Relating Norwegian palynological records and archaeological datasets

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Introduction

- We present the first results of a project that aims to create detailed GIS-based paleoenvironmental information from a comprehensive dataset of pollen core data from Norway.

- The study will use quantitative statistics and software tools like R, QGIS, SAGA and GRASS GIS to create a paleoenvironmental dataset of high temporal and spatial resolution for the last ~10.000 years of South-East Norway.

- This new paleoenvironmental data set, will help to better analyze and understand the Holocene history and archeology of Norway, by relating to archaeological spatial datasets from the Museum of Cultural History at the University of Oslo

Data

- The following data is necessary to infer the paleoenvironmental information, as conducted for this study:
  - Modern Pollen Samples (incl. location)
  - Modern environmental/climate data (for every modern pollen sample location)
  - Fossil pollen samples (incl. age & location)

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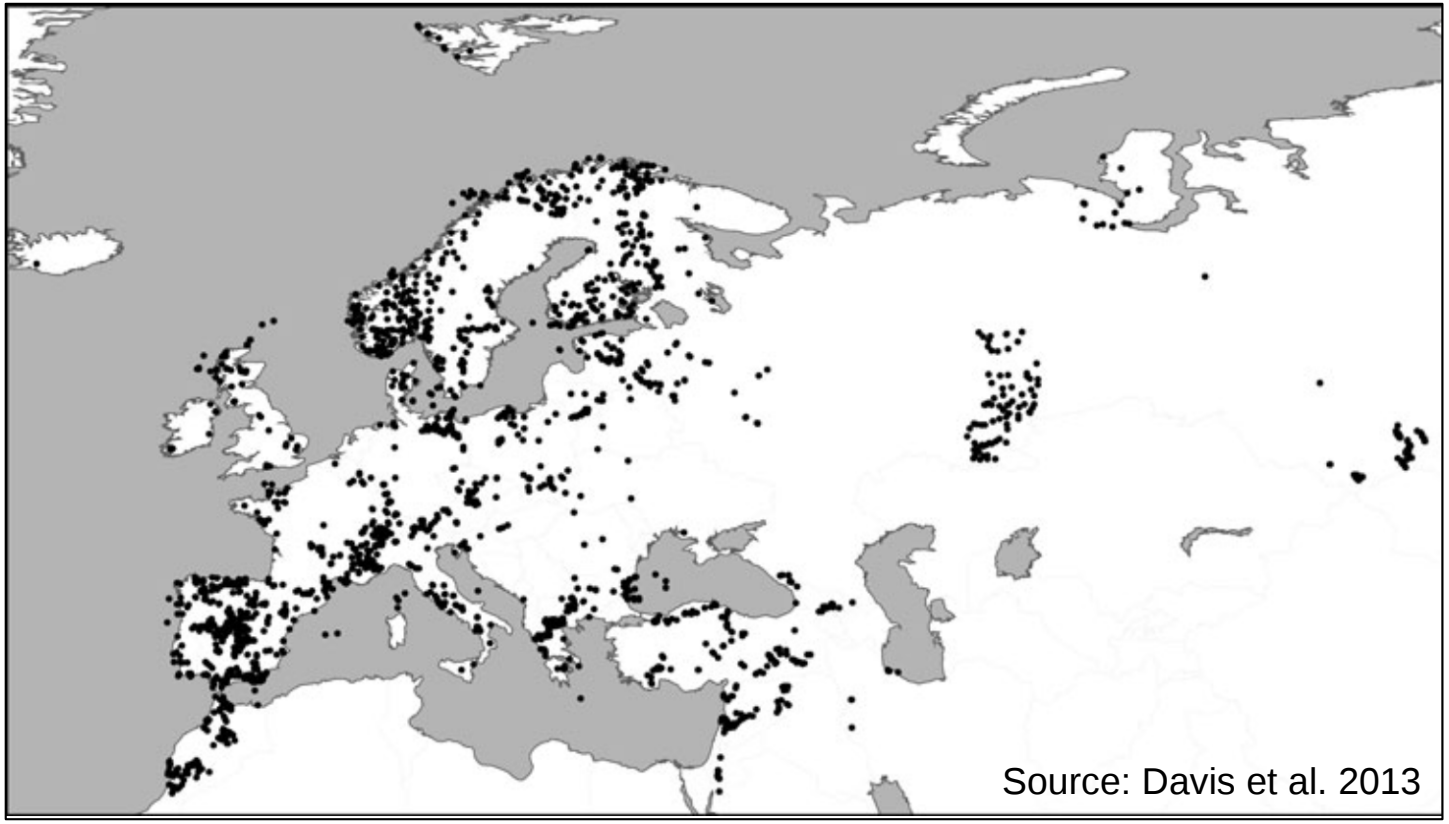
Modern Pollen Samples (EMPD Dataset)

- ~ 4000 pollen surface samples are available from the European Modern Pollen Database (EMPD) (Davis et al. 2013).
- Modern / recent climate data parameters (like T_ANN and P_ANN) are available for each of the sample locations.



Davis, B.A.S., Zanon, M., Collins, P. et al. Veget Hist Archaeobot (2013) 22: 521.

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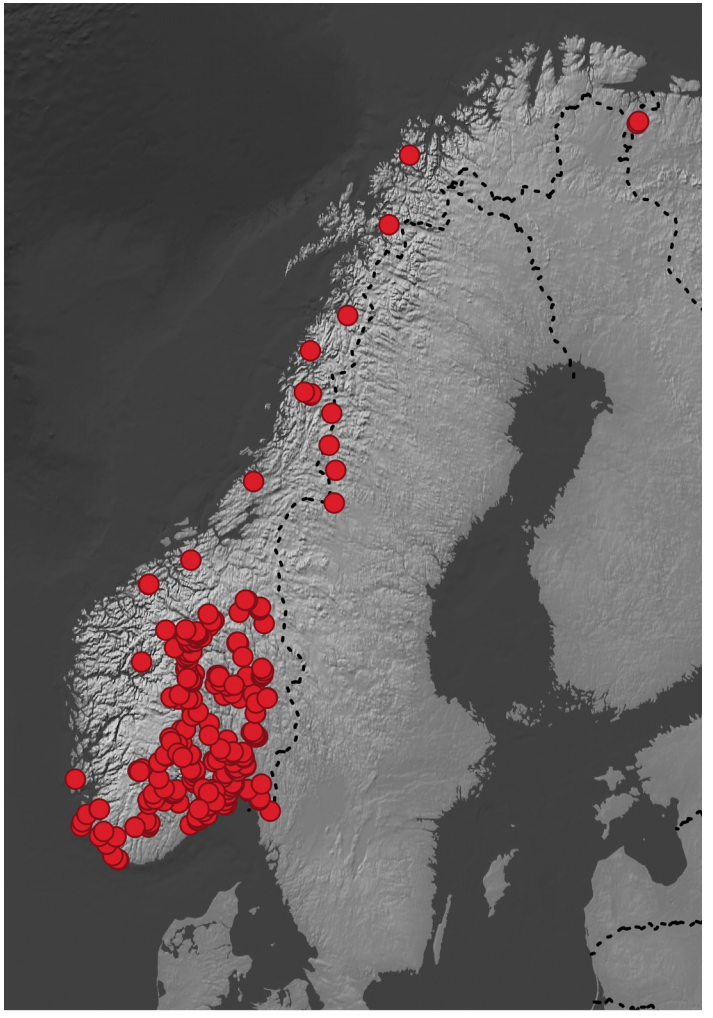
Pollen Data (Norwegian Sites)

- This comprehensive dataset was created by the Norwegian paleobotanist Helge Høeg during more than 30 years.
- The pollen data comes from **302 drill cores** and the main part of them are collected as part of archaeological excavation projects in South-Eastern Norway.
- The dataset consists of **1858** Tilia (.til, .tgx) data files.



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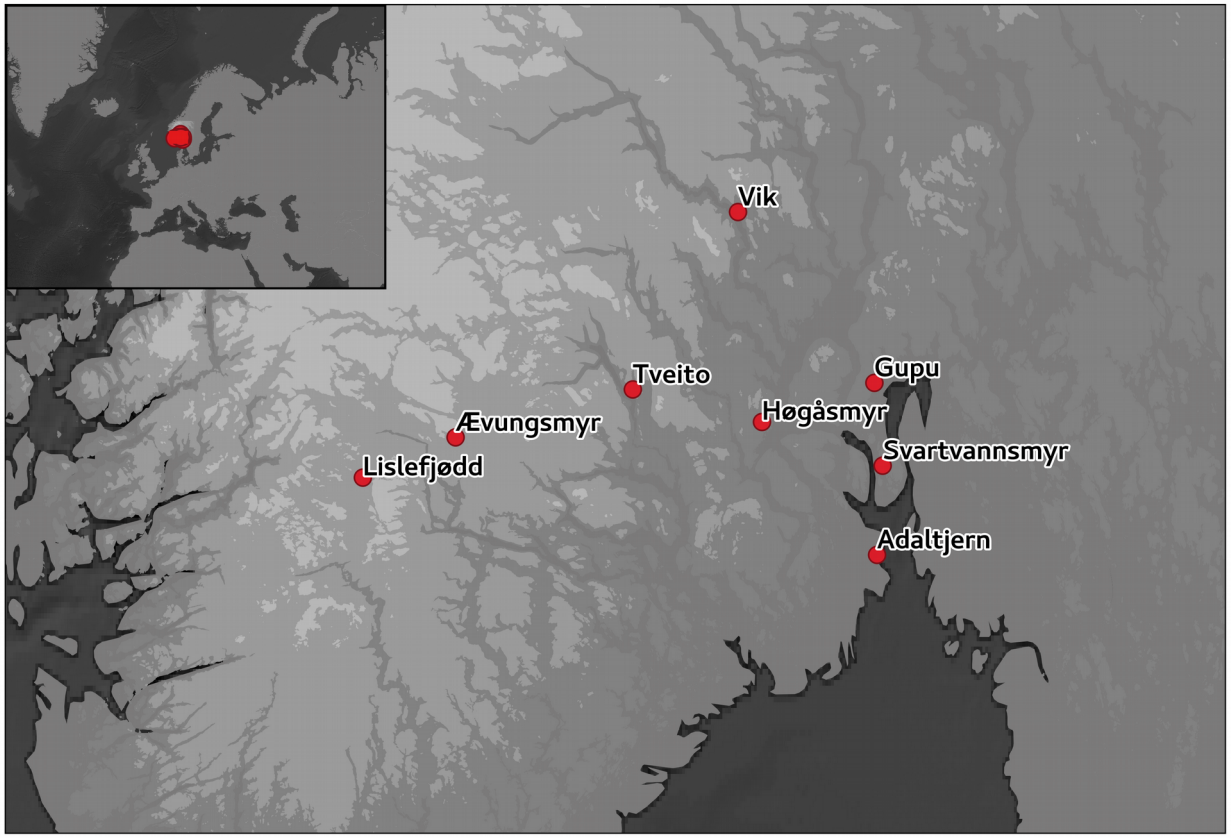
Fossil Pollen Data (Norwegian Sites)

- 8 exemplary sites were selected for this first study on the pollen dataset by Helge Høeg.
- The sites represent a good diversity in terms of climate conditions (different altitudes)



