POTSDAM-INSTITUT FÜR KLIMAFOLGENFORSCHUNG

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University of Applied Sciences

Bundesamt für Naturschutz

Die globale Bedeutung borealer Wälder als Kohlenstoffsenke und –speicher

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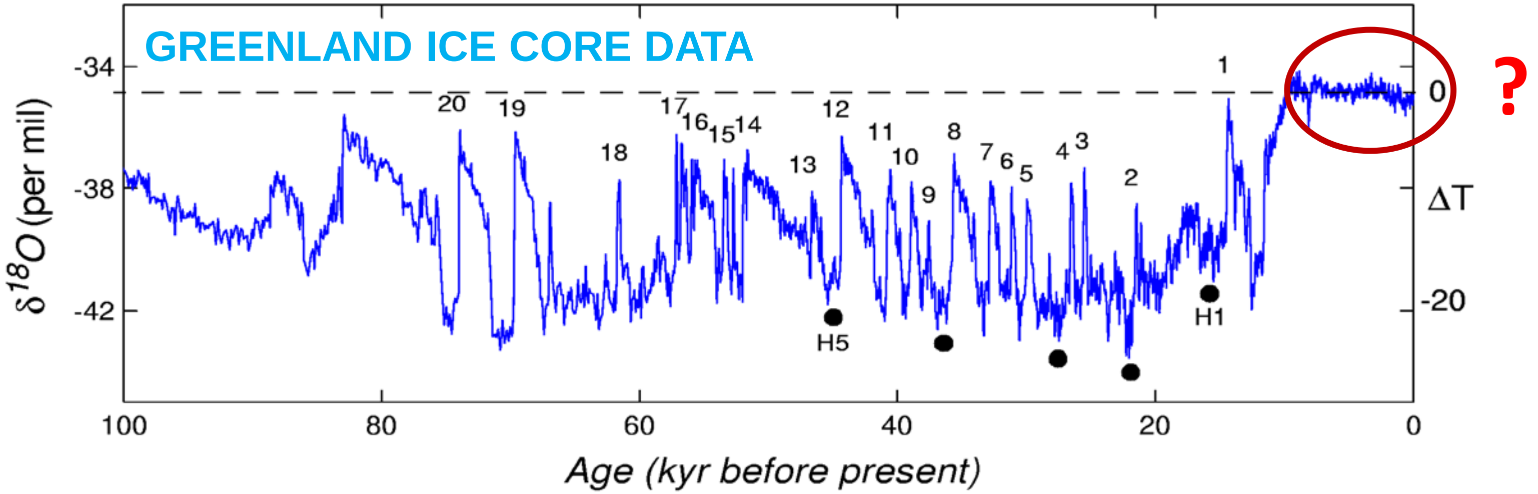
Leibniz-Gemeinschaft

Food and Agriculture Organization of the United Nations

State of the World's Forests 2014

Enhancing the socioeconomic benefits from forests

Die mögliche globale Bedeutung borealer Regionen als Klimaregulativ (Forschungsbedarf)



Welche Prozesse in borealen Regionen regulieren das Klima?

- Kohlenstoffkreislauf in Kombination mit anderen Stoffflüssen (Wasser, Stickstoff, …) als Quelle von Biogenen Volatilen Organischen Compounds (BVOCs)
- Ökosystemleistungen – Biodiversität als stabilisierender Faktor
- **Kohlenstoffsenke & Kohlenstoffspeicher**

Die globale Bedeutung borealer Wälder als Kohlenstoffsenke und Kohlenstoffspeicher

1. Funktion borealer Regionen als Klimaregulativ?
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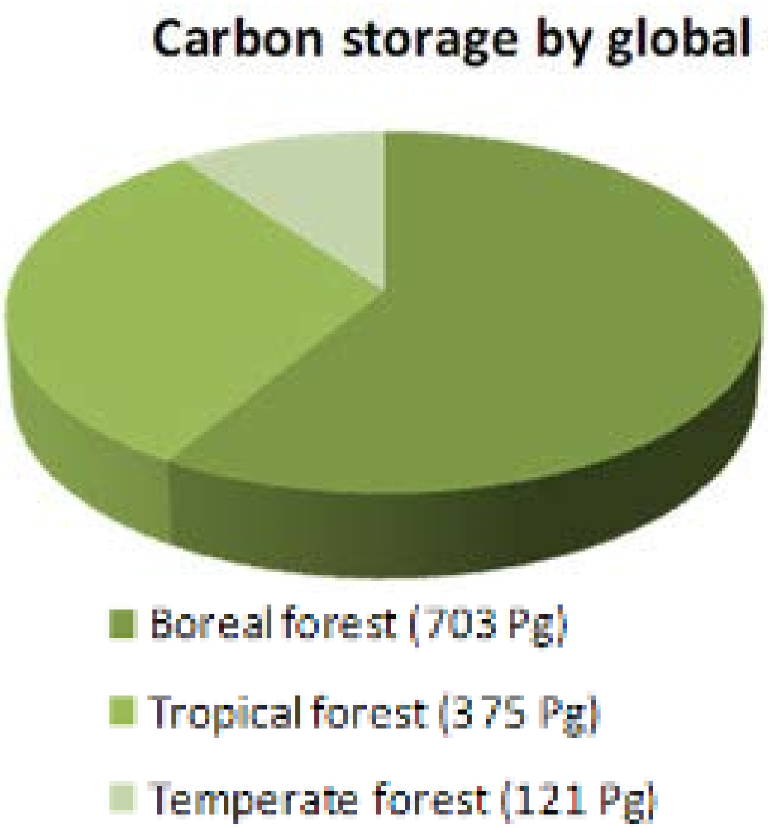
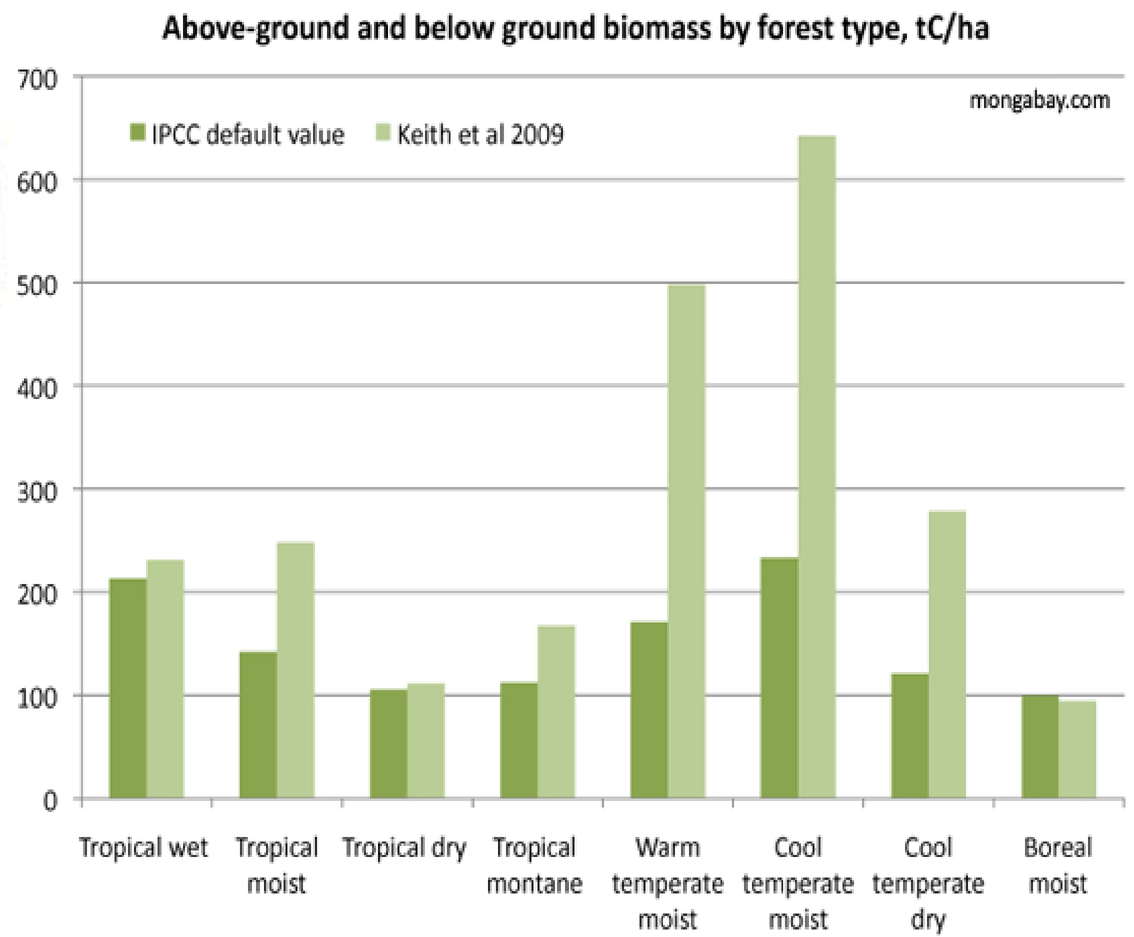
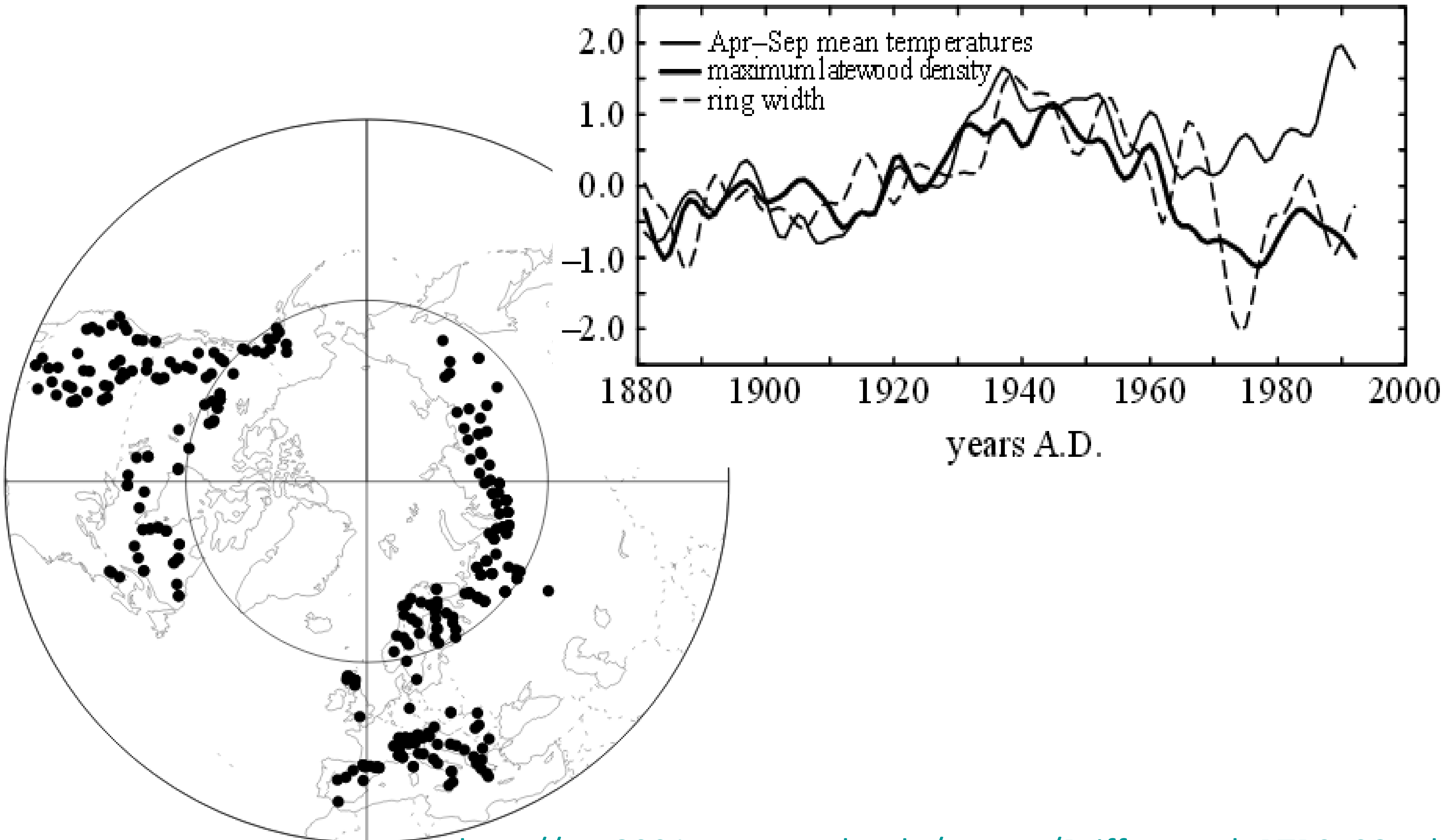
Wälder als Kohlenstoffspeicher





