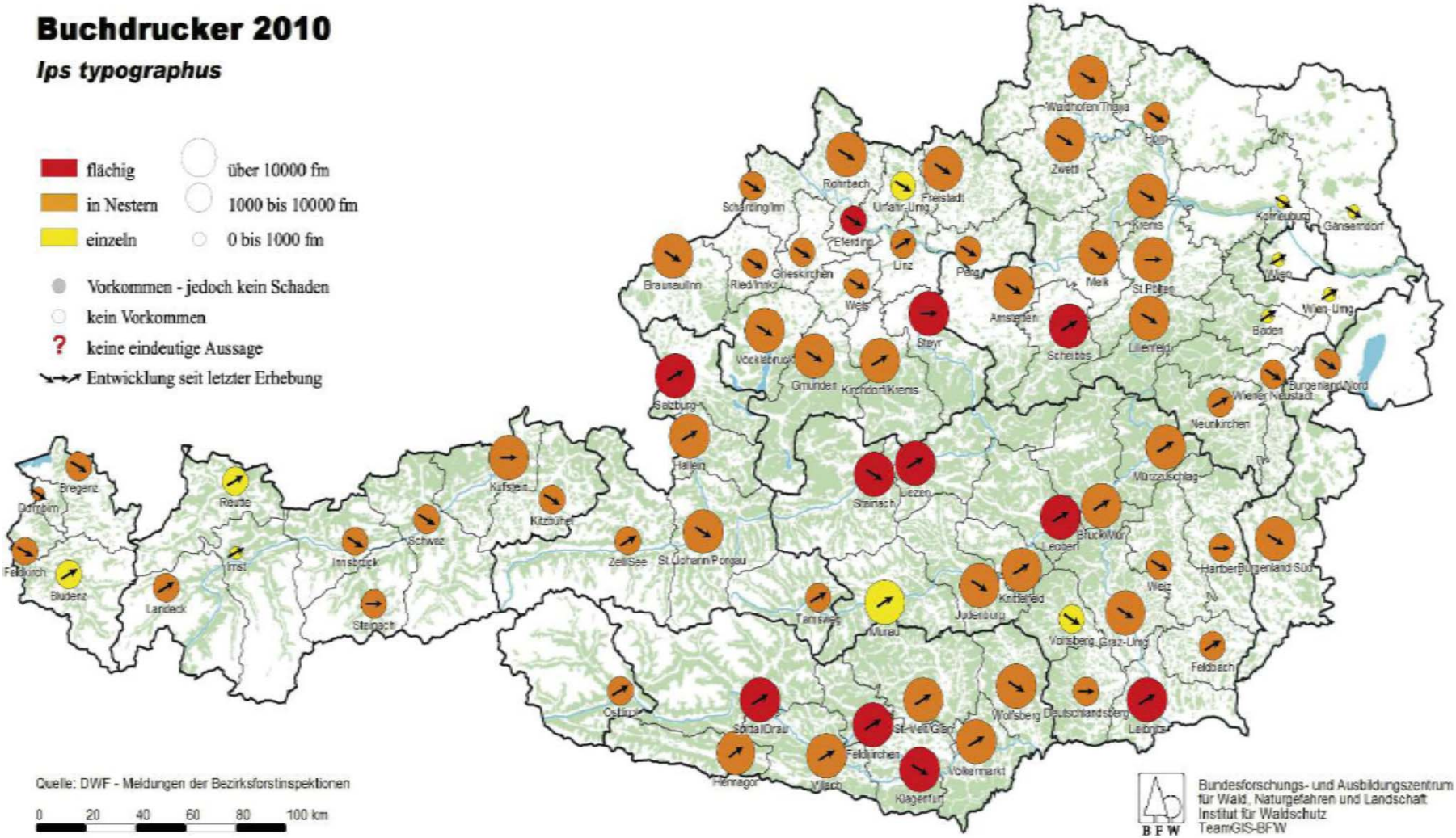
Source: Federal Research and Training Centre for Forests, Natural Hazards and Landscape 2011 / Austrian Forest Inventory 2007/09

Outbreaks in “secondary” spruce forests …

- in areas where *Picea abies* is planted in high numbers, but naturally not occurring in high abundance,
- in the foreland and in the foothills of the Alps (low elevation),
- in summer-dry areas in the Eastern parts of Austria,
- in areas with frequent storm events,
- in years with relatively high temperature just from the beginning of the vegetation period in spring,
- …

