BACC II Chapter 6.4
Land cover and resource management

M.-J. Gaillard et al.

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Co-authors

- **Anna Wramneby**, former Lead Author, Lund University, Sweden
- **Anne Birgitte Nielsen**, Lund University, Sweden (pollen proxies)
- **Patrick Samuelsson**, SMHI, Sweden
- **Camille Sandström, Hjalmar Laudon, and Johan Bergh**, SLU, Alnarp, Sweden
- **Thomas Kleinen**, MPI, Hamburg
- **Jed Kaplan**, EPFL, Lausanne, Switzerland

Aim of the chapter

- Review our current understanding of land cover changes, both in terms of land use and natural vegetation changes, and how these land surface dynamic processes influence regional climate change in the Baltic Sea Basin
- Past, present and future

Avoid overlaps with 2.2, 5.2.2 and 5.3.1 ????

Current status of Chapter 6.4

15 pages written on ca 33 planned

- **1. Introduction Marie-José Gaillard and Anna Wramneby ca. 2 pages**
  Still to be revised and completed

- **2. Feedbacks between land surface and atmosphere**
  Patrick Samuelsson and Thomas Kleinen ca. 9 pages

  – **Radiation and energy balance Patrick Samuelsson ca. 3 pages**
    NEW TEXT EXPECTED END of FEBRUARY

  – **Biogeophysical and biogeochemical feedbacks**
    Anna Wramneby, Thomas Kleinen ca. 6 pages
    New text revised and completed by Thomas Kleinen- state February 6th

    - ***Biogeochemical feedbacks***
      - ***Albedo feedbacks***
      - ***Hydrological cycle feedbacks***
    - ***Biogeochemical feedbacks***

- **3. Historical land cover changes and feedbacks**
  Marie-José Gaillard, Anne Birgitte Nielsen and Jed Kaplan
  ca 8-10 pages

  TO BE WRITTEN! One new co-author TEXT expected for end of March

  - **Holocene land-cover changes – climate and/or human induced**
    ca. 5 pages
    !!!!! Avoid overlaps with Past climate variability Holocene - 2.2

  - **Evidences of past land-cover feedbacks ca. 5 pages**

- **4. Potential future trends in land cover and associated feedbacks**
  ca. 10 pages

  - **Resource management Camille Sandström, Hjalmar Laudon, Johan Bergh**
    ca 5 pages
    TO BE WRITTEN ! Two new co-authors
    TEXT expected for the end of February

    !!!!!! Avoid possible overlaps with socio-economic impacts 5.3.1 ???

- **Future land cover change scenarios and associated feedbacks**
  Anna Wramneby, Thomas Kleinen, and Marie-José Gaillard? ca. 5 pages
  Text revised and complemented by Thomas Kleinen
  State February 6th 2012

  - ***Biogeophysical feedbacks to the regional climate mean state***
  - ***Biogeophysical feedbacks to regional climate variability***
  - ***Biogeochemical feedbacks*** ***STILL TO BE WRITTEN***

- ***5.*** **Summary** **MJ Gaillard and A Wramneby 1-2 pages**
  Still to be completed and revised

- **6. References**
  Now ca. 25 references
  Still to be completed!! Of course many more!

Introduction

- Understanding of land cover-climate feedbacks has increased over the last decade through sensitivity studies with global Earth System Models
- Since the mechanisms involved in e.g. biophysical feedbacks in particular are governed by regional mechanisms, the use of regional climate and vegetation models could potentially identify feedbacks not captured at the course resolution of global models.
- For the Baltic Sea region such studies are few
- A growing number of regional future land use scenarios enable a more realistic approach to explore the role of land cover changes in regional climate change using RCMs

General knowledge based on sensitivity model experiments

- current understanding of the direct effects of biogeophysical and biogeochemical feedbacks, and future trends in these feedbacks associated with changes in land use and resource management
  - biogeochemical feedbacks
    - *Albedo feedbacks*
    - *Hydrological cycle feedbacks*
  - biogeochemical feedbacks

NOTE: our current understanding of land cover changes and their biogeophysical feedbacks in regional climate change is limited in comparison to the large scale carbon cycle feedbacks (large number of studies on carbon cycle feedbacks)

Historical land cover changes and feedbacks

- **Holocene land-cover changes – climate and/or human induced**

  ca. 5 pages

  !!!!! Avoid overlaps with Past climate variability Holocene - 2.2

  - ***Holocene pollen-inferred land-cover reconstructions (biomization, modern analogue approach, mechanistic modelling approach) much literature on Europe; we will extract the Baltic area information***

  - ***Modelling Holocene potential vegetation using dynamic vegetation models (LPJGuess) – a way to separate climate-induced from human-induced vegetation in the pollen-inferred land-cover reconstructions***

  - ***Anthropogenic land-cover change scenarios (HYDE database, Kaplan et al's KK10, Pongratz et al. approach, etc…)***
    on global and continental scale; we will extract the Baltic area information

APPLICATION OF THE REVEALS MODEL (Sugita 2007)

Translation of pollen percentages into plant percentage cover using models of the pollen/vegetation relationship including pollen dispersion and deposition models

