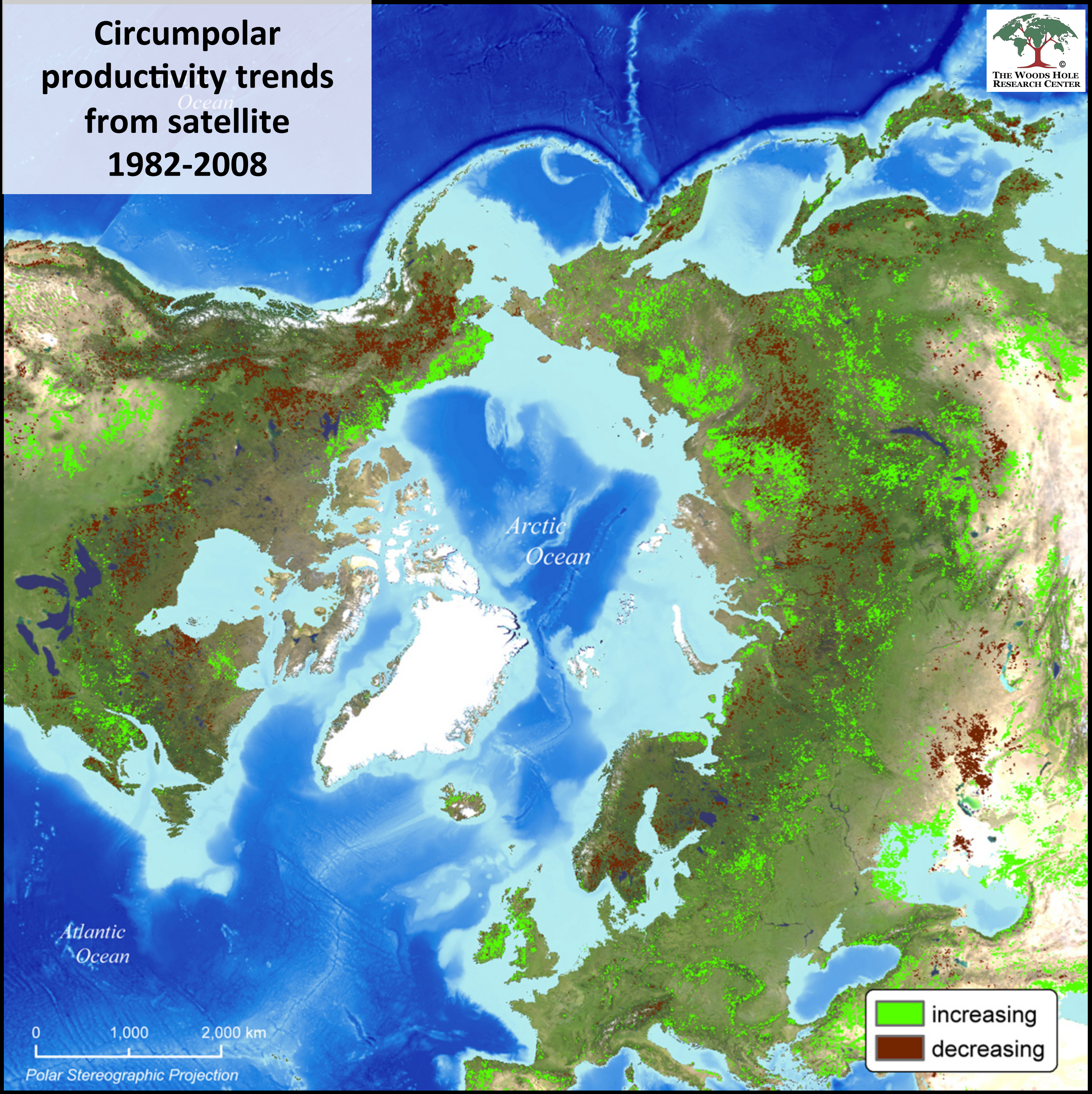
Boreal productivity trends, recovery from fire disturbance, and associated composition changes

SCOTT GOETZ
UAF / LTER WORKSHOPS FEB 2012

THE WOODS HOLE RESEARCH CENTER

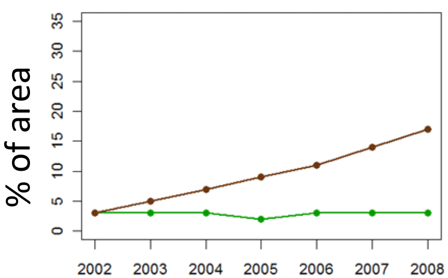
Circumpolar productivity trends from satellite 1982-2008

