Methodologies for Determining Empirical Critical Loads and Exceedances for California Ecosystems

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Objectives

- To provide an overview of methods for deriving empirical CL and CL exceedances in California, including:

- N deposition methods
- Ecological responders or parameters used to develop critical loads in 7 vegetation types in California
- Development of statewide CL exceedance maps

Briefly: Why Empirical Critical Loads?

- **Uncertainty in modeled CL values**
- **As a 'real world' check on computed CL**
- **Relationships between modeled CL (or thresholds for key input variables) and biological effects often poorly defined**
- **Models can't fully simulate complexities of ecological conditions and stressors**

Limiting Factors in the Setting of Empirical Critical Loads

- Inadequate N input range (either as N addition or deposition)
- Lowest N input level too high (above the CL)
- N response variables measured at few points
- Confounding environmental factors across N gradients
- N addition treatments may be short term; need long term responses
- N deposition isn't known or well quantified
- Lack of an established N response threshold for setting an empirical CL
- Complex ecosystem responses (e.g., sustainability, multiple stress complexes, etc.)

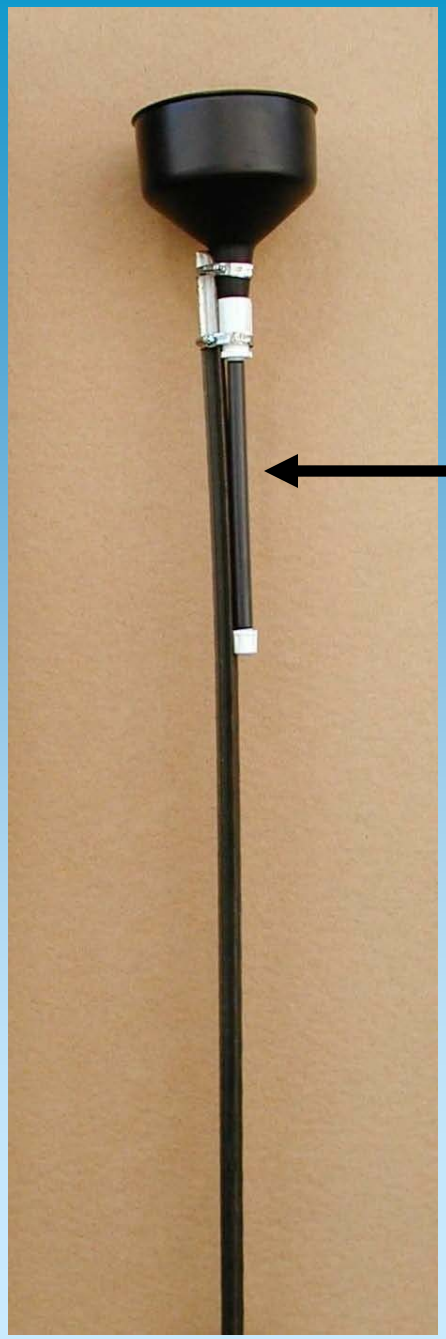
Nitrogen Deposition Methodologies

- Ion exchange resin (IER) throughfall collectors
- USEPA, CMAQ simulated deposition: (Models-3/Community Multiscale Air Quality) model
- Inferential method (dry dep) + NADP (wet dep) used for comparison with CMAQ at selected sites
- CMAQ used to develop statewide exceedance maps

Ion exchange resin (IER) throughfall collector.

Ions in throughfall or precipitation samples are adsorbed by anion and cation exchange resin beads within the IER column.

After exposure, ions of interest are extracted from the columns, analyzed and deposition fluxes calculated.



