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

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Creekside Center for Earth Observation

Cal-IPC Symposium 2011
North Lake Tahoe

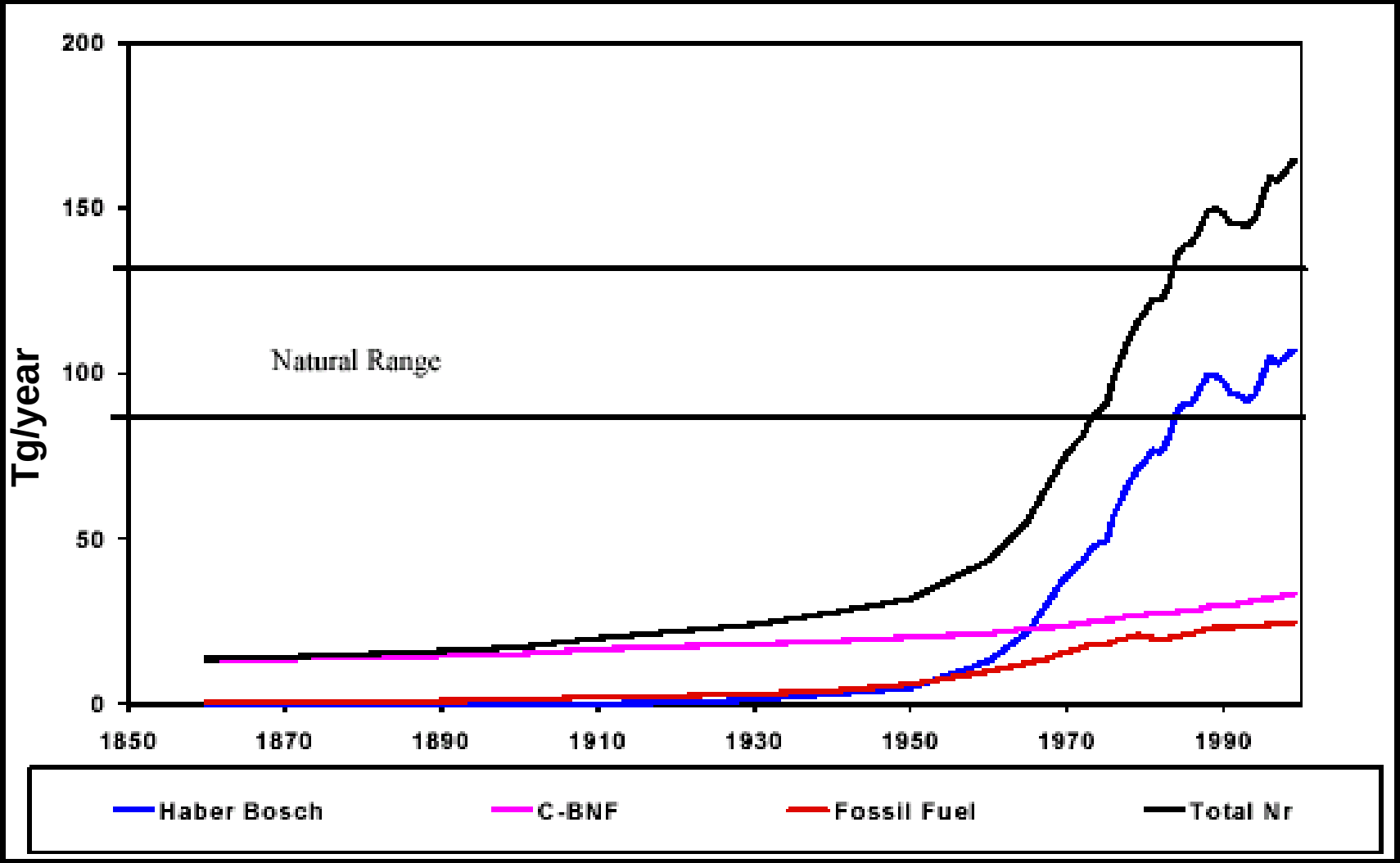
C

The biggest global environmental change almost everybody has heard of

N_r

The biggest global environmental change (almost) nobody has ever heard of

Global N_r Overdose



Galloway et al 2003 Bioscience

Talk Topics

Nitrogen cycling

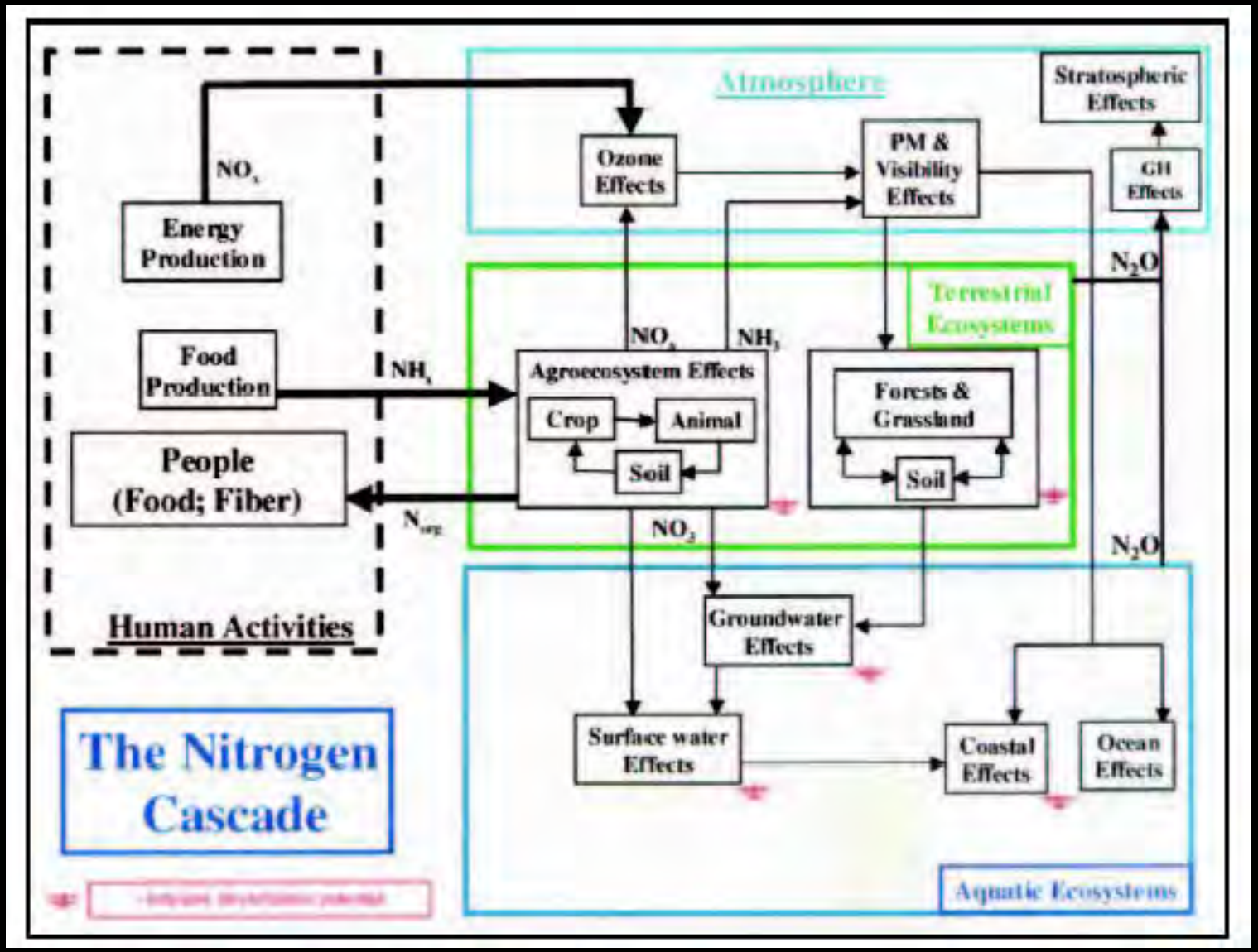
Deposition process

Ecosystem impacts

