Risks and Intensification in Planted Forests: *Abiotic Risks*

Barry Gardiner

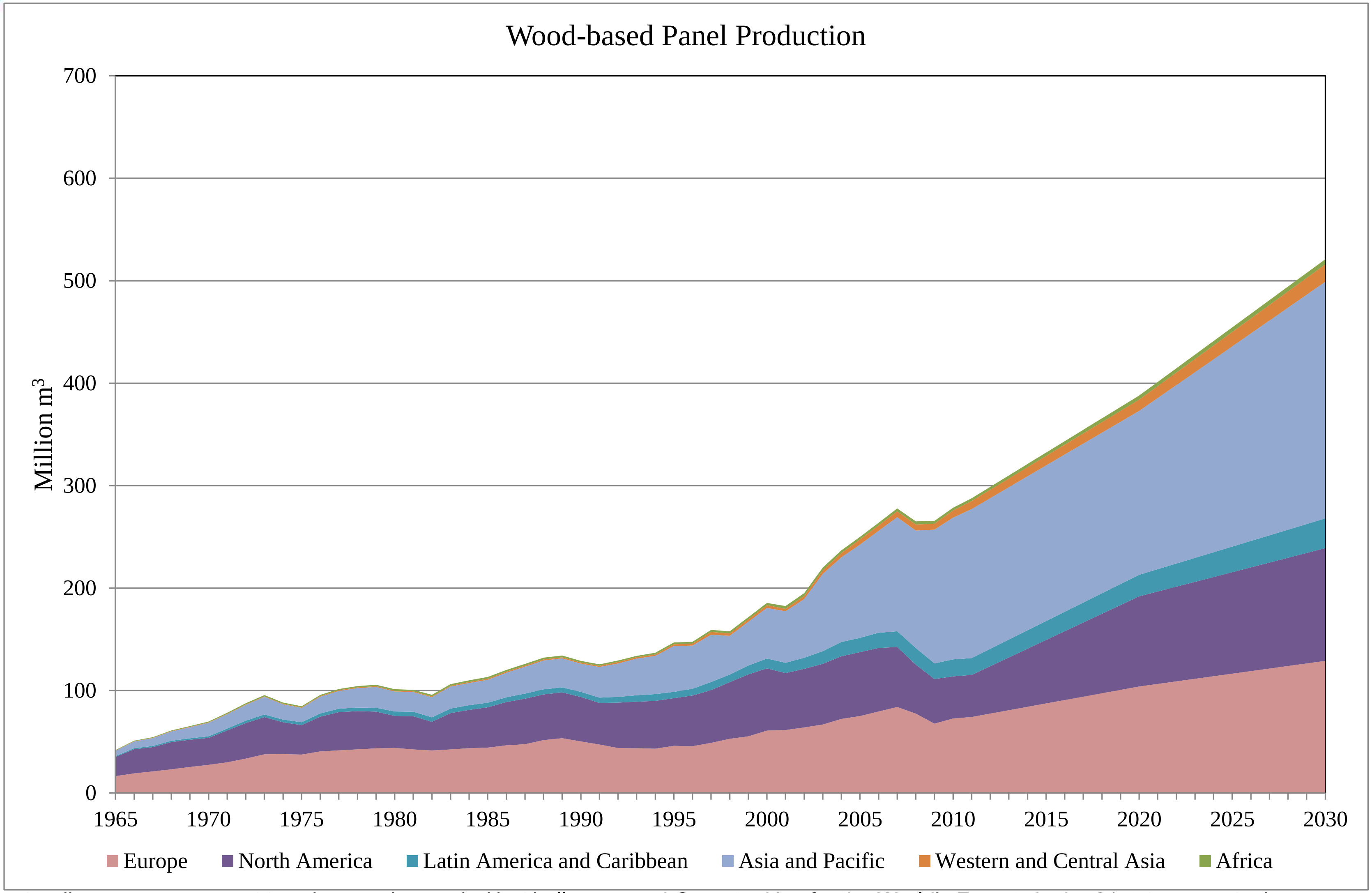
EFI Atlantic and INRA, Bordeaux, France

EUROPEAN FOREST INSTITUTE
ATLANTIC EUROPEAN REGIONAL OFFICE – EFIATLANTIC
INRA
SCIENCE & IMPACT

Outline of Presentation

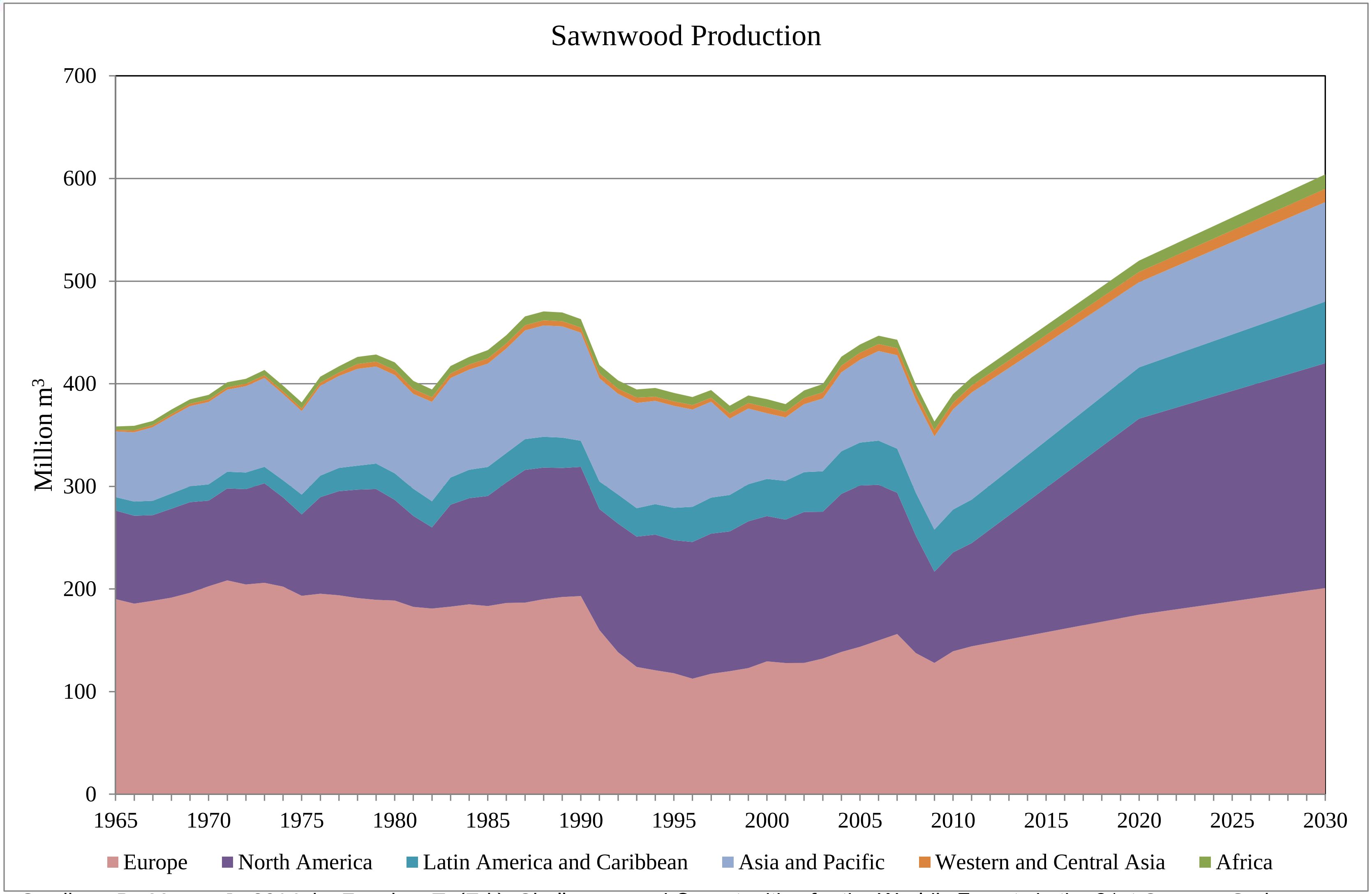
- What do we mean by “Intensification”
- What are the implications for forestry
- Examples of the major abiotic hazards for European forests
- How will forest intensification affect risk to forests
    - Examples for wind
    - Examples for fire
    - Examples for drought
    - Examples for snow/ice/frost
- How do we manage for both increased productivity and reduced risk
- Summary and Conclusions

