Monitoring and Modeling Wetland Chloride Concentrations in Relationship to Oil and Gas Development

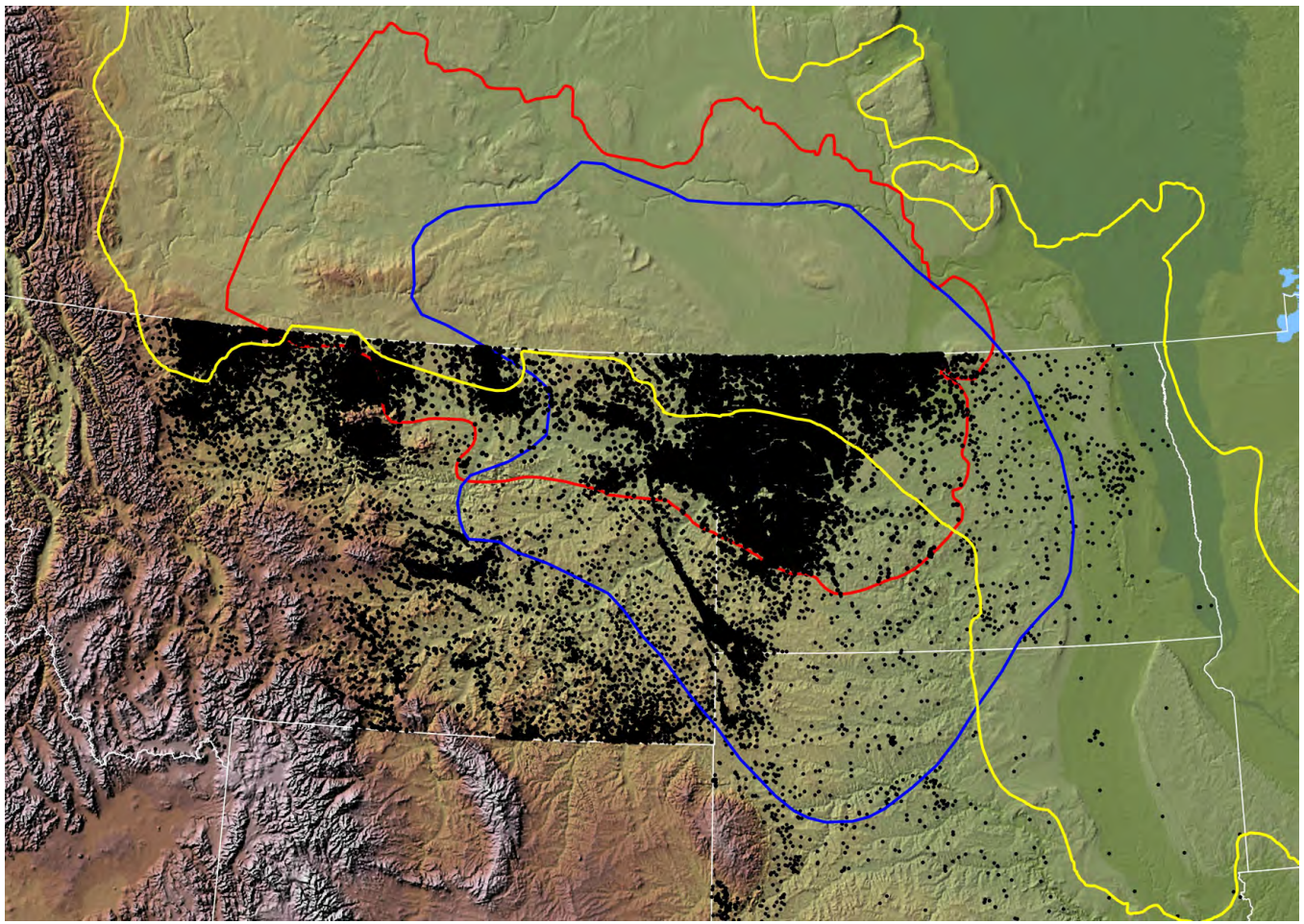
Max Post van der Burg & Brian Tangen

USGS Northern Prairie Wildlife Research Center
Jamestown, ND

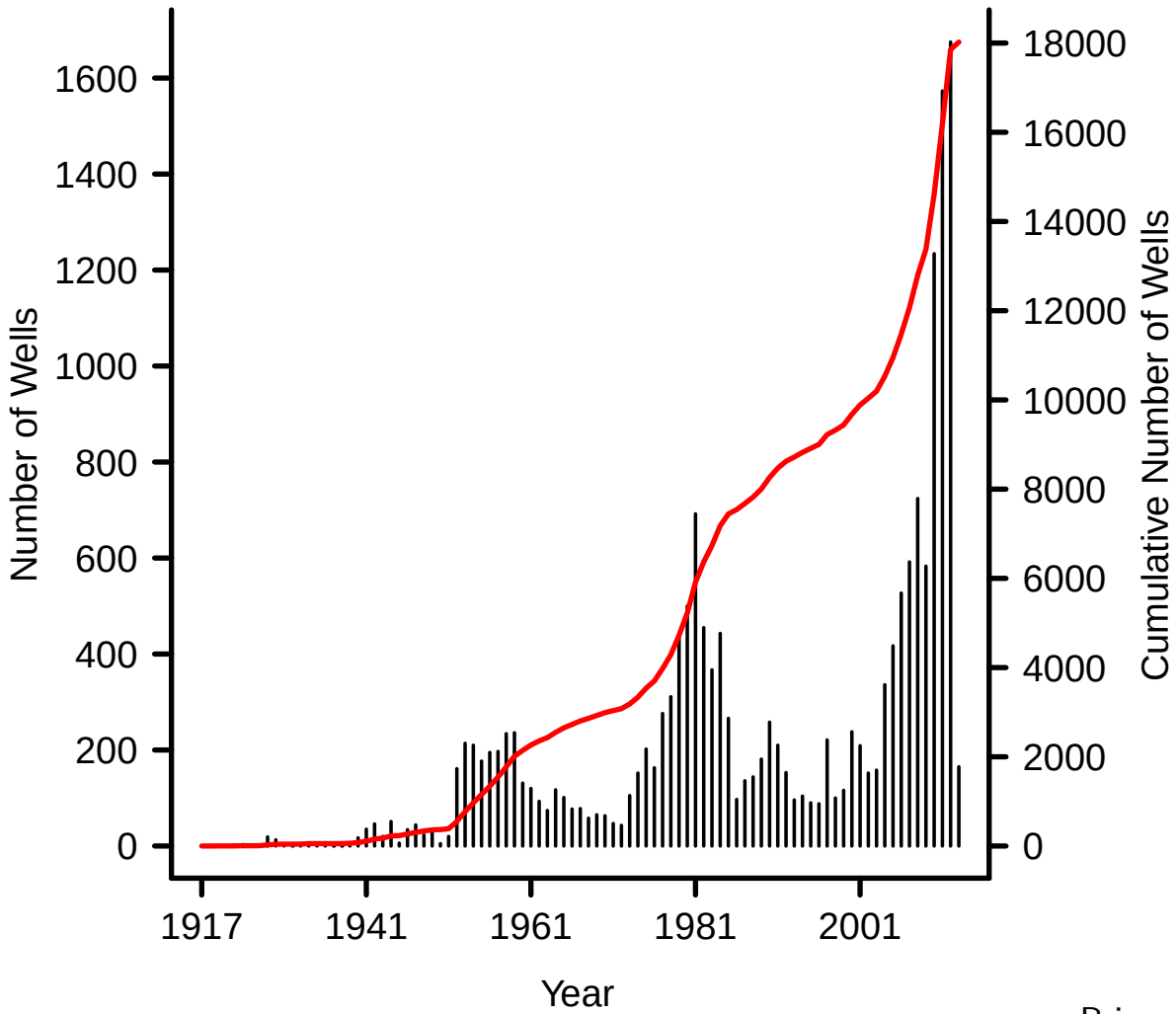
March 5, 2014

USGS
science for a changing world

Williston Basin and Bakken Formation



Oil and Gas Development Trends



USGS science for a changing world

The problem of brine contamination

- Co-produced water (a.k.a. "brines") largest waste stream
- Concern over brine spills and aquatic systems
- Assess sites with known contamination
  - Eastern Montana
  - Beaver Lake WPA
  - Vulnerability assessments (e.g. Preston et al. 2013)