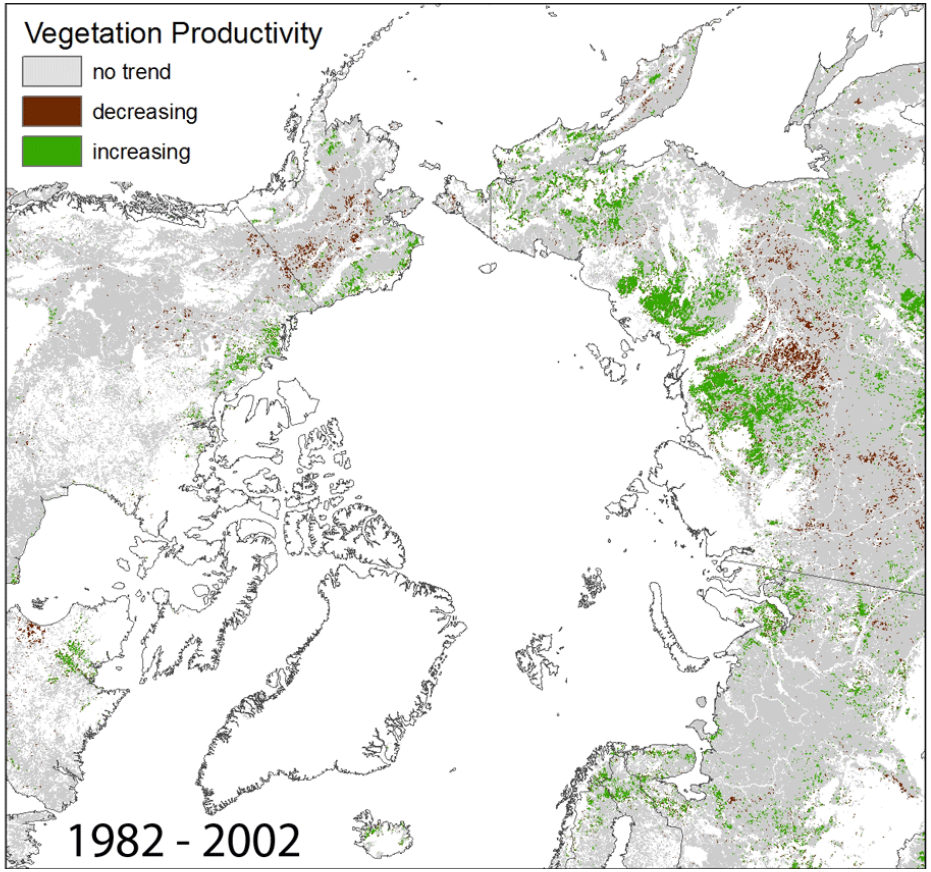


Circumpolar productivity trend time series

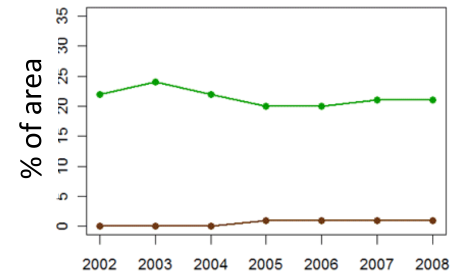
Tundra – N America

Boreal – N America

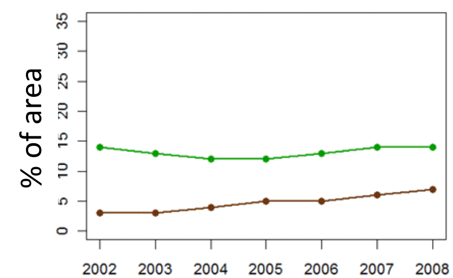




Tundra – N Eurasia



Boreal – N Eurasia



Goetz et al., PNAS 2005
Bunn & Goetz, EI 2006
Beck & Goetz, ERL 2011

Recent work confirms drought influence on boreal productivity & mortality

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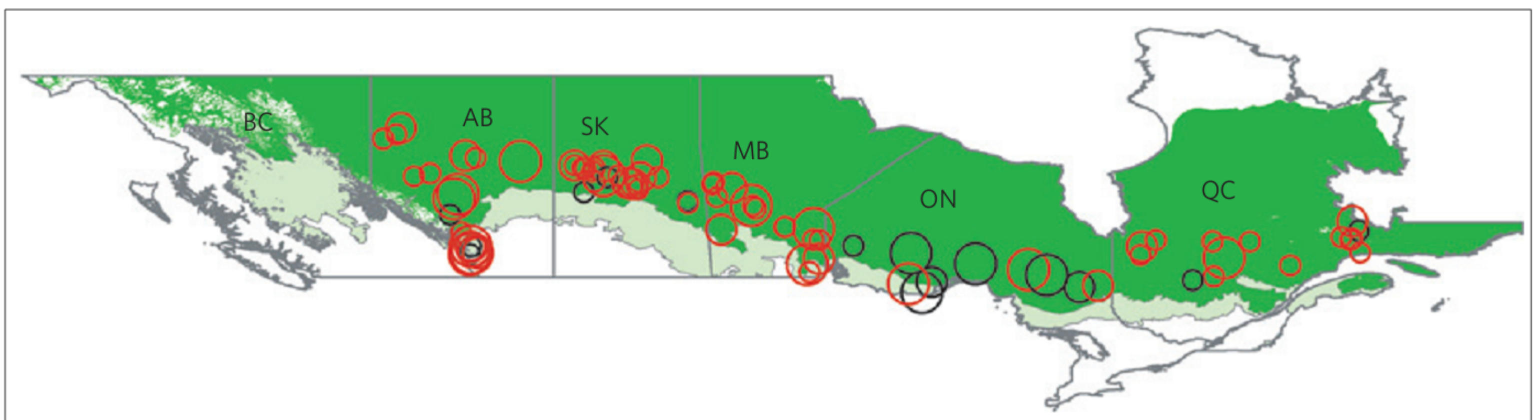
PNAS

Ma *et al.* 2012 Proceedings of the National Academy of Sciences of the United States of America

Regional drought-induced reduction in the biomass carbon sink of Canada's boreal forests

Zhihai Ma[a,1], Changhui Peng[a,b,1,2], Qiuan Zhu[b], Huai Chen[b], Guirui Yu[c], Weizhong Li[b], Xiaolu Zhou[a], Weifeng Wang[a], and Wenhua Zhang[a]

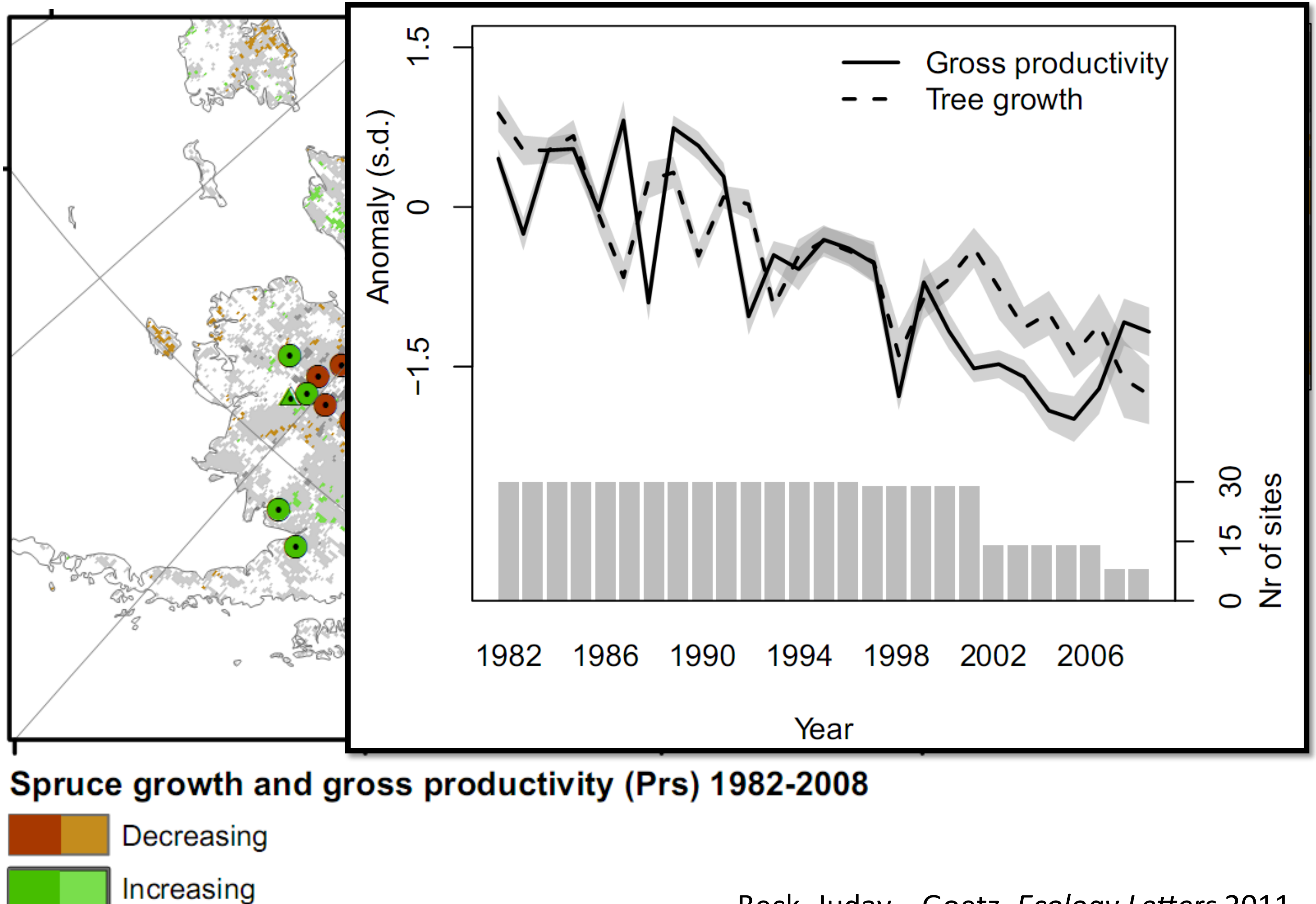
LETTERS Peng *et al.* 2011 NATURE CLIMATE CHANGE DOI: 10.1038/NCLIMATE1293



Tree mortality in the last 45 years at the southern extent of the Boreal biome.