World Demand for Panel Products



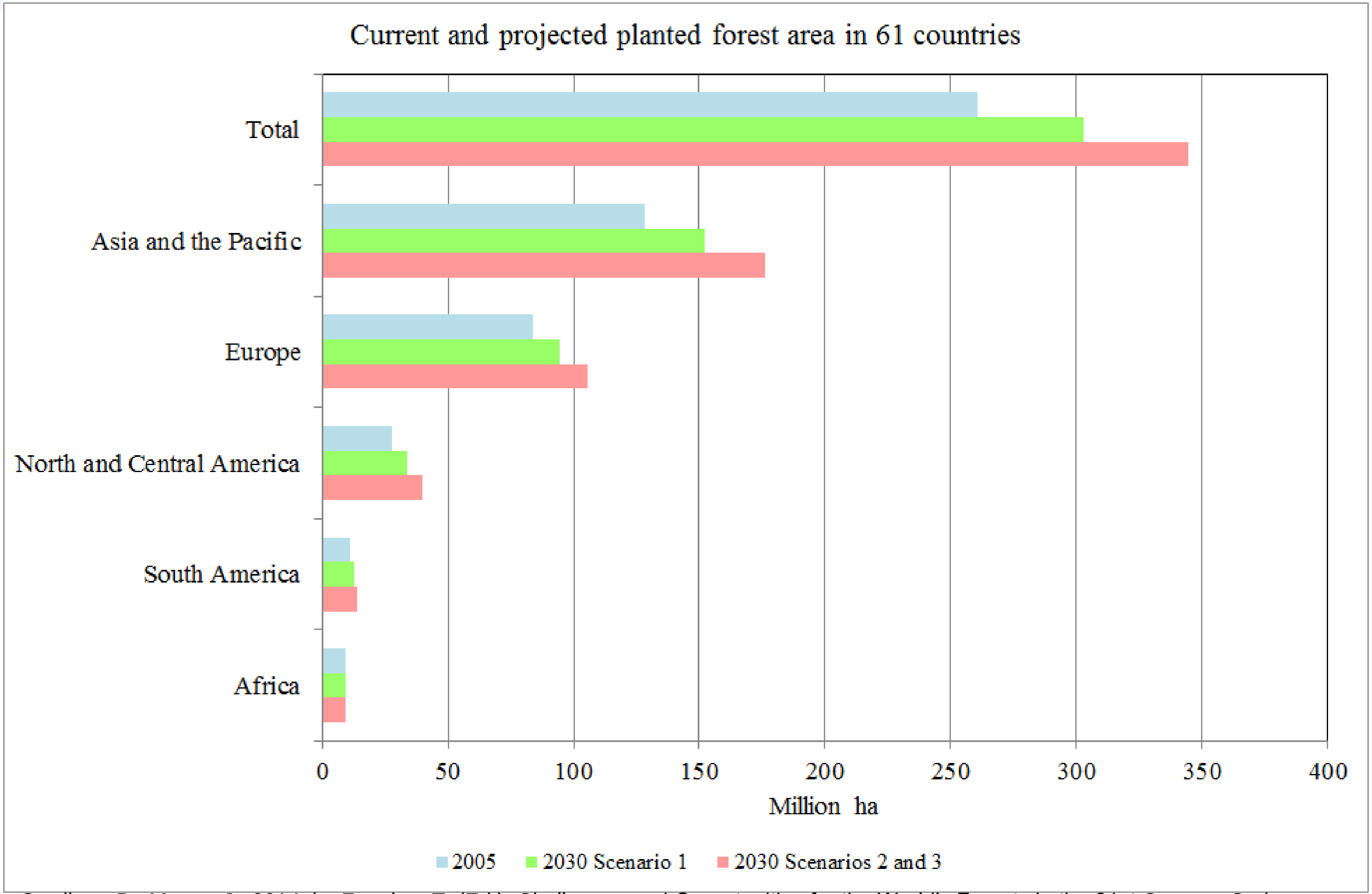
Gardiner, B., Moore, J., 2014. in: Fenning, T. (Ed.), Challenges and Opportunities for the World's Forests in the 21st Century. Springer

World Demand for Sawnwood Products



Gardiner, B., Moore, J., 2014. in: Fenning, T. (Ed.), Challenges and Opportunities for the World's Forests in the 21st Century. Springer

Current and Projected Planted Forests



Gardiner, B., Moore, J., 2014. in: Fenning, T. (Ed.), Challenges and Opportunities for the World's Forests in the 21st Century. Springer

Plantation Forestry

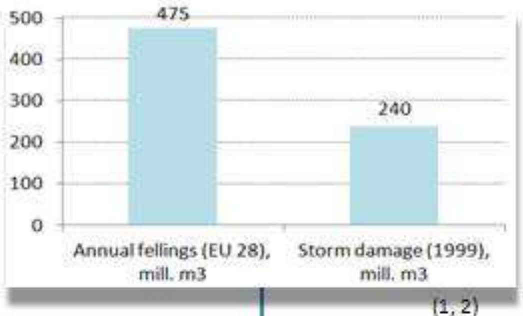
Plantation Forestry

Implications of Forest Intensification

What has intensification meant to date (more or less)

- Monocultures
- Fast growing species, provenances, or clones
- Often exotic species
- Higher input (e.g. fertilizer, improved genetic material, herbicides, etc.)
- Higher outputs
- Reduction in dependency on natural forests

Examples of Recent Damage to European Forests



(1, 2)

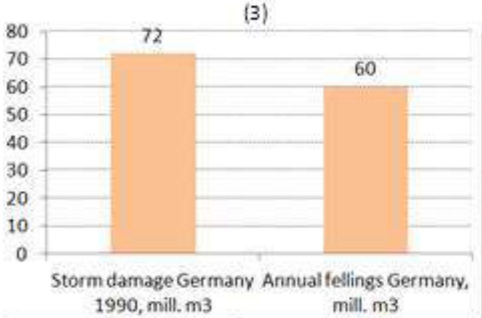
(3)

(6)

- >60 lives lost
- >5 bill. € damage
- Area burnt > Luxembourg
- >100 individual forest fires

(4)

(8)

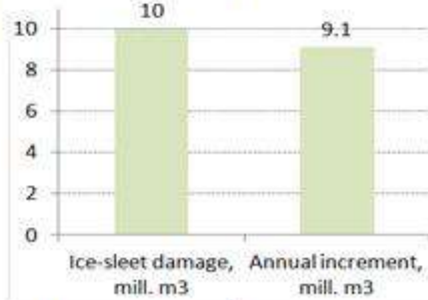


(1, 2)

(5)

- ~ 5000 km² /year
- ~ 2x land area Luxembourg

(4)



(7)

- ~215 mill. € forest damage
- ~430 mill. € total damage

(7)

Winter storms 1990 | Winter storms 1999 | Wildfire average burnt area /year | Wildfire Greece 2007 | Ice-sleet storm Slovenia 2014

Impacts of Recent Damage to European Forests

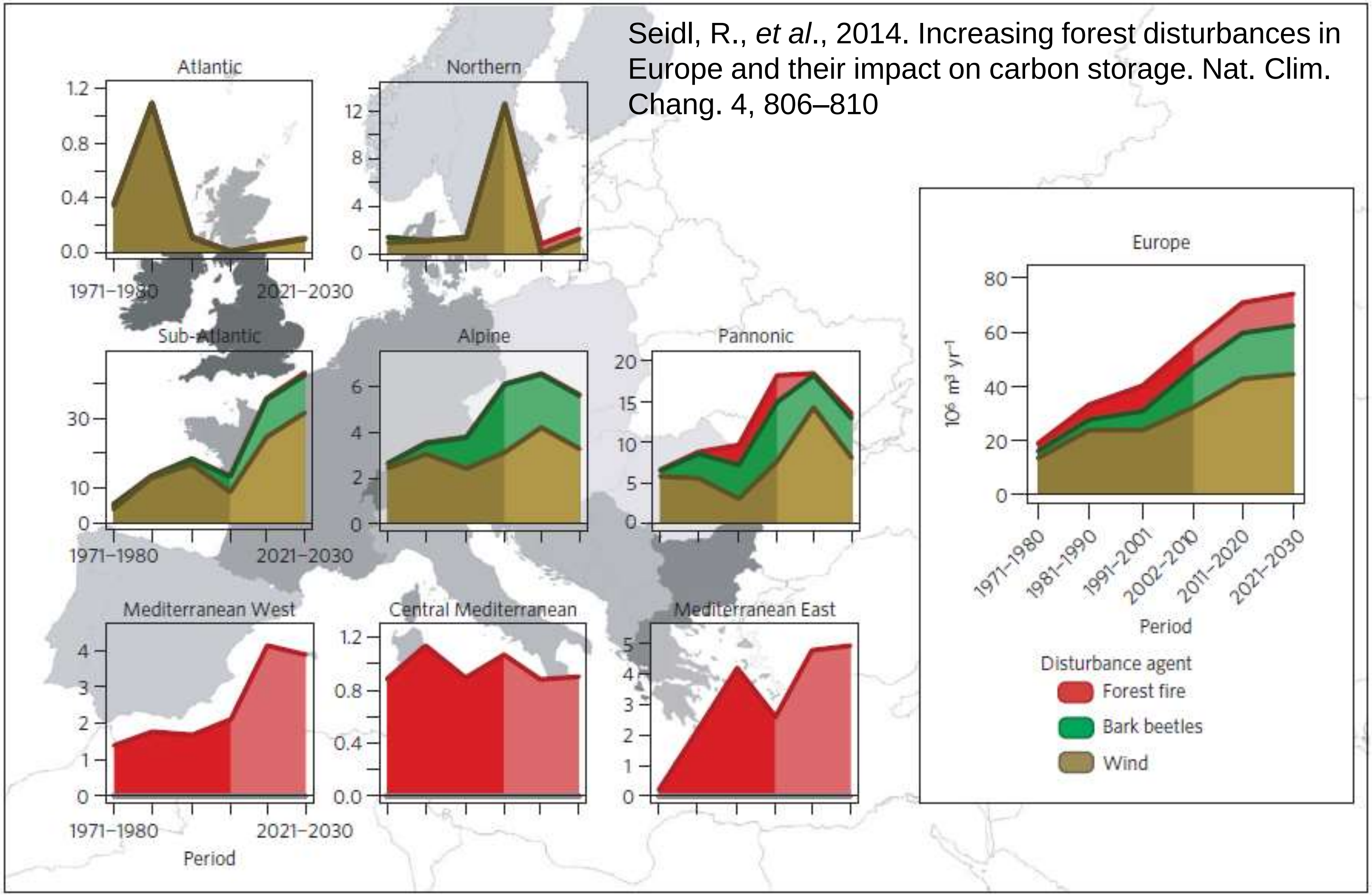
- **Forest fires:**
  - In 2005, Portugal: 800 million € worth damage and 13 casualties
  - In 2007, Greece: 5 billion € worth damage and 64 casualties
- **Storms:**

  Responsible for more than 50% of all damage by volume in Europe:
  - In 1999, France: 180 millions m^3 were destroyed = 6 billion €
  - In 2005, Sweden: 75 millions m^3 were destroyed = 2.4 billion €
- **Pests and diseases:**

