AMoN Site Characterization Study: Phase I Field Measurements

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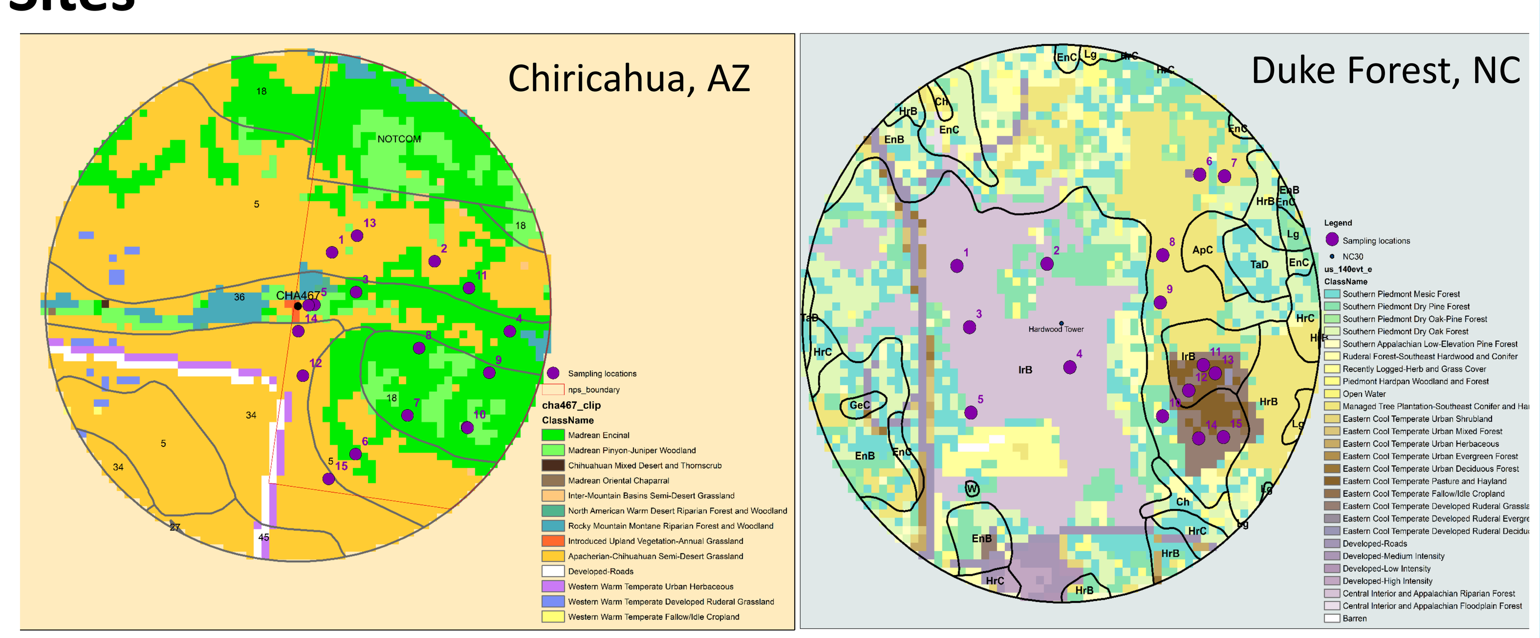
Abstract: Reduced inorganic nitrogen (NH_3 + NH_4^+) is an increasingly important contributor to the total nitrogen deposition budget, yet the bi-directional nature of NH_3 air-surface exchange makes incorporation of NH_3 measurements into dry deposition schemes in field-scale and regional chemical transport models (CTMs) difficult. The purpose of this study is to develop a methodology for providing NADP with modeled NH_3 fluxes using bi-weekly AMoN concentrations. NH_3 fluxes derived from site specific NH_3 measurements (AMoN) and surface parameterizations (i.e., compensation points) can provide "best" estimates of NH_3 deposition for developing ecosystem specific deposition budgets and assessing sub-grid variability of NH_3 fluxes in CTMs. This effort will therefore improve the total nitrogen deposition estimates provided by TDEP, which does not currently use the AMoN NH_3 concentrations for dry deposition estimates.

