Critical Loads forAtmospheric Nitrogen Deposition in California

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Dry Nitrogen Deposition
Smog is slow release N-fertilizer

Atmospheric Chemistry 101

Combustion, soils

$NO \leftrightarrow NO_2$ (hv) $\leftrightarrow O_3$

$NO_2 \rightarrow [OH^*]$

$HNO_3 + NH_3 \rightleftharpoons NO_3NH_4(p)$

Fertilizer, animal wastes, vehicles, vegetation,

Dry deposition

up to >50 kg-N/acre/year, pre-industrial background is 0.5 kg-N/acre/year

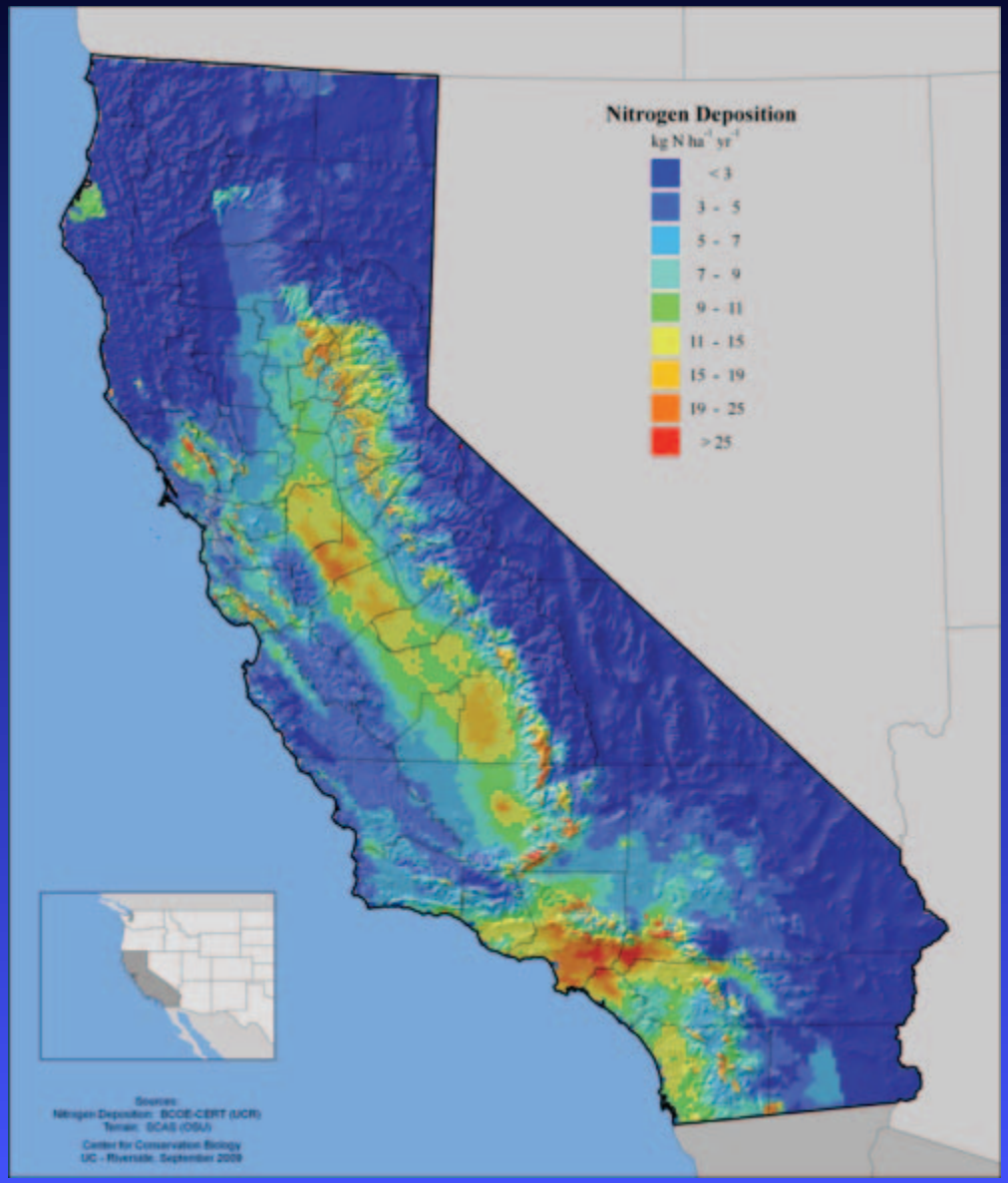
NO_2 and NH_3 gases are taken up through stomata

