Using the Landscape Reconstruction Algorithm (LRA) to estimate Holocene regional and local vegetation composition in the Boreal Forests of Alaska

Geography and Environment

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Background

The Arctic is sensitive to climate change and it is predicted that the region will experience rapid changes with future global warming. Vegetation is already responding to increasing global temperatures. Woody species are migrating northwards in a process called "greening". Lakes are important features within these changing landscapes, and lake ecosystems are affected by the vegetation in their catchments. Use of dated sediment archives can reveal how lakes responded to past changes over timescales relevant to vegetation dynamics (decades to centuries).

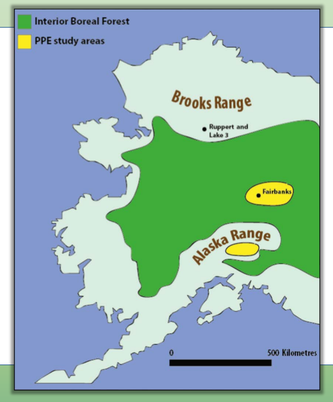

Fig.1. Location map of study sites

Aims and Study Sites

This project will reconstruct Holocene vegetation changes in two small lake catchments in Alaska (Ruppert and Lake 3) to help us to understand the long-term interactions between vegetation and within-lake processes. Determining quantitative vegetation cover around these small lakes is vital for understanding long-term lake ecosystem dynamics. Estimates of how much pollen different plants produce (Pollen Productivity Estimates or PPEs) are one of the major parameters used to make quantitative estimates of land cover from palaeodata. Our aim is to obtain the first PPEs for the dominant forest and tundra taxa in Alaska and use them within the Landscape Reconstruction Algorithm (LRA) to estimate regional and local vegetation history in the central Brooks Range.

Pollen Productivity Estimates

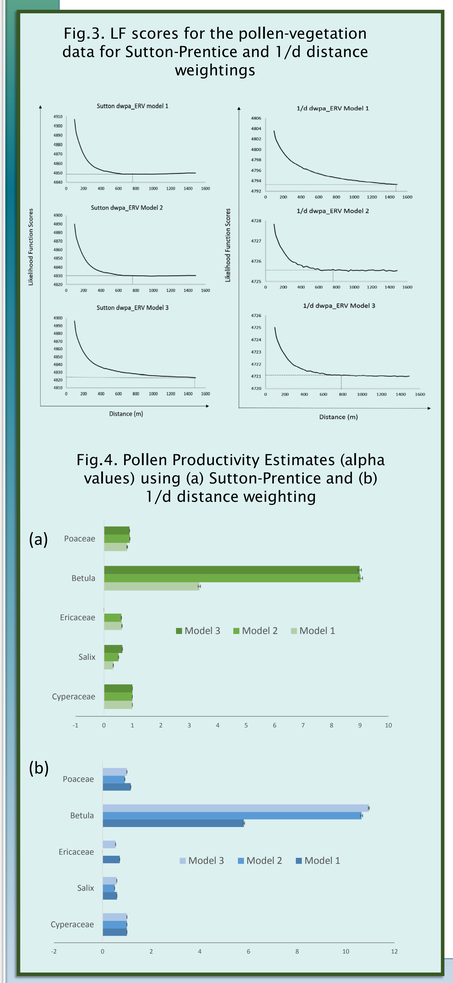

Fig.3. LF scores for the pollen-vegetation data for Sutton-Prentice and 1/d distance weightings

Fig.4. Pollen Productivity Estimates (alpha values) using (a) Sutton-Prentice and (b) 1/d distance weighting

Fig.2. Salix and *Betula* shrub tundra

Moss polsters were collected from 22 sites in central Alaska to obtain PPEs. 10 sites were located in the tundra (in the Alaska Range) and 12 in the boreal forests around Fairbanks (Fig.1 and 2). Preliminary results from the tundra dataset are presented here.

