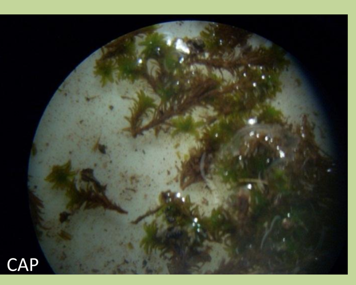
Moss nutrient plasticity in desert ecosystems: a hot-cold desert comparison

Becky A. Ball[1]* and Ross A. Virginia[2]
[1]School of Mathematical and Natural Sciences, Arizona State University at the West Campus, Glendale, AZ, USA
[2]Environmental Studies Program, Dartmouth College, Hanover, NH, USA
*becky.ball@asu.edu



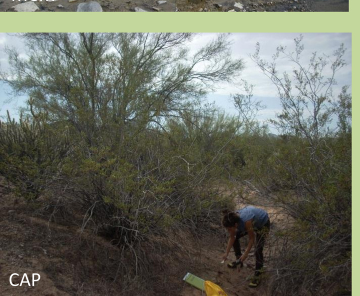








Introduction:

- Desert biology live close to the physical limitations for life, constrained by low availability of water and nutrients. Projections of future climate change suggest that many deserts will experience alterations in water availability, which will influence soil biology and biogeochemical processes.
- In the McMurdo Dry Valleys, a polar desert in Antarctica, moss are the only above-ground primary producers and therefore represent a potentially significant contribution to ecosystem biogeochemistry.
- In the Sonoran Desert in Arizona, moss are a ubiquitous riparian vegetation, and therefore represent a potentially significant terrestrial-aquatic linkage.
- In both hot and cold deserts, moss may play an important role connecting soil and stream nutrient cycling, where stream nutrients may be taken up by moss growing at the terrestrial-aquatic interface, which may be windblown into the nearby soil to become an organic matter source in the soil.
- Despite its importance, very little is known about moss's role in biogeochemical cycles, such the plasticity of their nutrient uptake and stoichiometry, and therefore it is unclear how water and nutrient pulses will affect their functional significance as an integrator of nutrient cycling in deserts.

Research Questions:

To preliminarily investigate the functional role of moss in desert biogeochemical cycles, we sampled moss from two deserts over known gradients in nutrient availability. We asked:

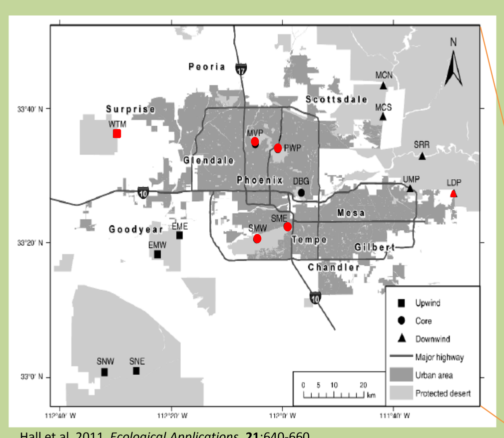
1. How much does moss stoichiometry vary with geography, geology, and variations in resource availability?

2. What is the main source of moss nutrients?

Methods:

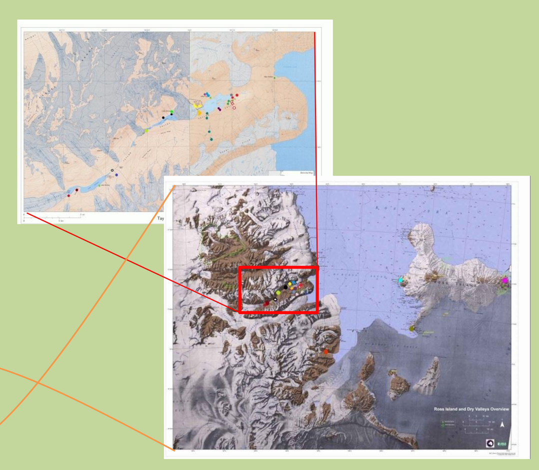
Sites: Sonoran Desert Central Arizona-Phoenix (CAP) — McMurdo Dry Valleys Antarctica (MCM)

*CAP sampling is ongoing



Hall et al. 2011. *Ecological Applications*. **21**:640-660.

Soil N is higher inside the city core than outside (upwind or downwind) due to anthropogenic N deposition.



N and P availability vary according to landscape history, geology, stream nutrient load, and the presence/absence of penguin rookeries.