Assessed using chloride index (Reiten and Tischmak 1993)

$$\frac{Cl^{-}\,mgL^{-1}}{SC\mu s\ cm^{-1}}$$

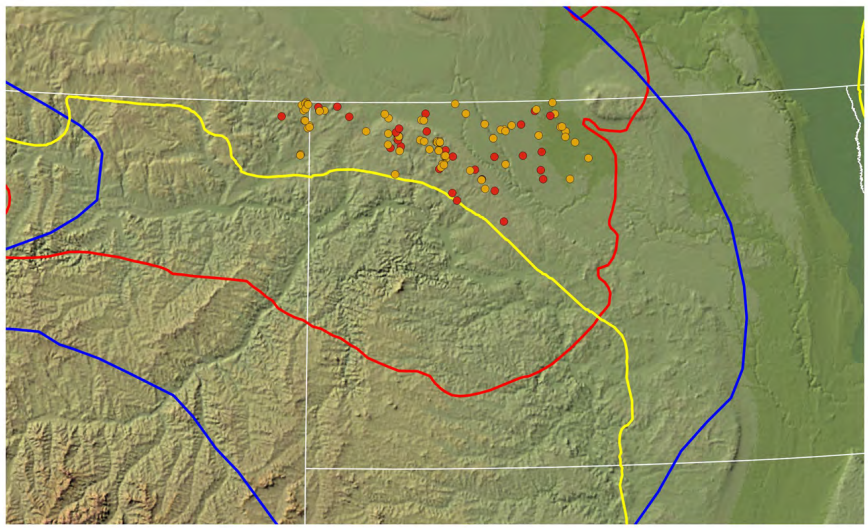
Pilot study

Questions:

- Is the chloride index a useful way to look at contamination risk at a large scale?
- Are there any landscape level patterns between the chloride index and oil and gas development?

Drawing a random sample

- Universe of +310,000 wetlands
- Stratified random sample
  - Stratified by:
    - distance to well ($\leq$5%, 5%-25%)
    - ownership (FWS, Private)
    - wetland type (Seasonal, Semipermanent)
  - 20 Primary; 20 Secondary for each "bin"
- 122 sites sampled (92 FWS, 30 Private)



USGS science for a changing world

Surface water sampling and lab analysis

- Visited wetlands Jun. - Aug., 2012
- Field Measurements
- Grab sample from "center" of wetland
- Sent ND Department of Health Lab
- Major ions, trace metals, salinity, etc.

Analysis

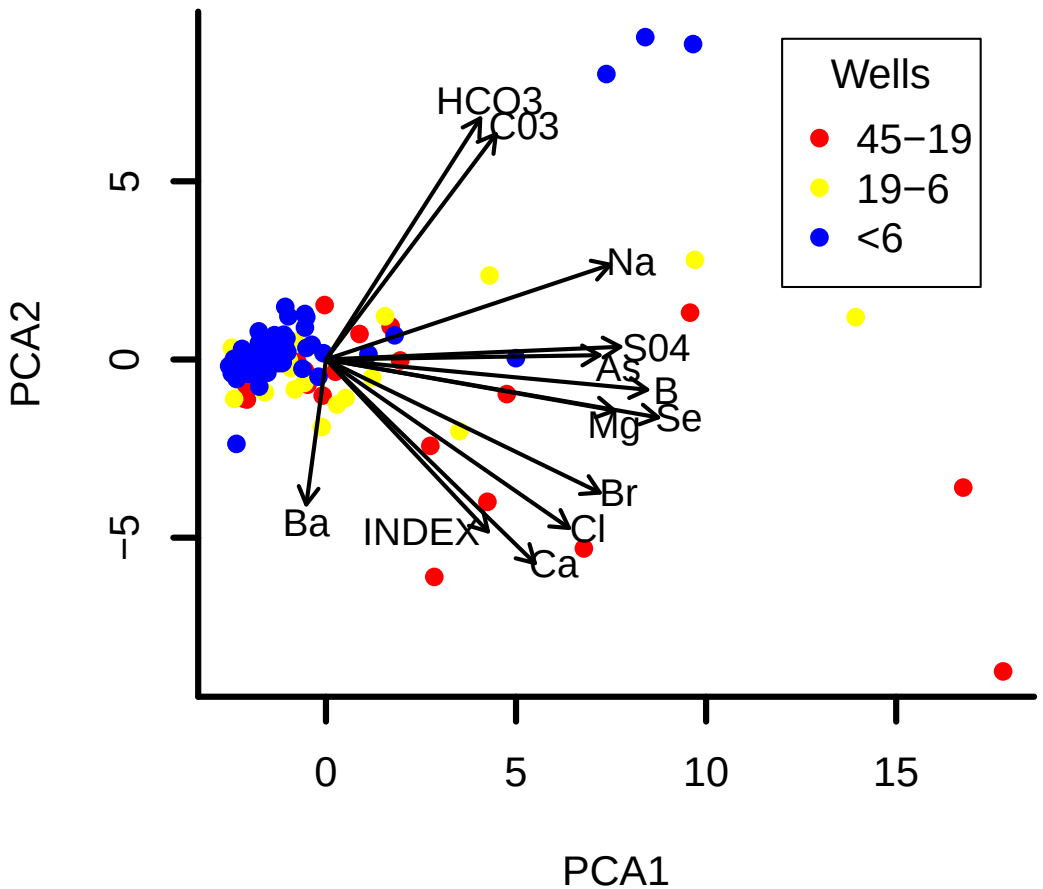
- Look for patterns with PCA
- Statistical model for landscape predictions