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Fossil Pollen Data (Norwegian Sites)

Site	Altitude	Chron	Samples	Citation
Adaltjern, Borre Vestfold	85 m	9554	74	1996 b Pollenanalytiske undersøkelser. I: Jerpåsen, G.B.: Gunnerød - En arkeologisk landskapsanalyse. Varia 35 Universitetets Oldsaksamling.
Ævungsmyr, Rauland, Vinje, Telemark	859 m	10602	57	Høeg 1978 The immigration of Picea abies to southeastern Norway with special regard to Telemark (a preliminary report). Norwegian Journal of Botany 25 s. 19-21.
Gupu, Bærum, Akershus	291 m	10437	58	2000b Pollenanalytiske undersøkelser på Gupu, Bærum kommune, Akershus I: Larsen, Stenseng og Kittelsen: Vestmarka, seterliv og kølabrenning
Høgåsmyr, Øvre Eiker, Buskerud	313 m	8872	39	Upubl.
Lislefjødd, Øvre Breive, Bykle, Aust-Agder	995 m	8950	22	Upubl. (Manuskript in prep)
Svartvannsmyr, Hurum, Buskerud	173 m	11145	63	Pollenanalyse Hurum. Årbok 1999, Det norske videnskapsakademi
Tveito, Hovin, Gransherad, Telemark	419 m	11306	58	Høeg 1989 a Noen resultater fra den pollenananlytiske undersøkelsen i Telemark. I: E. Mikkelsen: Fra jeger til bonde.. Utviklingen av jordbrukssamfunn i Telemark i steinalder og bronsealder. Universitetets Oldsaksamling Skrifter Ny rekke nr. 11 s. 372-421. Oslo
Vik, Flå, Buskerud	155 m	8485	32	Upubl.

Technique for infering paleoenvironment information

- For analysing the pollen data we us R package “**rioja**”

- rioja: Analysis of Quaternary Science Data
  - Functions for the analysis of Quaternary science data, including constrained clustering, [...] transfer functions, and stratigraphic diagrams. (cited from CRAN)

- In particular we use the **Modern Analogue Technique (MAT),** to infer paleoenvironment information

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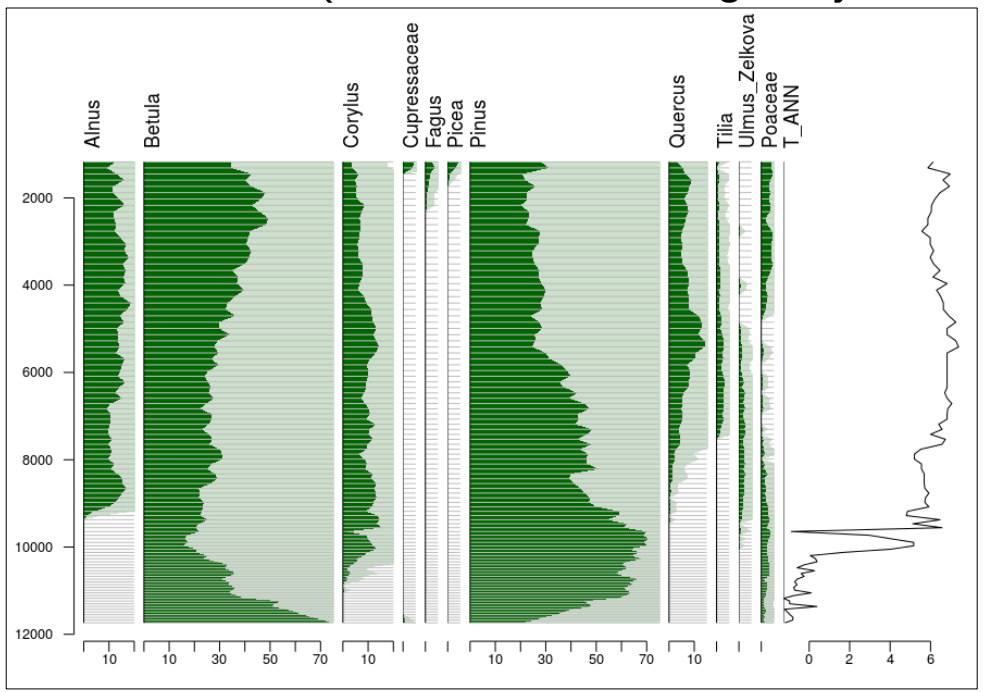
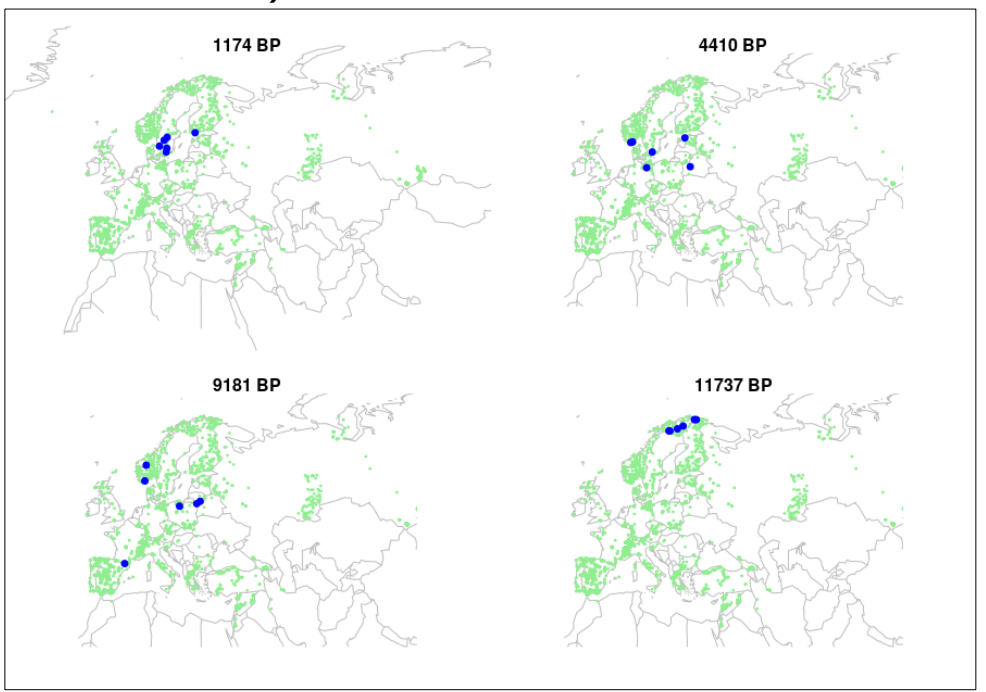
Modern Analogue Technique (MAT)

- Function MAT takes a training dataset of biological data (species abundances) y and a single associated environmental variable x, and generates a model of closest analogues, or matches. (Cited from “Package rioja” R documentation).





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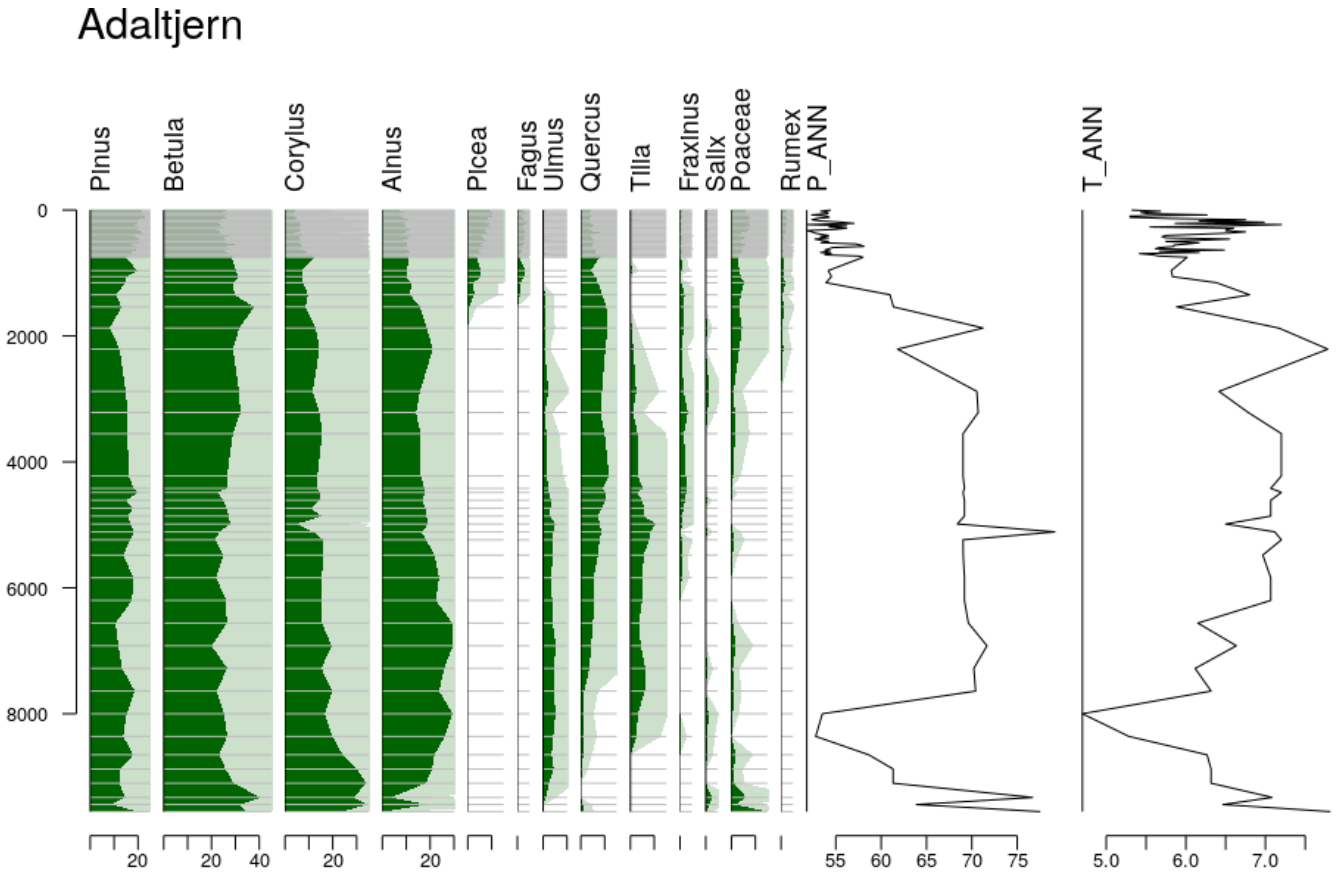
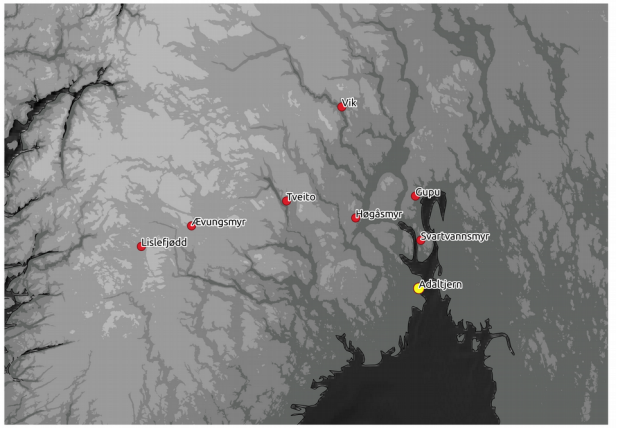
Results of Pollen Analysis





