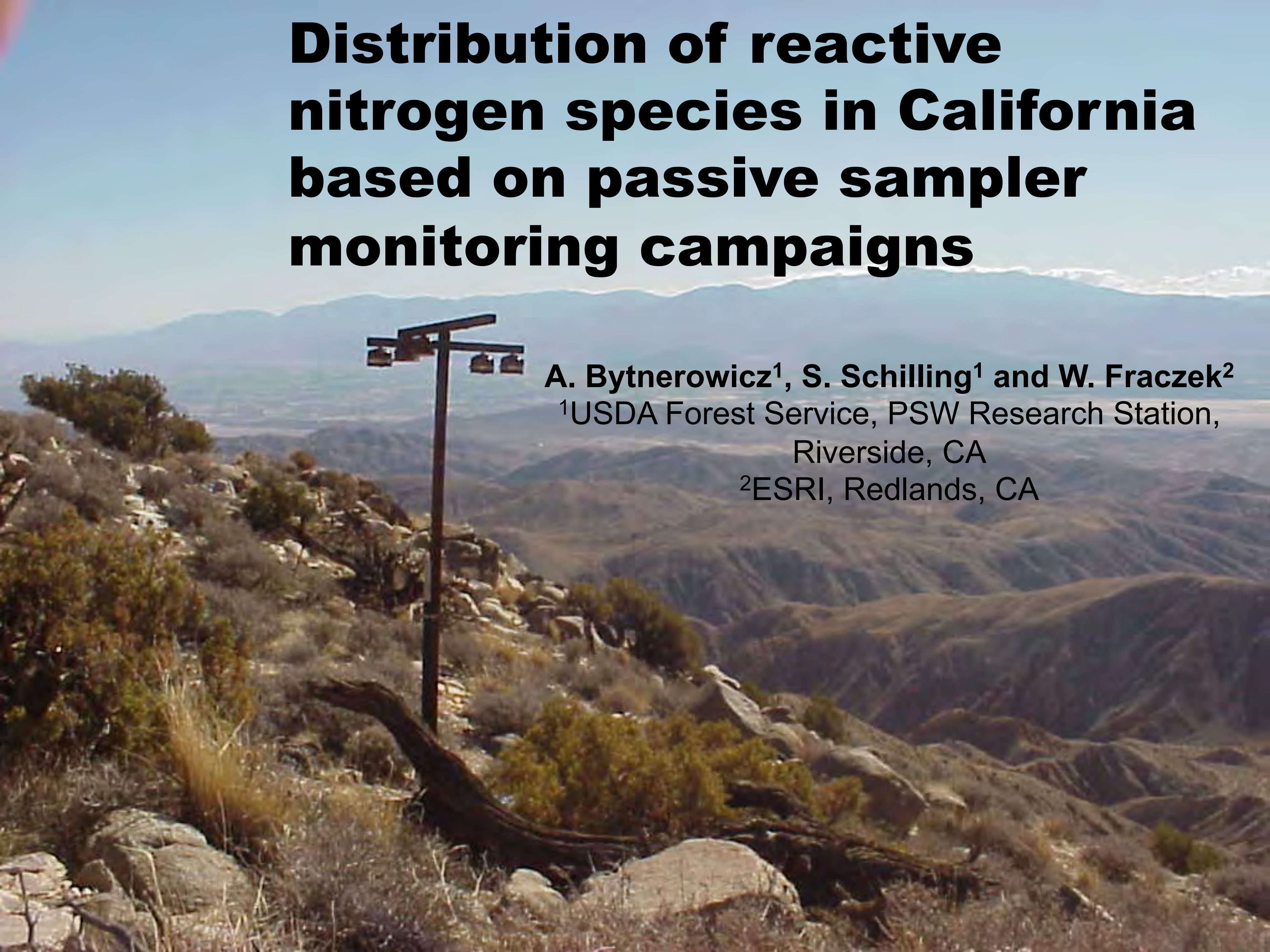


Distribution of reactive nitrogen species in California based on passive sampler monitoring campaigns

A. Bytnerowicz[1], S. Schilling[1] and W. Fraczek[2]
[1]USDA Forest Service, PSW Research Station, Riverside, CA
[2]ESRI, Redlands, CA

Dr. Andrzej Bytnerowicz

USDA FS Riverside, CA

Passive samplers are used for monitoring:

Ozone (O_3)

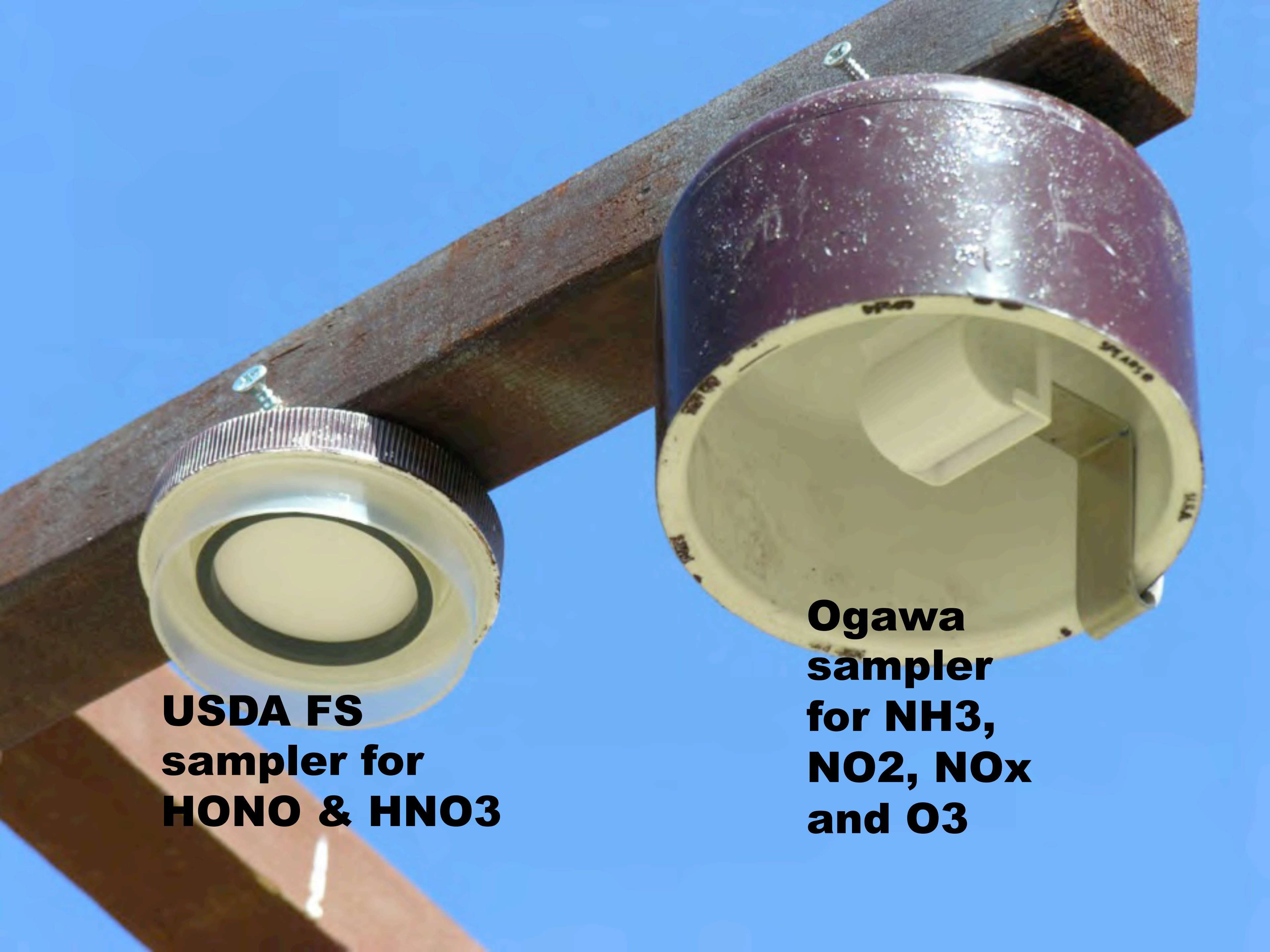
Nitrogen dioxide (NO_2)

