

Deposition of Reduced Nitrogen (NH_x) in California and Other Western Regions: Prevalence and Ecological Importance

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PSW Res. Stn.

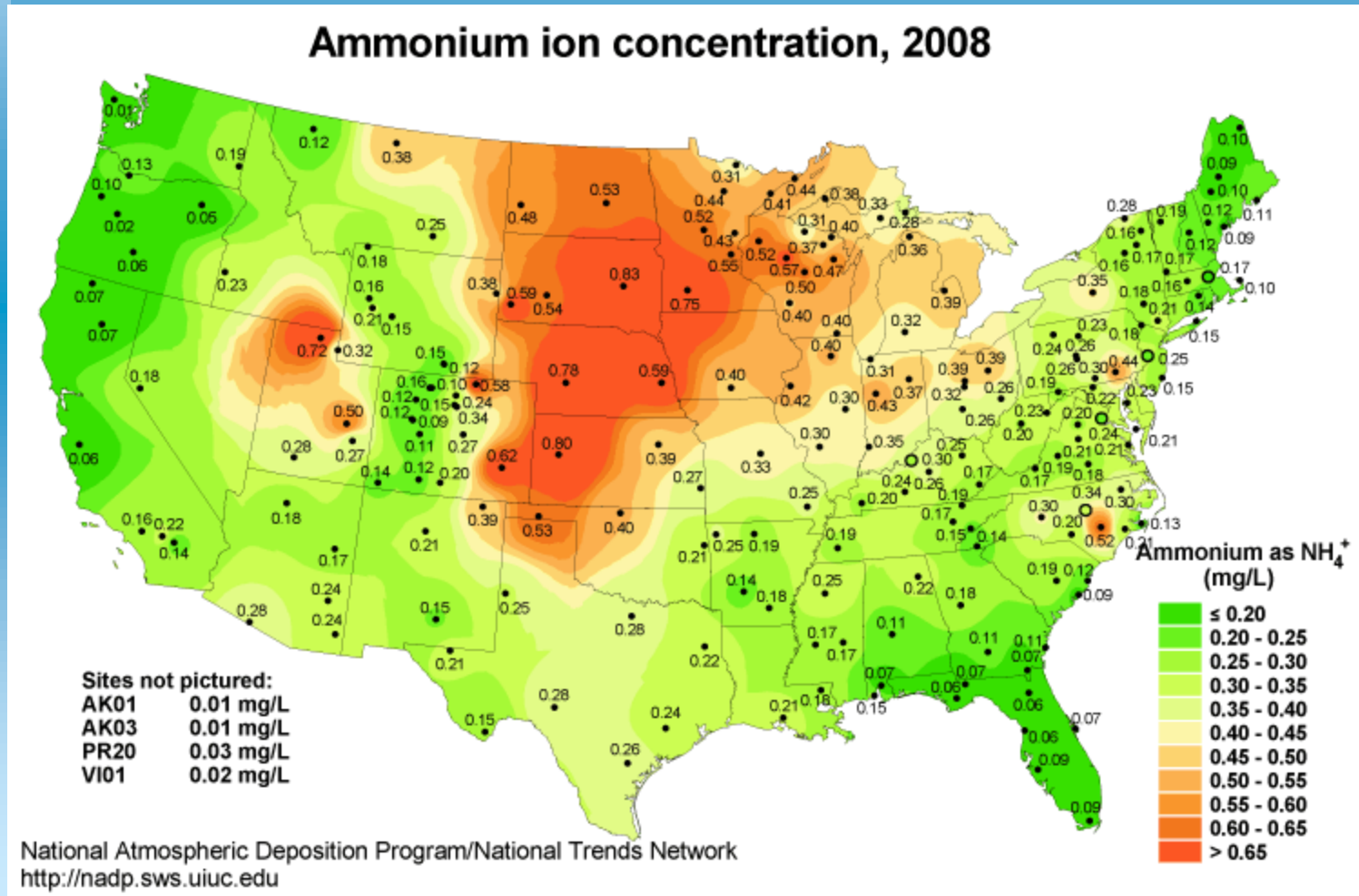
Ammonia: Environmental Problems

- **Eutrophication and acidification of ecosystems, including biodiversity impacts**
- **Odors**
- **Major contributor to fine particulate pollution and aerosol formation. Aerosols contribute to:**
 - **Effects on climate change**
 - **Visibility impairment**
 - **Health concerns**

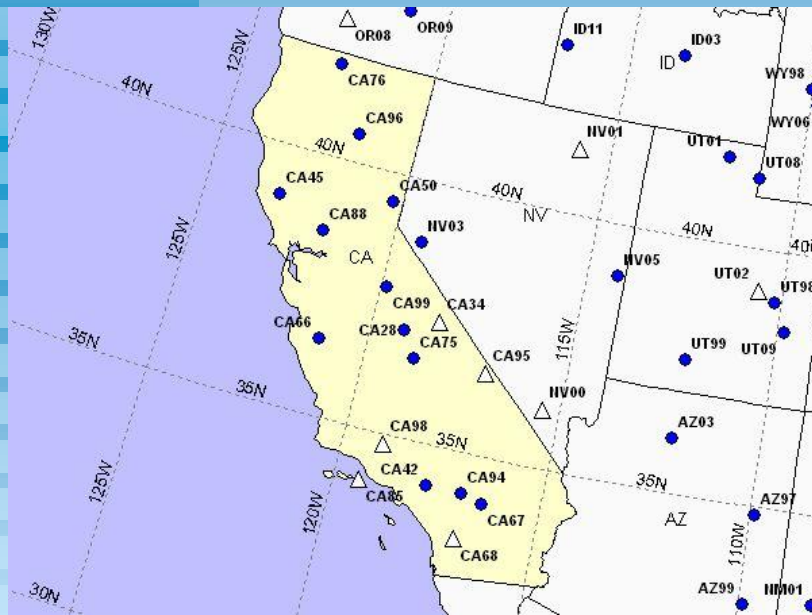
Why Talk About NH_x Deposition in CA & Elsewhere?

- Extensive agricultural emissions from the Central Valley of California; upwind of Sierra Nevada
- Increasing data showing high NH_x in areas traditionally dominated by NO_y
- Modern light duty vehicles an important source of NH_3
- Observations of elevated NH_3 in remote sites of California
- High sensitivity of lichens and vegetative communities to NH_3
- Observations of increasing relative importance of NH_x compared to NO_x in many locations, not just near ag source regions

NADP Map: Looks like deposition of reduced N isn't important in California and many other states

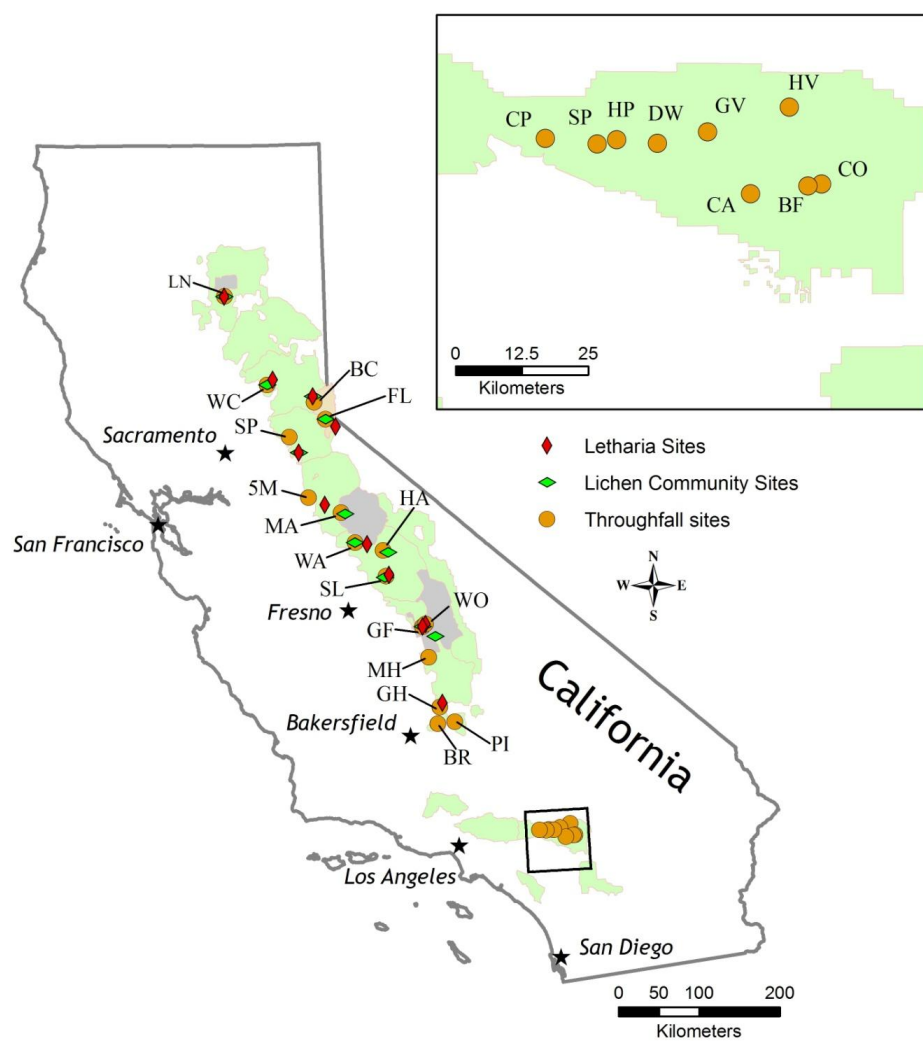


Wet N Deposition (kg/ha/yr) and NH₄:NO₃ Ratios in California; NADP Data



Location	Total N	NH ₄ :NO ₃
San Dimas Exptl Forest, LA Basin	1.9	1.1
Converse Flats, San Bernardino Mts	1.6	1.5
Joshua Tree NP	0.3	1.3
Sequoia NP	2.5	2.0
Yosemite NP	1.3	0.9
Davis	2.2	4.0
Lassen NP	0.8	1.2
Montague	0.2	1.0
Hopland	0.4	1.1
Kings River Exptl Watershed, Sierra Nevada	2.0	1.4
Sagehen	0.3	0.4
Pinnacles NM	0.3	0.7
Death Valley NP	0.3	1.3
Smith Valley (Nevada)	0.3	2.4

NH₄:NO₃ Ratios in Throughfall (2002-2004): Average Values by Region



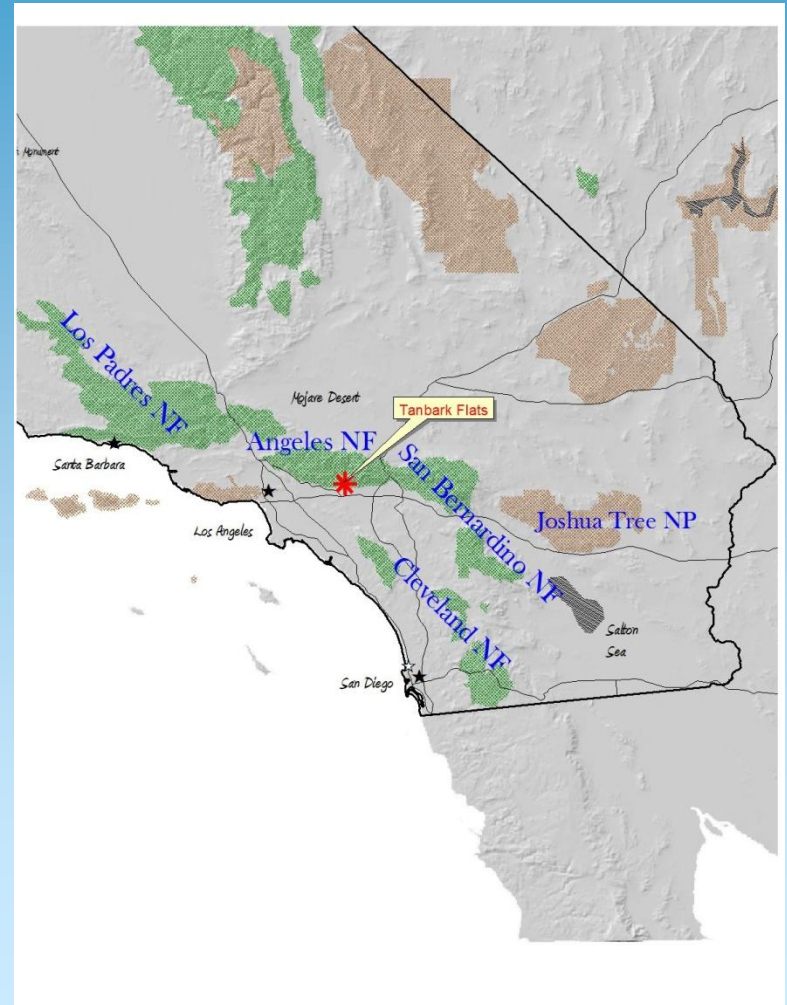
San Bernardino Mts: 0.76

Lake Tahoe Sites: 0.80

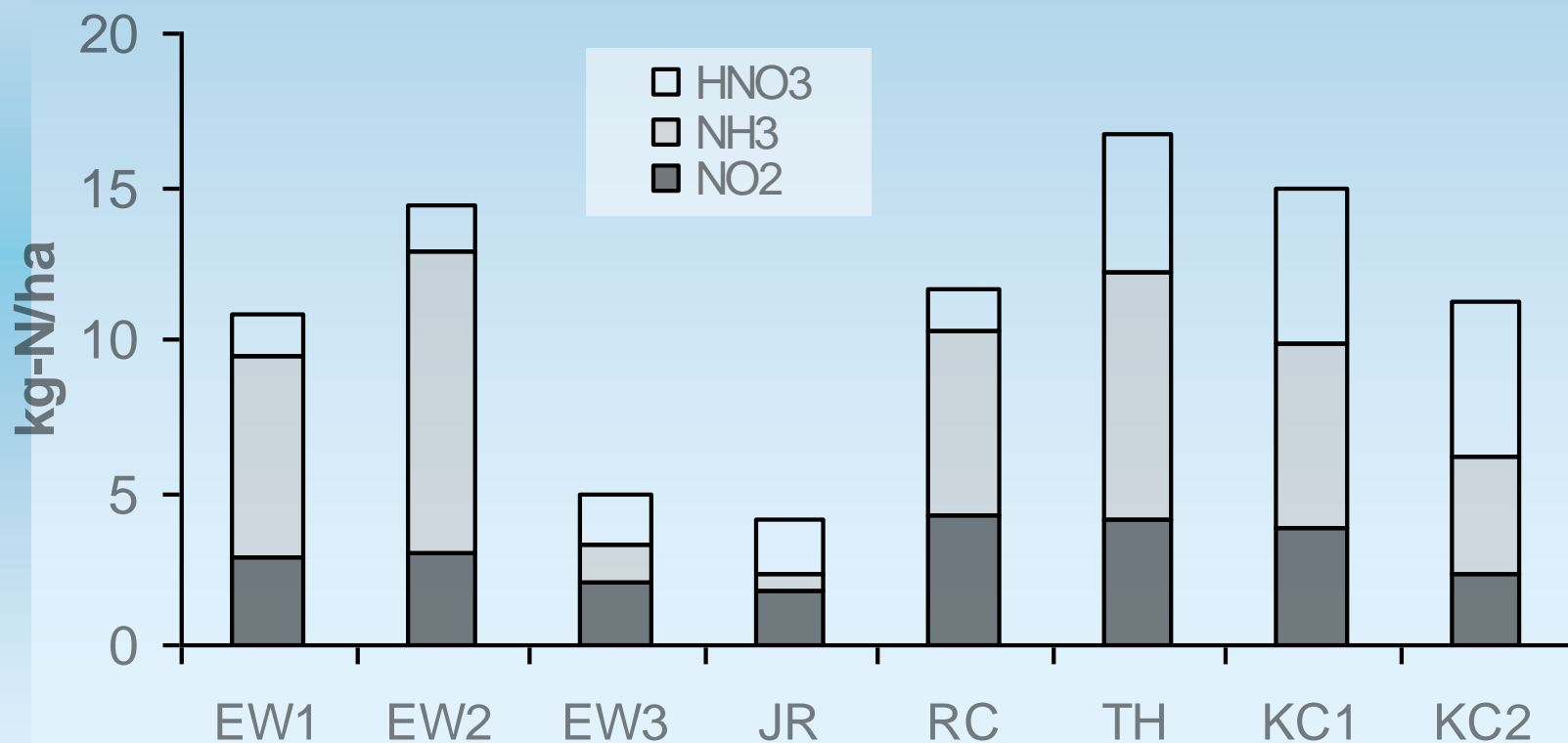
Other Sierra Nevada Sites: 1.23

NH₄:NO₃ Ratios in Bulk Deposition & Throughfall (2009): Urban, Suburban and Forest Sites in the LA Basin

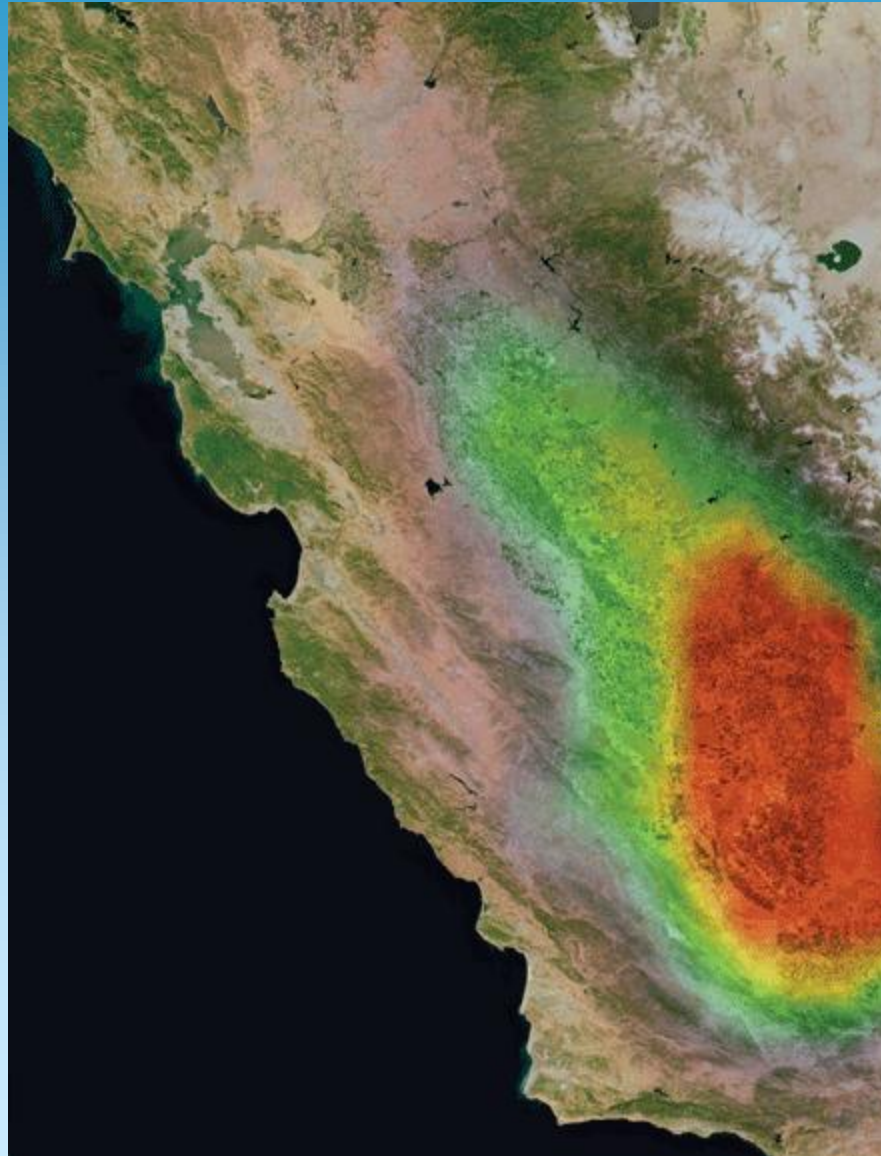
Region & Deposition Type	NH ₄ :NO ₃ Ratio
Los Angeles (LA), Open	1.07
Riverside, Open	1.15
CP: San Bdo Mts, Open	1.13
Throughfall	
(under pine except where indicated):	
LA: I-10 Transect	1.98
LA: Hwy 110 Transect	1.11
LA, Eucalyptus	0.95
LA, Pine	0.97
LA, Ficus trees	1.49
LA, Pine	0.90
Riverside	0.98
CF: San Bdo Mts	1.05



