P cycling variations—geologic to agronomic

- Can we get traction on the glacial-interglacial timescale?
- Need terrestrial records
- Need a dynamic model of P weathering including erosion, glacial weathering, soil development, much more
- Need “downstream” record
One approach I have used for terrestrial variations

- **Standard method**—Soil chronosequences and terrestrial P cycle
  - substitution of space for time
  - assumes constant climate, lithology for comparing sites in a chronosequence
    - Hawaiian Island lava flows

- **Lake sediment records and terrestrial P cycle**
  - climate and lithology held constant
  - assumes P geochemistry of lake sediments representative of conditions in watershed
Approach to determining paleocycling of terrestrial P

- Soil development and P transformations linked to bio-availability
- Changes in soil development with glaciation
- Terrestrial P cycle poorly understood in the past
- Lake sediment records and P geochemistry may provide framework

Role of landscapes and the dynamic nature of P cycling
Phosphorus transformations during soil development
### Anderson and Jackson Ponds, Western Appalachian Plateau

<table>
<thead>
<tr>
<th>Age (yr B.P.)</th>
<th>Full Glacial</th>
<th>Late Glacial</th>
<th>Early-Mid Holocene</th>
<th>Late Holocene</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spruce Forest; Deep Open ponds, Low organic productivity</td>
<td>Spruce dominated, Jack Pine declined, Sedge increased, Open boreal forest</td>
<td>Spruce declines, mixed deciduous forest and woodland dominates</td>
<td>Grasses increase, Mixed deciduous forest and Prairie</td>
</tr>
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</table>

P accumulation rate:
- Anderson Pond: 1000 µmol•cm•kyr⁻¹
- Jackson Pond: 500 µmol•cm•kyr⁻¹

P concentration:
- Anderson Pond: 20 µmol•g⁻¹
- Jackson Pond: 15 µmol•g⁻¹

### Environmental History

- **Late Glacial**: Spruce dominated, Jack Pine declined, Sedge increased, Open boreal forest
- **Early-Mid Holocene**: Spruce declines, mixed deciduous forest and woodland dominates
- **Late Holocene**: Grasses increase, Mixed deciduous forest and Prairie

- **Full Glacial**: Closed Spruce Forest; Deep Open ponds, Low organic productivity
- **Late Glacial**: Spruce Forest; Deep Open ponds, Low organic productivity
- **Early-Mid Holocene**: Mixed deciduous forest and woodland dominates
- **Late Holocene**: Mixed deciduous forest and Prairie
Phosphorus geochemistry - western Appalachian Plateau

Weight of P/unit area of soil

Initial

Holocene

Mineral P

Occluded P

Organic P

$P_{\text{total}}$
Kokwaskey Lake, Coast Mountains, British Columbia
Phosphorus geochemistry - Kokwaskey Lake

Weight of P/unit area of soil

Initial → Holocene
LIA ←

Mineral P
Occluded P
Organic P

$P_{\text{total}}$
Lower Joffre versus GISP2

GISP2 $\delta^{18}O$ (per mil)

-34.0  -34.5  -35.0  -35.5  -36.0  -36.5  -37.0

% mineral P
Pre-Columbian influence on soil P chemistry
Future of the Phosphorus Cycle