Nitrogen oxides (NO_x)

Nitric acid vapor (HNO_3)

Ammonia (NH_3)

Sulfur dioxide (SO_2)


USDA FS
sampler for
HONO & HNO3
Ogawa
sampler
for NH3,
NO2, NOx
and O3

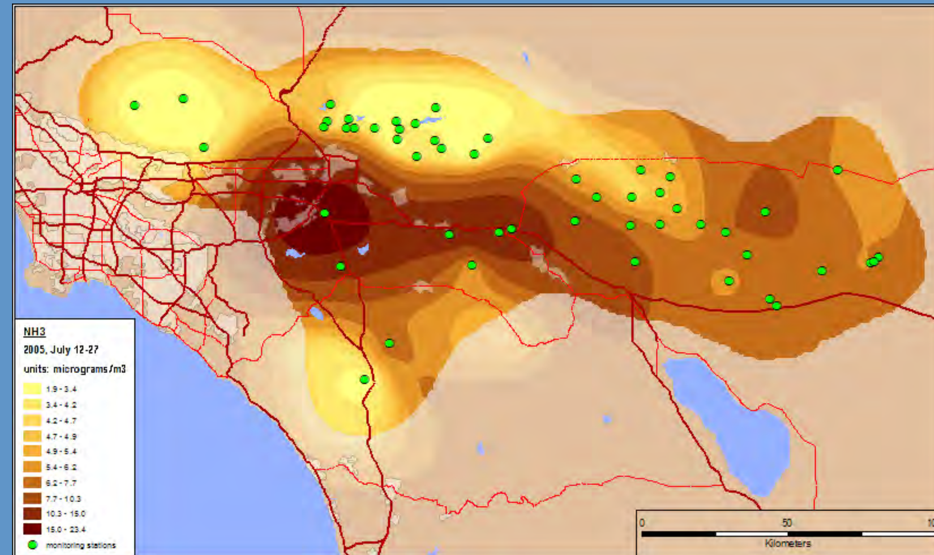
Forms of N deposition to forests and other ecosystems

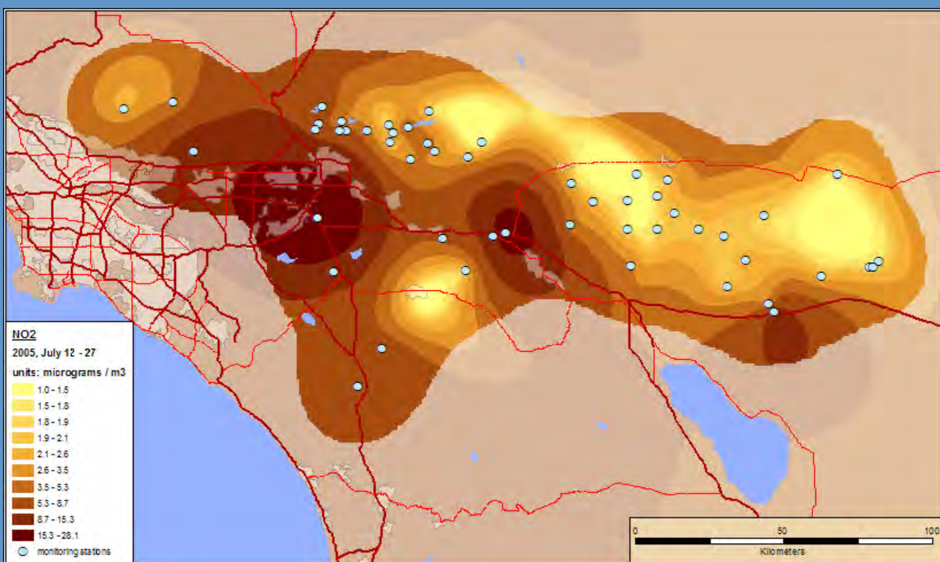
- Wet deposition (rain, fog, cloud, snow) of NO_3^- and NH_4^+
- Dry surface deposition of HNO_3, NH_3 and particulate NO_3^- and NH_4^+
- Stomatal uptake of NO, NO_2, NH_3, HNO_3, PAN and PPN
- **In the Mediterranean climate (California) dry deposition of N dominates**

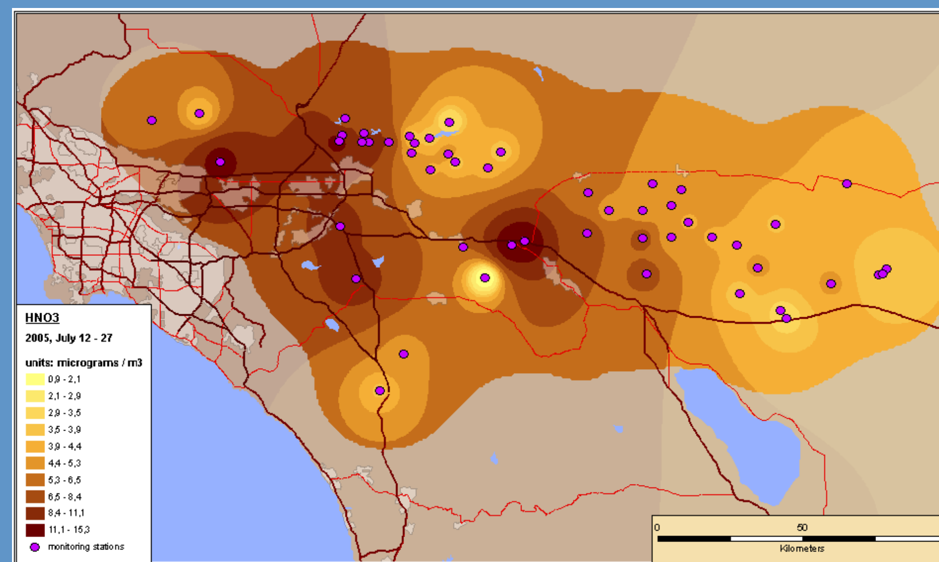
Geostatistics

- Use of ArcGIS Geostatistical Analysts (ESRI, Redlands, CA) for development of distribution maps.
- Various types of Krigin, Co-Kriging and Inversed Distance Weighing (IDW) have been used for conversion of point data from passive sampler networks into landscape surfaces.