Biodiversity impacts

Policy responses

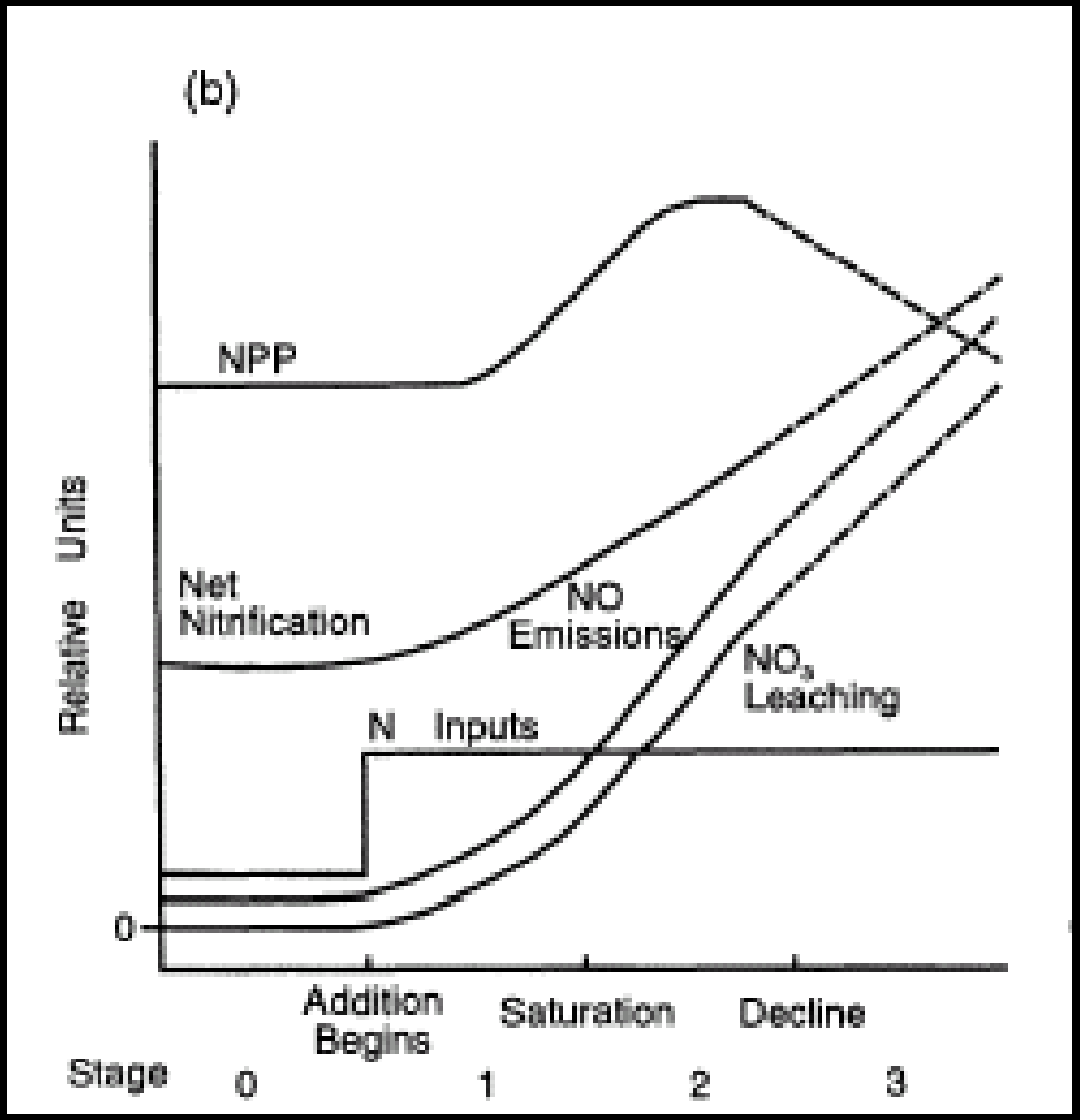
N- the gift that keeps on giving



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


CATERPILLAR
627E

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

“Atmospheric Chemistry 101”

Combustion, soils

$NO \leftrightarrow O_3$ (hv)

$NO \leftrightarrow NO_2$ (hv)

$NO_2 \rightarrow HNO_3$ ([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

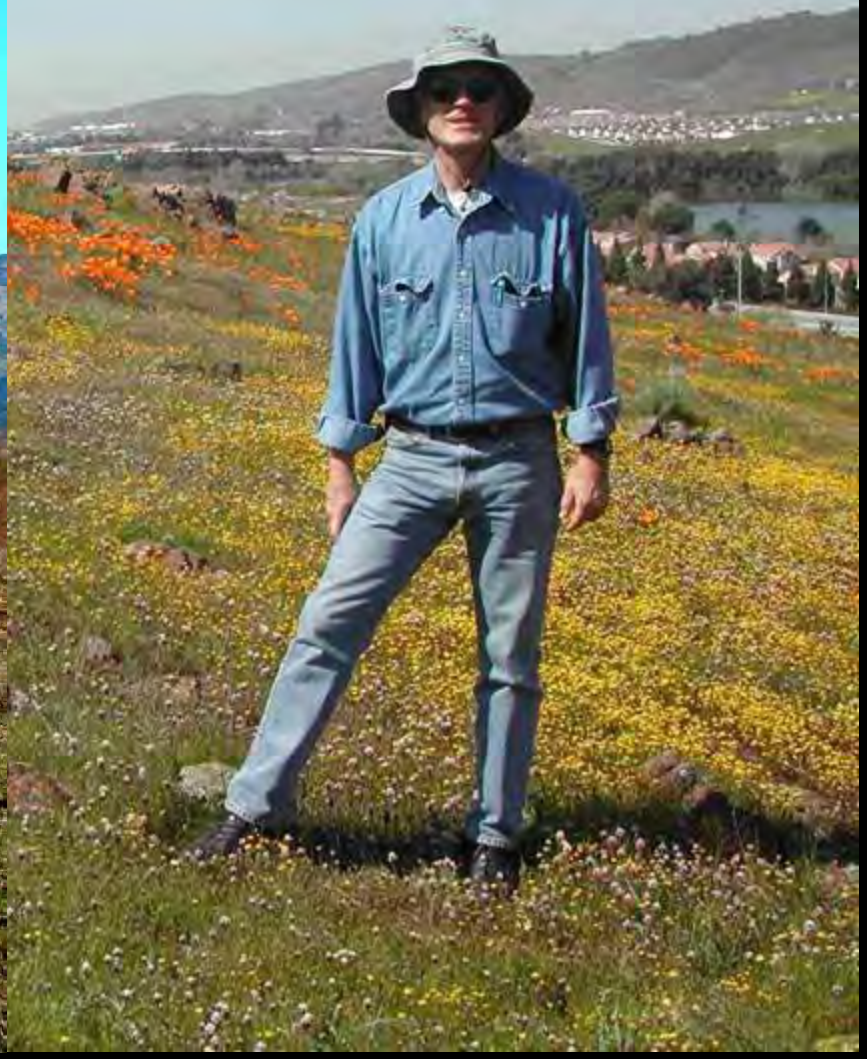
HNO_3 and NH_3 stick to surfaces, even “dry” surfaces