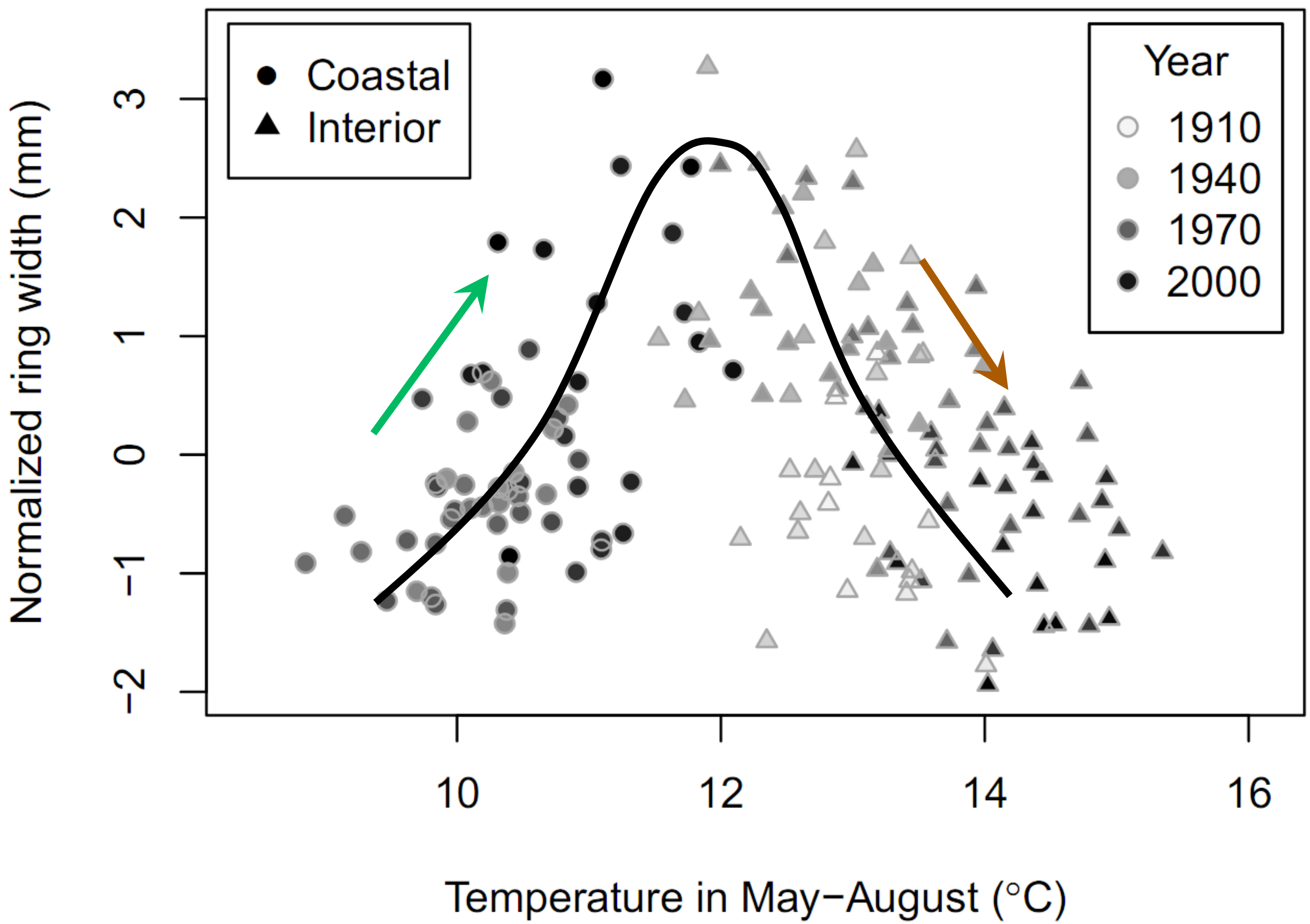
Increasing: ○ Decreasing: ○

Tree ring data support evidence for satellite observed boreal productivity

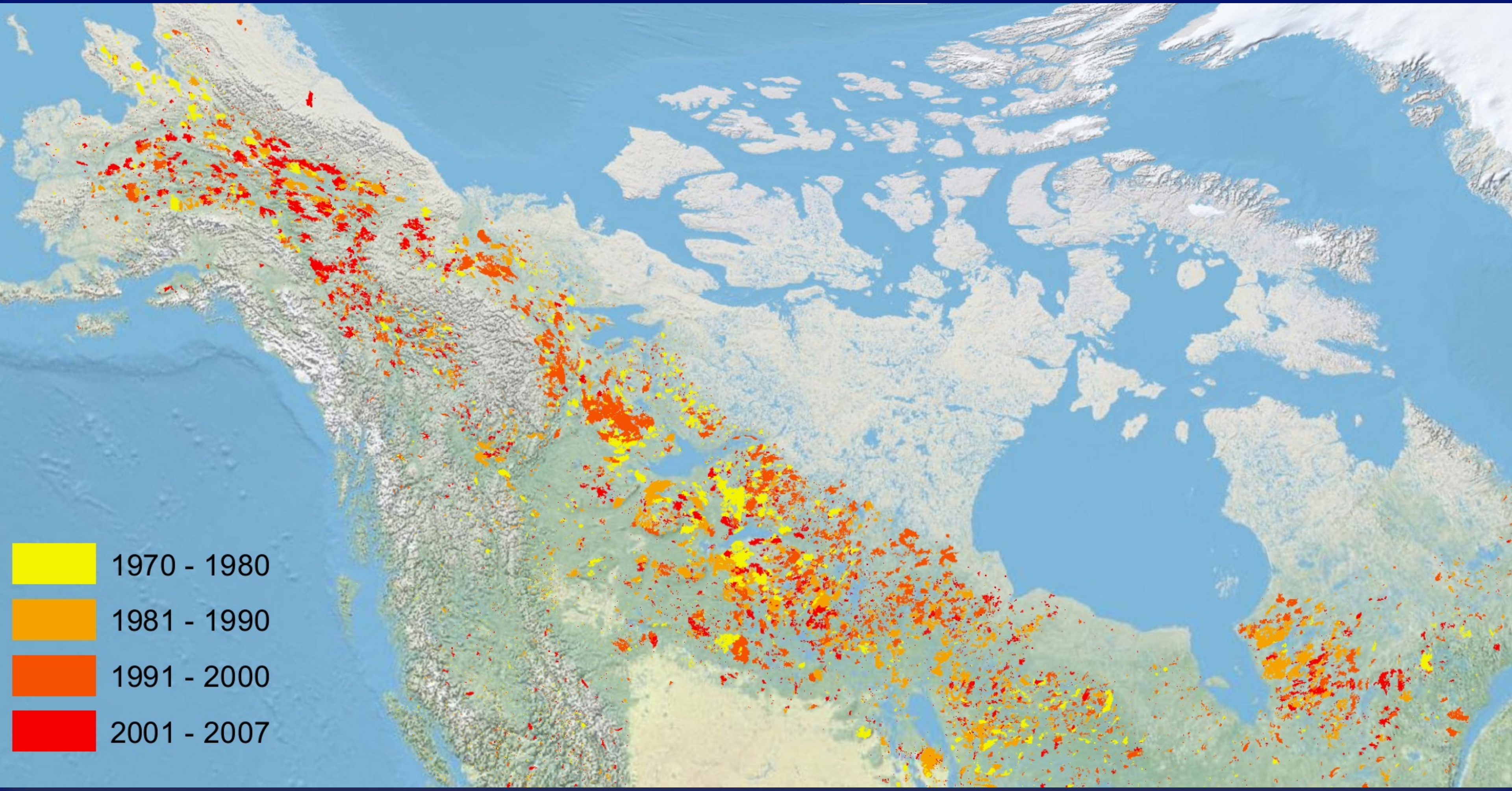


Beck, Juday… Goetz, *Ecology Letters* 2011

Tree ring observations are consistent with a "biome shift"

