Smog is Fertilizer: Atmospheric Nitrogen Deposition Drives Weed Invasions and Biodiversity Loss

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Cal-IPC Symposium 2011
North Lake Tahoe
The biggest global environmental change almost everybody has heard of
The biggest global environmental change (almost) nobody has ever heard of
Global $N_r$ Overdose

Galloway et al 2003 Bioscience
Talk Topics

Nitrogen cycling
Deposition process
Ecosystem impacts
Biodiversity impacts
Policy responses
N- the gift that keeps on giving

Galloway et al 2003 Bioscience
Stages of N-saturation in western xeric forests
(Fenn, Poth et al. 1998)
Charismatic meso-invertebrate
Hostplants and Nectar Sources
Cars, cows and checkerspot butterflies

In absence of cattle grazing in South Bay (1 cow-calf/10 ac), introduced annual grasses overrun habitat within several years (repeatable- too many times).
Dry Nitrogen Deposition

Smog is slow release N-fertilizer
Combustion, soils

\[ \text{NO} \quad \text{NO}_2 \quad \text{O}_3 \quad [\text{OH}^*] \]

\[ \text{HNO}_3 + \text{NH}_3 \leftrightarrow \text{NO}_3\text{NH}_4(p) \]

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
Dr. Andrzej Bytnerowicz
USDA FS Riverside, CA
Highway 280 carries 113,000 vehicles per day, often at capacity southbound in AM
Simple deposition model, monthly average deposition velocities for wet and dry season.

\[ \text{HNO}_3 > \text{NH}_3 >> \text{NO}_2 >> > > \text{NO} \]
N-side Tulare Hill 2002
N-side Tulare Hill 2007
Metcalf Energy Center, Tulare Hill

Large point source, incremental effects in an already polluted region (cumulative impacts)

Precedent setting mitigation in 2000:
131 acres + $1.4 million endowment + operating expenses 30-years

Two other powerplants,
80 acres + $700,000 endowment
Widening Highway 101: 2001

500+ acres. Fee title, managed by SCCOSA
Commit to Santa Clara County HCP/NCCP: MOU signed in 2005
Santa Clara County HCP/NCCP

Comprehensive plan to protect imperiled species in southern Santa Clara County

Address cumulative impacts of N-deposition and development

Habitat acquisition/easements + MANAGEMENT MONEY

Long-term (50 years), >$600,000,000

Elected officials voting in 2011-2012
Keystone Species: Ranchers
The Case of the Drive-by Extinction: Search for the Subtlety Smoking Tailpipe

Another episode of CSI Redwood City
Bay checkerspot habitat (blue outlines) bisected by Highway 280

113,000 vehicles/day

35 acres in the main habitat area “B”
9,000 larvae in 1997
The last larva in 2002
NH$_3$ from catalytic converters!
“The subtlety smoking tailpipe”
Mowing

Early May Timing
Mowing passes the “O-test”
Reintroduction in 2007
“Navigating the Regulatory Ecosystem”
Failure in 2007, Re-reintroduction in 2011 “Navigating the Regulatory Ecosystem” again, bigger hammer, better year”
Catalytic converters now produce ammonia
EVERY ROADSIDE IS FERTILIZED
Vehicular Ammonia Emissions: Unintended Consequences

- Three way catalytic converters have been an air quality miracle for NO\textsubscript{x}, CO, and VOC
- But, they can over-reduce NO\textsubscript{x} to NH\textsubscript{3}
- High Vehicle Specific Power = High NH\textsubscript{3}
- AMMONIA IS A NASTY POLLUTANT! PM\textsubscript{2.5}
- Potent deposition agent short range
- Technological improvements over last decade – decrease in emissions
Lake Tahoe N-limitation to P-limitation
Nitrogen makes the annual grass grow

- Serpentine grasslands
- Coastal sage scrub
- Desert
- Grasslands, vernal pools
- Other poor soils
- Crowd out native forbs
- Change the fire cycle
- Other weeds!
Vernal Pools: grass invasion in absence of grazing (Jamie Marty TNC)
23 T&E, 22 Rare in Vernal Pools

- Blennosperma bakeri
- Orcuttia pilosa
- Pogogyne abramsii
- Limnanthes vinculans
- Limnanthes gracilis parishii
- Lasthenia conjugens
Desert weed invasions

Med. splitgrass
Red brome
Sahara mustard
99/225 (44%) listed T&E plants exposed to > 5 kg-N ha$^{-1}$ yr$^{-1}$

Table in PIER report

names names
CMAQ 4 km Total Nitrogen Deposition
2002

Serpentine (1:250,000 Statewide) outlined in black

Stuart B. Weiss, Ph.D. June 2007
Exposure of 173 CNDDDB Plant Taxa (R,T,& E) in SF Bay Area

110 > 5 kg-N ha\(^{-1}\) yr\(^{-1}\)

Conservation Land Network

www.bayarealand.org
Chemical Climate of California
Nitrogen critical loads and management alternatives for N-impacted ecosystems in California

NO$_x$ is down, but NH$_3$ is up!
Operation Flower Power: The Ultimate Grassroots Lobbying
Congressman
Jerry McNerney (2005)

Docent lead tours 2007
Action items

• Solid science, N increases weeds
• Precedents for mitigation of N-deposition
• Roads increase N and weed habitat/dispersal
• WMAs reduce weeds
• Fund WMAs through mitigation for roads and developments, endowments!
• CEQA, ESA, other laws
• Institutional voices – Cal-IPC, CNPS, others
For more information:
www.creeksidescience.com/nitrogen

California Energy Commission report
(CA Biodiversity Impacts)

Cars, Cows and Checkerspot Butterflies