Sampling frequency: typically 2x/yr

Methods paper: Fenn & Poth, 2004.
J. Env. Qual. 33:2007-2014

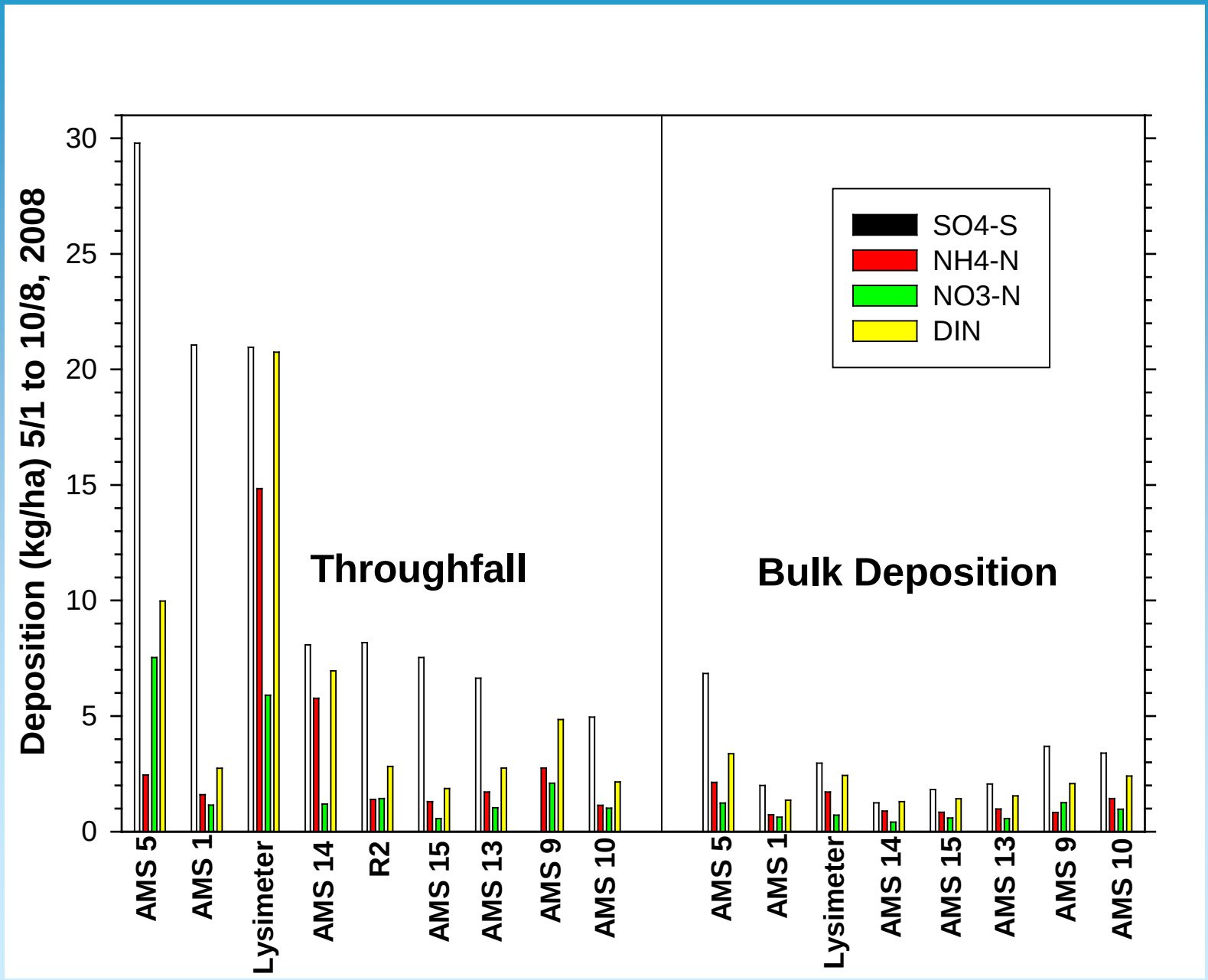
Bulk Deposition: In Open Sites

Biological Challenges to Field Monitoring

Bear Damaged Collectors

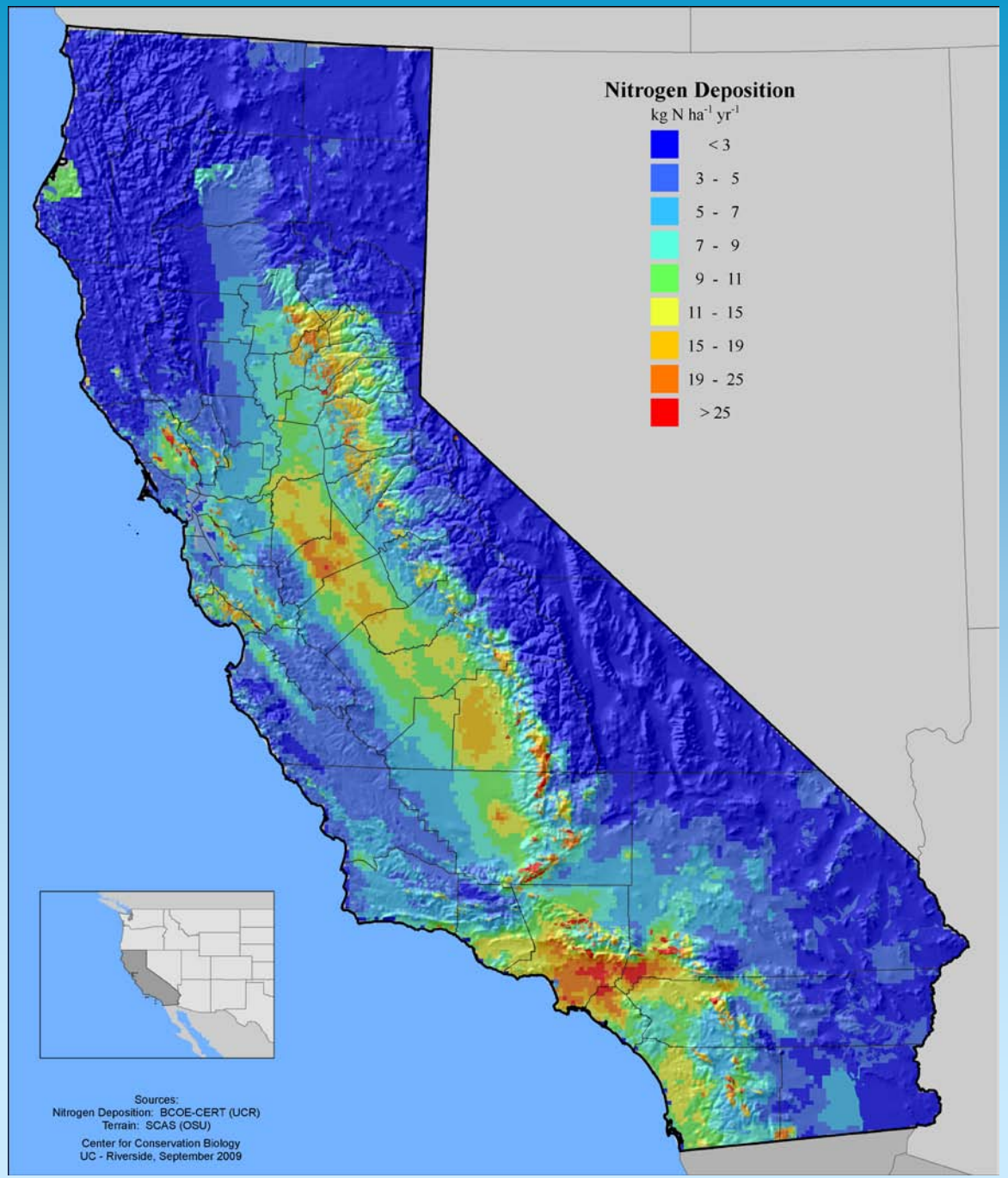
Oil Sands Monitoring Network in N. Alberta, Canada

N and S Deposition Data: Oil Sands Region, N. Alberta, Canada



CMAQ Simulated N Deposition for California

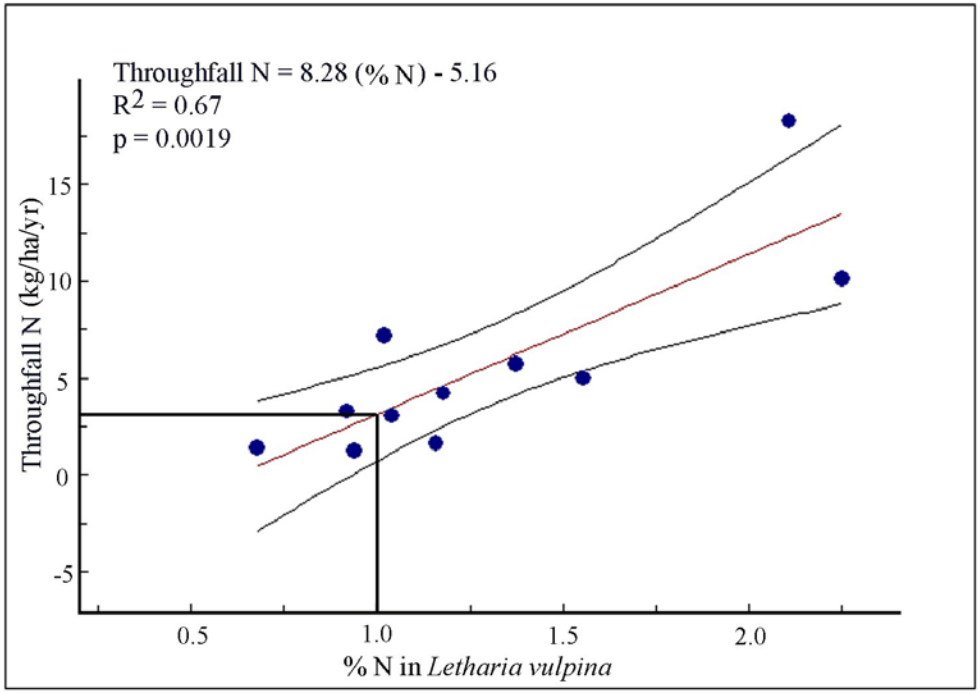
4 x 4 km grid scale over 2/3 of state; Rest is 36 km grid