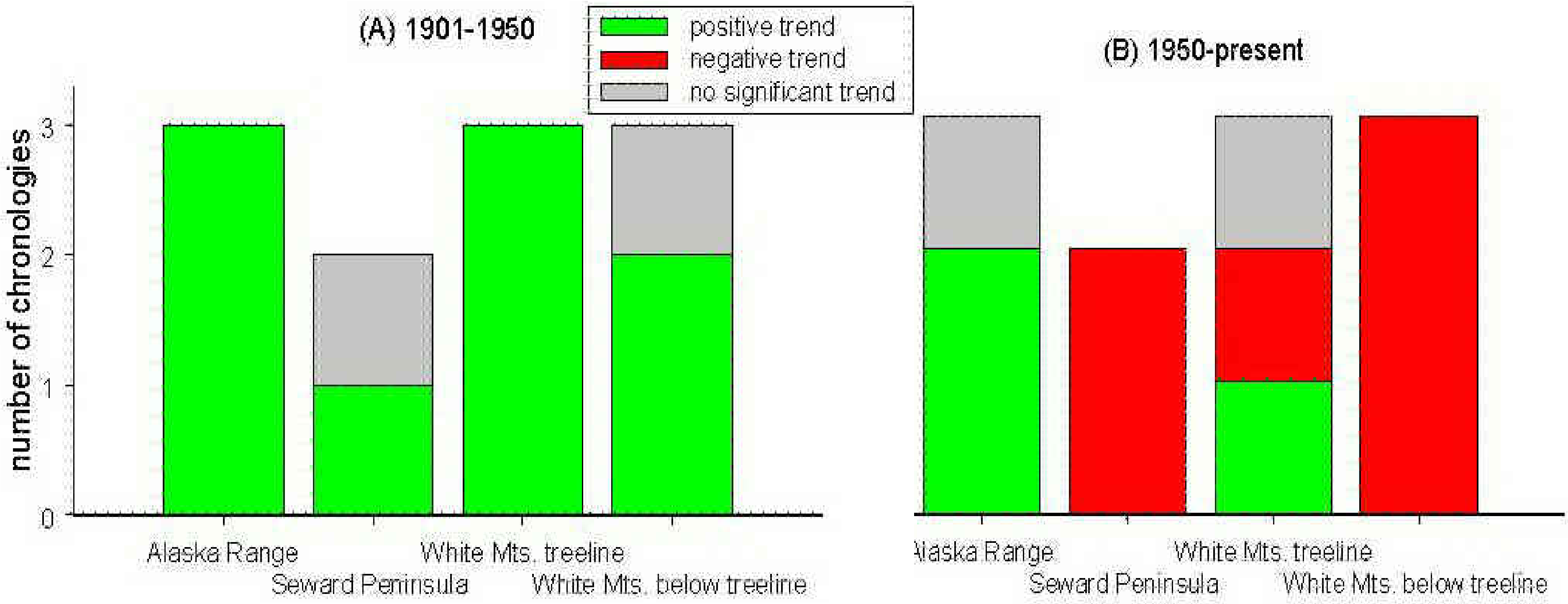
http://forestindustries.eu/content/temperate-and-boreal-forests-still-considerable-carbon-sink

Holzwachstum und Apr.-Sept.-Temperatur



http://eas8001.eas.gatech.edu/papers/Briffa_et_al_PTRS_98.pdf

Growth trends of trees in three regions of Alaska



The results suggest that inverse responses to temperature are widespread, affecting even the coldest parts of the boreal forest. Growth declines were most common in the warmer and drier sites, and thus support the hypothesis that
drought-stress may accompany increased warming in the boreal forest.

https://www.ncdc.noaa.gov/paleo/pubs/lloyd2002/lloyd2002.html

PIK

Tree ring-width series

Lloyd et al., 2011, SibirianTaiga

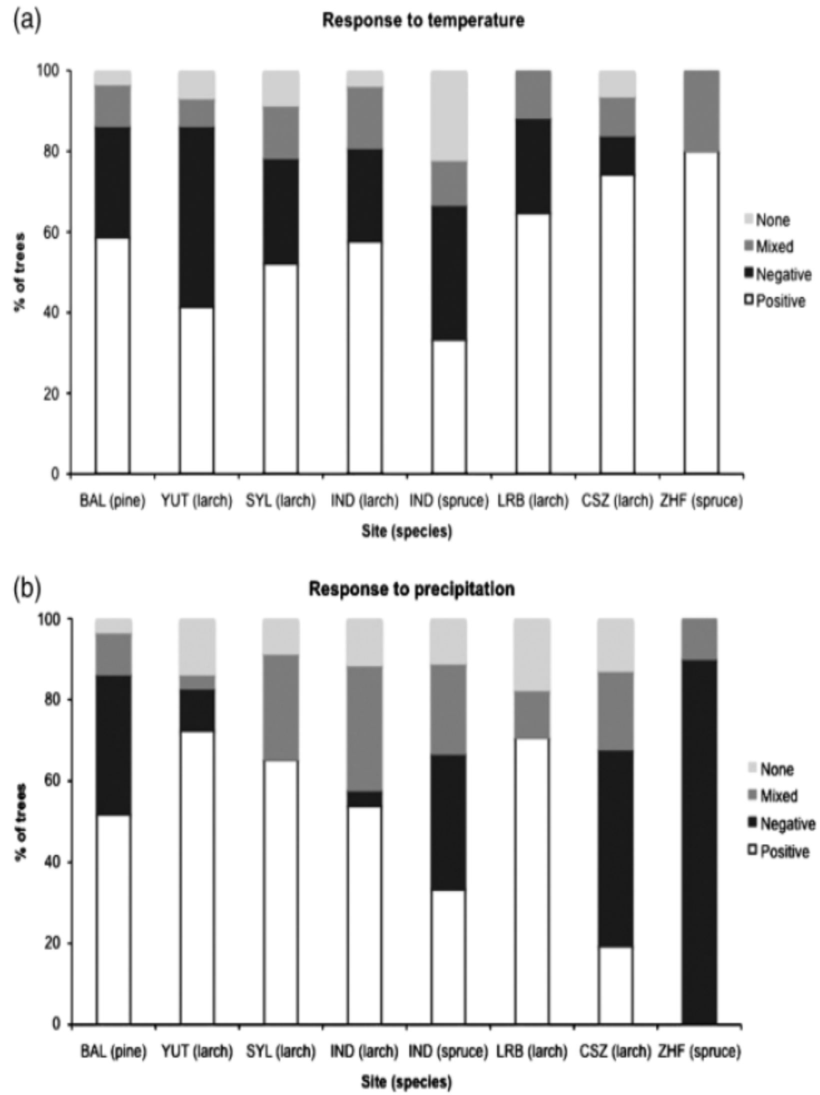
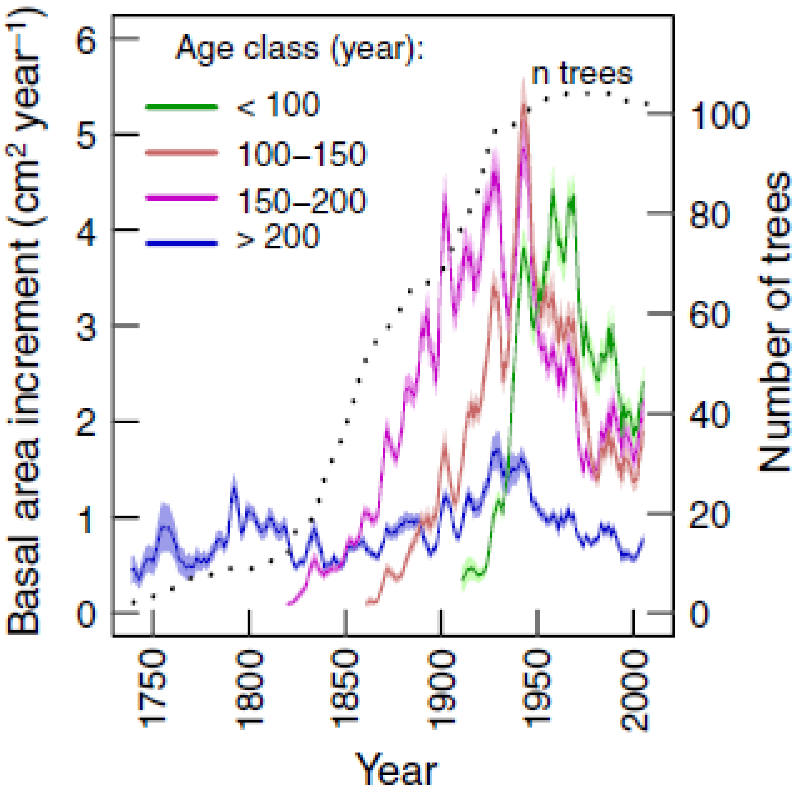
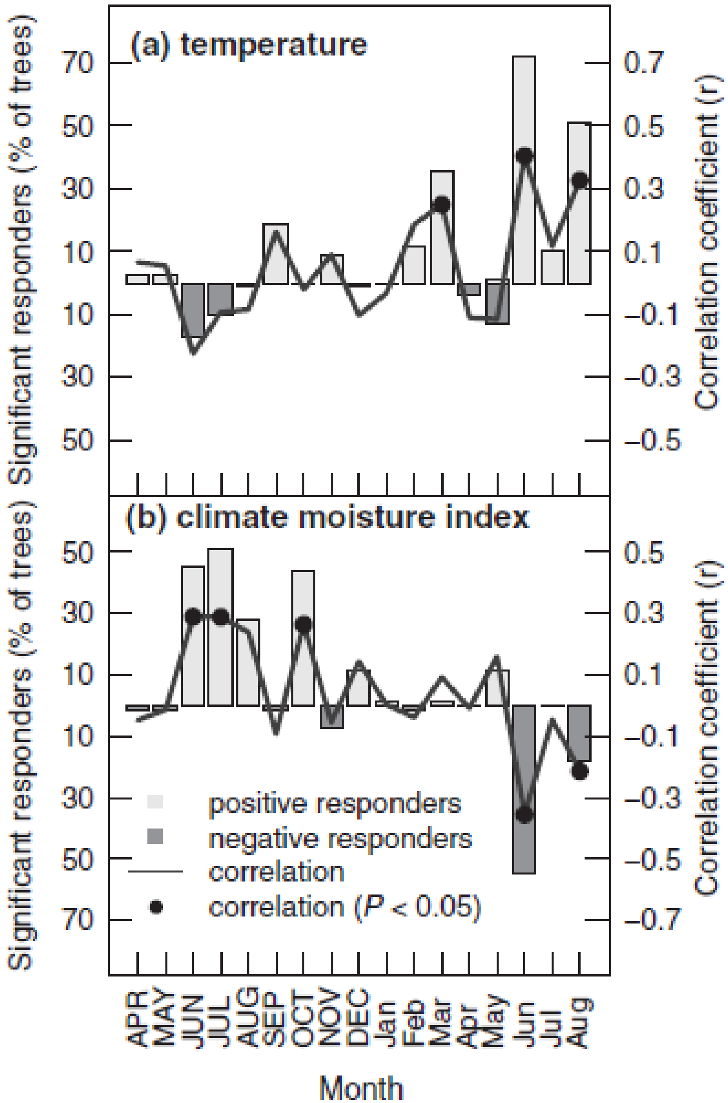