Sample Collection:

- Moss sample (clean spoon)
- Soil sample beneath the moss (clean scoop)
- Groundwater sample beneath the moss (piezometer)
- Surface water sample near the moss (filtered to bottle)

Sample Analyses:

- Moss C:N:P and cations (elemental analyzer and ICP-OES)
- Soil C:N, mineral N and P (elemental analyzer, Lachat)
- Groundwater N and P (Lachat autoanalyzer)
- Stream water N and P (Lachat autoanalyzer)
- Soil water content (SWC) (oven drying)

Results & Discussion:

Variation in moss stoichiometry among sites:

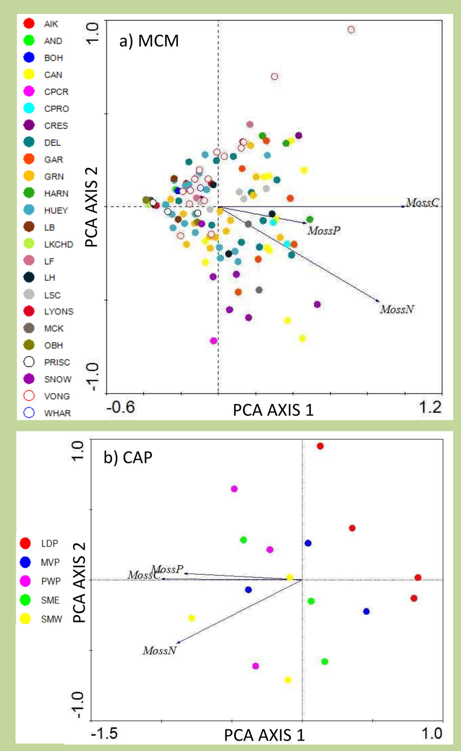


Figure 1. Principal components analysis (PCA) of nutrient content data measured in moss samples collected from a variety of sites in (a) a polar desert (MCM) and (b) a hot desert (CAP).

In the polar desert, there is a fair amount of variability in moss C:N:P within and among sites, such that moss at some sites differ in stoichiometry, but with no distinct pattern by site geography. In the hot desert, C:N:P is much more clearly influenced by site, where the sites inside the city core have higher moss N content than the site outside the city core. Sampling is ongoing to determine whether this pattern holds for other sites outside the city.

Similar results are found when micro-nutrient cations are considered. In both deserts, moss at some sites tend to differ in overall cation content, particularly in Ca and Fe.

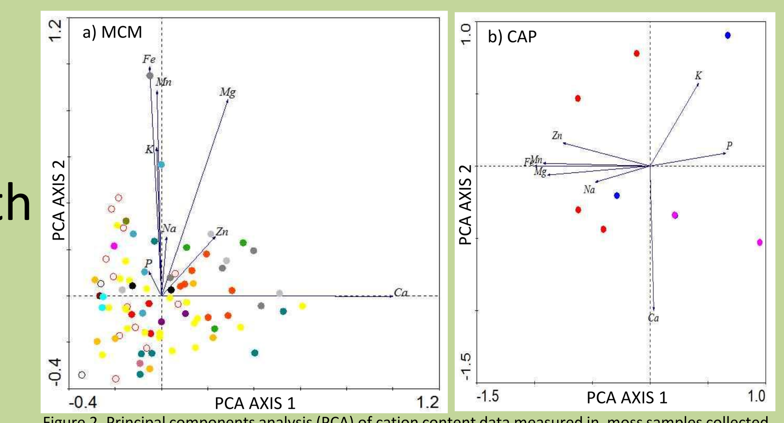


Figure 2. Principal components analysis (PCA) of cation content data measured in moss samples collected from a variety of sites in (a) a polar desert (MCM) and (b) a hot desert (CAP). See Figure 1 for legend.

Sources of nutrients:

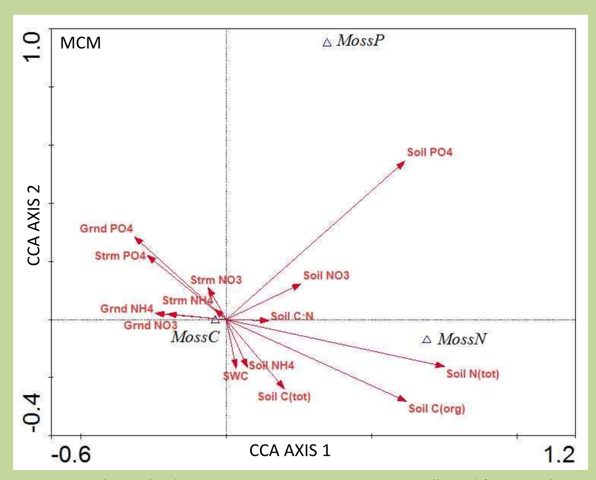


Figure 3. Relationship between nutrient content in moss collected from a polar desert (MCM) and potential nutrient sources in the environment.