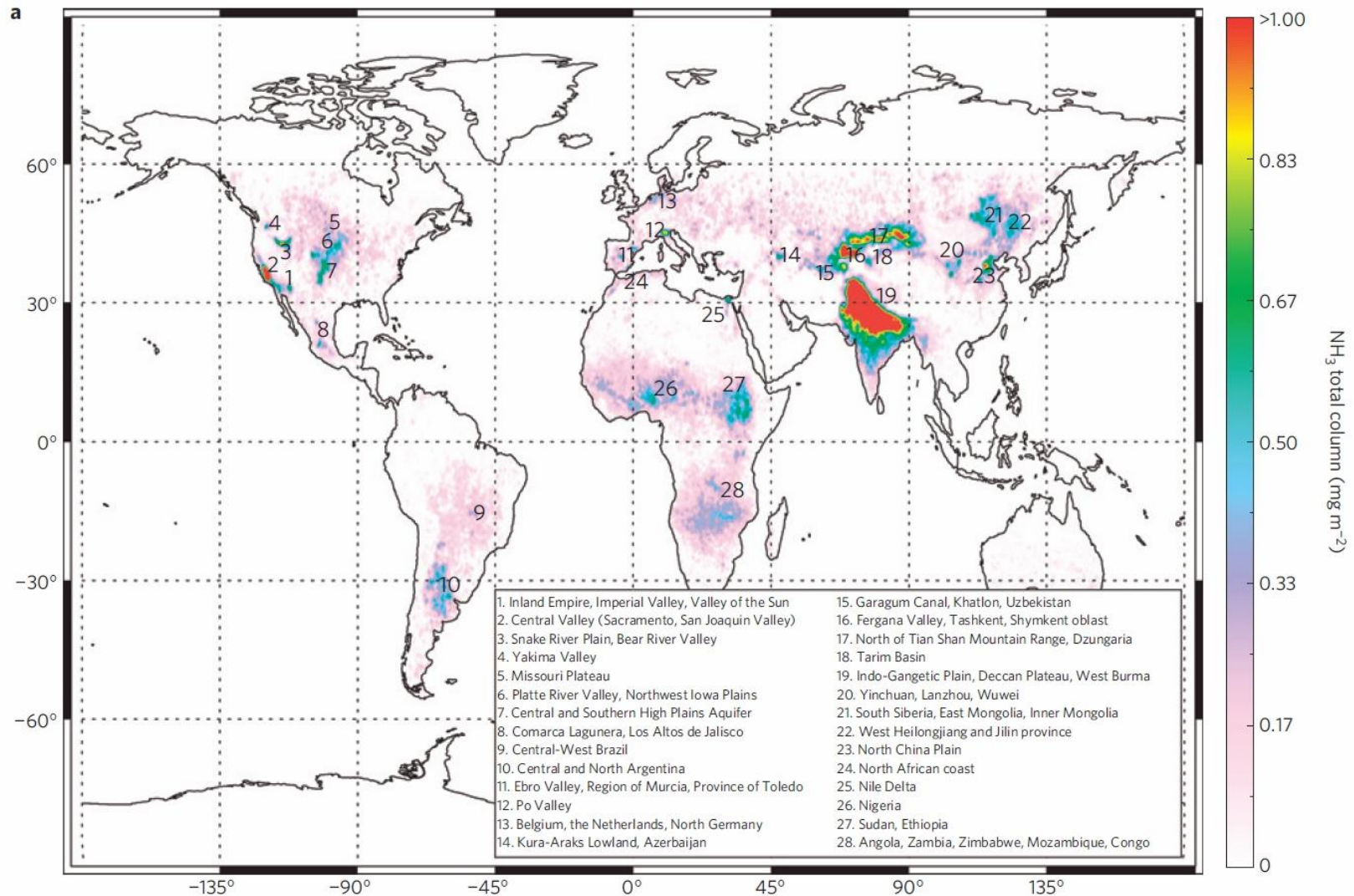
Comparison of N gaseous pollutant deposition to a California grassland near a major highway (280) in the coastal San Francisco peninsula and in near-urban sites



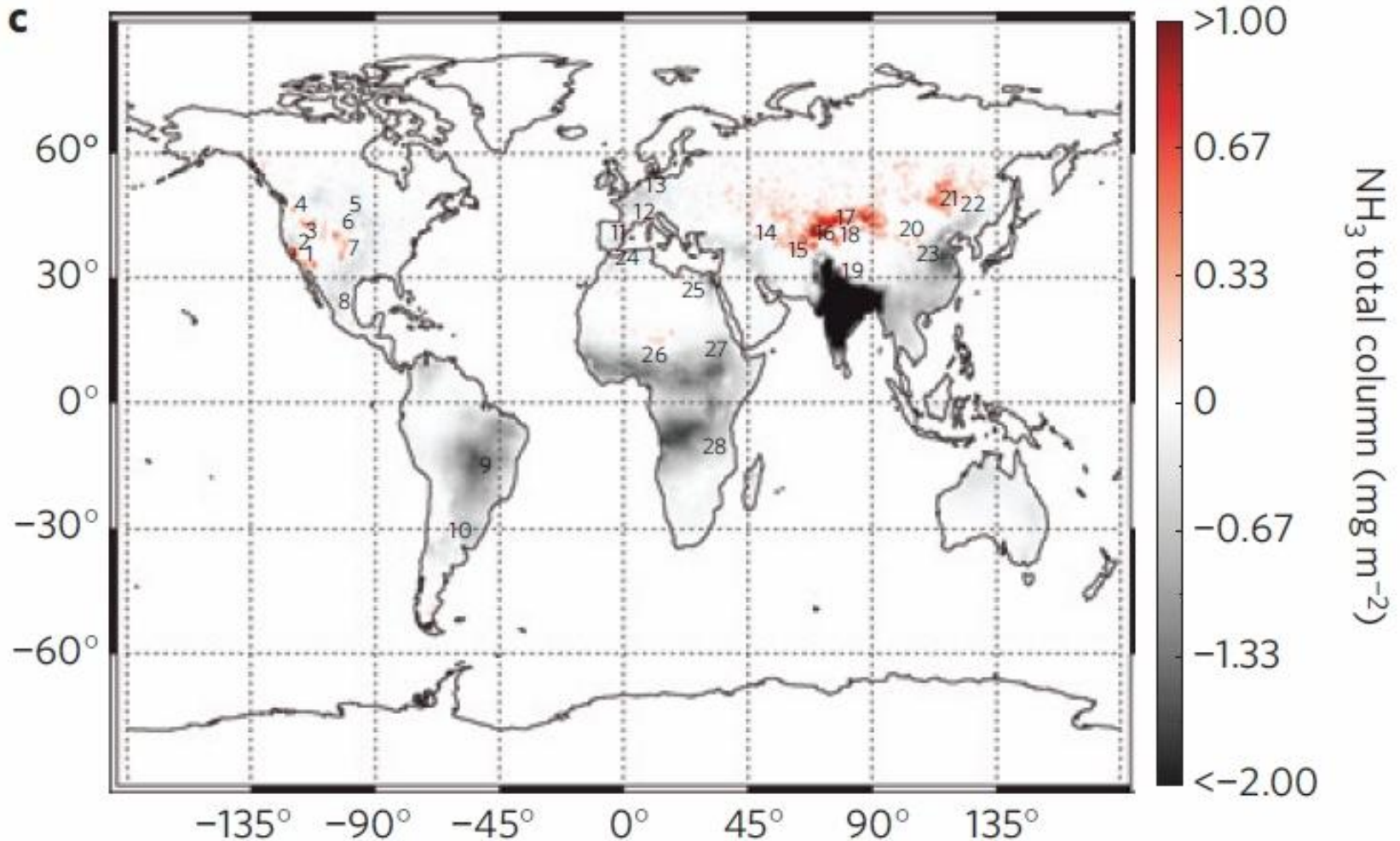
Cover of Nature Geoscience, July 2009; Central Valley of CA shown as an NH_3 hotspot---based on remote sensing of NH_3 ; Clarisse et al. 2009.



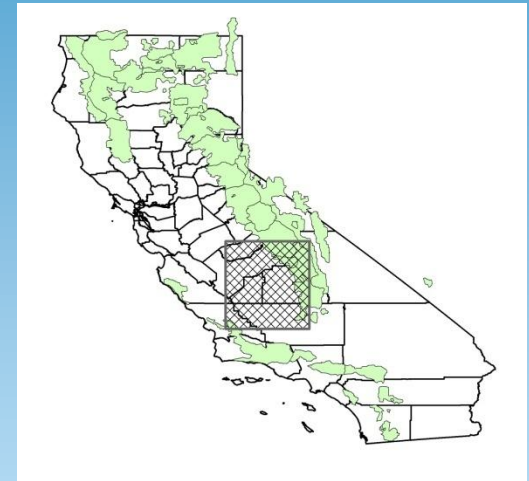
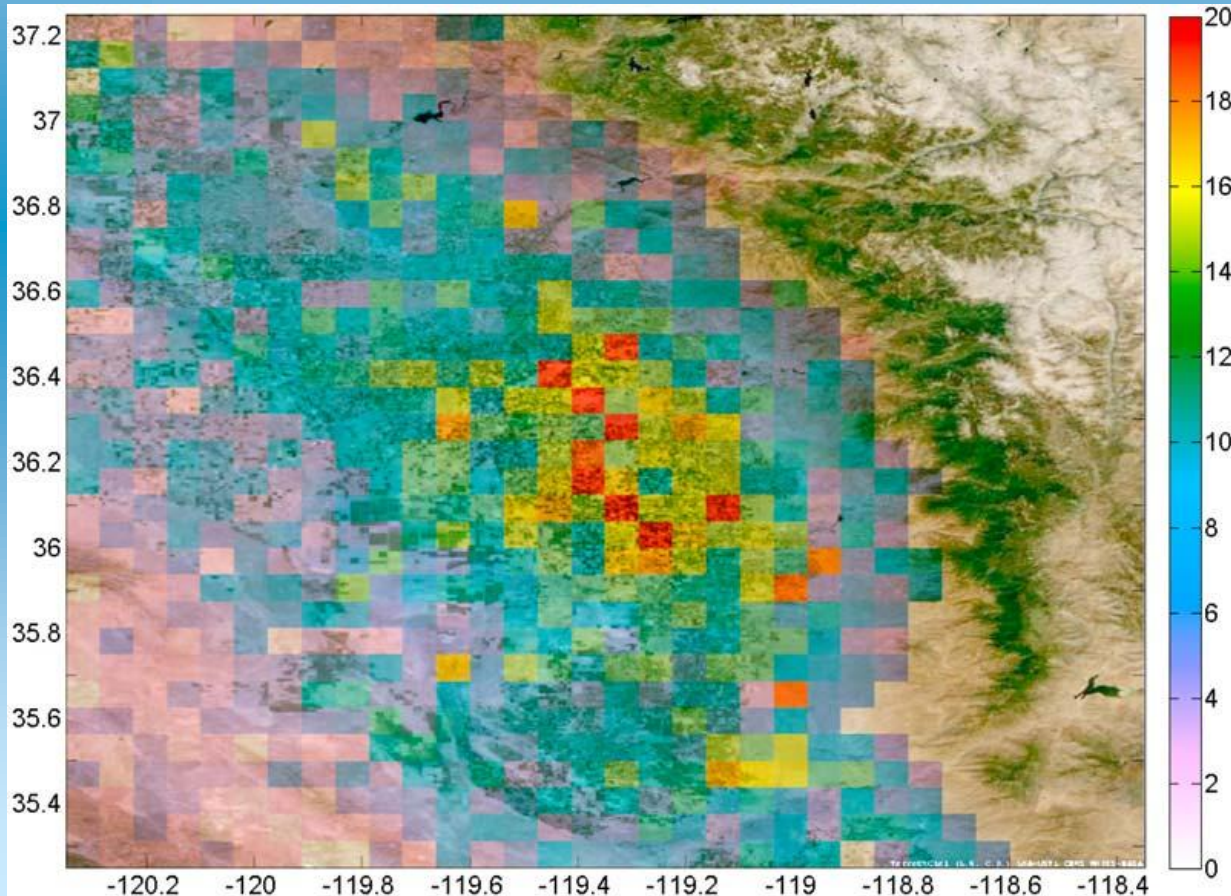
Yearly average total columns of NH_3 in 2008 based on remote sensing; Clarisse et al. 2009



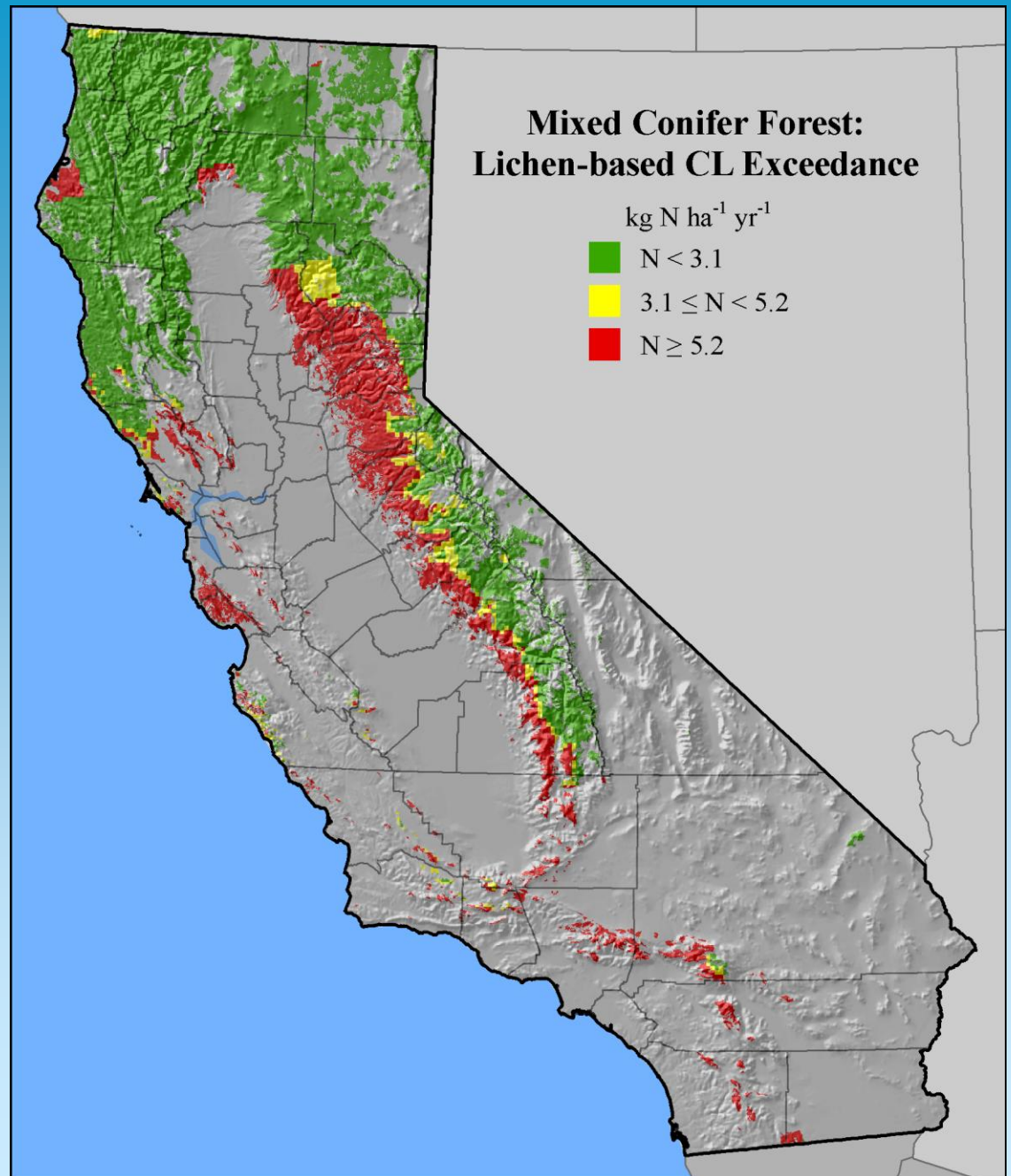
Underestimates of NH_3 Concentrations in the Northern Hemisphere; Clarisse et al. 2009



Average March to October NH_3 concentrations in the San Joaquin Valley, California from satellite infrared sounders. Average concentrations of 3-15 ppb; up to 10 times higher than emissions inventories and models indicate. From Clarisse et al. 2010, J. Geophys. Res.