Fig. 3 Patterns of response to (a) temperature and (b) precipitation. Response categories are defined in the Materials and methods. Bars indicate the percent of trees at each site in each response category. Sites are arranged from southernmost (BAL) to northernmost (ZHF). Total number of trees varied among sites: $n_{BAL} = 29$, $n_{YUT} = 29$, $n_{SYL} = 23$, $n_{IND} = 26$ larch and nine spruce, $n_{LRB} = 17$, $n_{CSZ} = 31$, $n_{ZHF} = 10$.

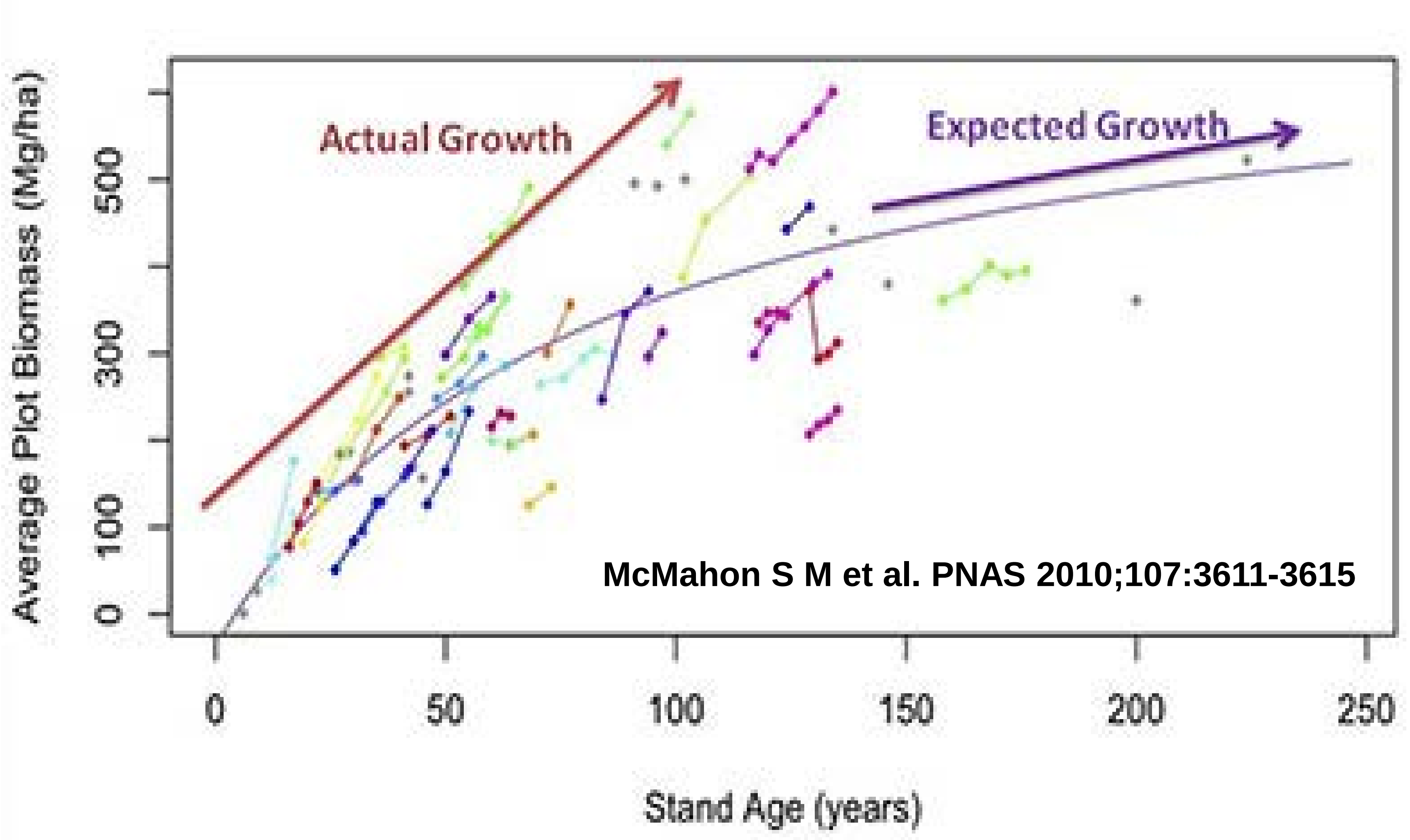
Tree ring-width series





Berner et al., 2013, forest-tundra ecotone in northeastern Siberia

Evidence for a recent increase in forest growth



http://ecosystems.serc.si.edu/forests-and-climate-change/

Die globale Bedeutung borealer Wälder als Kohlenstoffsenke und Kohlenstoffspeicher

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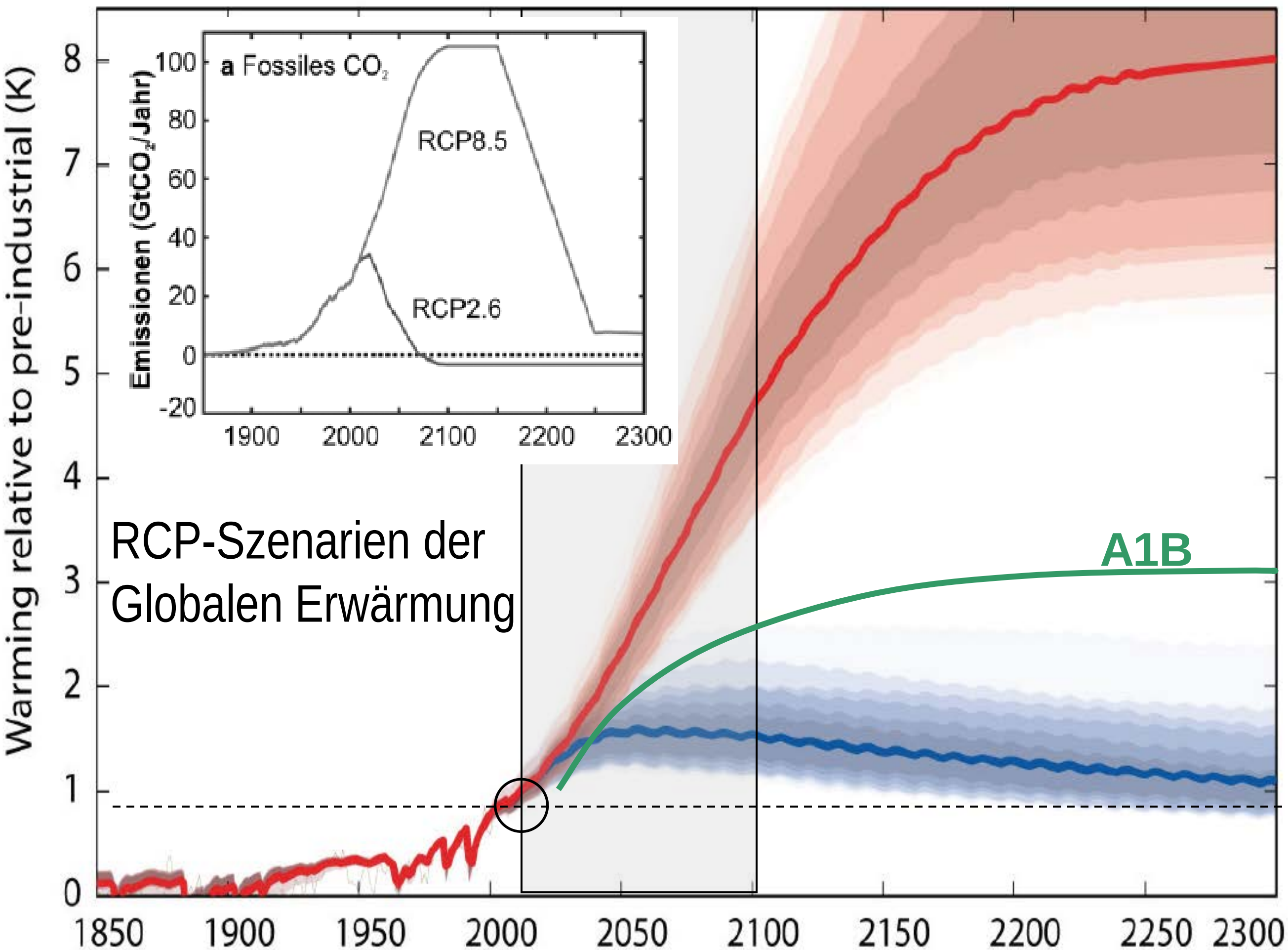
Die neuen Ergebnisse des Weltklimarats (IPCC) 2013/2014

I. Der fünfte Sachstandsbericht (AR5) hat die bestehenden Erkenntnisse zum derzeitigen Klimawandel und dem Einfluss der anthropogenen Treibhausgasemissionen bestätigt und weiter konkretisiert.