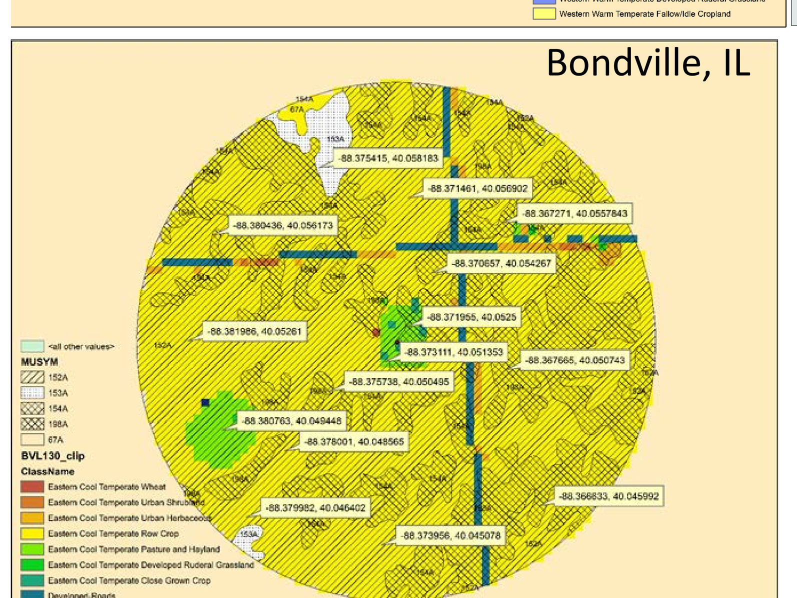
This project consists of two phases:

- Phase I - Develop a database of soil and vegetation chemistry, micrometeorology, and surface physical characteristics at three pilot AMoN sites
- Phase II - Use datasets to parameterize and test a two-layer bi-directional NH_3 flux model for implementation at AMoN sites
  - Assess model sensitivities to biogeochemical and meteorological inputs
  - Develop methodologies for use of time-integrated NH_3 concentrations
  - Standardize model configuration for implementation across AMoN

Phase 1 field measurements began in the summer of 2017 and will continue through spring 2018. This paper describes field and laboratory methods and presents preliminary results of soil chemistry measurements.

Sites





- Chiricahua National Monument, AZ
  - Desert
- Duke Forest, NC
  - Hardwood forest
- Bondville, IL
  - Agricultural
- Sites represent a wide range of atmospheric NH_3, meteorology, land cover, and biogeochemistry.

Figure 1: Sampling locations around the Chiricahua National Monument (AZ98), Duke Forest (NC30), and Bondville (IL11) AMoN sites identified as black dots in the center of a sampling domain of 1 km radius. Maps include overlay of soil (NRCS Web Soil Survey) and vegetation types (LANDFIRE).