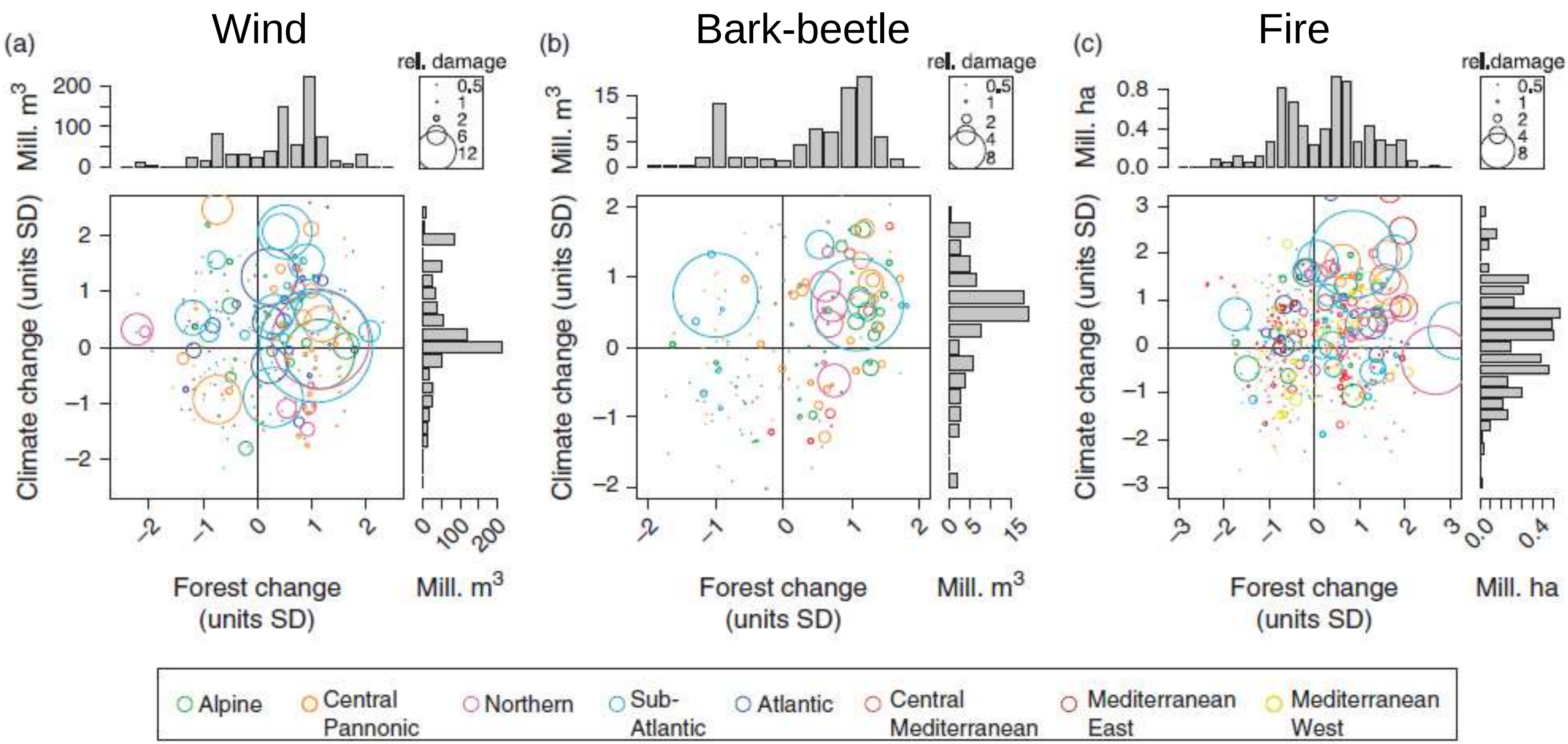
  About 2.7% of the forest area in Europe is adversely affected by insects and diseases (new species entering Europe due to climate change)

Trends in Damage to European Forests

Seidl, R., *et al*., 2014. Increasing forest disturbances in Europe and their impact on carbon storage. Nat. Clim. Chang. 4, 806–810



Influence of Management and Climate Change



Seidl, R., Schelhaas, M.-J., Lexer, M.J., 2011. Glob. Chang. Biol. 17, 2842–2852.

Climate Change is Happening Very Quickly

feet per day

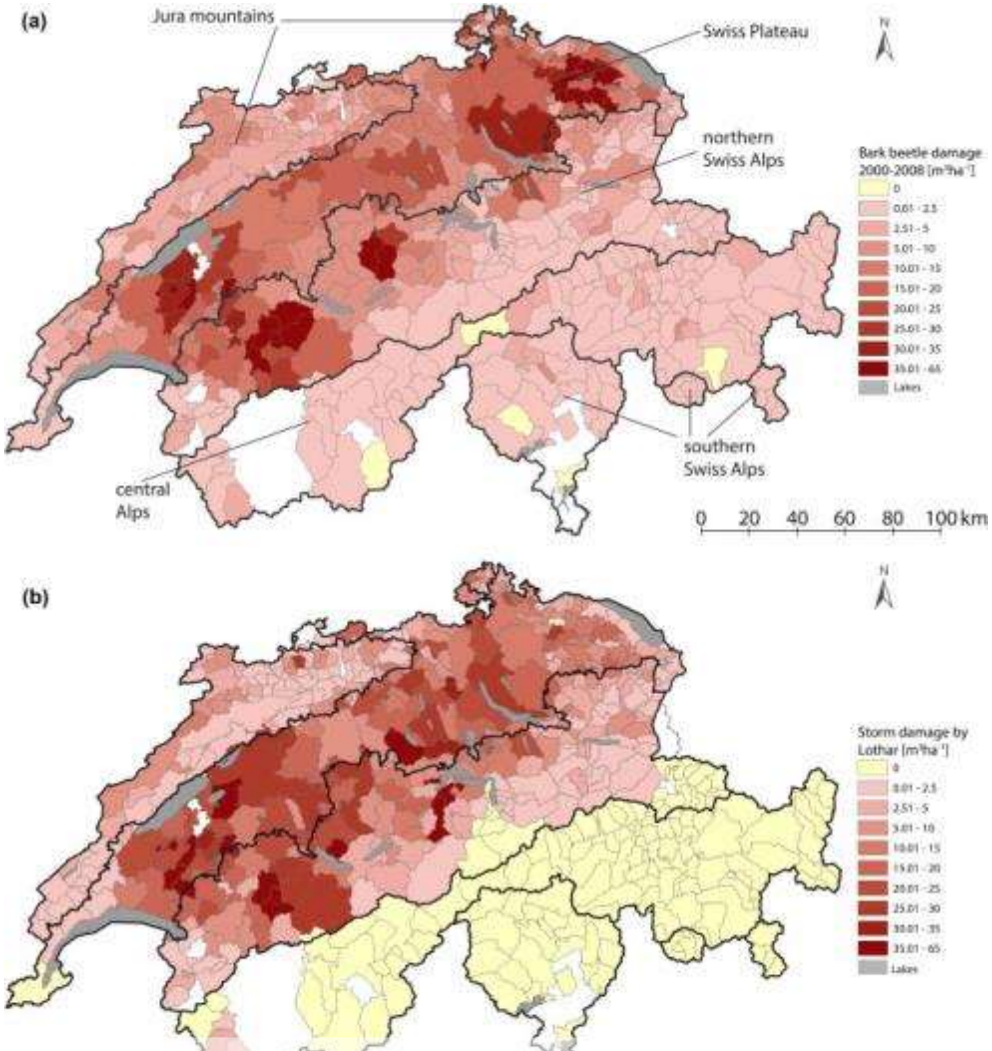
(12 metres/day)

"The distribution of tree species will inevitably change in response to climate warming. However, if the trees are to stay within appropriate climatic envelopes there will be a requirement for species migration rates to be more than 10 times faster than those achieved in reaching present distributions after the last ice age".

Major Hazards to European Forests

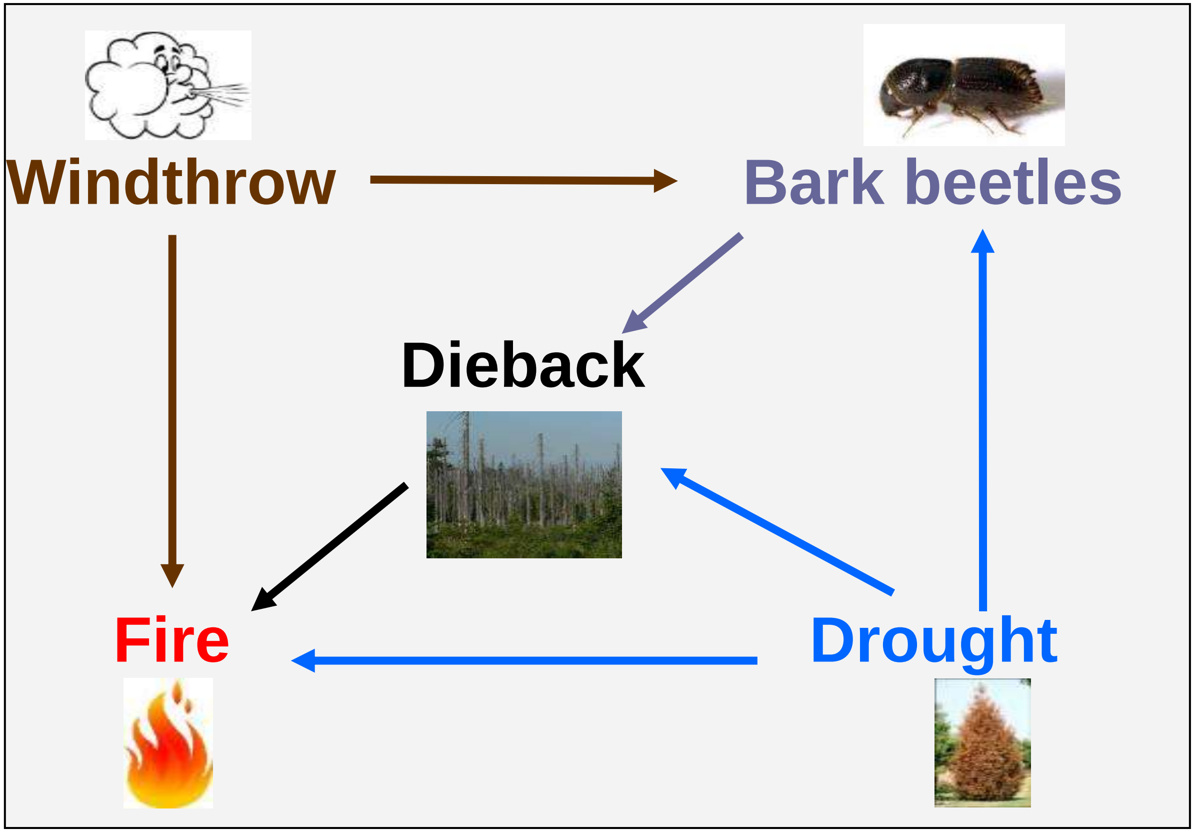
- Wind 
- Fire 
- Insects/pests 
- Drought 
- Pathogens 
- Snow/Ice/Frost 
- Other biotic pests 