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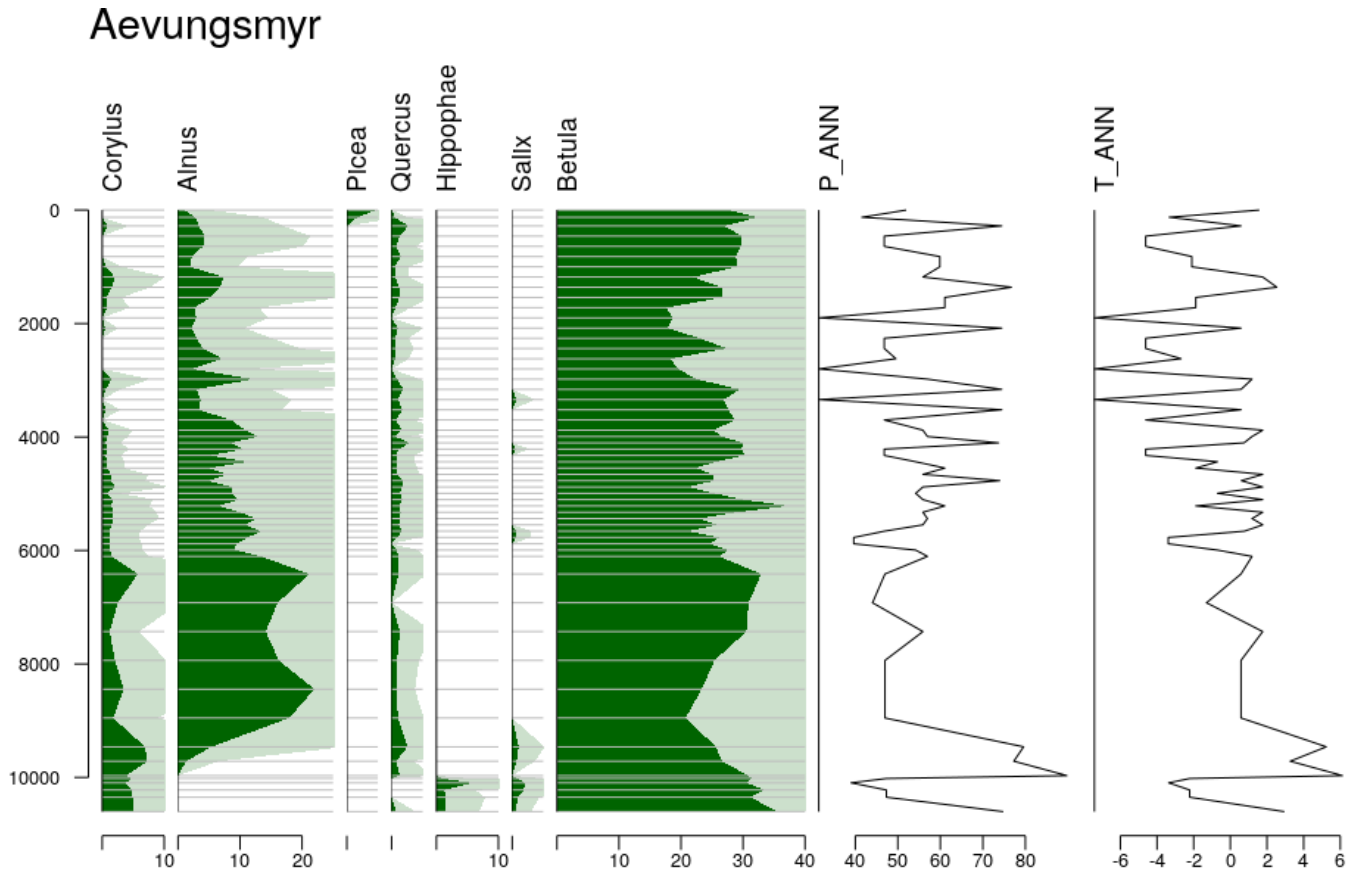

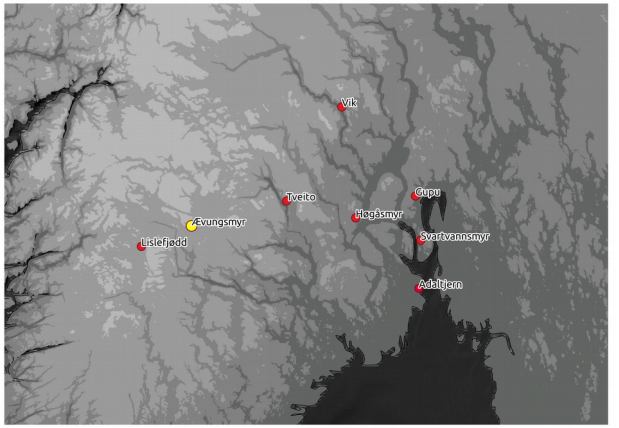

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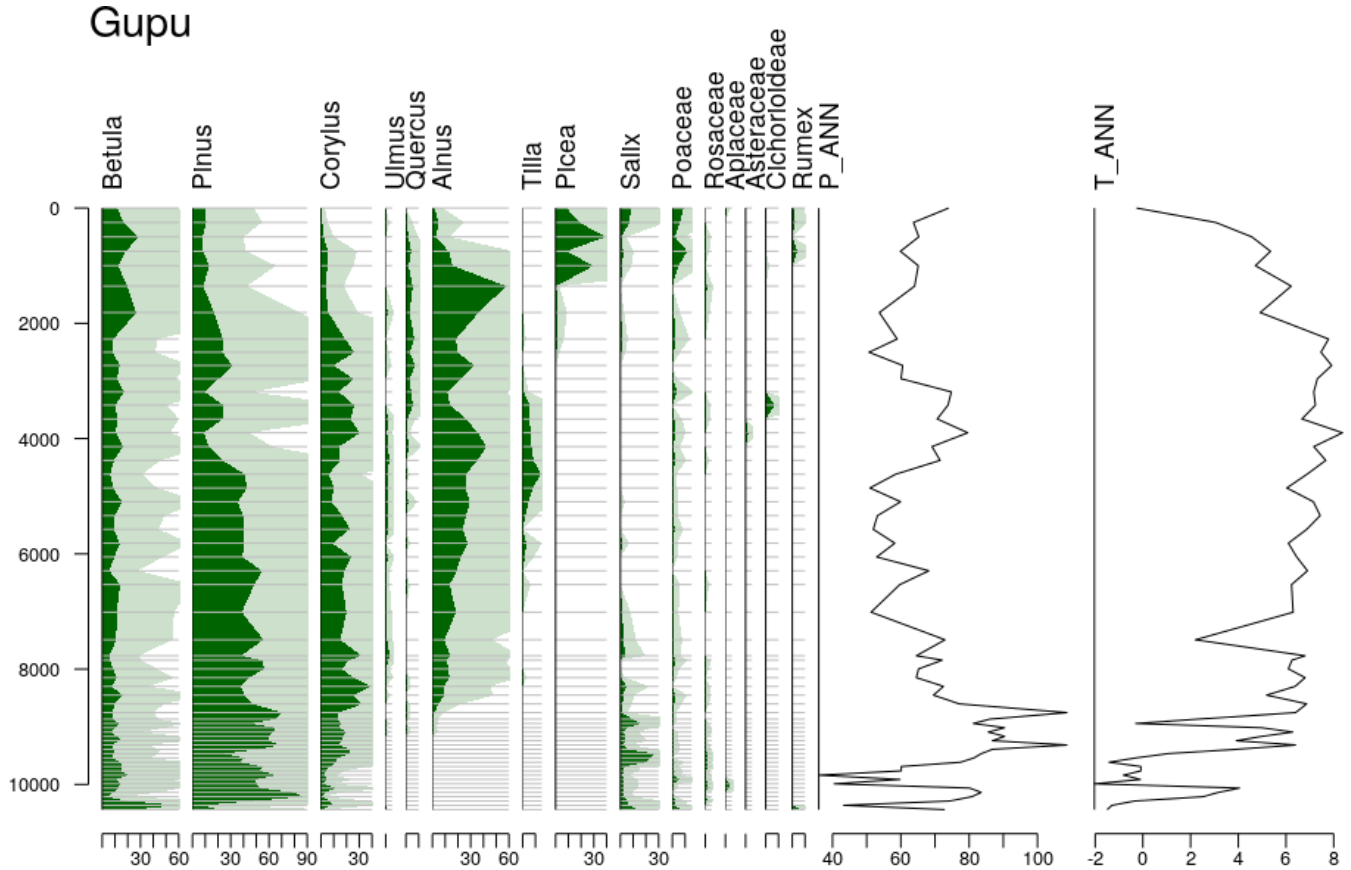