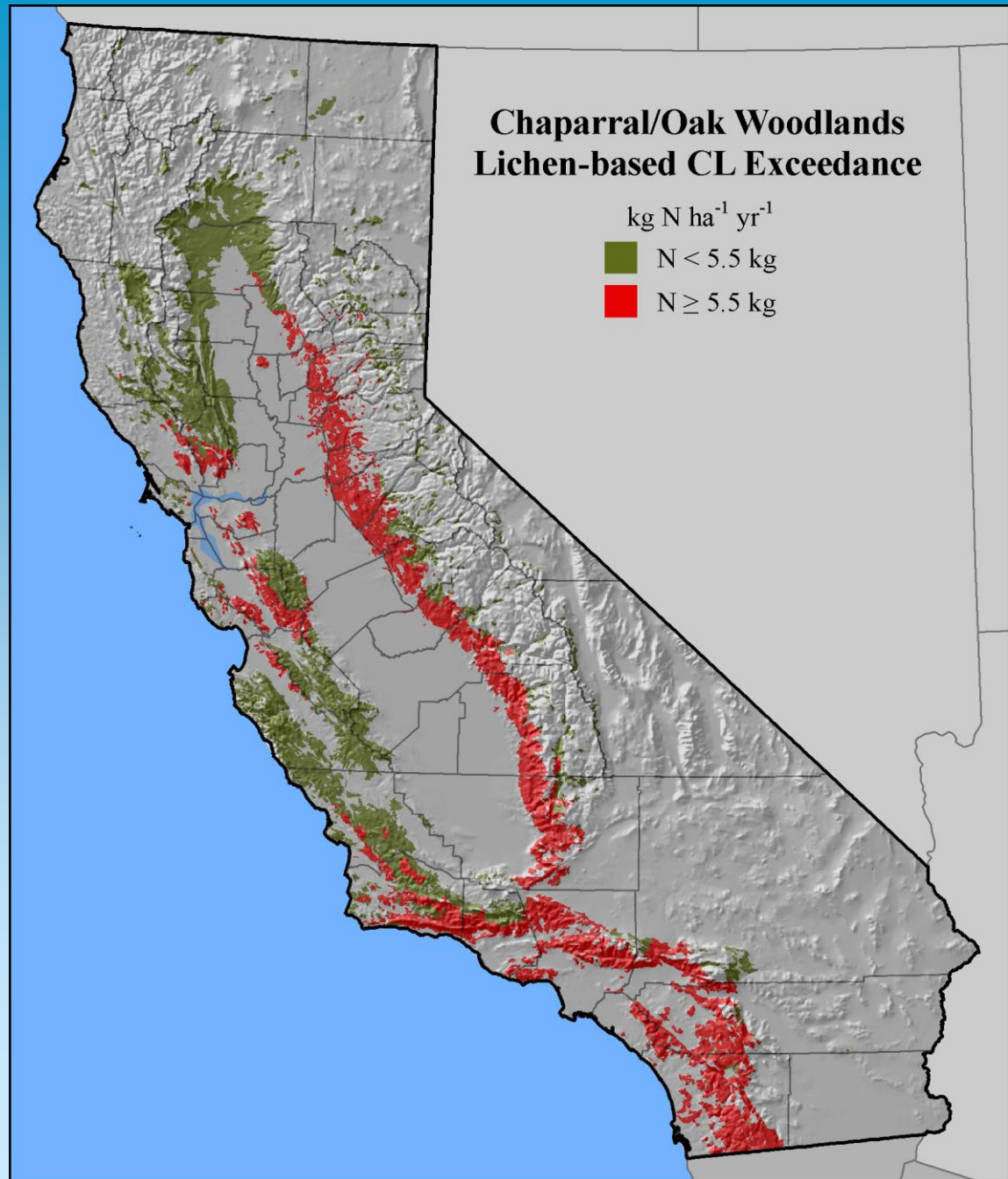
N Effects In California



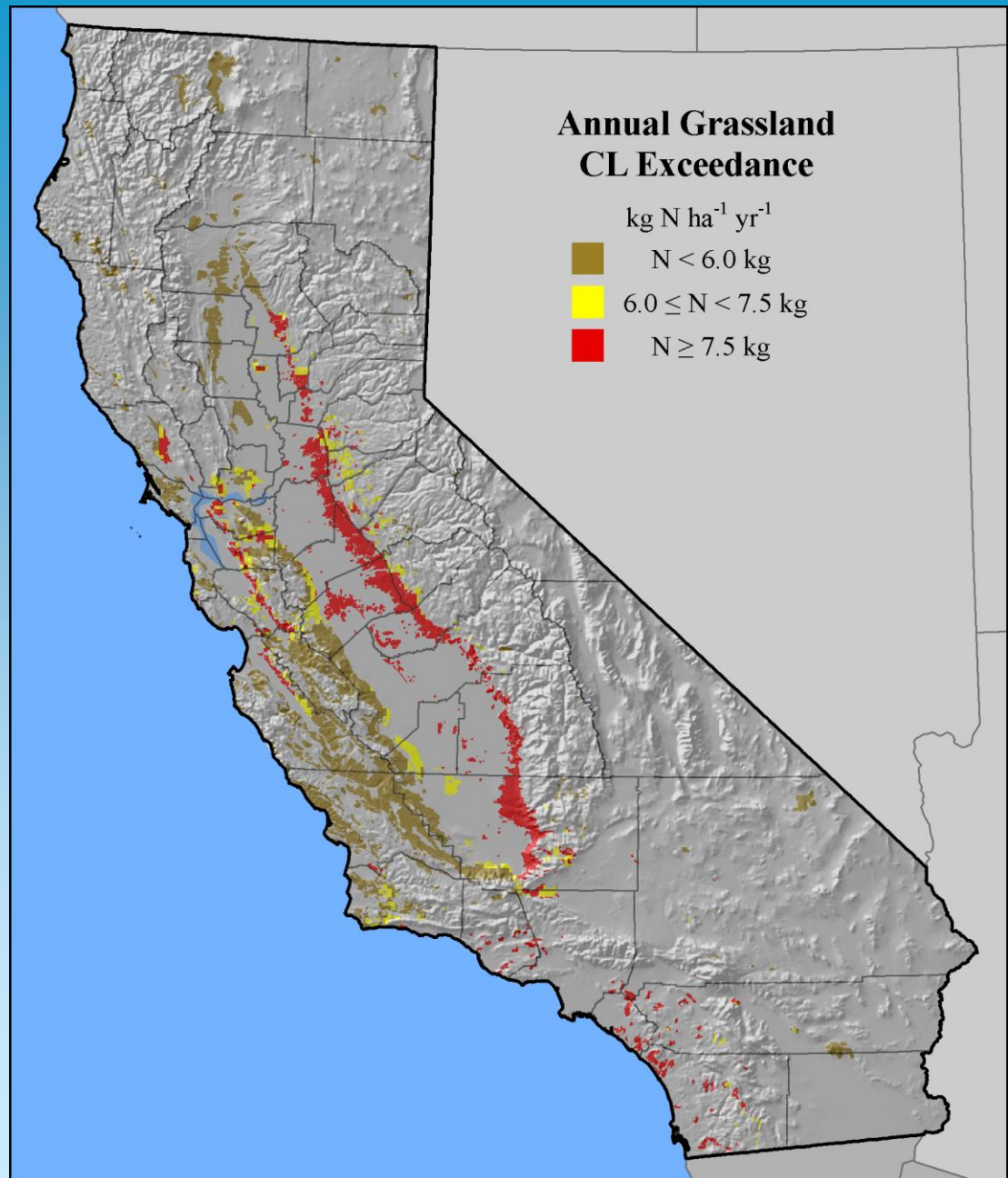
From Fenn et al.
2010; J of Env Mgt

N Effects in California

From Fenn et al.
2010; J of Env Mgt



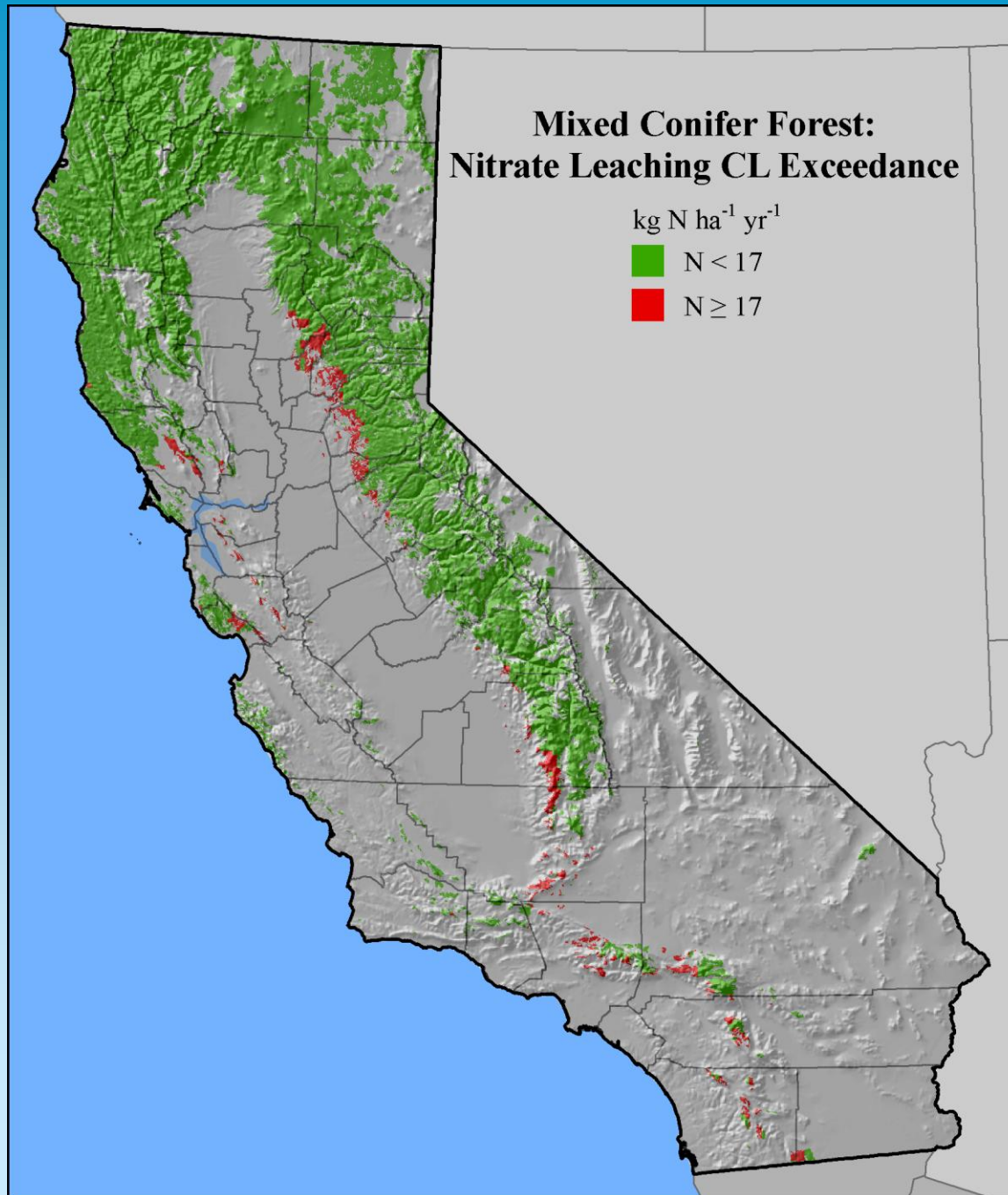
N Effects in California



From Fenn et al.
2010; J of Env Mgt

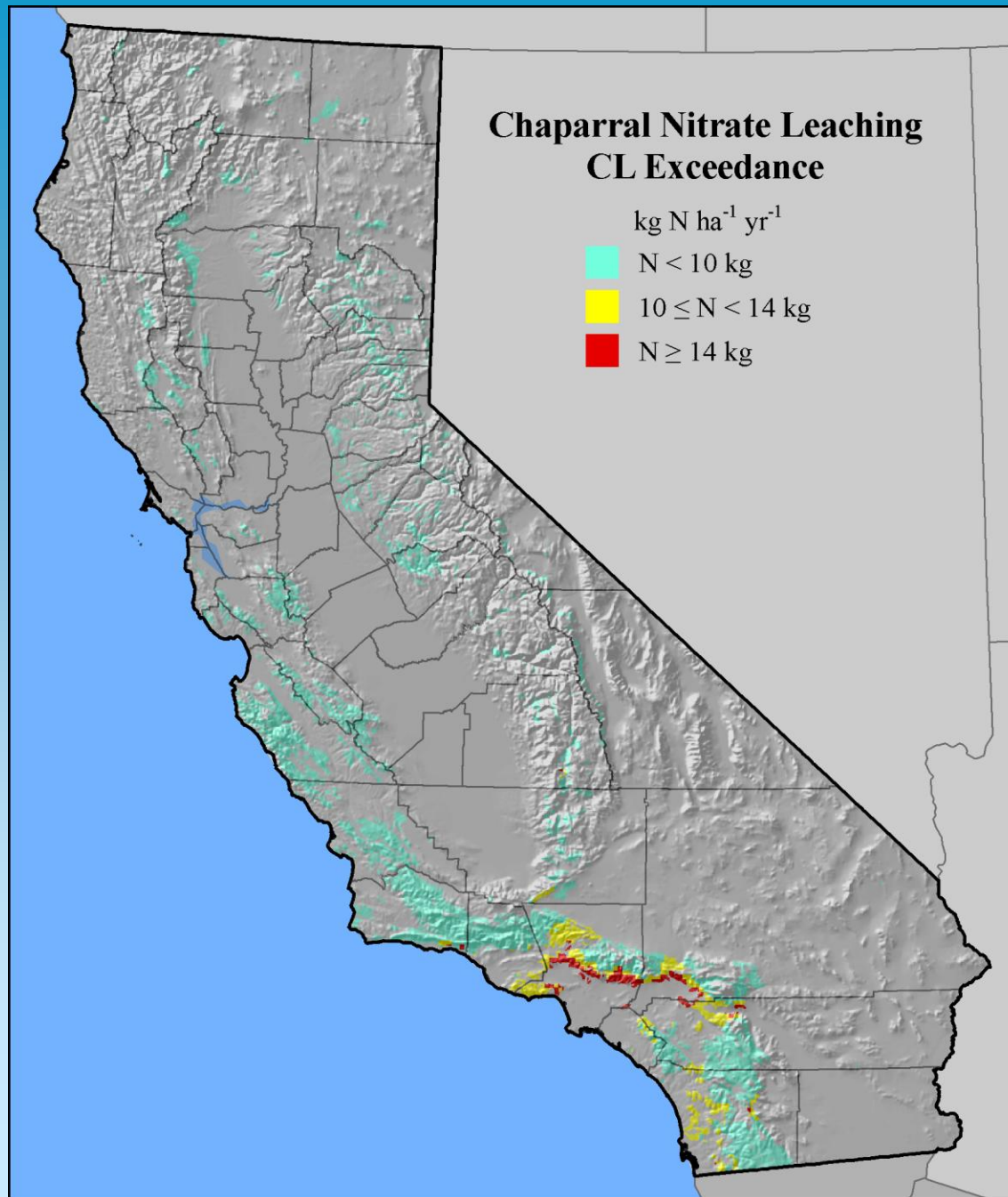
N Effects in California

From Fenn et al.
2010; J of Env Mgt



N Effects in California

From Fenn et al.
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Statewide NO_x Emission Trends

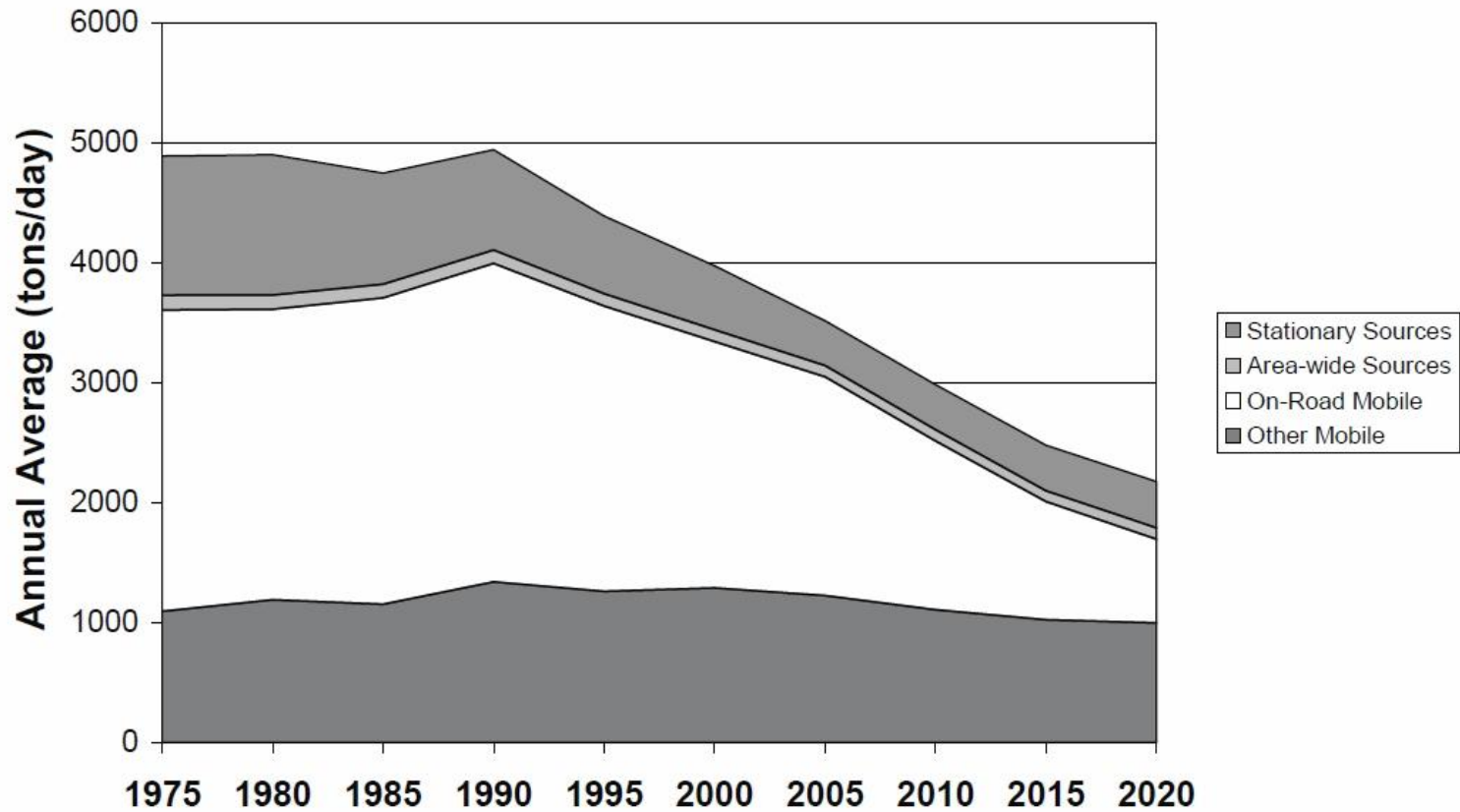


Figure 3-15

Trends in NO_x and NH_x Emissions in California

Emissions: tons/year

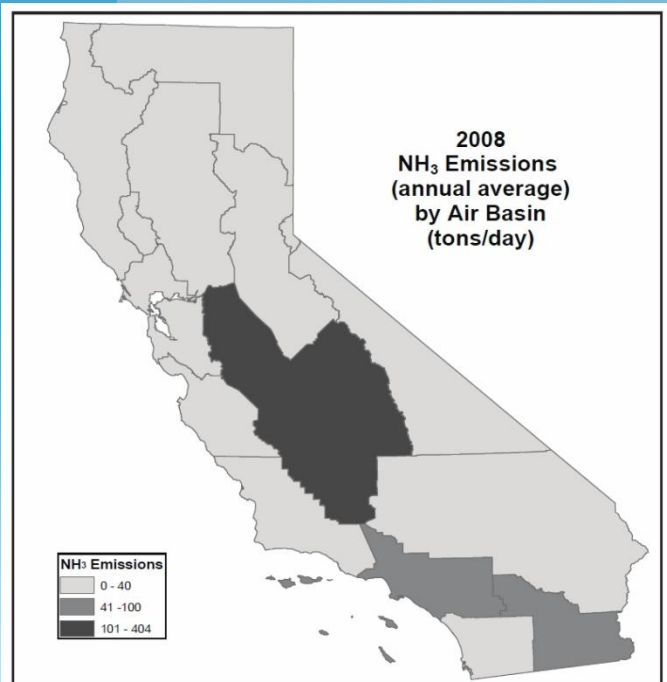
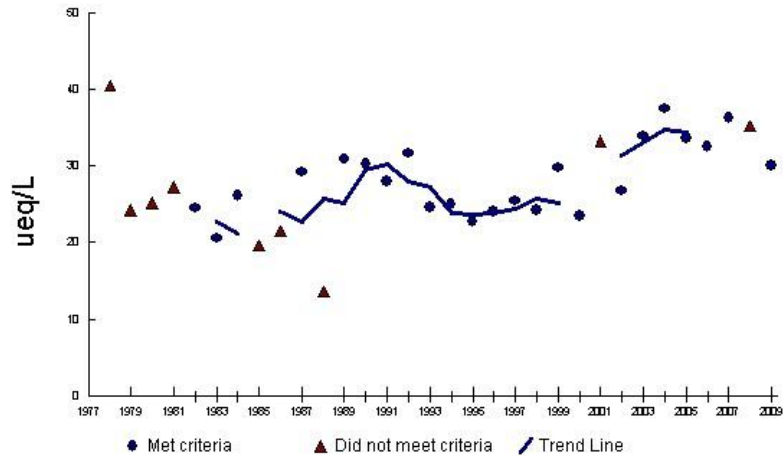


Figure 2-24

Year	NO _x -N	NH _x -N	NO _x :NH _x
2005	431,874	179,120	2.41
2008	356,556	227,245	1.57
% change	-17.4	26.9	

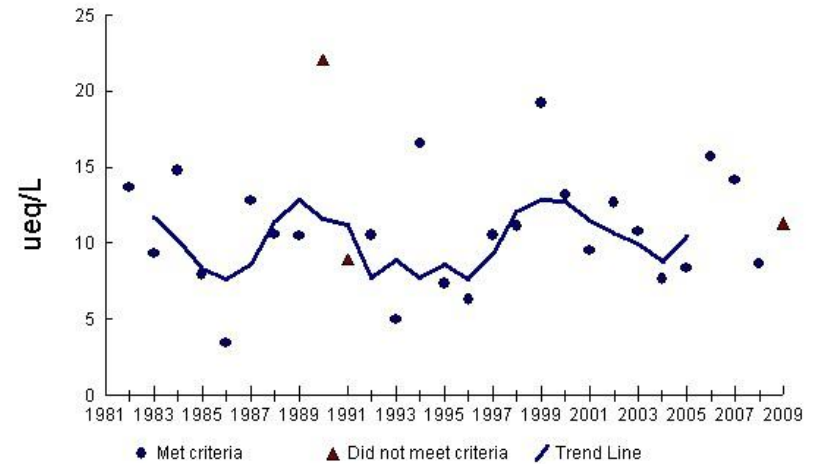
Davis, CA

NADP/NTN Site CA88
Annual NH₄ concentrations, 1978-2009

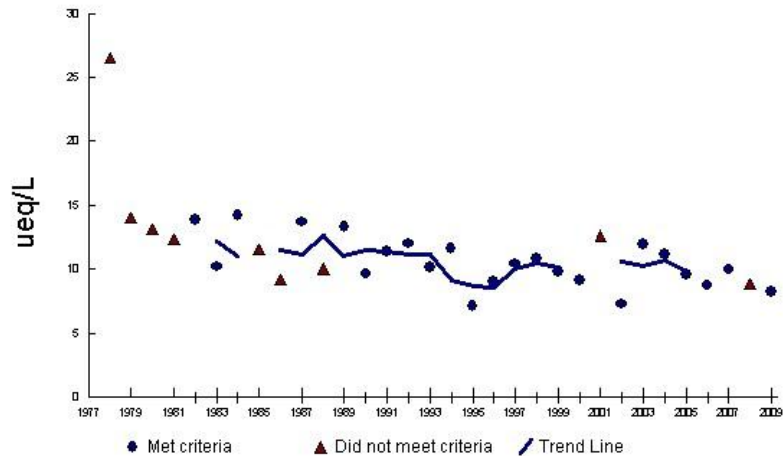


SDEF, near Los Angeles

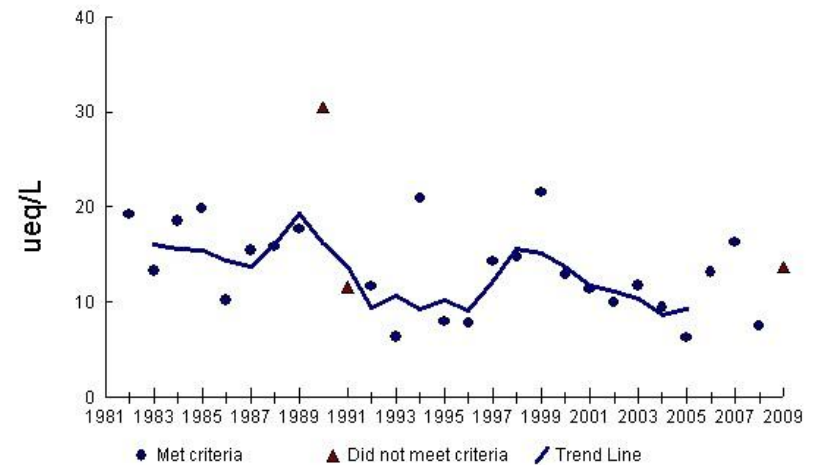
NADP/NTN Site CA42
Annual NH₄ concentrations, 1982-2009



