Where does the nitrogen go?

Christopher Kelley
Washington State University
School of the Environment

Outline

- My background
- Research in Eastern Washington
  - Background
  - Previous research on nitrate leaching
  - Current research on nitrate leaching
- How I hope to apply this knowledge to Southern Willamette Valley

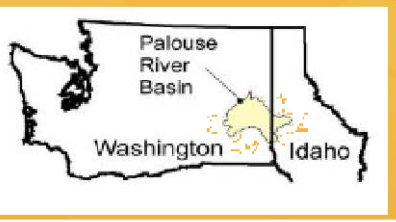
My background

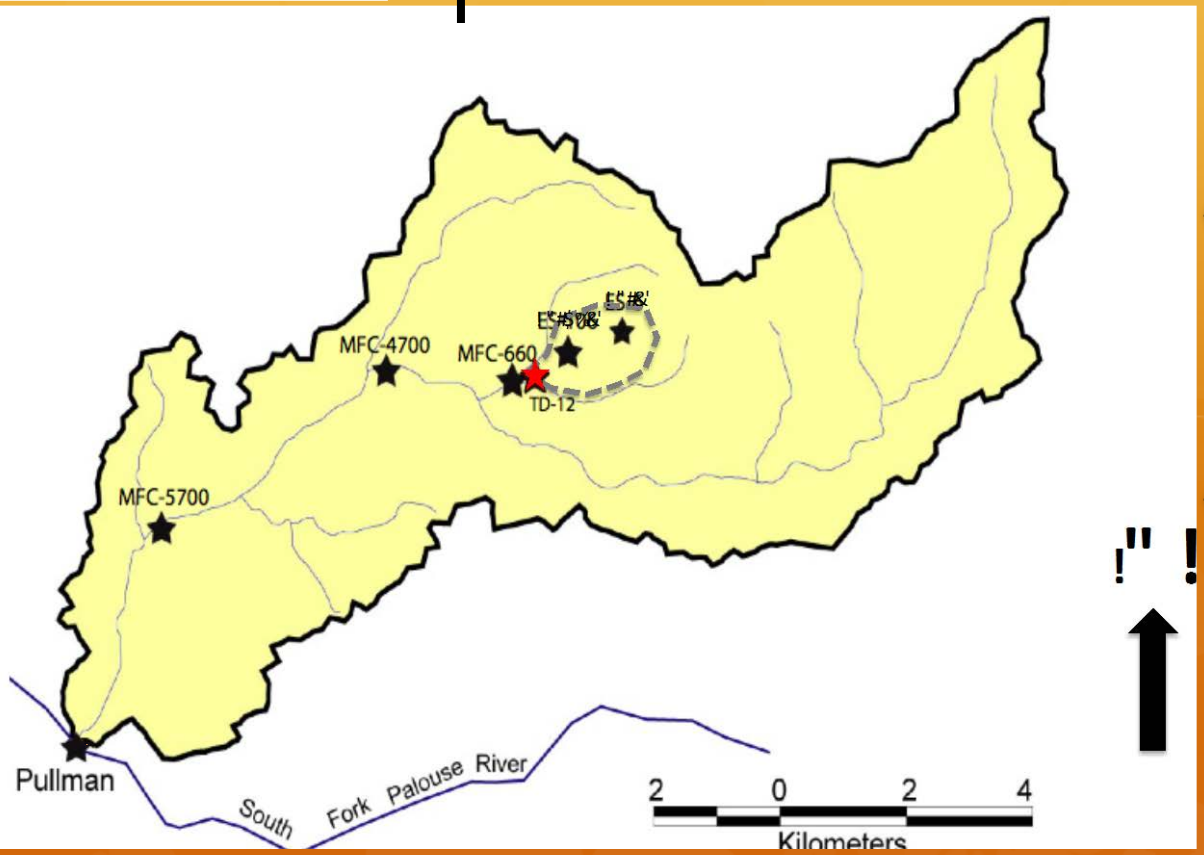
- Grew up in Palouse, WA (15 miles north of Pullman)
- B.S. Environmental Geological Sciences, Central Washington University (2008)
- M.S. Geology (Hydrogeology Focus), Washington State University (2011)
  - Thesis: Nitrate-nitrogen and nitrate-oxygen isotope ratios for identification of nitrate sources and dominant nitrogen cycle processes in a tile-drained dryland agricultural field.
- PhD Geology (Hydrogeology Focus), Washington State University (In Progress)
  - NSPIRE Fellow

What is NSPIRE?