II. Verstärkt sich der Klimawandel in den kommenden Jahrzehnten weiter, nimmt Hitzestress zu, Extremereignisse werden voraussichtlich häufiger und führen zu stärkeren negativen Folgen: Risiken bestehen z.B. durch Extremtemperaturen, Dürreperioden, Stürme und Überflutungen.

III. Aber: Das Zwei-Grad-Ziel ist machbar – mit technologischem und institutionellem Wandel!

Szenarien globaler Erwärmung im Klimawandel

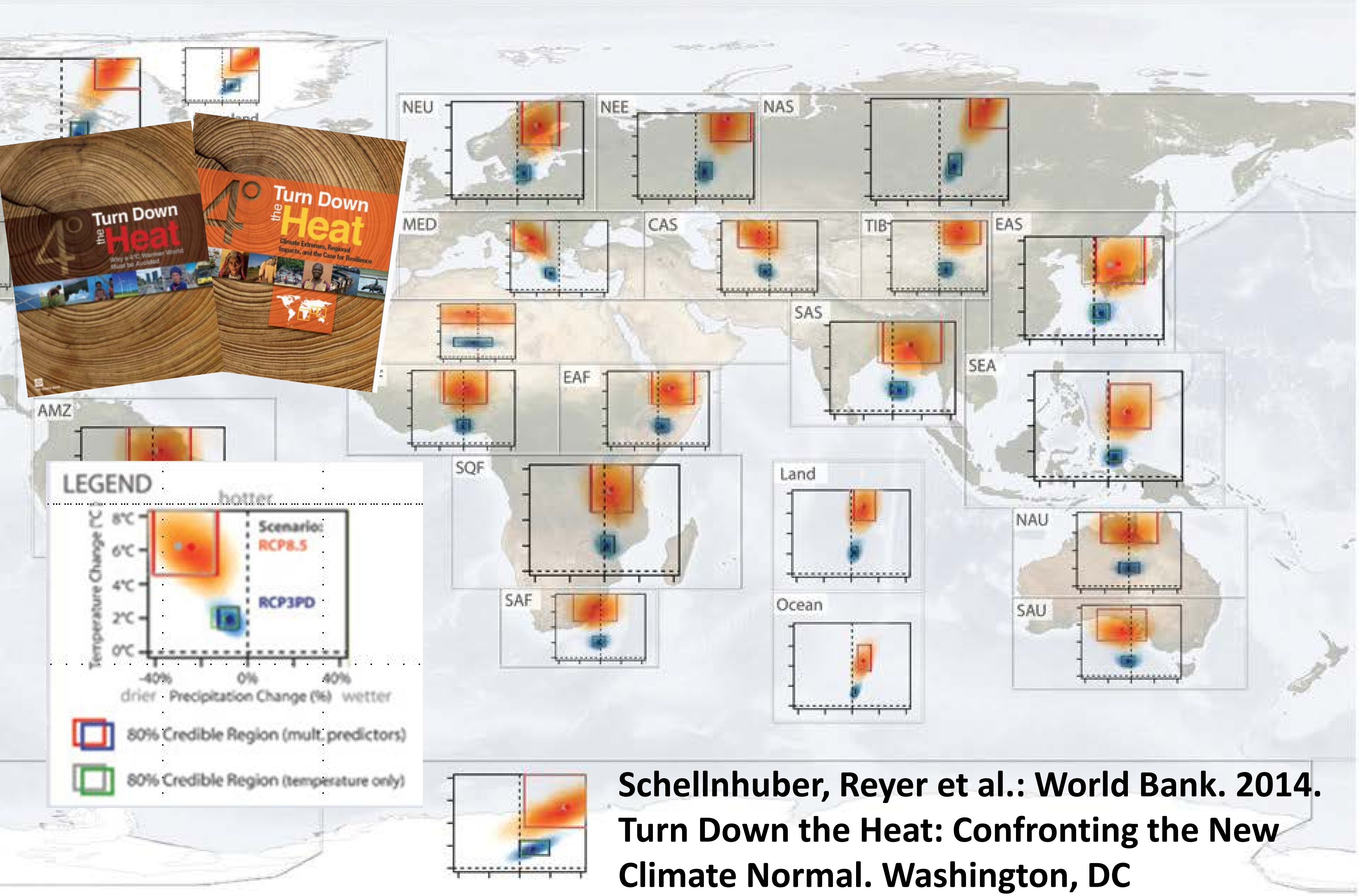


RCP 8.5
ohne Klimaschutz
→ ungebremste globale Erwärmung mit hohem Risiko und hohen Schadenskosten

A1B: bisher übliches Szenarium für mögliche Auswirkungen des Klimawandels bei 3-4° C

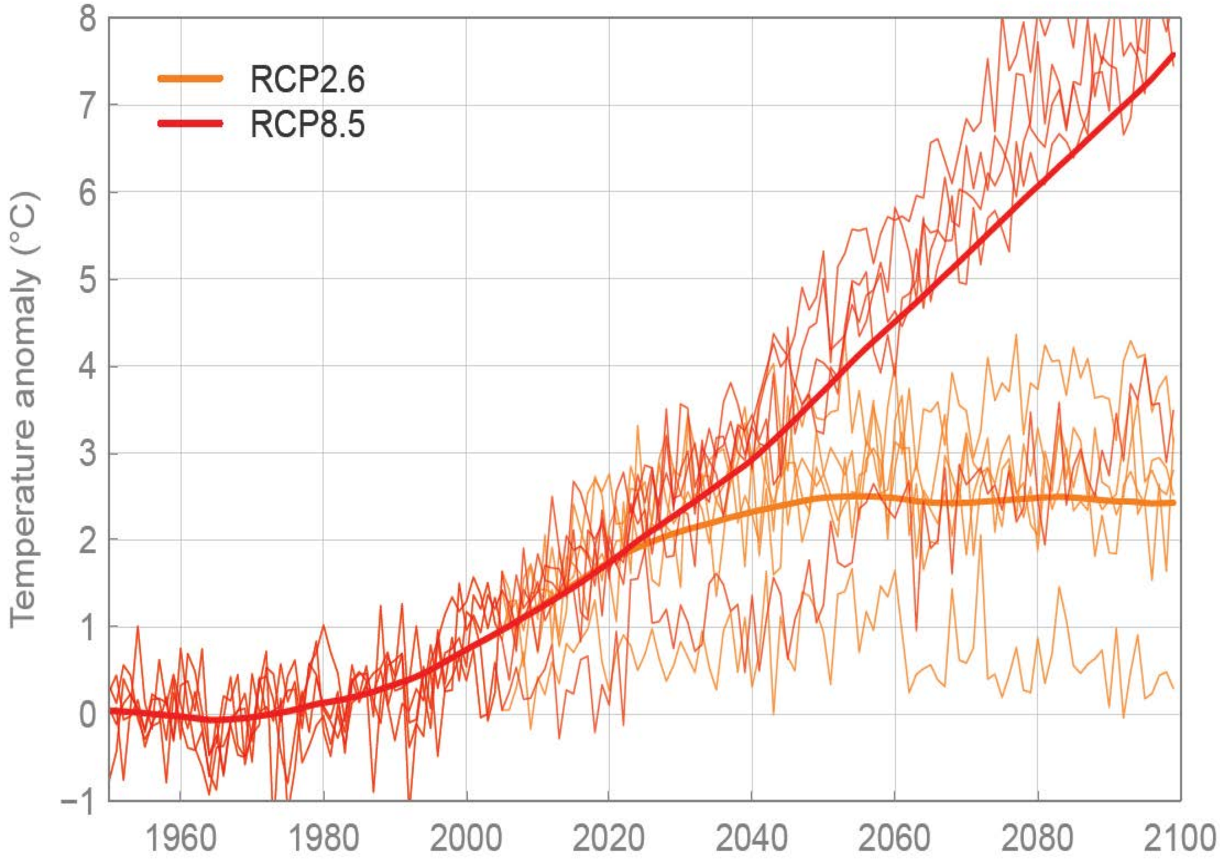
RCP 2.6
Investitionen in den Klimaschutz global und regional kann die globale Erwärmung auf 2° begrenzen

Meinshausen et al. 2011



Schellnhuber, Reyer et al.: World Bank. 2014. Turn Down the Heat: Confronting the New Climate Normal. Washington, DC

Projektionen der regionalen Temperaturänderung in Europa und Zentralasien für Juni-August



~4° C World

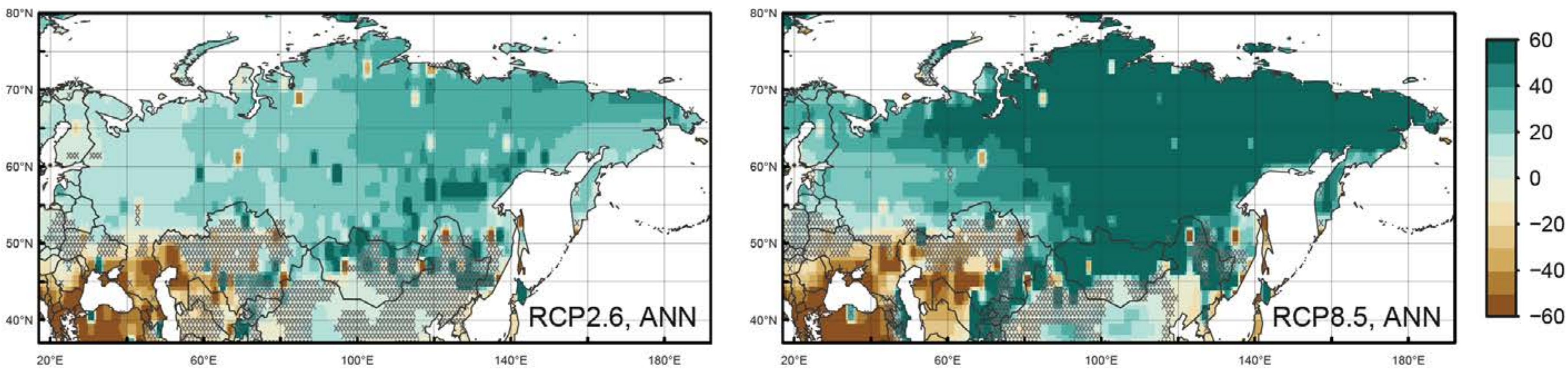
~2° C World

- Die Erwärmung ist wahrscheinlich höher als im globalen Mittel

Climate Change Projections

- Warming is likely to be more than global average
- Increase in precipitation more pronounced over winter than summer

~2° C World ~4° C World



Multi-model mean of the percentage change in the aridity index AI
for RCP2.6 (left) and RCP8.5 (right)
for the European and Central Asian region by 2071-2099 relative to 1951-1980.