NADP/NTN Site CA88
Annual NO₃ concentrations, 1978-2009

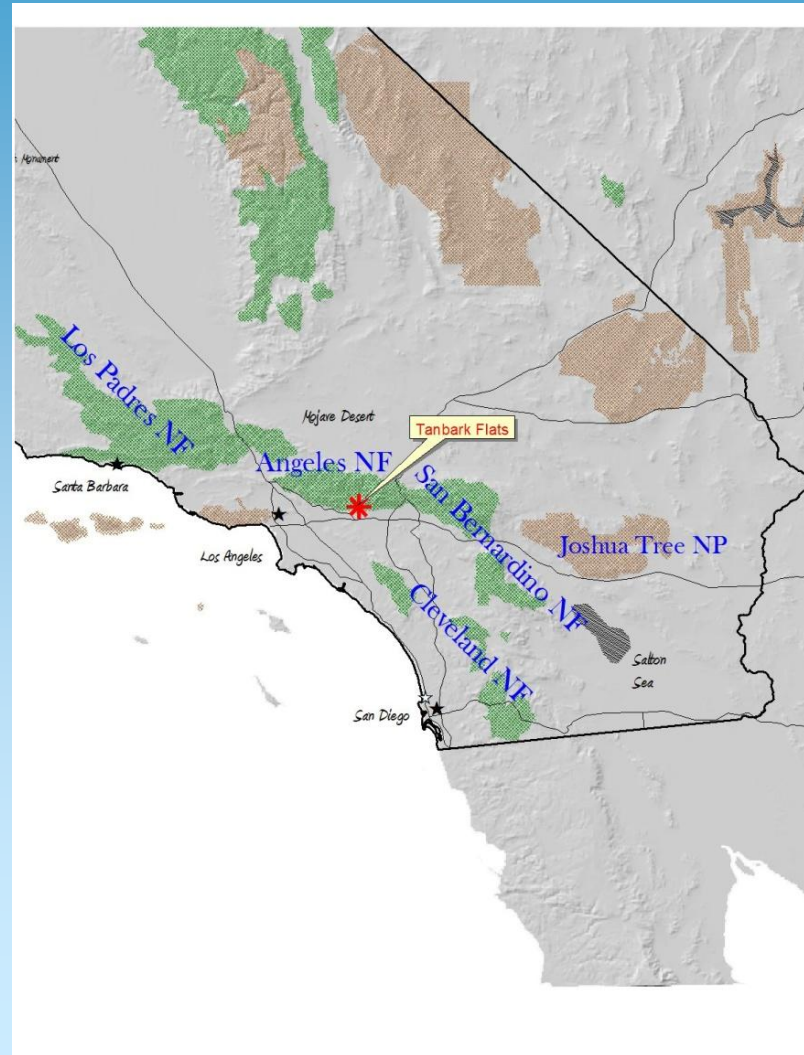


NADP/NTN Site CA42
Annual NO₃ concentrations, 1982-2009

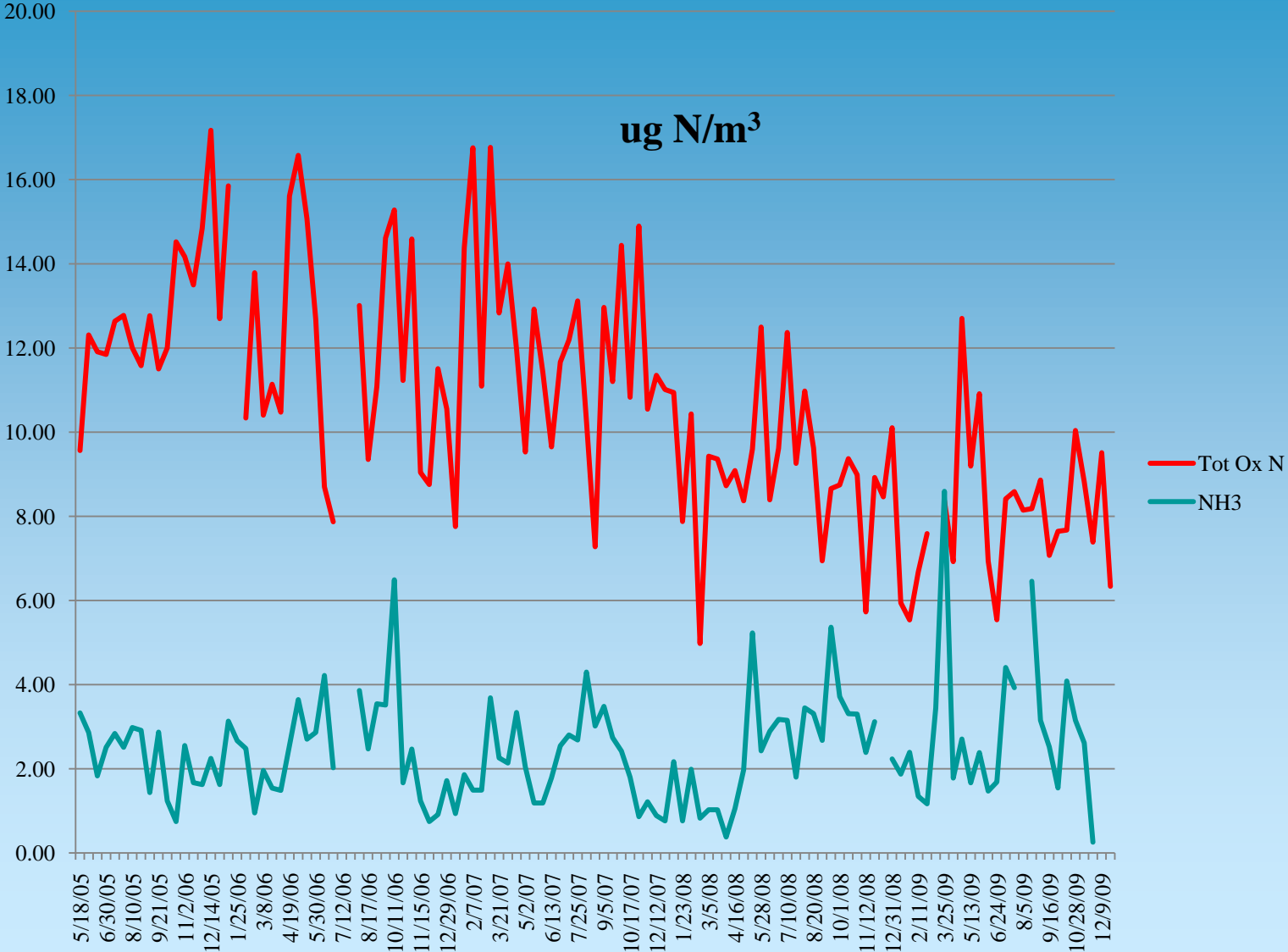


Wet deposition trends in an agriculture and urban influenced site

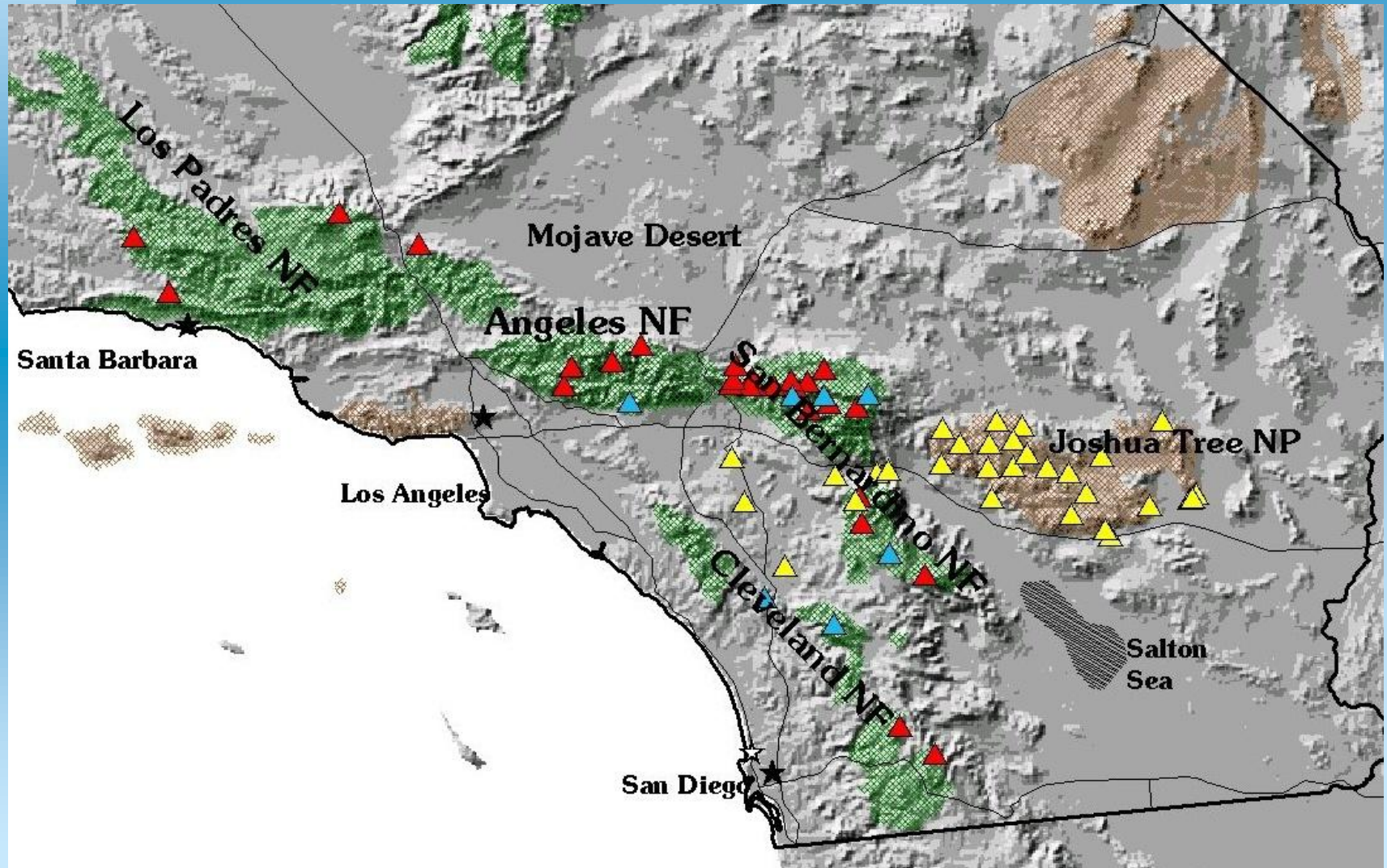
Tanbark Flats—San Dimas Experiment Forest: Trends in N Pollutant Concentrations, 2005 to 2009



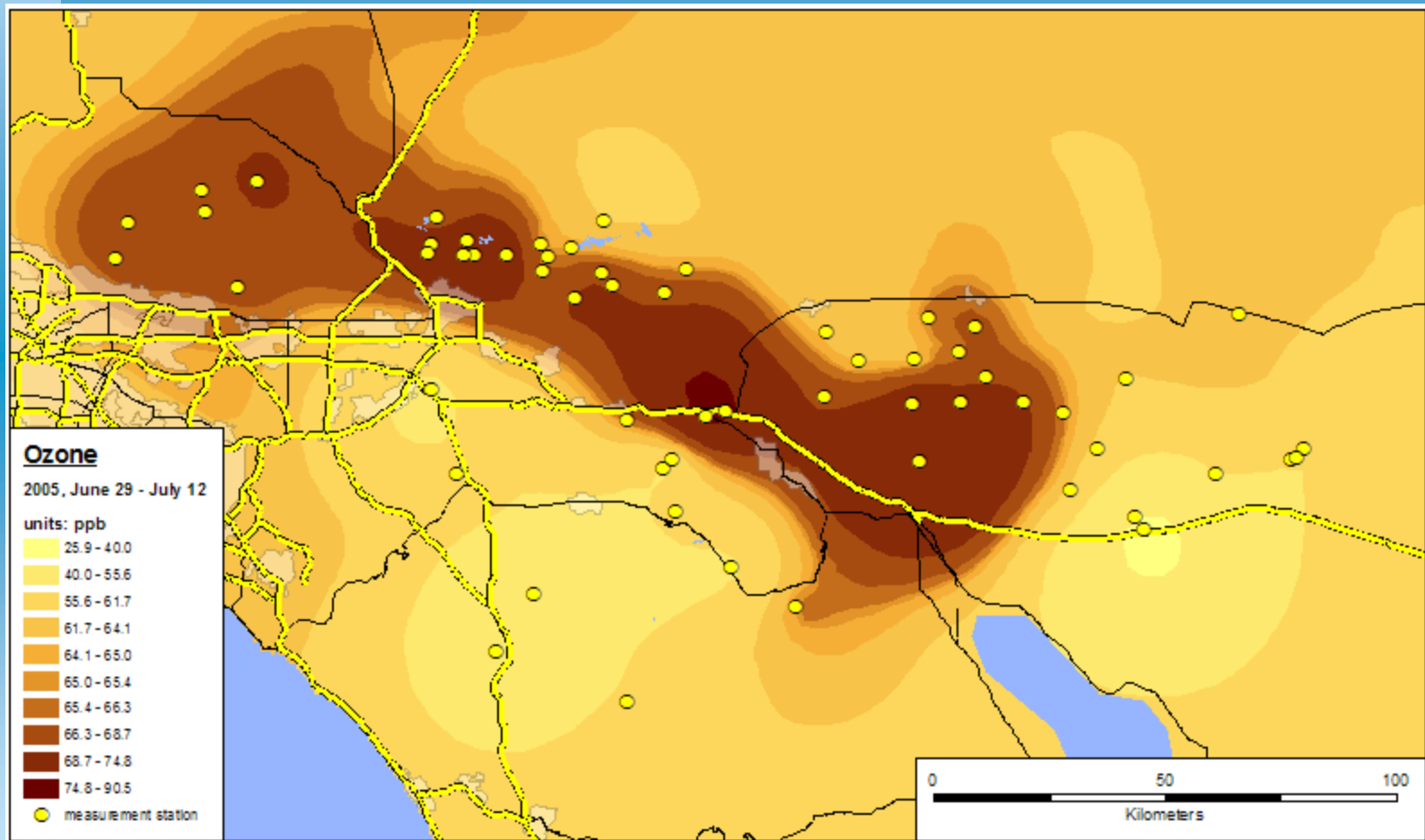
Tanbark Flats



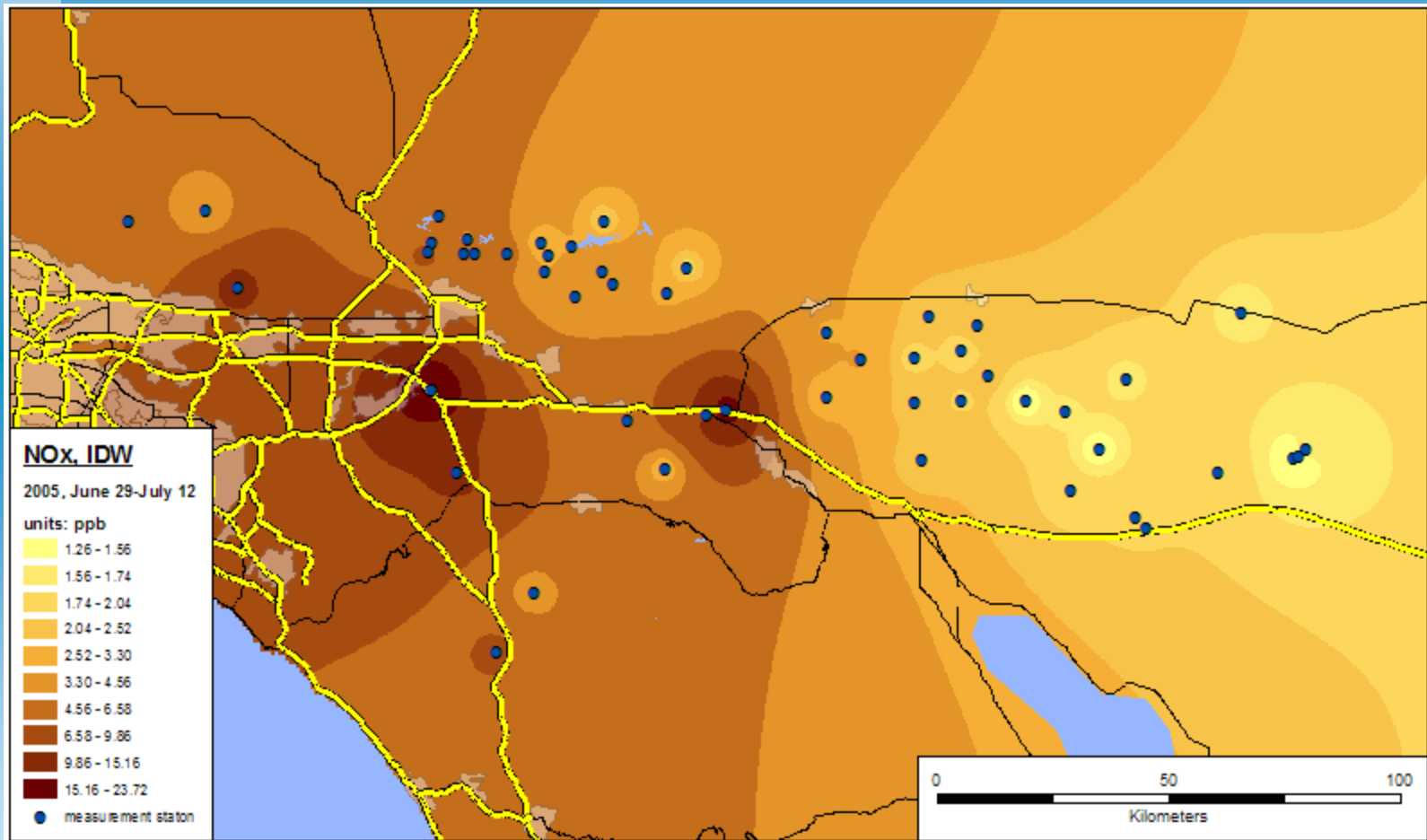
Southern California Air Monitoring Network