Coupled Risks: Bark Beetles after Wind



Stadelmann et al. (2013). Forest Ecology and Management, 305

Coupled Risks: Bark Beetles after Wind



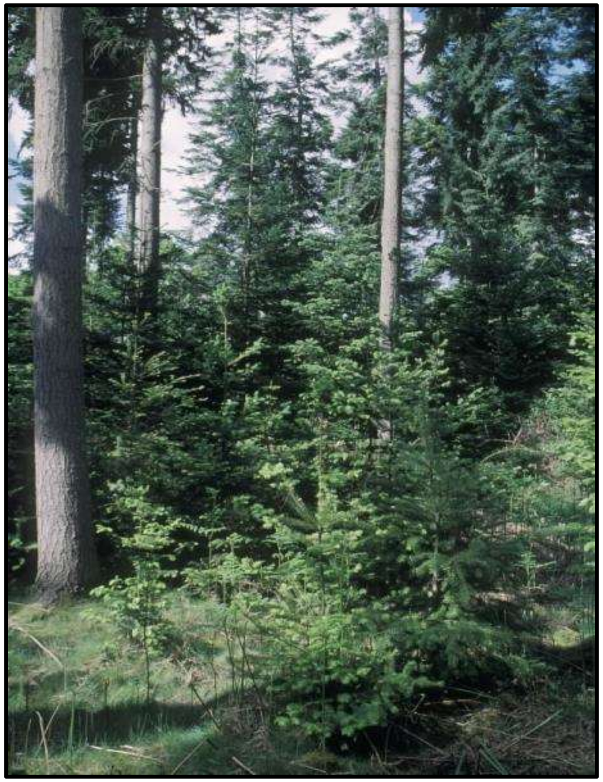
Forest Risks: Wind

Forest Risks: Wind

Wind: Mitigation/Adaptation Strategies

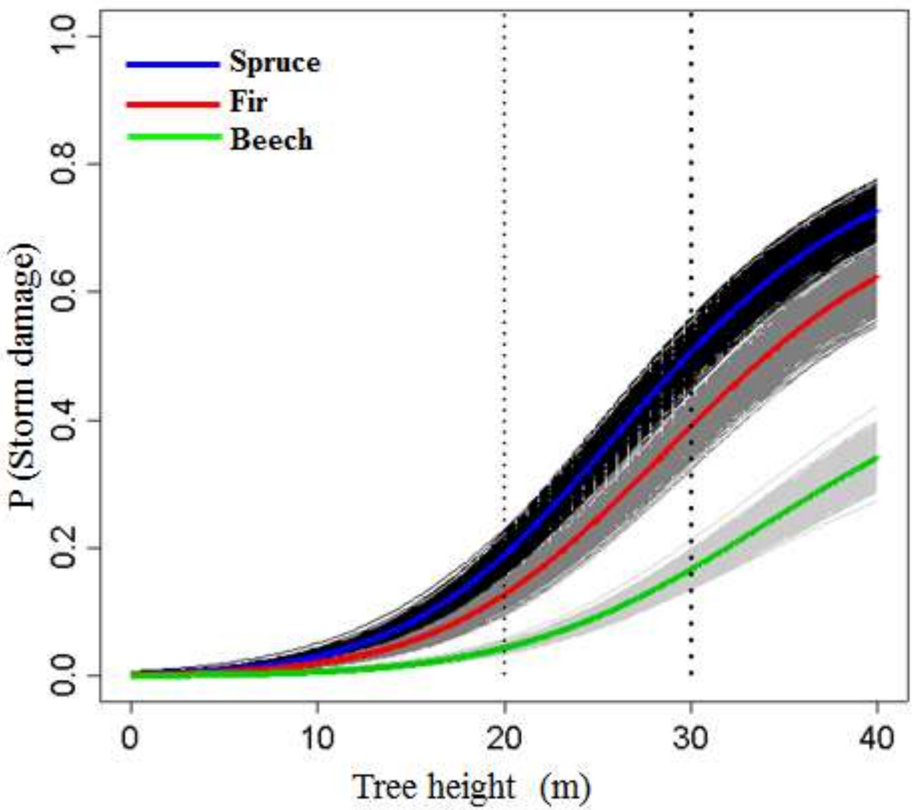
continuous cover

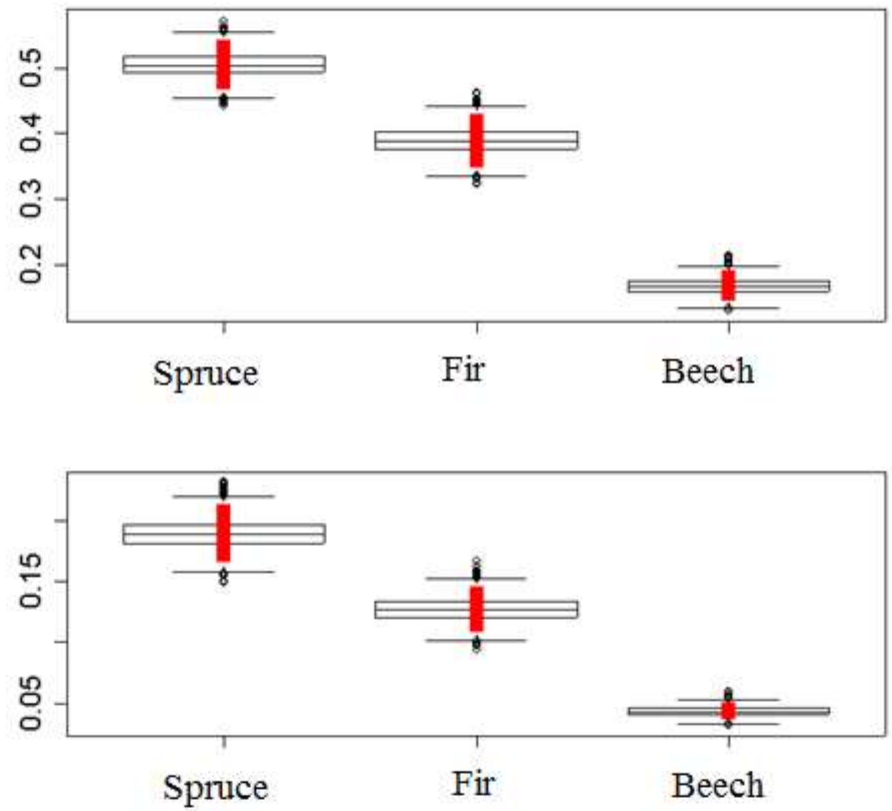
even-aged
regular



uneven-aged
irregular

Wind: Mitigation/Adaptation Strategies



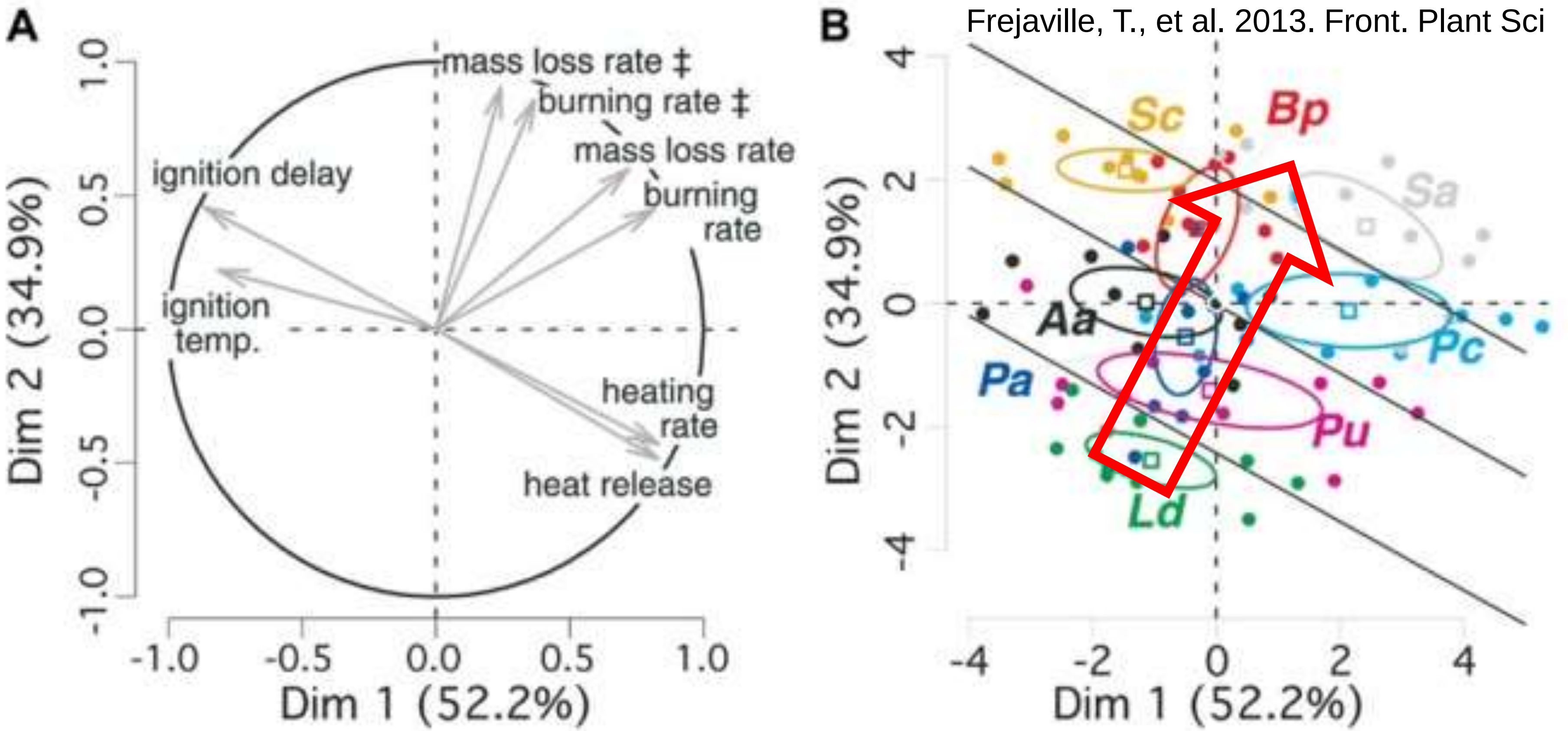


Hanewinkel, M. et al. 2013. Influence of stand characteristics and landscape structure on wind damage
Living with Storm Damage to Forests: What Science Can Tell Us. EFI.