HNO_3 and NH_3 stick to surfaces, even “dry” surfaces

Particulates and other gases are relatively minor contributors

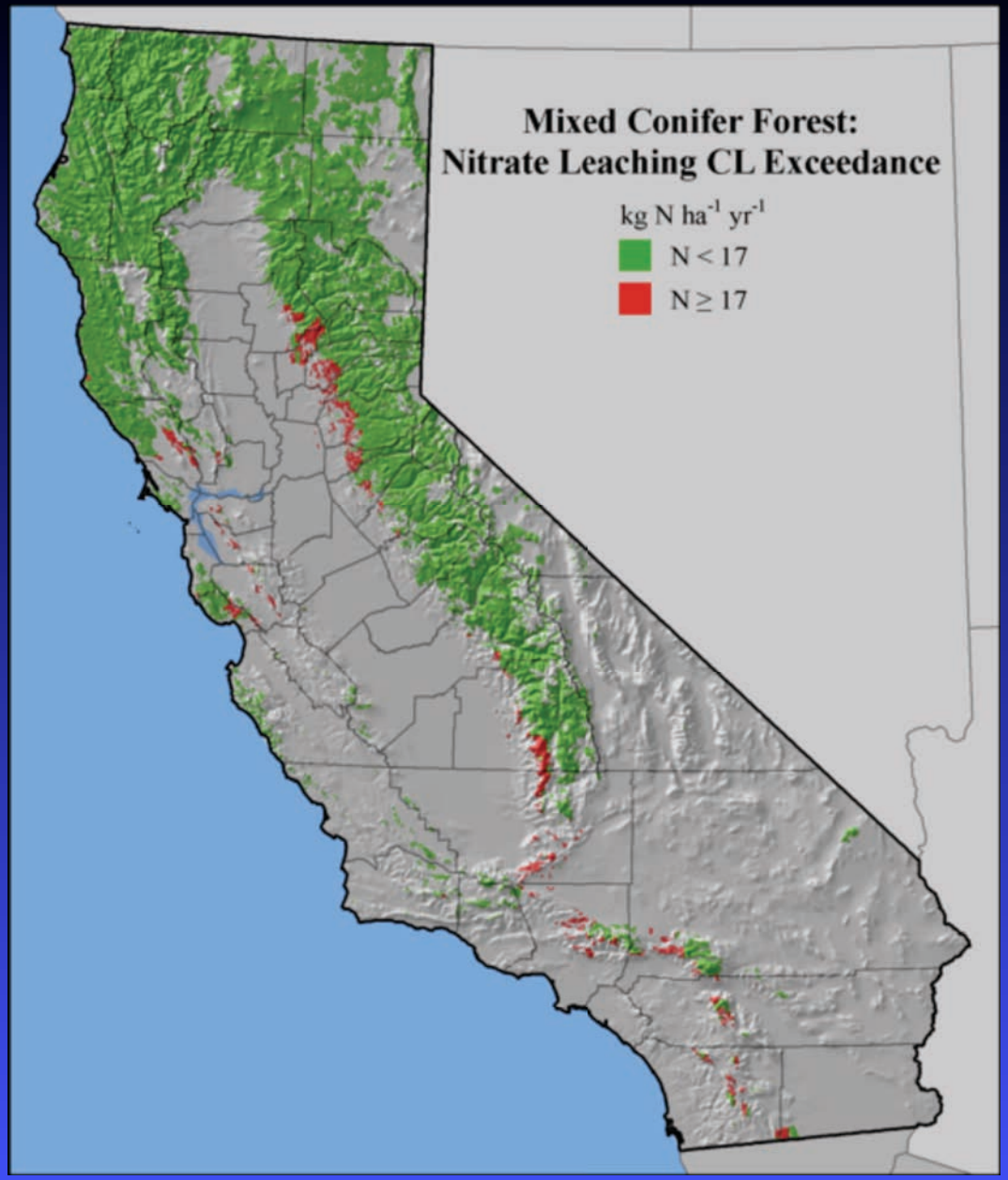
Dry deposition is >80-90% in polluted regions of California, wet deposition is of lesser importance most places

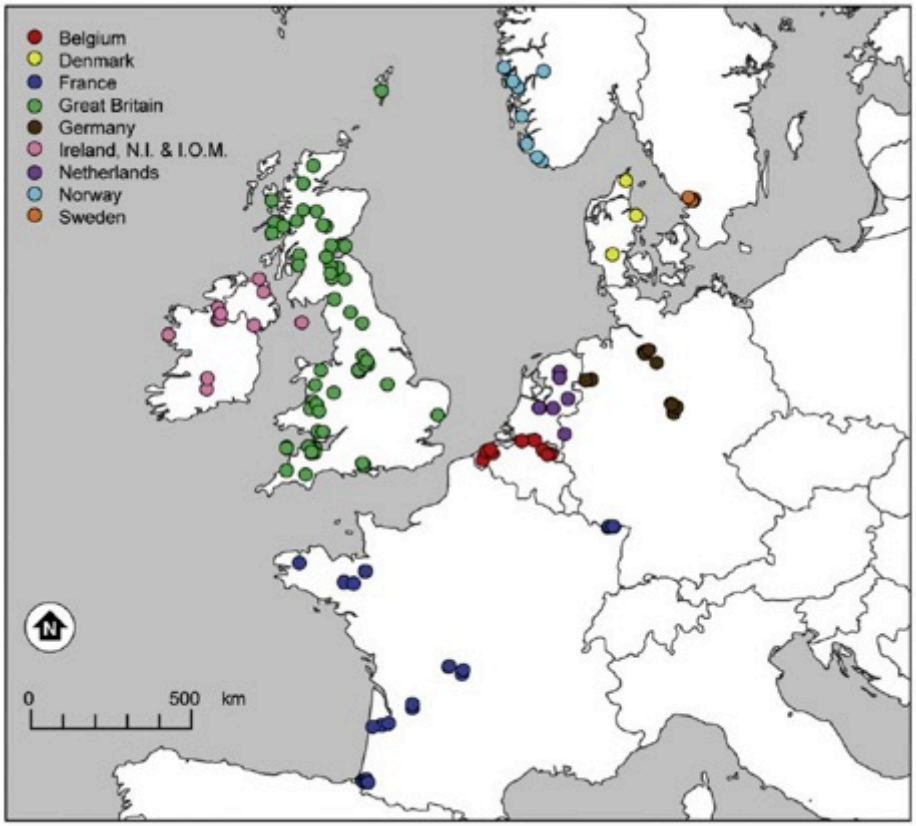
Nitrogen Deposition Levels in CA



Bulk Deposition Samplers in the Santa Monica Mountains National Recreataion Area

Elevated nitrate levels in soil solution or surface water runoff is the cardinal sign of ecosystem nitrogen overload