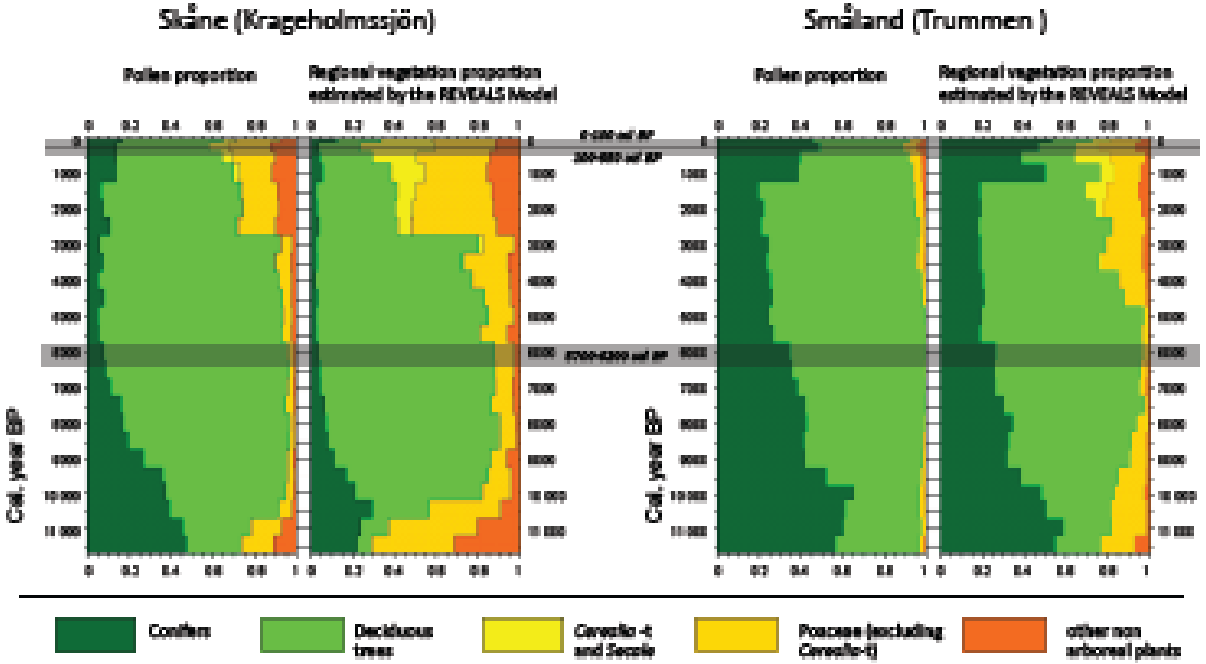
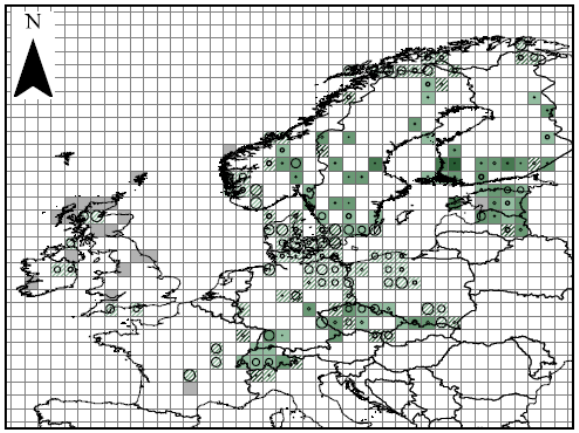


Fig. 7. REVEALS reconstructions of Holocene vegetation changes (right in each panel) in southern Sweden based on the pollen records (left in each panel) from Kragehomssjön (province of Skåne, left) and Lake Trummen (province of Småland, right) (from Sugita et al., 2008, modified). See Fig. 8 for the locations of Skåne and Småland. The selected three major time-windows studied in the LANDCLIM project are indicated. REVEALS was run with 24 pollen taxa with the pollen productivity estimates from southern Sweden (Broström et al., 2004). The taxa included in the groups "conifers", "deciduous trees", "Cerealia-t" (cereals, rye excluded) and "other non-arboreal plants" (herbs and shrubs) are the same as in Fig. 6. *Secale*=rye; Poaceae=grasses.

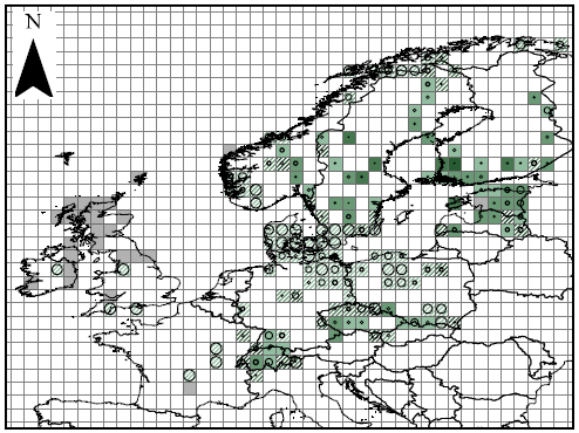
From Gaillard et al. 2010,
Climate of the Past 6

TBE1– Shade-tolerant evergreen trees (Picea)