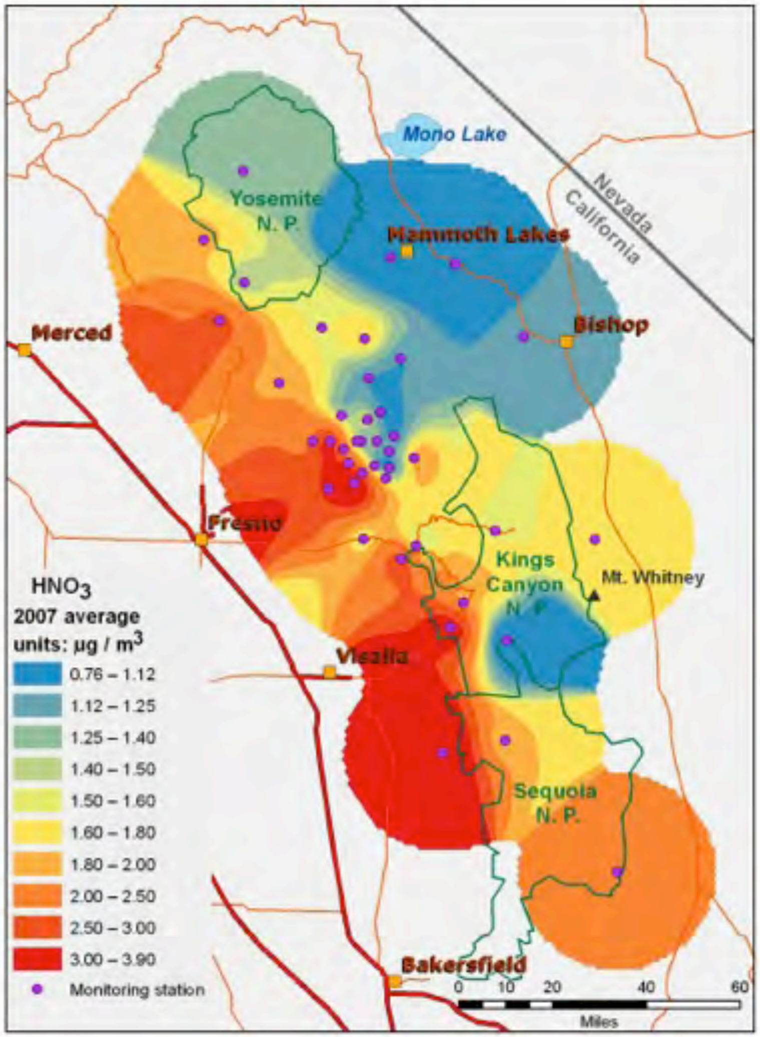
N air pollutants in southern California - summer 2005

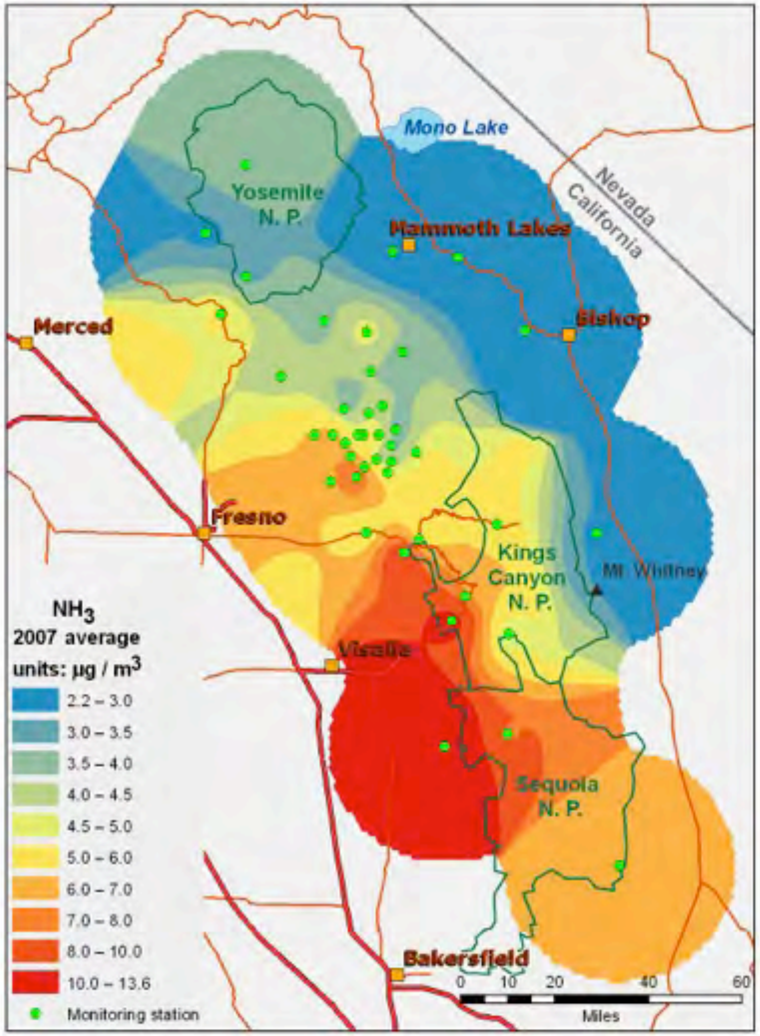






HNO_3 and NH_3 is southern Sierra Nevada, summer 2007





Modified inferential method for N dry deposition estimates - example of the San Bernardino Mountains

- A new approach to estimates of atmospheric nitrogen deposition to forests and other ecosystems in arid and semi-arid areas using a modified, GIS-based inferential method.
- Can be used for identifying areas receiving excessive amounts of nitrogen (exceedance of "Critical Load")