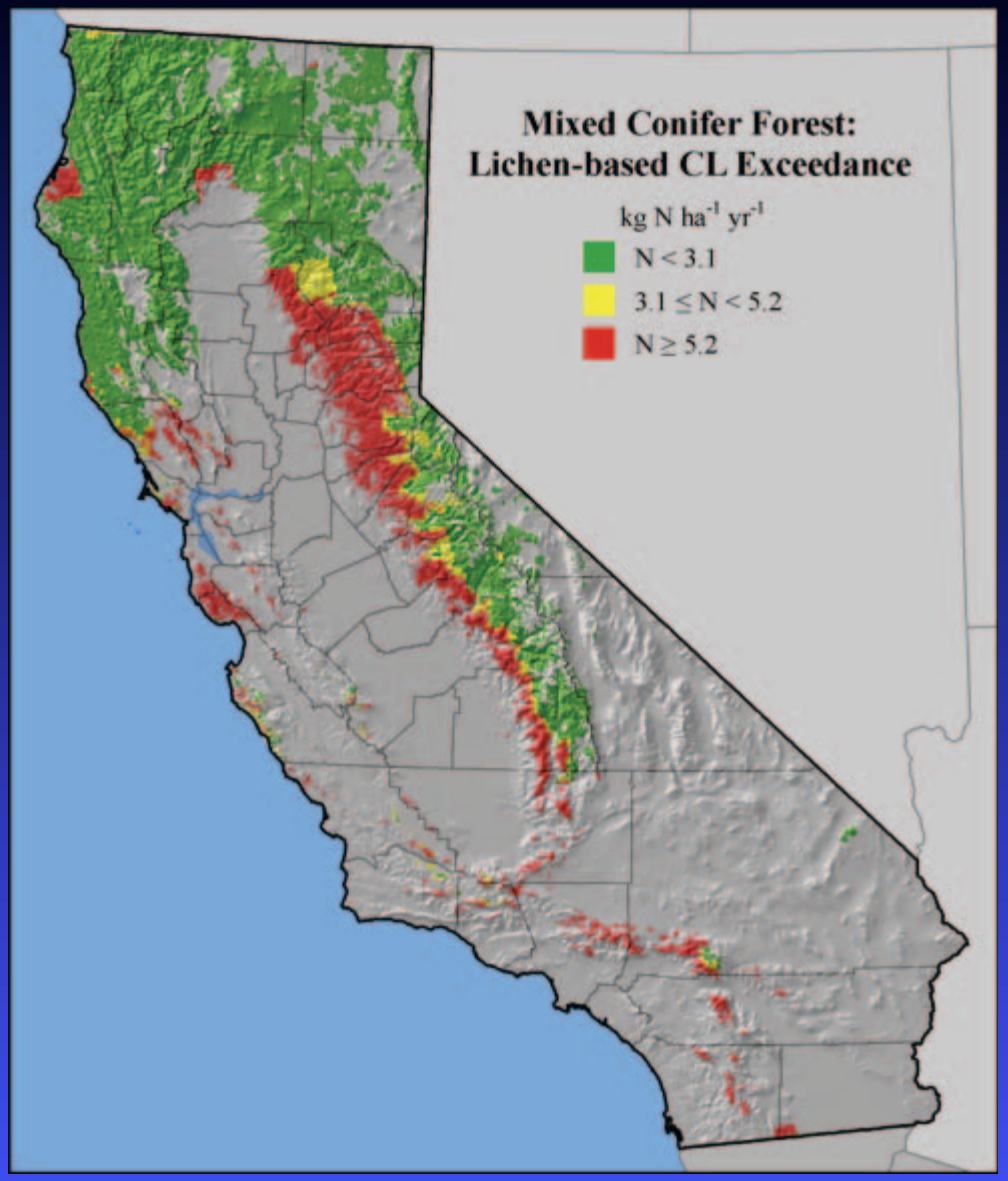
N deposition effects on plant species richness in acid grasslands in Europe

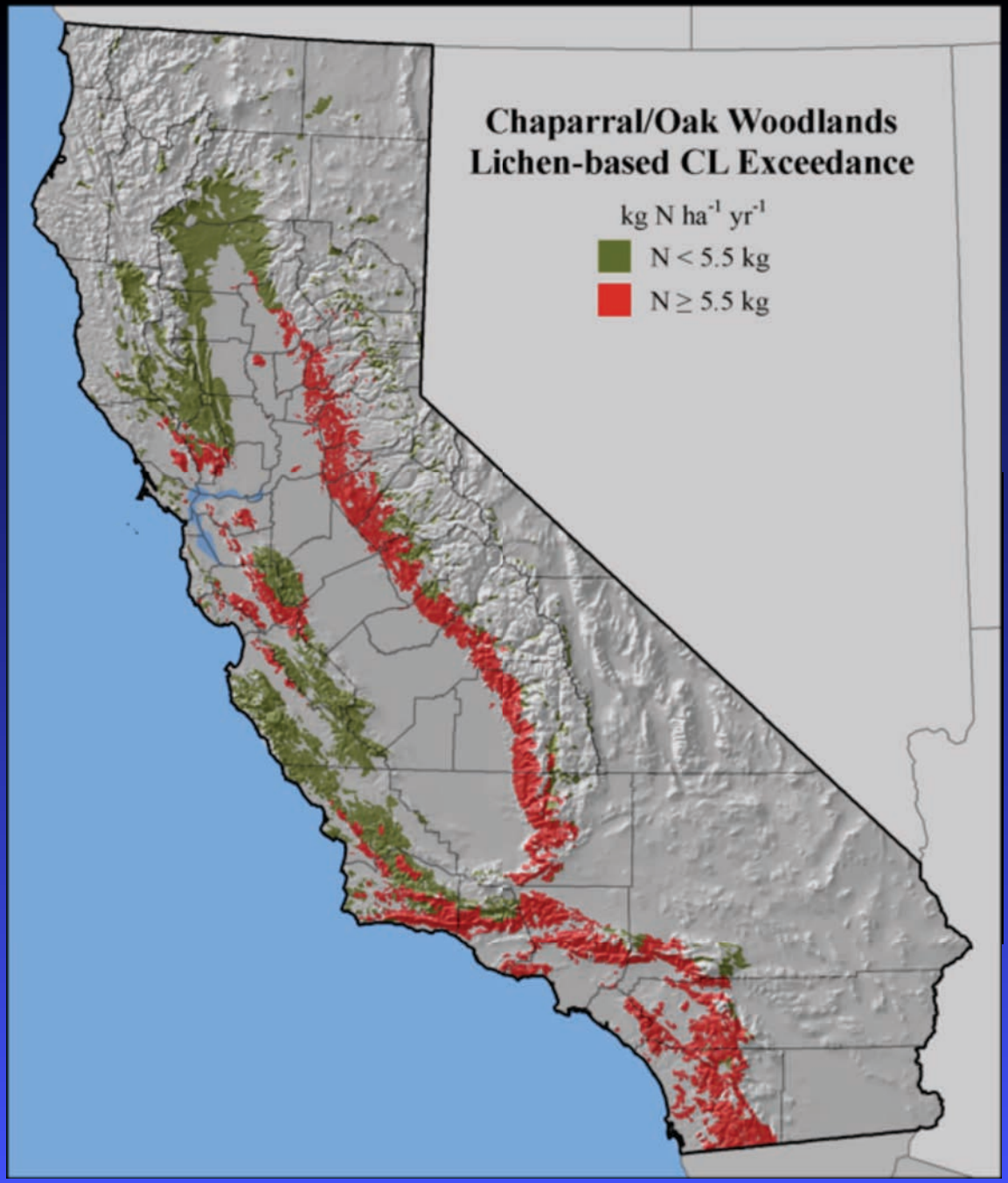
Stevens et al., 2010

Critical Load: Atmospheric deposition level below which harmful effects do not occur on specified sensitive elements of the environment.