Particulates and other gases are relatively minor contributors

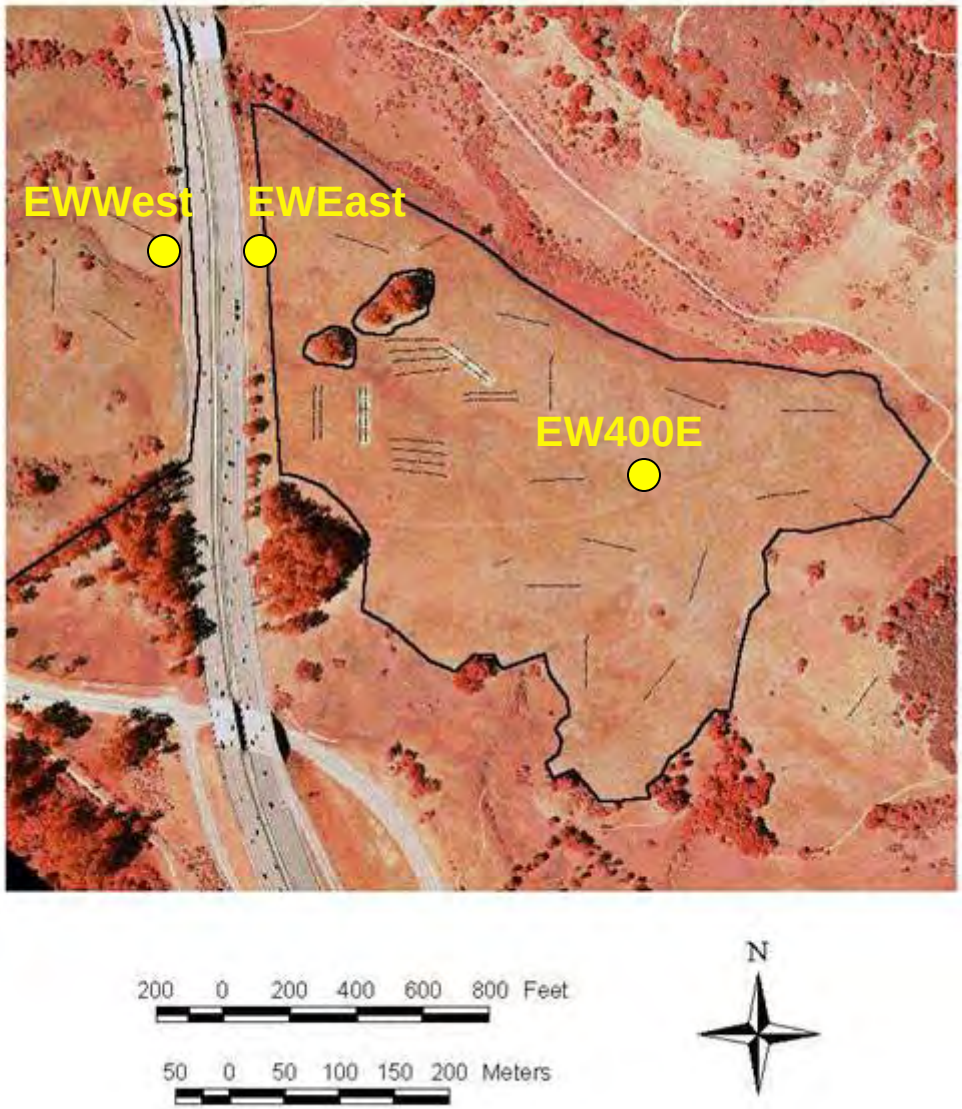
Dry deposition is >80-90% in polluted regions of California, wet deposition is of lesser importance most places