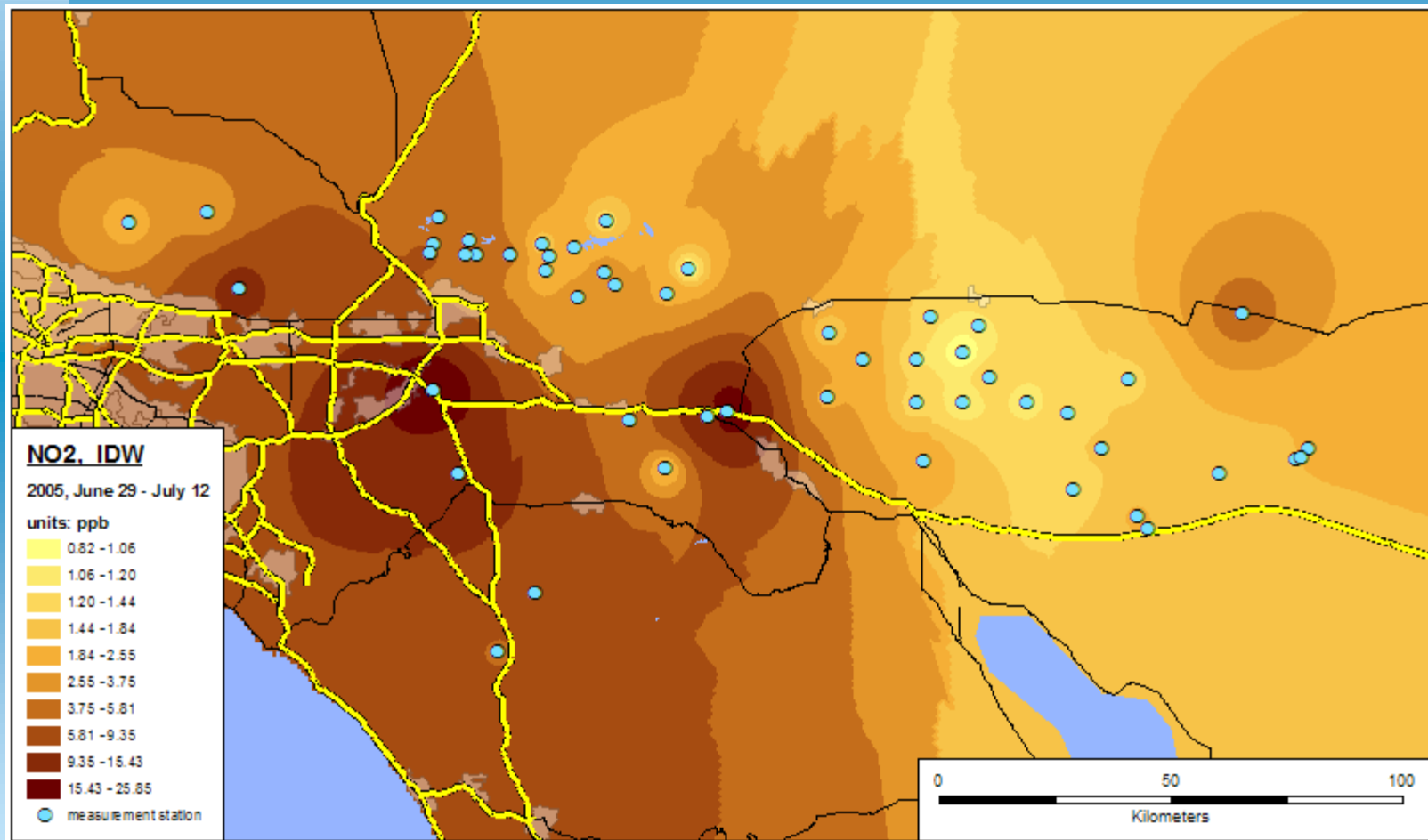
Ozone, June 29 – July 12, 2005



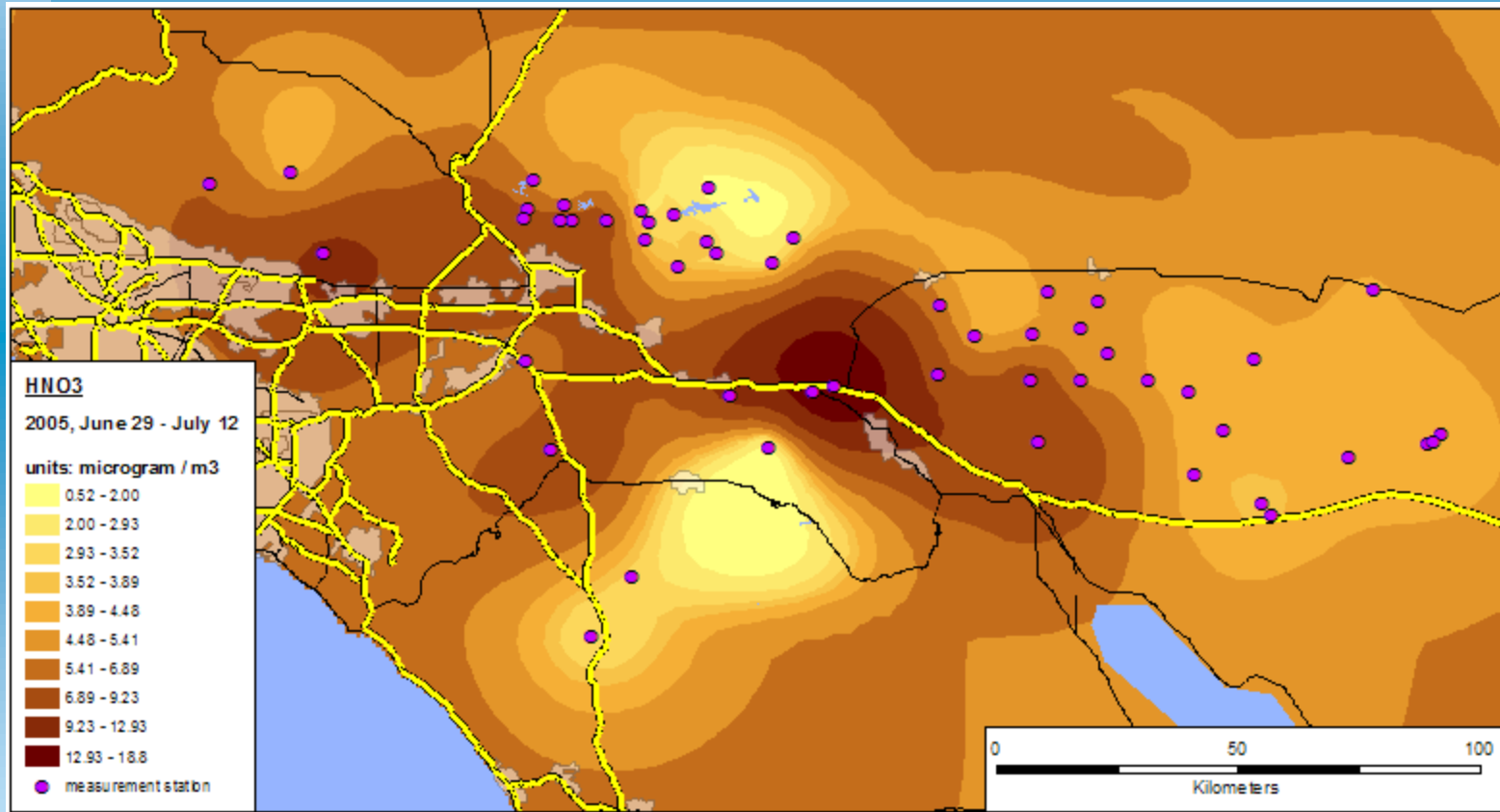
Nitrogen oxides, June 29 - July 12, 2005



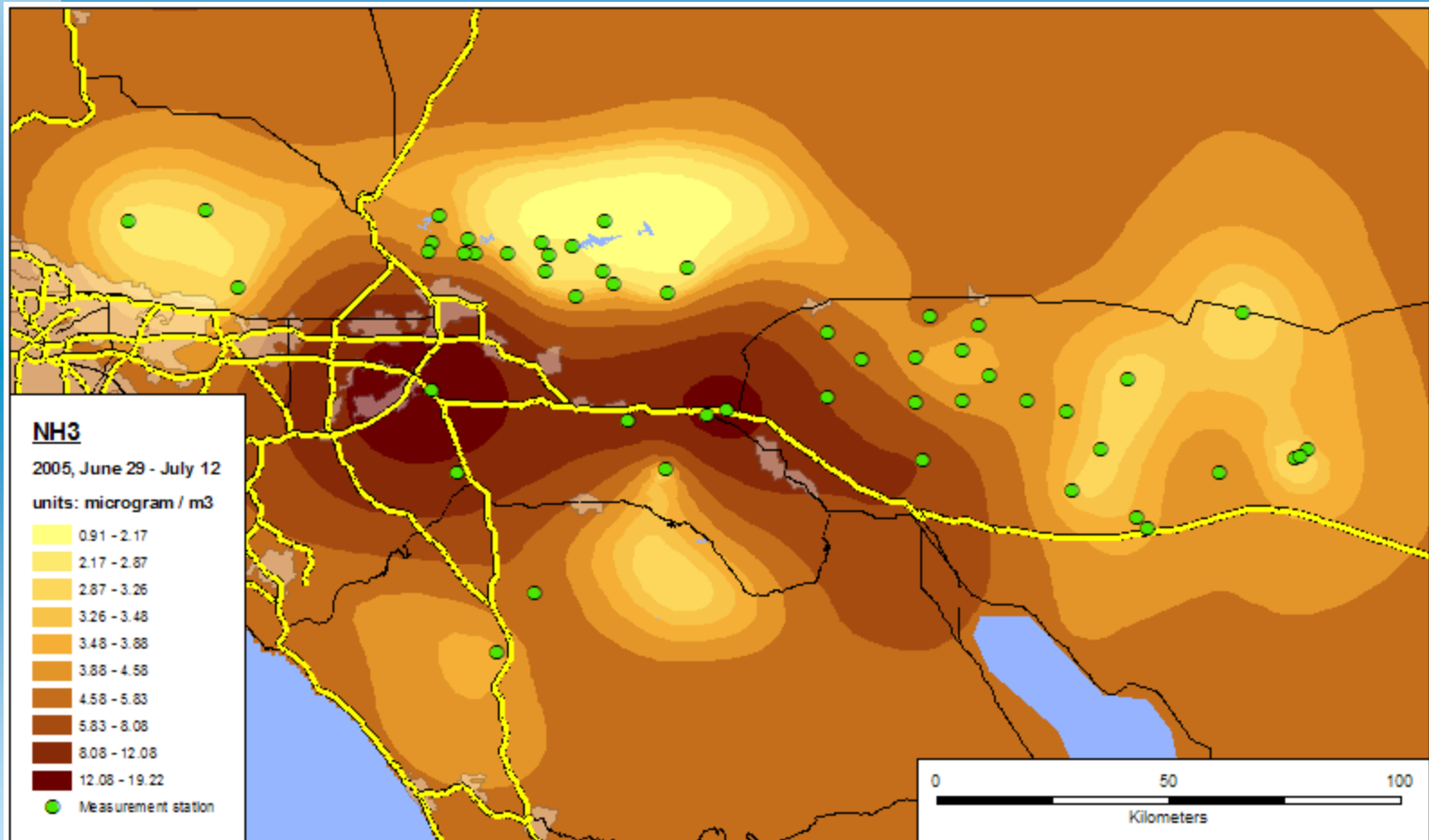
Nitrogen dioxide, June 29 – July 12, 2005



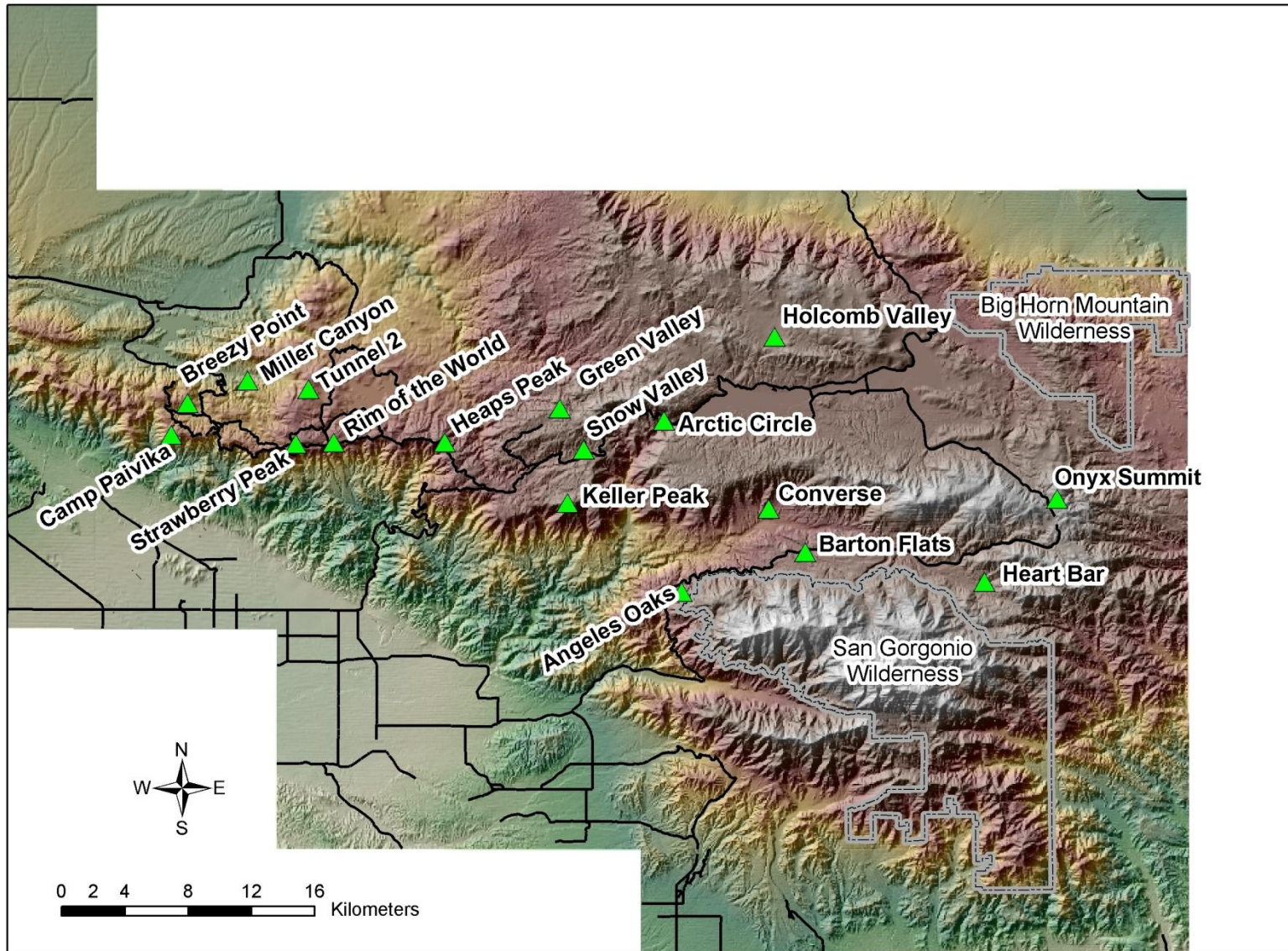
Nitric acid vapor, June 29 – July 12, 2005