Letharia vulpina; wolf lichen;
In the Sierra Nevada of California Epiphytic lichen communities begin to change at a CL of ≤ 3.2 kg/ha/yr (Fenn et al., 2008, 2010).

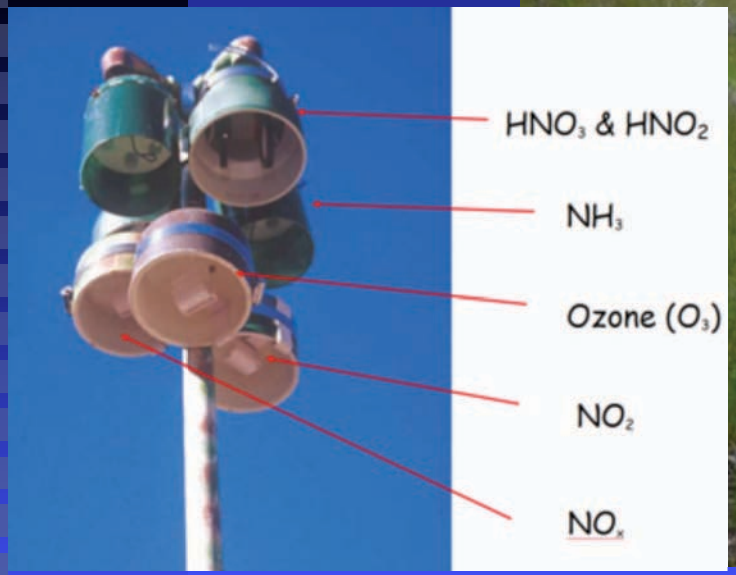
Platismatia glauca

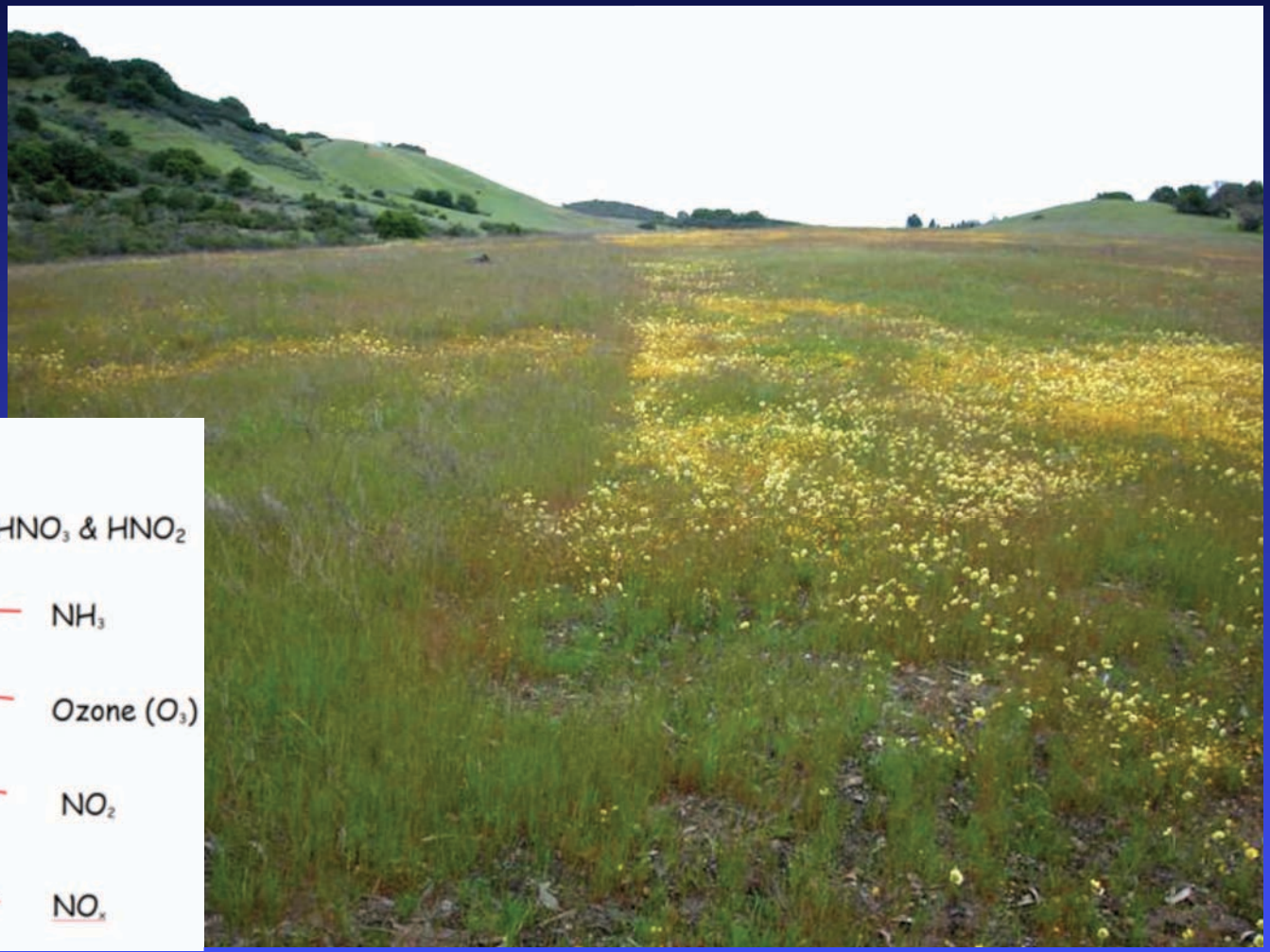



Chaparral/Oak Woodlands
Lichen-based CL Exceedance
kg N ha-1 yr-1
N < 5.5 kg
N ≥ 5.5 kg