Buchdrucker 2010

Ips typographus



Quelle: DWF - Meldungen der Bezirksforstinspektionen

0 20 40 60 80 100 km

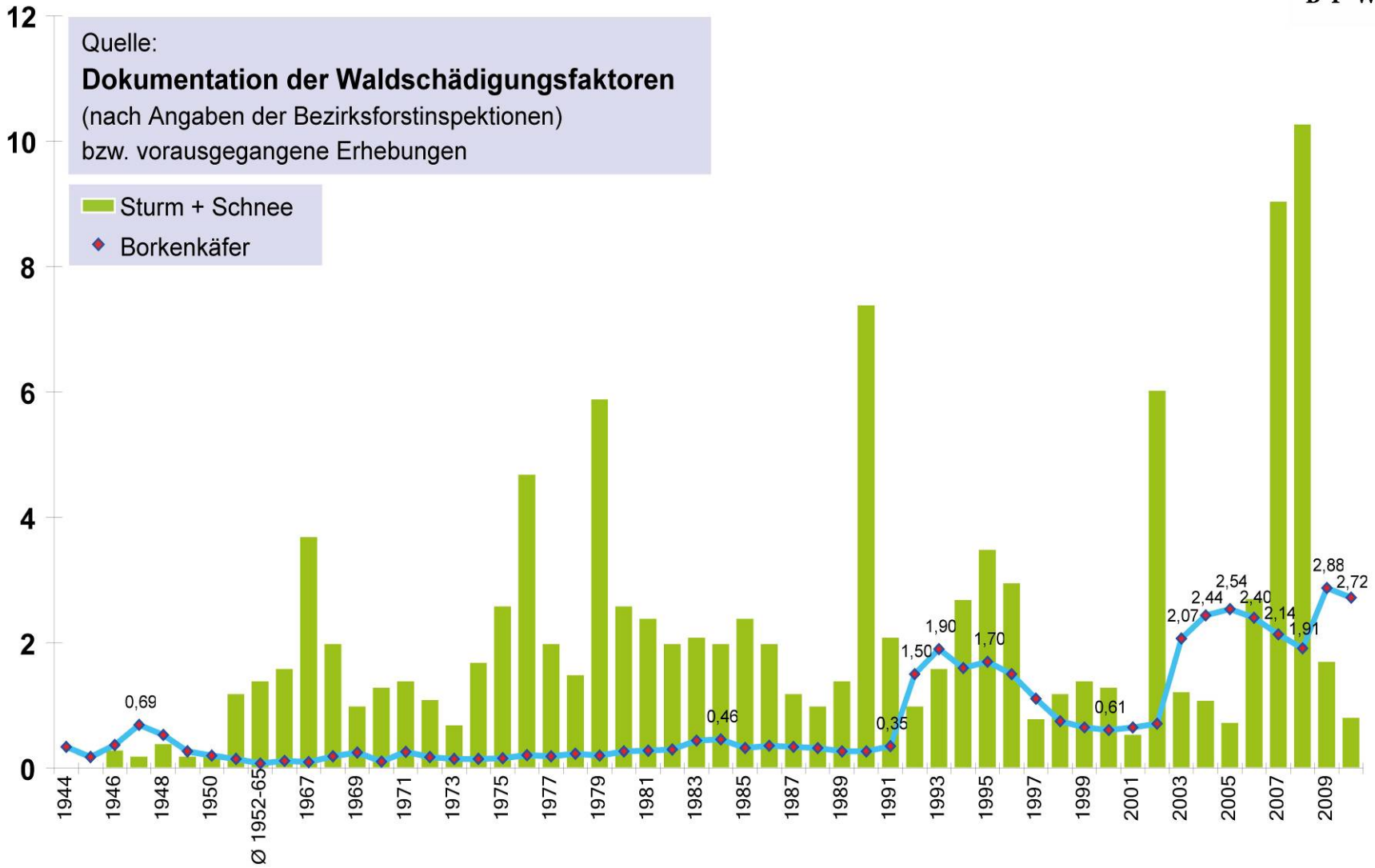
BFW

Bundesforschungs- und Ausbildungszentrum
für Wald, Naturgefahren und Landschaft
Institut für Waldschutz
TeamGIS-BFW

Schadholzmengen in Mio. Efm
durch Sturm / Schnee sowie Borkenkäferbefall

B F W

Quelle:
Dokumentation der Waldschädigungsfaktoren
(nach Angaben der Bezirksforstinspektionen)
bzw. vorausgegangene Erhebungen



Bark beetle outbreaks benefit from:

- excessive food supply: good quality of food and exorbitant quantity of food,
- temporal and spatial coincidence of bark beetles with susceptible trees,
- favorable abiotic conditions: temperature, wind, rain …, but diapause (day-length!), …
- insufficient and inefficient natural enemies.