- **N**itrogen **S**ystems **P**olicy-oriented **I**ntegrated **R**esearch and **E**ducation
  - igert.nspire.wsu.edu
- NSF funded multidisciplinary student doctoral training program designed to create a new generation of scientists who merge science with public policy.
  - Combines student from Soil Science, Biology, Chemistry, Engineering, Geology, Botany, Animal Sciences and Atmospheric Sciences
- Focused on understanding the complex interactions and the impacts of reactive nitrogen in atmospheric, terrestrial, and hydrologic systems.

Missouri Flat Creek

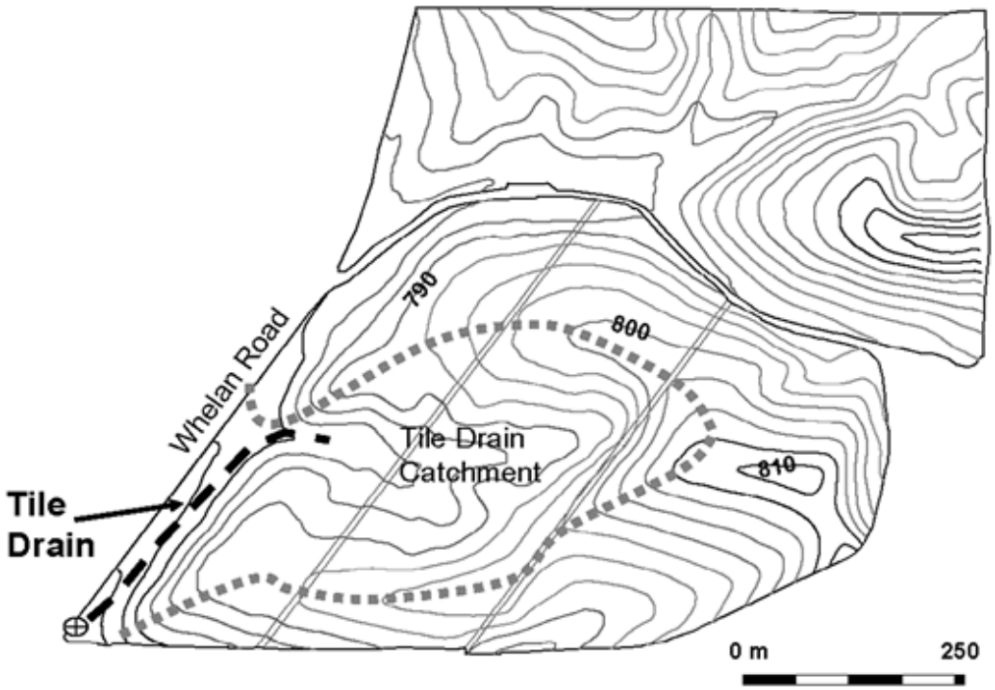




- In the Palouse Region of eastern Washington and northern Idaho
- Part of the Missouri Flat Creek Watershed
- CAF located ~8km northeast of Pullman, WA

Cook Agronomy Farm

- 12 ha tile-drained section in the southwest portion of CAF (~1 m below the surface).
- Vegetated buffer strip along Whelan Road.



- Soils consist of silt loam Mollisols that are mapped as part of the Palouse-Thatuna Association soil series.
- Clay argillic layer exist ~1 m below the surface and are not spatially extensive.