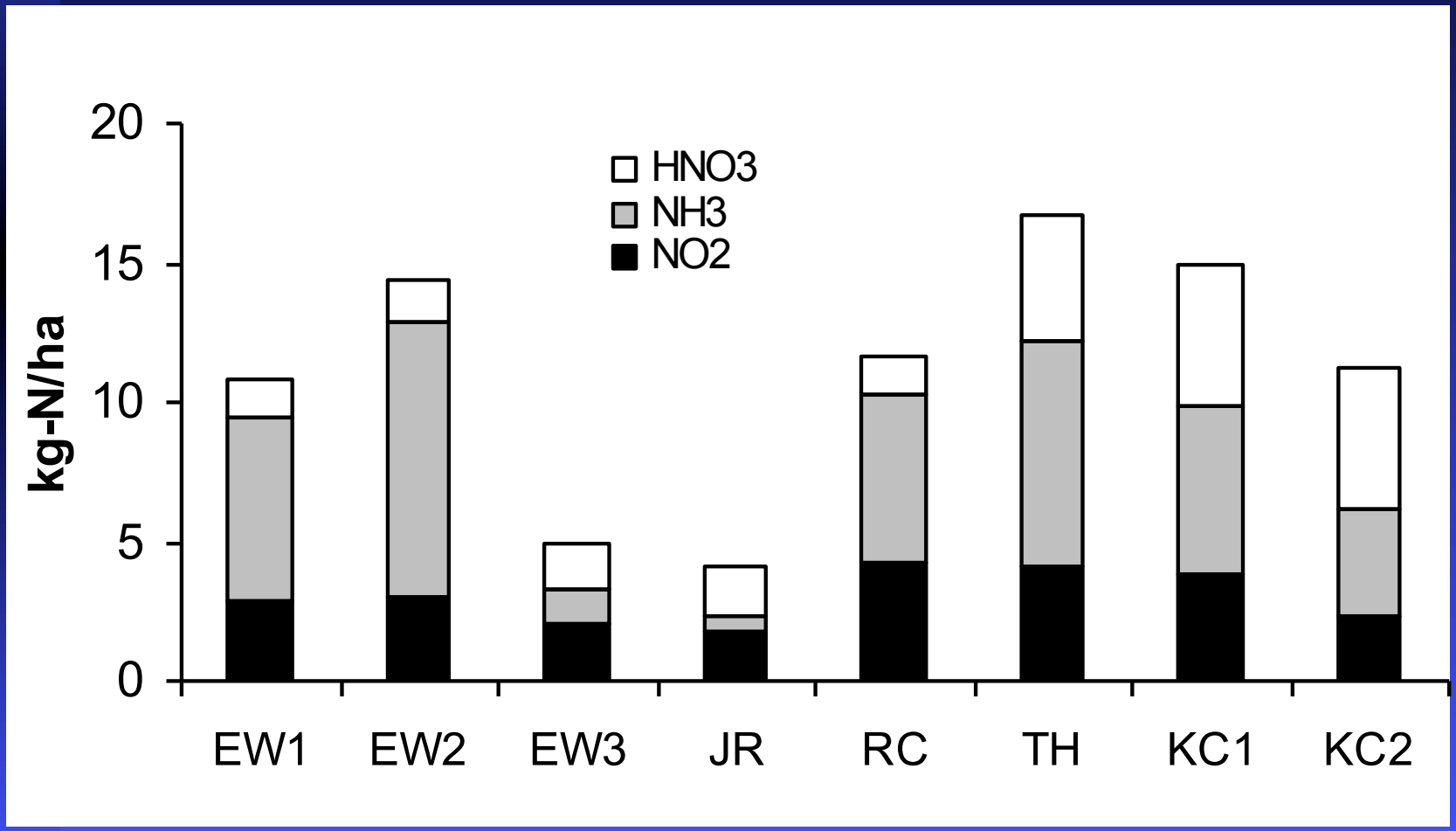
Serpentine Grassland: CL based on exotic annual grass invasion

N deposition measurement: Inferential method using passive samplers for major gaseous N pollutants (dry deposition) plus wet deposition of N (precip)





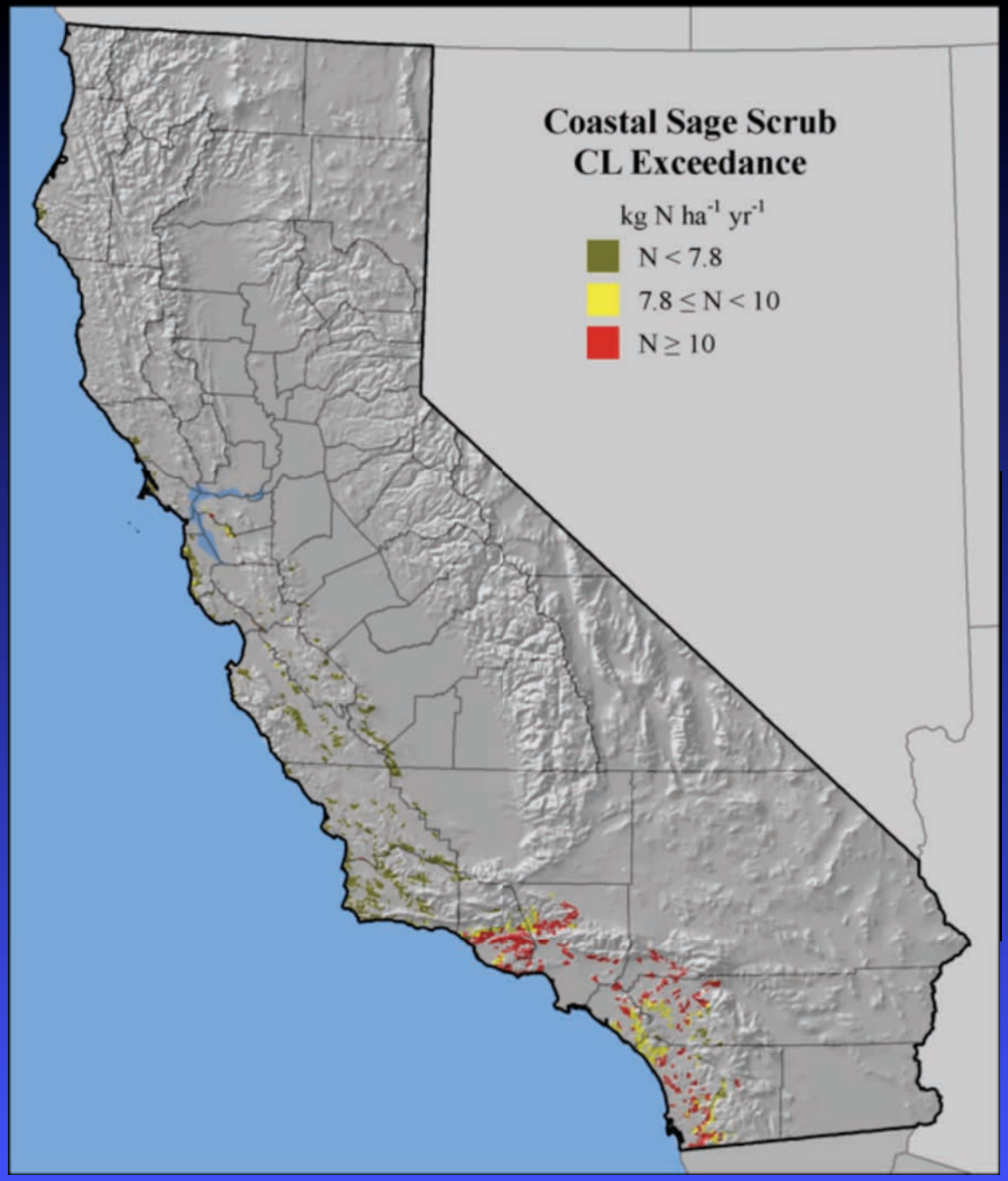
CL based on a roadside gradient at the Edgewood Natural Preserve: Transect at Highway 280, San Francisco Peninsula