Modeling Framework

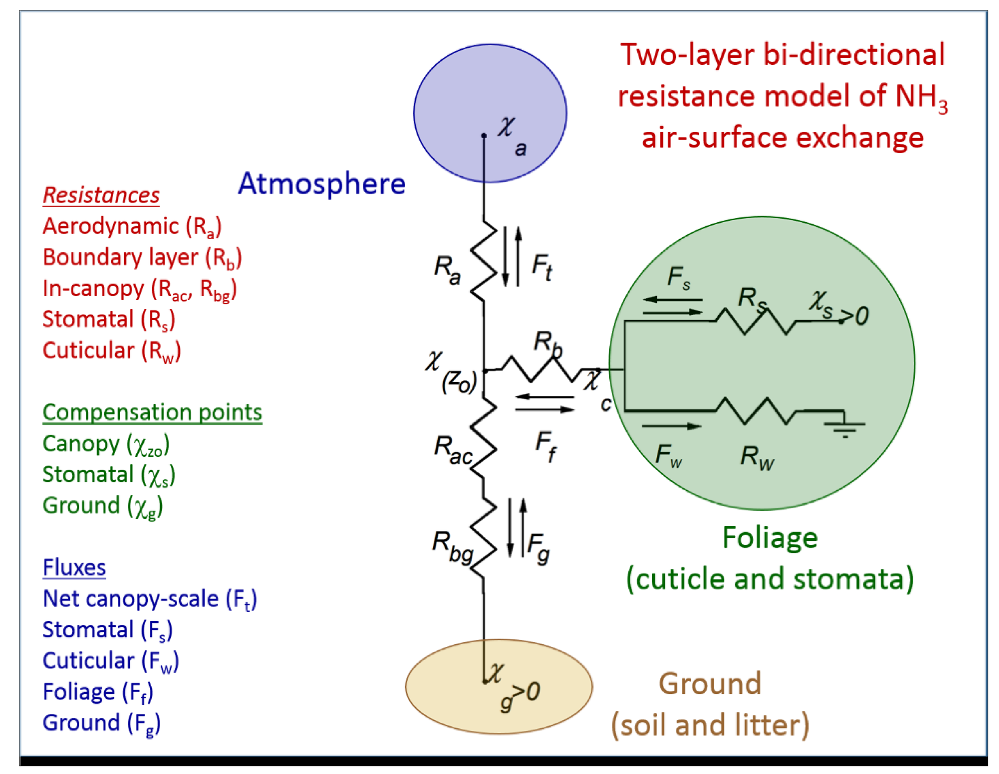


Figure 2: Two-layer bidirectional NH_3 flux model (see Massad et al., 2010)

- Modeling approach will follow bidirectional framework described by Massad et al., 2010.
- Parameterizations will be consistent with CMAQ where possible.
- Soil, live vegetation, and leaf litter will be sampled seasonally to develop estimates of surface NH_3 emission potentials (Γ) from which NH_3 compensation points (χ) will be derived.

Compensation point

$$\chi = \frac{161500}{T}\exp\left(-\frac{10380}{T}\right)\frac{[NH_4^+]}{[H^+]}$$

Emission potential (Γ)

- May revise model to include litter component based on field measurements.
  - Γ_{soil}, Γ_{litter}, $\Gamma_{stomatal}$, χ_{soil}, χ_{litter}, $\chi_{stomata}$

Methods

Table 1: Data collected during Phase 1.

Category	Parameter	Frequency
Micrometeorology	3D wind, solar radiation, RH, surface wetness, precipitation	Continuous; reported as hourly
Soil conditions	Moisture, temperature	Continuous; reported as hourly
Soil chemistry	$[NH_4^+]$, $[NO_3^-]$, pH	Seasonal, dominant soil types
Vegetation structure	LAI	Seasonal
Vegetation chemistry	Bulk leaf and litter analyzed for moisture, pH, soluble total [N], $[NH_4^+]$	Seasonal, litter and dominant vegetation
Atmospheric chemistry (CASTNET; NADP/AMoN)	NH_4^+, NH_3, HNO_3, NO_3^-, SO_2, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-	Weekly (CASTNET); bi-weekly (AMoN)
Wet deposition (NADP/NTN)	pH, specific conductance, NO_3^-, NH_4^+, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-	Weekly

Soils: Two depths, N extractions with 0.01 M $CaCl_2$, pH in 1:1 water and 1:2 $CaCl_2$

- Measurements of NH_4^+ and H^+ used to calculate Γ_{soil}

Litter and Vegetation: Samples ground in liquid N, extracted in water

- Measurements of bulk soluble NH_4^+ and H^+ used to calculate $\Gamma_{stomatal}$, Γ_{litter}
- Mass of NH_4^+ collected from extracts using sealed headspace diffusion technique (recovery > 98%)