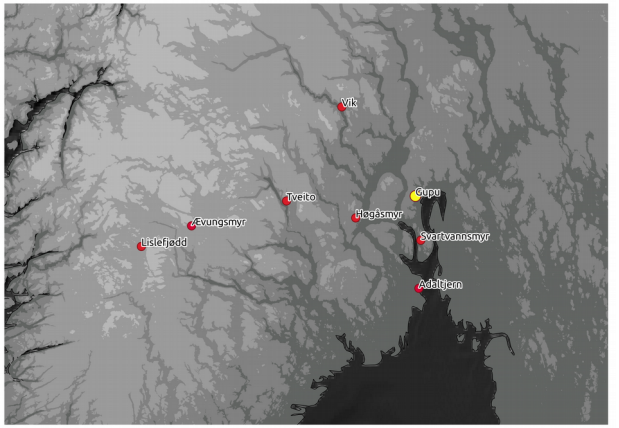

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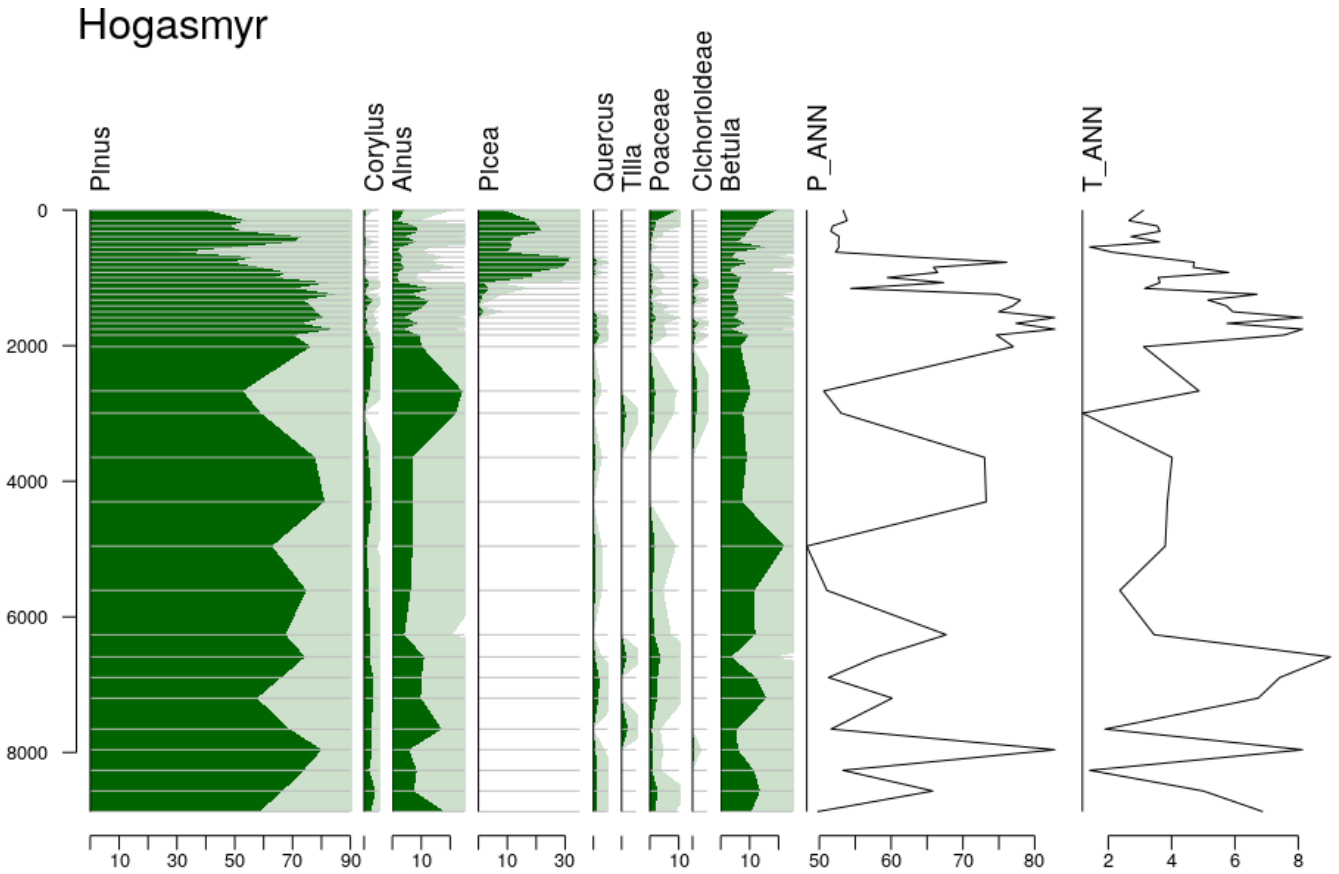

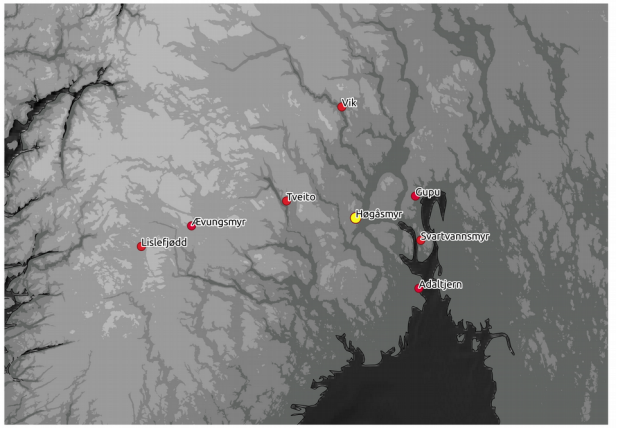

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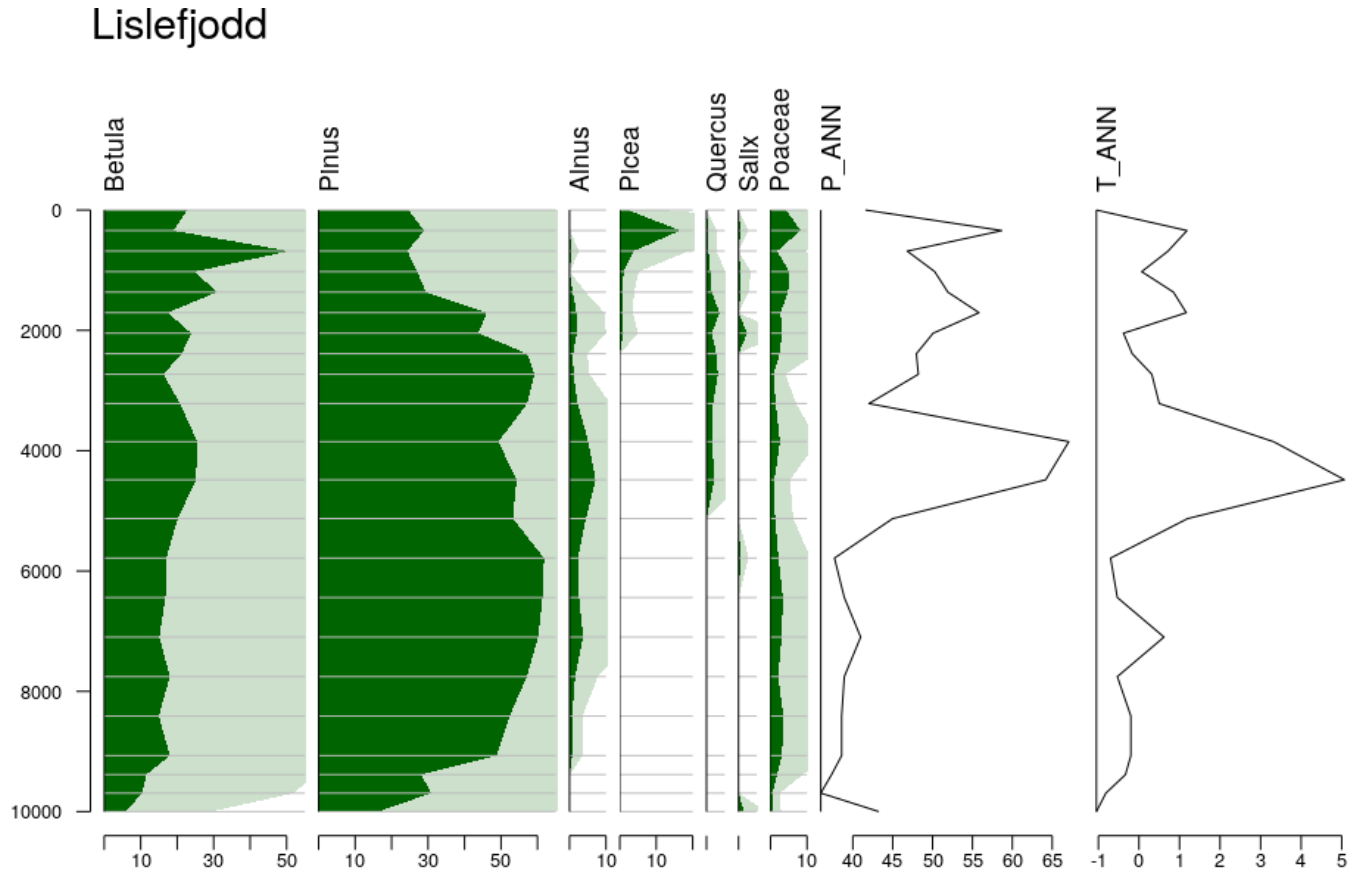

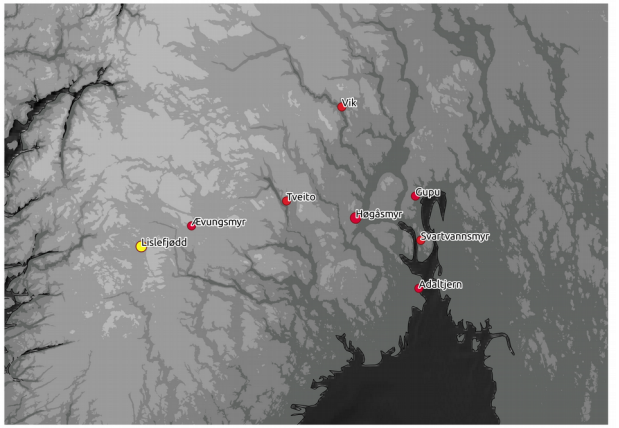

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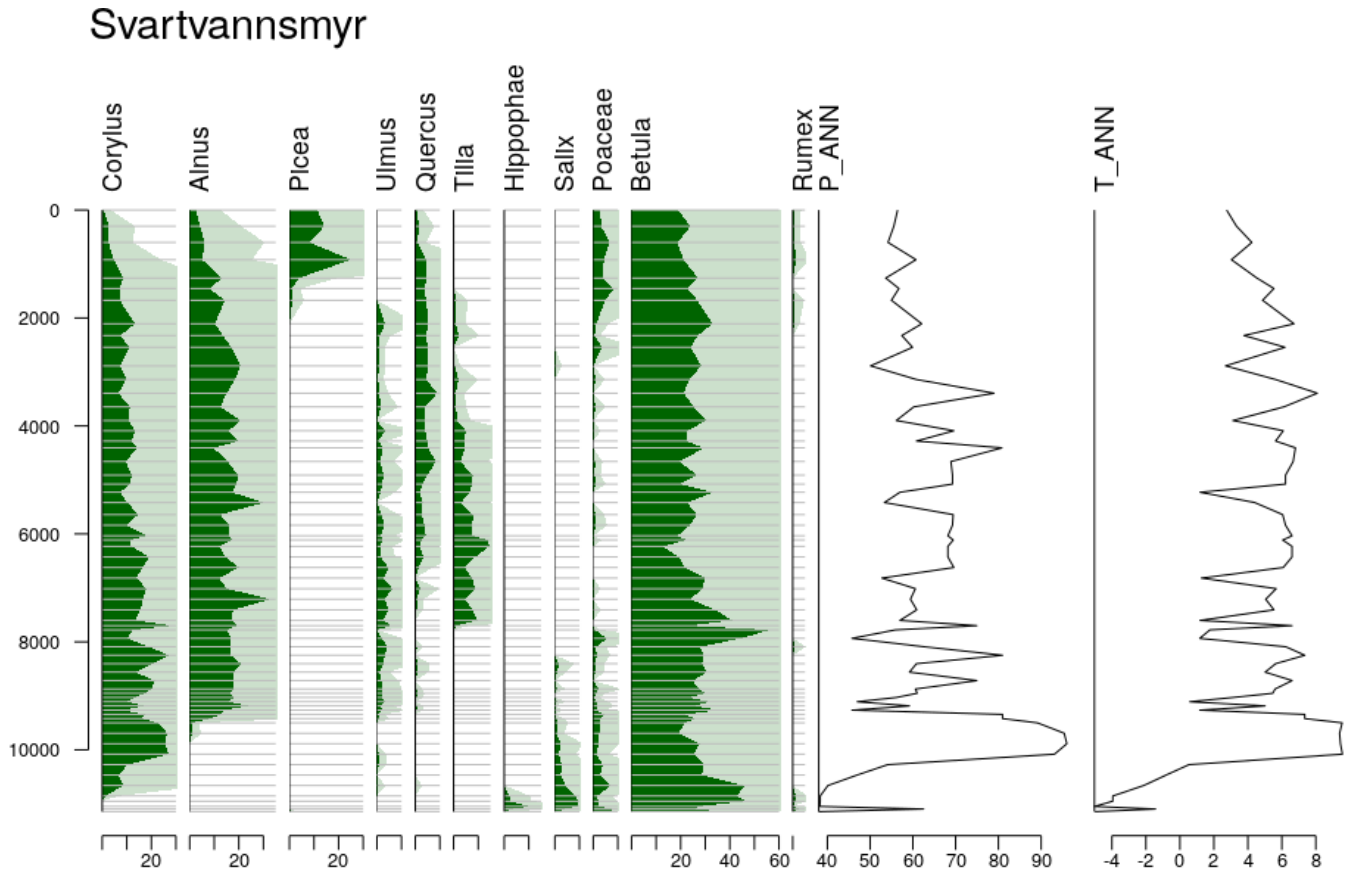