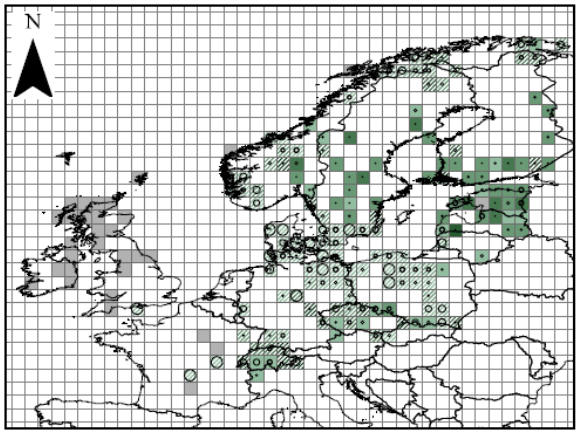
x-100 cal BP



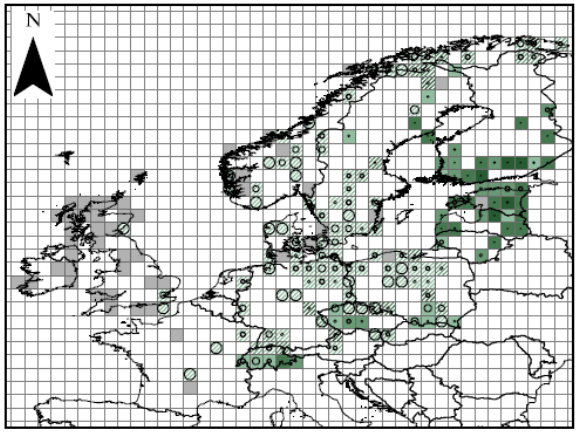
100-350 cal BP



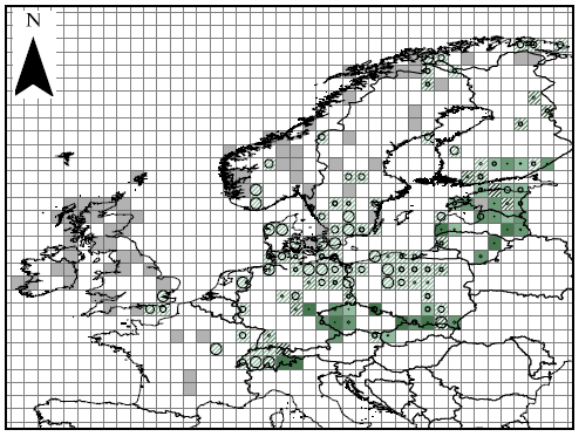
350-700 cal BP



2700-3200 cal BP



5700-6200 cal BP



CLIM LAND

TBE1 cover %

REVEALS reconstruction - Europe - all results

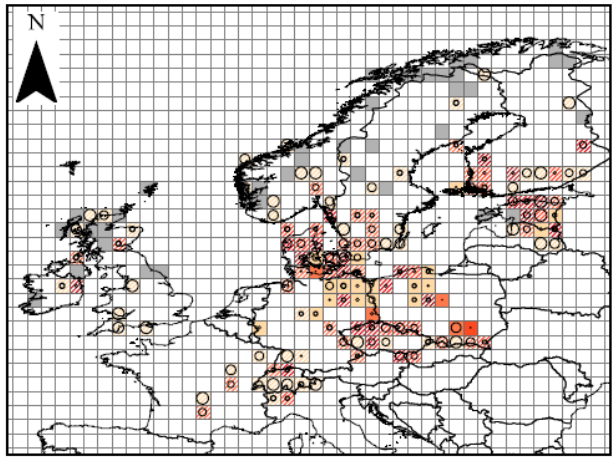
VR-LANDCLIM v. 21 June 2011

MANUS to be submitted in MAY 2012

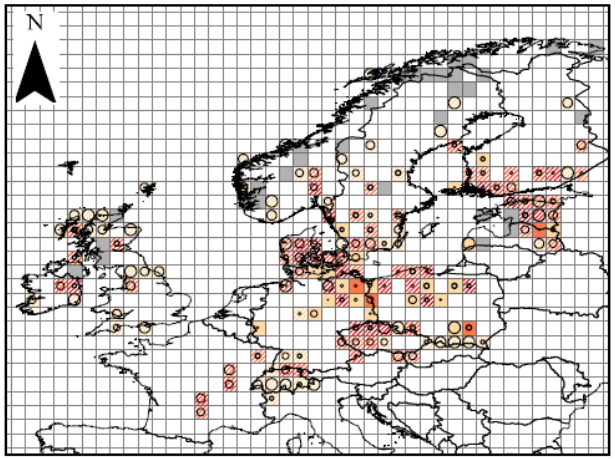
The larger the circle, the larger the SE. When the circle fills the grid, SE ≥ REVEALS mean, i.e. the estimate is not reliable (occurs for low values of REVEALS).

