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

Late Glacial: Spruce dominated, Jack Pine declined, Sedge increased. Open boreal forest

Full Glacial: Closed Spruce Forest; Deep Open ponds, Low organic productivity

Early-Mid Holocene: Spruce declines, mixed deciduous forest and woodland dominates

Late Holocene: Grasses increase. Mixed deciduous forest and Prairie

P concentration ($\mu$mol•g$^{-1}$)

P accumulation rate ($\mu$mol•cm$^{-2}$•kyr$^{-1}$)

Organic P

Oxidized P

Mineral P
Phosphorus geochemistry - western Appalachian Plateau

Weight of P/unit area of soil

Initial Holocene

Mineral P

Organic P

Occluded P

$P_{total}$
Kokwaskey percent of Total P

Full glacial:
Watershed ice covered

Little Ice Age

Landscape Stability:
Onset of soil and ecosystem development

Deglaciation:
Rapid sedimentation and landscape instability

Full glacial:
Watershed ice covered

Total P accumulation rate (μmol•cm⁻²•kyr⁻¹)

Kokwaskey percent of Total P

Occluded P

Mineral P

Organic P
Phosphorus geochemistry - Kokwaskey Lake

Weight of P/unit area of soil

Mineral P

Occluded P

Organic P

Initial Holocene

LIA

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

GISP2 δ¹⁸O (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

![Graph showing the future of the Phosphorus Cycle with data points for Total, Deforestation, Fertilizers, and Sewage over different years.]