Forest Risks: Fire

Fire: Mitigation/Adaptation Strategies

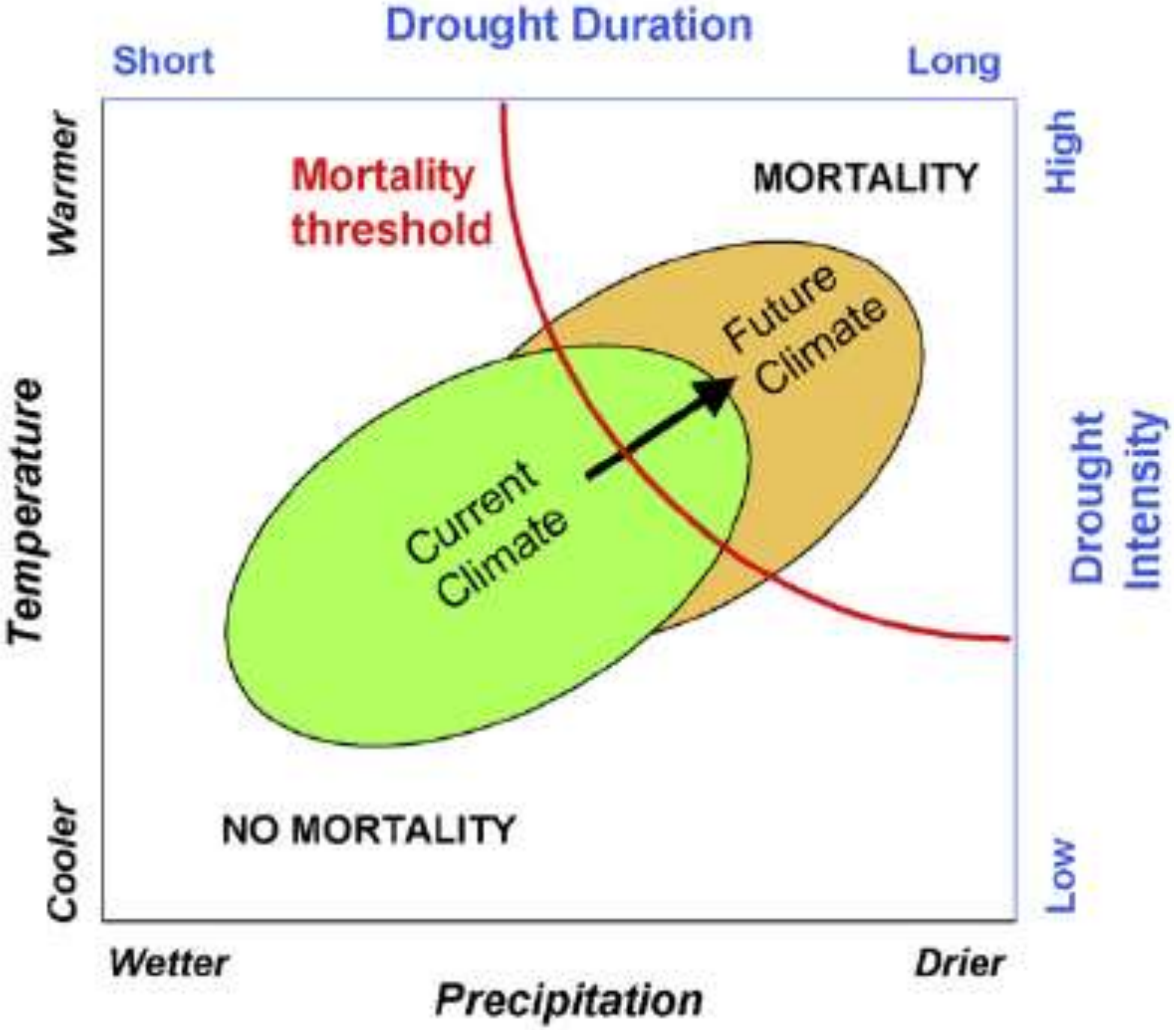
Fire: Mitigation/Adaptation Strategies



Ld for *Larix decidua*; Aa, *Abies alba*; Pu, *Pinus uncinata* ;Pa, *Picea abies*, Pc, *Pinus cembra*; Sc, *Salix caprea*; Bp, *Betula pendula*; Sa, *Sorbus aucuparia*

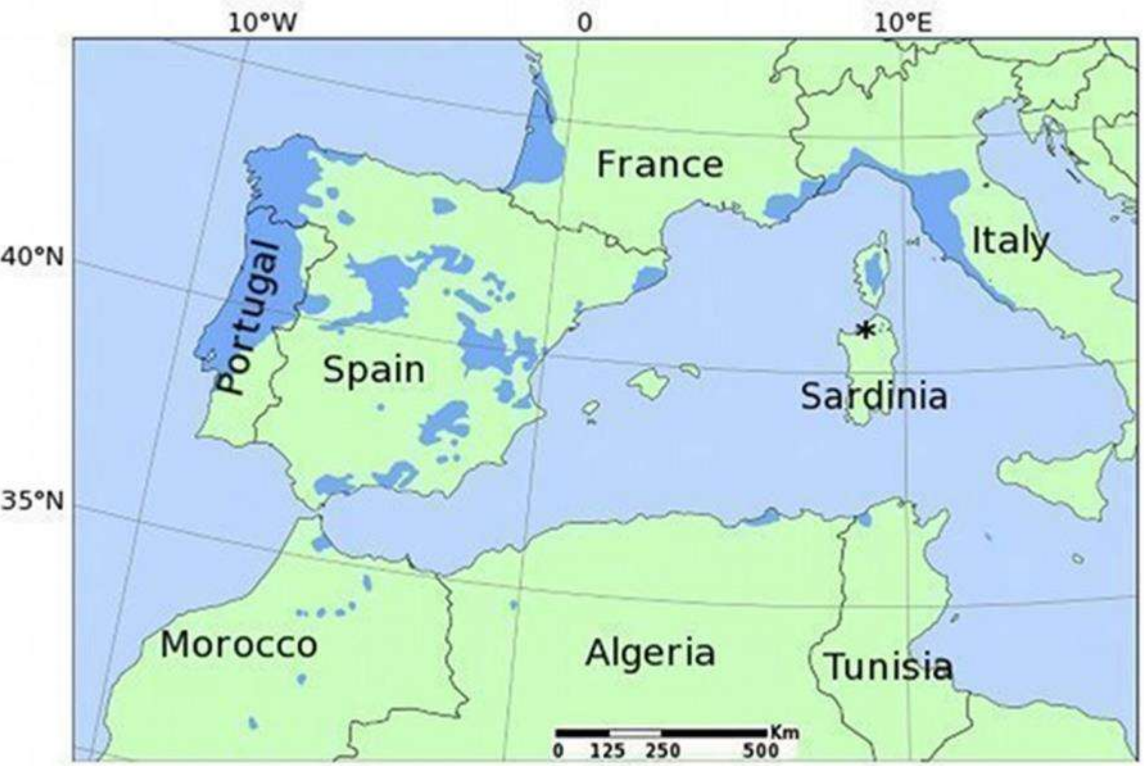
Forest Risks: Drought

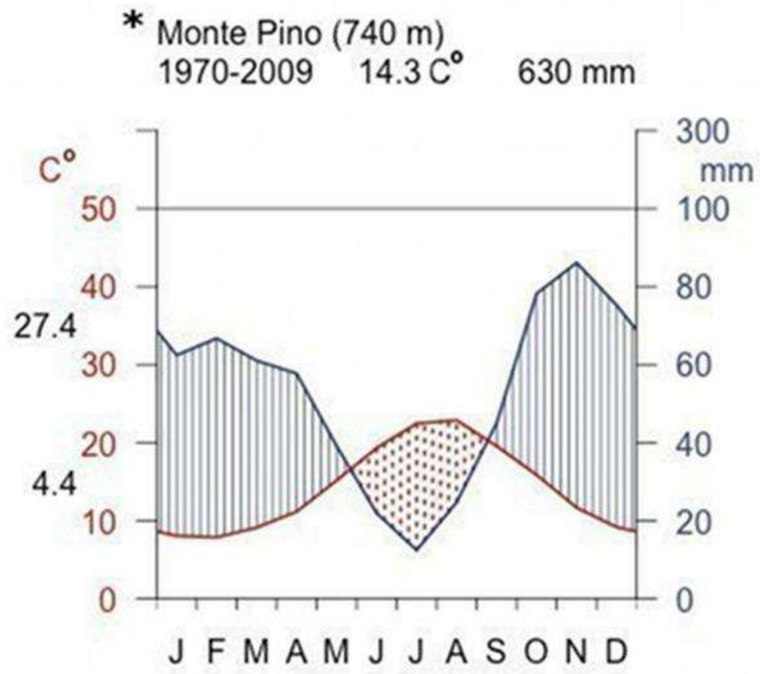
Forest Risks: Drought



Allen, C.D., et al., 2010. For. Ecol. Manage.