Forest Productivity

Productivity decline	Productivity increase
• late summer browning → decrease in productivity (Beck et al., 2011; Berner et al., 2013; Bunn & Goetz, 2006). • within interior boreal forests → warming-induced drought stress (Barber et al., 2000; Dulamsuren et al., 2013; McDowell, 2011). • increasing number of sites → negative reaction to warmer temperatures (Lloyd & Bunn, (2007).	• greening trends in transition to Tundra and wetlands during summer (Beck & Goetz, 2012; Bunn & Goetz, 2006) • past decade (2000-2009) → warming increased NPP north of 47.5° , despite concurrent drying but with high heterogeneity over Siberia (Zhao & Running, 2010) • longer growing season related to changes in NPP (Piao et al. 2008)

Projections Timber Harvest

- Gap & economic model
- Synthetic climate scenarios
- 2° C = increase; 4° C = decrease
- 2° C = decrease; 4° C = increase (but species shift)

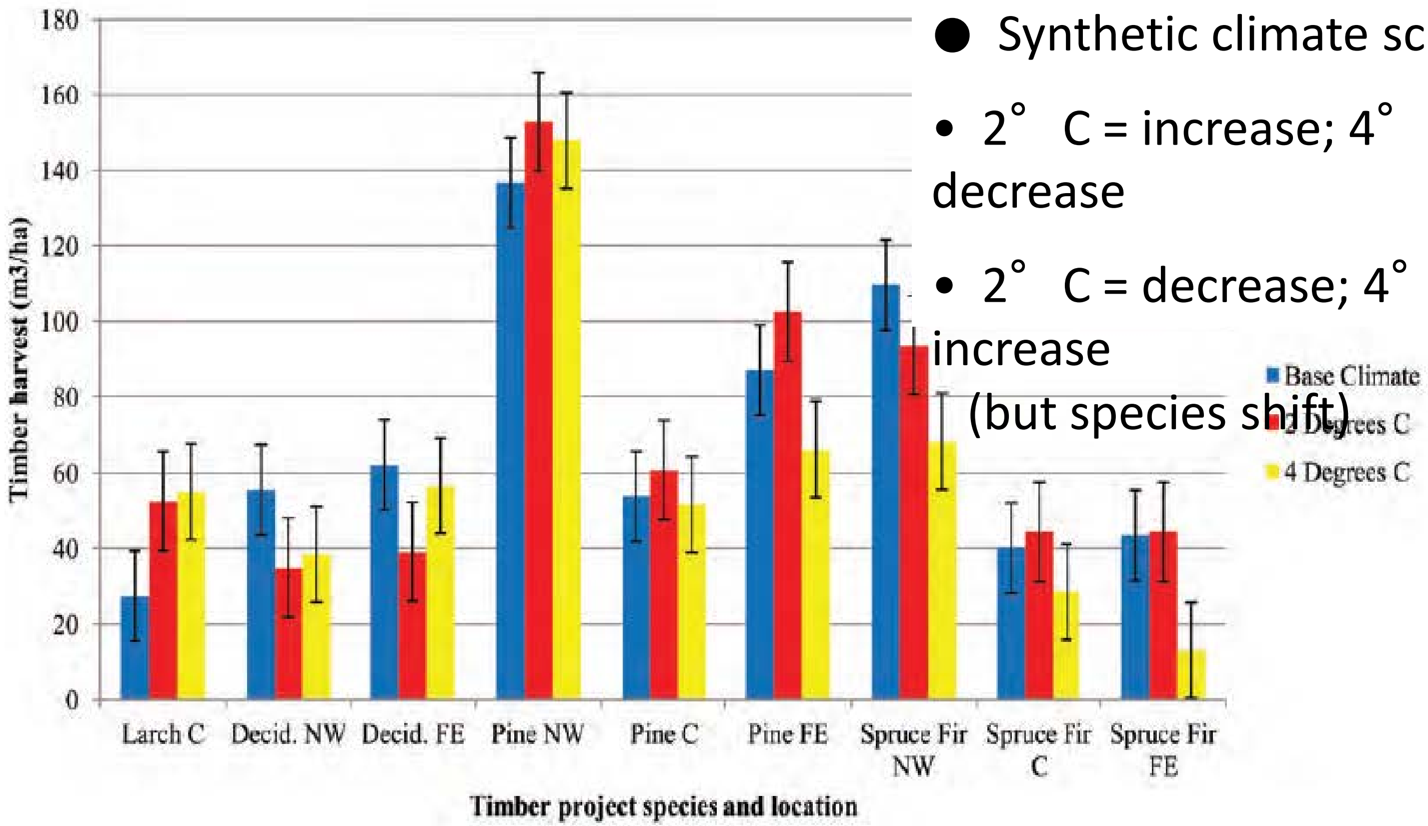
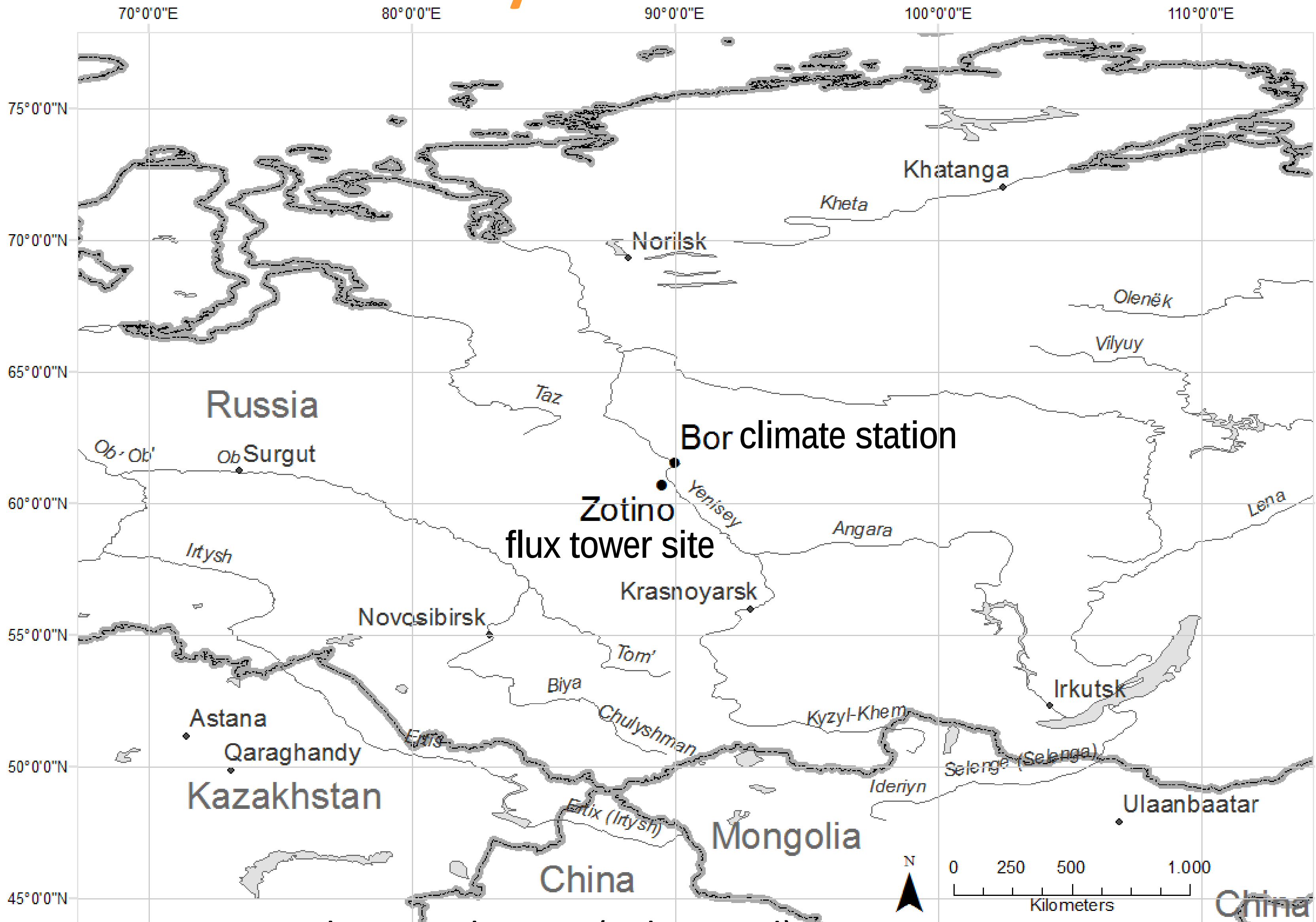


Figure 2 Timber harvest at financially optimal rotation periods for nine timber projects within Russia at varying magnitudes of climate change. Blue bars represent harvest returns under current climate conditions; yellow indicates harvest given an expected increase of 2°C by 2100 and red bars indicate harvest given a linear 4°C increase. A colour version of this figure is available on the *Forestry* website.