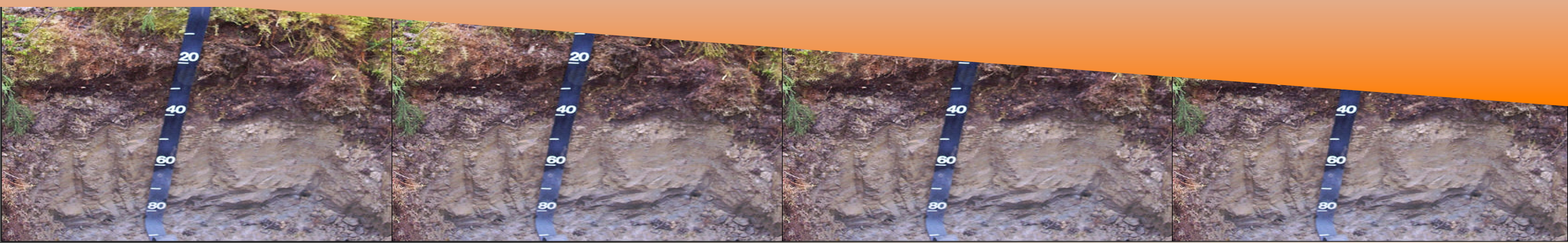


Drought also intensifies the fire regime – will fire disturbance accelerate a biome shift?



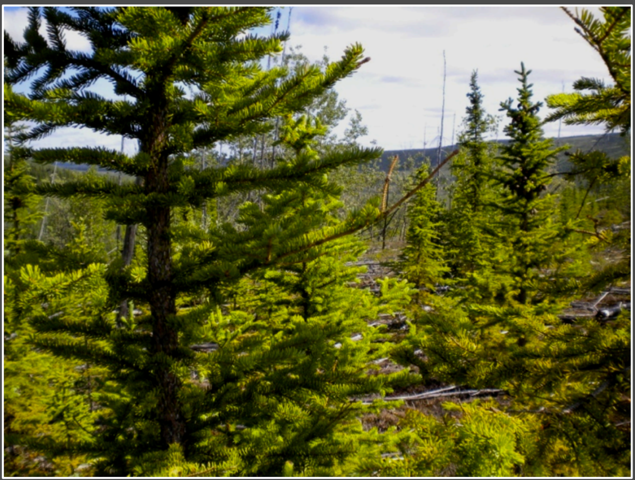
Boreal fire is common, widespread and increasingly intense (greater burn severity)

Kasischke & Turetsky 2006 GRL



burn severity →

← **post-fire organic layer depth**



OL = 10 cm

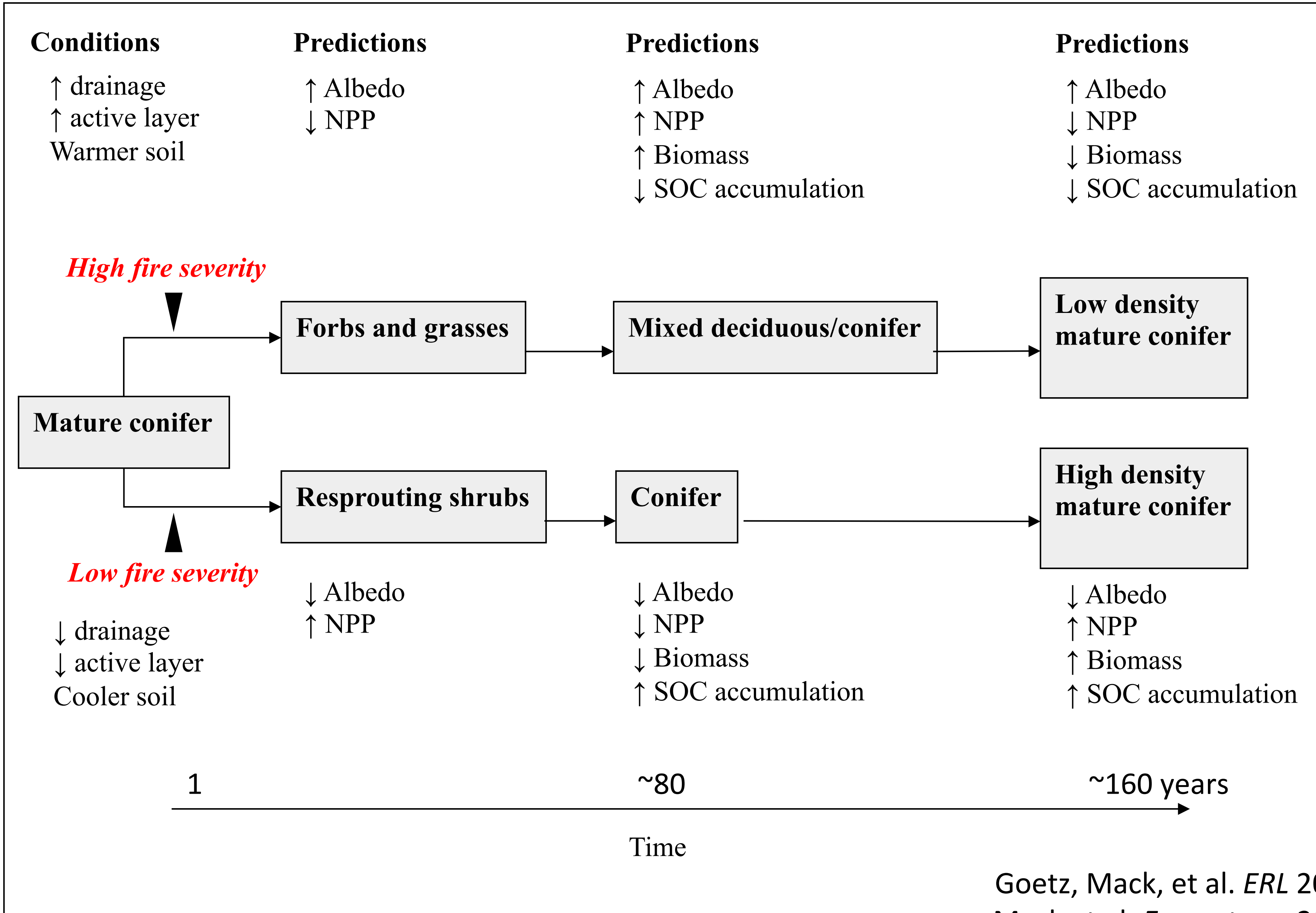
OL = 5 cm

OL = 2 cm

Johnstone *et al.* 2010 Glob Change Biol.
Kasischke *et al.* 2010 CJFR and Kasischke & Hoy 2012 GCB
Turetsky *et al.* 2010 Nature GeoSci.
Barrett *et al.* 2011 Ecol. Appl.; Alexander *et al*. in press