Nitrogen CL for Risk of Major Vegetation Type Change: Grassland

- Best defined vegetation change CL; based on roadside gradient in serpentine grassland
- CL = 6 kg N/ha/yr for invasion of exotic annual grasses

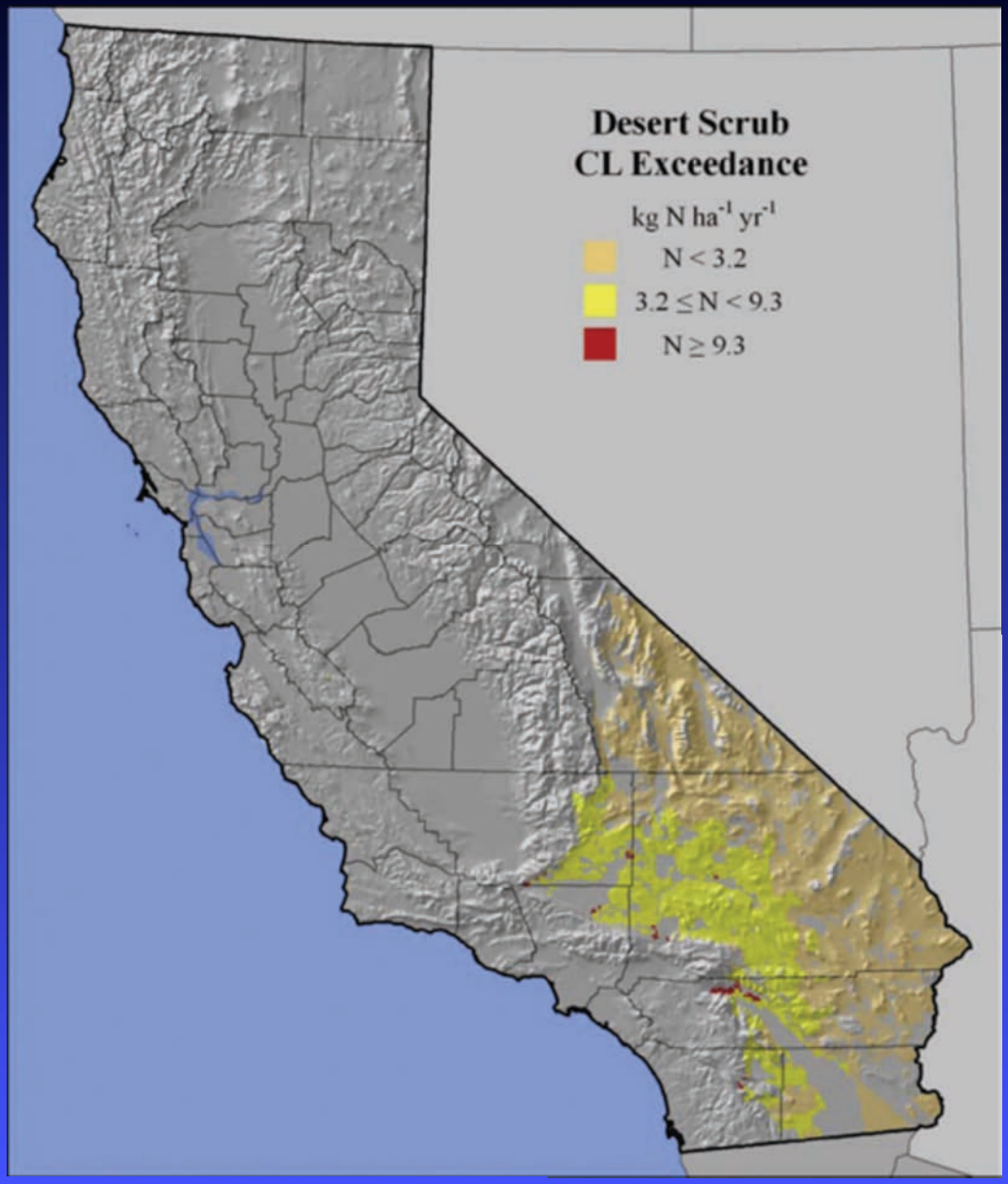
Coastal Sage Scrub: CL based on invasion of exotic grasses and changes in mycorrhizal communities across a deposition gradient