Lichen-based CL developed for mixed conifer forests, chaparral and oak woodlands

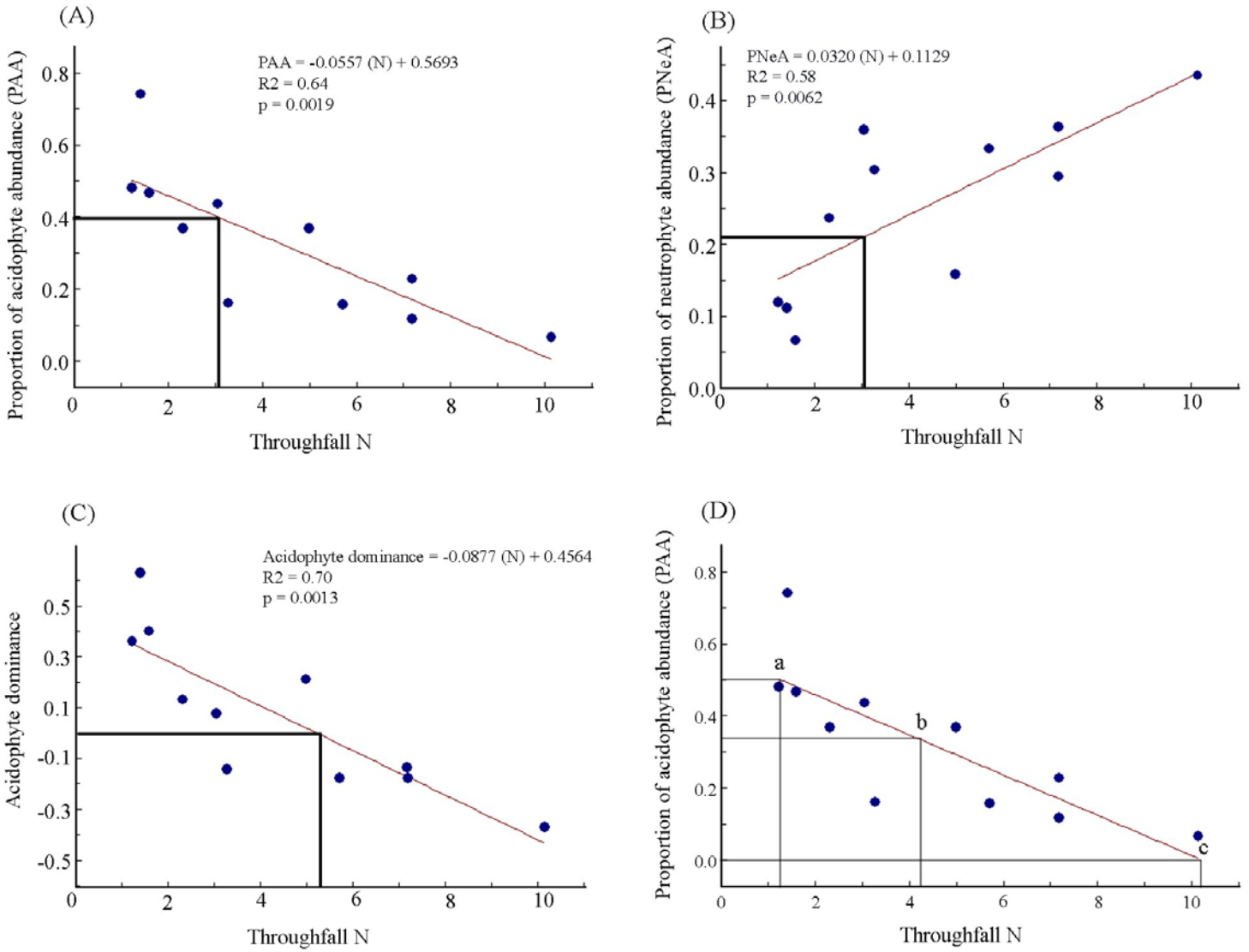
***Letharia vulpina*; wolf lichen;**
In the Sierra Nevada of California concentrations of N in *L. vulpina* are correlated with N deposition and adverse changes in lichen community composition.

Mixed Conifer Forest Throughfall N vs. N in *L. vulpina*



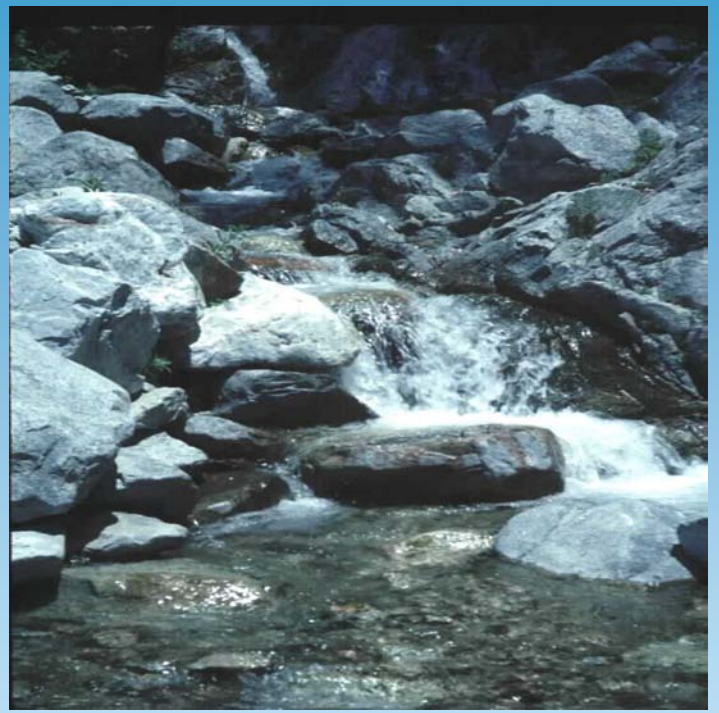
Threshold N concentration = 1.0% N in *L. vulpina*; Corresponds with a CL of 3.1 kg N ha^{-1} yr^{-1} in the Sierra Nevada Mountains of California.