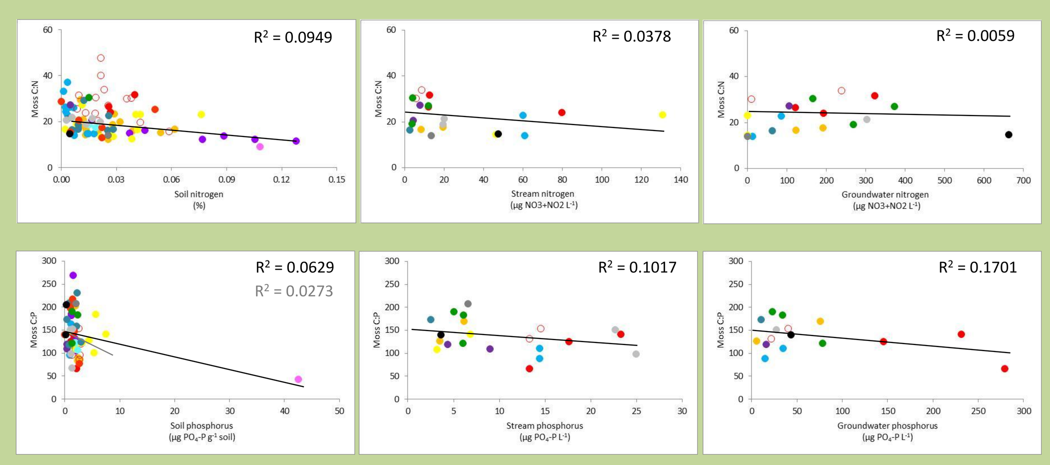


Figure 4. Regressions demonstrating the correlations between moss C:N (top row) and C:P (bottom row) and potential nutrient sources of soil, surface water, and groundwater in a polar desert (MCM). See Figure 1 for legend.

In the polar desert, moss N appears to be most closely related to soil N (particularly total %N), more so than surface or groundwater. Moss P is related to both soil and water PO_4. Regressions show that increased nutrient availability tends to decrease stoichiometric ratios, but there is great variability in moss C:N and C:P at low levels of soil N and P availability.

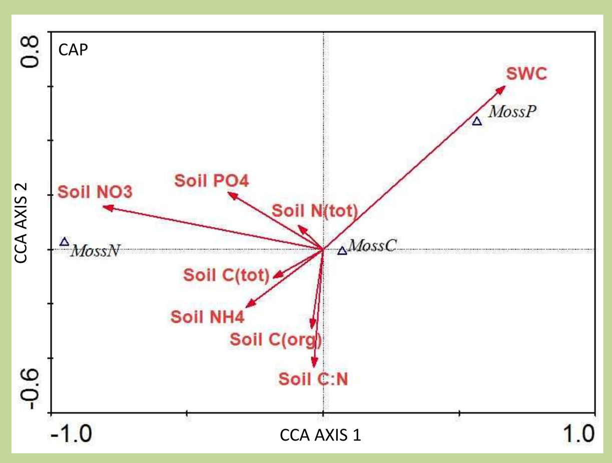


Figure 5. Relationship between nutrient content in moss collected from a hot desert (CAP) and potential soil nutrient sources.

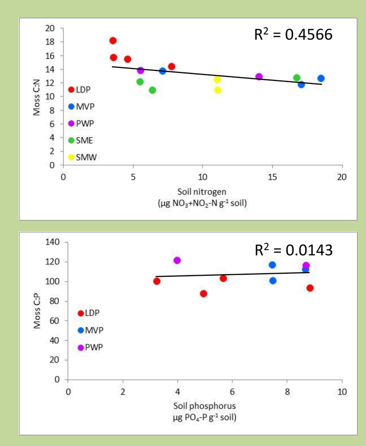


Figure 6. Regressions demonstrating the correlations between moss C:N (top) and C:P (bottom) and potential soil mineral nutrients in a hot desert.

In the hot desert, where water samples were not available, moss N is closely correlated with soil N (particularly NO_3). Moss P, however, is closely related to soil water content, rather than soil PO_4. Notably, moss P is *lower* in wetter soils, but it did not vary greatly among sites.

Conclusions:

- Polar desert (MCM) moss C:N:P loosely varies according to soil (and water) nutrient availability, but hot desert (CAP) mosses clearly take advantage of excess soil N availability.
- There is great variability in MCM moss stoichiometry, with some significant differences between sites, but the mechanism for the patterns are not clearly based on resource patterns as they are in CAP.
- Results suggest that moss play an important role integrating soil and water resources, but the main source of nutrient uptake differs when considering N versus P.
- Results also suggest that moss stoichiometry will change if nutrient availability in the environment is altered.

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