Coastal Sage Scrub
CL Exceedance
kg N ha-1 yr-1
N < 7.8
7.8 ≤ N < 10
N ≥ 10

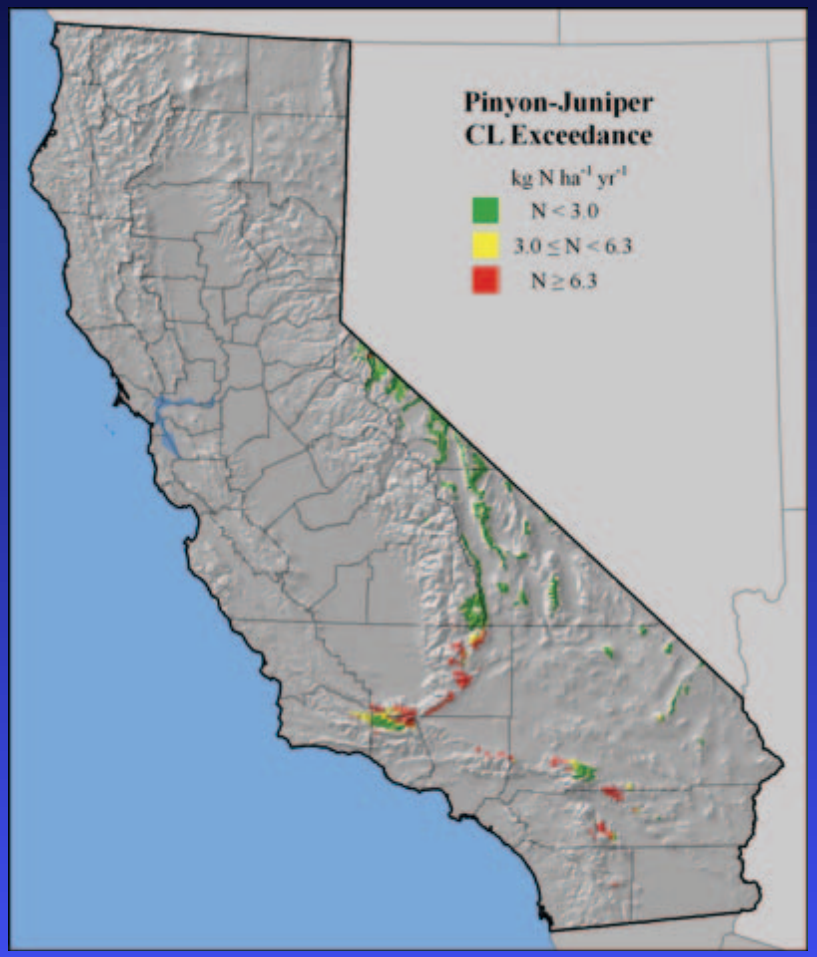
Desert Scrub: Joshua Tree NP

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

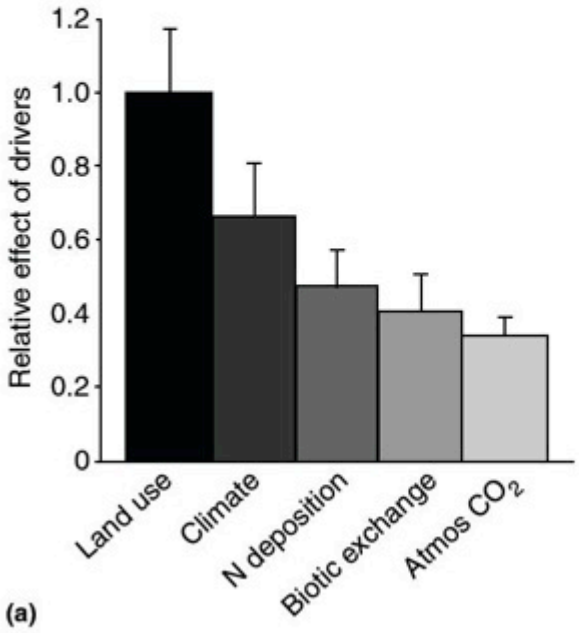
Desert Scrub CL Exceedence

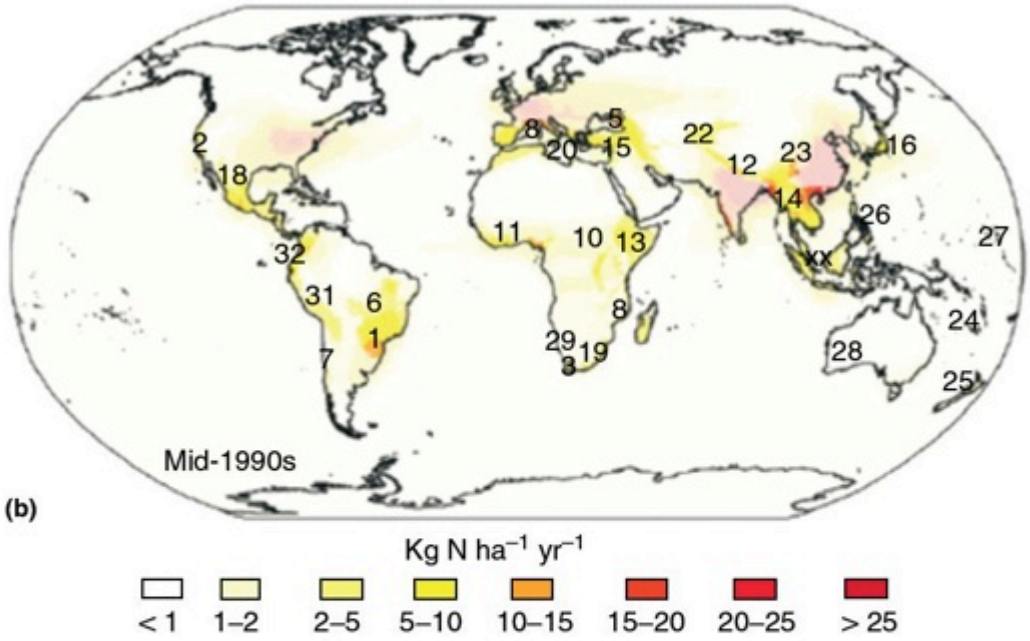


Pinyon-Juniper Habitat: CL based on N deposition levels that increase biomass production of invasive grasses---and risk of fire



