Application of the Landscape Reconstruction Algorithm: the LANDCLIM project and beyond

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Outline

1. Regional changes in vegetation and land cover: assumptions and conditions
2. Local-scale reconstruction of vegetation and land cover: theory and caveats
3. Challenges
Landscape Reconstruction Algorithm

Step 1

pollen counts from large sites

(≥100-500 ha)

REVEALS

(Regional Estimates of Vegetation Abundance from Large Sites)

Regional vegetation composition

estimates of pollen productivity

estimates of the relevant source area of pollen at target sites

Generalized R-value Model (Davis 1963) by incorporating (1) intertaxonomic differences in pollen dispersal characteristics and (2) basin size

Sugita (2007a,b)
The Holocene, 17, 229-241 & 243-257
Simulation design to evaluate REVEALS (Sugita 2007a)

<table>
<thead>
<tr>
<th></th>
<th>Matrix</th>
<th>Patch type 1</th>
<th>Patch type 2</th>
<th>Patch type 3</th>
<th>Regional vegetation composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional proportion of area</td>
<td>0.40</td>
<td>0.30</td>
<td>0.20</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Mean size (ha)</td>
<td>30±10</td>
<td>5±4</td>
<td>2±1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poaceae (grass)</td>
<td>0.95</td>
<td>0.01</td>
<td>0.05</td>
<td>0.30</td>
<td>0.423</td>
</tr>
<tr>
<td>Picea (spruce)</td>
<td>0.01</td>
<td>0.75</td>
<td>0.01</td>
<td>0.01</td>
<td>0.232</td>
</tr>
<tr>
<td>Betula (birch)</td>
<td>0.01</td>
<td>0.20</td>
<td>0.25</td>
<td>0.30</td>
<td>0.144</td>
</tr>
<tr>
<td>Quercus (oak)</td>
<td>0.01</td>
<td>0.03</td>
<td>0.14</td>
<td>0.38</td>
<td>0.079</td>
</tr>
<tr>
<td>Fagus (beech)</td>
<td>0.02</td>
<td>0.01</td>
<td>0.55</td>
<td>0.01</td>
<td>0.122</td>
</tr>
</tbody>
</table>

30 lakes; lake radius 20–, 390–, and 750–m; neutral atmosphere
Estimated vegetation composition

Lake size

Radius = 20m (0.13 ha)

Radius = 390 m (48 ha)

Radius = 750 m (177 ha)

Sugita 2007a

abundance at individual sites with standard error estimate

mean abundance over 30 sites with standard error estimate
Regional changes in vegetation and land cover: Caveats for REVEALS applications

• REVEALS assumes no pollen source on sedimentary basins; records from mires and bogs are problematic.

• Smaller-sized sites can be used; however, large errors are expected.

• Spatial patterns of regional vegetation are assumed to be stationary.

• Sites are distributed randomly.

⇒ Impacts of departures from the assumptions on outcomes need evaluation! (Mazier et al. in prep.)
Regional changes in vegetation and land cover in Estonia (Kangur, Koff, Sugita and others, in prep.)

- NE (5 lakes)
- NW (6 lakes)
- South (6 lakes)
Regional changes in vegetation and land cover in Estonia (Sugita, Kangur, Koff and others, in prep)
Regional changes in vegetation and land cover in Estonia (Sugita, Kangur, Koff and others, in prep)

Pinus

- NE (N=5)
- NW (N=6)
- South (N=6)

Picea

- NE (N=5)
- NW (N=6)
- South (N=6)

Pollen proportion REVEALS-based vegetation composition
Regional changes in vegetation and land cover in Estonia (Sugita, Kangur, Koff and others, in prep)
Regional changes in vegetation and land cover in Estonia (Sugita, Kangur, Koff and others, in prep)
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**Landscape Reconstruction Algorithm**

**Step 1**

Sugita (2007a,b) *The Holocene, 17, 229-241 & 243-257*

**Step 2**

Generalized Extended R-value Model (Prentice & Parsons 1983; Sugita 1994) by incorporating changes in regional vegetation and landscape, and thus background pollen, through time.

- Pollen counts from target sites
- LOVE (Local Vegetation Estimates)
- Vegetation composition within the relevant source area of pollen
- Estimates of pollen productivity
- Estimates of the relevant source area of pollen at target sites

Defined as the area (or distance) beyond which correlations between pollen loading and vegetation abundance *for all taxa* in a region do not continue to improve.
Why does the relevant source area of pollen matter for vegetation reconstruction?

The RSAP is the *smallest spatial unit* of vegetation and land cover that can be quantified from pollen records.

⇒ Spatial patterns of vegetation and land cover *within the RSAP* cannot be estimated using the pollen record alone.
**Background Pollen Loading**

Relevant source area of pollen (RSAP)

Distance-Weighted Plant Abundance (DWPA) of Species $i$ within the RSAP
Relationship between pollen % and local vegetation and landscape is complex and hard to evaluate.

Observations (Broström et al., 1998)

- Southern Skåne (open agricultural landscape)
- Northern Skåne & Småland (semi-open landscape)

Broström 2002

Map showing distribution of Southern and Northern Skåne and Småland regions.
Simulation 1
Open Agricultural Landscape

Simulation 2
Half-Open Forested Landscape

Sugita, Gaillard, & Broström 1999
Simulated pollen assemblages in open and semi-open landscapes:

Pollen % vs vegetation composition of Poaceae

Sugita (2007)
The Holocene, 17, 243-257

Poaceae composition within 1000 m from lake shore
Simulated pollen assemblages in open and semi-open landscapes:

**REVEALS-LOVE prediction vs vegetation composition for Poaceae**

Sugita (2007)
*The Holocene, 17, 243-57*
LOVE-based estimates of local vegetation composition in northern Michigan

Surface pollen samples from 35 forest hollow sites and vegetation data within a 1000-m radius at each site in Sylvania Wilderness, northern Michigan (Calcote 1995; Davis et al. 1998) are used for data analysis.

Two lakes > 300 ha were selected to estimate regional vegetation using surface pollen assemblages.
Northern Michigan

- 2 large lakes >300 ha used for REVEALS
- 35 hollow sites used for LOVE
- RSAP estimate: within a 123-m radius

Sugita et al. 2010
LRA applications for local scale reconstruction of vegetation and land cover

Nielsen & Odgaard 2010
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Regional changes in vegetation and land cover:

Other regions/projects underway or planned:

- Africa (Cameroon and vicinity: A.-M. Lézine)
- Australia (tropical savanna: S. Haberle)
- USA (Great Plains: K. McLachlan)
- India (southern India, eastern & western Himalaya: A. Krishnamurthy)
- China (northern China: Li Ping)
- Japan (northern Japan: T. Nakamura)
Regional changes in vegetation and land cover:
Other regions/projects underway or planned

• Estimating the regional changes in vegetation and land cover is a critical step for quantitative reconstruction of local plant abundance at individual sites.
Challenges for the LRA applications

- Pollen productivity estimates using
  - ERV-based approach
  - Pollen traps
  - Pollen in anther/flower
  - Litter/flower traps
- Availability/selection of sampling sites
- Comparison with other reconstruction methods
- Relevant source area of pollen in the past
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LANDCLIM members (2009–2011)

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