AL – Agricultural Land *(Cerealia-t and Secale-t)*

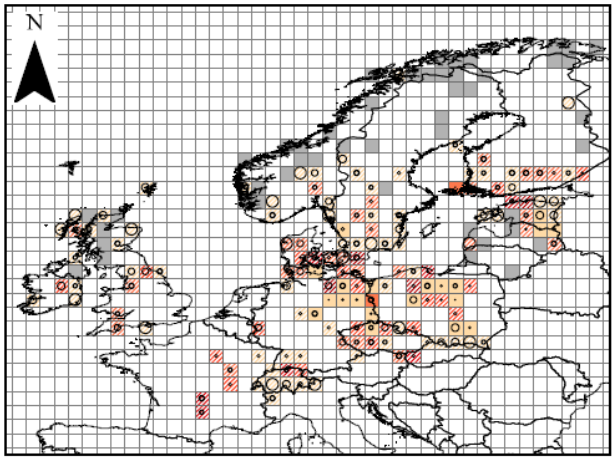
x-100 cal BP



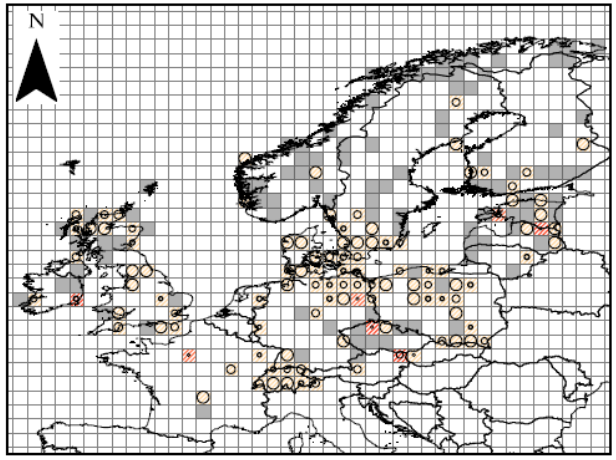
100-350 cal BP



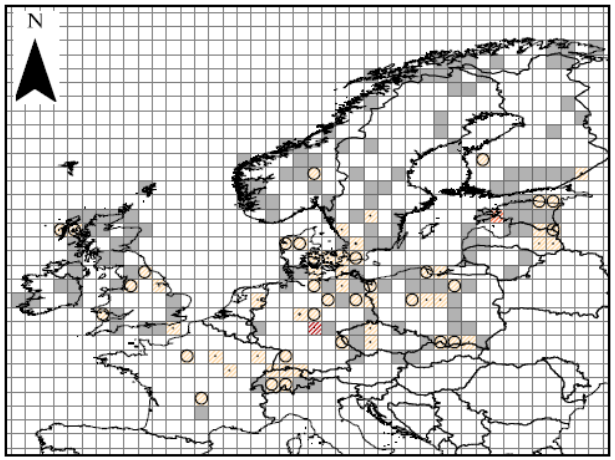
350-700 cal BP



2700-3200 cal BP

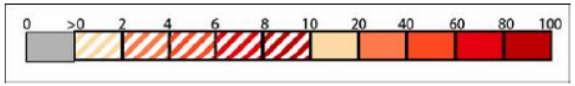