Drivers Affecting Biodiversity



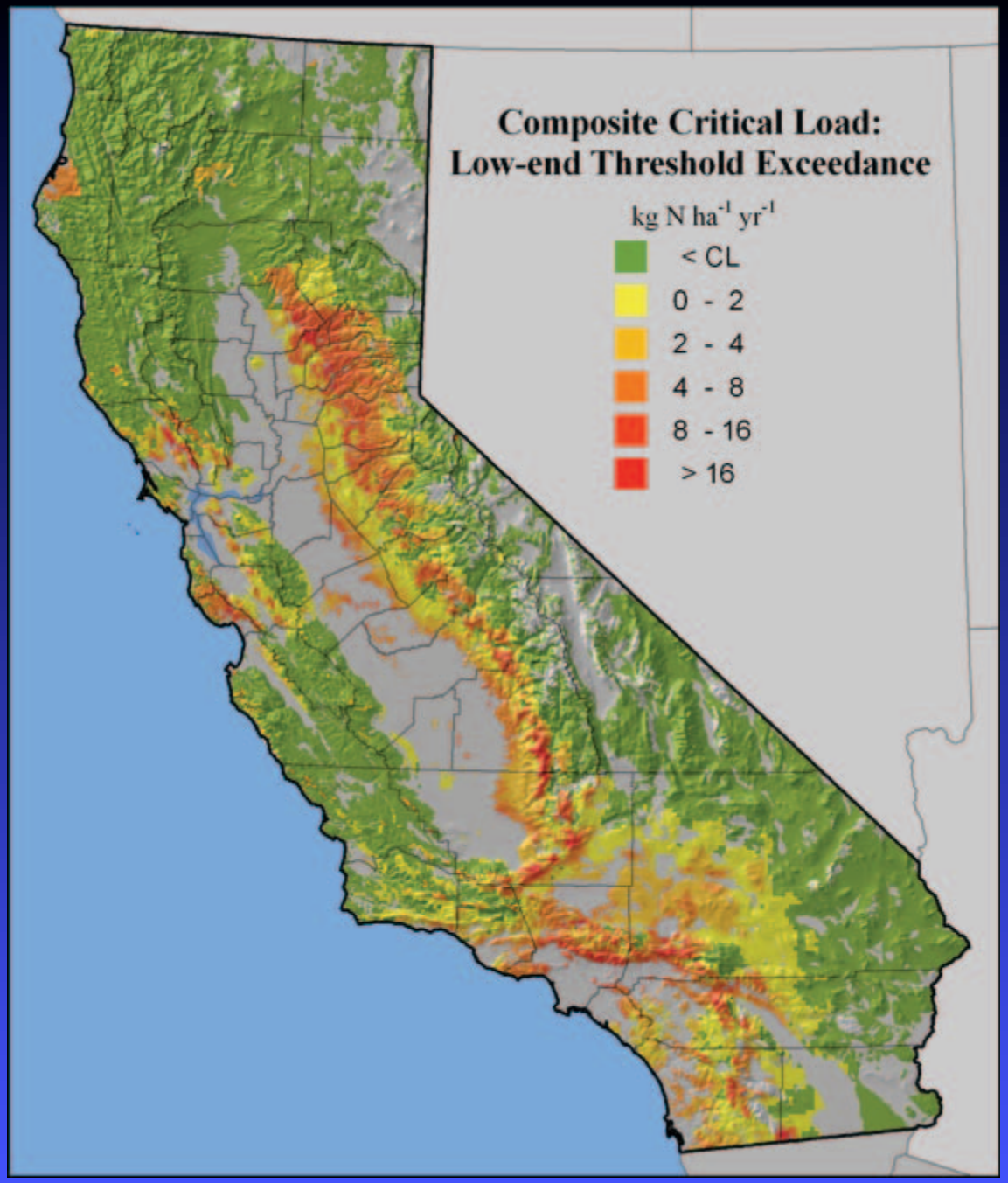


Biodiversity

- Nitrogen deposition is a major driver affecting plant biodiversity
- Nitrogen also affects aquatic biodiversity
- Epiphytic (tree-dwelling) lichen communities are dramatically altered by atmospheric N
- ‘Weedy’ invasive plant species are strongly favored by increased nitrogen

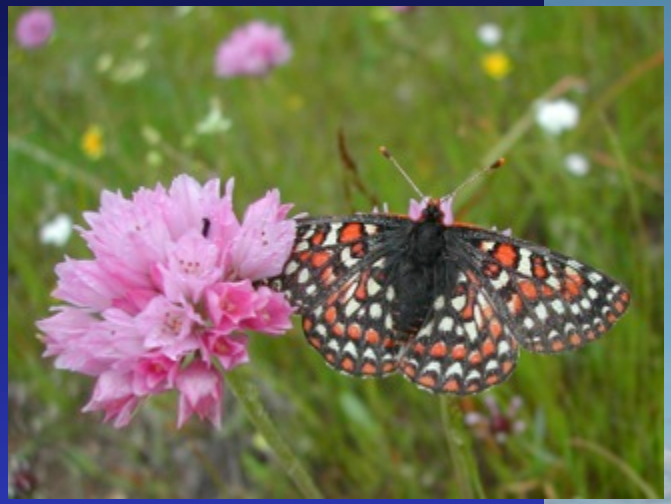
Empirical CL Exceedance for 7 Vegetation Types:

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



Management Strategies

- Reduce N deposition
- Reduce site N capital:
- N release in fire, mowing, harvest, cattle grazing



Cars, cows, and checkerspot butterflies: Nitrogen deposition and management of nutrient-poor grasslands for a threatened species; paper by Stuart Weiss

Fire can be used to remove a portion of the excess N accumulated from chronic N deposition

Summary: The N Problem

- "Since the 1950s, Nr production has greatly increased, representing perhaps the greatest single experiment in global geoengineering." (Sutton & van Grinsven, 2011)
- The ecological and environmental impacts of this excess Nr are observed far and wide
- Quantifying atmospheric deposition inputs across the landscapes is difficult but we are making progress; Multiple approaches are needed
- Critical loads for N are increasingly being developed and used for ecosystem protection in the U.S.
- Management of systems affected by excess N is labor intensive and costly; Decreasing N emissions is the ultimate solution