Hierarchical model

$$log(y_i) = \beta_0 + \Sigma\beta_i X_i + s_i + \epsilon_i$$

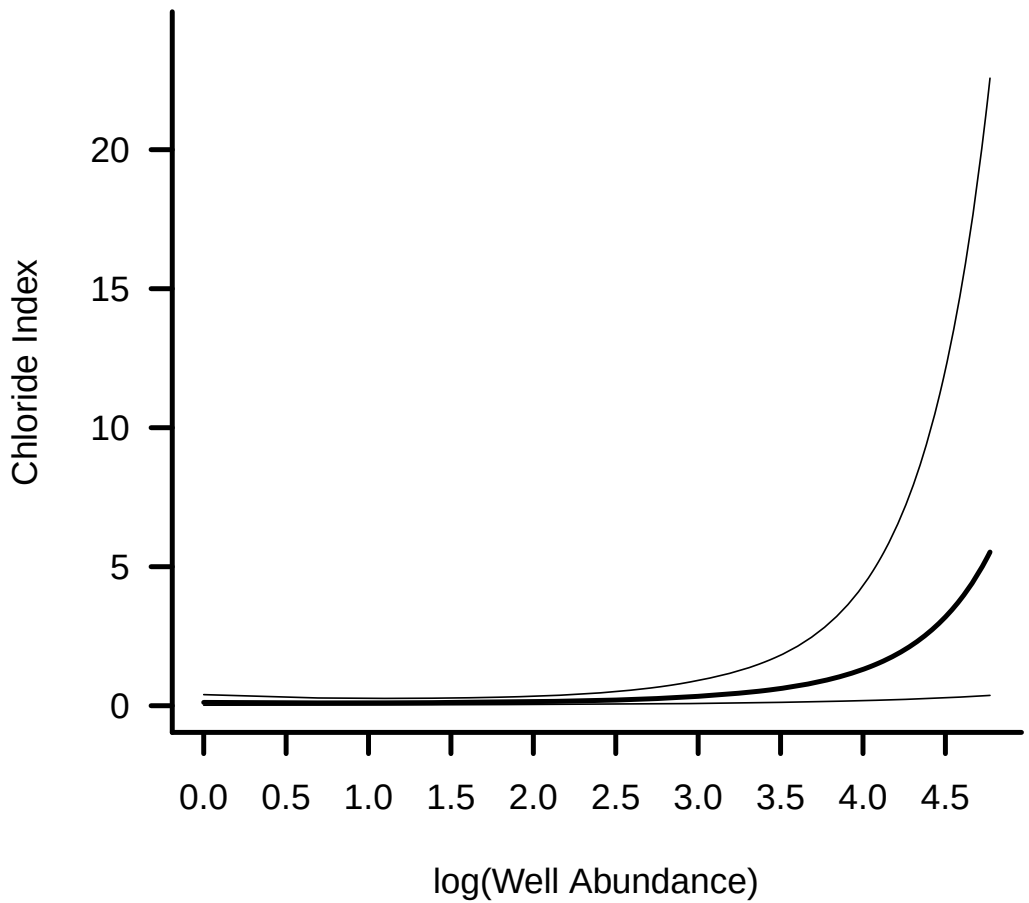
- Bayesian Model Averaging:
  - Considered: nearest well, well age, well abundance, ownership
  - Intercept, nearest well, nearest well^2, well abundance, well abundance^2