Dr. Andrzej Bytnerowicz

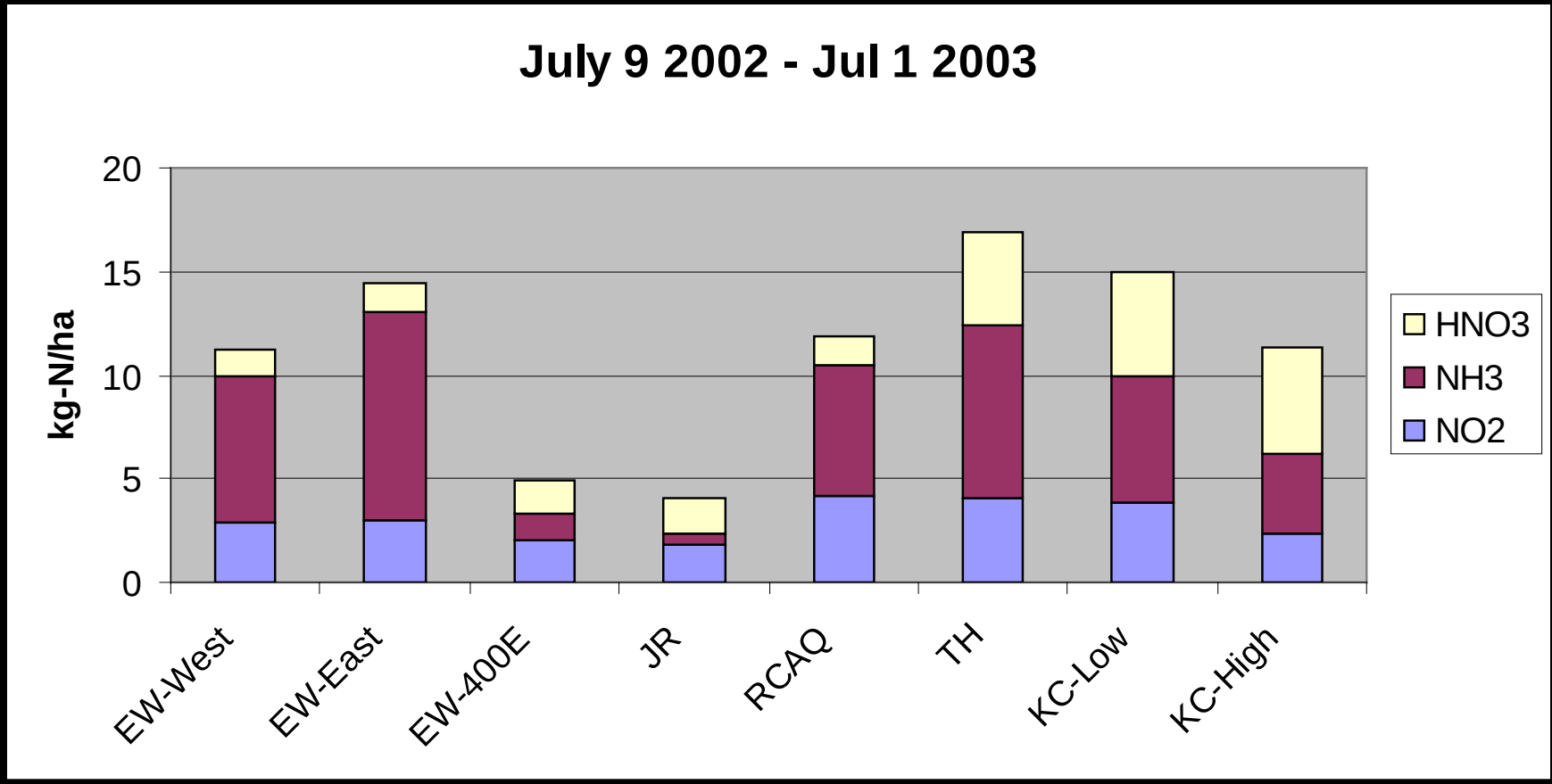
USDA FS Riverside, CA




1-3 EW
5 RCAQ
4 JR
SJAQ
6 Tulare
7-8 KC



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.

$HNO_3 > NH_3 >> NO_2 >>> NO$

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 + MANGEMENT 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

500 0 500 Meters

1000 0 1000 Feet

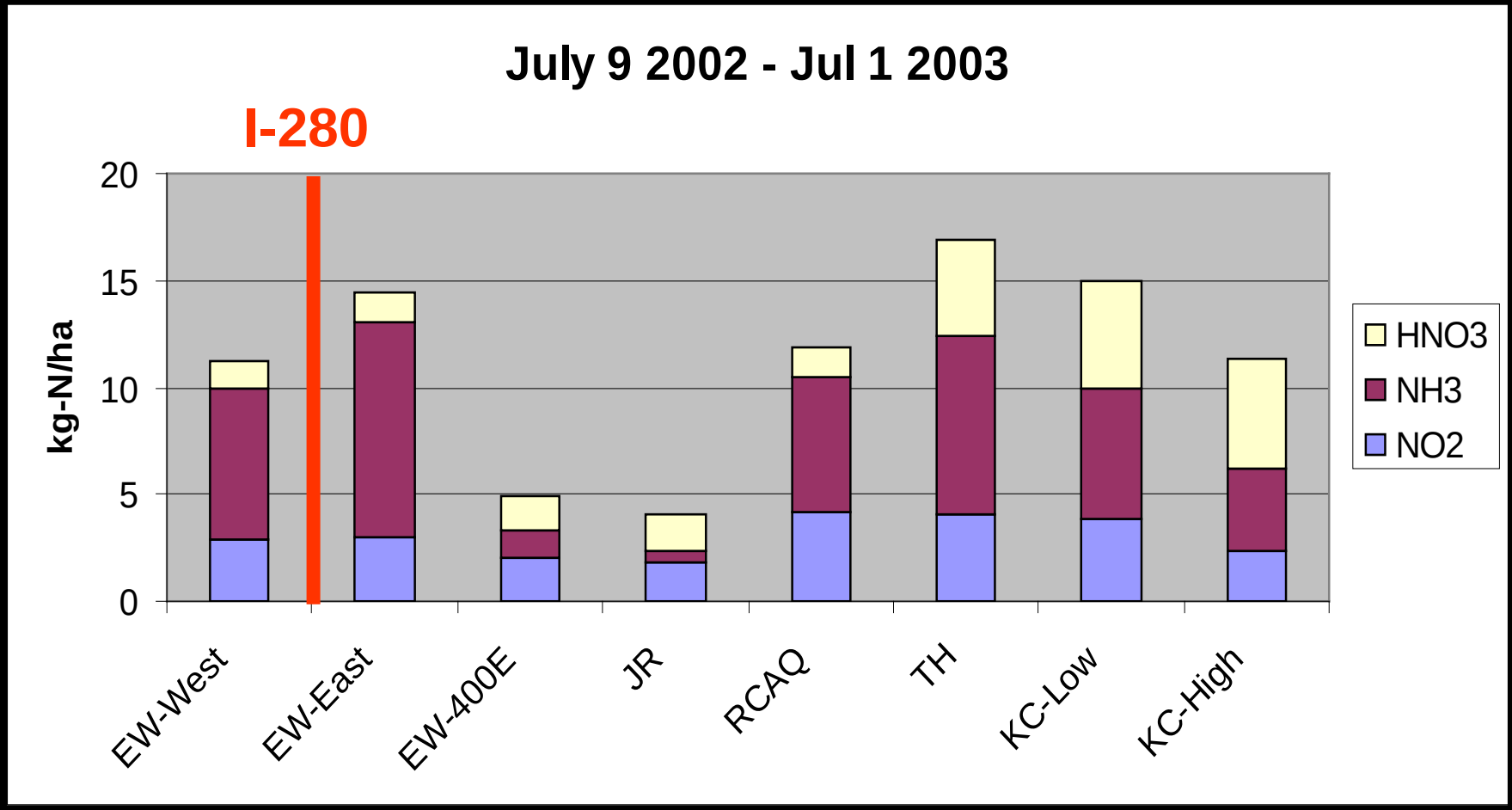
N

Bay checkerspot habitat (blue outlines) bisected by Highway 280

113,000 vehicles/day

35 acres in the main habitat area “B”