➔But no disturbances included…

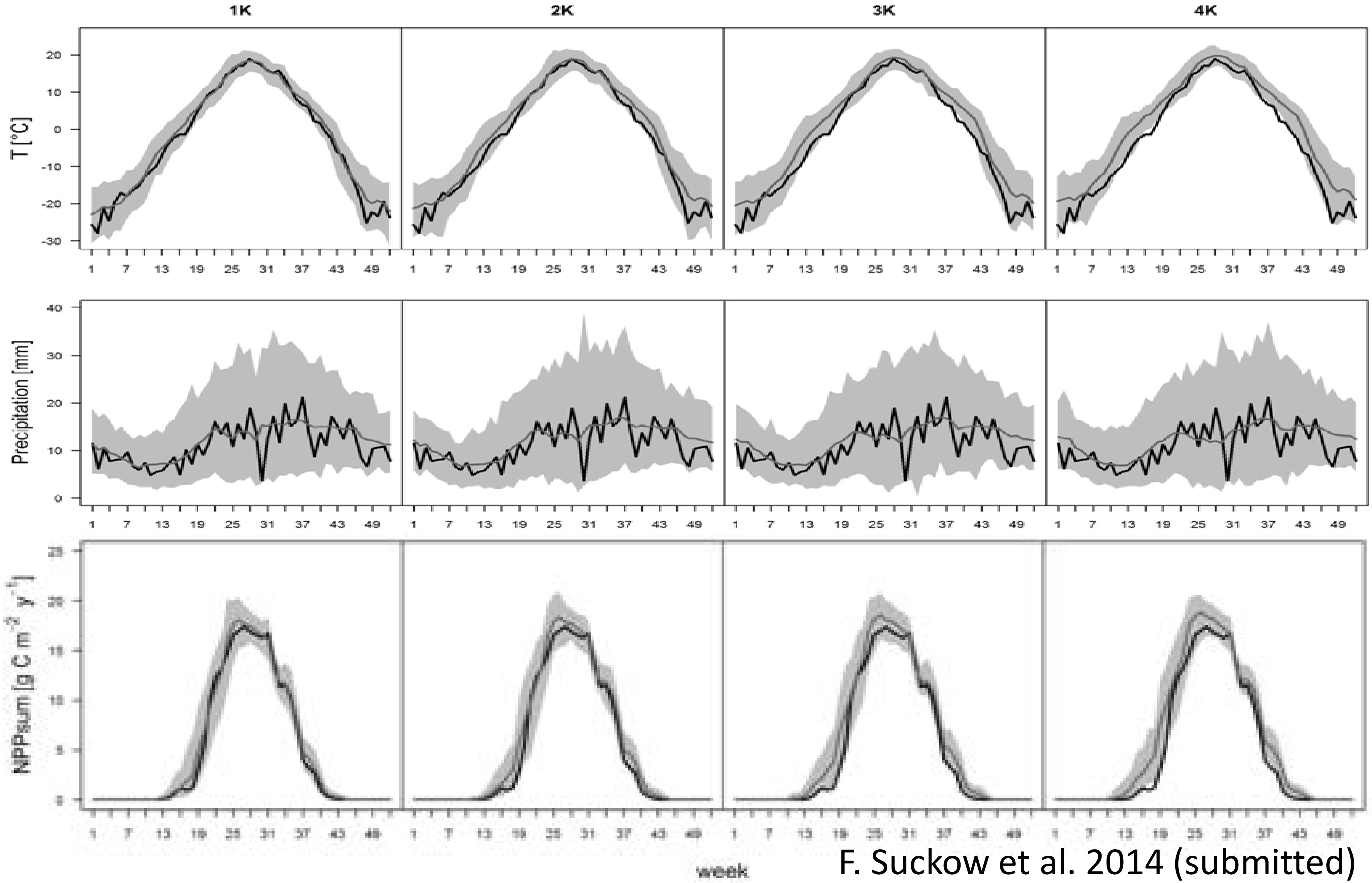
Lutz et al. 2013, Shanin et al. 2011

Zotino Study Site in Central Siberia



F. Suckow et al. 2014 (submitted)

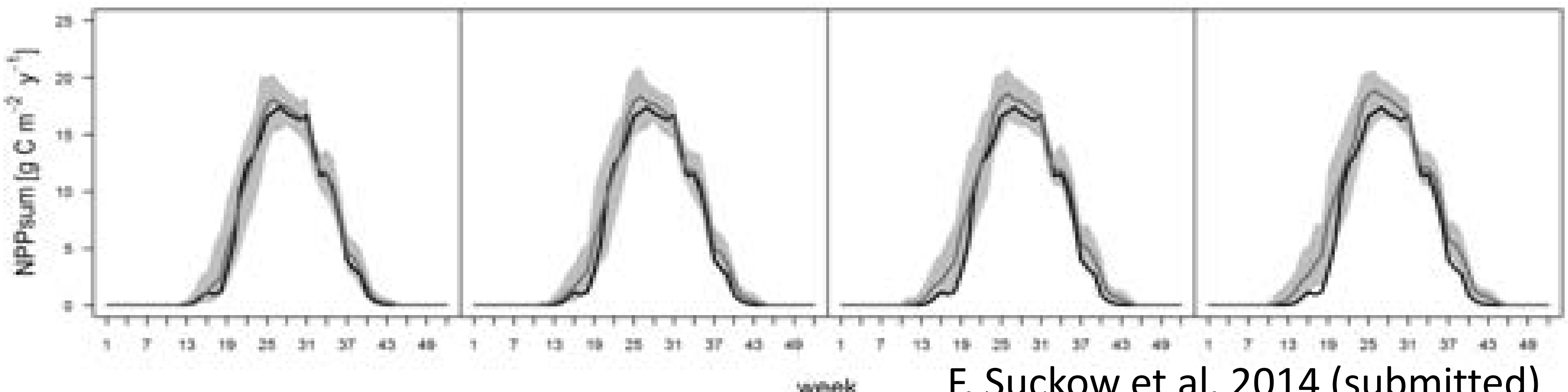
Zotino Study Results (1995-2004 vs 1000 x 2050)



F. Suckow et al. 2014 (submitted)

Zotino Study Results (1995-2004 vs 1000 x 2050)

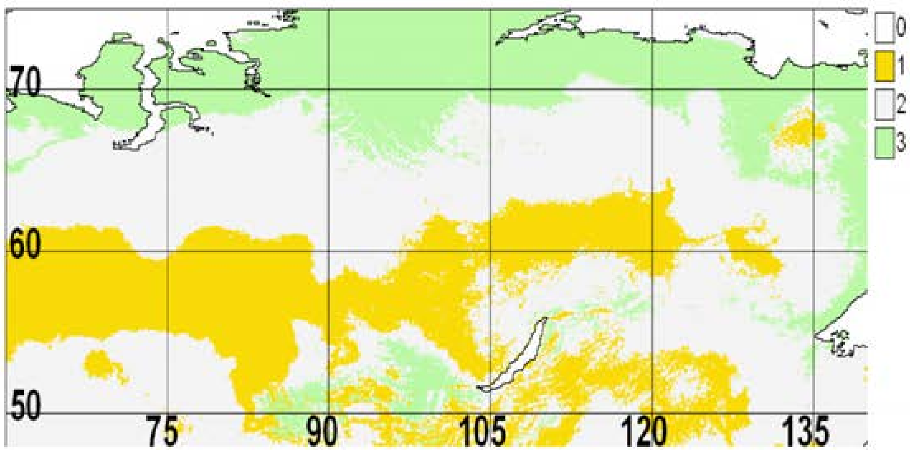
The regional statistical climate model STARS were used to develop a set of climate change scenarios assuming a temperature increase by 2050 of 1K, 2K, 3K and 4K. The process-based forest growth model 4C is applied to a 200 year old pine forest to analyse impacts on carbon and water balance as well as the risk of fire and insect outbreak under these climate change scenarios. The climate scenarios indicate precipitation increases mainly during winter and decreases during summer with increasing temperature trend. These changes lead to increasing productivity of the forest stand due to longer vegetation period and higher temperature. At the same time, the risk of fire indicated by the Nesterov-Index as well as the risk of occurrence of insect outbreak indicated by a nun moth risk index clearly increases.



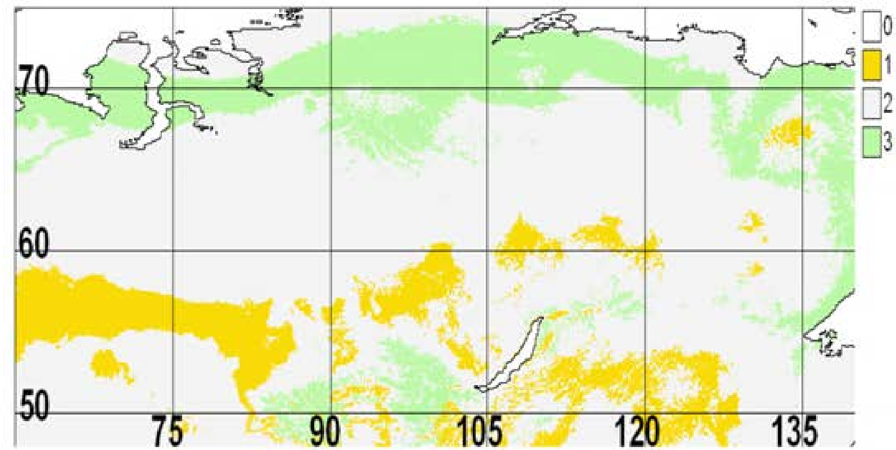
F. Suckow et al. 2014 (submitted)

Projected Vegetation Distribution

~4° C World



~2° C World



Vegetation distribution in Siberia in 2080

- Forest to steppe change (1—yellow)
- Tundra to forest change (3—green)
- ‘no change’ in major vegetation classes (2—light gray)

Tchebakova et al. (2009)

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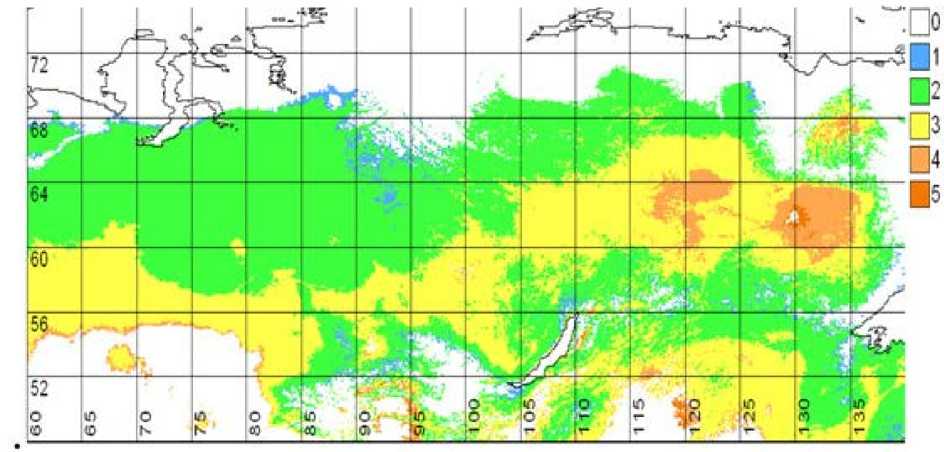
Projections of Fire Risk