Indices of lichen N indicator groups



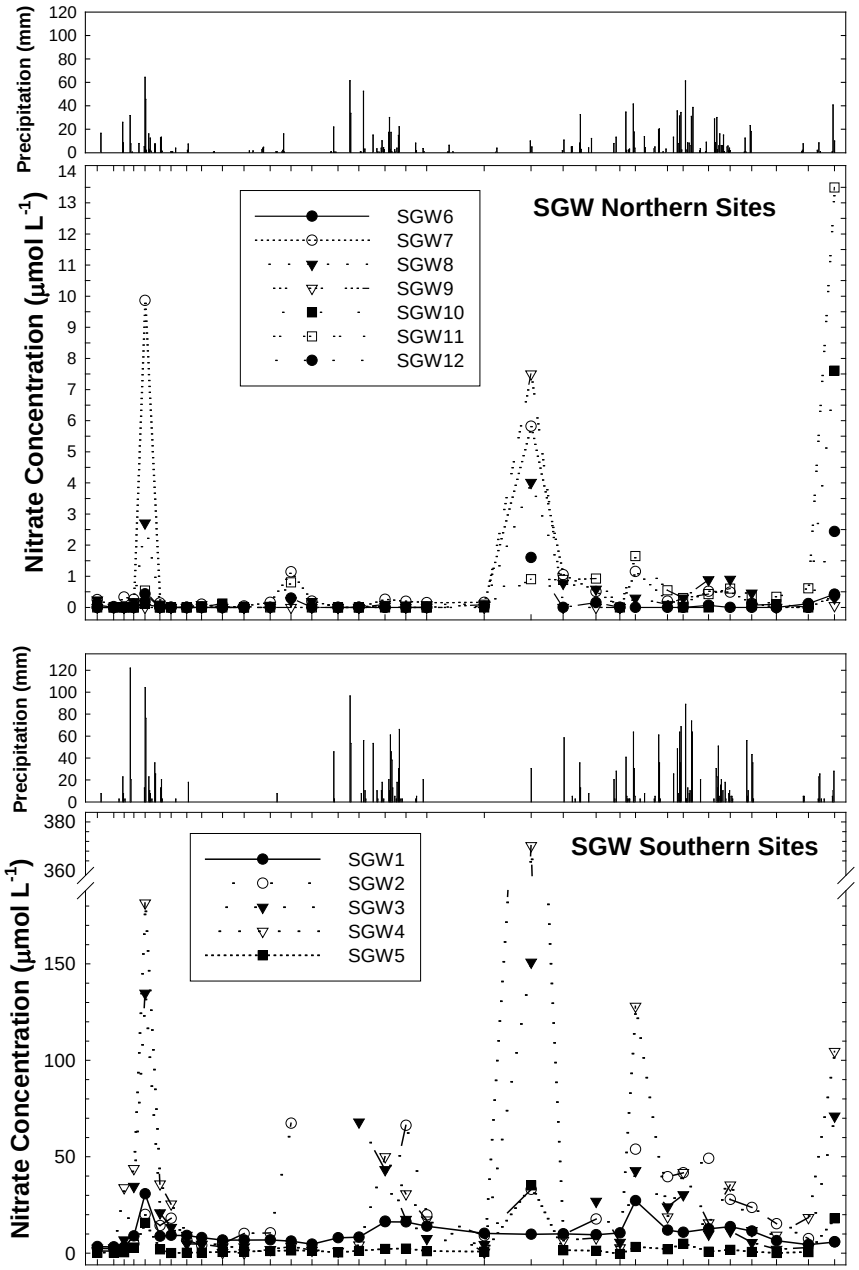
(C) Acidophyte dominance shifts to neutrophyte dominance at 5.2 kg N ha^{-1} yr^{-1}.

Streamwater Nitrate Leaching Critical Load: Forests and Chaparral Catchments



Nitrogen Deposition → **Elevated NO_3 in runoff**

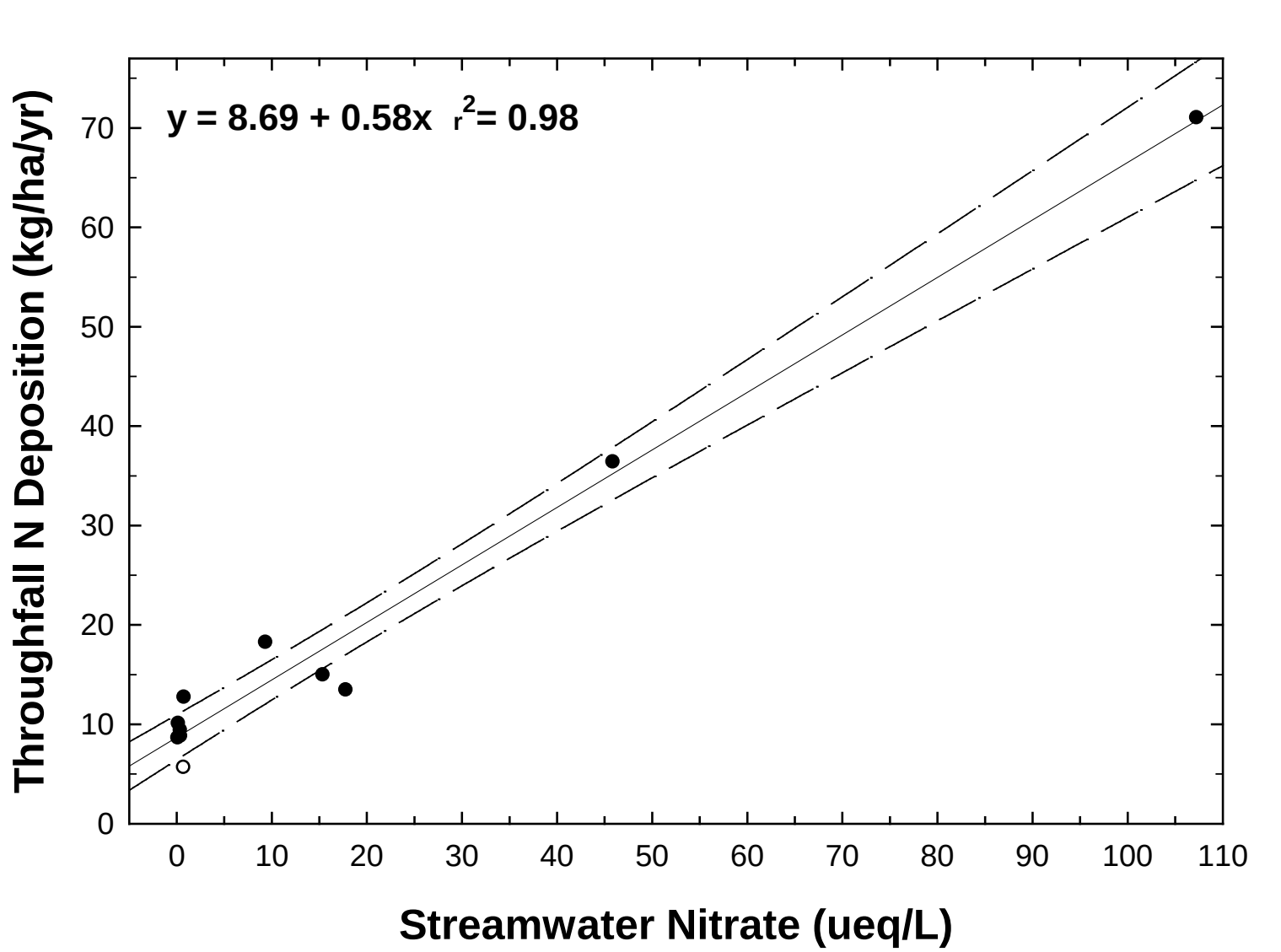
Deposition: Measured as throughfall; however chaparral and oak woodland lichen CL are based on CMAQ deposition estimates