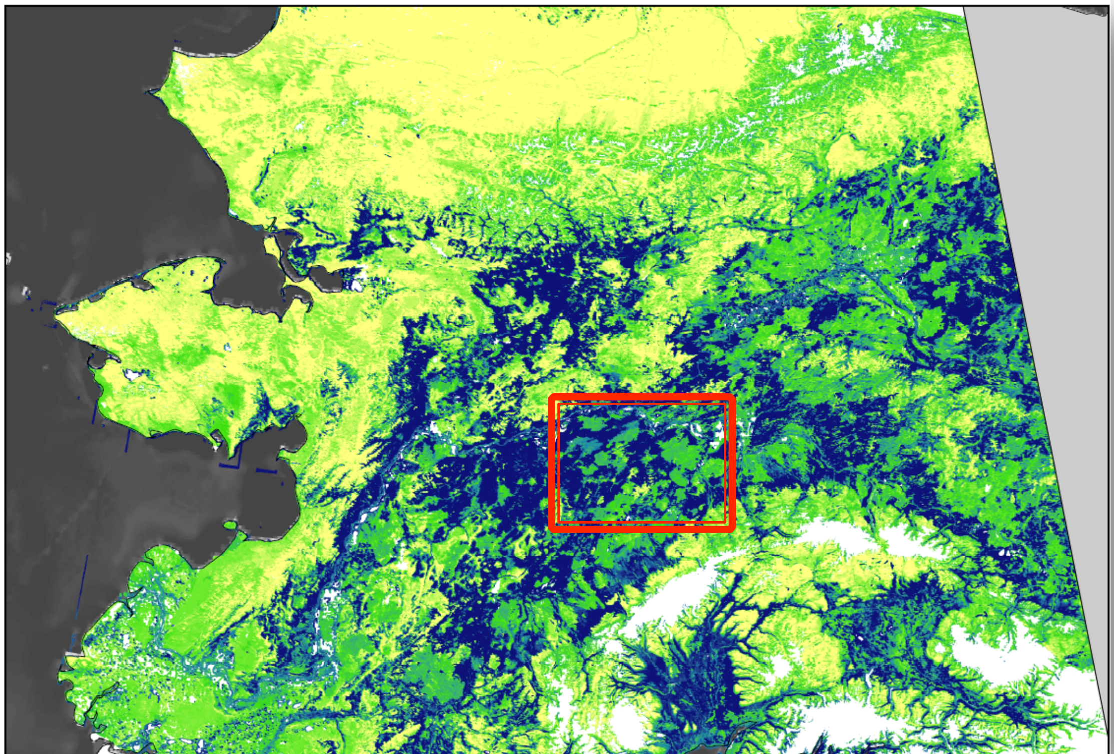
1983 Minto Flats Burn
Interior Alaska
Alexander and Mack

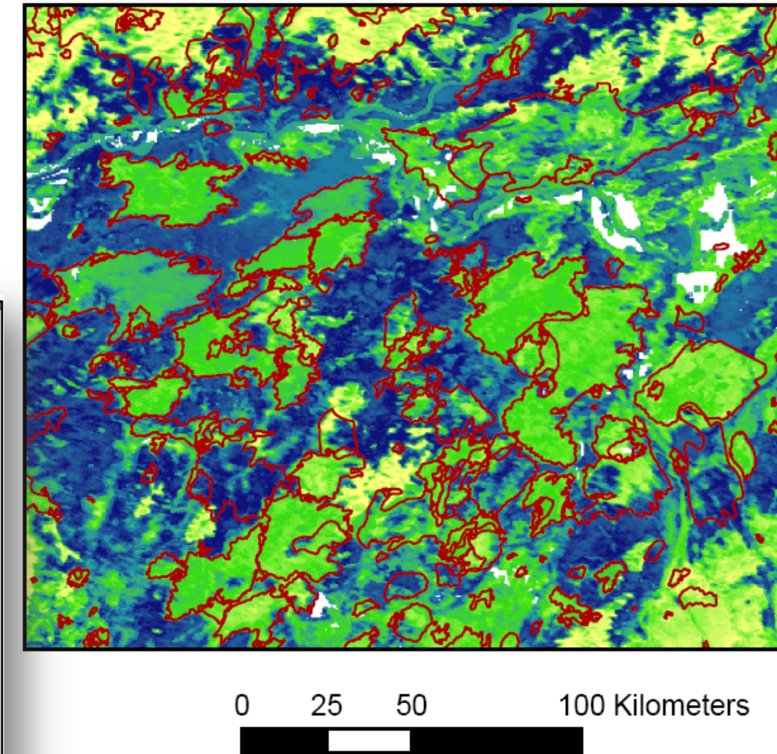
Hypothesized Implications of Fire Severity on Successional Trajectories