5700-6200 cal BP



CLIM LAND

AL cover %

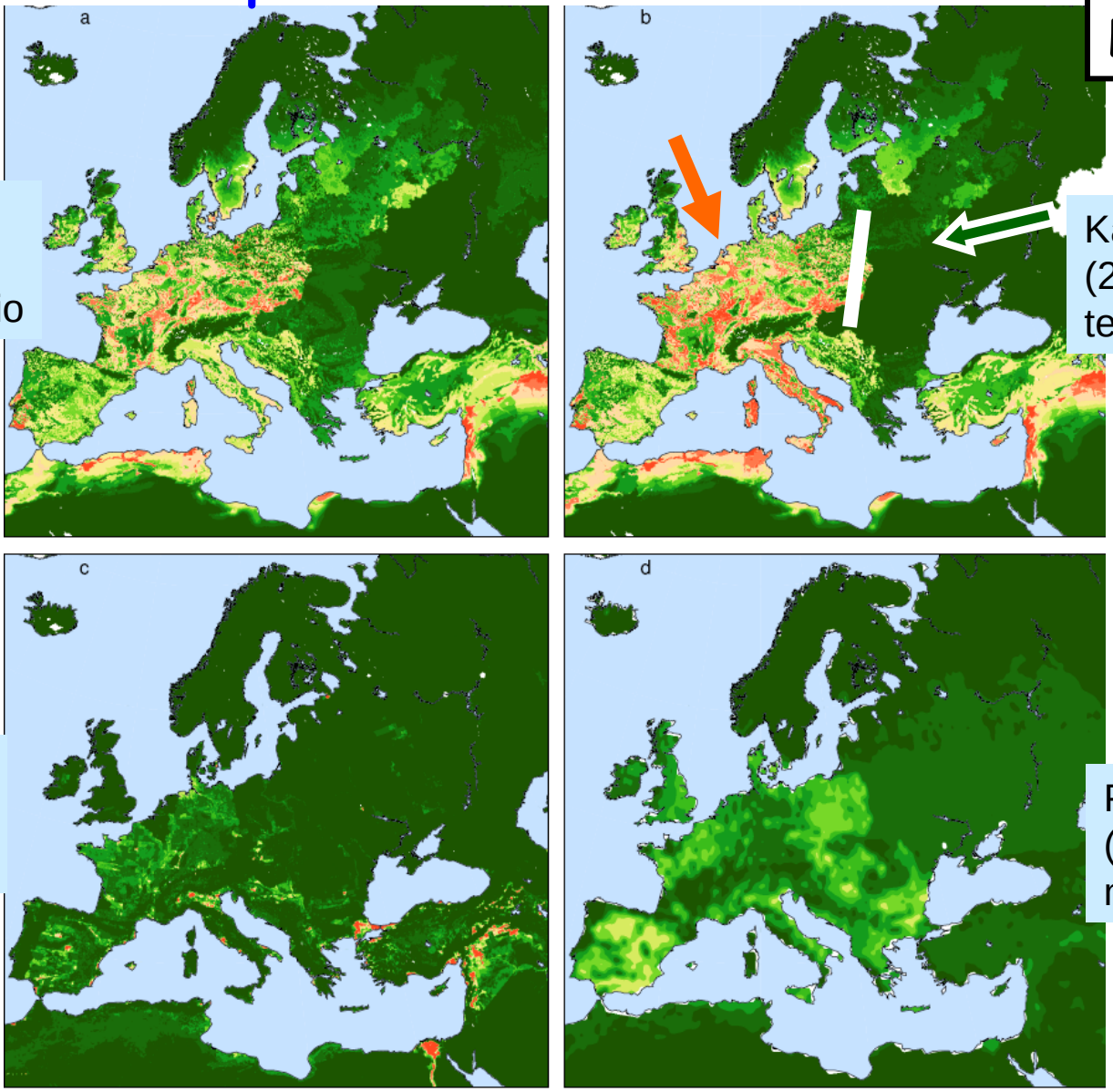


MANUS to be submitted in MAY 2012

Comparison between ALC

AD 800
Late Iron Age

Kaplan et al. (2009) standard scenario

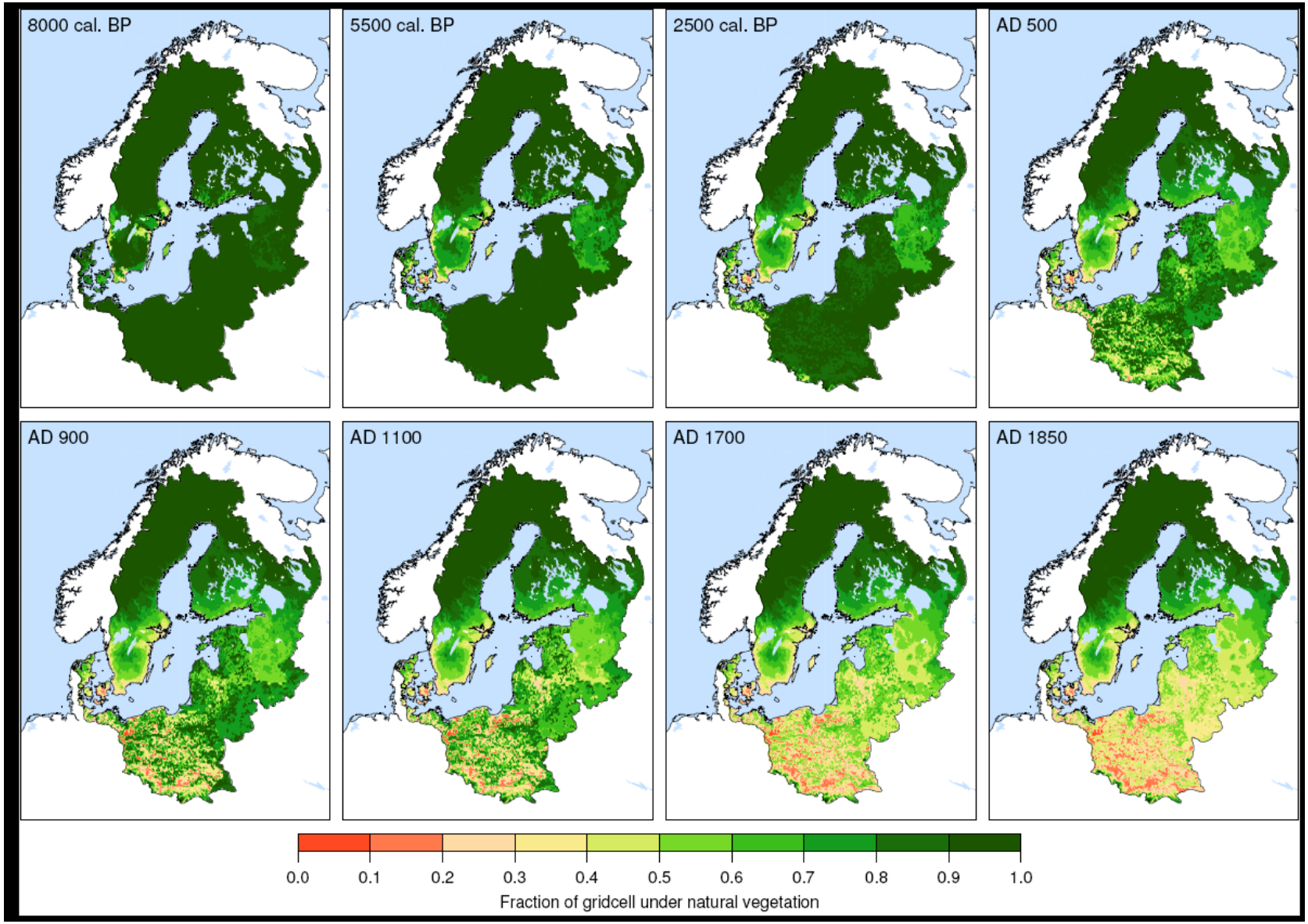


Kaplan et al. (2009) technology scenario