Patterns of Cl and other indicators

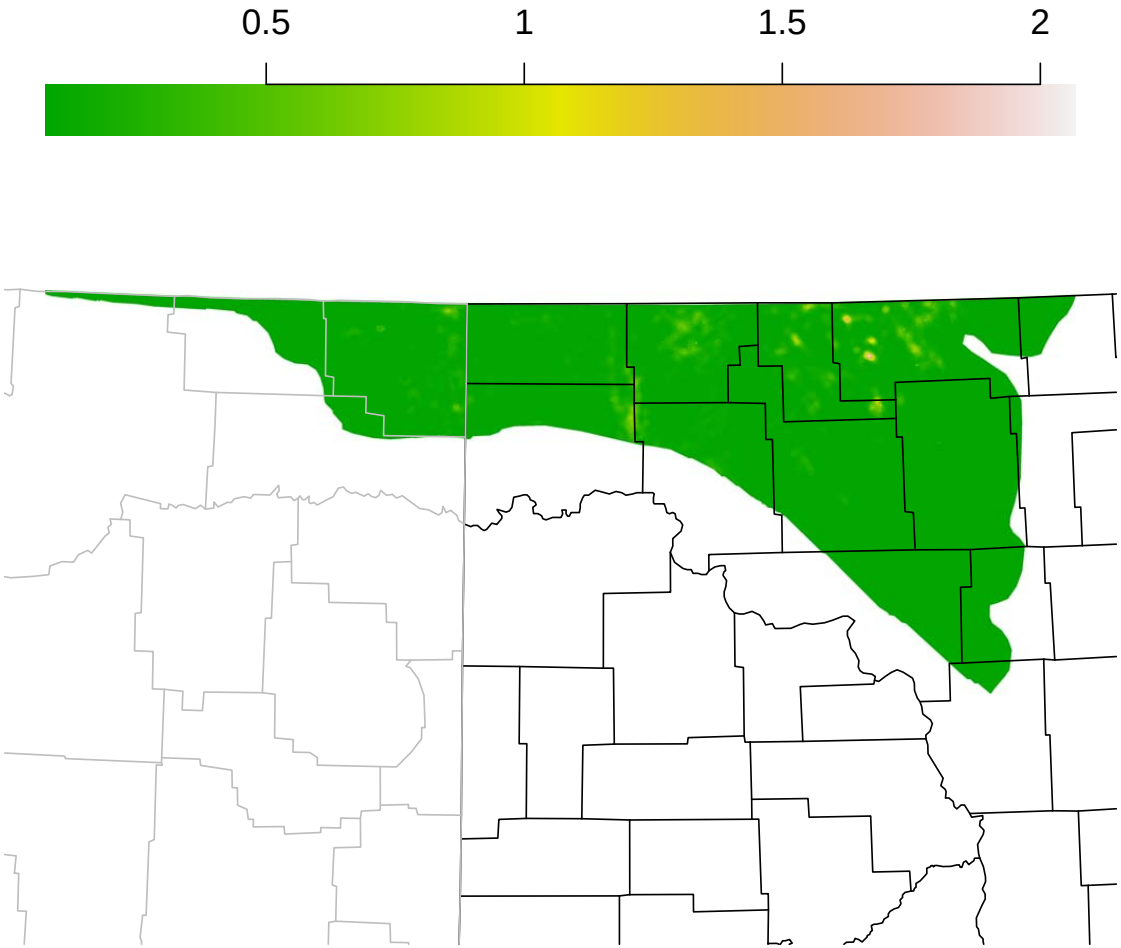


Landscape patterns

- Well Abundance^2 Model had posterior probability of 0.99



Spatial predictions



Implications for monitoring

- Index maybe useful
- May need more context
  - Wetland chloride highly variable
  - East-west gradient in soil chloride across ND
  - Indicators may help to distinguish between natural and produced chloride
- May need to be cautious about using index to assign contamination status

Implications for monitoring

- Could help to identify locations in need of sampling
- Modeling allows for Bayesian updating and prior information
- Adaptive monitoring

Acknowledgments

- Mike Ell, ND Department of Health
- USGS DOI on the Landscape Funding
- Technicians: Chelsea Johnson, Brett Goehner, Matt Johnson
- USGS Science Team about Energy and Prairie Pothole Environments (a.k.a. STEPPE Team)