Current Climate

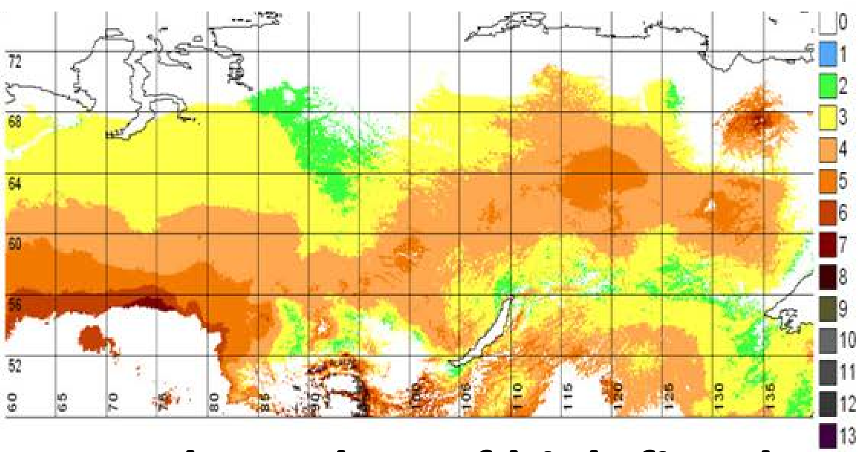


area of maximum fire risk doubles (Malevsky-Malevich 2008)

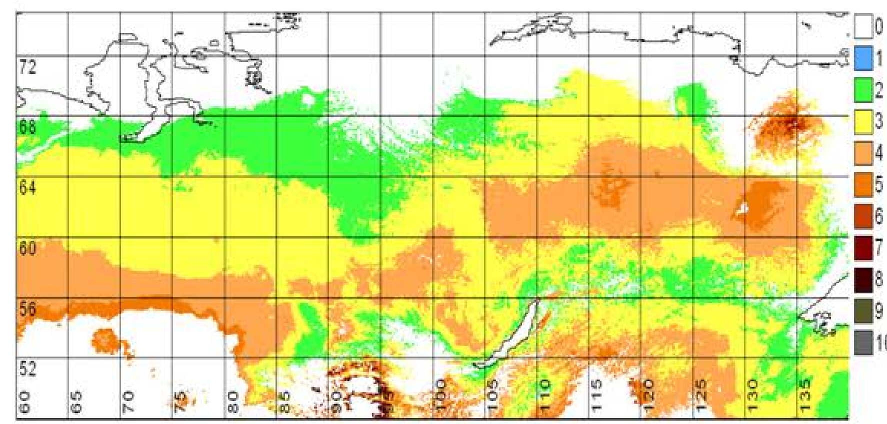
earlier start of fire season (Stocks et al. 1998)

decreasing risk if precipitation increases & moderate warming (Mokhov et al. 2006)

~4° C World



~2° C World



annual number of high fire danger days

Tchebakova et al. 2009

Disturbances: Fire

- **despite large variability, area affected by fire seems to increase** **(Zamolodchikov et al. 2013, Shvidenko & Schepaschenko 2013a).**
- **climate change & socio-economic changes (reduced fire-fighting funds) ➔ increase fire intensity & area burned in Tuva region (Ivanova et al. 2010)**
- **2010 fires ➔ unusual meteorological conditions but also poor forest governance & management ➔ increasing area of abandoned farmlands ➔ declining numbers of forest managers, forest fire fighters & less efficient forest protection systems (Isaev & Korovin 2014)**

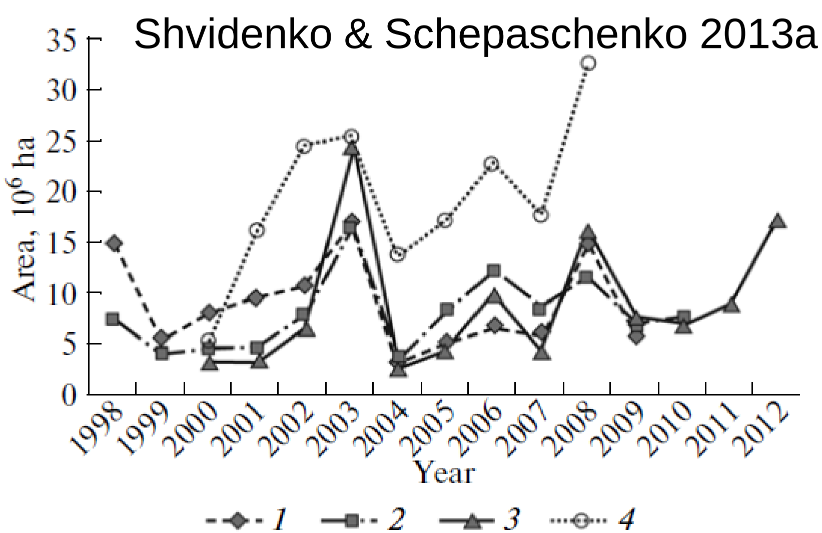


Fig. 1. Dynamics of total area of wildfires according to different sources: (1) GFDE3 (44), (2) Refined data provided by the Institute of Forest, Russian Academy of Sciences (1), (3) Space Research Institute, Russian Academy of Sciences (average value of (2, 8), (4) (4).

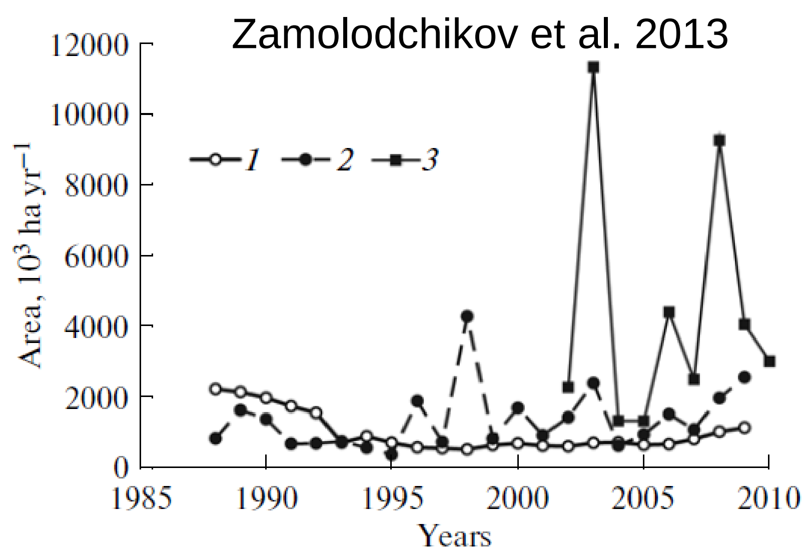


Fig. 1. Dynamics of key damages in forests of the Russian Federation: (1) area of total clear-cuts, (2) area of forest fires according the forestry statistics, (3) area of forest fires according to the ISDM.

Disturbances

Pests & insects	Fire
•13*10^6 ha & 2 billion m³ growing stock killed by insects in East Sibiria (Shvidenko et al. 2013b)	•forest carbon burnt in 1998-2010: 92±18 TgC yr-1 (Shvidenko & Schepaschenko 2013a)
•*one outbreak* touched 10 million ha of usually unaffected larch forest (Shvidenko et al. 2013b)	•area burnt in 1998-2010: 8.2-9.2*10^6 ha yr-1 and for 2000-2010 8.5*10^6 ha yr-1 (Shvidenko & Schepaschenko 2013a)
•area increasing from 2.73*10^6 ha during 1973-1987 to 5.48*10^6 ha for 1998-2010 (Shvidenko et al., 2013b)	•area burnt in 1990s is 29% greater than in 1980s & 19% higher than reported for a 47-yr mean (Soja et al. 2007).
•more studies on fires than on pests ➔ although climate change leads to northwards shifts, longer summer season & increasing thermal budget for growth & reproduction of insects (Bale et al., 2002).	•increase of fire severity during 1998-2006 (Soja et al. 2007).
	•post fire die-back is uncertain & may amount to 90-100 TgC yr-1 (Shvidenko & Schepaschenko 2013a)
	•higher share of crown & underground fires (Shvidenko & Schepaschenko 2013)

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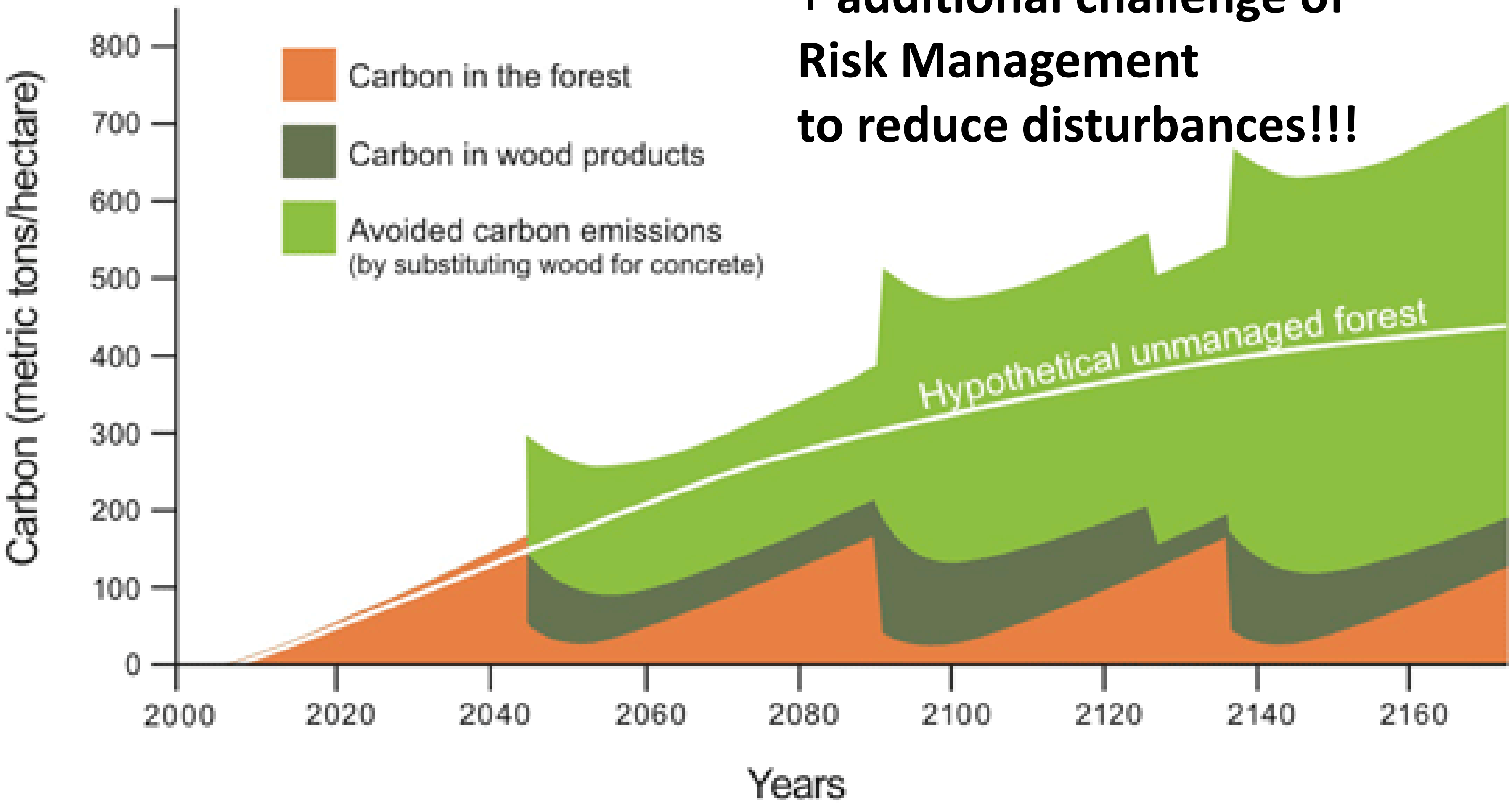
Die borealen Wälder Russlands haben eine große Bedeutung als Kohlenstoffspeicher im Klimawandel