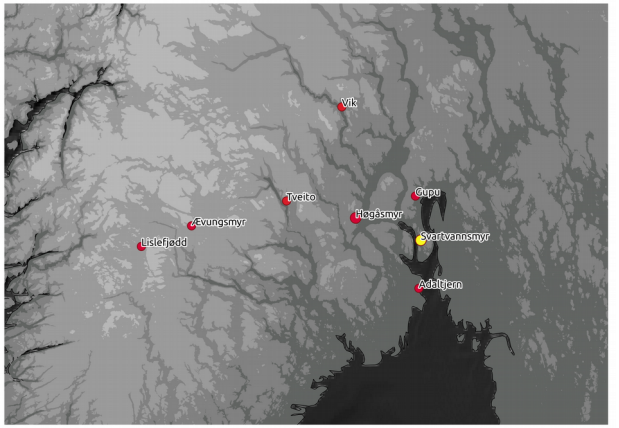

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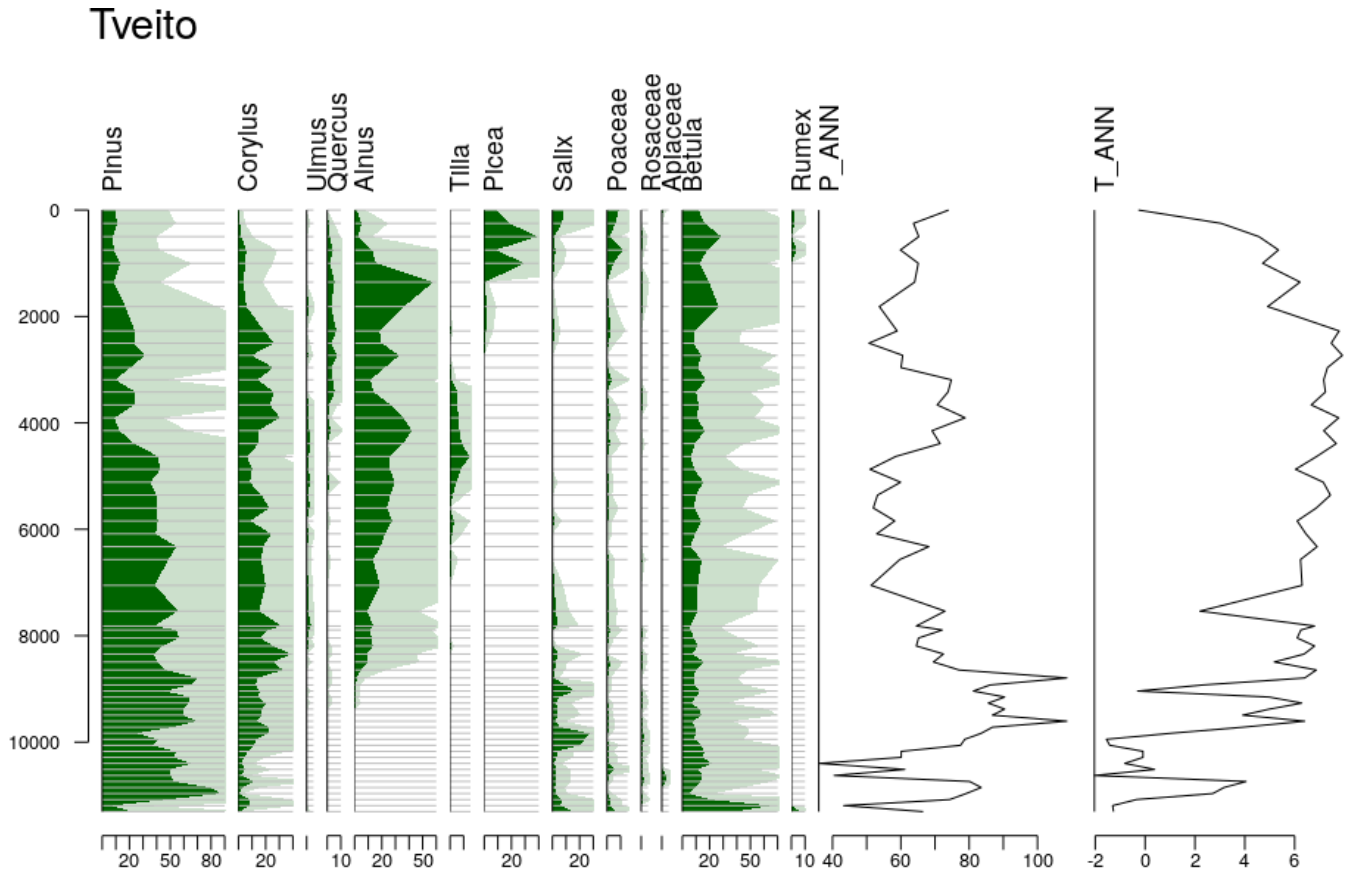

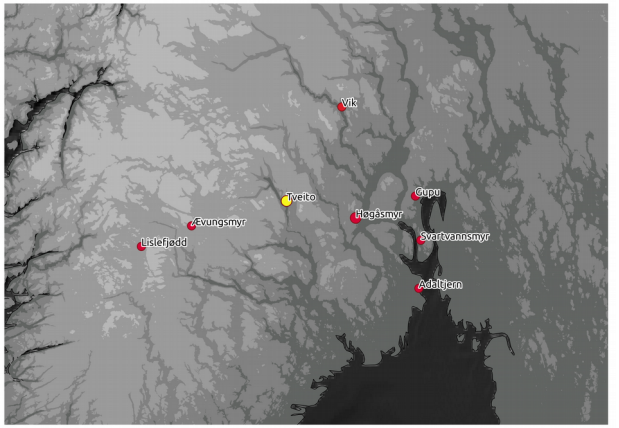

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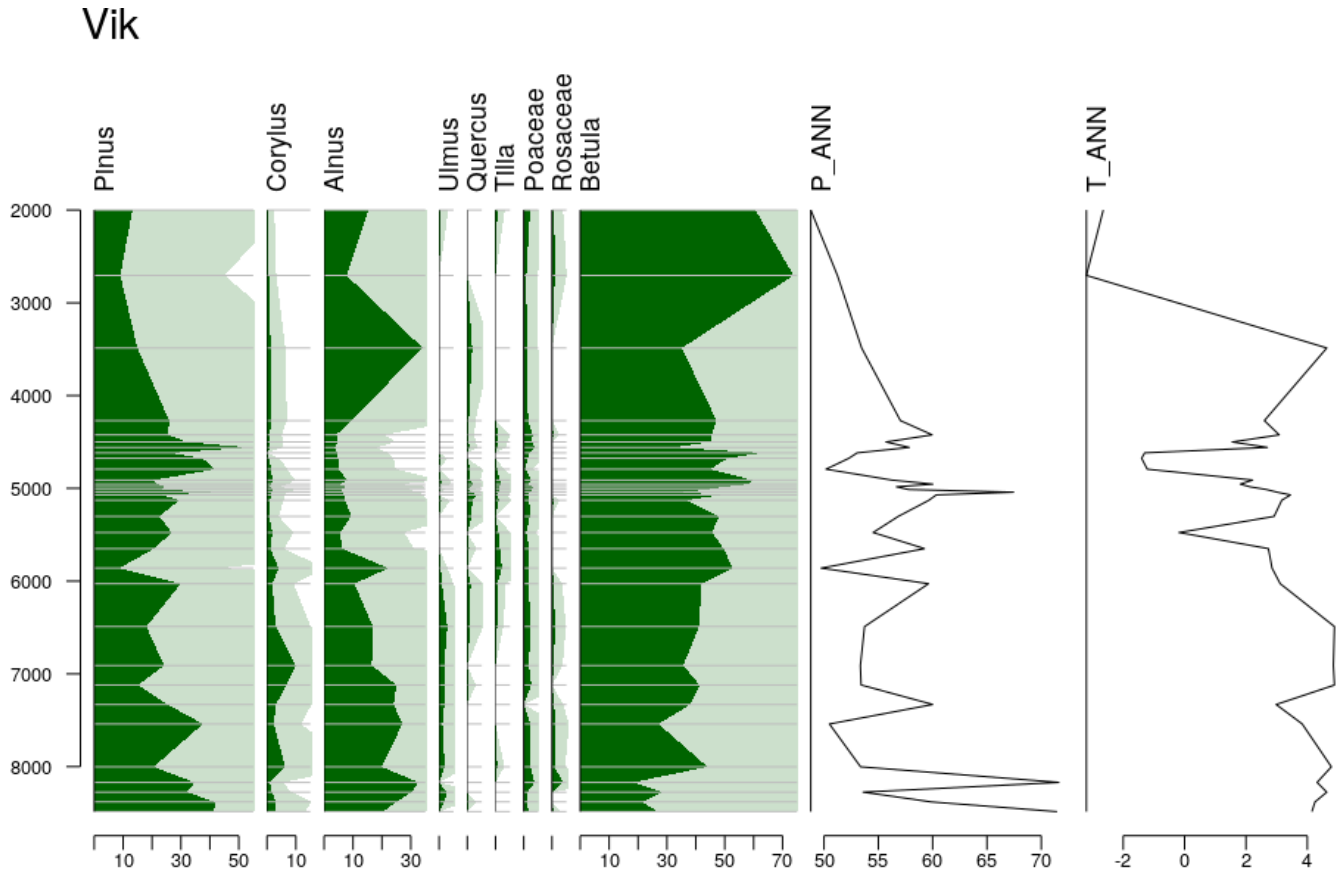