A total of 1000 pollen grains were counted and vegetation survey data were distance-weighted for each plot. Estimates of pollen productivity and of the Relative Source Area of Pollen (RSAP) were obtained using POLERV (Middleton, unpublished program). Cyperaceae was used as the reference taxon and all 3 ERV sub-models were run. The Likelihood Function Scores (LF scores, Fig.3) represent the goodness of fit between pollen-vegetation data and when they reach an asymptote that is where the RSAP is reached. **In the tundra the RSAP is around 800m**.

The LF scores suggest that ERV sub-models 2 and 3 perform best with our dataset. *Betula* produces the highest PPEs using Sutton-Prentice (9.02 Model 2; 8.98 Model 3) and 1/d distance-weighting methods (10.65 Model 2; 10.95 Model 3).

The LRA

The Landscape Reconstruction Algorithm (LRA) is a two step framework of quantitative reconstruction of vegetation and landscape (Sugita, 2007). REVEALS estimates the regional vegetation abundance from large sites and LOVE calculates the background pollen and incorporates this into the reconstruction of vegetation composition within the RSAP.

An initial test run of REVEALS on Sithylemenkat Lake, Alaska (Anderson *et al*, 1990) throughout the Late Glacial illustrates the comparison between pollen percentages and REVEALS estimates when using the preliminary tundra PPEs and existing European PPEs from the LANDCLIM project (Gaillard *et al*, 2010, Fig.5).

Preliminary findings: The vegetation trends are the same but different sets of PPEs produces marked differences in the representation of taxa. The Alaskan tundra PPEs indicate that *Betula* is dramatically over-represented in pollen percentages, and in reconstructed land cover using REVEALS it loses its dominance to *Salix*.

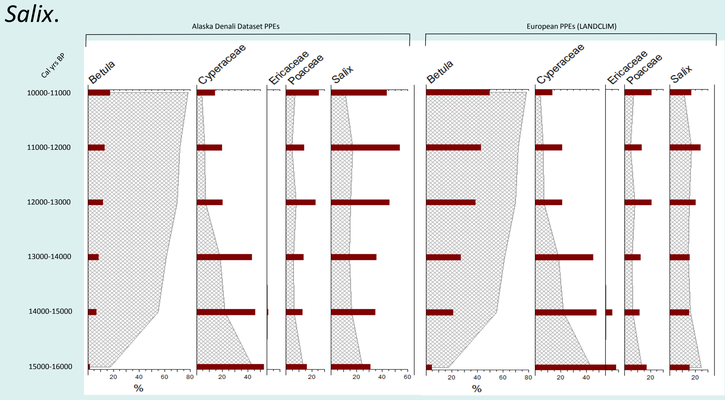

Fig.5. Initial REVEALS results on Sithylemenkat Lake. Grey shading = pollen percentages and Red Bars = REVEALS estimates

Summary

- The RSAP of 800m is comparable with other open landscapes in Europe
- *Betula* is a high pollen producer in the tundra in Alaska
- Using different sets of PPEs with REVEALS produces marked differences in the representation of taxa in the Late Glacial
- Using the Alaskan tundra PPEs with REVEALS the relationship between *Betula* and *Salix* is inverted
- The differences in PPEs between Europe and Alaska may largely be attributed to different species, for example *Betula glandulosa* (Alaska) vs. *B. nana* (Europe).
- Different species of *Betula* and *Salix* are present in the Forest dataset. These have produced PPEs that differ from those of tundra species.

Future work

- Compare full set of PPEs from the tundra and forest datasets
- Test LOVE on modern samples from small lakes in Alaska
- Apply LRA reconstruction to small lakes in the Brooks Range

References

Anderson, P.M., Reanier, R.E. and Brubaker, L.B. (1990) A 14,000-year pollen record from Sithylemenkat Lake, north-central Alaska, *Quaternary Research*, 33(3):400-404

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