Drought: Mitigation/Adaptation Strategies





Forest Risks: Snow/Ice

Snow/Ice: Adaptation/Mitigation Strategies

Forest Risks: Frost

Frost: Mitigation/Adaptation Strategies

COLD HARDY EUCALYPTUS - FROST DAMAGE EVALUATION

GALICIAN HIGHLANDS (NW SPAIN) - FROSTY WEEK - DECEMBER 2008

info@git-forestry.com

- **7 consecutive frost & ice events**, for an ongoing total of 17 events (November & December) during winter 2008-2009.
- Absolute minimum air temperature **-5.7ºC** (ca. 22ºF). Gradual decrease of daily absolute minima.
- Longest risk period was **16 hours below 0ºC** (32ºF) (66% of day length below zero, 33% of day length above zero)
- Daily maxima always over 0ºC (32ºF) for 100% frost events, and over 5ºC (41ºF) for 80% frost events.
- Soil temperature reaching an absolute minimum of 2.2ºC (ca. 36ºF), always over 0ºC (32ºF)

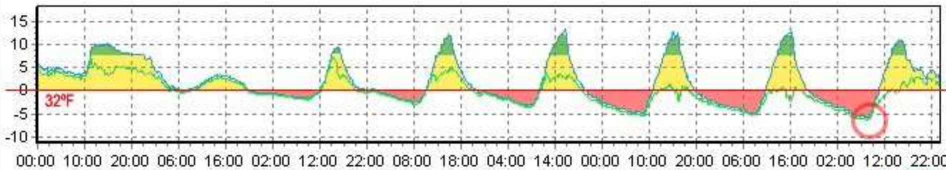


Fig 1 - Air temperature (ºC) and Dew Point (ºC) at crop effect height (+ 3 m) -5.7 ºC (ca. 22ºF)

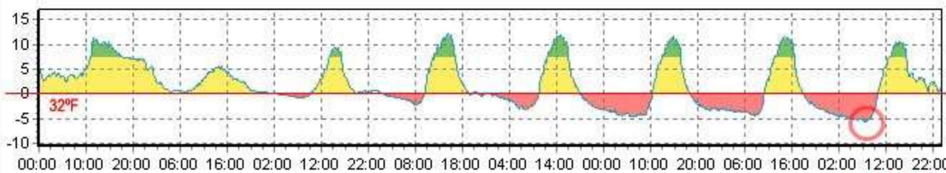


Fig 2 - Air temperature (ºC) near soil surface (+ 0.1 m) -5.2 ºC (ca. 23ºF)

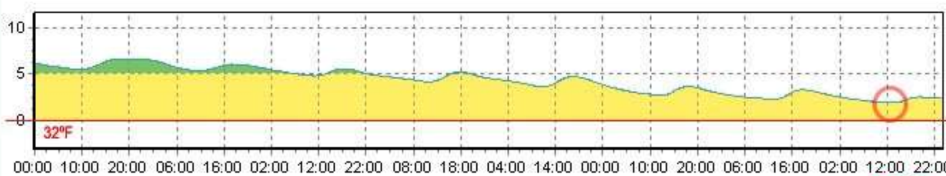


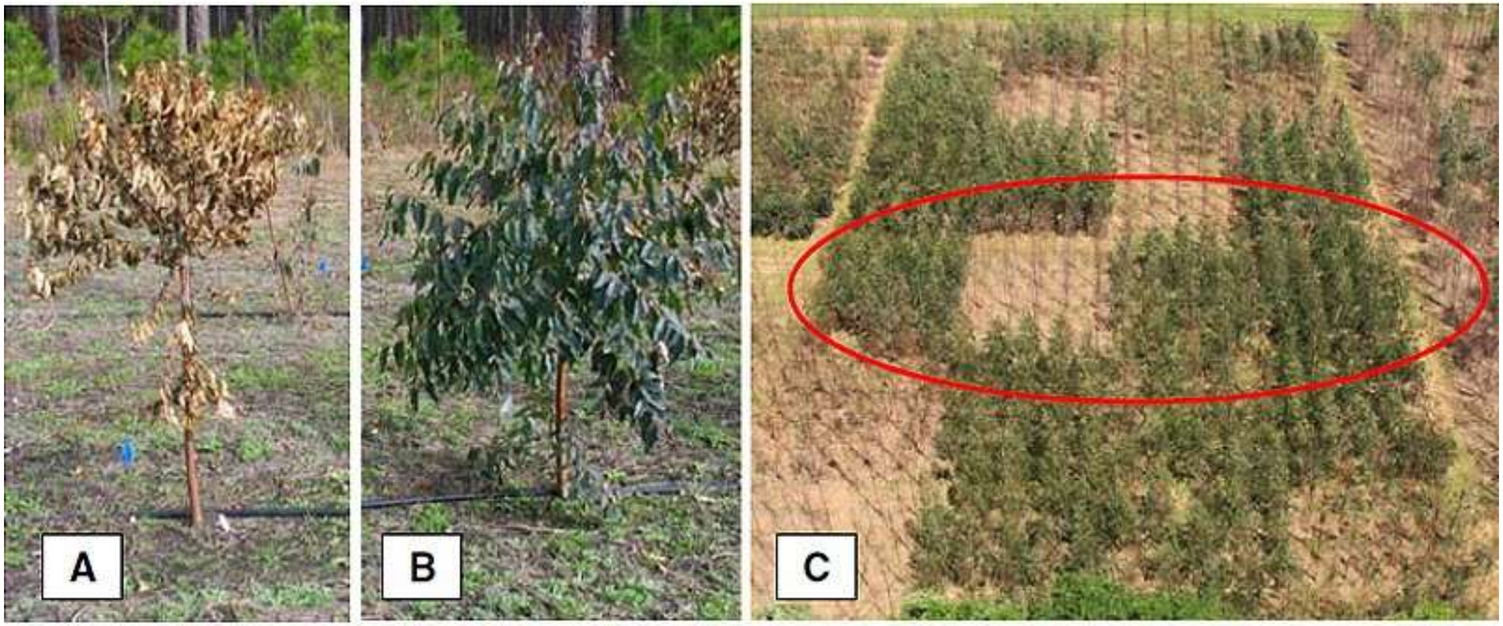
Fig 3 - Soil temperature (ºC) at shallow root depth (- 0.1 m) 2.2 ºC (ca. 36ºF)

Expected damage will include **low impact ice induced frost injuries** to juvenile and intermediate foliage in ***E. nitens*** reaching Level 1 (0 to <25% of alive crown). No irrecoverable damage is expected in sampled populations. Absolute min of -9ºC (ca. 15ºF) caused <5% tree casualties in previous years. Minimum soil temperatures well above 0ºC (32ºF) suggest **nil cold induced damage to fine roots** and a potentially fast recovery for any damaged specimen. **Similar conditions would cause moderate to heavy damage to *E. globulus*.**

Frost: Mitigation/Adaptation Strategies

Controlled clonal hybrid transgenic *Eucalyptus* trials in SouthEastern USA

Performance, growth & cold hardiness tests



Control after -9°C

Freeze Tolerant Gene added (transgenic) after -9°C

Comparative performance blocks within a trial (transgenic & non transgenic) after -7°C

"**ArborGen** has introduced the *Arabidopsis* CBF2 transcription factor driven by the *Arabidopsis* RD29a stress inducible promoter (Yamaguchi-Shinozaki & Shinozaki 1993) into a highly productive tropical *Eucalyptus* (***E. grandis* × *E. urophylla***) genotype. The new transgenic variety, Freeze-tolerant *Eucalyptus*, has demonstrated tolerance to **-9°C** (16°F) across multiple years and multiple field trial locations while essentially maintaining its exceptional productivity."

Visual summary by GIT Forestry. Source: Hinchee et al, 2009 - DOI 10.1007/s11627-009-9235-5

ARBORGEN

Forest Productivity and Risk
Very, very simplified

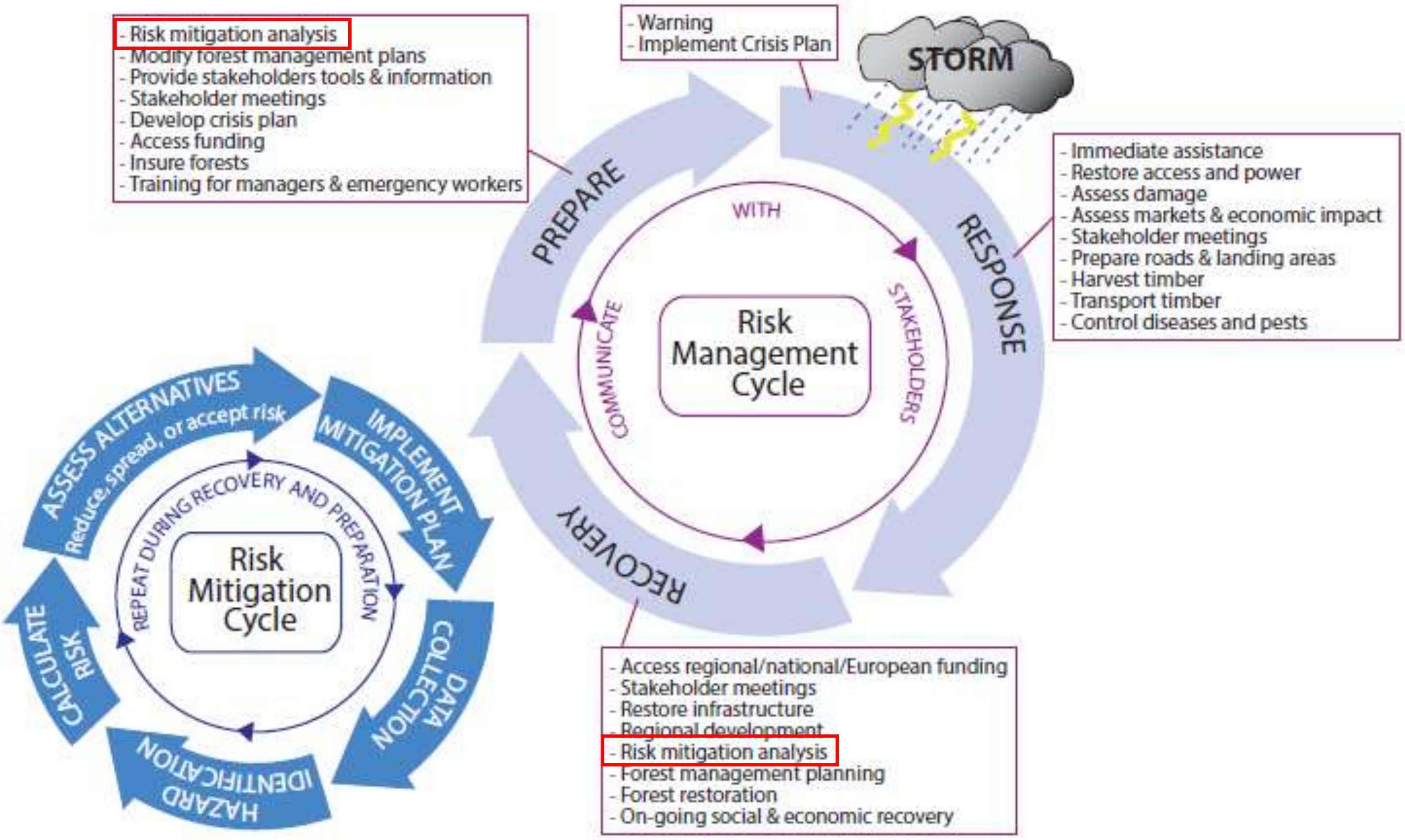
	Mono-cultures	Exotic Species	Single Clone	Single Provenance	Mixed Species
Productivity	↗	↗	↗	↗	↗ →
Risk	↗	↘↗	↗	↗	↘