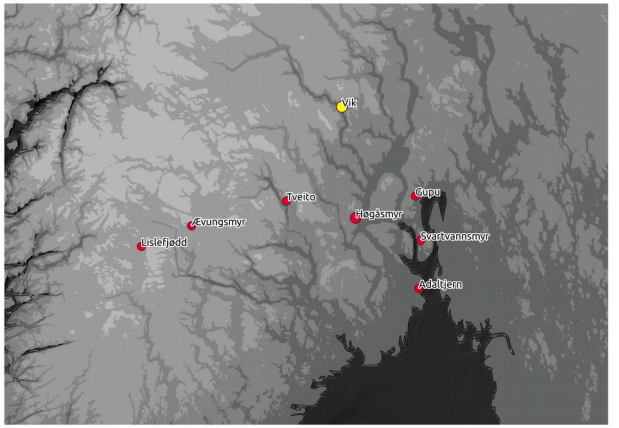

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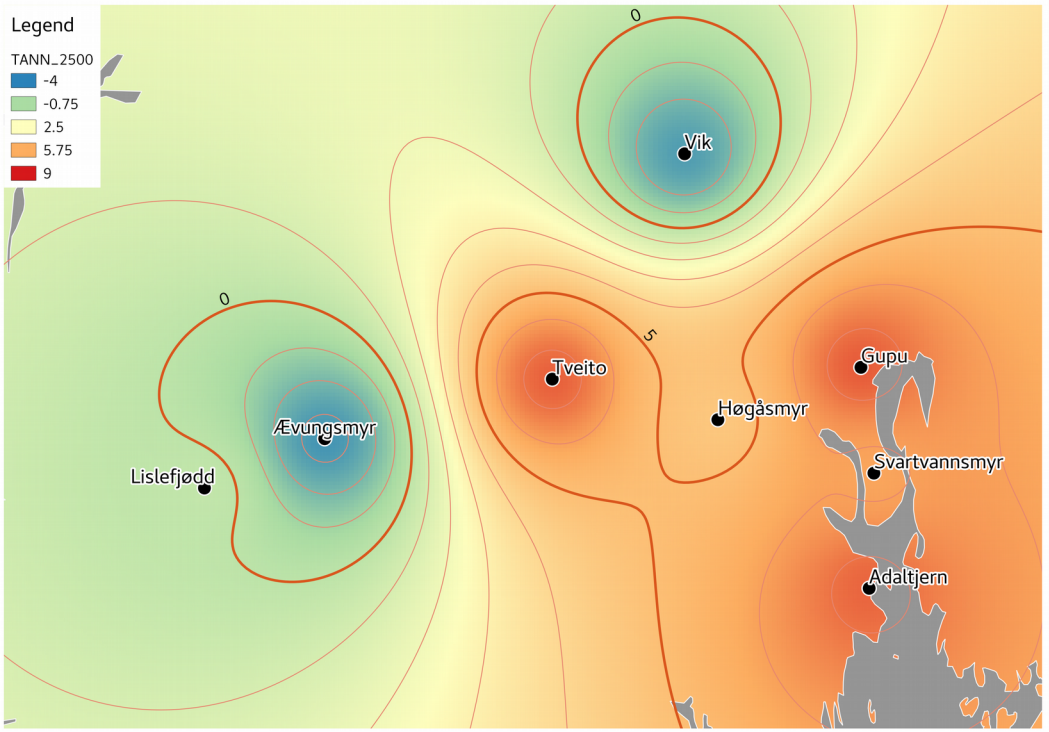
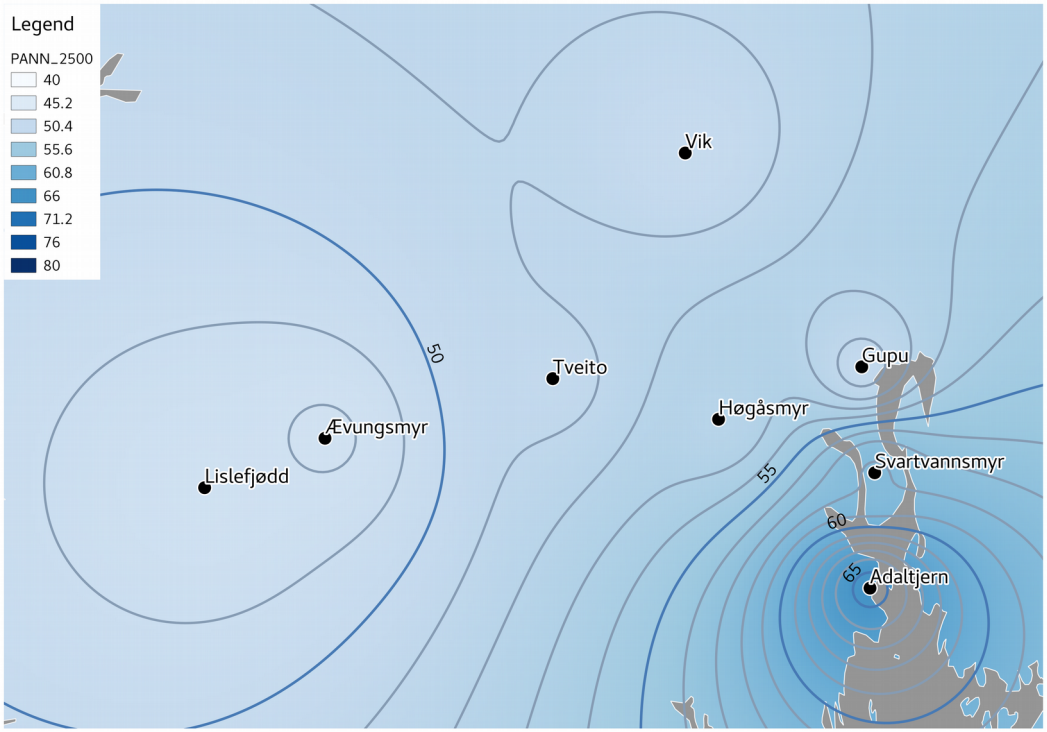
Creation of paleoenvironment maps

- IDW interpolation for three time steps of T_ANN and P_ANN

Site	T 2500	T 3500	T 5000	P 2500	P 3500	P 5000
Svartvannsmyr	5.9	6	6.2	58.1	62	69
Høgåsmyr	4.7	3.9	3.8	52.1	70.5	48.3
Vik	-3	4.6	2.1	50	54	56.6
Ævungsmyr	-3.3	0.4	-0.5	47.8	69.9	54.4
Tveito	7.4	7.1	6.9	50.6	73.2	58.1
Lislefjødd	0.2	2.9	1.6	48	64.1	47
Adaltjern	7.4	7.1	7	50.6	72.9	58.5
Gupu	7.5	7.2	7.1	50.5	73.5	59

Paleoenvironment maps: 2500 BP





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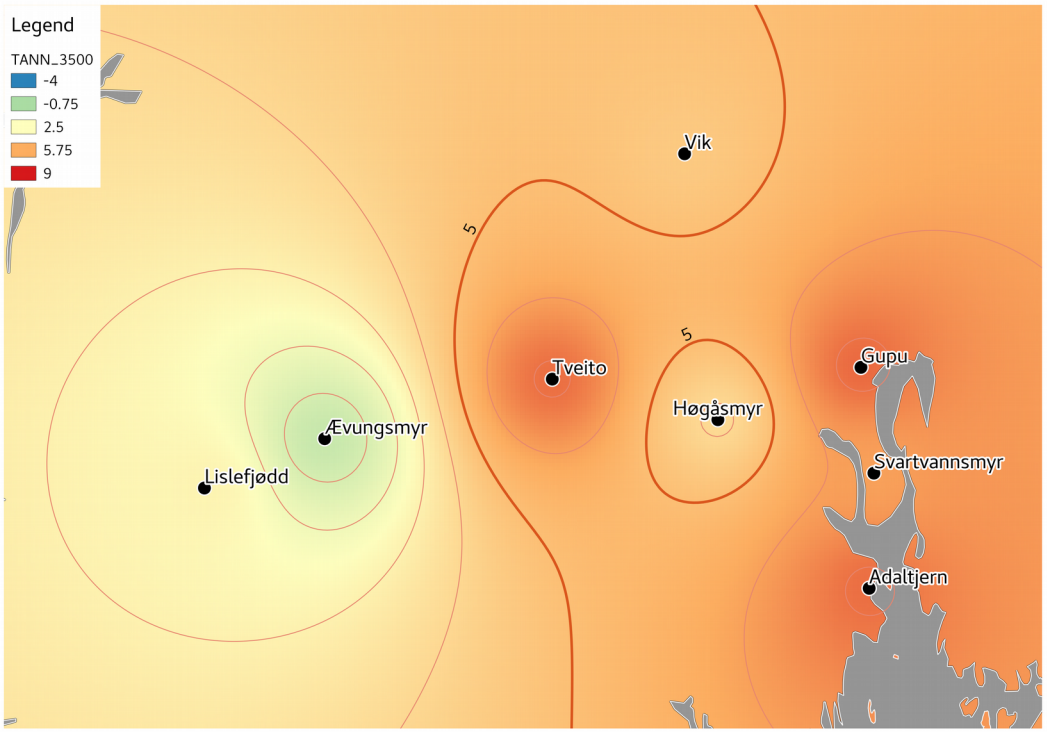
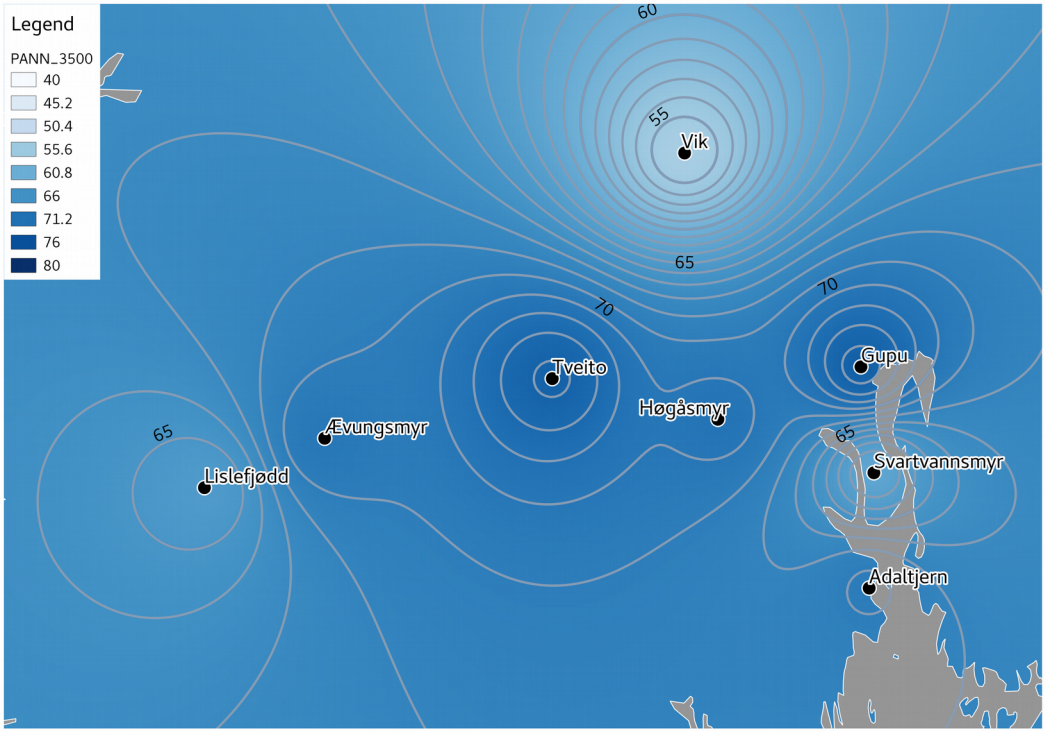
Paleoenvironment maps: 3500 BP