GIS-based inferential method approach to N dry deposition estimates – data input

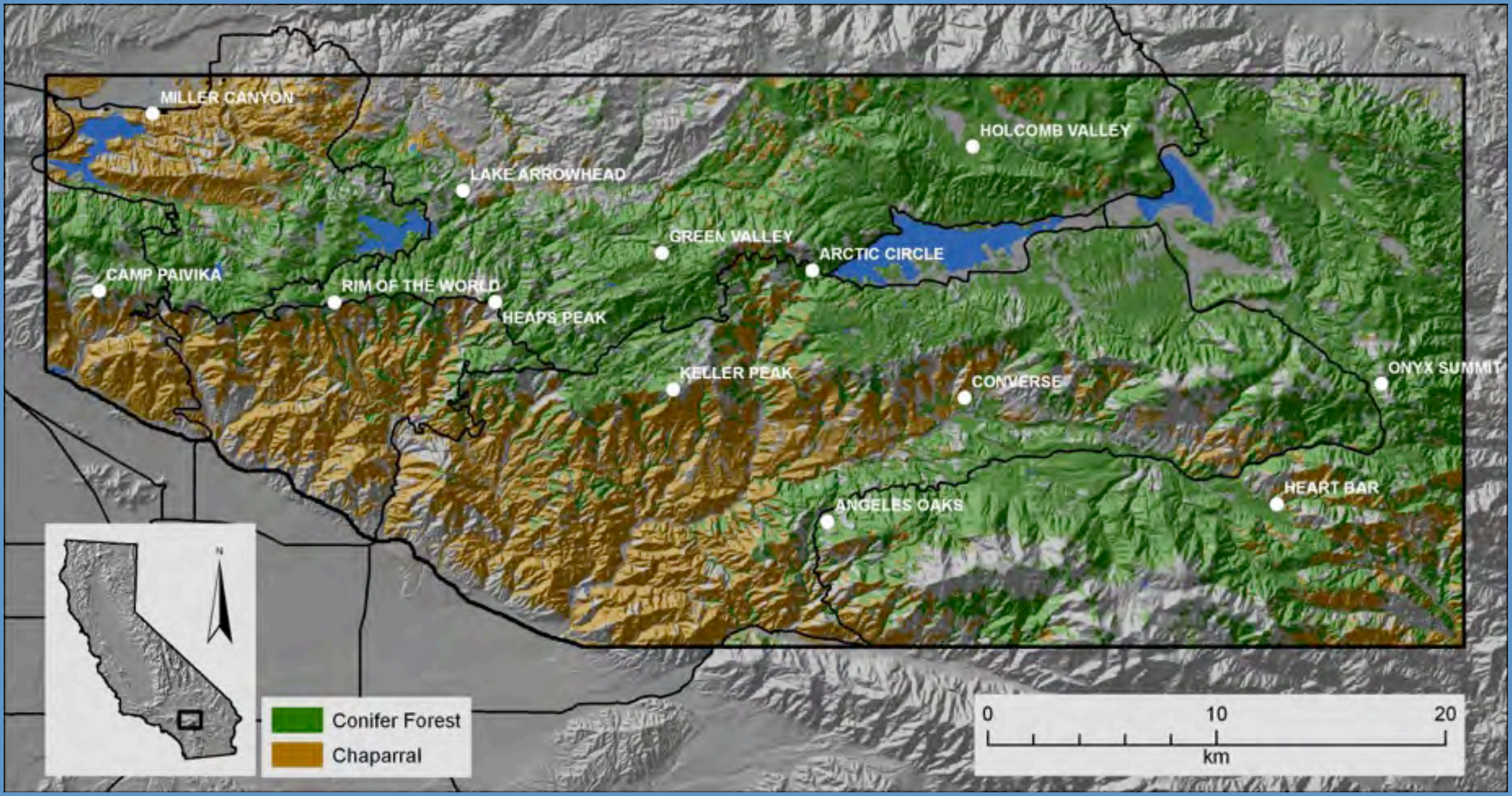
- **Concentrations** of major reactive N gases (HNO_3, NH_3, NO and NO_2) from passive samplers (c) for 2002 – 2006 summer seasons.
- **Leaf area index** (LAI) from MODIS images (1 x 1 km) for periods corresponding with passive sampler exposures.
- **Land cover** based on classification of the Society of American Foresters.

GIS-based inferential method approach to N dry deposition estimates - calculations

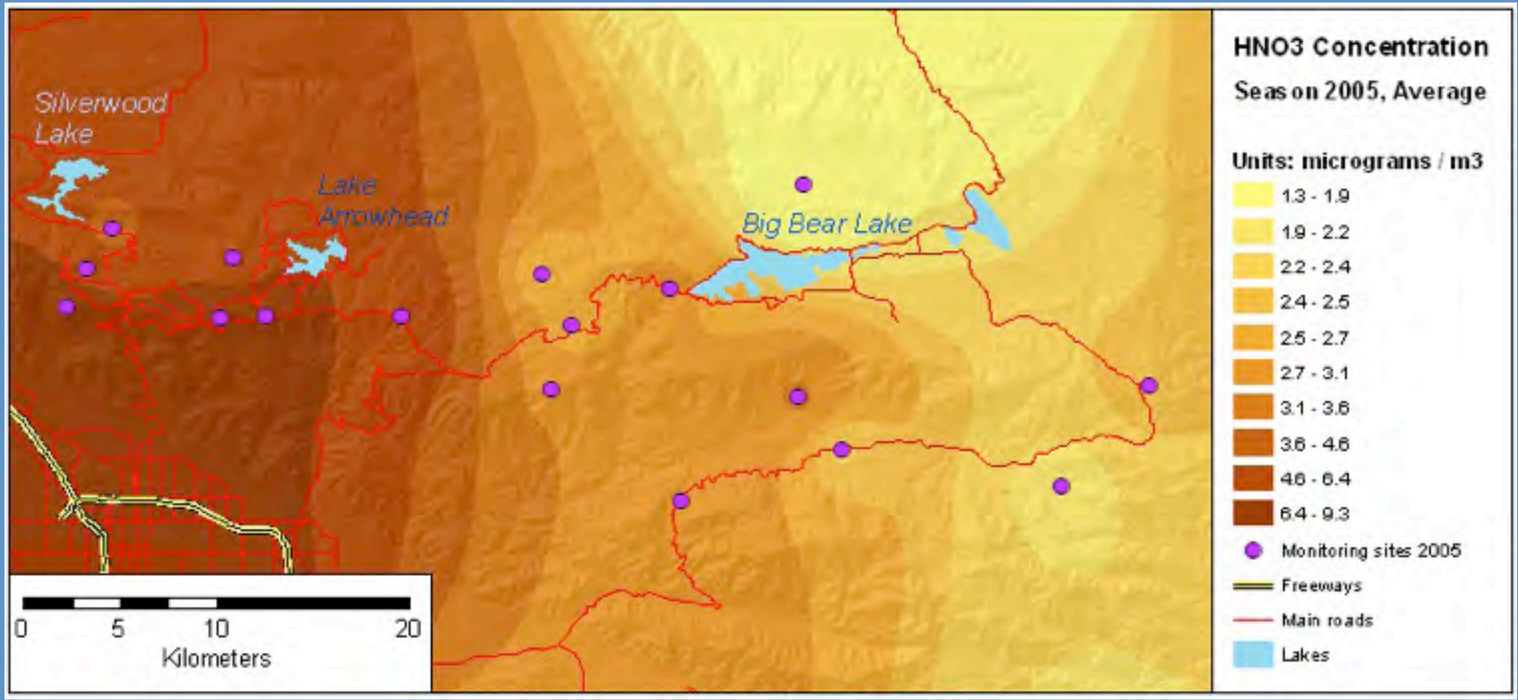
- **Empirical (HNO_3 + $NO_3^-{}_{part.}$) and (NH_3 + $NH_4^+{}_{part.}$) conductance** (K) to calculate NO_3^- and NH_4^+ surface flux (ponderosa pine, white fir, California black oak, hoaryleaf ceanothus, pinion pine) based on branch rinsing.
- **Surface flux** (F) = c x K x LAI
- **Stomatal uptake** for NO, NO_2, NH_3 and HNO_3 based on stomatal conductance (c_s) of key species.
- **Total N dry deposition** = sum of all surface fluxes and stomatal uptake of individual reactive gases.
-

BASIC PARAMETERS:

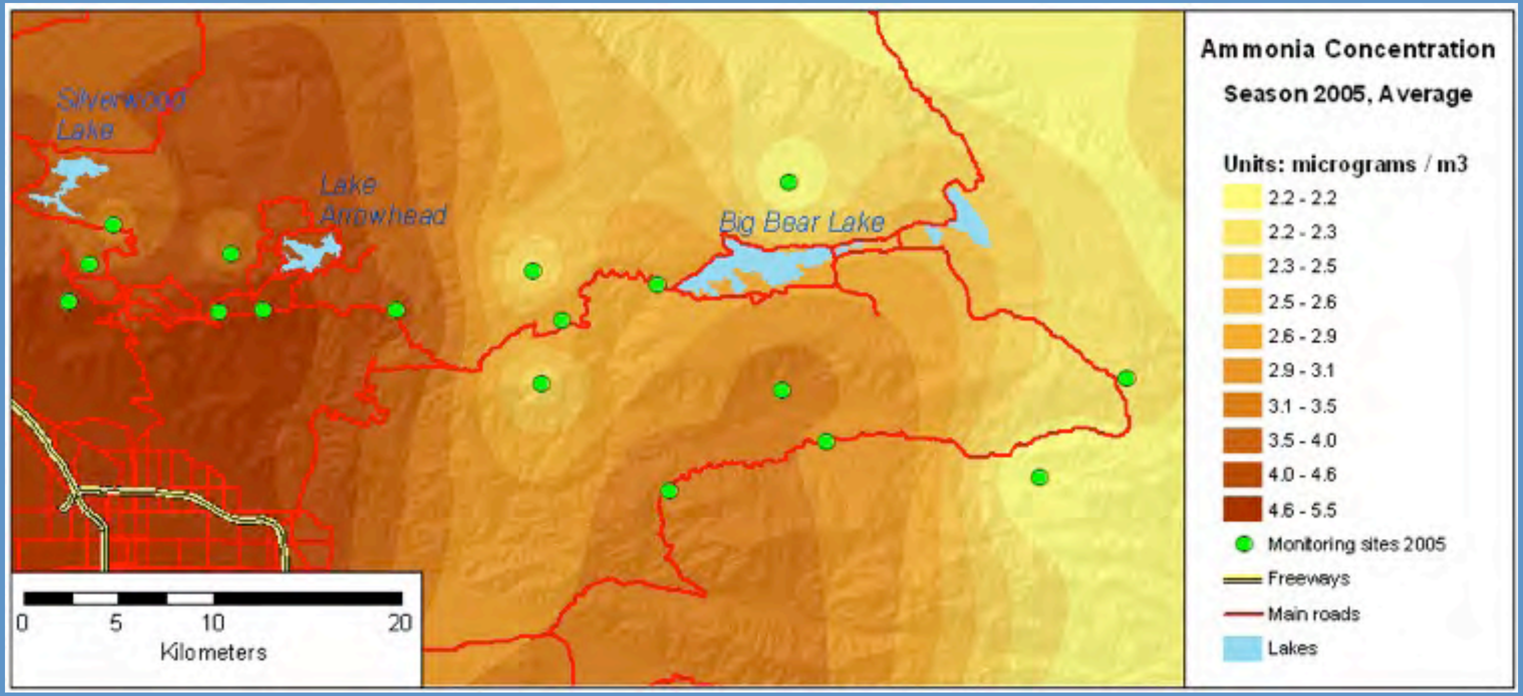
Monitoring network for ambient N pollutants: 14 day averages, June – September, 2002 – 2006



HNO_3



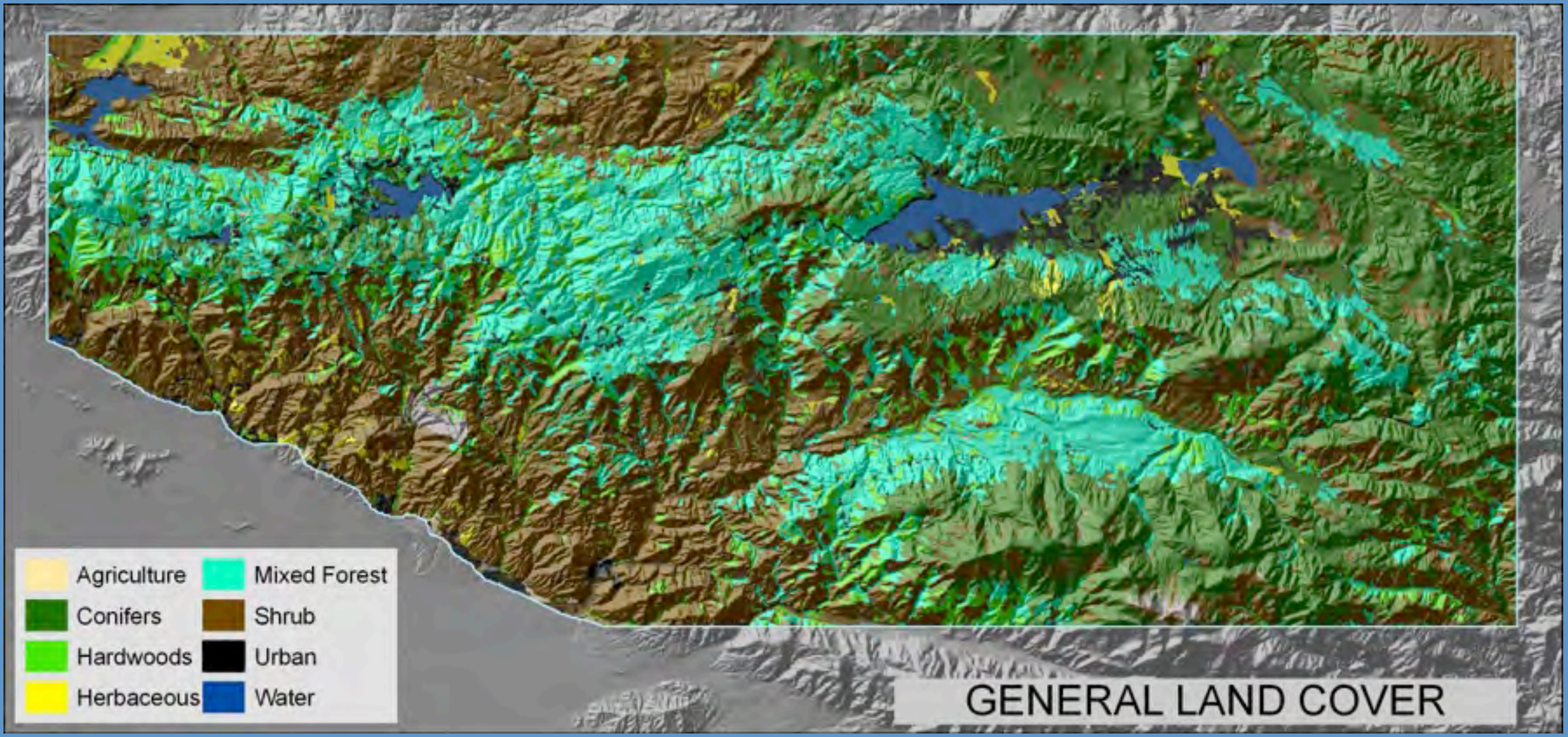
Silverwood Lake
Lake Arrowhead
Big Bear Lake
0 5 10 20
Kilometers
HNO3 Concentration
Season 2005, Average
Units: micrograms / m3
1.3 - 1.9
1.9 - 2.2
2.2 - 2.4
2.4 - 2.5
2.5 - 2.7
2.7 - 3.1
3.1 - 3.6
3.6 - 4.6
4.6 - 6.4
6.4 - 9.3
Monitoring sites 2005
Freeways
Main roads
Lakes



