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

A. Bytnerowicz\textsuperscript{1}, S. Schilling\textsuperscript{1} and W. Fraczek\textsuperscript{2}

\textsuperscript{1}USDA Forest Service, PSW Research Station, Riverside, CA

\textsuperscript{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 \((SO_2)\)
Ogawa sampler for NH3, NO2, NOx and O3

USDA FS sampler for HONO & HNO3
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 (HNO₃, NH₃, NO and NO₂) 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** \((HNO_3 + NO_3^{− \text{part.}})\) and \((NH_3 + NH_4^{+ \text{part.}})\) 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** \((F) = c \times K \times LAI\)

• **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
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 – NH₃

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) [1,607 above]
- 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 !!!