Climate and Crops

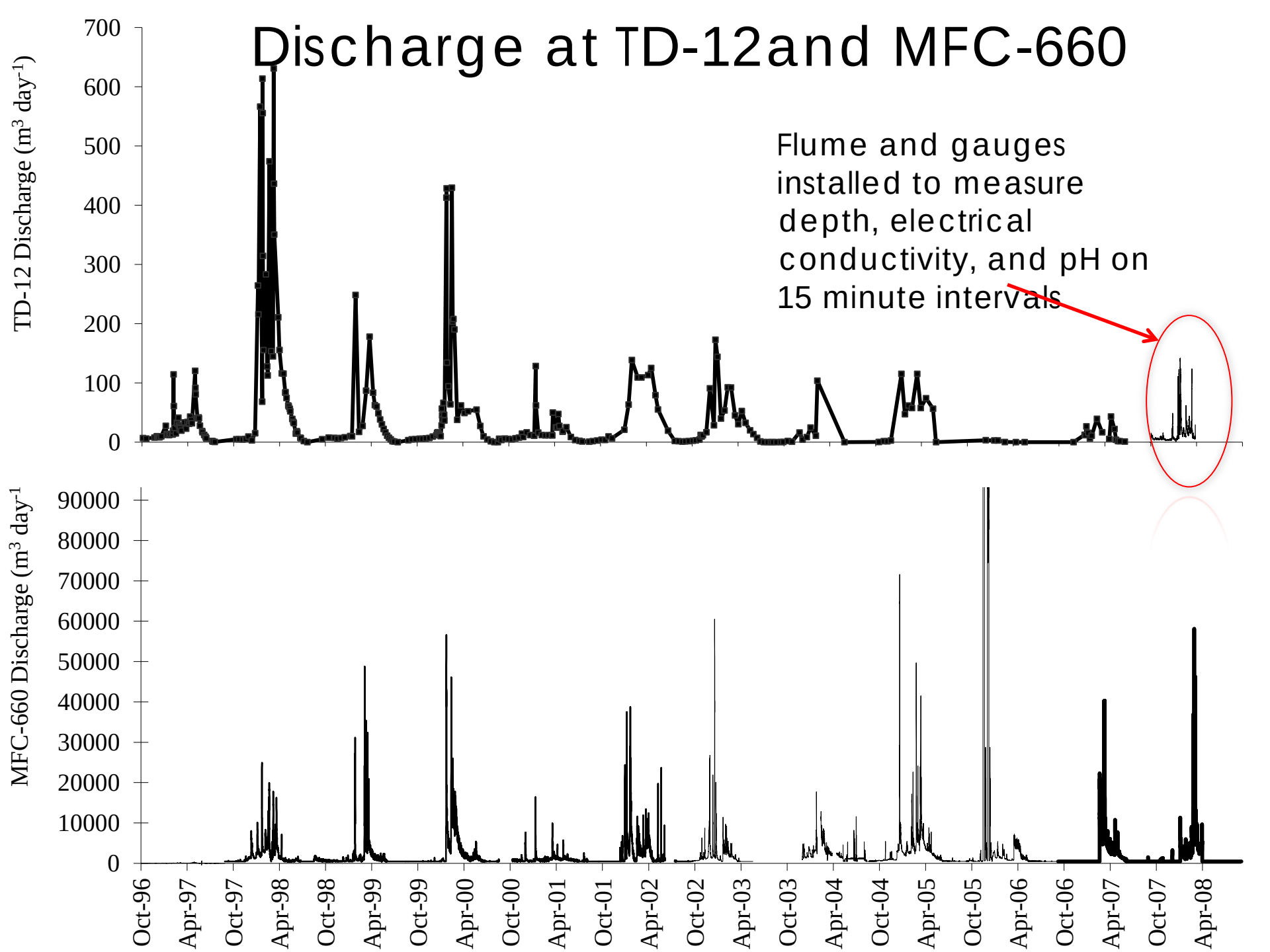
Climate

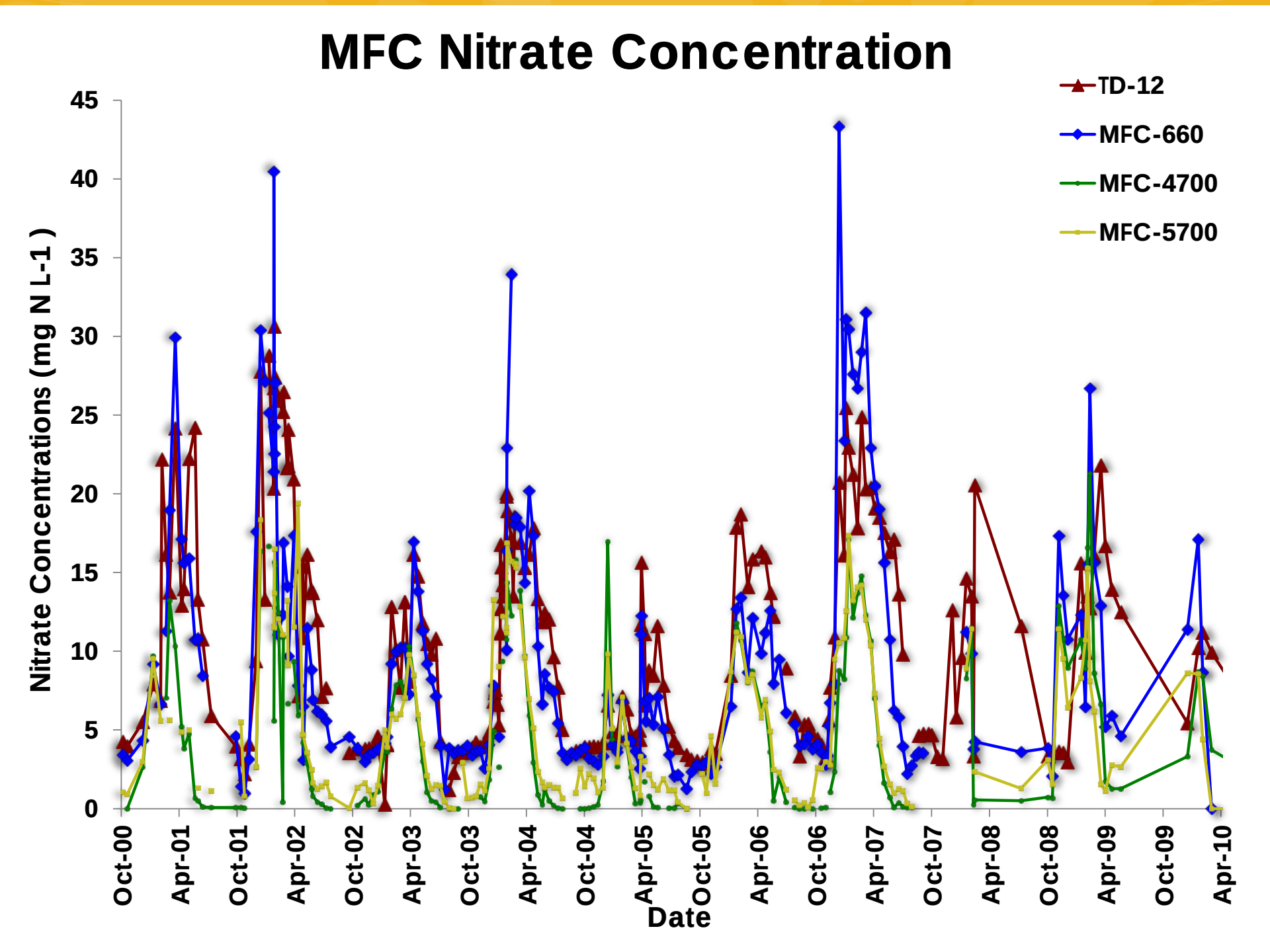
- Mediterranean climate with cold wet winters and hot dry summers.
- Average precipitation of ~510 mm (20 inches) per year.

Crops/ farming practices

- Rotation of winter wheat, spring wheat, and chickpeas.
- No-till since the mid 1990s.
- Buffer strip planted in the spring of 2006
- Historic fertilizer applications range from 123 – 215 kg N/ha/yr (110 – 192 lb N/ac/yr).
- Fertilizer applications occur during the fall (winter wheat)and in the spring (spring wheat).
- In the process of transitioning to precision fertilizer applications methods.