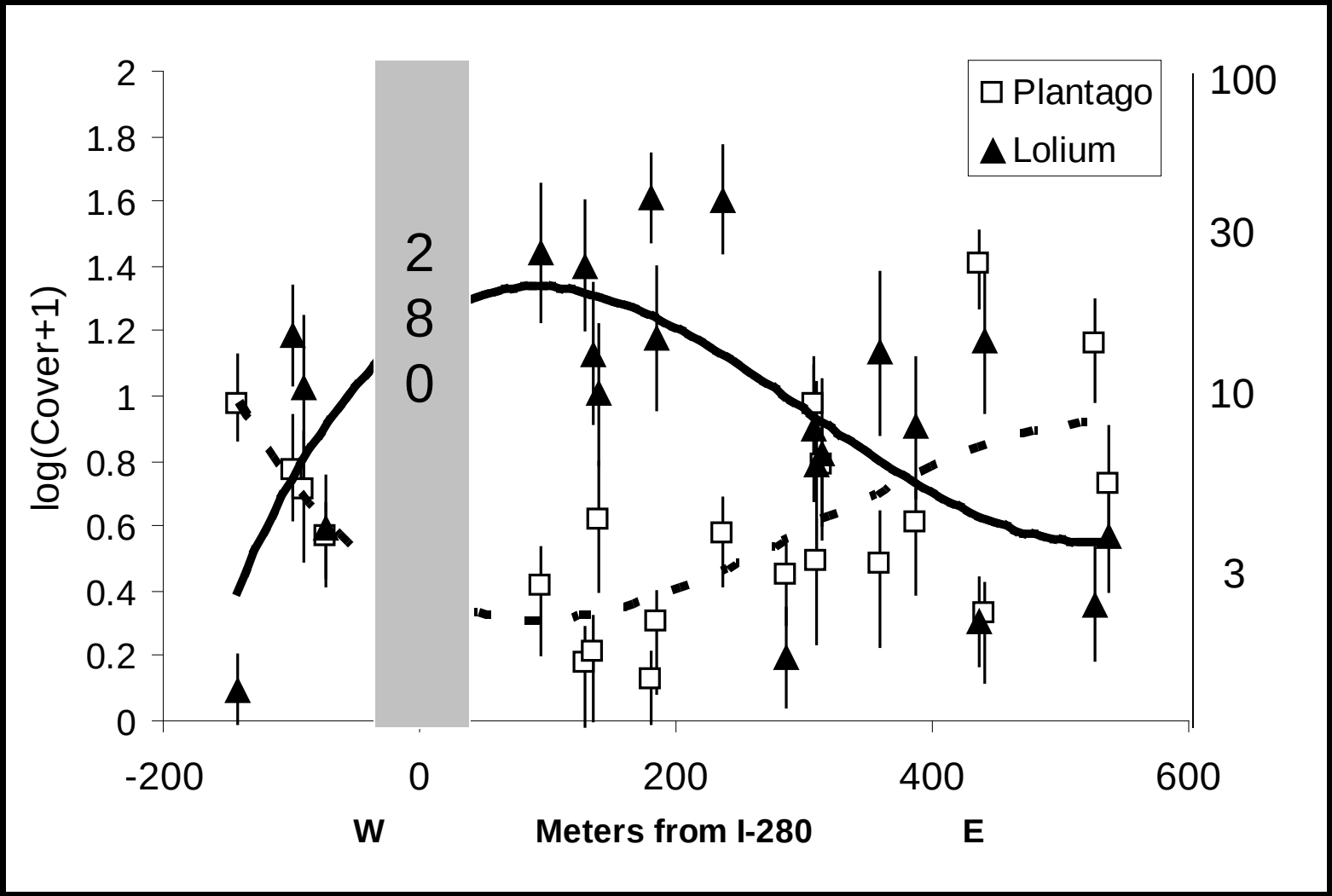
9,000 larvae in 1997
The last larva in 2002



NH_3 from catalytic converters!

"The subtlety smoking tailpipe"

Edgewood 2001



Mowing

Early May Timing

Mowing passes the “O-test”


2006
2007
2005
2003
2007
280
© 2005 TeleAtlas
Google
Pointer 37°27'46.24" N 122°17'15.61" W elev 623 ft
Streaming 100%
Eye alt 3422 ft

Reintroduction in 2007
“Navigating the Regulatory Ecosystem”

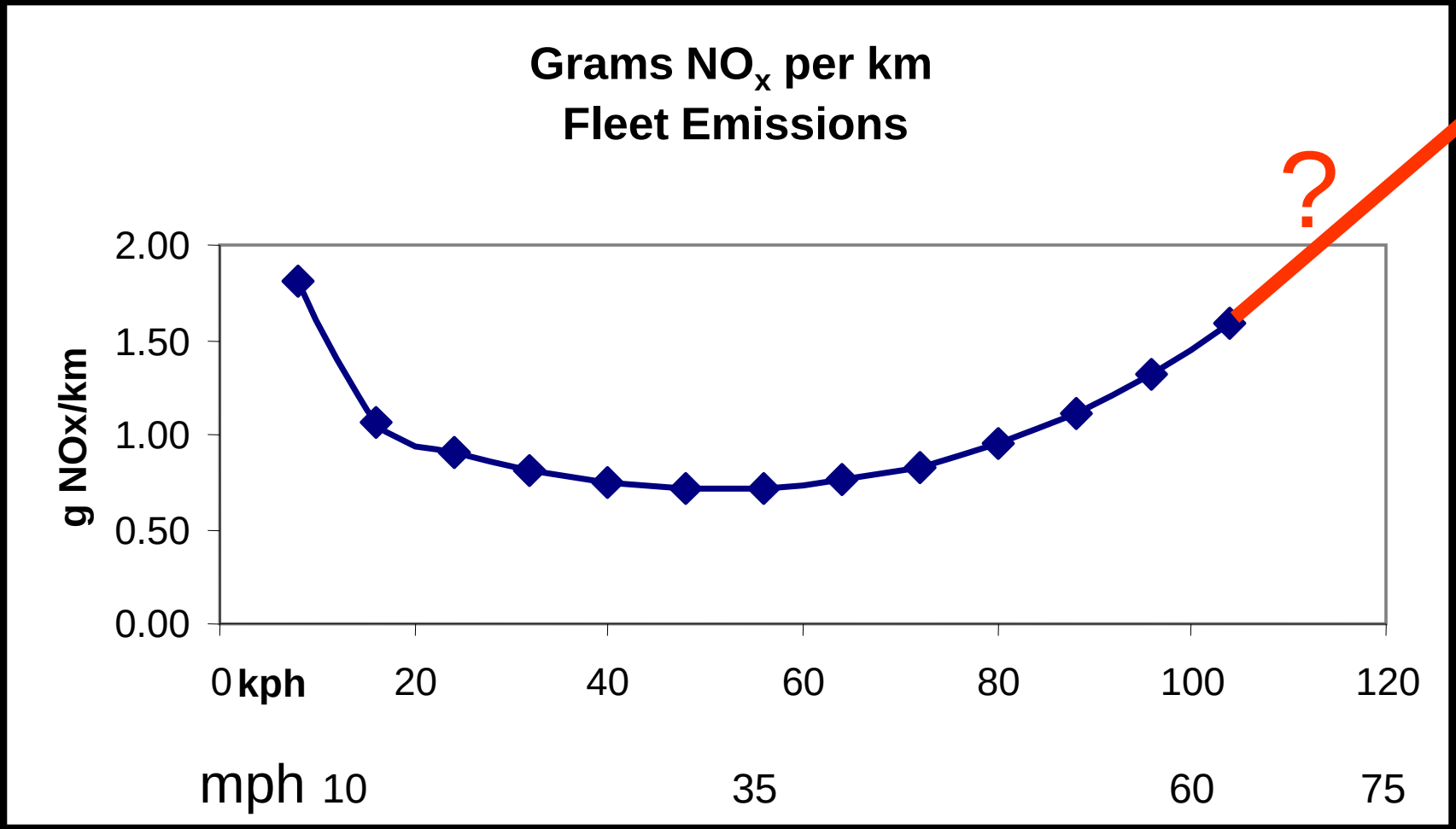

AREA CLOSED
FRAGILE WILDFLOWER
& BUTTERFLY HABITAT
DO NOT ENTER


JULIA BOTT
COUNTY OF SAN MATEO
FOUNDED 1856


COUNTY OF SAN MATEO


Vigoro
Sulfate
21-0-0
For Trees, Shrubs, Hedges, Evergreens and in Flower & Vegetable Gardens

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_x, CO, and VOC
- But, they can over-reduce NO_x to NH_3
- High Vehicle Specific Power = High NH_3
- AMMONIA IS A NASTY POLLUTANT! $PM_{2.5}$
- 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