Silverwood Lake
Lake Arrowhead
Big Bear Lake
0 5 10 20
Kilometers
Ammonia Concentration
Season 2005, Average
Units: micrograms / m3
2.2 - 2.2
2.2 - 2.3
2.3 - 2.5
2.5 - 2.6
2.6 - 2.9
2.9 - 3.1
3.1 - 3.5
3.5 - 4.0
4.0 - 4.6
4.6 - 5.5
Monitoring sites 2005
Freeways
Main roads
Lakes

NH_3

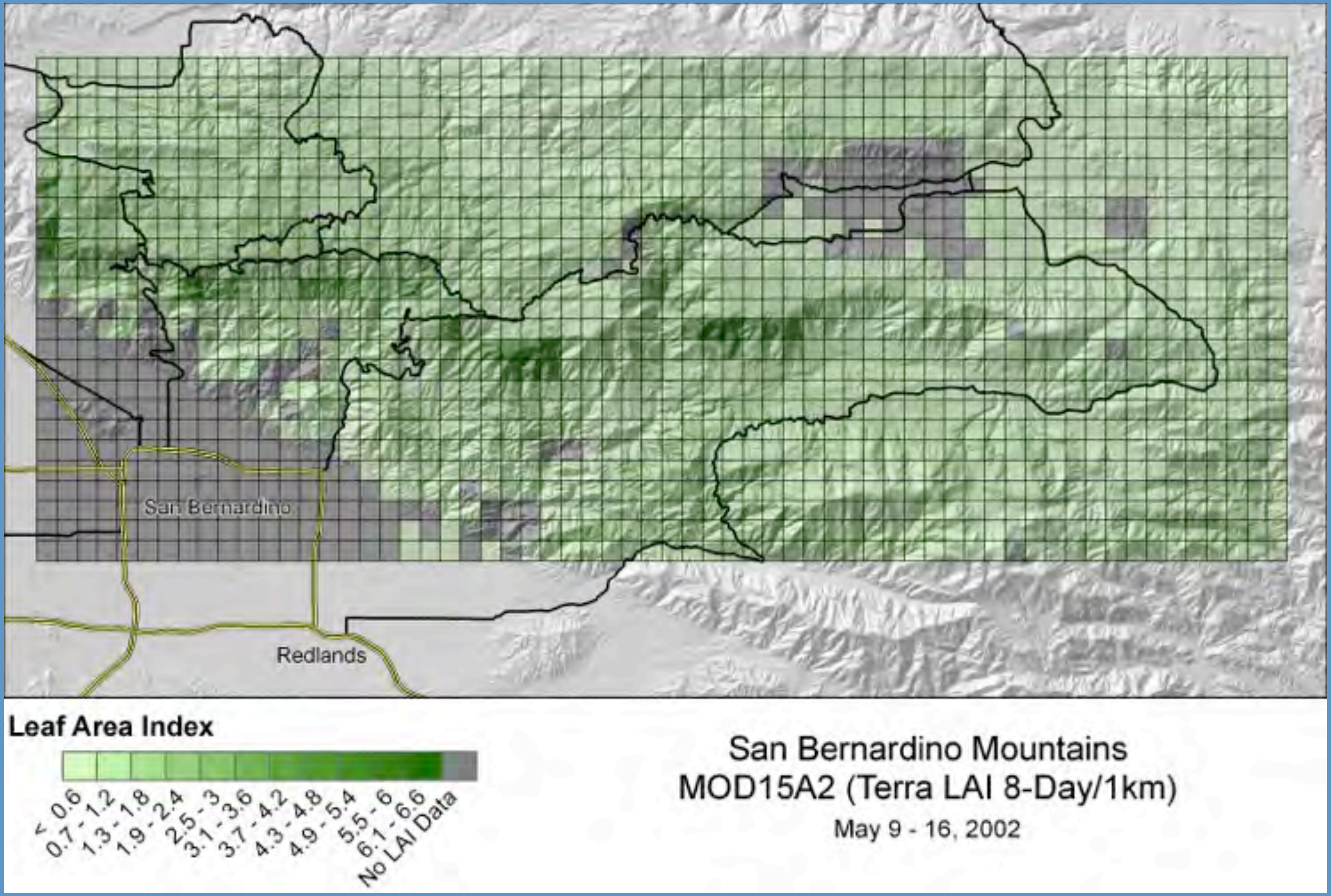
Land Cover



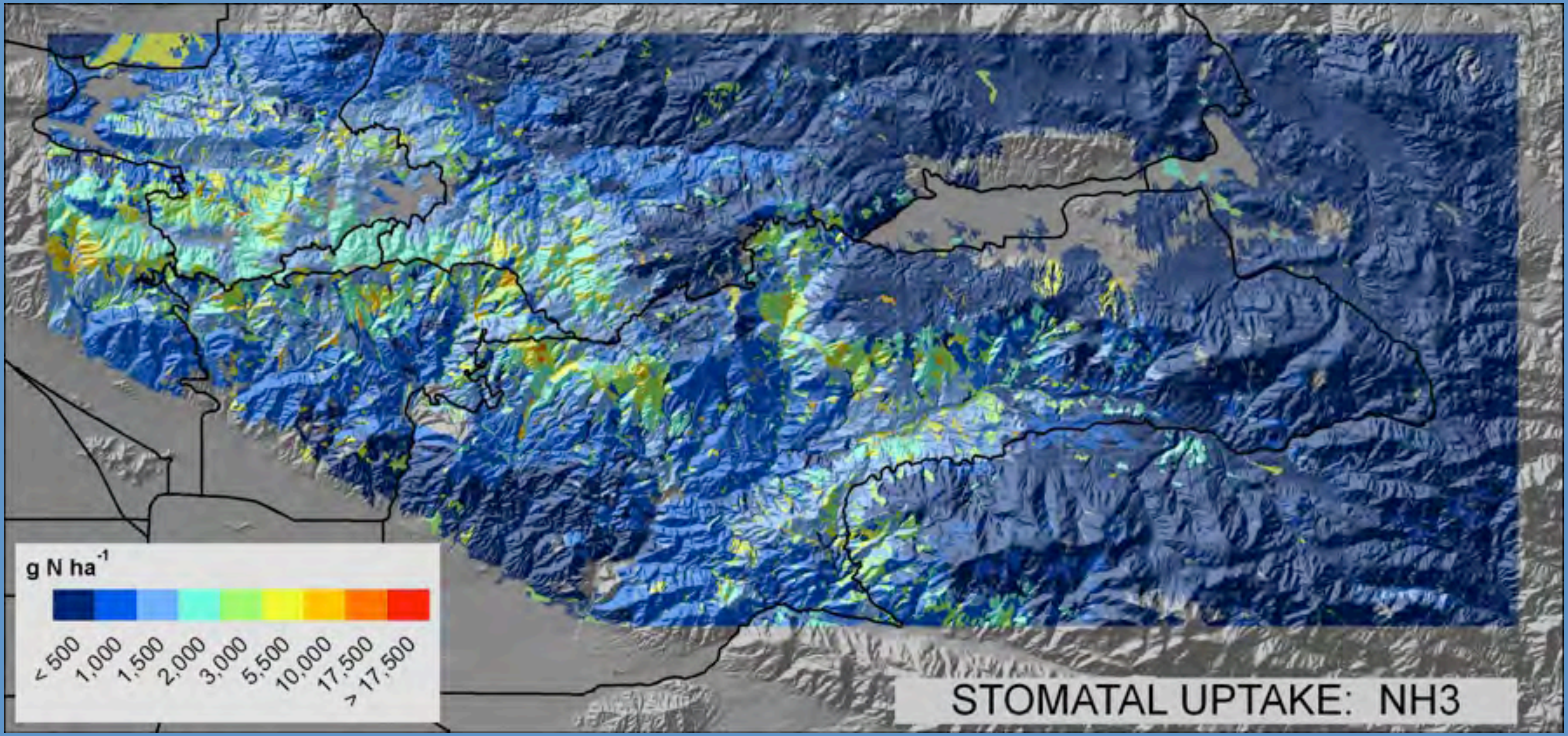
- Source: USFS "Eveg" Spatial Data Product
- Temporal Currency: 2002-2003
- Scale: 1:24,000
- Classification: SAF and SRM (for non-forest types)
- Provides geometry with identified surface area