Discharge at TD-12and MFC-660

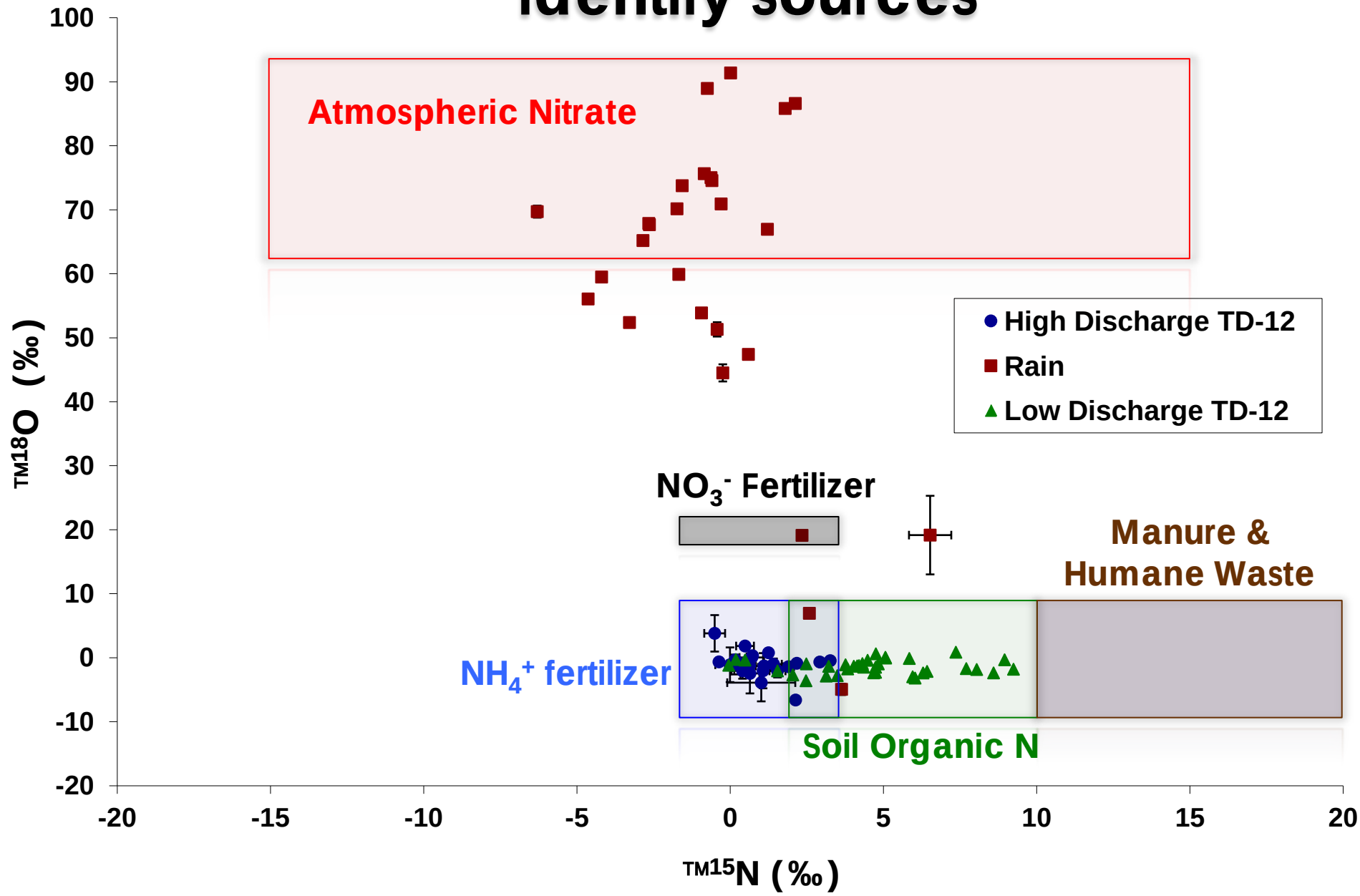



MFC Nitrate Concentration
TD-12
MFC-660
MFC-4700
MFC-5700
Nitrate Concentrations (mg N L-1)
45
40
35
30
25
20
15
10
5
0
Oct-00
Apr-01
Oct-01
Apr-02
Oct-02
Apr-03
Oct-03
Apr-04
Oct-04
Apr-05
Oct-05
Apr-06
Oct-06
Apr-07
Oct-07
Apr-08
Oct-08
Apr-09
Oct-09
Apr-10
Date

Past Nitrogen Leaching Research at MFC and CAF

- Keller et al. (2008); High [NO_3^-] from soil transported after 150mm of winter precipitation. Hypothesized NO_3^- leached at the onset of discharge is from a combination of fall fertilizer and summer soil mineralization of soil organic nitrogen.
- Moravec et al., (2010): Source of TD-12 and Missouri Flat Creek discharge is winter precipitation, which has a MRT of 4-7 months in the soil. NO_3^- leaching is driven by winter precipitation.
- Kelley et al. (In review): Two seasonal sources of NO_3^- in TD-12 discharge; fertilizer during the high-discharge season and mineralized soil organic nitrogen during the low-discharge season, leached N fertilizer is lost 3-6 months after application. Nitrification is the dominant nitrogen cycle process.