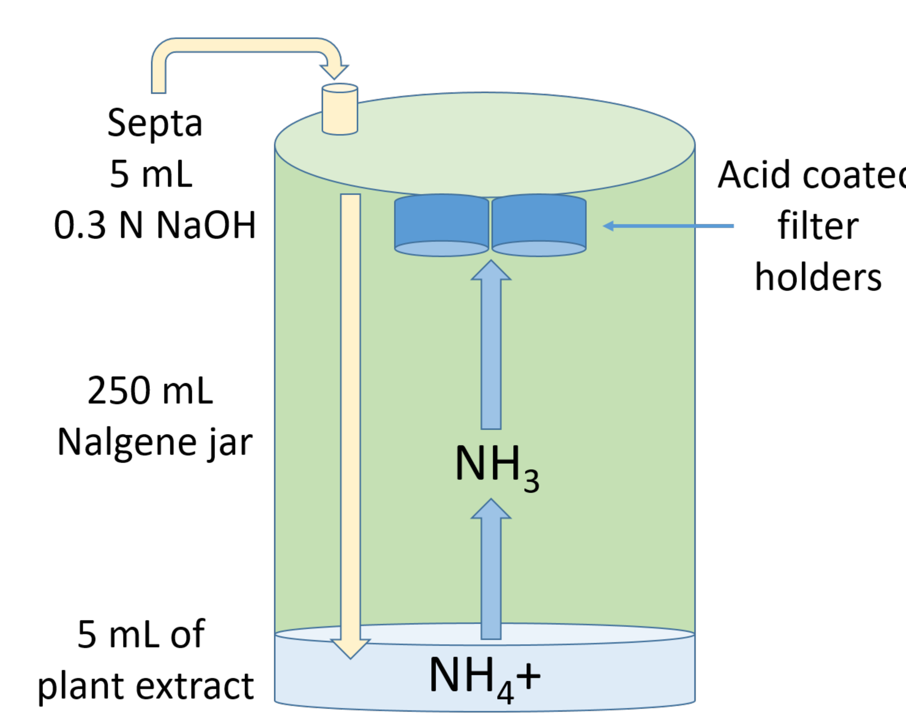
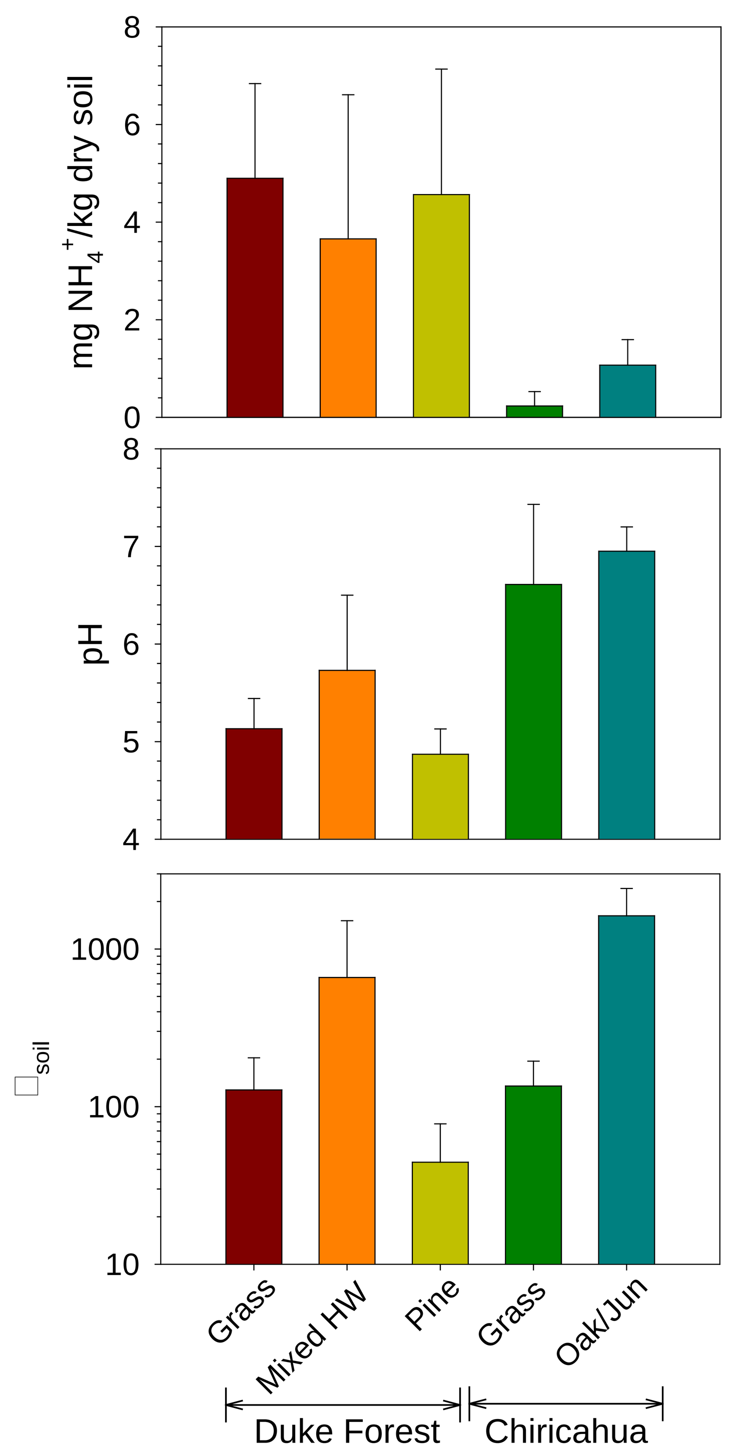


Figure 3: Schematic of sealed headspace diffusion sampler for collection of NH_4^+ from vegetation extracts.