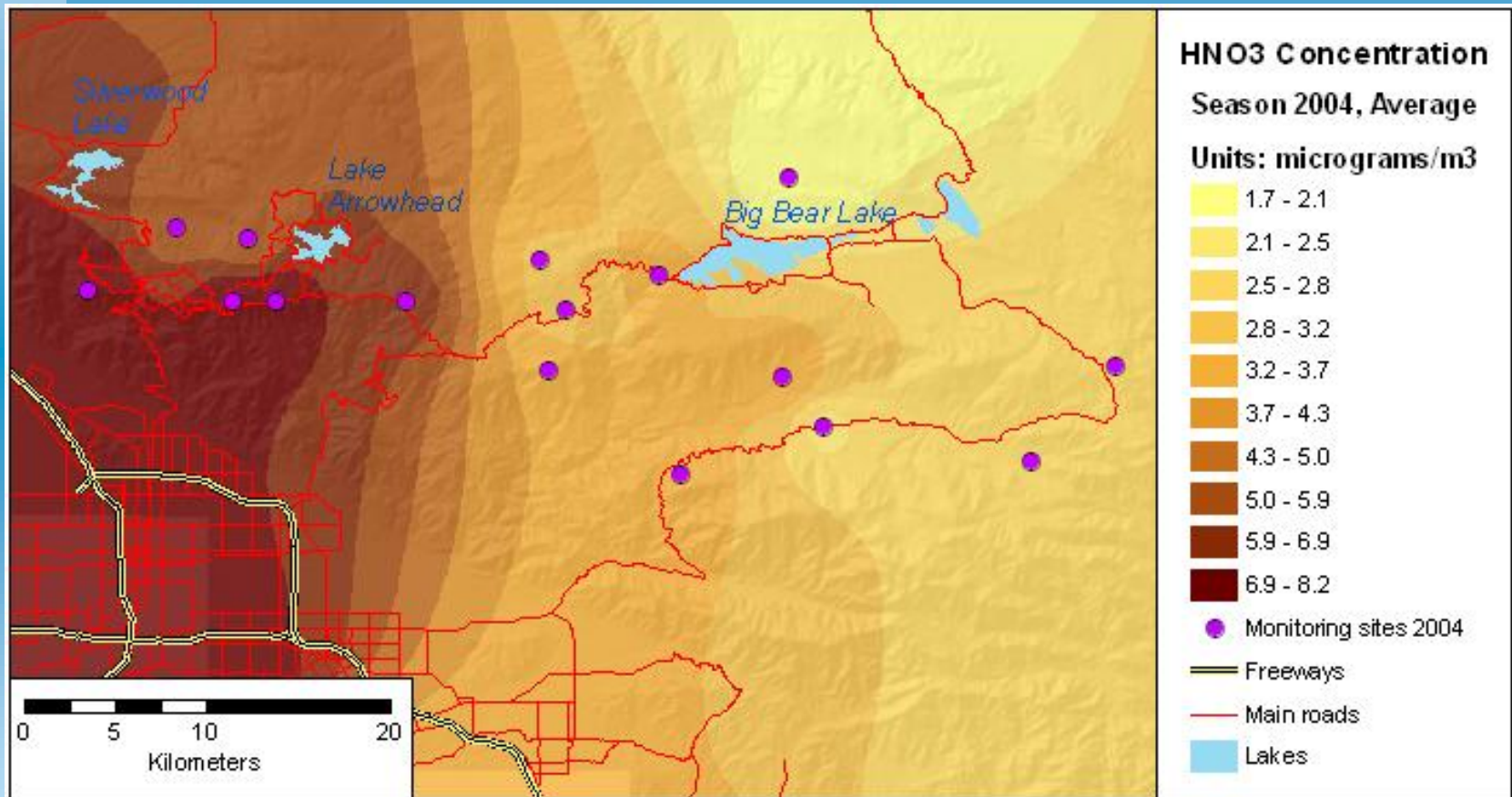
Ammonia, June 29 – July 12, 2005



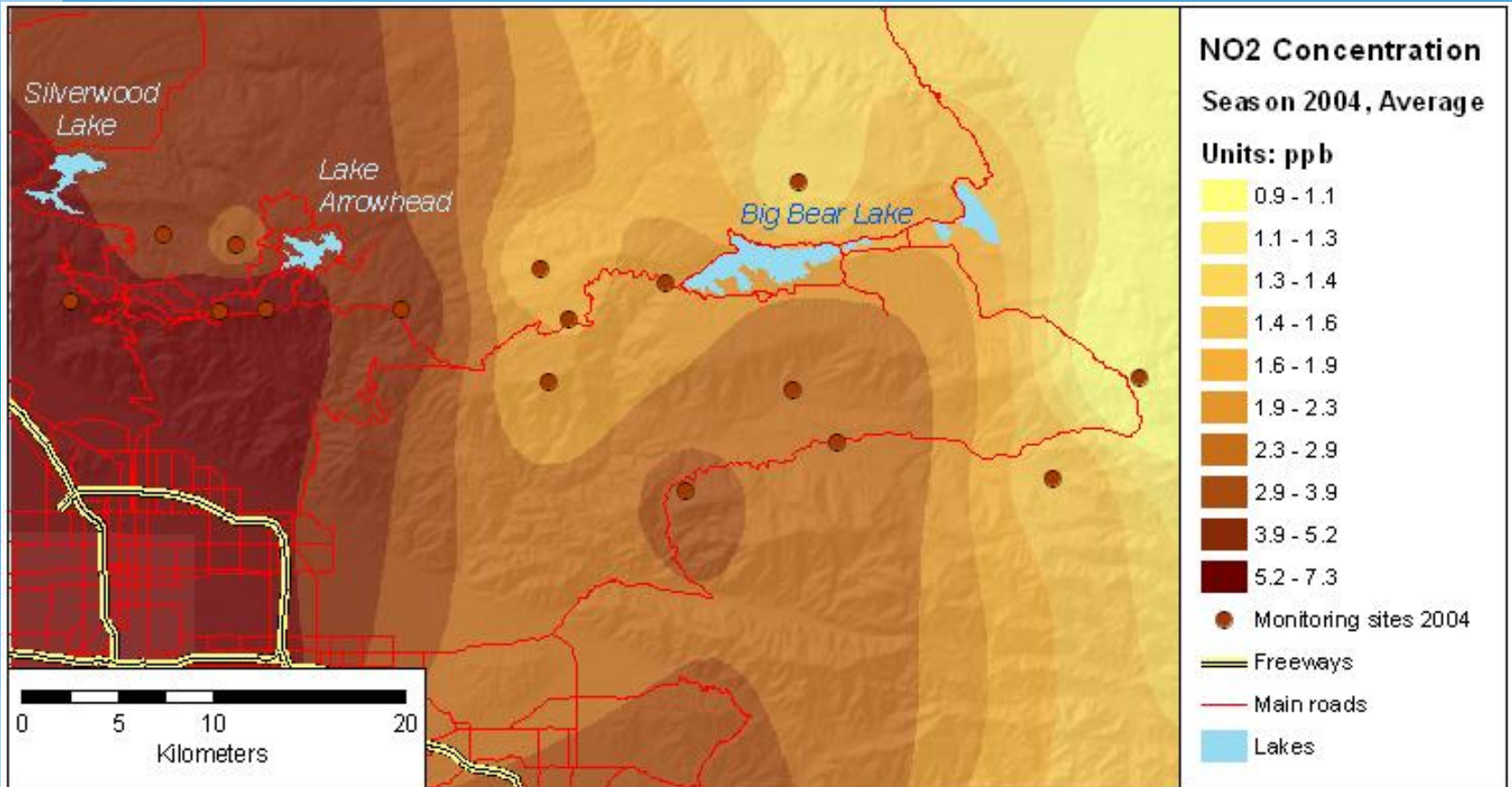
San Bernardino Mountains network



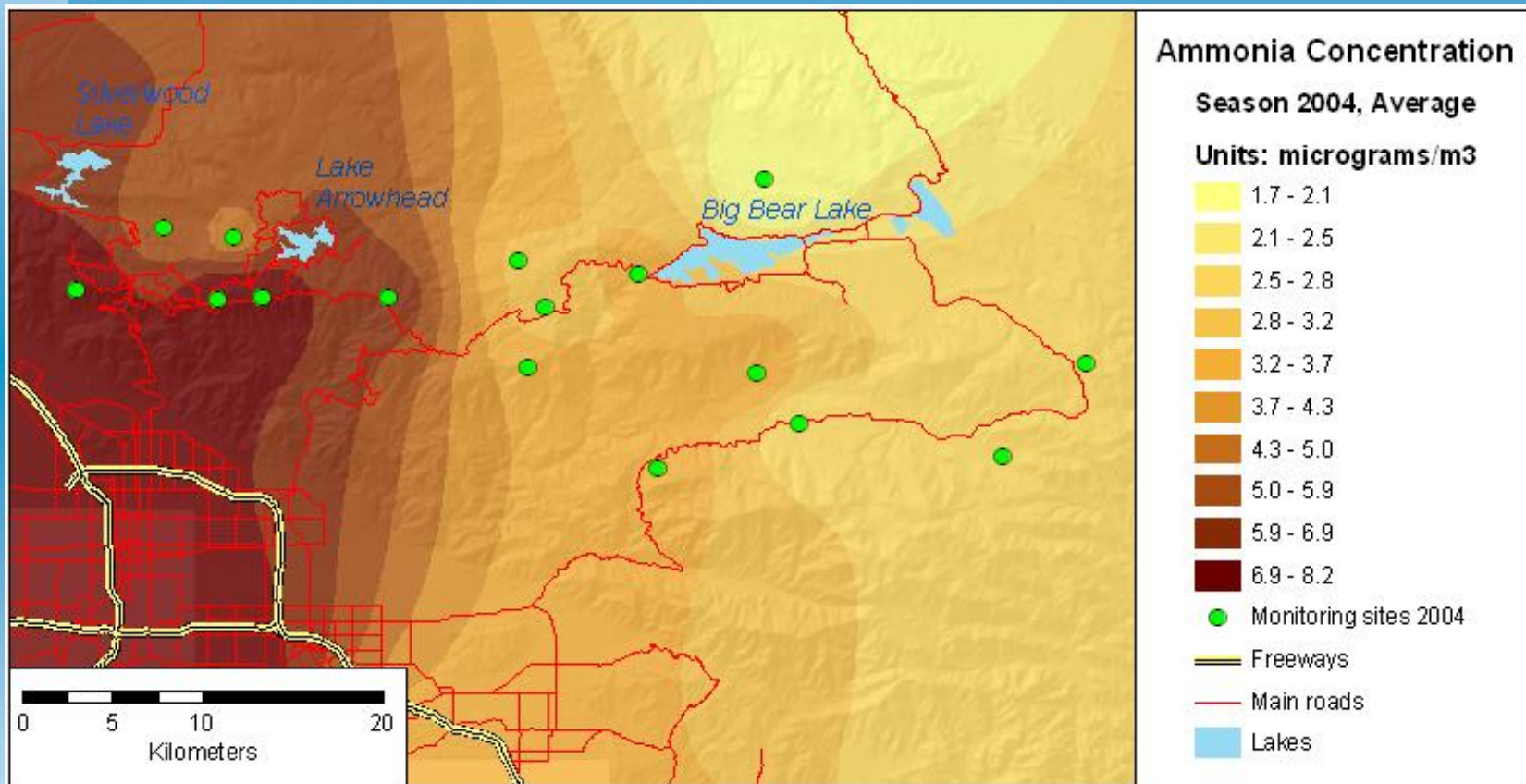
HNO₃ - 2004



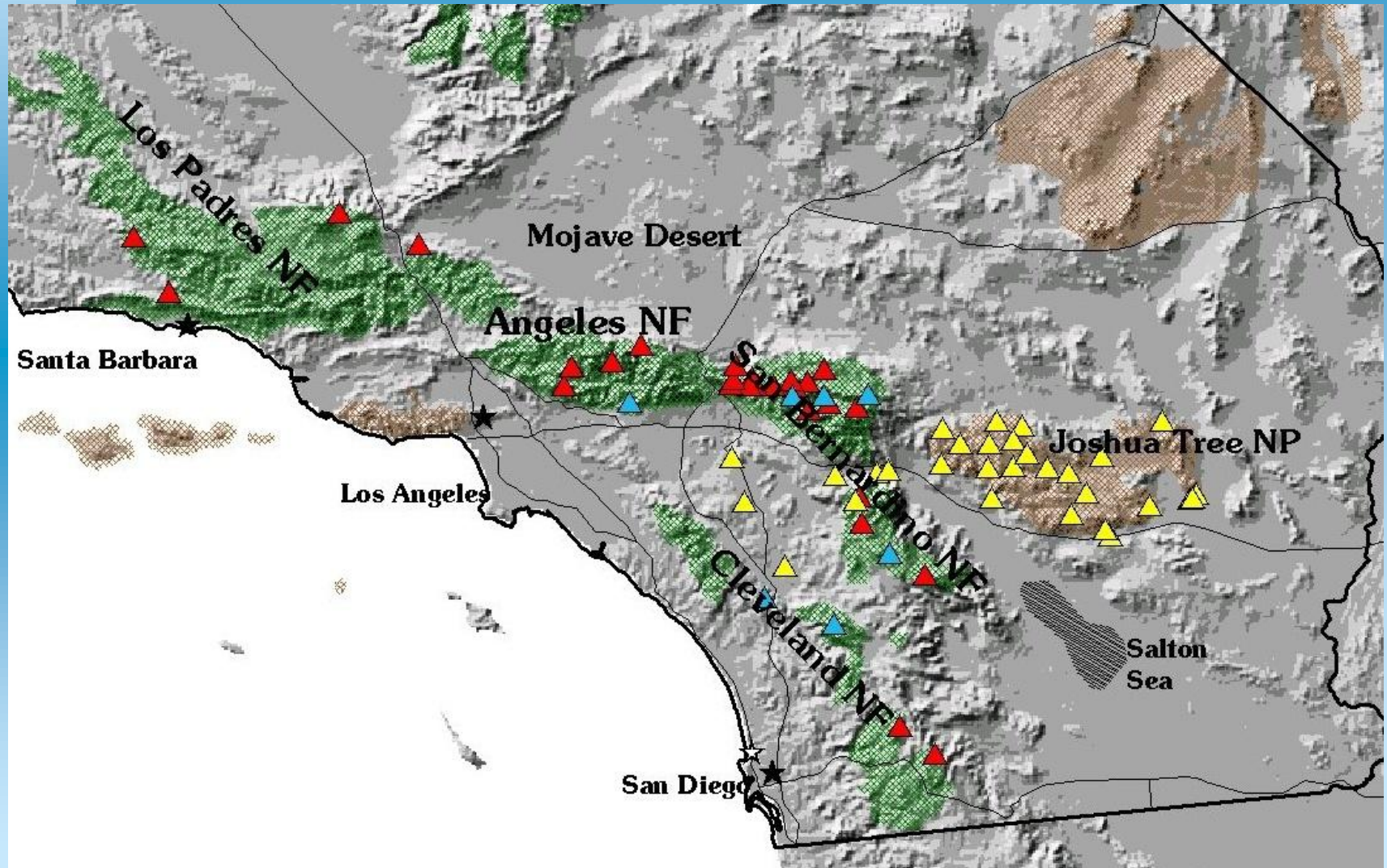
NO₂ - 2004



Ammonia - 2004

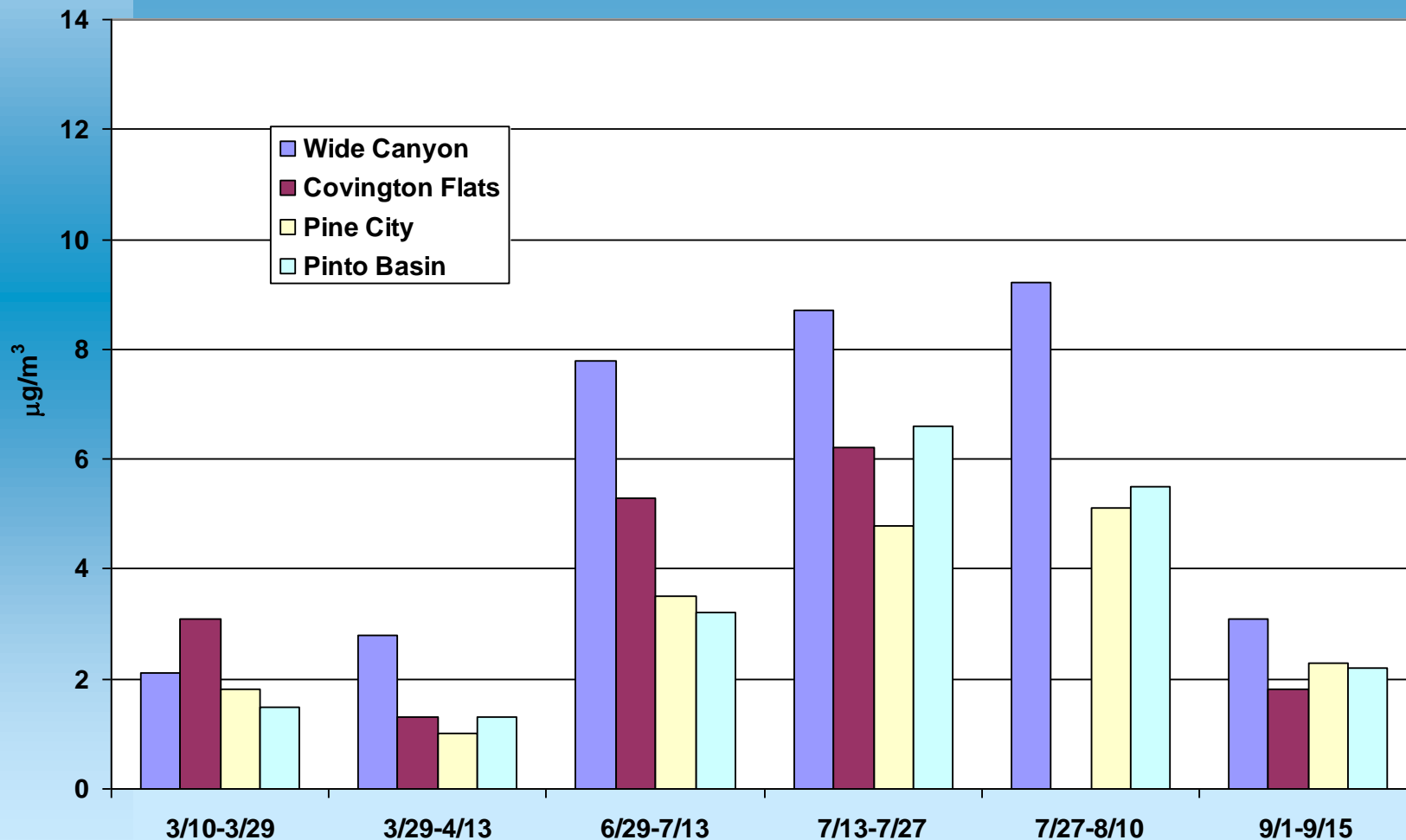


Southern California Air Monitoring Network

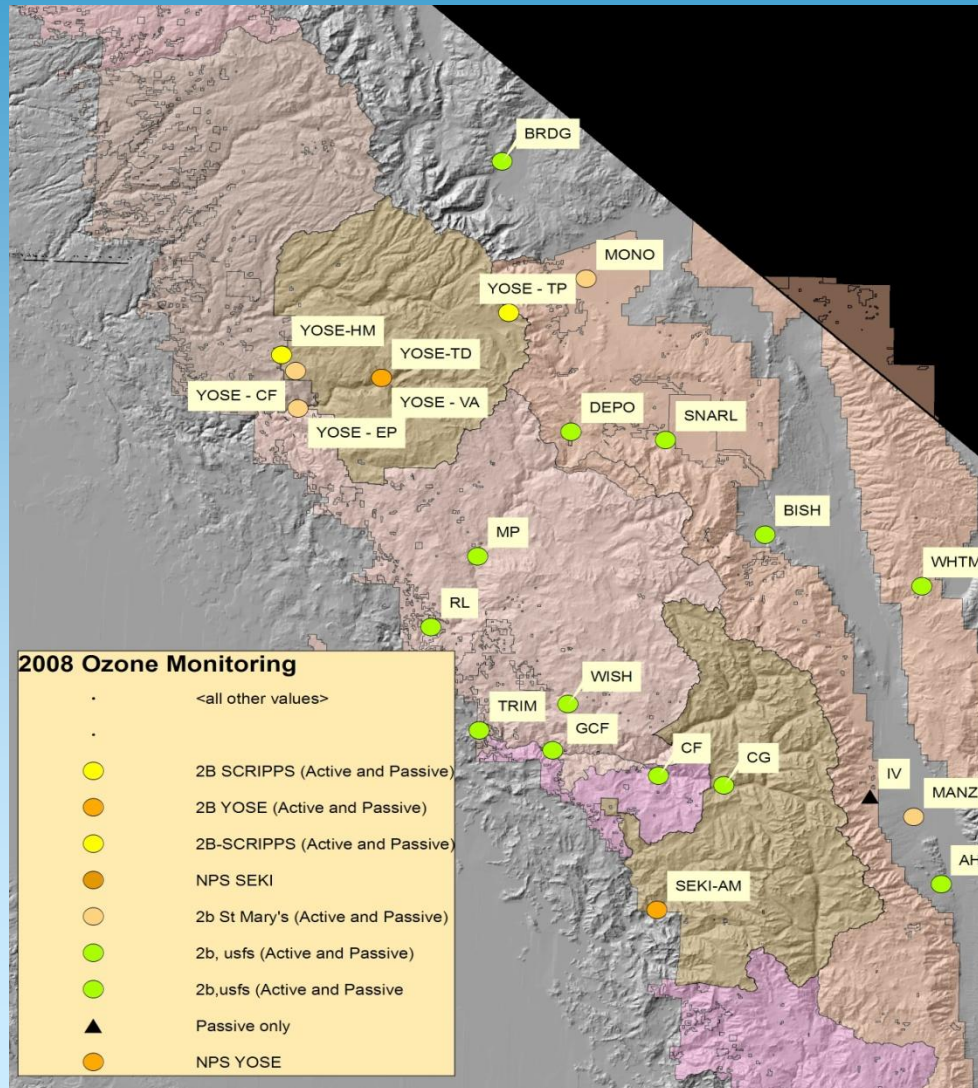


2005 winter vs. summer NH₃ concentrations in JTNP

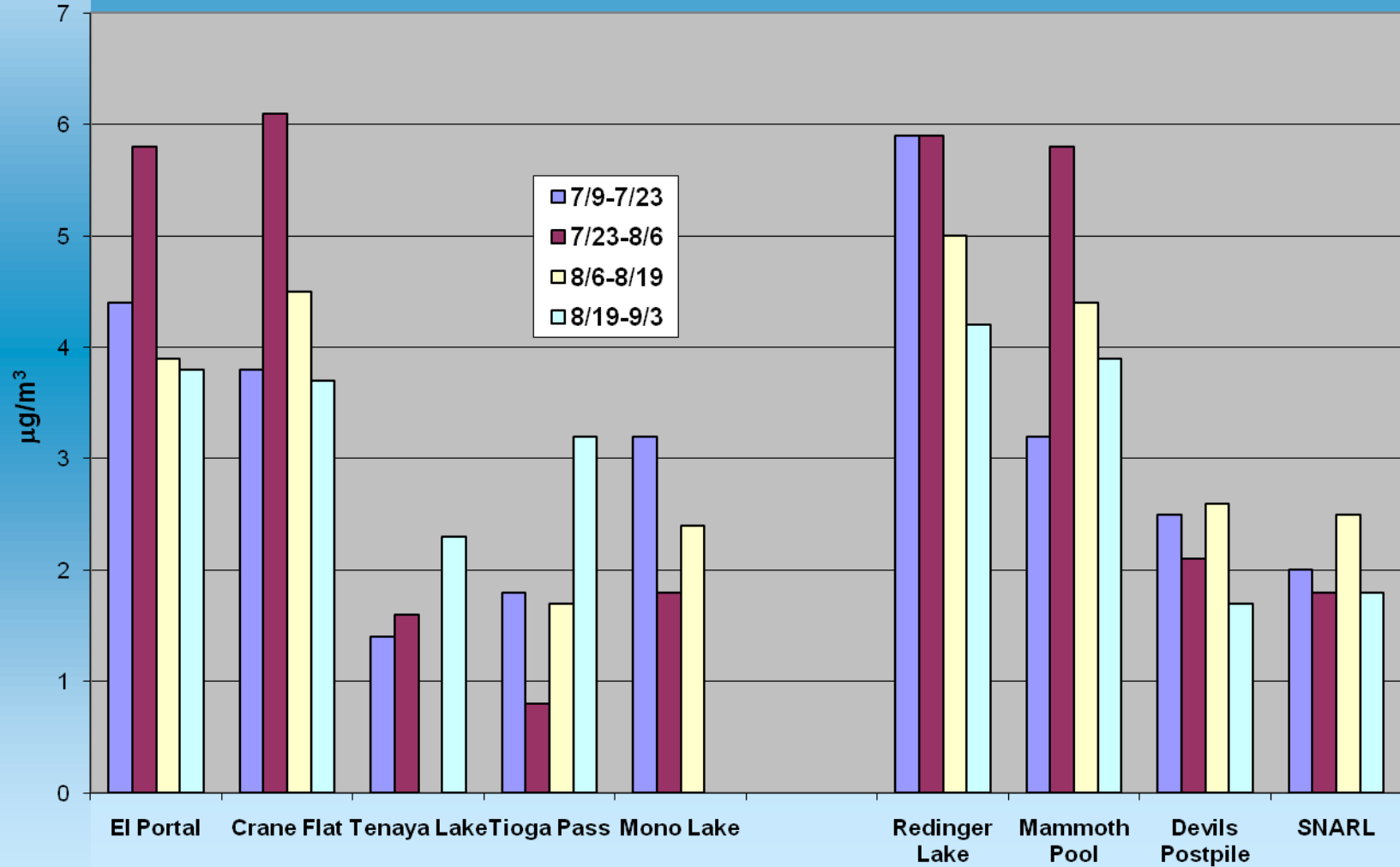
NH₃ - 2005



Sierra Nevada Mountains, including Yosemite and San Joaquin River Drainage



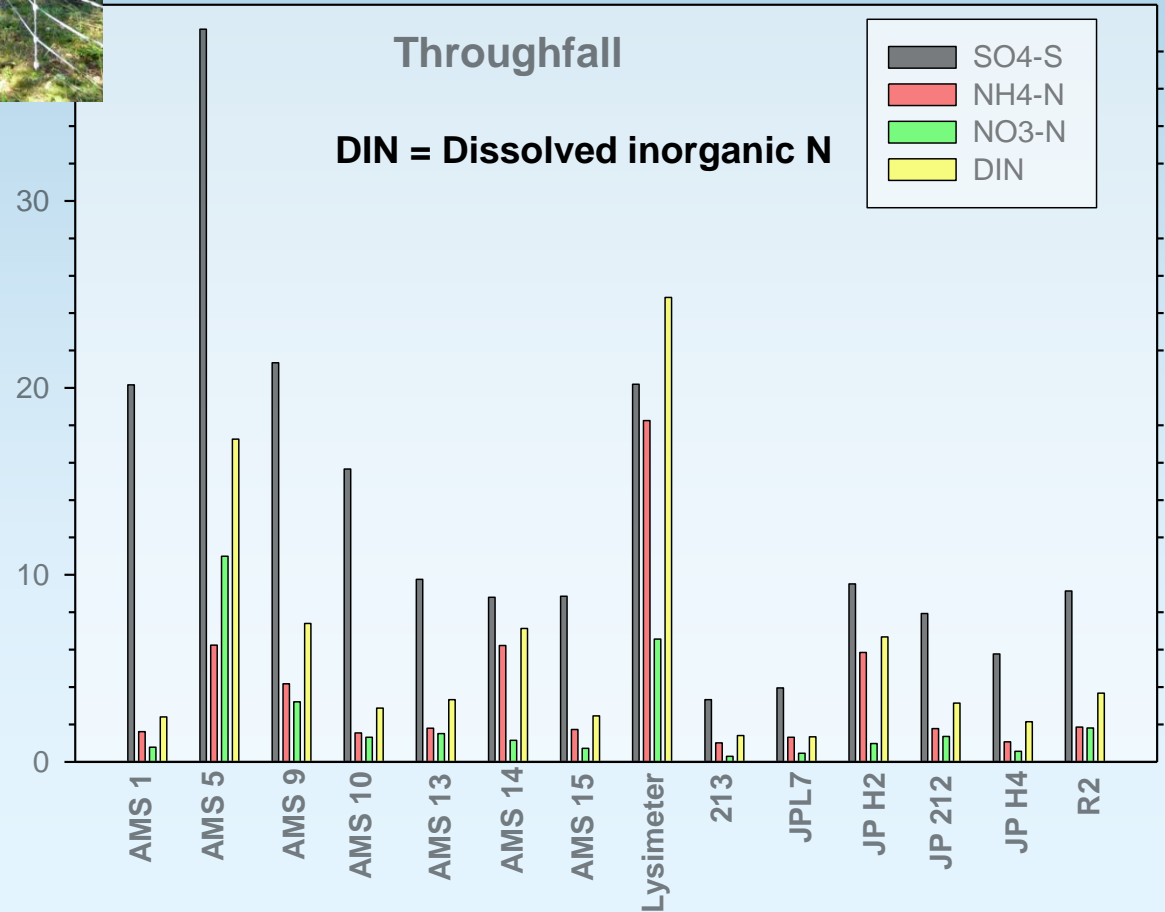
Ammonia, Yosemite & San Joaquin River transects, summer 2008