Managing Risk in High Productivity Forests
Sustainable Intensification

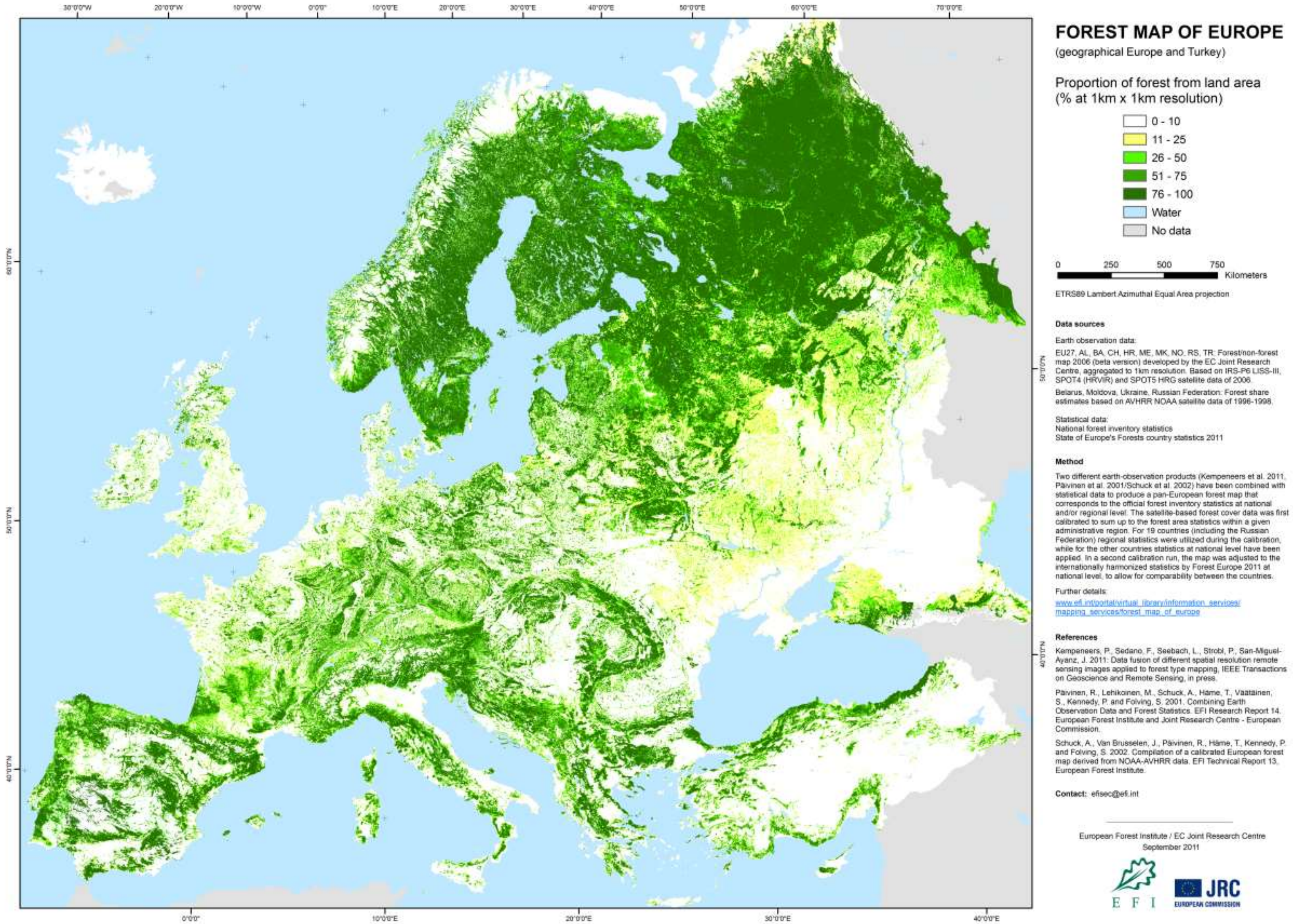
How do we increase productivity without increased risk to forests?

- Different species
- Different provenances and clones
- Mixed age and species stands
- Plan at the landscape level not only at the stand level
- Contingency plans
- Risk management and mitigation planning
- Holistic approach to forest hazards. Stop thinking in isolation
- Have a better scientific understanding of the interaction of trees and site and hazard

