Hydrogeology

Konza LTER Workshop
1 September 2007
Gwen Macpherson
What We’ve Learned

• Water flux
  – Aquifer-atmosphere link
  – Stream-aquifer interactions

• Chemistry
Aquifer-Atmosphere Link

– up to 33% of evapotranspiration is groundwater supported

• **Mill Creek**: York JP et al., 2002, Putting aquifers into atmospheric simulation models: an example from the Mill Creek Watershed, northeastern Kansas: ADVANCES IN WATER RESOURCES 25 (2): 221-238. 

– daily oscillation in groundwater-level occurs during extended dry periods in the growing season

• **Konza Prairie**: Kissing, K. R., and G. L. Macpherson, 2006, Short-term water-level fluctuations and long-term water-level decline at the Konza Prairie—drought or vegetation?: GSA Abstracts with Programs 38 (1): A
Daily water-level fluctuations:
during growing season AND no rainfall

~ 3 cm
Atmosphere-Aquifer Interactions

- Annual pattern
- Impact of
  - lower annual precipitation
  - timing shift
2006 high-resolution water-level elevation in one well

Water Level Fluctuations '06 (3-5 Mor)

aquifer recharge
Stream-Aquifer Interactions

- Response times
- Direction
Stream-Aquifer Responses, Types 1 & 2

Water Level (cm)

Precip (in.)

Stream Discharge (ft³/s)

Delayed aquifer response

No stream response

Rapid stream response
Stream-Aquifer Response, Type 3

- Water Level (cm)
- Precip (in.)
- Stream Discharge (ft³/s)

Delayed aquifer response

Downstream stream response after aquifer response
Stream-Aquifer Interactions – the future

- Computer models (D. Steward?)
What We Have Learned

• Water flux
  – Aquifer-atmosphere link
  – Stream-aquifer interactions

• Chemistry
  – Annual cycles
  – Solute sources
  – Nutrient export
  – CO$_2$
Annual chemical cycles

Limestone dissolving

Dilution

- pH, standard units
- Difference from 6-98 measurement, mmol L⁻¹

DDB pH
Modeled pH
Alkalinity
Calcium
Magnesium
Solute sources

\[ y = 3 \times 10^{-6} x + 0.7082 \]

\(87\text{Sr}/86\text{Sr}\) from 1997-1999

Wood, 2001

from dust?
Solute sources, cont.

<table>
<thead>
<tr>
<th>Boron</th>
<th>$\delta^{11}B$</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>A:</td>
<td>low</td>
<td>low grass phytoliths?</td>
</tr>
<tr>
<td>B:</td>
<td>intermedi.</td>
<td>high rain?</td>
</tr>
<tr>
<td>C:</td>
<td>high</td>
<td>low bedrock?</td>
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</tbody>
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Kissing, Kim, 2005 KU summer undergraduate research award project
Nutrient export

Rapid Snowmelt Event (RSE)
Rapid Snowmelt Event, RSE

Feb. 18 groundwater sampling

~8:30 pm, 2-18-07

~7:30 pm, 2-19-07
Rapid Snowmelt Event, RSE

N04d Stream

- **K (AAS or IC)**
- **K (ICP-AES)**
- **K/Ca, molar**

**K, ppm**

**K/Ca, molar**

**Dates:**
- 10/01/89
- 10/01/94
- 10/01/99
- 09/30/04
Rapid Snowmelt Event, RSE

N04d Stream

- K (AAS or IC)
- K (ICP-AES)
- NO3-N

Time

K, ppm

NO3-N, ppm

10/1/89 10/1/94 10/1/99 9/30/04 10/1/09
CO$_2$ 1990-2005

Groundwater CO$_2$ increase: $\sim$20% (2100 ppm)
Atmospheric CO$_2$ increase: $\sim$7% (23 ppm)

log P-CO$_2$, groundwater

Niwot Ridge CO (Tans and Conway, 2005)
Planning for the future (cont’d)…

• Develop new initiatives for LTER VI
  - Grassland responses to chronic N enrichment
  - Chronosequence of sites for restoration studies
  - Bison and fire as drivers of spatial patterns and consumer responses; linkages across temporal and spatial scales
  - Potential changes in fire/grazing treatments (?) to promote new science while ensuring site integrity
  - Groundwater sequestration of grassland CO$_2$

• Integration of LTER with other major bioscience initiatives (LTER Regional Science Initiative, NEON, KSU Ecological Genomics program)
Are grasslands using more CO$_2$ than we think??

- NEE
- CO$_2$ production
- net CO$_2$ flux
- Other fluxes in unsaturated zone
- GSC
- Water flux
Hydrogeochemistry
–the future

• Will annual cycles change because of changing lengths of seasons?
• With less meteoric precipitation, will chemical weathering affect bedrock relatively more?
• With a drier climate, will dust imports become more important, “restock” the soils with easily weatherable solids?
• With change in flora (more C3’s? or more zerophytes??), will biogeochemical cycling change?
• Is there an atmosphere-groundwater CO$_2$ link, and will it cause faster chemical weathering?
Approaches

• Watershed-scale measurements:
  – Soil CO$_2$ to groundwater -- quantify the flux
  – Dust import--quantify the flux
  – Trace element cycling--what is unique about grasslands?
  – Cross-site comparisons toward a global assessment

• Experiments:
  – Isotope-tagged CO$_2$ transport