Goldewijk et al. (2010) HYDE 3.1

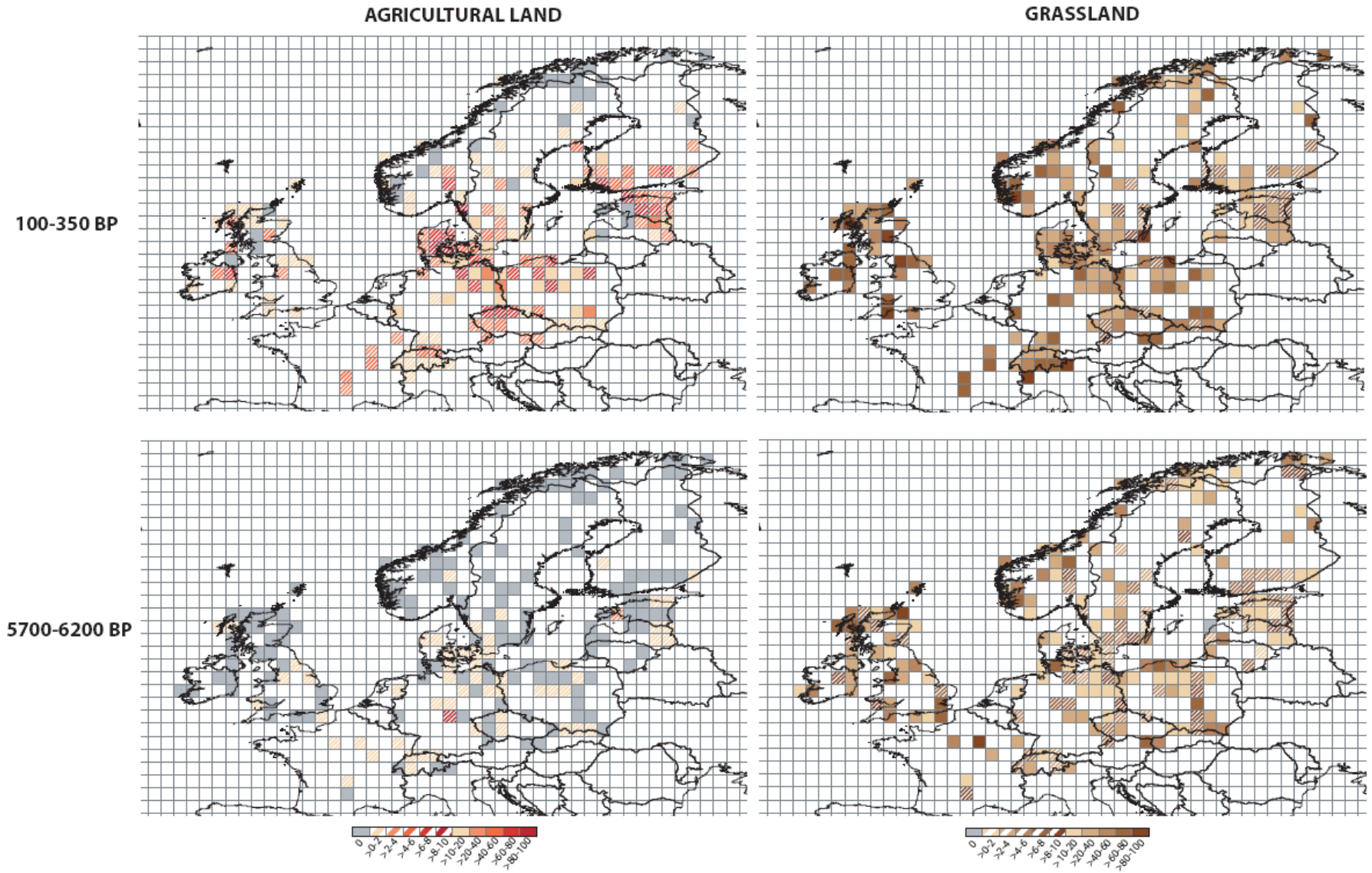
Pongratz et al. (2008) maximum scenario

From Gaillard et al. 2010, *Climate of the Past* 6

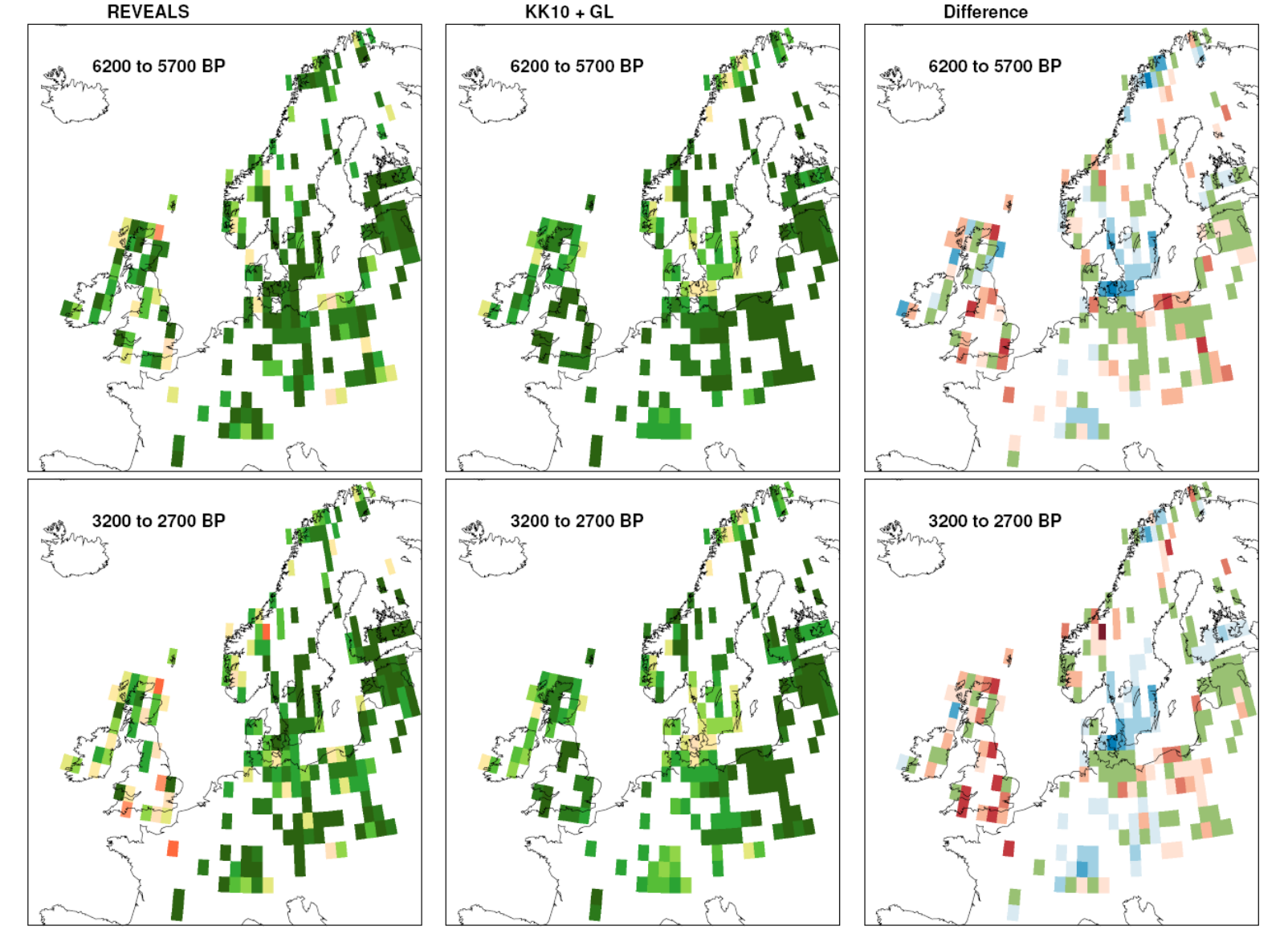


New maps from Kaplan, extracted from published KK10 Database, Kaplan et al., 2009