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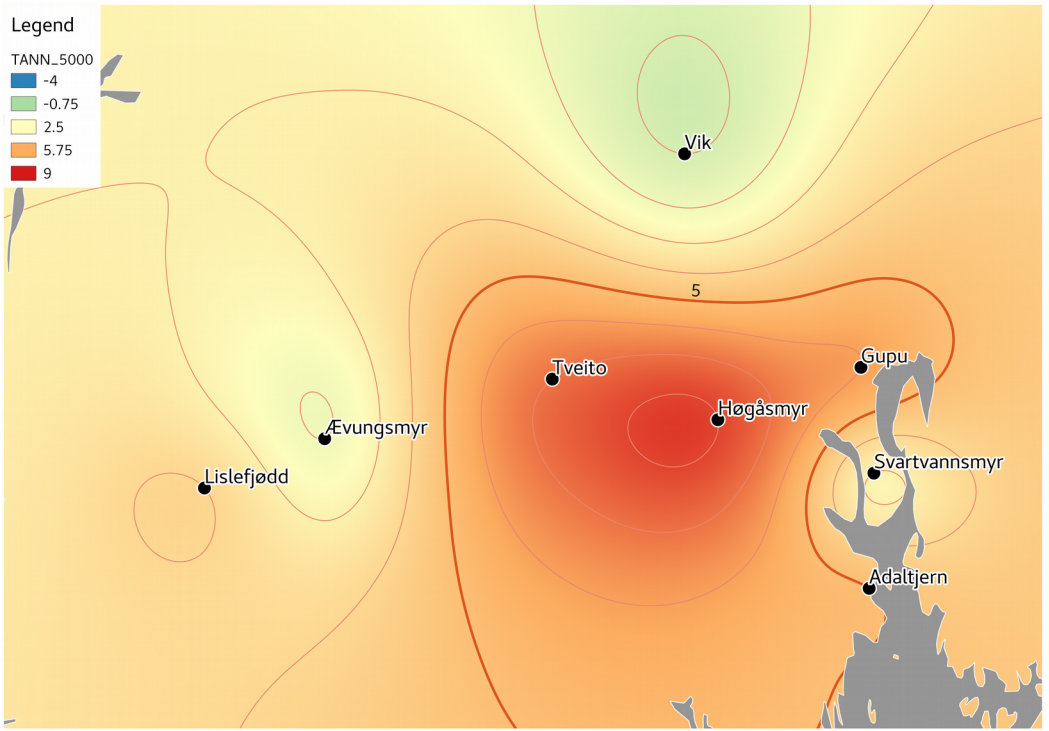
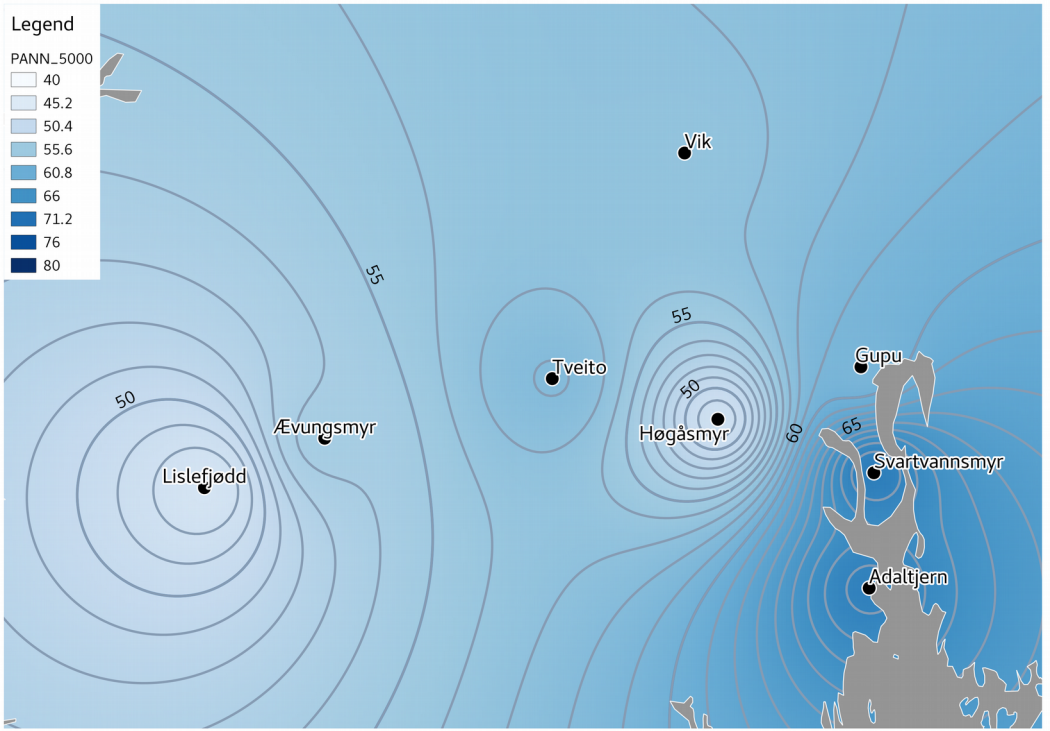
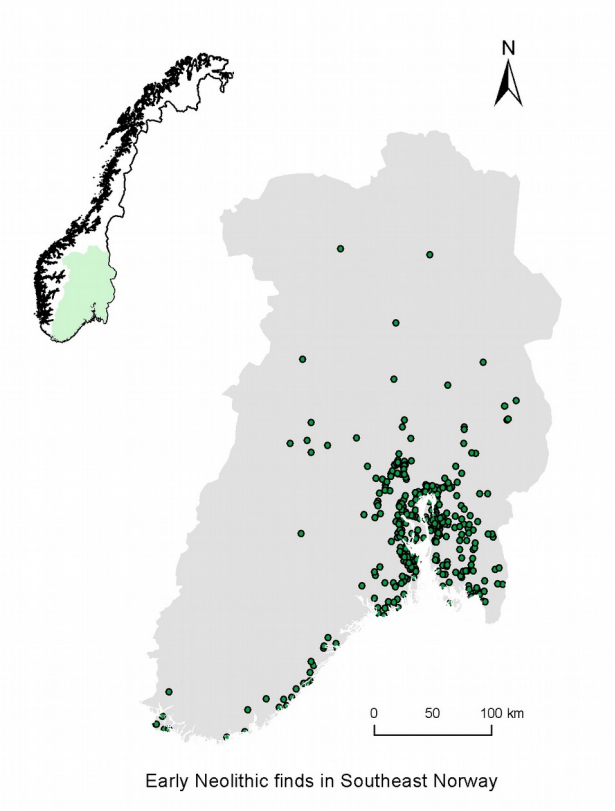
Paleoenvironment maps: 5000 BP

