Nitrogen deposition in endemic-rich California serpentine grasslands
Project details

1. Historical reconstruction of anthropogenic N inputs into a Bay Area serpentine ecosystem using tree ring $\delta^{15}N$ analysis

High rates of aerial N deposition (11-16 kg N/ha/yr) have been documented recently at the Coyote Ridge serpentine ecosystem with above-surface ammonium and nitrate collectors. We seek to quantify whether and how this N has been assimilated into serpentine ecosystems over recent decades and whether it has translated into changes in plant-available N and plant N uptake. Tree rings can record long-term alterations to the regional N cycle and changes in N input sources to ecosystems. Previous work has demonstrated that deposition rates comparable to those at our study site shift the 15N content of bioavailable N in tree rings over time toward the 15N content of the regional pollutant source.

We will use tree rings of long-lived woody plants (Quercus durata) growing on serpentine soils at Coyote Ridge to reconstruct linked changes in growth rate, total plant N, and anthropogenic N content over the last 50-100 years. We can use these patterns to identify changes in rates of anthropogenic inputs into the ecosystem via a putative air-to-soil-to-plants pathway, although some direct uptake from air by plant leaves can also occur.

2. A 115-year δ15N record of cumulative nitrogen pollution in California serpentine grasslands using plant museum specimens

Natural abundance stable isotopes of N in vegetation have been increasingly used as bio-indicators of N deposition patterns and subsequent changes to plant N cycling and assimilation. However, the long-term record of atmospheric reactive N enrichment and the resulting changes in ecosystem N dynamics have yet to be adequately reconstructed in many ecosystems. Museum archives of vascular plant tissue are valuable sources of materials to reconstruct temporal and spatial isotopic patterns of N inputs to ecosystems. In this study, we are collecting N stable isotope data from archived and current specimens of an endemic California serpentine grassland species, leather oak (Quercus durata), since 1895 across the greater San Francisco Bay region. Results from this work will provide support for the use of natural abundance stable isotope values in leaves as indicators of variation in N pollution inputs across wide spatial and temporal scales and a valuable baseline against which to assess changes in regional N cycling and subsequent ecological impacts on vegetation.

3. Distribution, concentrations, and ecosystem consequences of atmospheric N pollutants at high- and low-deposition serpentine ecosystems

To date, few studies have attempted to quantify the spatial and temporal distribution and concentrations of multiple nitrogenous pollutant compounds in this sensitive ecosystem (although see Weiss 1999), nor do studies exist that examine the effects of these anthropogenic N inputs on soil N cycling rates or plant N status. The objective of this study is to characterize a range of gaseous N pollutant compounds (NH3, NOx, and NO2) along matched elevation gradients in serpentine grasslands throughout the Bay Area. These compounds are considered to be appropriate markers of increased N deposition from anthropogenic N sources such as traffic and factory emissions that have recently become more prevalent in the Bay Area. Spatial and temporal distribution of target pollutants will be evaluated along both local and regional scales of atmospheric N deposition. In addition, we will measure pools and flux rates of soil N, and N concentrations in aboveground plant biomass, to determine the ecosystem consequences of N deposition.

4. Effects of gaseous nitrogen dioxide deposition on plant nitrogen status and performance in key serpentine grassland species

Atmospheric nitrogen (N) deposition has the potential to strongly influence plant N status and performance either directly by stimulating growth or indirectly by influencing competition in plant communities. However, the role of N deposition and the mechanisms driving successful invasion and persistence of exotic species in serpentine grasslands remain unclear. Lolium multiflorum (Italian ryegrass), the most common invasive plant species in Bay Area serpentine grasslands, exhibits a high growth rate and low resource-use efficiency typical of invaders. Thus, increased N deposition may be a key factor allowing L. multiflorum to successfully invade and persist in a formerly low-resource environment that has resisted invasion for centuries. Using a growth chamber system, we exposed several native species in monoculture and in combination with L. multiflorum to different concentrations of gaseous nitrogen dioxide (NO_2; a common N pollutant) and soil NH_4NO_3 to simulate ~10 years of accumulated N from atmospheric deposition. Measurements included $\delta^{13}C$ and $\delta^{15}N$, specific leaf area, stomatal conductance, photosynthetic rate, and foliar and whole plant N, P, and Ca concentration. The objective of this study was to test how increased N deposition affects plant nutrition and the relative performance of key native and exotic species in a CA serpentine grassland. Results suggest that at concentrations commonly observed in the San Francisco Bay Area, NO_2 may act as a nutrient and stimulate greater biomass accumulation and greater allocation of N to photosynthetic tissue in invasive L. multiflorum than in native serpentine grassland species. This study contributes understanding of how physiological differences among species affect both the dynamics of N uptake in the serpentine ecosystem and the outcomes of competition between native and exotic species experiencing anthropogenic N loading.