Goetz, Mack, et al. *ERL* 2007
Mack et al. *Ecosystems* 2008

Deciduous : Evergreen cover mapped with MODIS imagery calibrated with field mmts

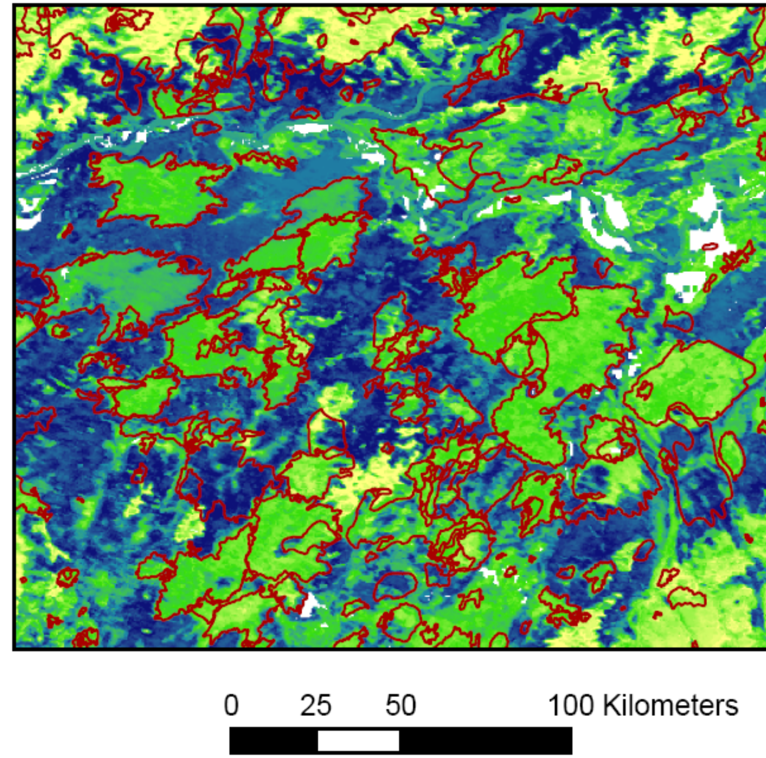




UF UNIVERSITY of FLORIDA

Beck, Goetz, Mack, Alexander, Jin, Randerson, 2011 *Global Change Biology*

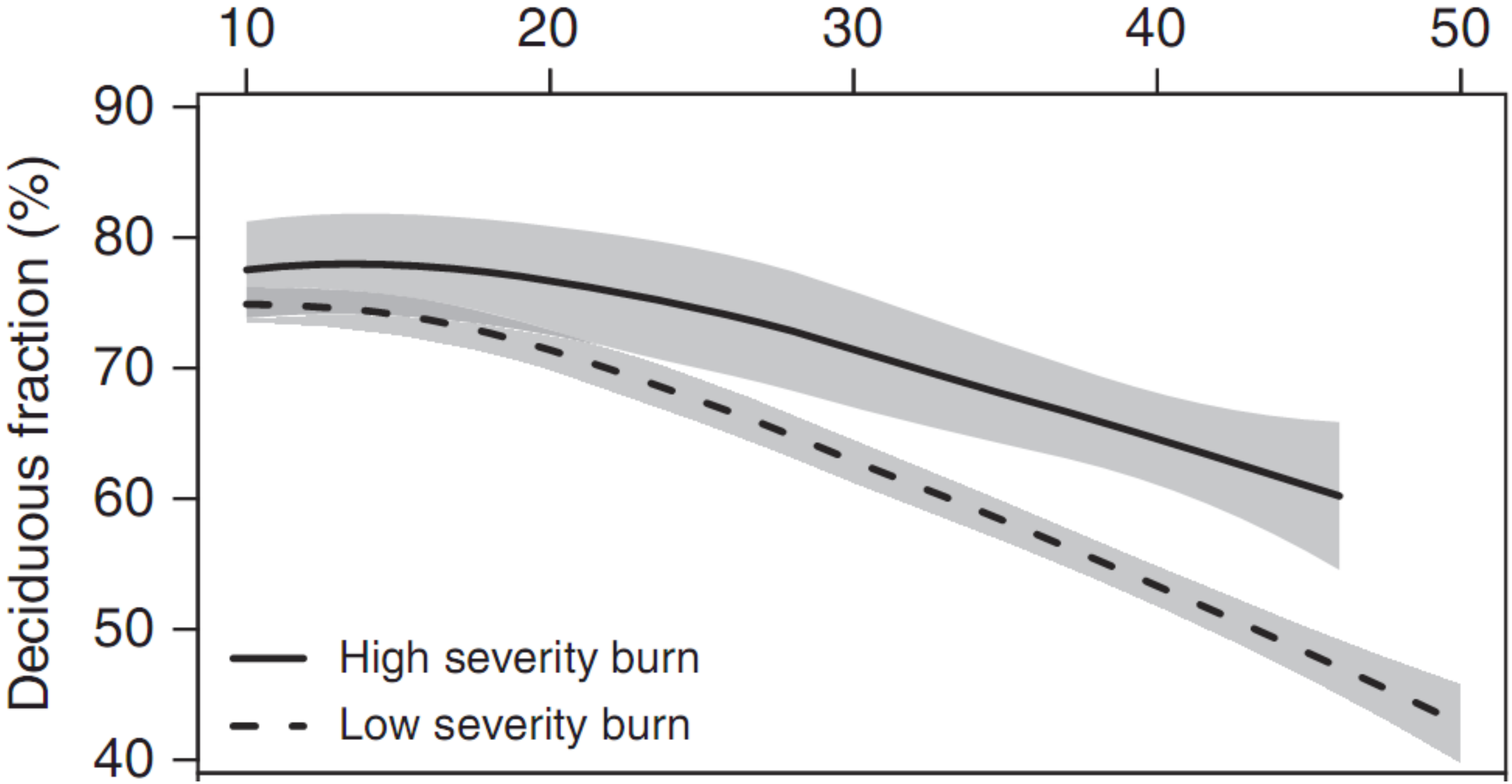
Remnant unburned areas excluded to avoid biasing results for areas / forest types resistant to burning



- Used dNBR in a relative sense by mapping it within and outside burn perimeters, tagging those not signif different from unburned
- Used lidar canopy heights to confirm unburned remnants had no signif height change (2003 – 2007)
- Tended to be more mesic and deciduous
- Used pre-burn LC, topography, drainage / wetness to develop a simple model to retrospectively detect areas unlikely to have burned
- Model detected 86% of unburned areas in post-2001 fires and was slightly biased towards over-prediction / exclusion (i.e. a conservative approach to ensure unbiased result wrt composition of regrowth)

Beck, Goetz, Mack, Alexander, Jin, Randerson, 2011 *Global Change Biology*

Even when averaging large areas and many burns, larger mid-to-late season fires, used as a proxy for more severe burning, have a different regrowth trajectory