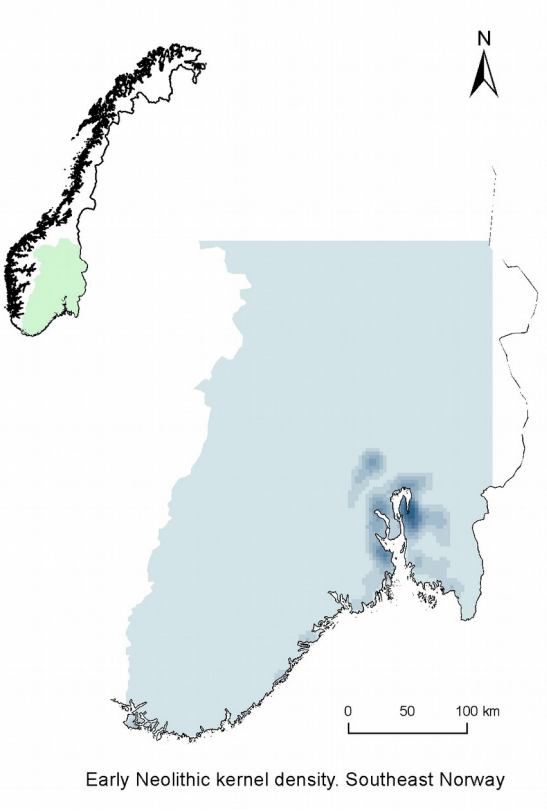




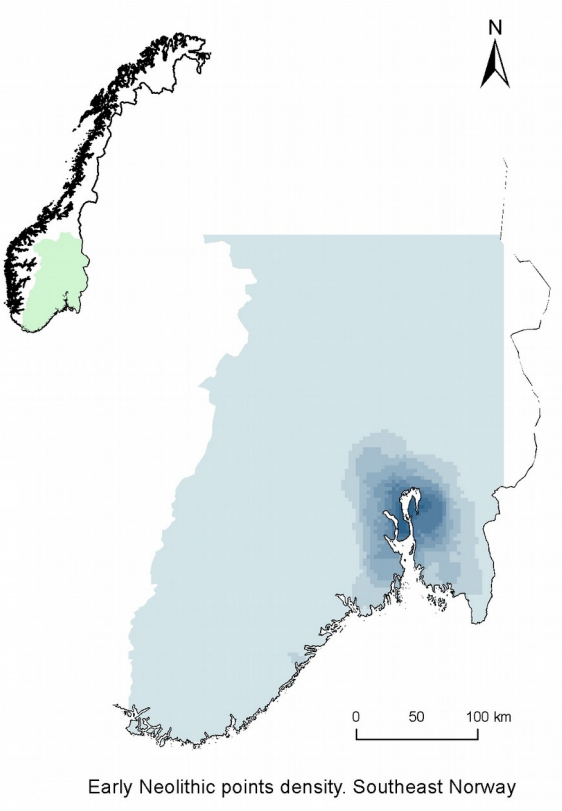
Archaeology: 5000 BP Early Neolithic



Early Neolithic finds in Southeast Norway



Early Neolithic kernel density. Southeast Norway



Early Neolithic points density. Southeast Norway

Data source: MUSIT database. http://unimus.no

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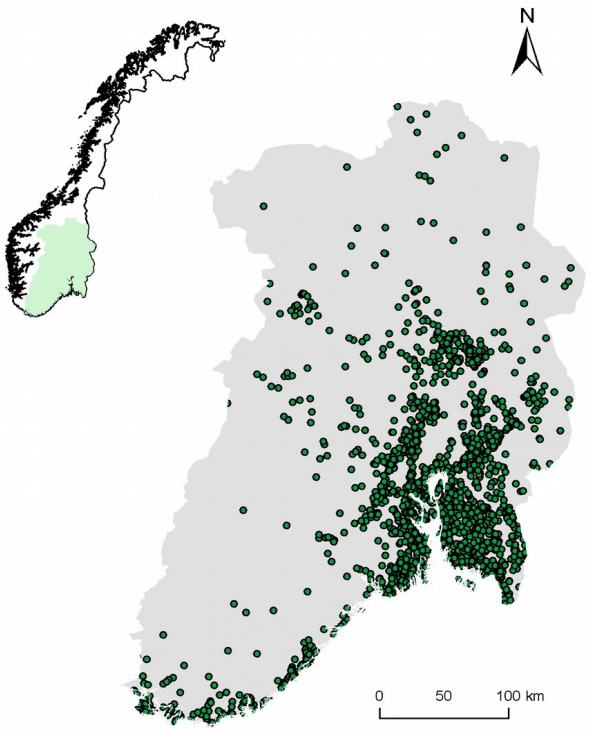
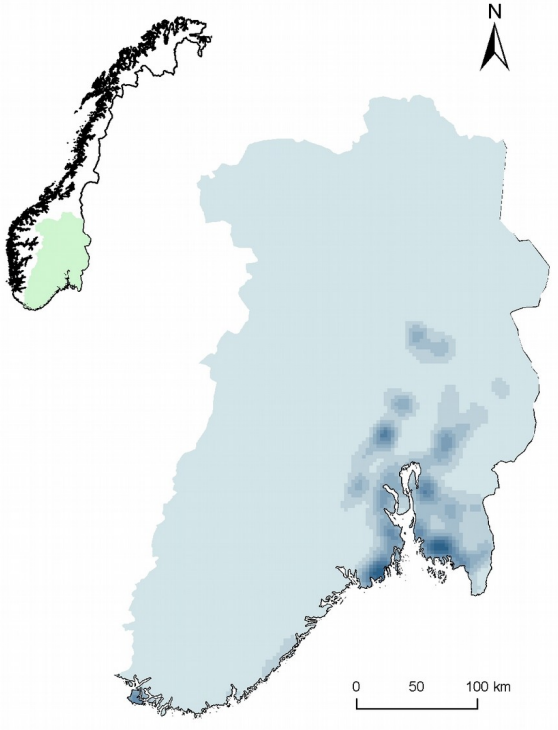
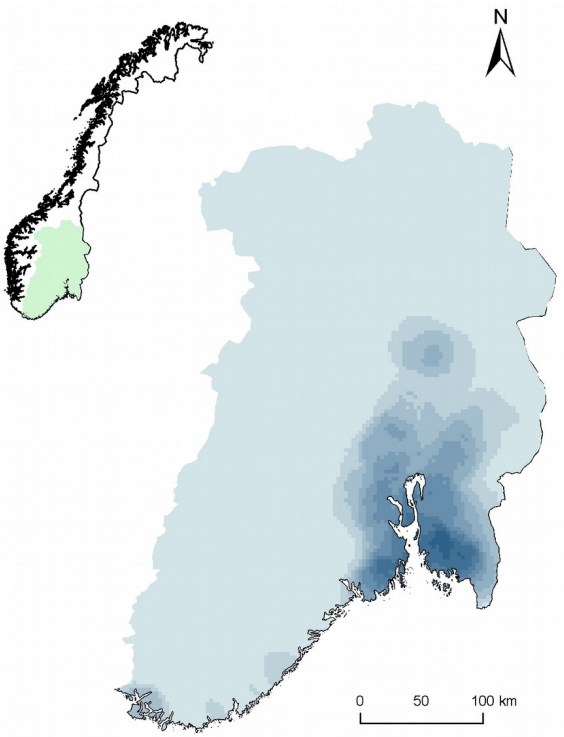
Archaeology: 3500 BP Late Neolithic



Late Neolithic finds in Southeast Norway



Late Neolithic kernel density. Southeast Norway



Late Neolithic point density. Southeast Norway

Data source: MUSIT database. http://unimus.no

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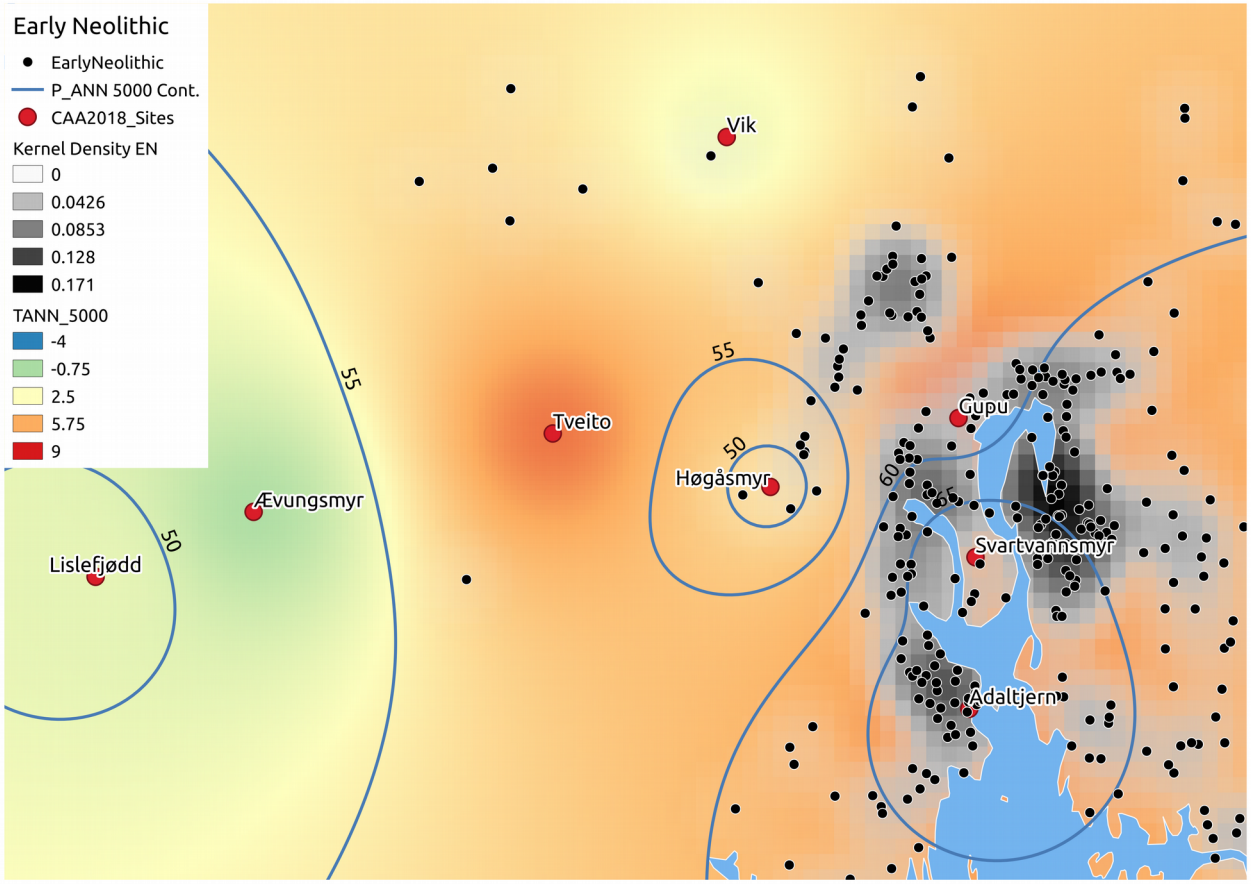
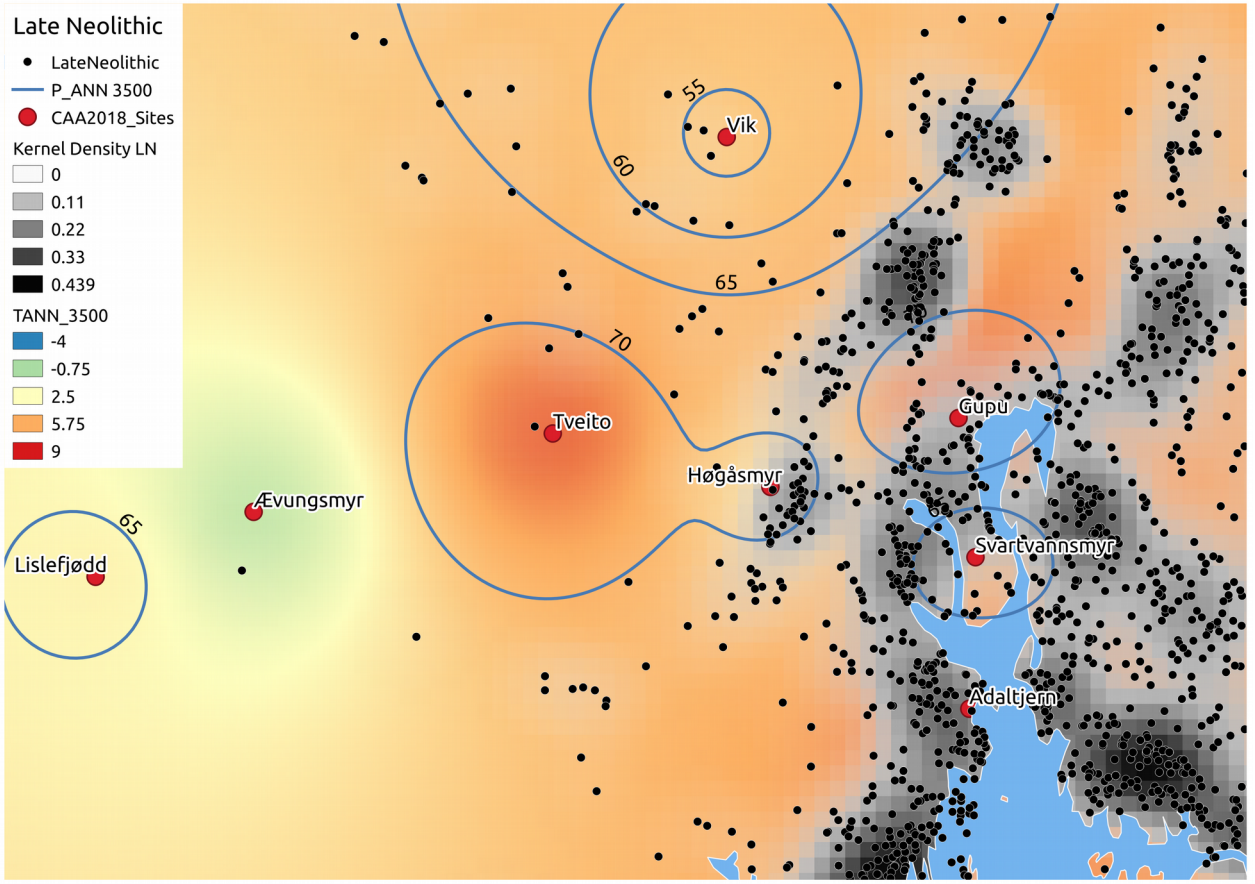
Relating paleoenvironment to archaeology



Relating paleoenvironment to archaeology



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Conclusions and Outlook

- Improve pollen data workflow (check species translations)
- Expert feedback on pollen data sets and interpretaions of it
- Improvement of Paleoenvironment maps
  - More Sites
  - DEM (tension) based interpolation for Temperature
  - Biomization of pollen spectra to create BIOME maps
  - Infer Köppen-Geiger Zones through MAT
- Develop validation methods to validate the paleoenvironment data.
- Apply state of the art Spatio-Temporal Interpolation Techniques, on inferred environment variables, to increase spatial and temporal resolution and accuracy.

Thank you!

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Workflow for creating paleoenvironment information

Data conversion

1. Open .til or .tlx file in Tilia software

2. Select complete Spreadsheet (Strg+A)

3. Copy and Paste the data into an empty Libre Office Calc SpreadSheet

5. Export Calc Spreadsheet as CSV using Tab as delimiter and UTF-8 for encoding

6. Read the Data into R

Workflow for creating paleoenvironment information

R code

```
[…]
train <- EMPD_climate[, 1:45]
T_ANN <- EMPD_climate[, "T_ANN"]
MAT.T_ANN <- MAT(train, T_ANN, dist.method = "sq.chord", k = 6)

MAT.T_ANN.h <- crossval(MAT.T_ANN, k=10, cv.method="h-block", h.dist=geo.dist,
h.cutoff=300)

p.species.MAT.T_ANN <- predict(MAT.T_ANN, p.species, k=6)
```