Critical Value for Peak Runoff NO_3 Concentration Used for Estimating the Empirical CL: 14.3 µ*M* or 0.2 mg N L^{-1}

If peak NO_3 concentrations regularly exceed this threshold, the CL for incipient NO_3 leaching is exceeded by definition.

Empirical Throughfall CL for Mixed Conifer Forests: 17 kg N ha^{-1} yr^{-1} (Based on acceptable leaching value of 0.2 mg L^{-1} or 14.3 µeq L^{-1})

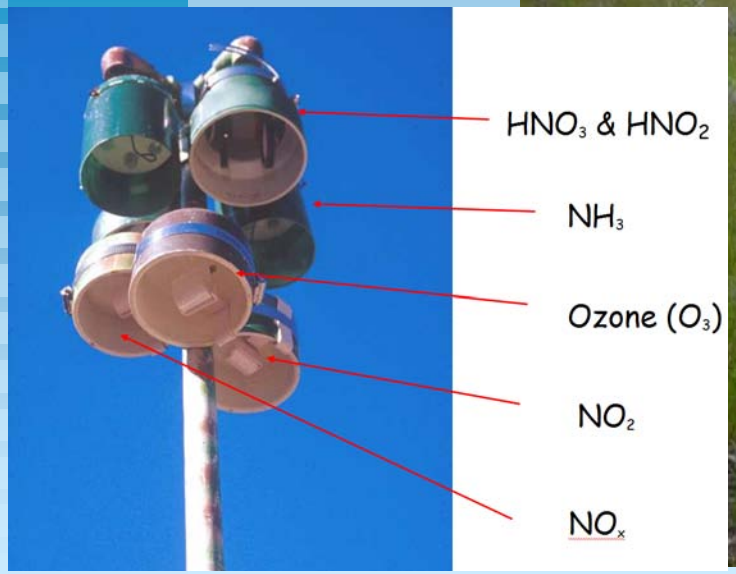


Coastal Sage Scrub: CL based on invasion of exotic grasses and changes in mycorrhizal communities across a deposition gradient

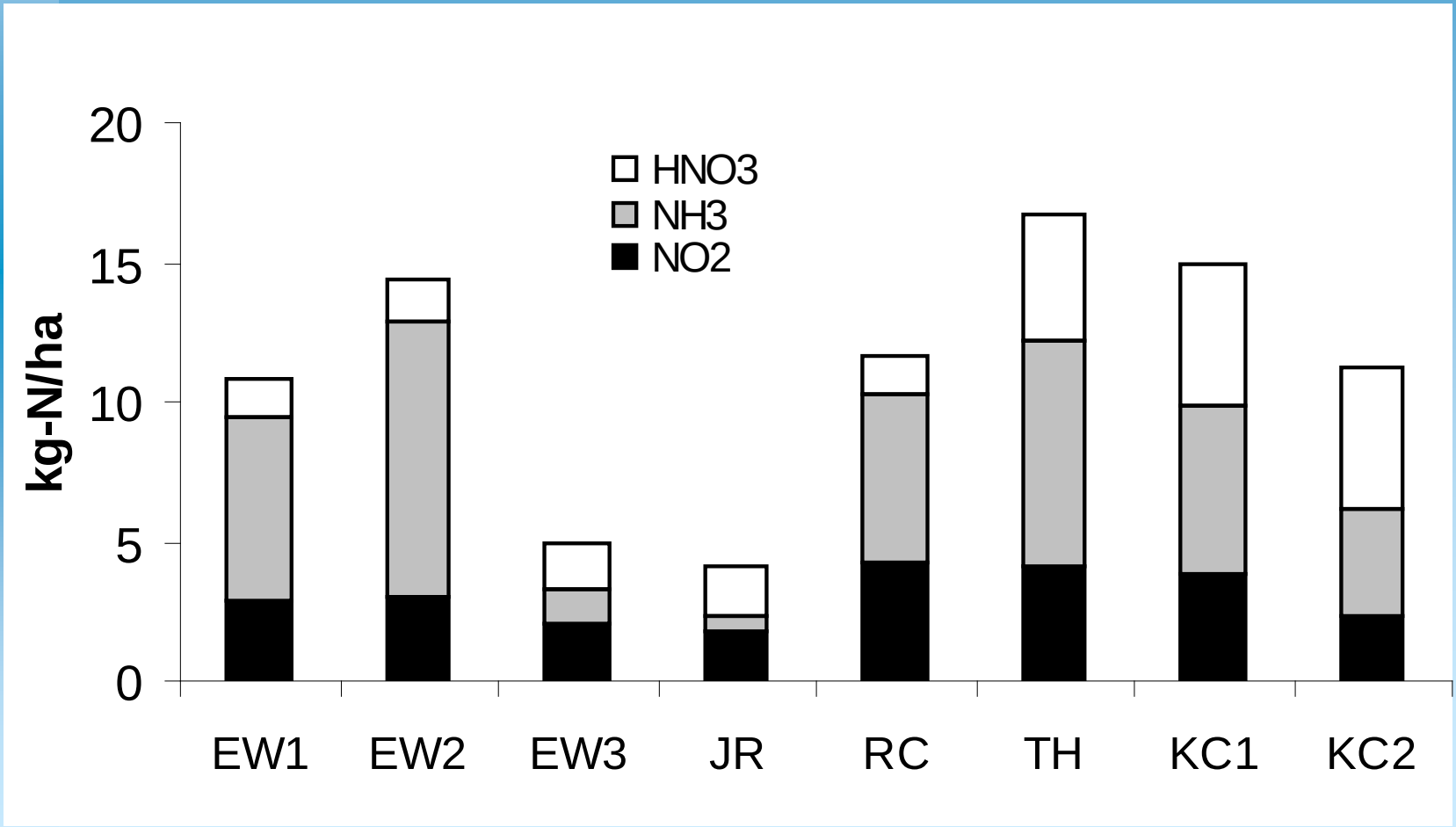
- **N deposition: CMAQ & Inferential method**