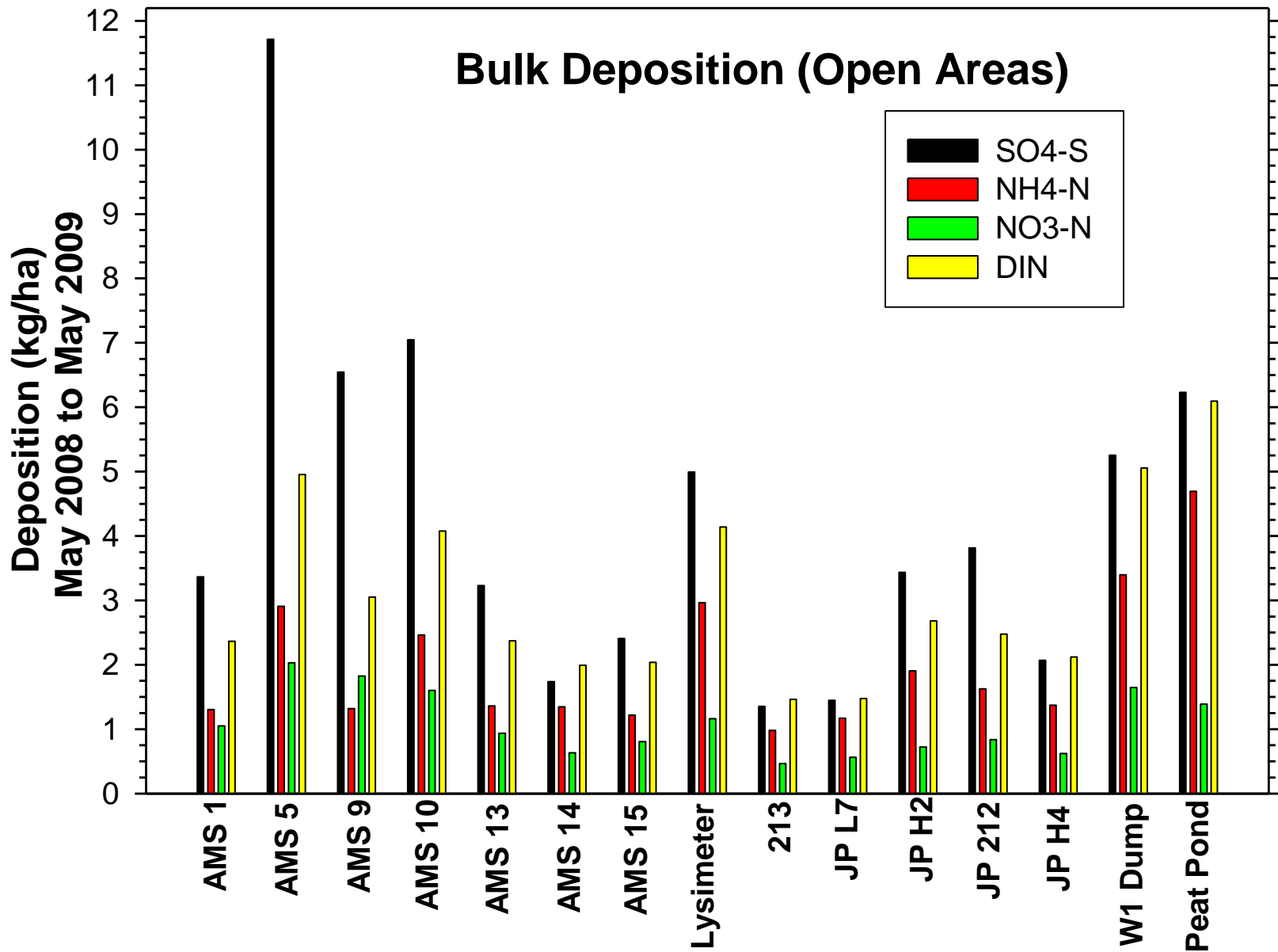


Athabasca Oil Sands Region, Northern Alberta, Canada



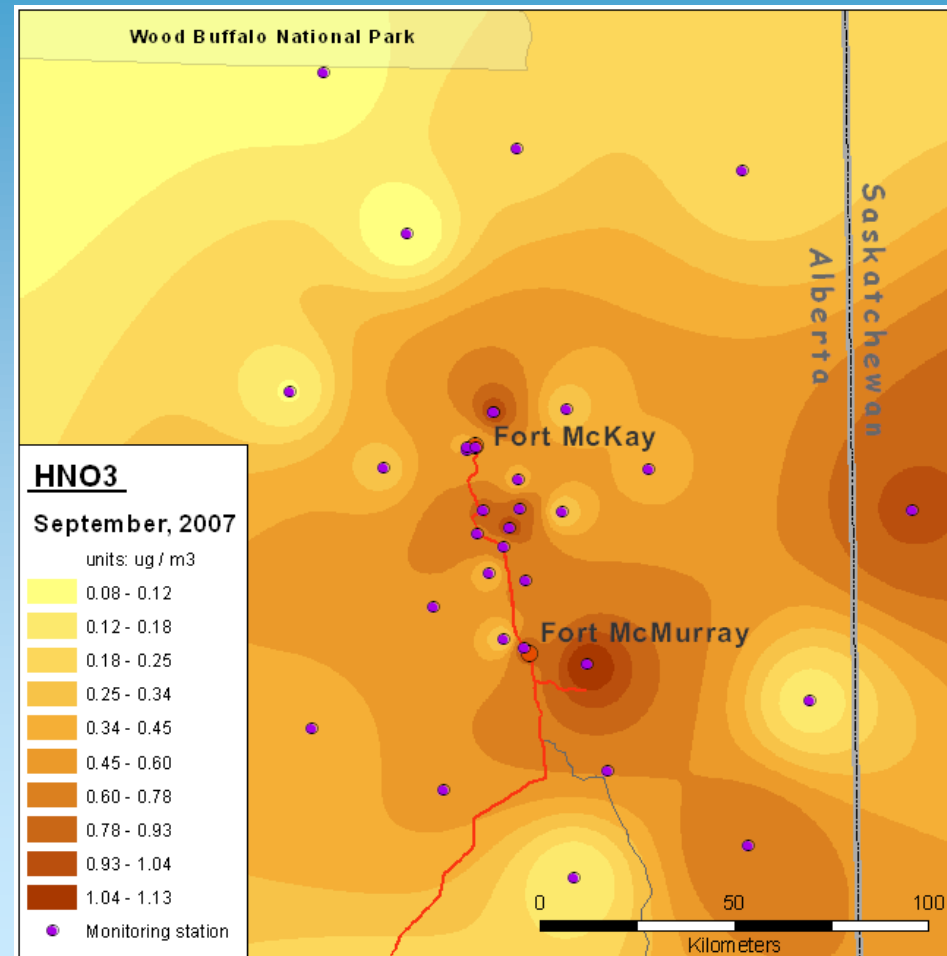
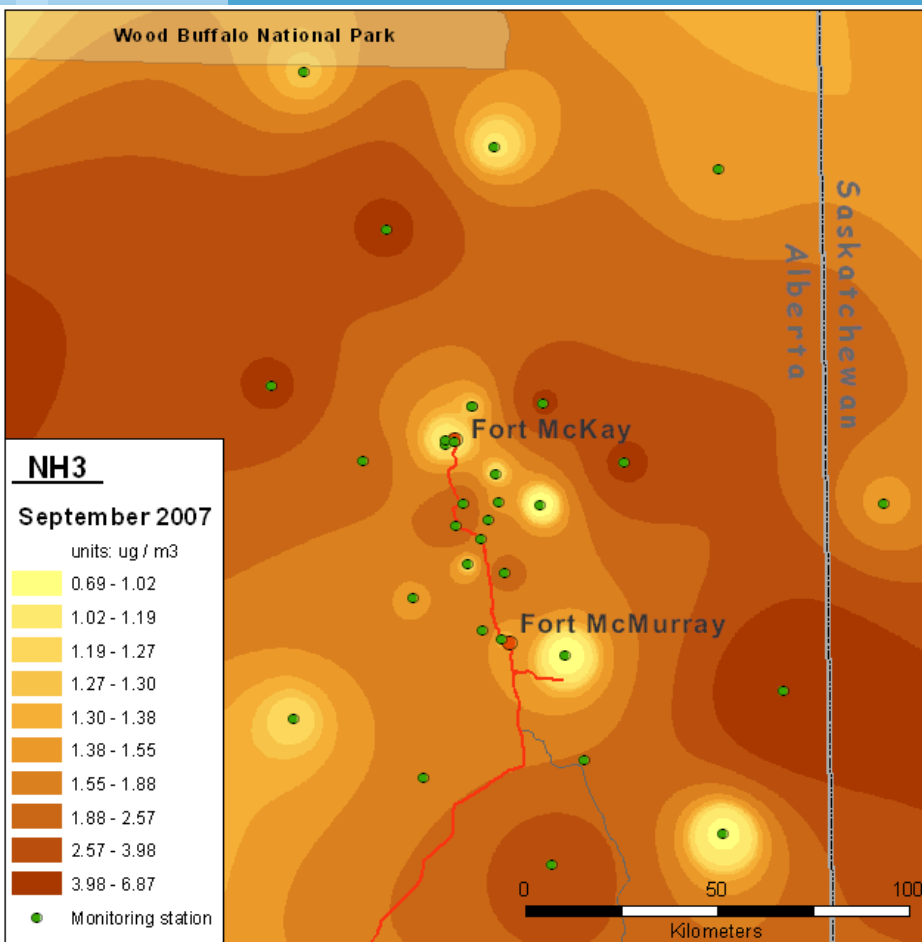
Deposition (kg/ha/yr)
May 2008 to May 2009





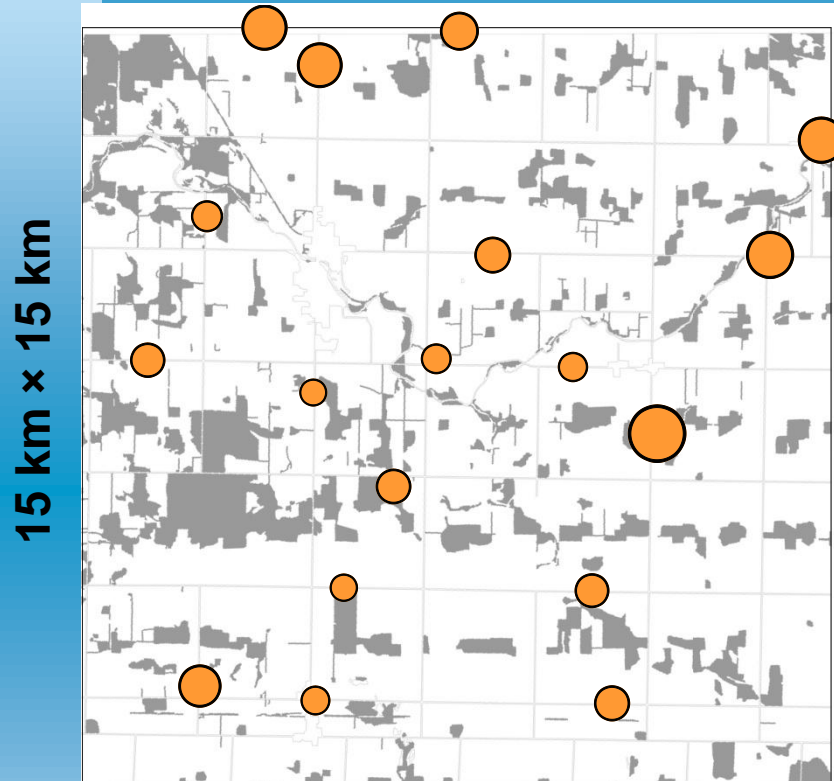
DIN = Dissolved inorganic N

Athabasca Oil Sands Region: Comparison of NH_3 and HNO_3 distribution: September 2007

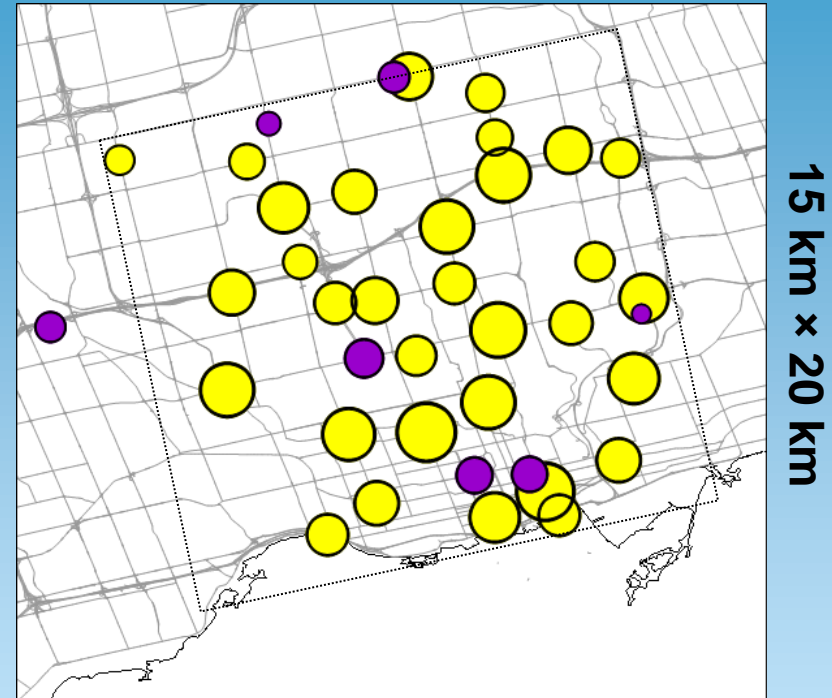


Spatial variability of atmospheric ammonia during July 6–20, 2010

Intensive agriculture NH₃ (Brussels, ON)



Urban NH₃ (Toronto, ON)



Ammonia concentrations range from 1.64–8.76 $\mu\text{g m}^{-3}$ (intensive agriculture) and 1.11–10.02 $\mu\text{g m}^{-3}$ (urban). Observations based on Willems Badge passive samplers except yellow circles (Gradko samplers normalised to Willems).

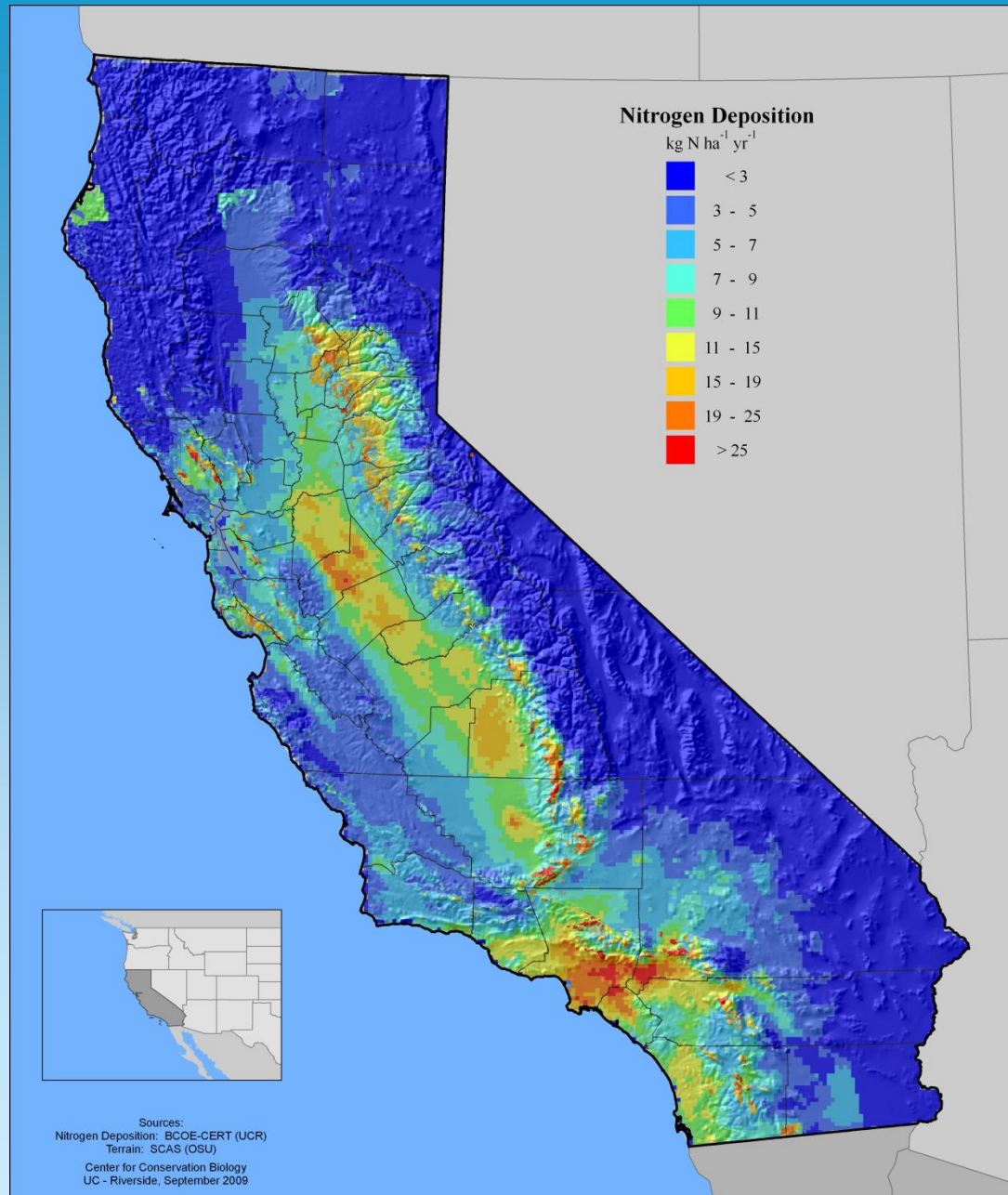
For further details see poster by Zbieranowski and Aherne
Funding: Environment Canada

Conclusions

- Elevated NH_x is common in areas traditionally thought to be dominated by NO_y
- Elevated NH_3 in remote sites of California---indicating long range transport
- NH_x is a major contributor to ecological & environmental effects in California and in many regions of North America
- Ongoing increase in proportion of atmospheric N as NH_x
- In urban areas and near freeways, light-duty vehicles are important NH_3 emissions sources
- NH_3 emissions controls is an important policy consideration