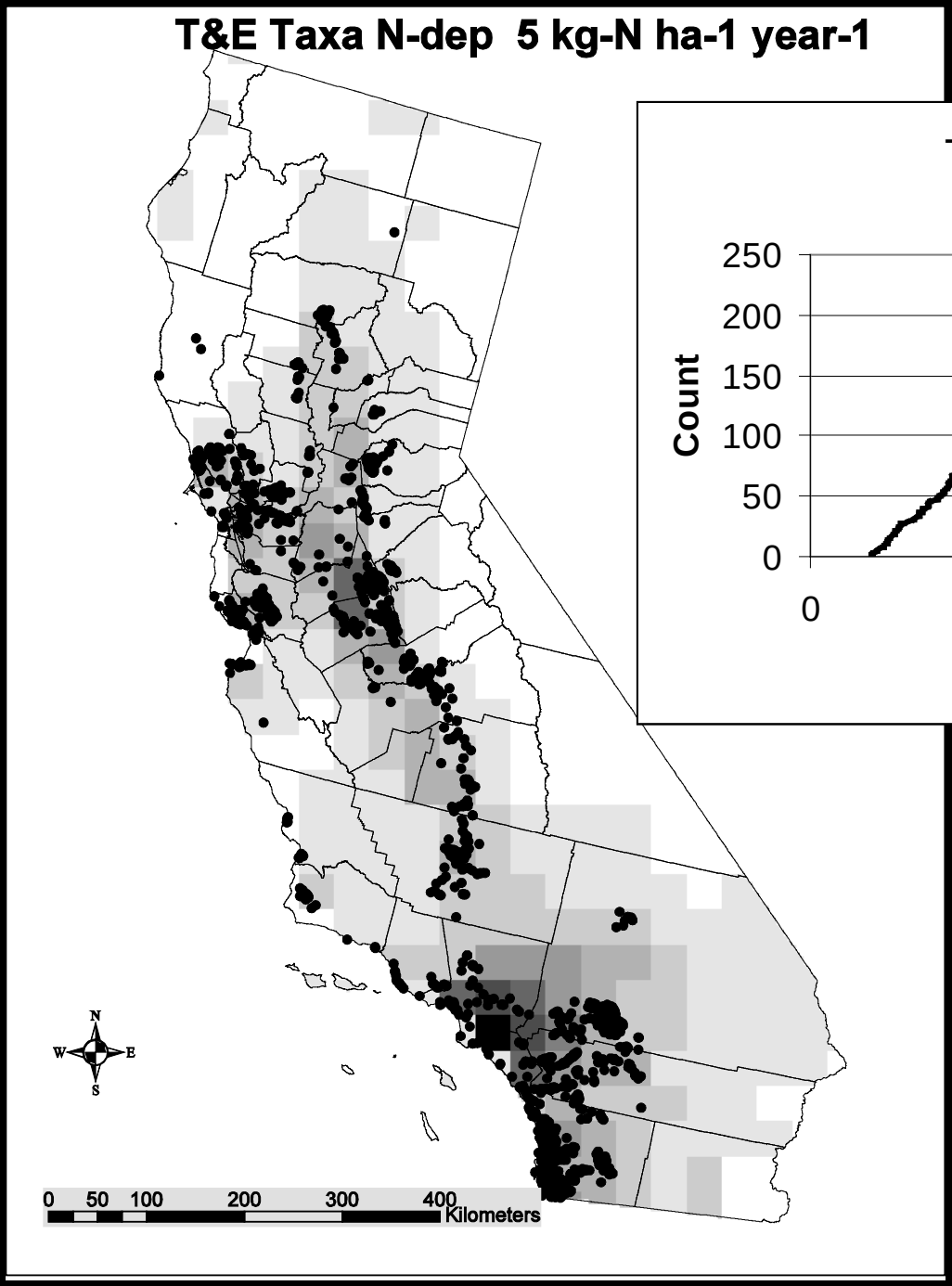
Desert weed invasions

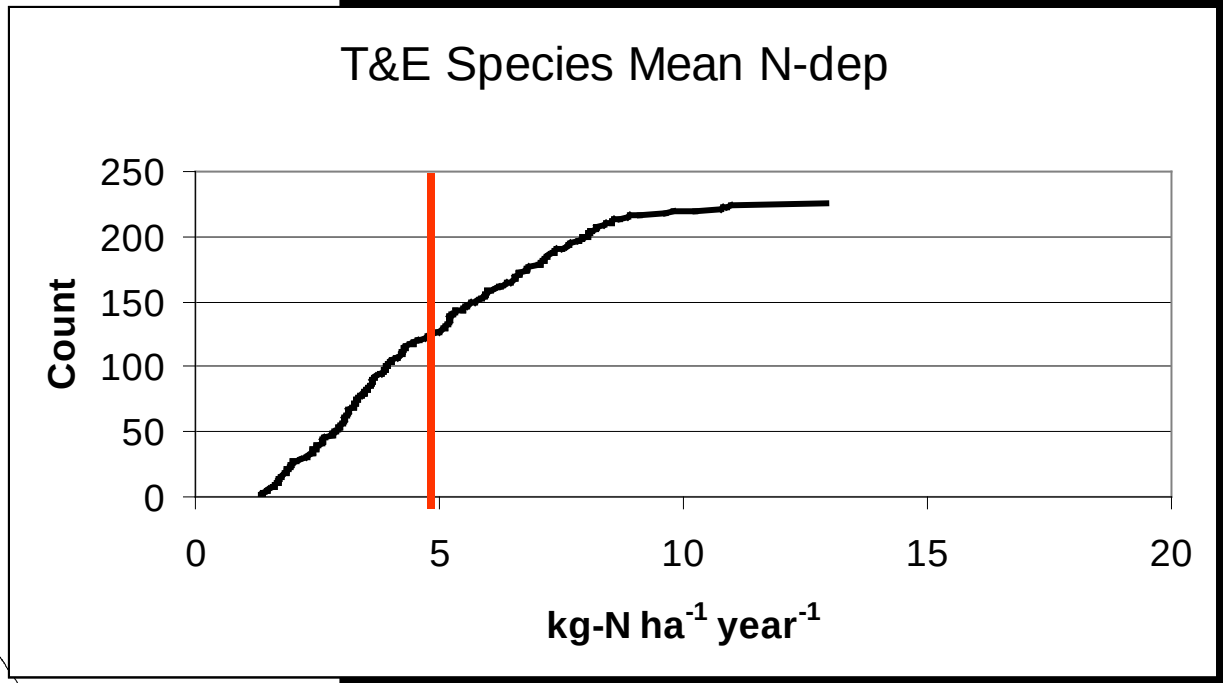
Med. splitgrass

Red brome

Sahara mustard

Plants

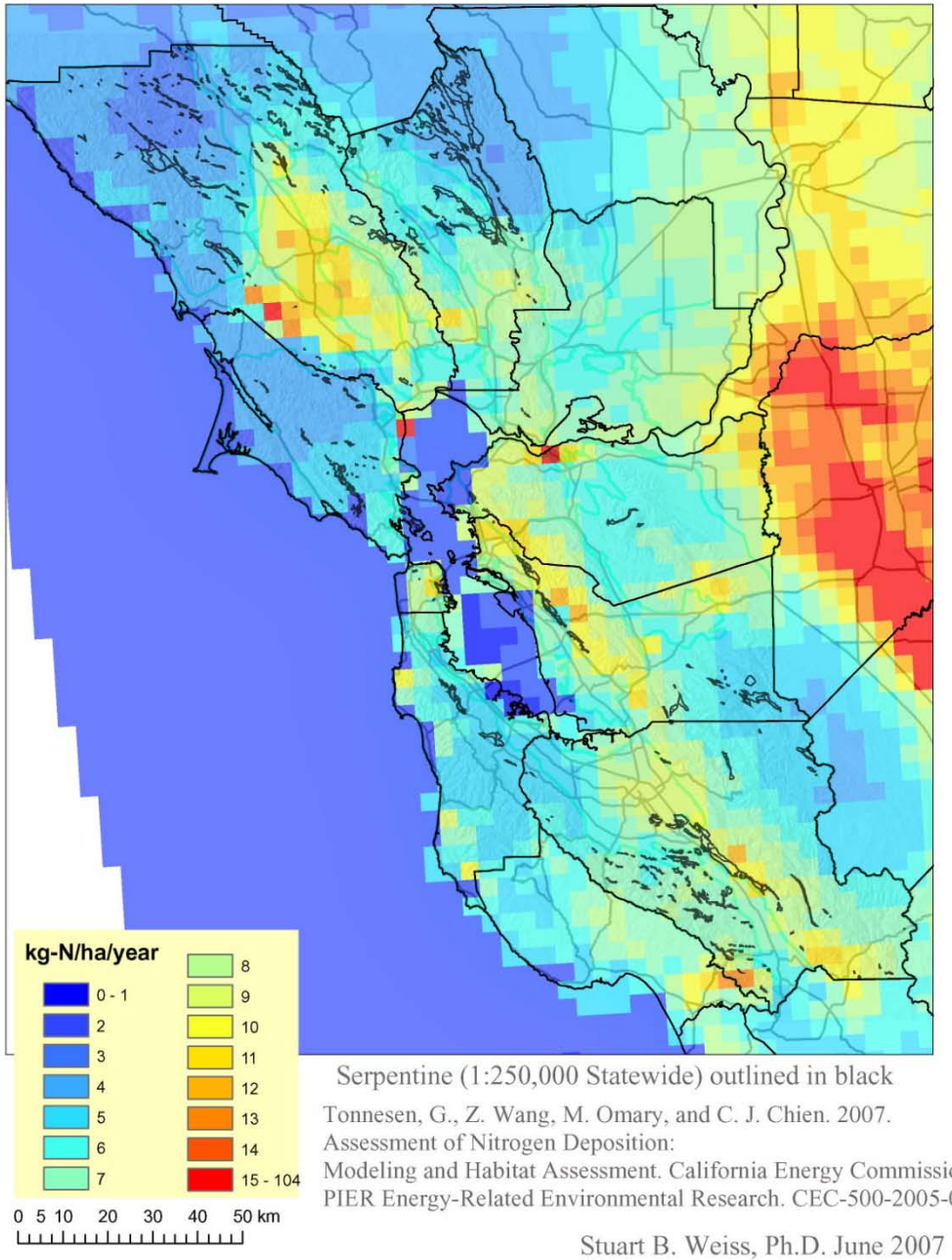




99/225 (44%) listed T&E plants exposed to > 5 kg-N ha^{-1} yr^{-1}

Table in PIER report names names