Infestation of a tree by bark beetles …

in two different episodes:

- *Host tree selection and first settlement* by male or female (= depending on species – monogamous or polygamous): ”primary attraction“ – activated by **Kairomones** (= tree-borne substances)
- *Mass-attack* of a tree – by **Aggregation pheromones** (= beetle-borne substances)

(not known from all bark beetle species!)

Kairomones

- Setting a signal for a bark beetle: ”here is an opportune food source“ or “here is an opportune egg laying substrate and food source for larvae and adults” – for bark beetles in conifers ⇨ different “terpenes“ (e.g. α-Pinen, β-Pinen, Limonen, Myrcen, …) ⇨ **”primary attraction“!**

- Stressed (weakened) trees release a “bouquet” of different volatiles …

Tree stress is …

”reversible“

⇩

tree recovers

⇩

in case of no beetle attack or tree is able to beat off a beetle attack

”irreversible“

⇩

tree does not recover

⇩

mass-attack of beetles, tree defense is not successful

Pheromones in bark beetles

Aggregation pheromones attracting males **and** females! ⇨ causes mass-attack of a tree = **"secondary attraction"!**

Once food resources are running short, breeding beetles start sending deflecting flavors: "dispersion pheromones" – e.g. in *Ips typographus* = "Verbenon"

Inhibition of development:

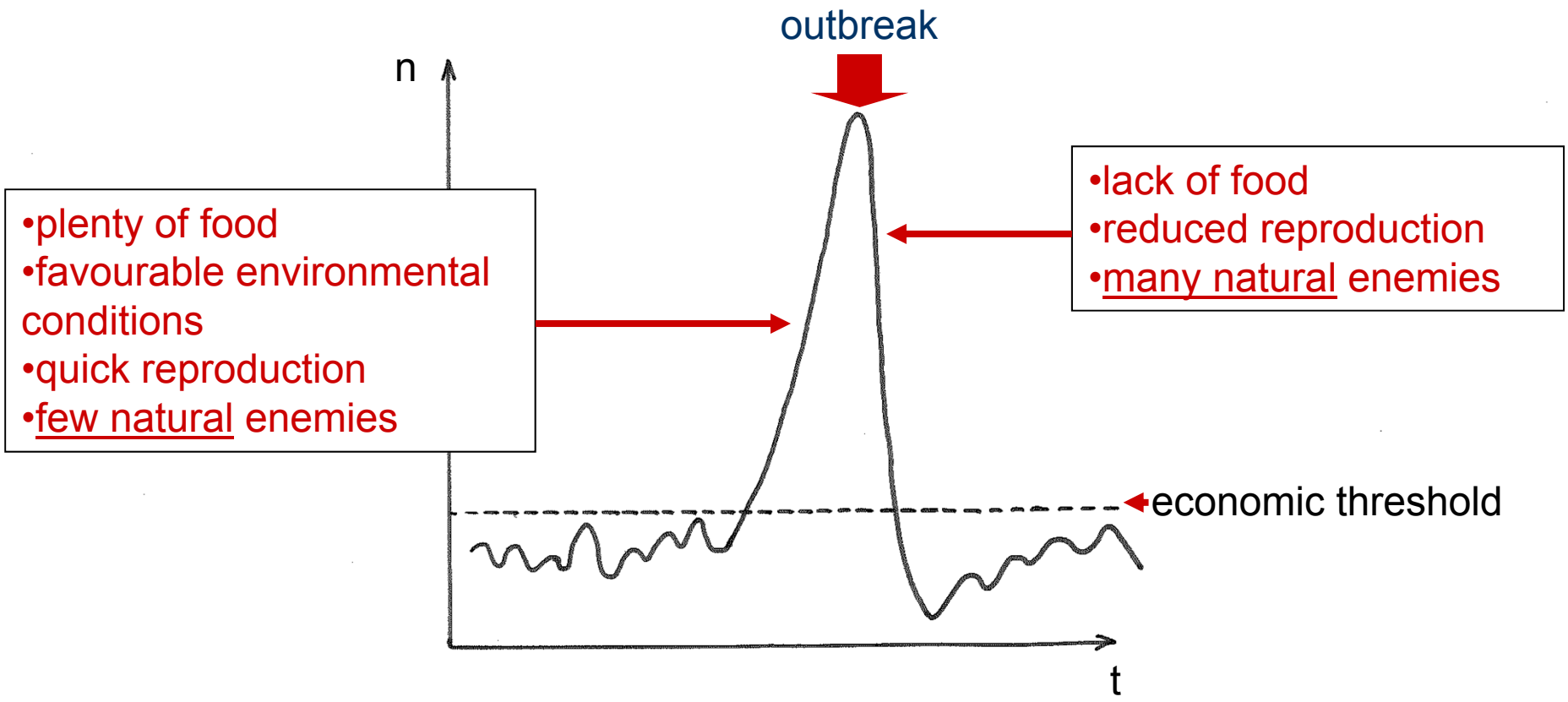
- direct sun radiation causing very (too) high temperature
- low temperature and/or precipitation and high bark humidity
- inter- and intra-specific competition for food sources
- presence of effective natural enemies