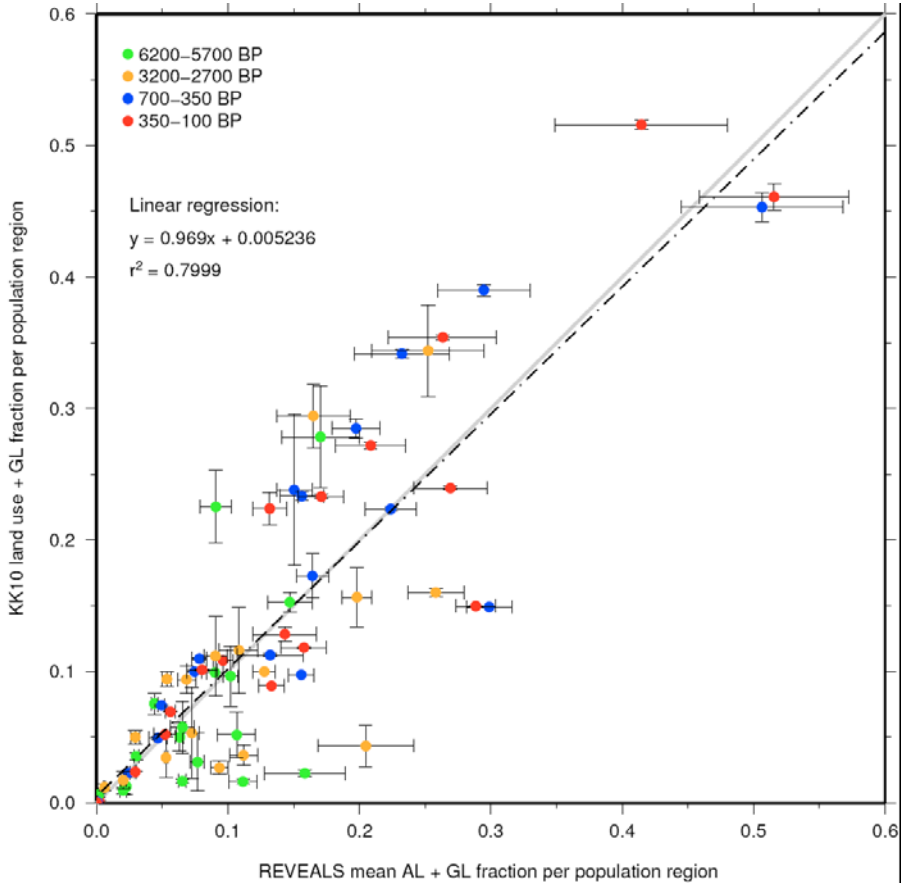
Major potential: evaluation of LPJGUESS simulations and Land-cover scenarios (e.g. KK and HYDE)



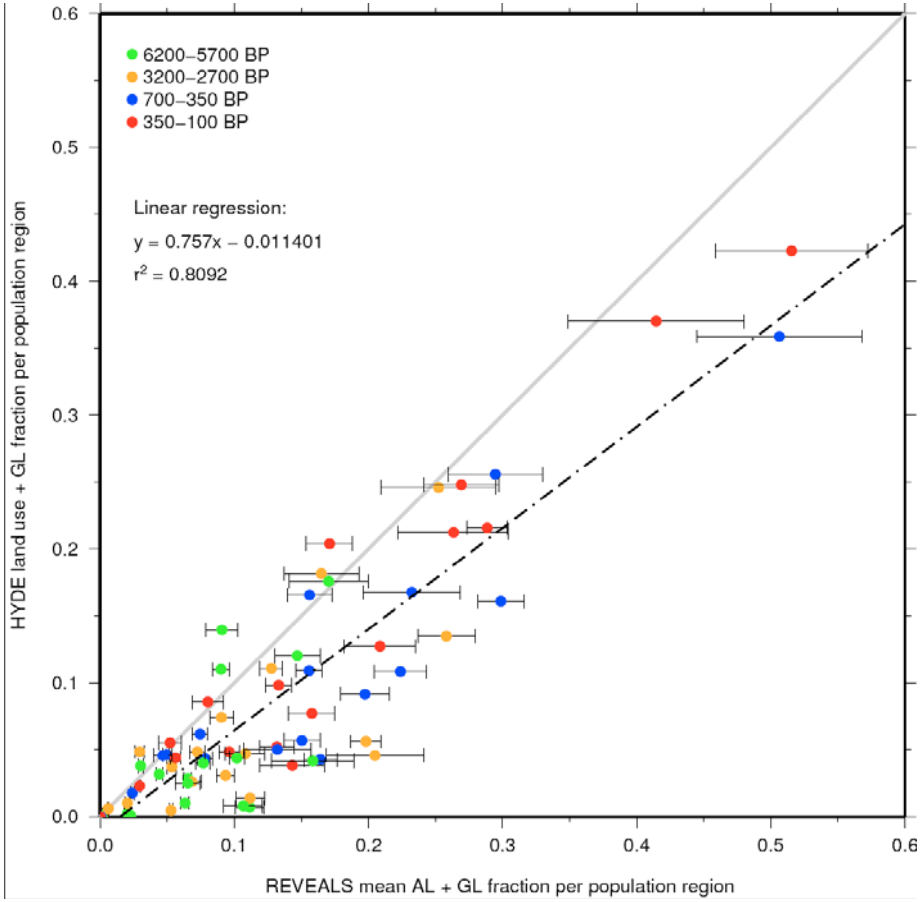
Comparison REVEALS – Kaplan's scenarios MANUS to be submitted in MAY 2012