Serpentine Grassland: CL based on exotic annual grass invasion

N deposition: Inferential method using passive samplers for major N species and wet deposition



CL based on a roadside gradient at the Edgewood Natural Preserve: Transect at Highway 280, San Francisco Peninsula



Desert Scrub: Joshua Tree NP

- CL based on exotic grass invasion with N additions
- Grass biomass leads to fuel buildup, increased fire frequency, and replacement of native species

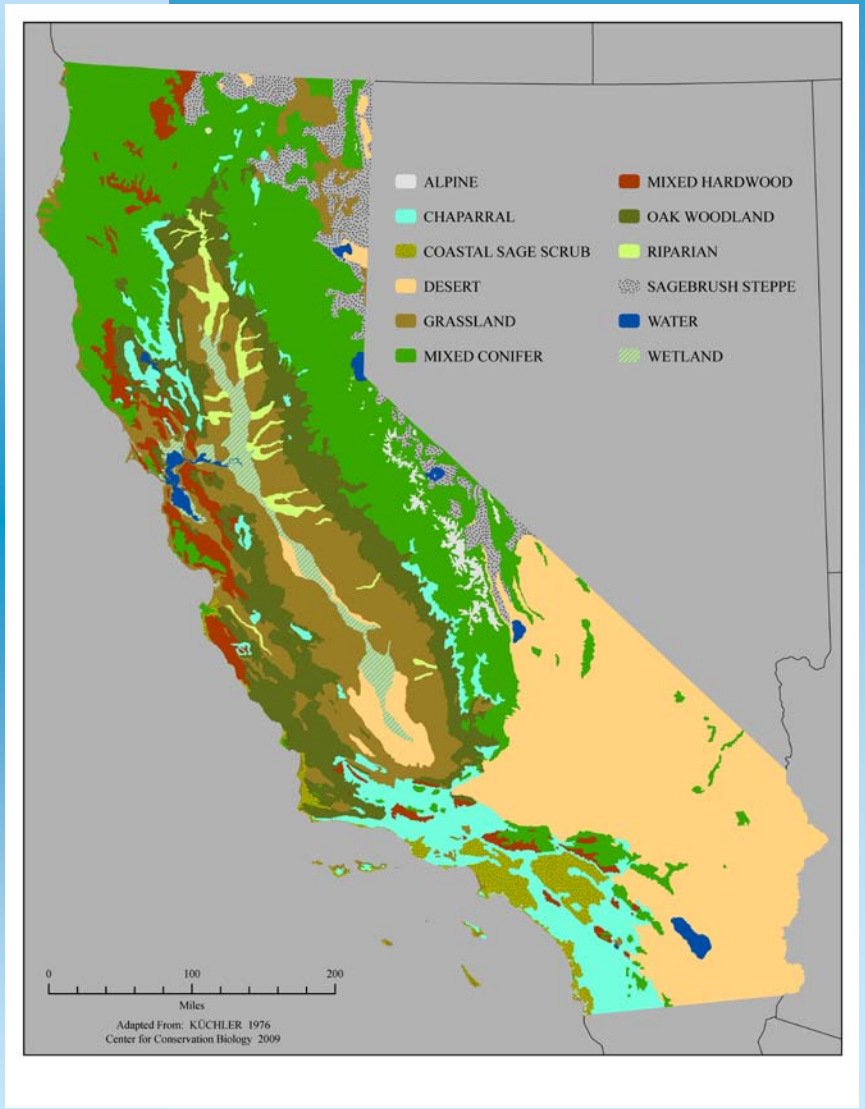
N fertilizer study sites:

Higher N deposition

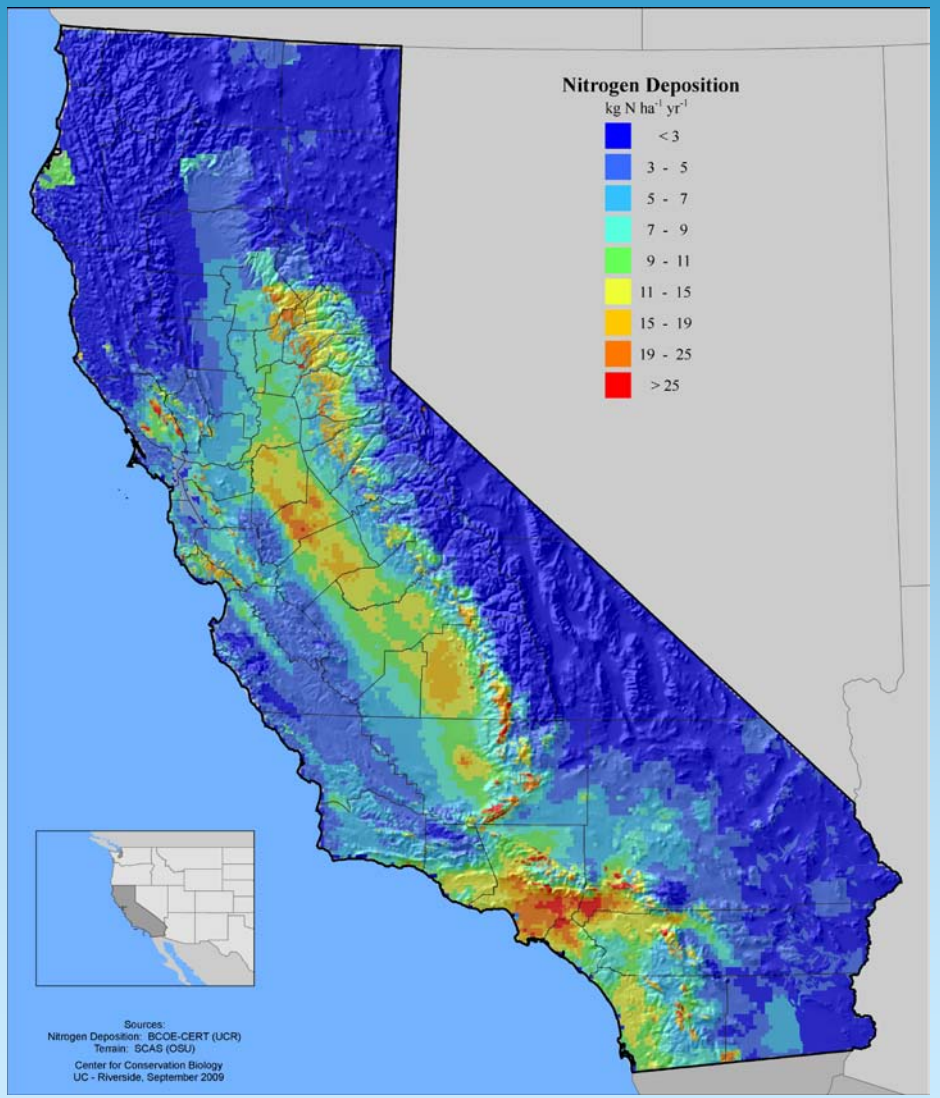
Lower N deposition

Invasive Grass Fuel Buildup in Desert

Empirical CL Exceedance Maps: Overlay CMAQ N deposition and vegetation map and the empirical CL for each vegetation type