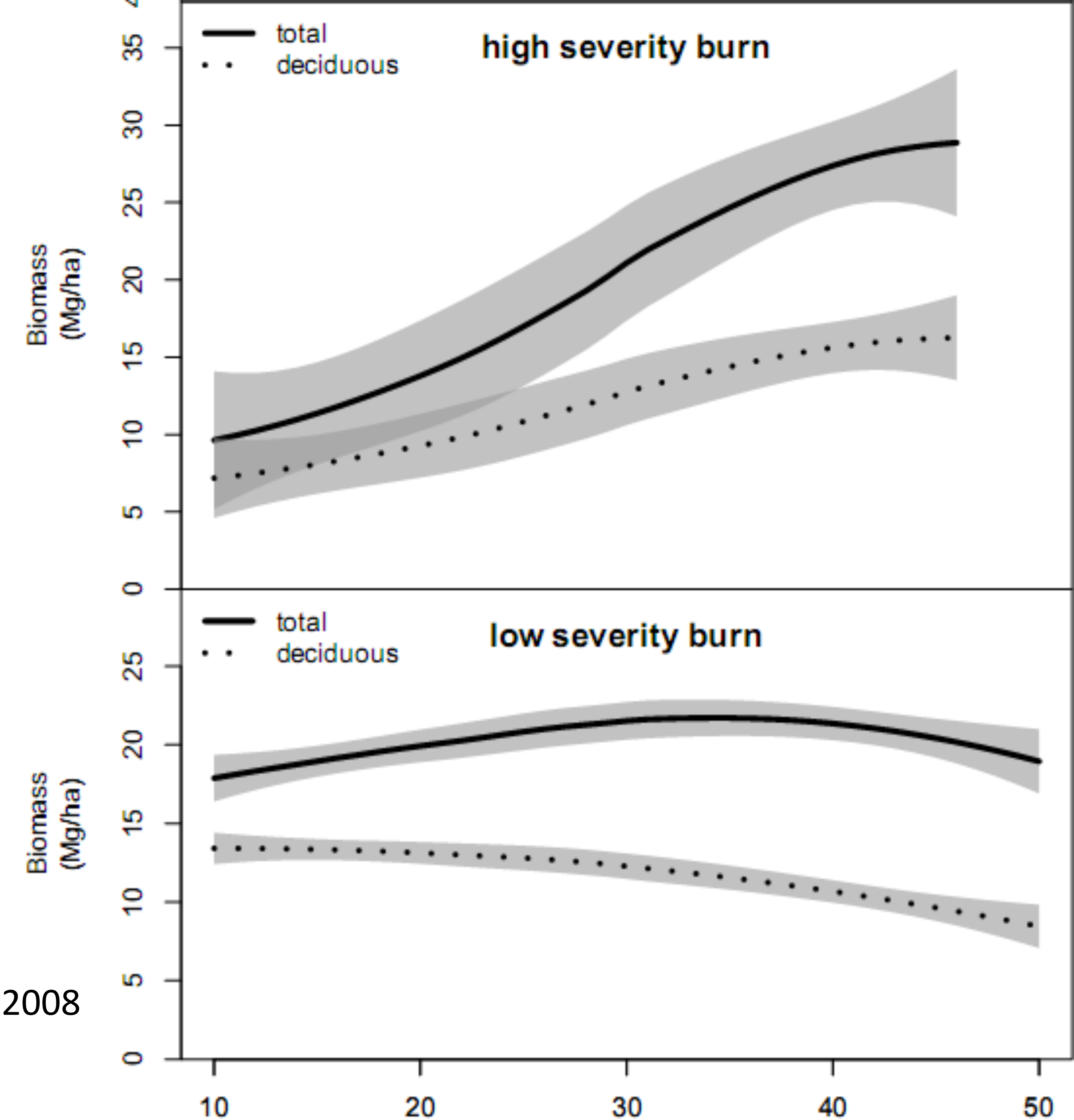


Years since fire ➔

Greater deciduous cover

Beck, Goetz, Mack, Alexander, Jin, Randerson, 2011 *Global Change Biology*

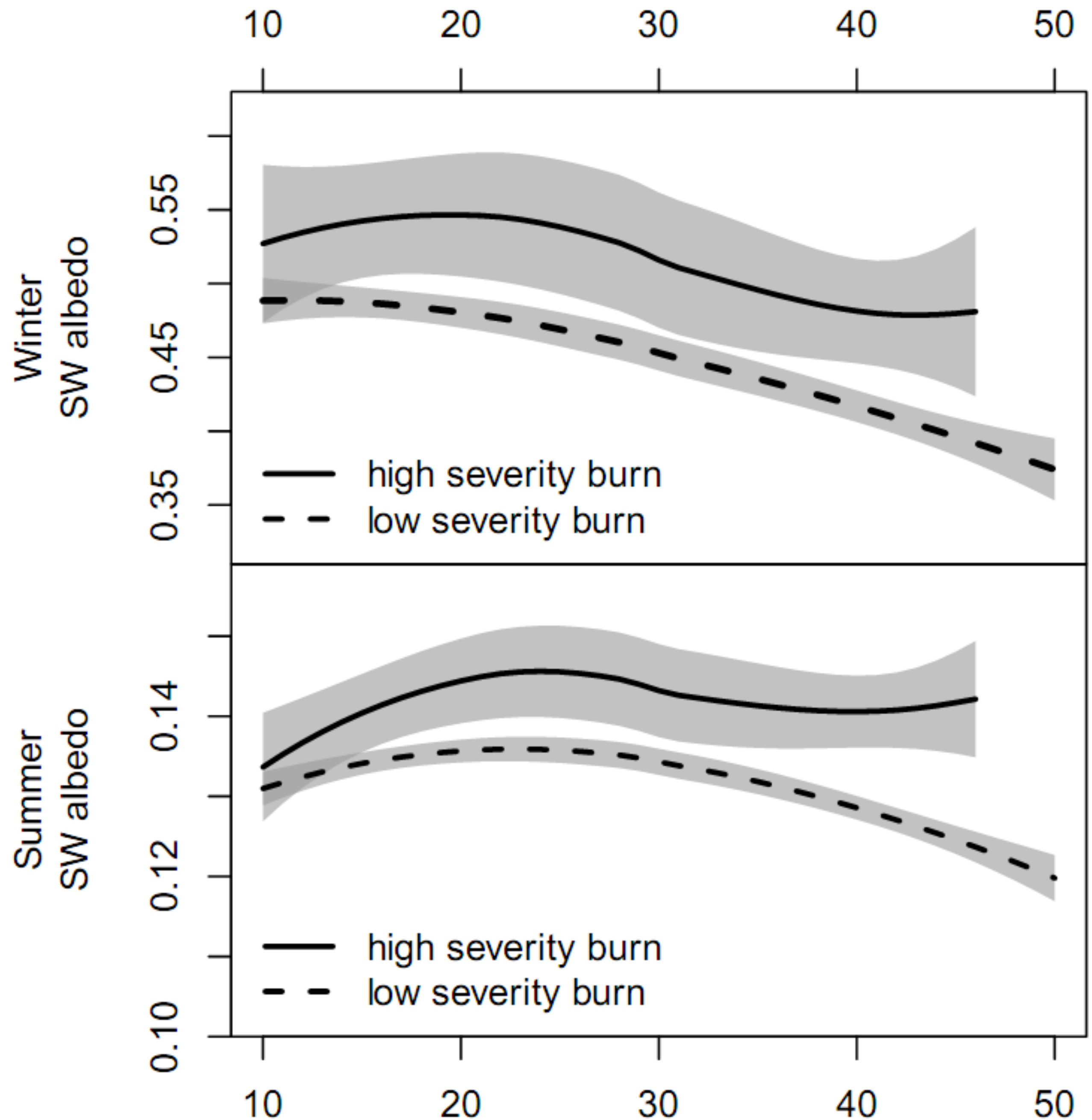
*Larger later fires also have a greater deciduous biomass component**



*biomass from Blackard et al. 2008

Beck, Goetz, Mack, Alexander, Jin, Randerson, 2011 *Global Change Biology*

A greater deciduous component translates into higher MODIS albedo – in both winter and summer



Beck, Goetz, Mack, Alexander, Jin, Randerson, 2011 *Global Change Biology*

Observations: Recent changes in North American boreal forest

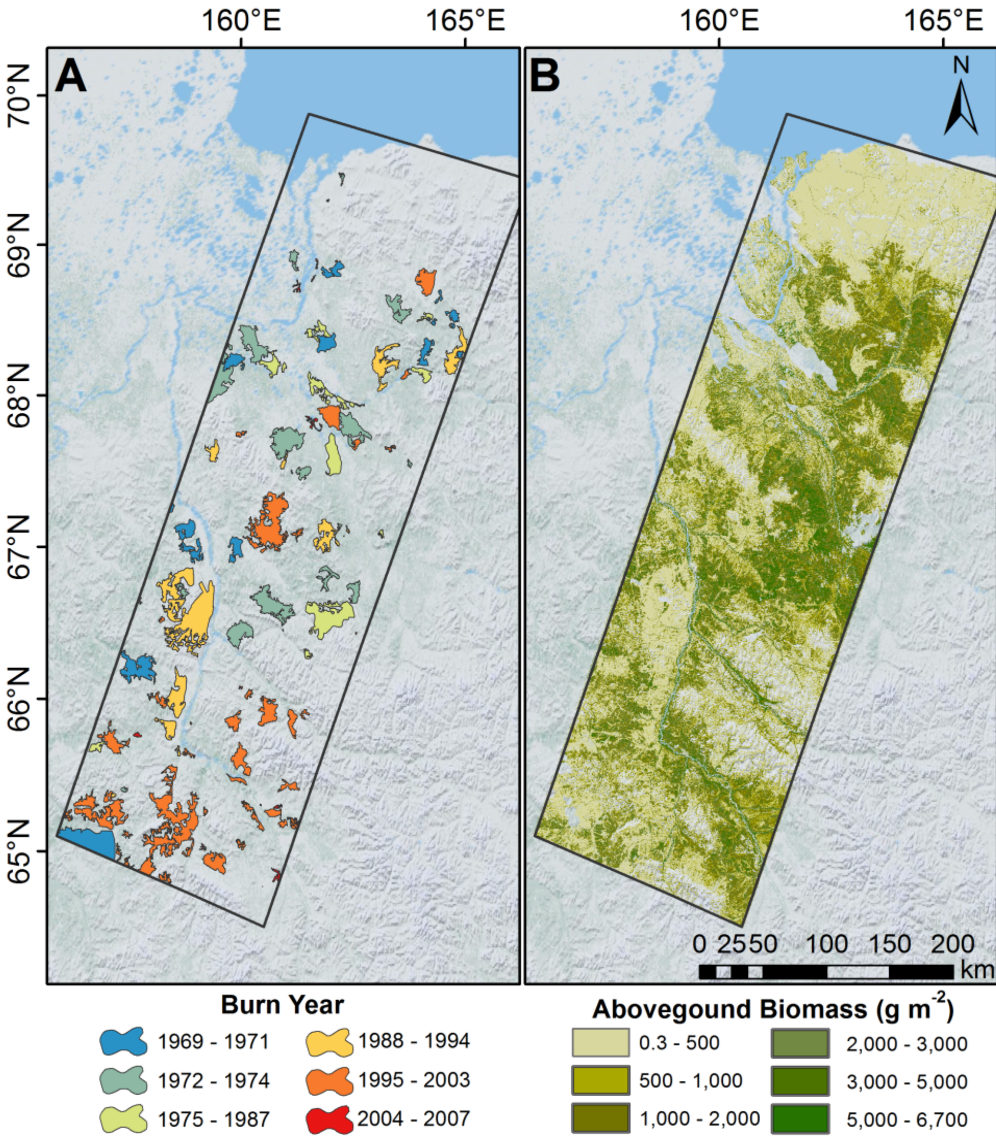
- ✧ Changing productivity trends in recent decades (declining)
- ✧ Primarily resulting from drought (increased VPD)
- ✧ Tree rings support the satellite observations
- ✧ Both are consistent with expected biome shift
  (albiet not well modeled)