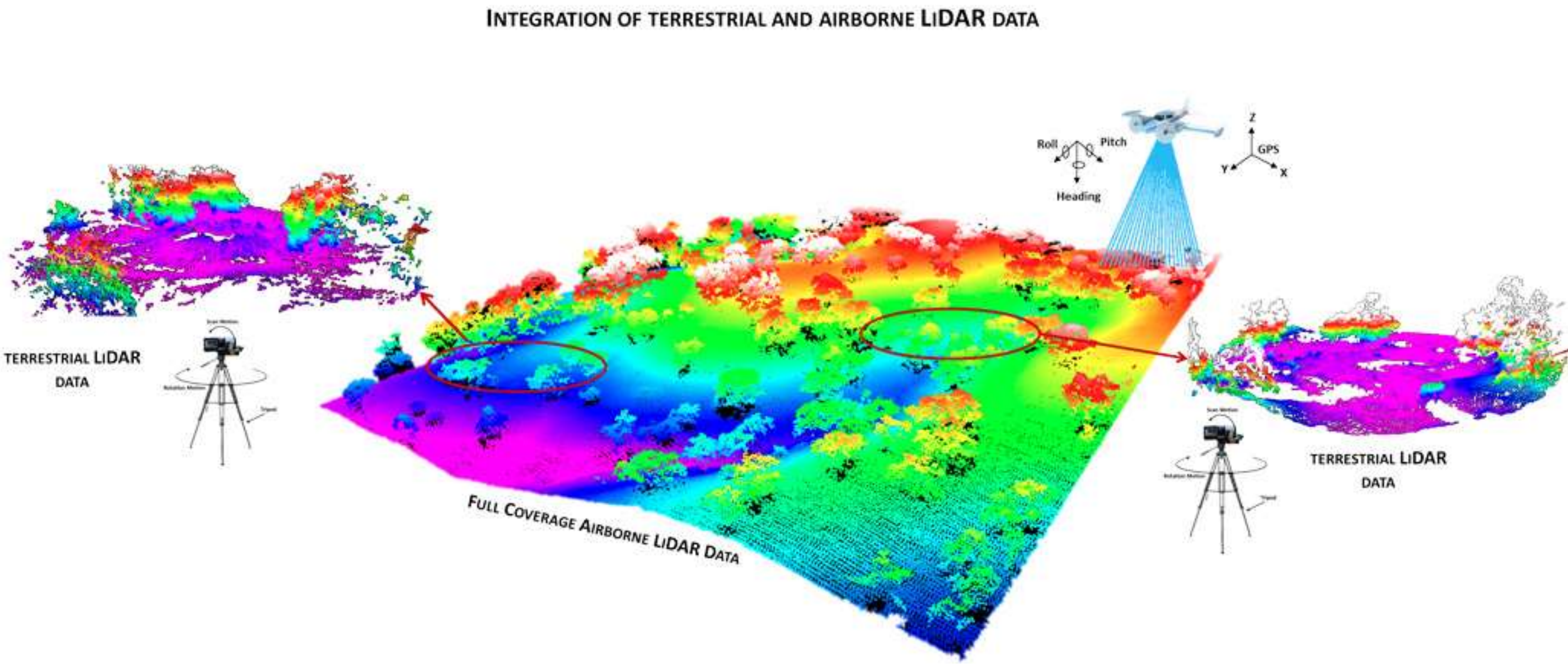
Risk Management and Mitigation



European Forest Data from EFISCEN-Space

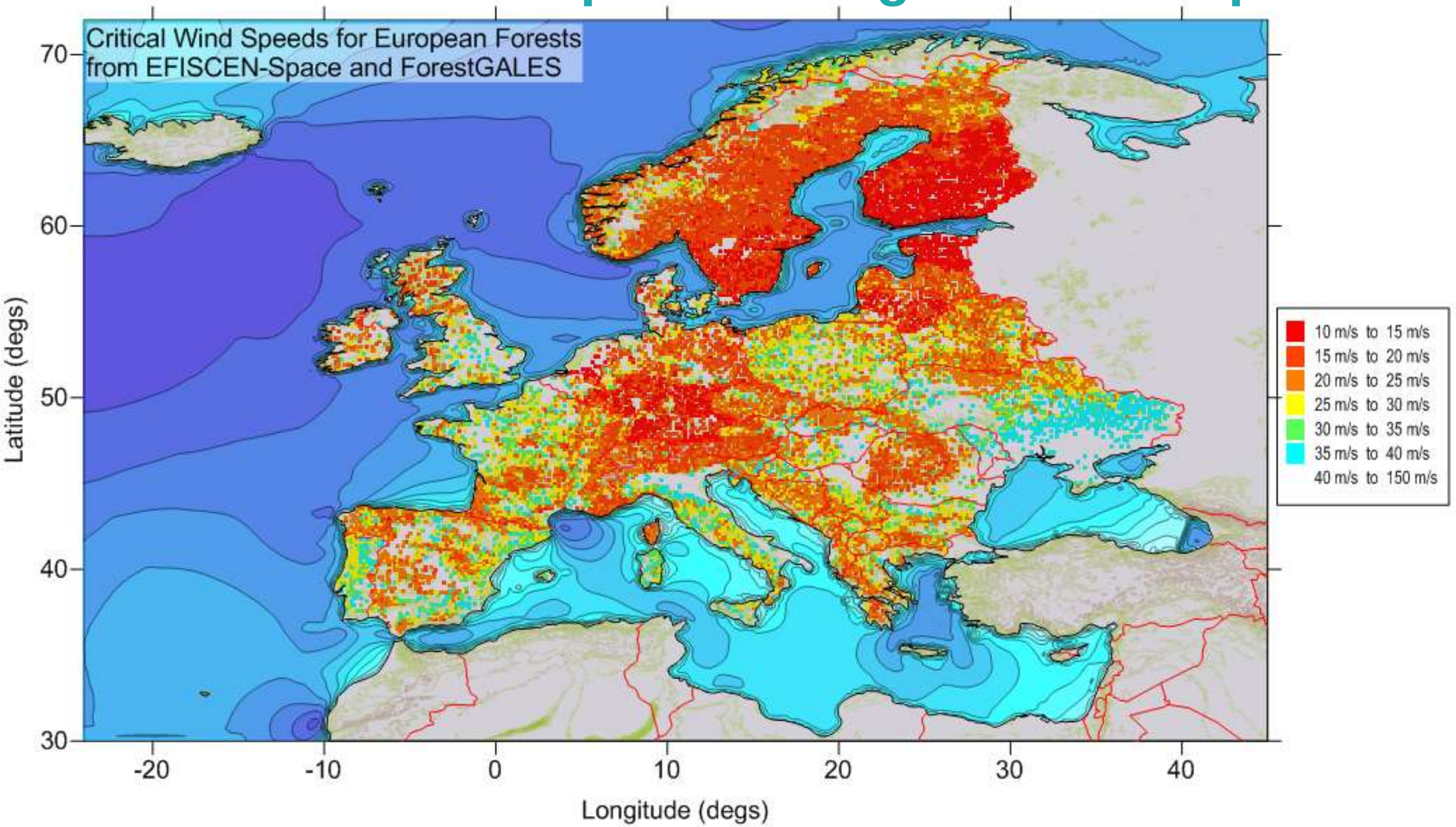


Data Capture: LiDAR and Hyperspectral

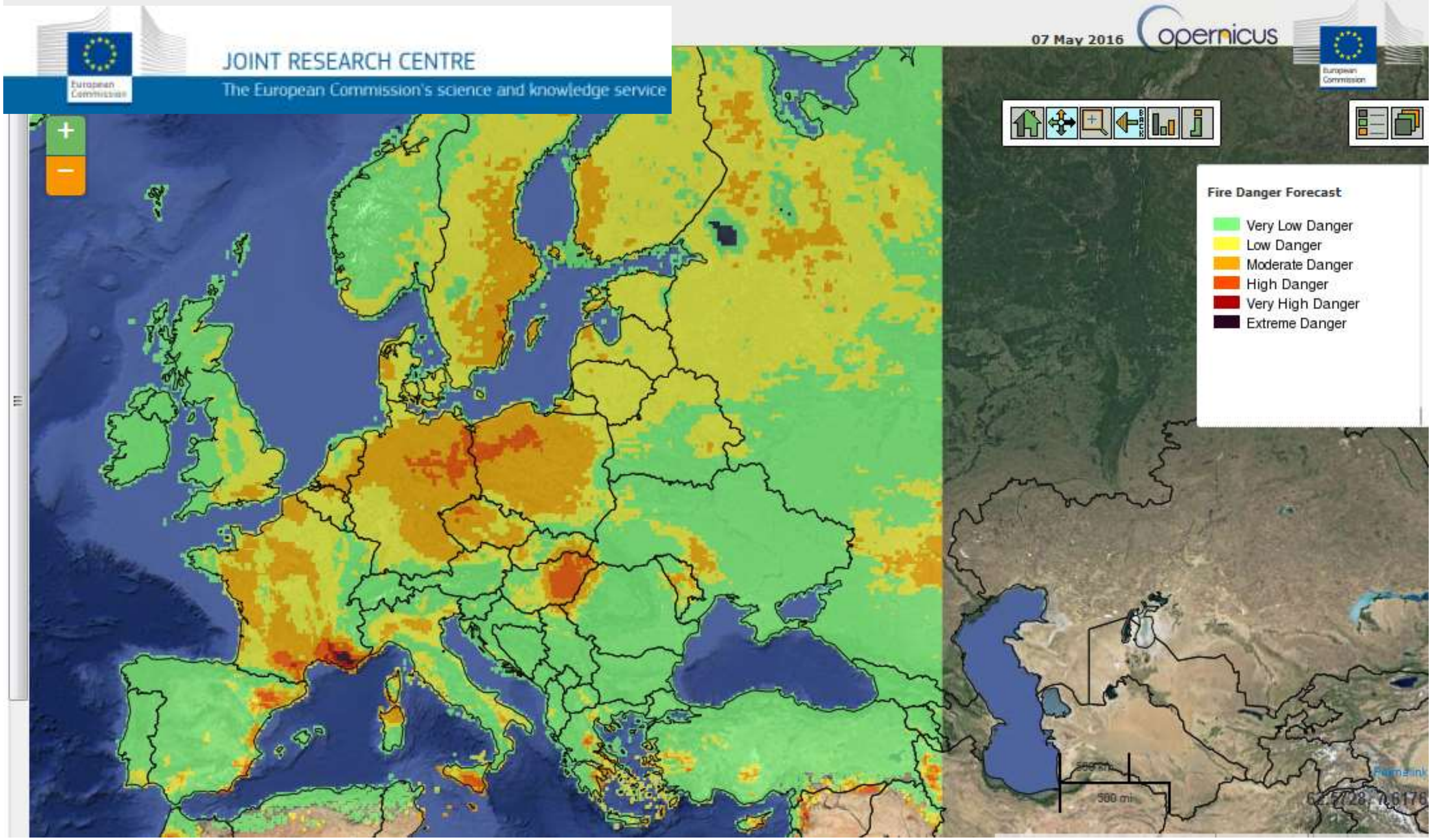


Data Capture: LiDAR and Hyperspectral

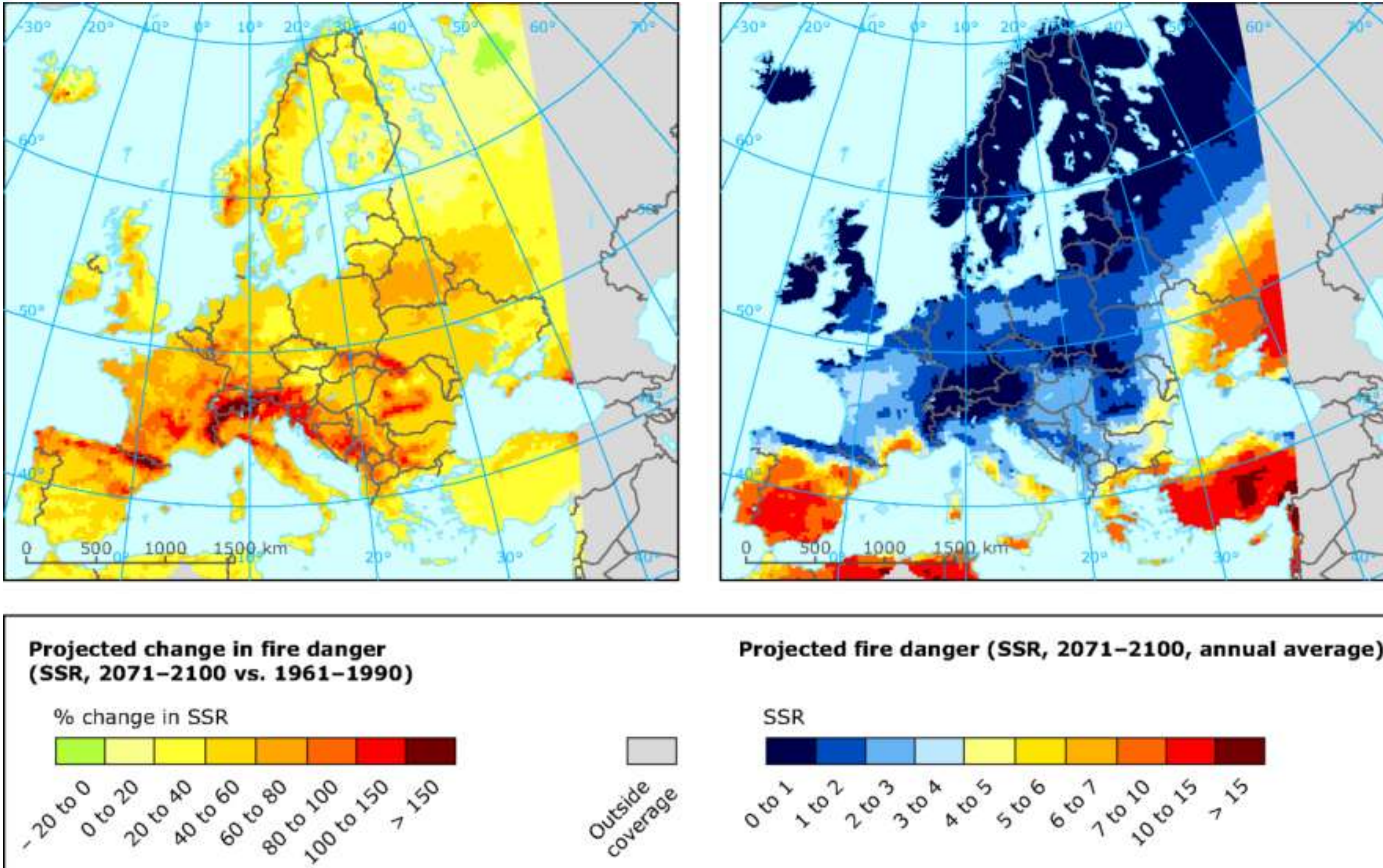
Critical Wind Speeds using EFISCEN-Space



European Forest Fire Information System



Predicted Future European Forest Fire Danger



A European Forest Risk Facility

Summary

- World demand for wood products is **increasing**
- Land available to produce wood is becoming **limited**
- Plantation forestry offers the **only** possibility to meet this need
- But damage to forests is **increasing** due to changing climate and intensification of our forestry practice
- We need to have **sustainable intensification** in forestry
- But the interaction between trees, sites and hazards is **complex** and difficult to predict
- We know a lot about forest management but much of our knowledge is based on **simple systems**
- A lot of **knowledge** exists on hazards to forestry but it is dispersed, not always available, and often forgotten

Conclusions

- Fundamental understanding of **tree physiology** is a priority
- Linking our knowledge across all disciplines and **sharing** this knowledge is the way forward
- Damage will continue to happen to forests but we can **be prepared** for it better

Thank You

“predicting the future accurately is not so important, being ready for it is”

- Pericles -

495 - 429 BC