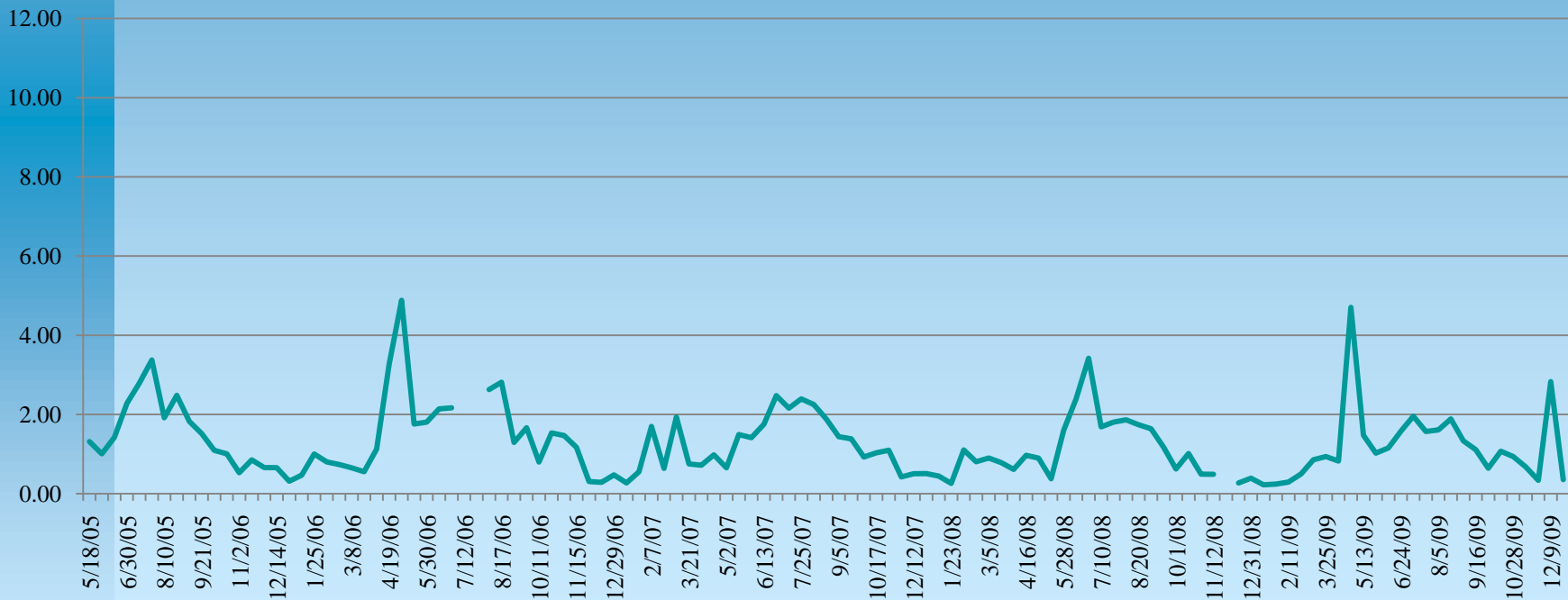


CMAQ simulated N deposition



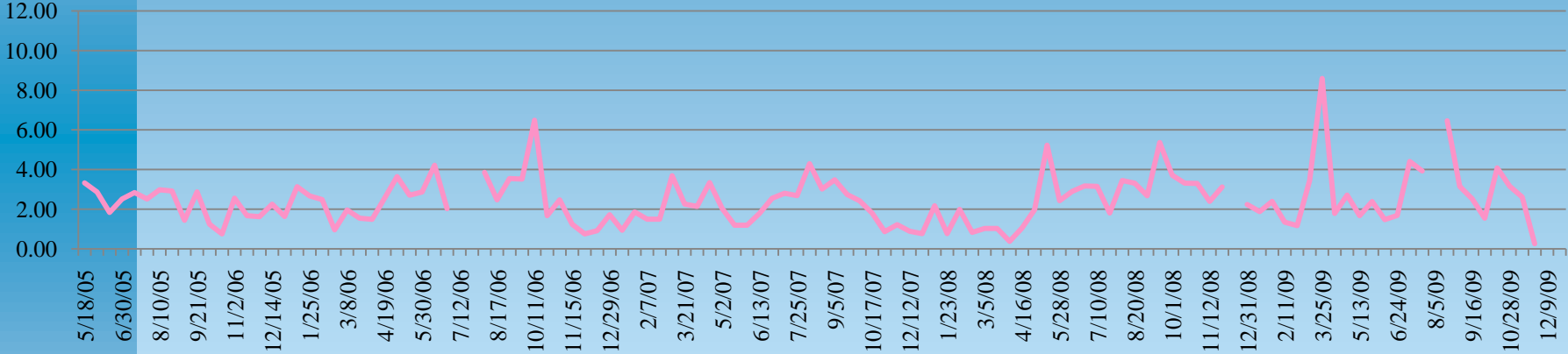
Tanbark Flats

HNO_3 ug-N/m³



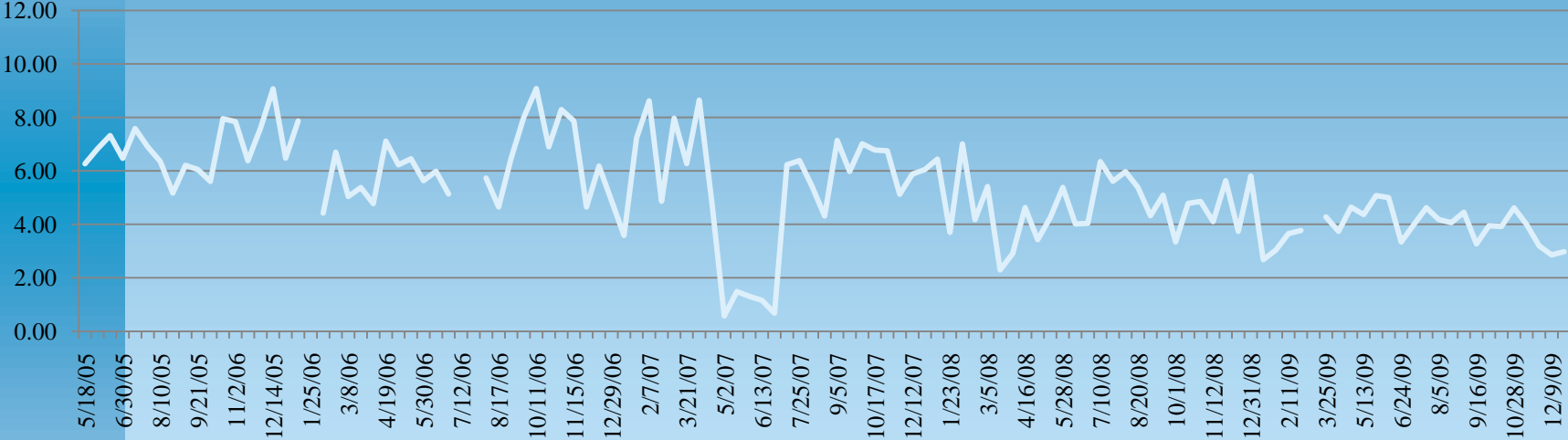
Tanbark Flats

NH₃ ug-N/m³



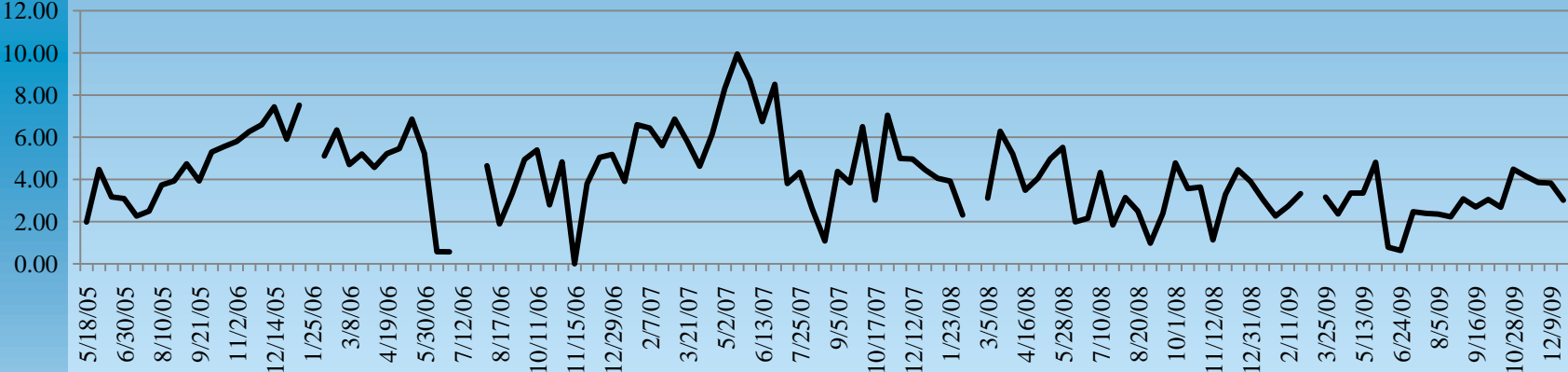
Tanbark Flats

NO₂ ug-N/m³



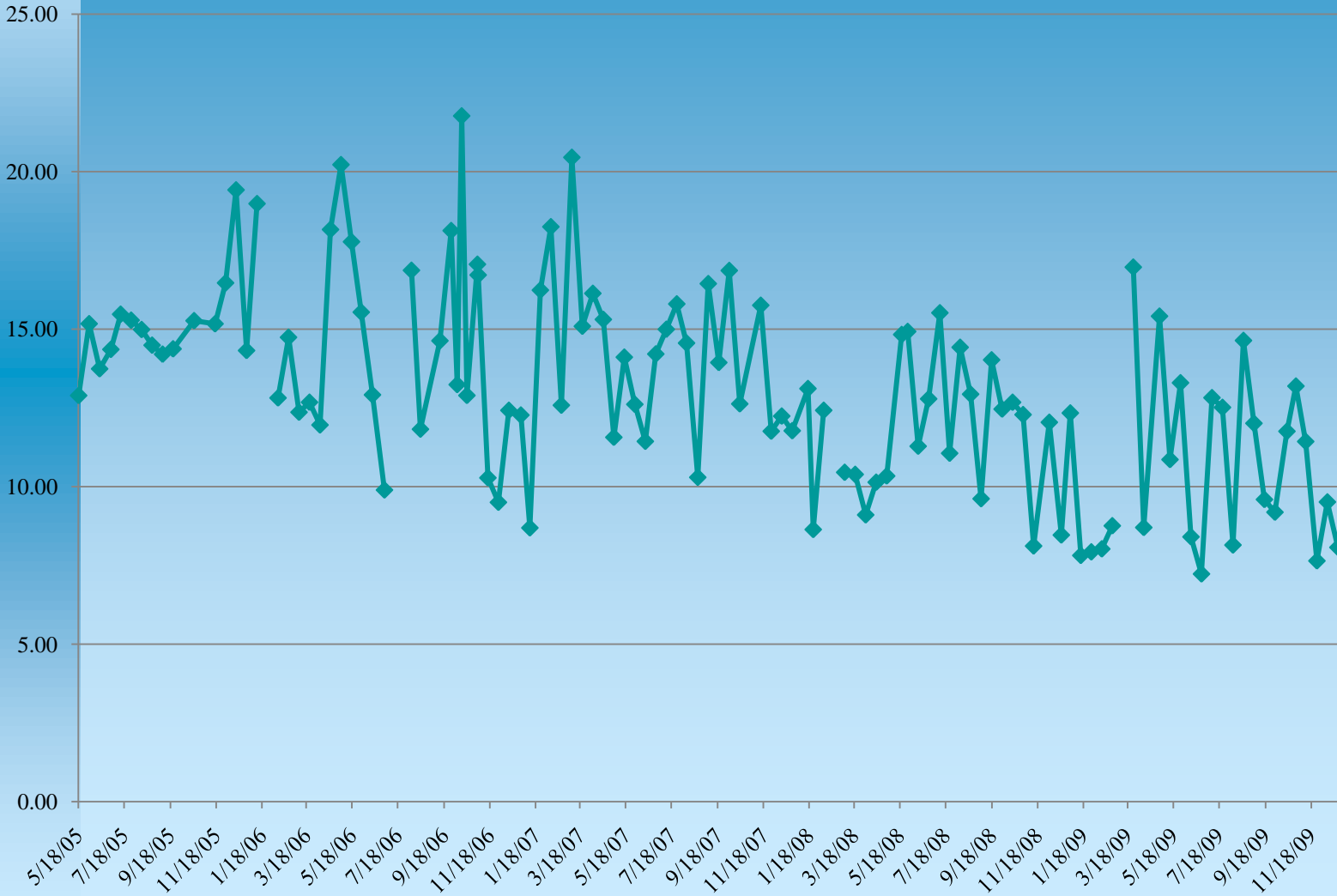
Tanbark Flats

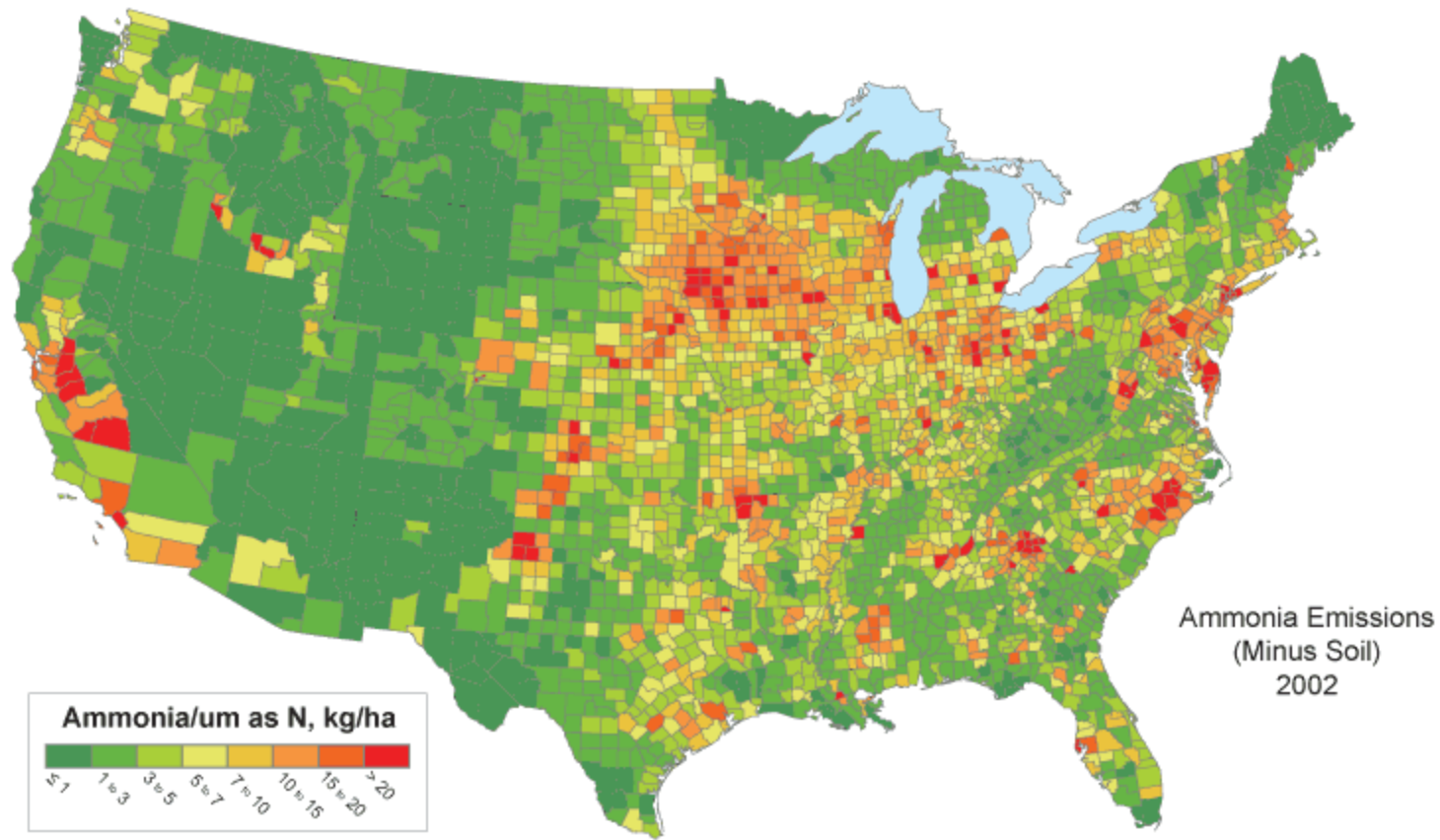
NO ug-N/m³



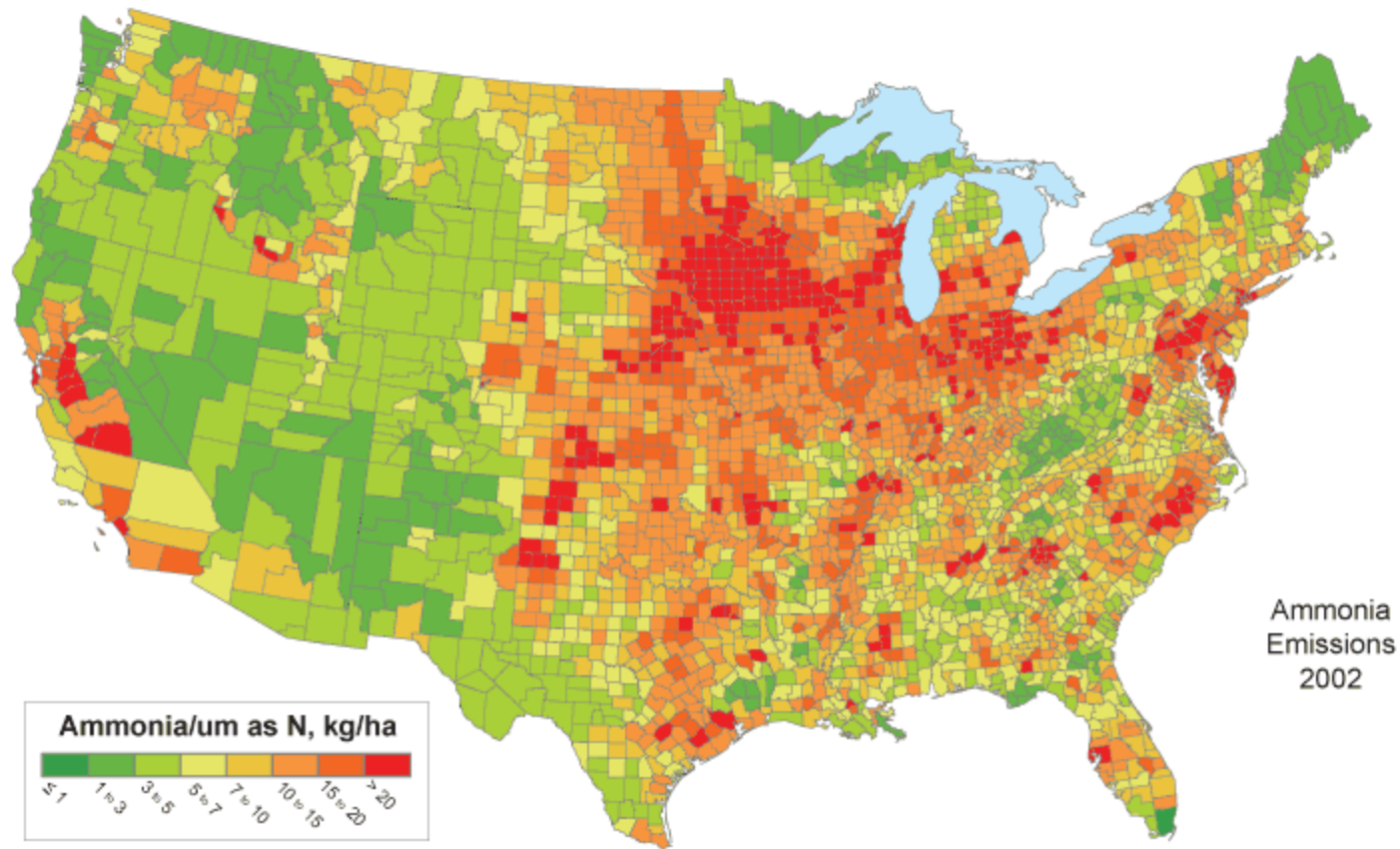
Tanbark Flats

Total-N ug N/m³





From NADP: <http://nadp.sws.uiuc.edu/nh3Net/>



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