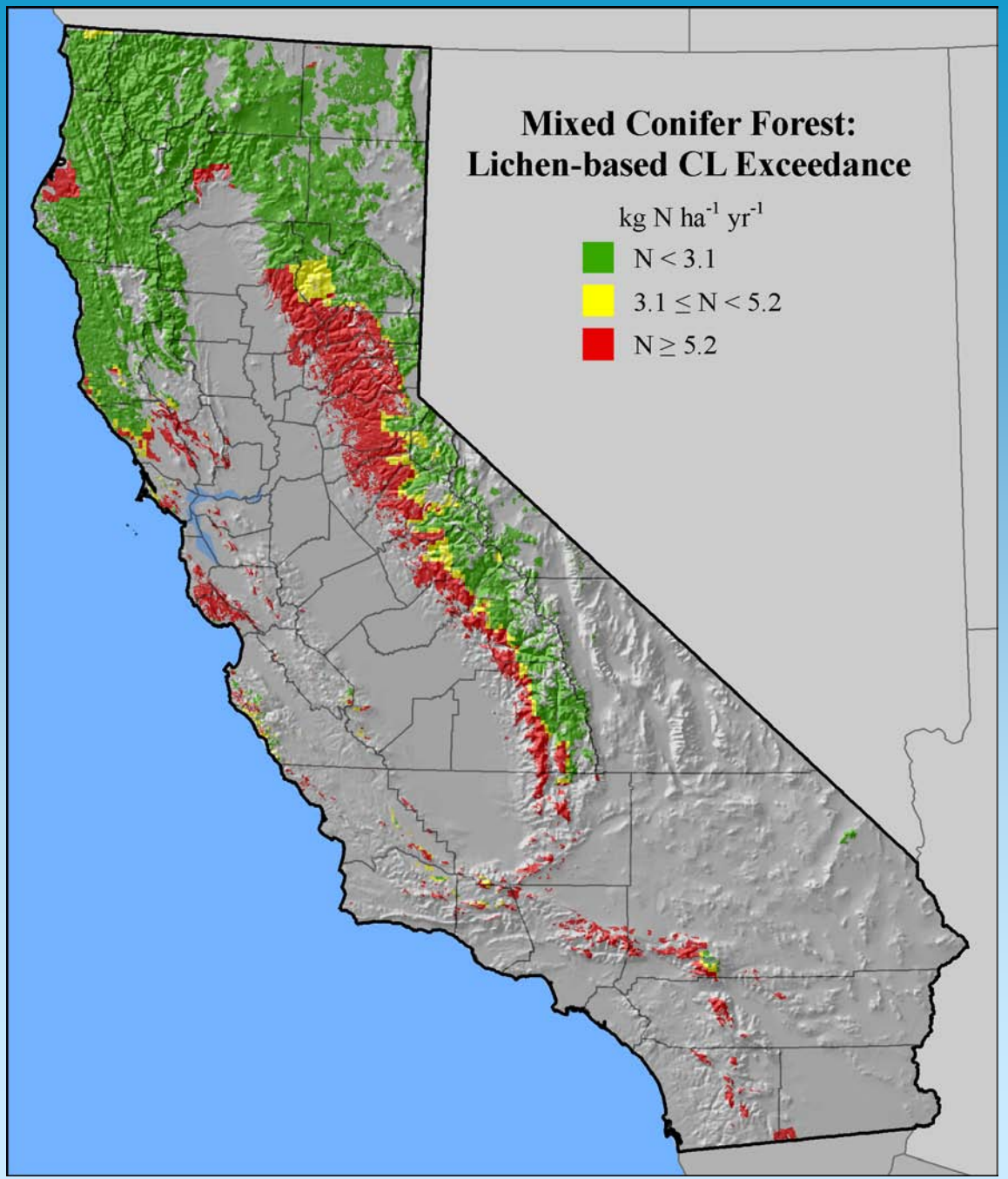


California Vegetation Map

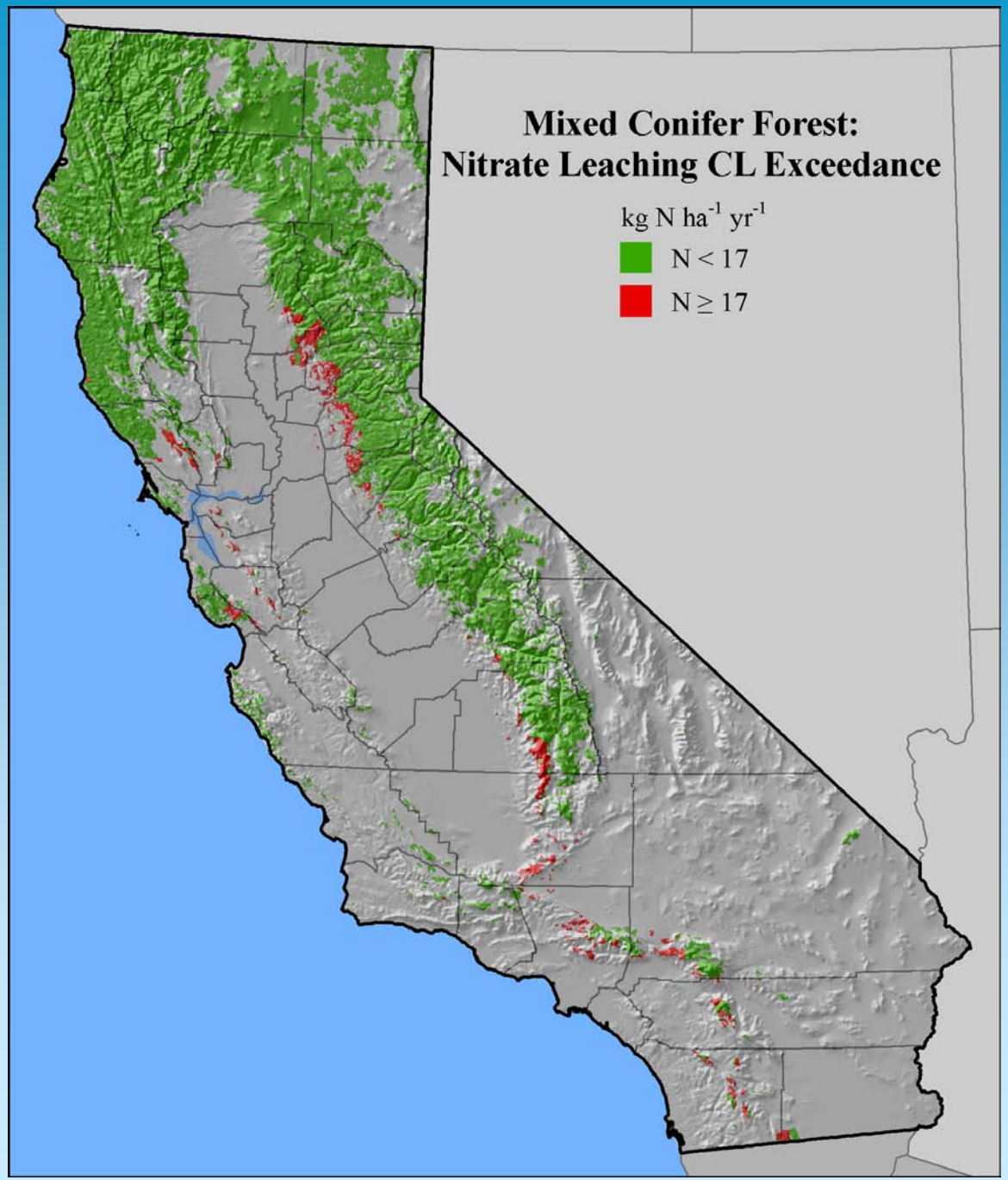


CMAQ N Deposition Map

Critical load exceedance map for coniferous forest

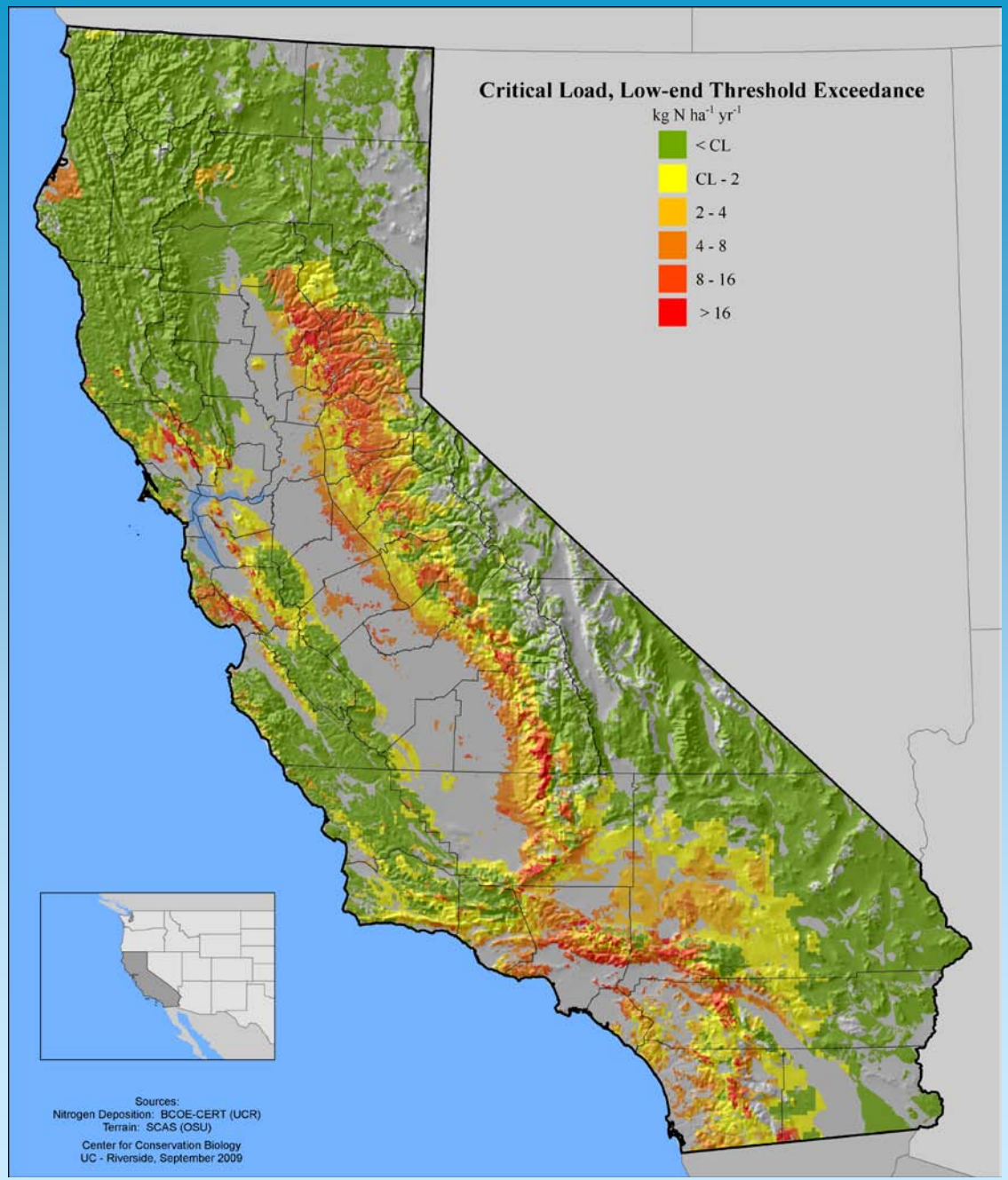


Critical load exceedance map for coniferous forest



Empirical CL Exceedance for 7 Vegetation Types:

- Mixed conifer forest
- Oak woodlands
- Chaparral
- Coastal sage scrub
- Grassland
- Desert scrub
- Pinyon-juniper



We are steadily making good progress on critical loads development in the U.S.