Preliminary Results

Soil chemistry – summer 2017



- Concentrations of soil extractable NH_4^+ much higher at forest site compared to desert site
- Higher pH observed in desert soils
- Lowest pH at Duke Forest observed in pine areas
- Variability in NH_4^+ and pH result in large inter- and intra-site differences in soil emission potential (Γ_{soil}).

Figure 4: Summer 2017 soil chemistry (NH_4^+, pH, and calculated Γ_{soil}) at Duke Forest and Chiricahua. Data (mean and standard deviation) are summarized by primary vegetation at soil sampling location. HW= hardwood, Jun = juniper

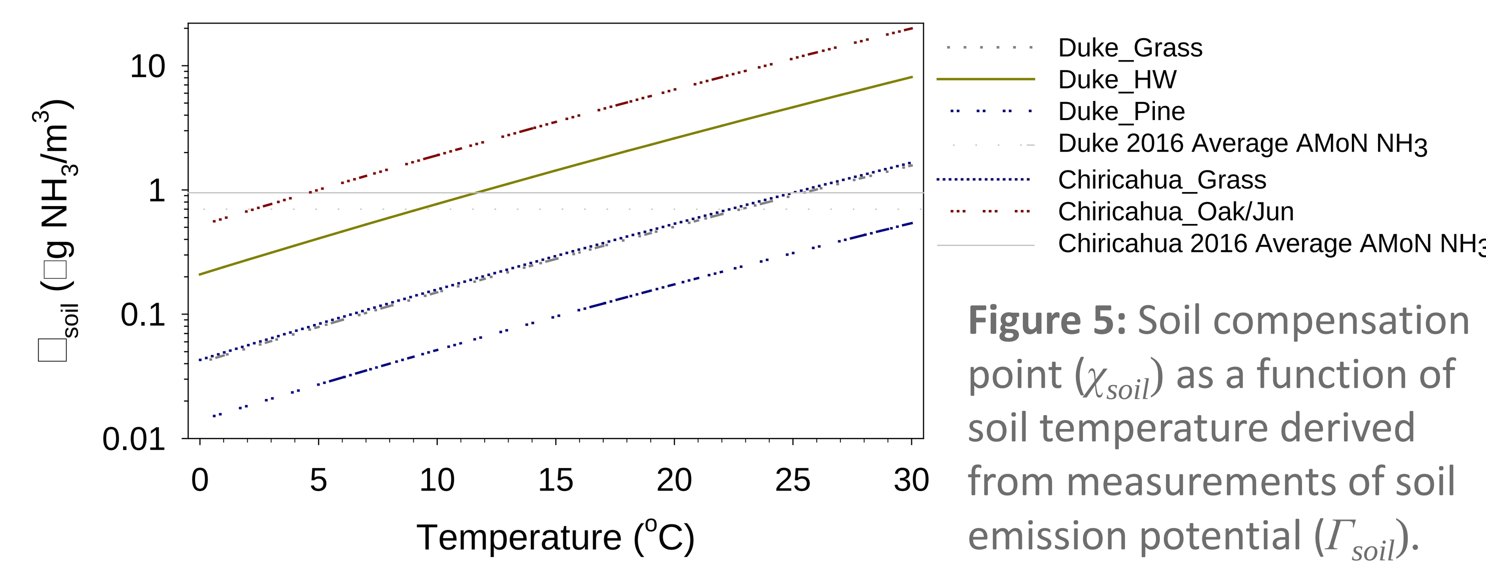


Figure 5: Soil compensation point (χ_{soil}) as a function of soil temperature derived from measurements of soil emission potential (Γ_{soil}).

- Variability in Γ_{soil} translates to large differences in soil compensation points (χ_{soil}).

Next Steps

- Continue seasonal sampling of LAI and biogeochemistry through spring 2018
- Develop Eddy Pro processing routines for sonic data
- Presentation of more complete analysis of soil and vegetation chemistry at spring NADP meeting

REFERENCES: Massad, R.S.; Nemitz, E.; Sutton, M.A. (2010) Review and parameterization of bi-directional ammonia exchange between vegetation and the atmosphere. Atmos. Chem. & Phys. (10) 10359-10386.