Leaf Area Index

- Source: MODIS (*terra*)/Science Data Product MOD15A2
- Resolution: 1 kilometer, 8 days

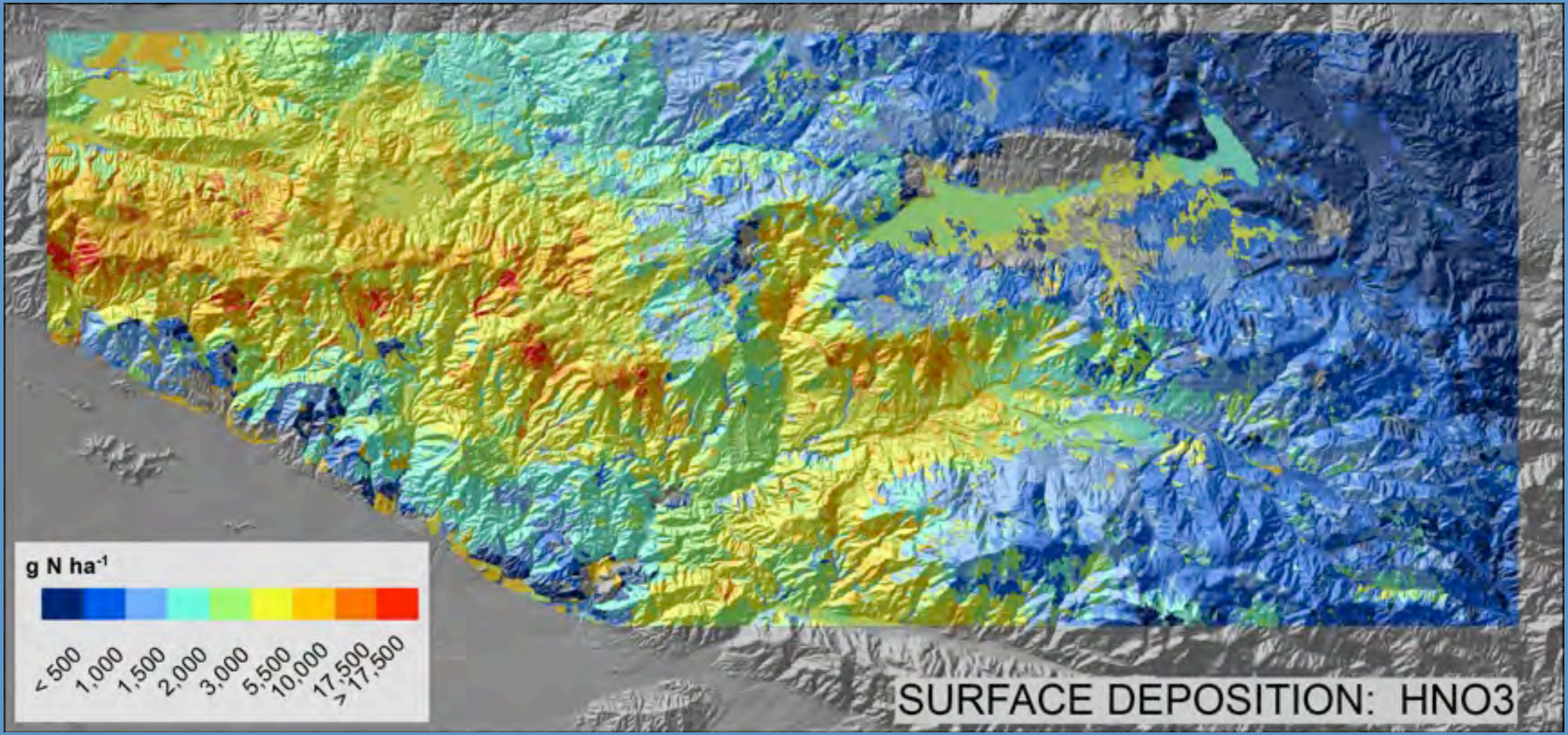


Highest stomatal uptake – NH_3



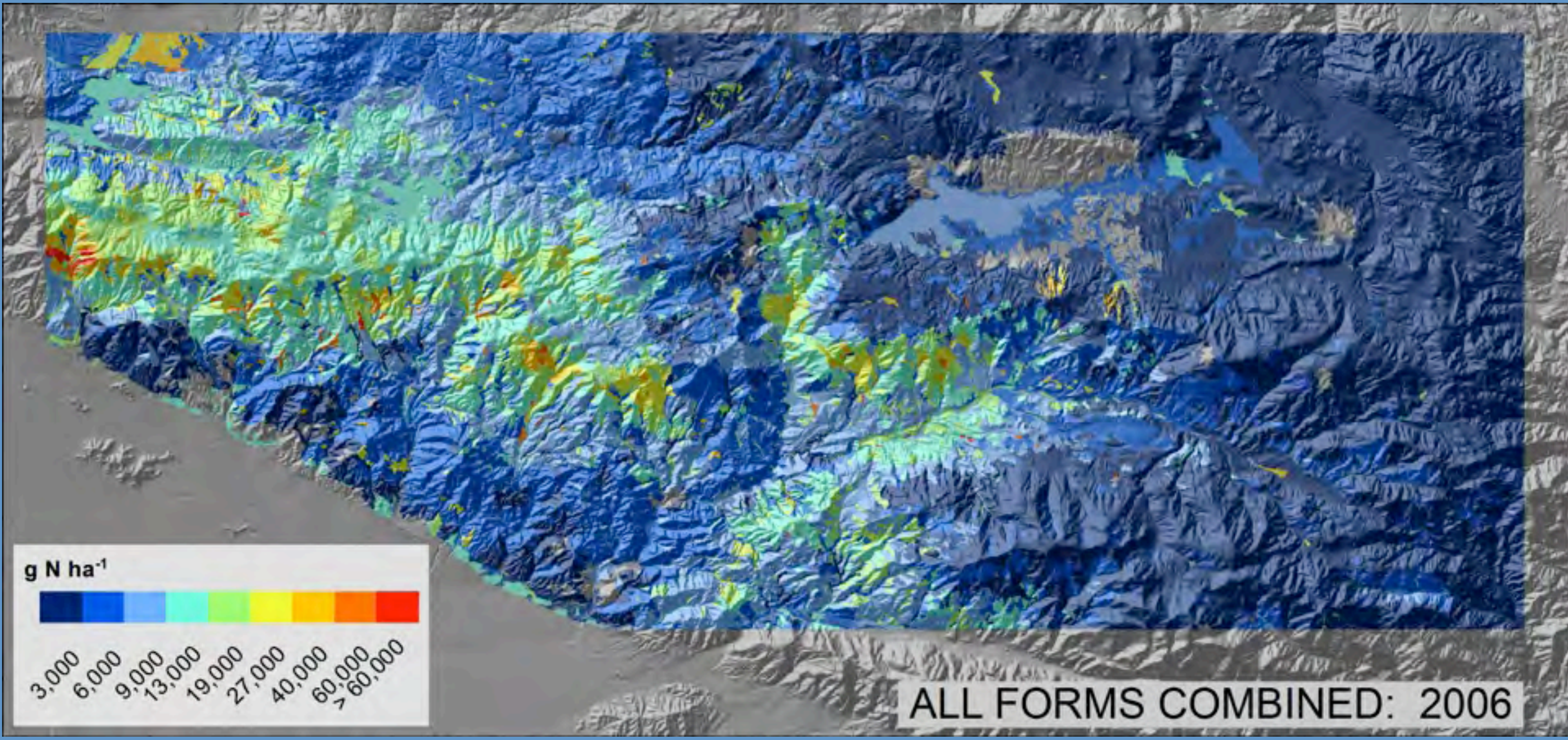
June – September, 2006

Highest surface deposition – HNO_3



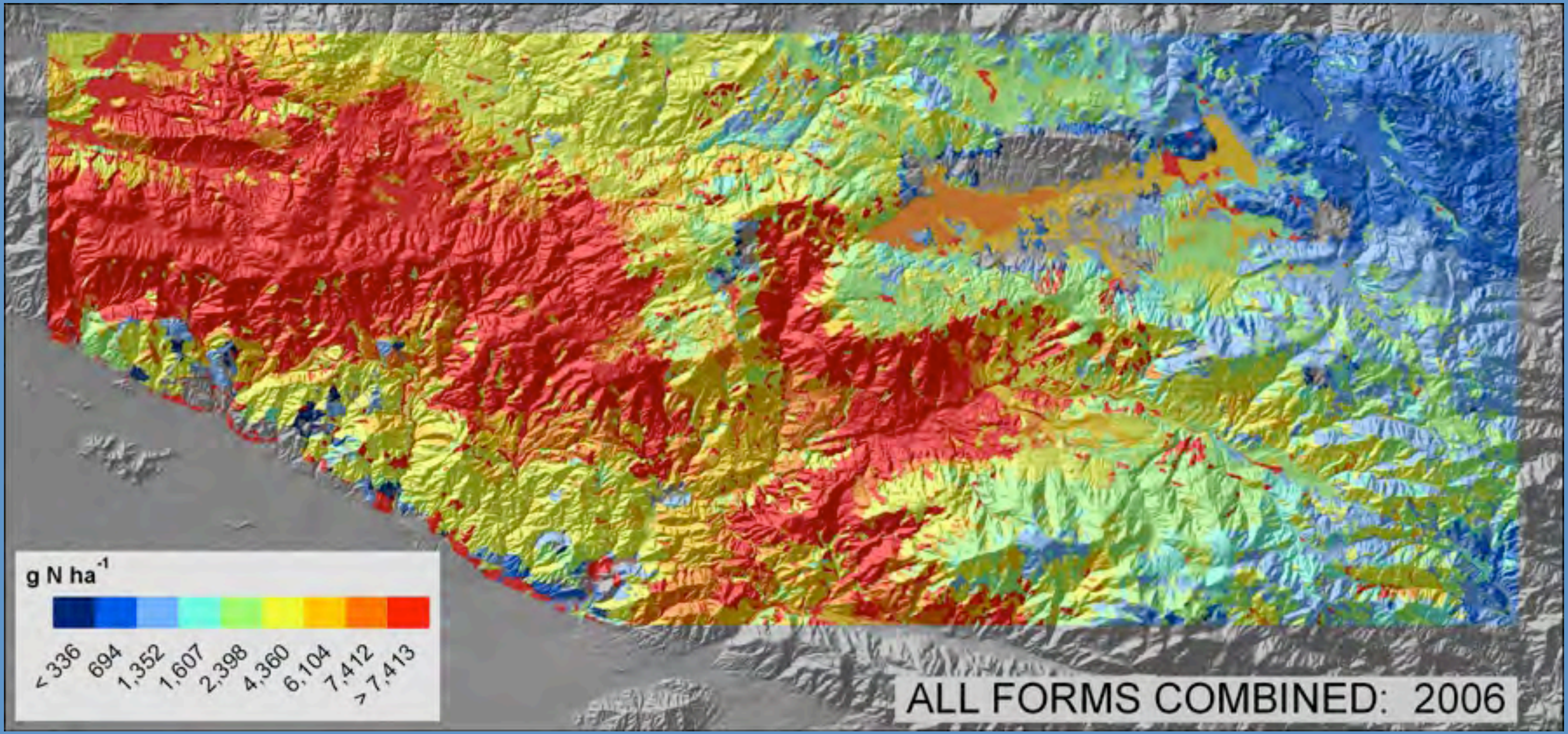
June – September, 2006

Total N dry deposition: internal uptake of NH_3, NO, NO_2 & HNO_3 plus surface deposition of HNO_3 & NH_3



June – September, 2006

Exceedances of Critical Loads – extrapolation to total annual N deposition values based on the 2002 CMAQ data for the SBM



3.1 kg N/ha yr (lichens, mixed conifers) [1,607above]
5.5 kg N/ha yr (lichens, chaparral) [2,398]
10.0 kg N/ha yr (low value for nitrate leaching, chaparral) [4,360]
14.0 kg N/ha yr (high value for nitrate leaching, chaparral) [6,104]
17.0 kg N/ha yr (nitrate leaching, mixed conifers) [7,412]

Conclusions

1. Pollution maps based on passive sampler data allow for seeing "hot spots" of individual pollutants and source of their origin.

2. Our modified inferential method provides an alternative to the CMAQ estimates of N deposition and allows for:

- detailed spatial and temporal resolution
- obtaining data for a desired specific season (year)
- evaluating impacts of N deposition on biodiversity changes (expansion of invasive species; exceedance of Critical Loads for sensitive indicators, e.g., lichen communities)

Thank you !!!