CMAQ 4 km Total Nitrogen Deposition
2002



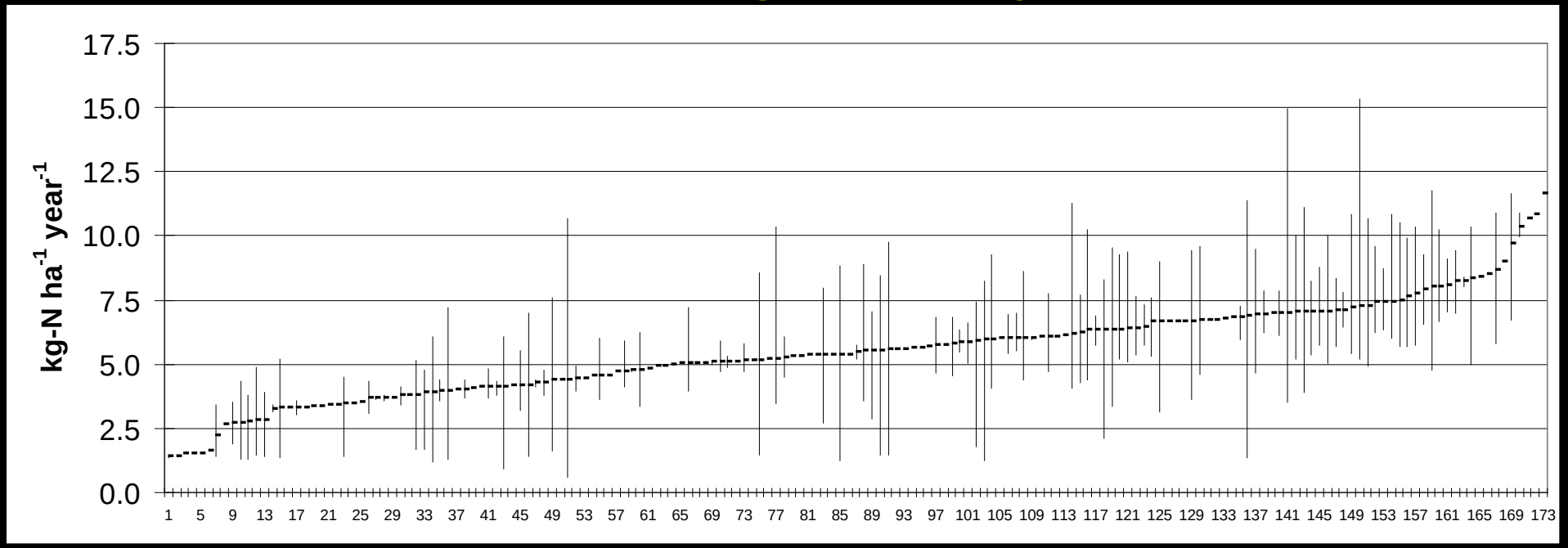
Serpentine (1:250,000 Statewide) outlined in black

Tonnesen, G., Z. Wang, M. Omary, and C. J. Chien. 2007. Assessment of Nitrogen Deposition: Modeling and Habitat Assessment. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-032.