REVEALS-Kaplan's KK10



REVEALS-HYDE



Comparison for 17 "population regions"

MANUS to be submitted in MAY 2012

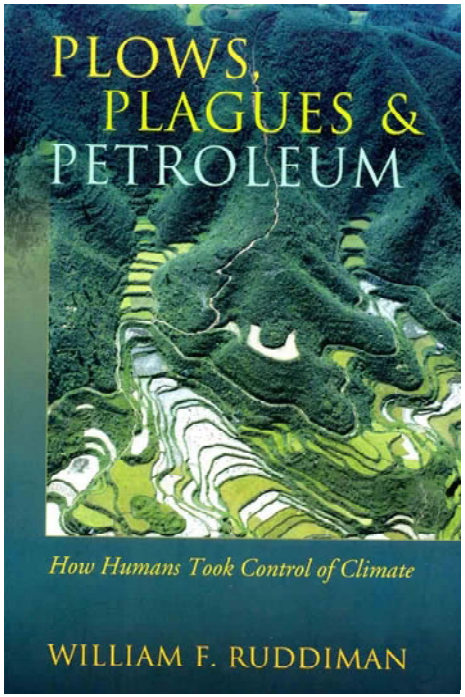
- **Evidences of past land-cover feedbacks**
  ca. 5 pages

  - **Brovkin et al. and others (Europe or global)**

  - **The Ruddiman hypothesis has generated a lot of modelling experiments on human-induced feedbacks on climate**

  A Special Issue of *THE HOLOCENE 2011 – primarily carbon-cycle feedbacks*

  Kaplan et al.
  Boyle et al.
  Many others….



Past human impact via land-cover change may have influenced climate in the past and may still influence our current and future climate in a larger degree than we think:

Ruddiman hypothesis (2005): human activities have affected atmospheric CO_2 and CH_4 over the last 5000-8000 years.

Potential future trends in land cover and associated feedbacks

1. Resource management **Camille Sandström, Hjalmar Laudon, Johan Bergh**

- *keywords: changes in policies, decision making in agriculture/forestry sectors, water resource management*

- ***Is it what 5.3.1 is already treating?***

2. Future land cover change scenarios and associated feedbacks

Anna Wramneby, Thomas Kleinen (and Marie-José Gaillard?)

- The general future land use trend in Europe, i.e. decrease in cultivated surfaces due to technical progress could be assumed to be applicable also for the Baltic Sea region…..
- But….. a few studies have indicated a sustained or even expanded agricultural fraction for some of the Baltic Sea countries (e.g. Denmark and Finland in Audsley et al., 2006).
- However….it seems safe to assume that these general trends will also apply here ????
- The feedbacks to climate from such regional land use changes are to a large extent unexplored.

  – Biogeochemical feedbacks from regional land use changes have been discussed in the framework of global climate change in some studies (Carter et al., 2007; Rounsevell and Reay, 2009) …..

  – The direct biogeophysical feedbacks in relation to expected land use changes are yet to be addressed.

- A wide range of global land cover-atmosphere modelling experiments have been performed over the last decades to infer the role of land surface dynamics both in terms of CO2 exchange and biogeophysical factors…..
- But….The majority of these studies have either explored the role of extreme shifts in land cover (Bala et al., 2007) or investigated the role of potential natural vegetation changes
- Except….Pongratz et al. (2009): influence of historical land use changes on radiative forcing
  - For all of Europe, with the exception of Scandinavia, a decrease of radiative forcing by 0.3 W/m2 was found between AD 800 and 1700.

Biogeophysical feedbacks to regional **climate mean state**

- albedo feedback
  - the albedo feedback and its amplifying effect on climate warming is expected to be the most important biogeophysical feedback in boreal regions such as northern Europe
  - It is predicted that it would be strong enough to compensate the climate gains from the increased carbon sequestration in forests
- There are no evidence that variations in cloudiness and precipitation over Europe could be attributed to vegetation dynamics.
  - But…. incorporating land use scenarios might strengthen the feedbacks identified so far and potentially also show feedbacks in precipitation and cloudiness.

Biogeophysical feedbacks to climate variability

- Short-term land cover-climate feedbacks might behave very differently from those feedbacks expected in the long-term:
  - the cooling effects from forests maintaining a reasonable evapotranspiration rate, as compared to open land, could be reversed at least during the initial stages of a climate warming

My questions

- Possible overlaps
- 2.2. Aim of the chapter: Climate!
  - Avoid too much text on vegetation history that is not absolutely necessary to understand the climate history?
- 5.2.2. and 5.3.1 Will there be maps of modern and future land cover? forest cover, cover of agricultural land