^{15}N and ^{18}O Isotopes of NO_3^- to identify sources

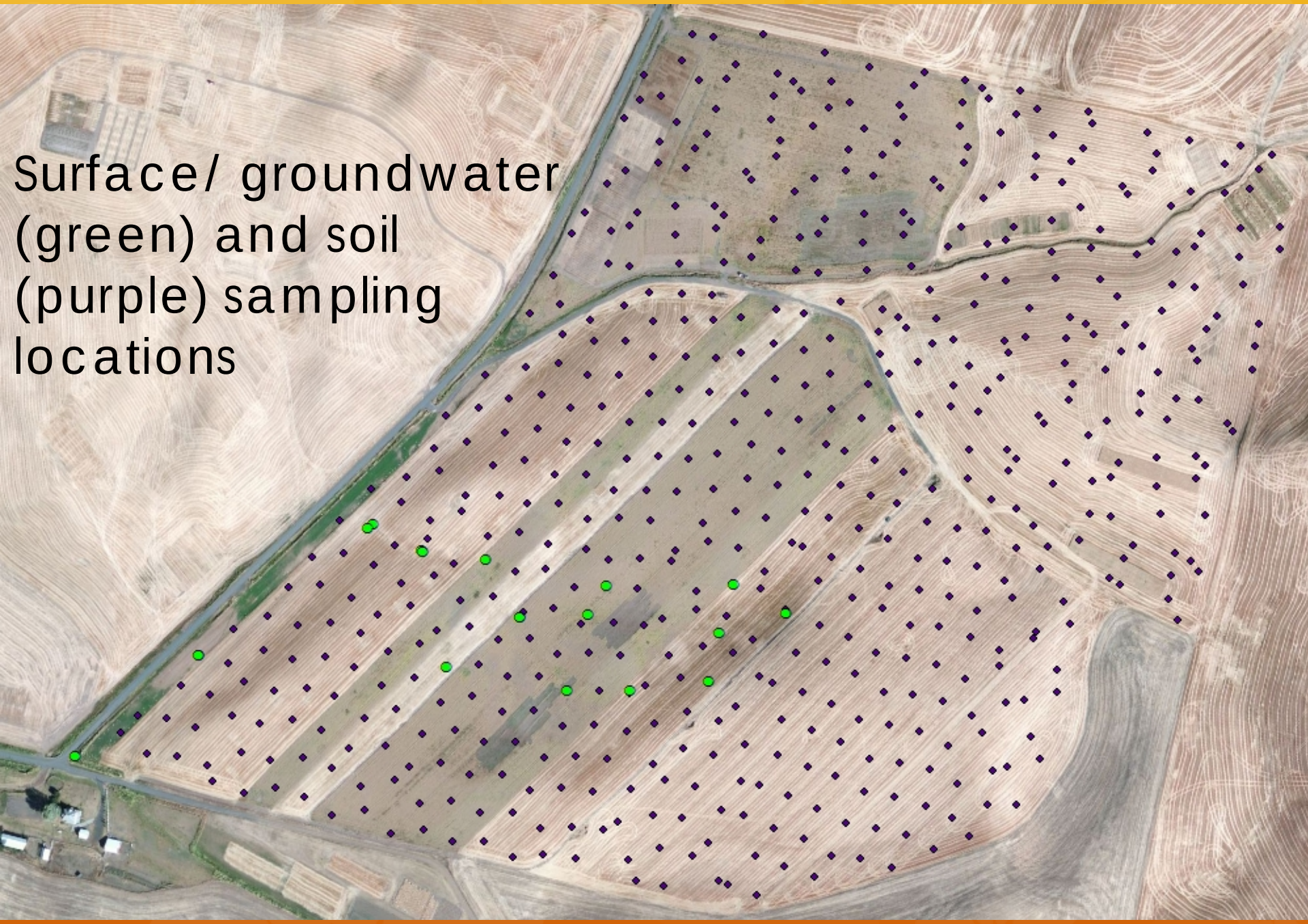


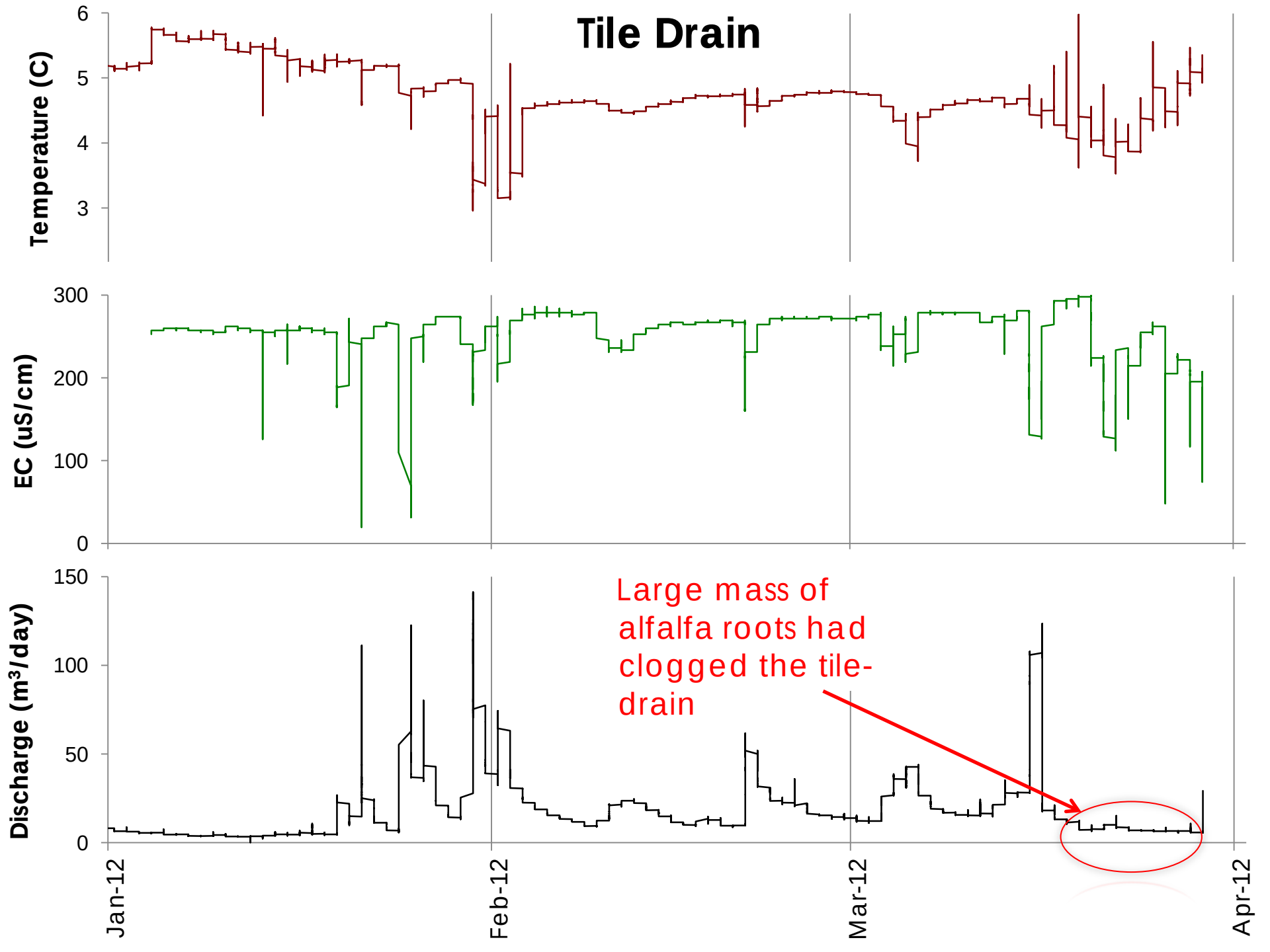
Current Research at CAF

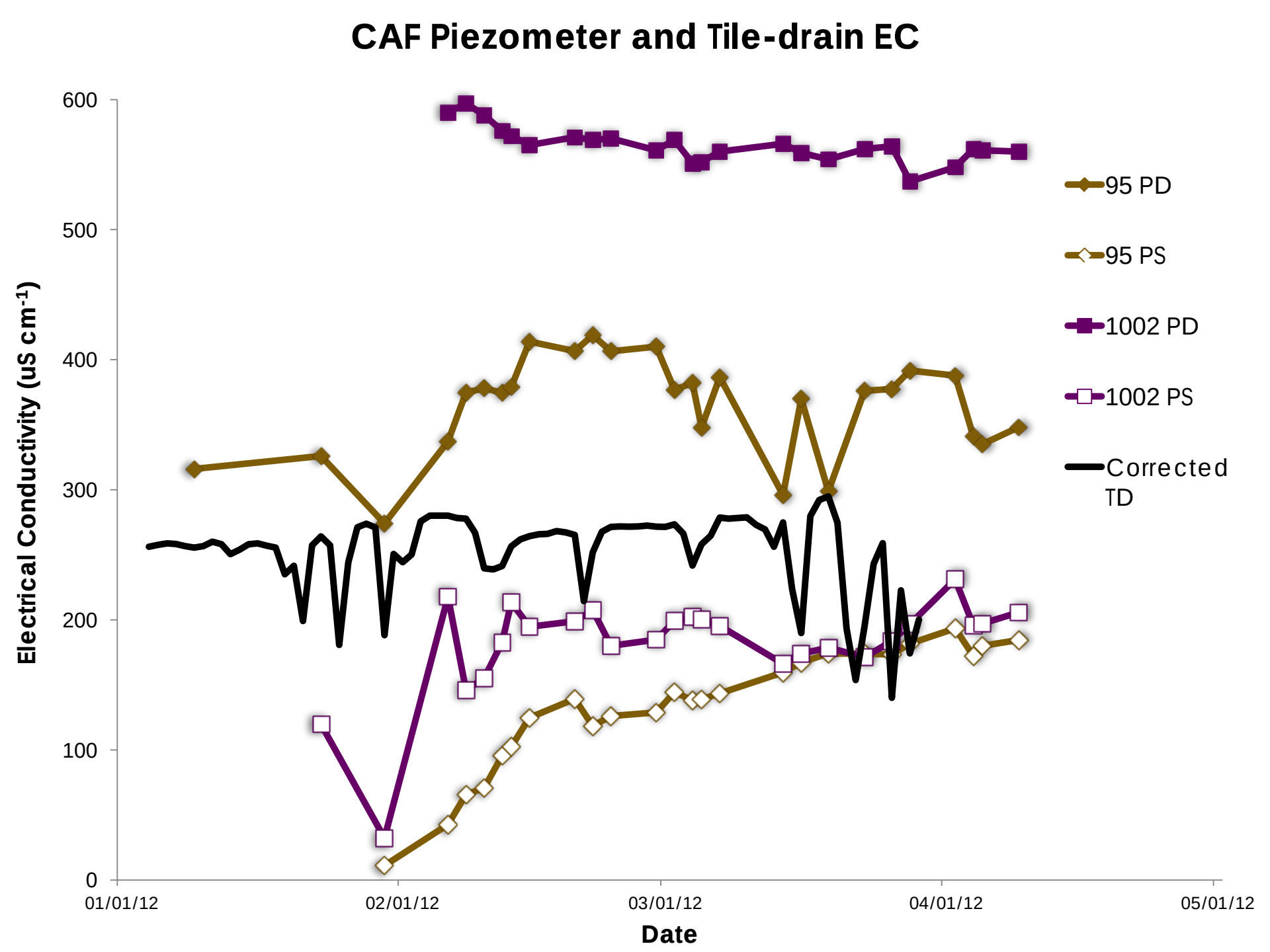
My research will address:

- Is NO_3^- leached through a tile drain outlet transported via shallow flow paths above an impeding layer, or via deeper flow paths below?
  - Are vegetated buffer strips an effective BMP to reduce nitrate leaching on the Palouse?
- How does soil hydrology influences nitrogen cycling during transport?
- Do the active nitrogen cycle processes below a clay impeding layer decrease or increase nitrate concentrations prior to leaching into a shallow bedrock aquifer?