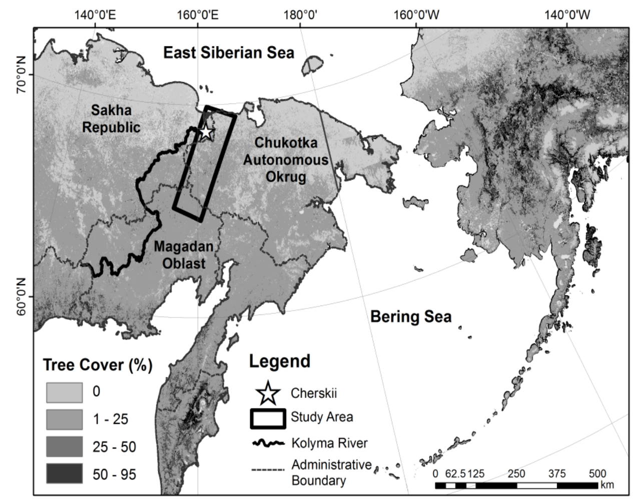
- ✧ Warming & drying also intensifies fire regime
- ✧ More severe burning changes composition of regrowth
  (greater deciduous component)
- ✧ Deciduous ⇧productivity & albedo
- ✧ Feedback to climate from ⇧deciduous may be net negative
  (i.e. mitigates additional warming)
- ✧ But net forcings must be considered across entire landscape
  (+incorporate other factors, e.g. direct emissions, thermokarsting, etc)

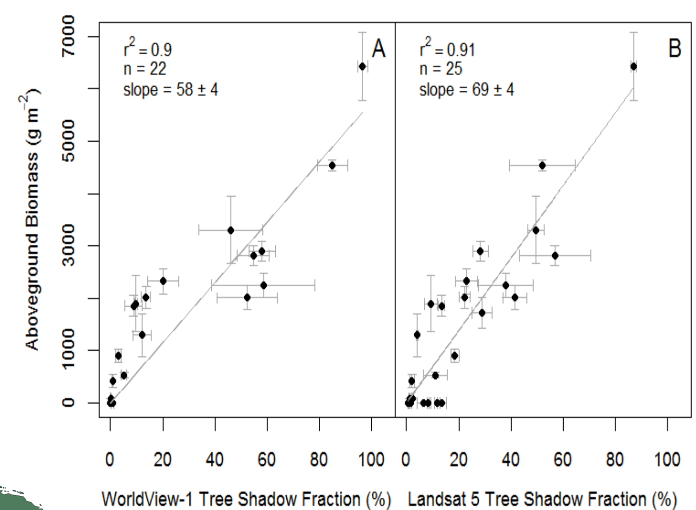
And then there's northern Eurasia..

- Forest area[1]: 600 to 900 x 10^6 ha
  - deciduous *larch* (+pine, spruce, fir, birch)
- Estimated forest carbon[1]: 46 - 148 Pg C
  - Alaska ~ 2 Pg C and Canada ~ 14 Pg C [2]
- Summers warmer and drier over 1900s [3]
- 3-7˚C projected warming by 2100 [3]
- Large changes in forests and fires are expected for 21st century [4]

Post-fire biomass recovery in the Cherskiy region







The Woods Hole Research Center

University of Florida

Field measurements in the Cherskiy region

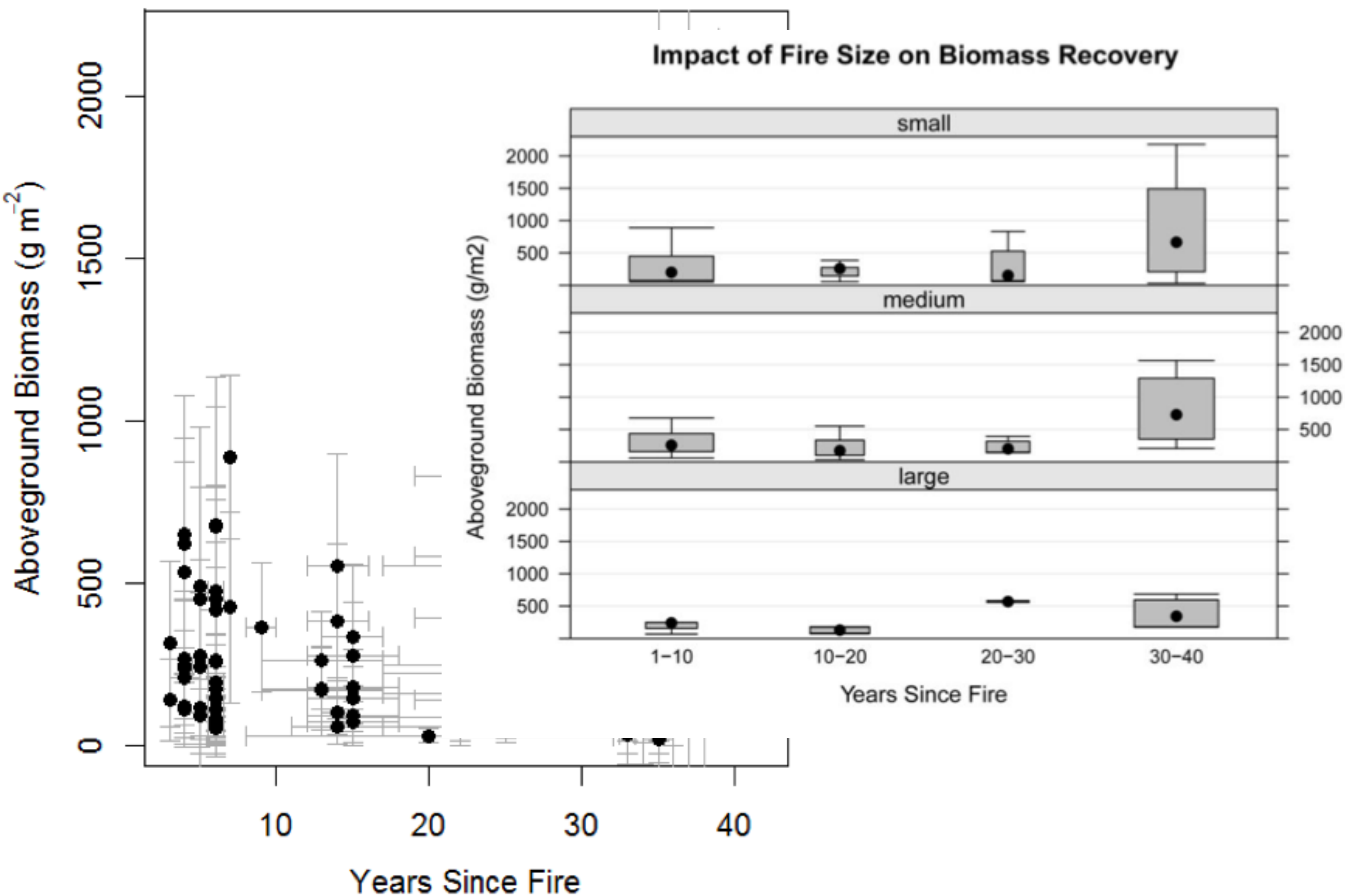
Field Inventory

- July 2010
- 17 sites
- 100 m transects, 5/10 plots
- Measurements (e.g.)
    - Height, Density, DBH

Tree Allometry

- DBH α Aboveground Biomass
- 30 trees harvested in 2002
    - Components partitioned, dried and weighed
- Biomass to C conversion
    - Foliage (46% C)
    - Stem (47% C)
    - Branches (48% C)
- Best fit power equation

Post-fire biomass recovery in the Cherskiy region



Acknowledgements

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- NOAA Global Carbon Program
- NSF International Polar Year

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