- Prinzipiell steigt die Produktivität borealer Wälder für alle Szenarien globaler Erwärmung bis 4 Grad
- Die Produktivität sinkt aber durch Störungen, wie
  1. Trockenstress
  2. Waldbrände
  3. Stürme
  4. Nutzungsfehler
  5. Schädlinge und Krankheiten
- Die Risiken durch Störungen steigen mit der Temperatur
- dadurch wächst die Gefahr, dass die Wälder Russlands von einer Senke zur Quelle von Kohlenstoff werden!
- Der Klimawandel erfordert die Begrenzung der Risiken durch klimabedingte Störungen durch gutes adaptives Forstmanagement
- Forschungsbedarf: modellbasierte Risikoabschätzungen für viele verschiedene lokale Standorte mit unterschiedlichen Bedingungen

Atmospheric Decarbonisation by Climate Change Adapted Forest Management

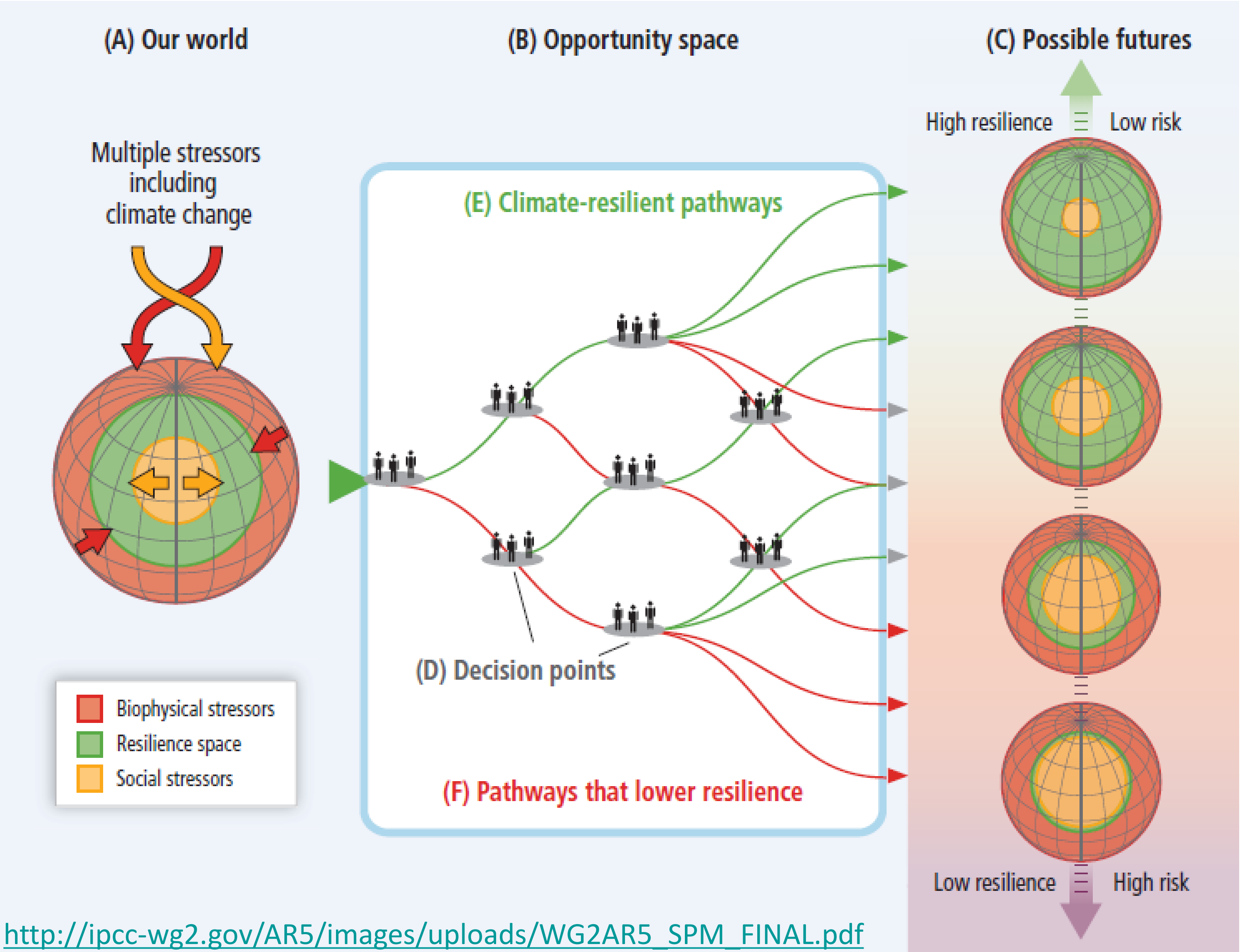
+ additional challenge of Risk Management to reduce disturbances!!!



http://www.naturallywood.com/sustainable-forests/climate-change

Prospects for climate-resilient pathways

Fig. SPM.9



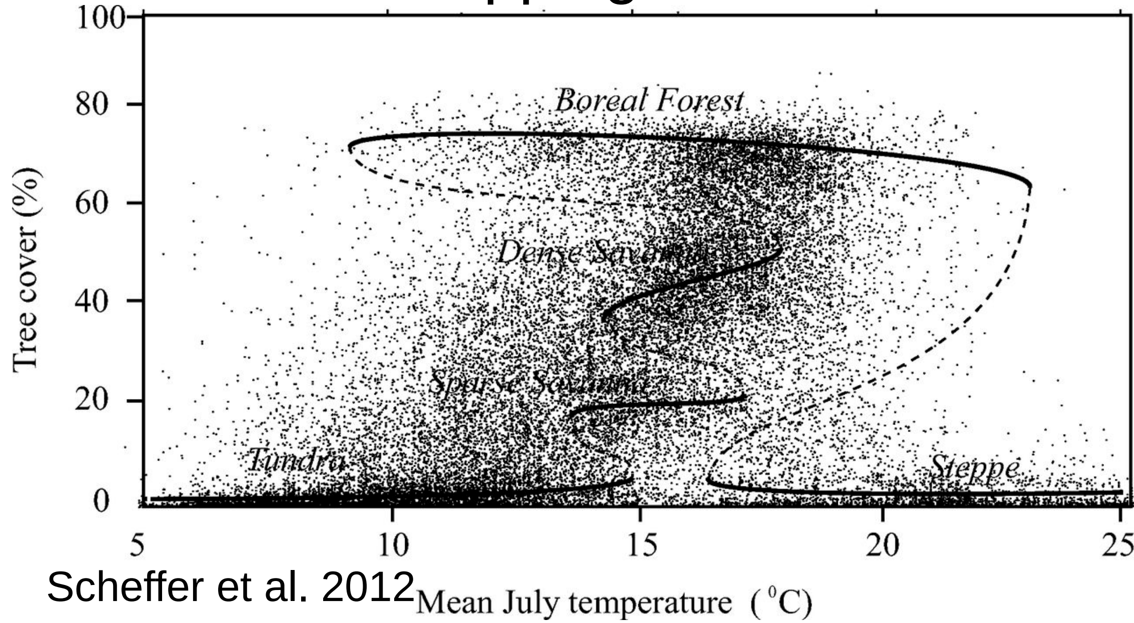
http://ipcc-wg2.gov/AR5/images/uploads/WG2AR5_SPM_FINAL.pdf

Mit Dank an meine Kollegen am PIK

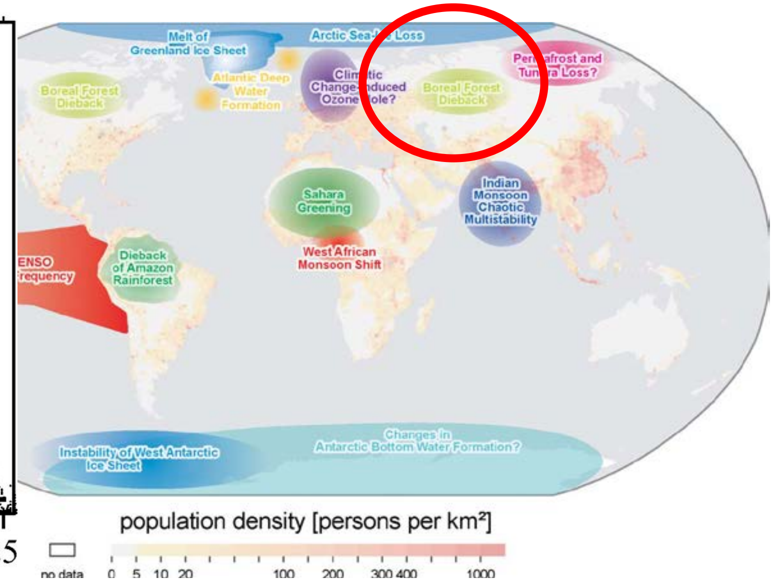
- Christopher Reyer
- Sibyll Schaphoff
- Felicitas Suckow
- Petra Lasch-Born
- Friedrich-Wilhelm Gerstengarbe
- Peter C. Werner

Life is mainly a matter of deciding what's important.

Boreal Forest Tipping Point?



Scheffer et al. 2012



Lenton et al. 2008

- „water stress, peak summer heat stress ➔ mortality, vulnerability to disease, fire & decreased reproduction rates ➔ large-scale forest dieback to open woodlands or grasslands" ➔3-5° C global warming (Lenton et al. 2008).
- possible states at the northern end & at the dry continental southern extremes are treeless tundra and respectively steppe (Scheffer et al. 2012)
- intermediate temperature range ➔ treeless states coexist with boreal forest
- tree covers of ≈10%, ≈30%, & ≈60% are rare➔ unstable states? (Scheffer et al. 2012)