Surface and groundwater sampling locations


Surface/ groundwater (green) and soil (purple) sampling locations


Tile Drain
Temperature (C)
6
5
4
3
EC (uS/cm)
300
200
100
0
Discharge (m³/day)
150
100
50
0
Large mass of alfalfa roots had clogged the tile-drain
Jan-12
Feb-12
Mar-12
Apr-12


CAF Piezometer and Tile-drain EC
Electrical Conductivity (uS cm-1)
600
500
400
300
200
100
0
01/01/12
02/01/12
03/01/12
04/01/12
05/01/12
Date
95 PD
95 PS
1002 PD
1002 PS
Corrected TD

How can I apply my knowledge of eastern Washington to western Oregon?

- Both systems have Mediterranean Climates
- Both systems have complicated soil hydrology/ groundwater flow dynamics
  - The Palouse has intermittent hard packed argillic clay layer
  - Willamette Valley has the intermittent Willamette Silt
- Factors controlling nitrogen cycle processes (i.e. temperature, soil pH, water content,…) are the same everywhere.

Summer Willamette Valley Project

- Combine DEQ water quality data for wells in the GWMA with previous research in the Willamette Valley and GIS data to:
  - Determine which BMPs are most likely to help decrease nitrate leaching.
  - Develop experimental plans to test the ability of current and future BMPs to reduce nitrate leaching.
  - Identify “high risk” areas with continued elevated nitrate levels and pair them with the suitable BMPs to reduce nitrate leaching.