Biotic factors – natural enemies:

- *Predators:*
  Invertebrates, Vertebrates

- *Parasites/Parasitoids*:
  Hymenoptera, Diptera; Nematoda; …

- *Pathogens*:
  Virus, Bacteria, Fungi, Microsporidia, Protozoa


outbreak
n
•plenty of food
•favourable environmental conditions
•quick reproduction
•few natural enemies
•lack of food
•reduced reproduction
•many natural enemies
economic threshold
t

Natural enemies - generalists or specialists:

- **Appropriate set** of natural enemies (abundance).
- Presence of all **essential ecological conditions** for natural enemies.
- **Spatial and temporal coincidence** of natural enemies with prey/host species (voltinism).
- „**Minimum prey/host density**“ → guarantees survival of „natural enemies“.
- Long term **refuge areas** (for natural enemies and prey/host species).

Natural enemies of *Ips typographus*

- ***Predators:***
  Coleoptera: Cleridae (3), Histeridae (3), Nitidulidae (7), Rhizophagidae (5), Salpingidae (5), Staphylinidae (9), Tenebrionidae (1), Trogossitidae (1)
  Diptera: Asilidae (3), Dolichopodidae (11), Lonchaeidae (5), Muscidae (2), Pallopteridae (1), Stratiomyidae (1).
  Heteroptera: Anthocoridae (1).
  Neuroptera: Chrysopidae (1).
  Raphidioptera: Raphidiidae (3).
  Acari: Acarophenacidae (1), Pyemotidae (1), Tarsonemidae (1).
  Aves: Fringilidae (1), Picidae (1).
- ***Parasitoids:***
  Hymenoptera: Braconidae (17), Pteromalidae (12), Eupelmidae (1), Eurytomidae (6).
- ***Pathogens:***
  Virus: ItEntomopoxvirus.
  Fungi: *Beauveria bassiana, Beauveria caledonica, Isaria farinosa, Isaria fumosorosea, Lecanicillium lecanii, Metarhizium anisopliae.*
  Microsporidia: *Nosema typographi, Chytridiopsis typographi, Unikaryon montanum.*
  Protozoa: *Malamoeba scolyti, Gregarina typographi, Mattesia schwenkei, Menzbieria chalcographi.*

Natural enemies

- Every species has co-evolved natural enemies (= natural enemy complex!)
  - Herbivore species
  - – Predators: …
  - – Parasitoids: …
  - – Pathogens: …
  - ↳ depending on local species spectrum of natural enemies ⇨ **effective regulation or not!**

Outbreak … what to do?

- What is the pest species?
- What is the pest abundance?
- What are the options for pest control?
- Are there any restrictions to use chemical insecticides – environmental problems?
- Are there any other control methods?
- …?

Measures start mostly “late”: in outbreak situation …

Outbreak … must do!

- Monitoring for the presence and abundance of pest species.
- Mechanical control methods (esp. against bark and wood boring insects):
  - reduction of the amount of host material available to the insect,
  - prompt disposal of logging residues,
  - rapid removal and destruction of infested trees.
- Biological control:
  - use of predators (e.g. *R. grandis* against *D. micans*),
  - use of hymenopteran parasitoids (e.g. *R. xylophagorum* against *I. grandicollis* or *D. caenopachoides* against *O. erosus*),
  - use of parasitic nematodes (*D. siricidicola* against *S. noctilio*),
  - use of microbials is an opportune method – at the moment not for bark and wood boring insects but e.g. against Leptidoptera.
- Insect growth regulators or chemical control.

Conclusion

- The risk is higher for insect attacks in areas with trees not in accordance with the local conditions.
- There is no food limit for herbivorous insects in monocultures (or in stands with minor tree species composition).
- Presence of aggressive pest insects and favorable climatic conditions effect a high risk for remarkable outbreaks.
- Insufficient and inefficient natural enemies increase the outbreak risk.


Eu agradeço a sua atenção !

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