Stuart B. Weiss, Ph.D. June 2007

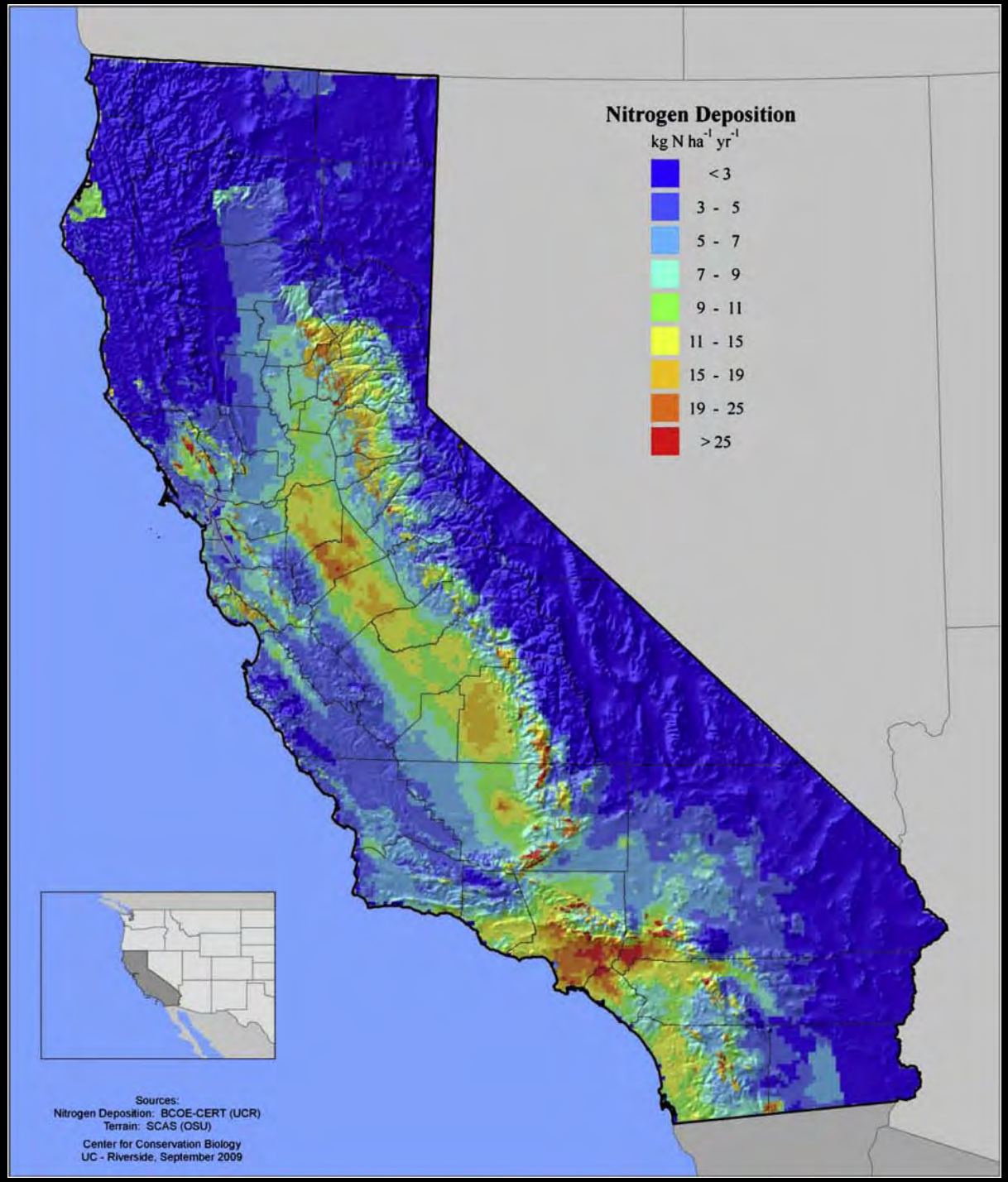
Exposure of 173 CNDDB Plant Taxa (R,T,& E) in SF Bay Area

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



Conservation Land Network

www.bayarealands.org



Chemical Climate of California

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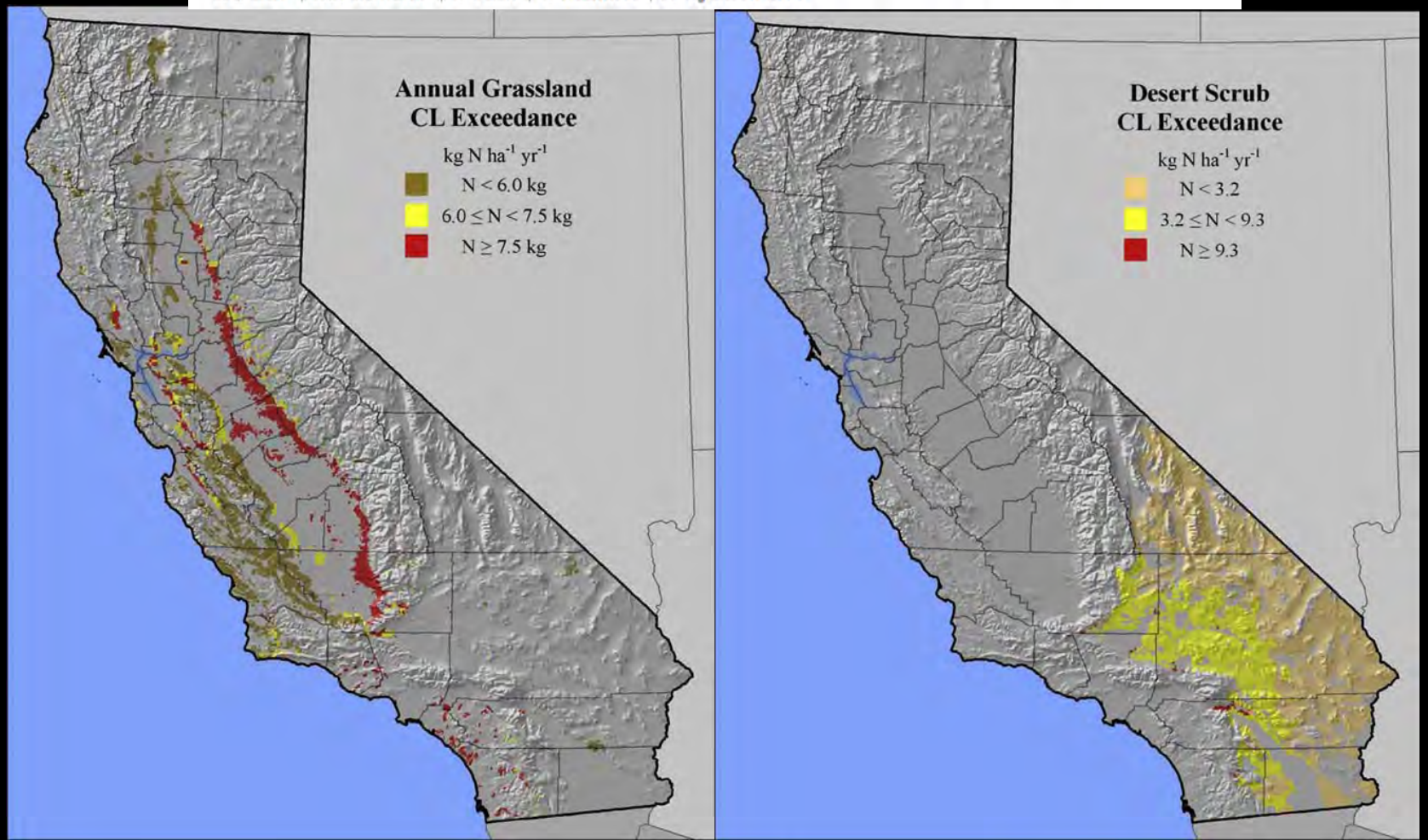
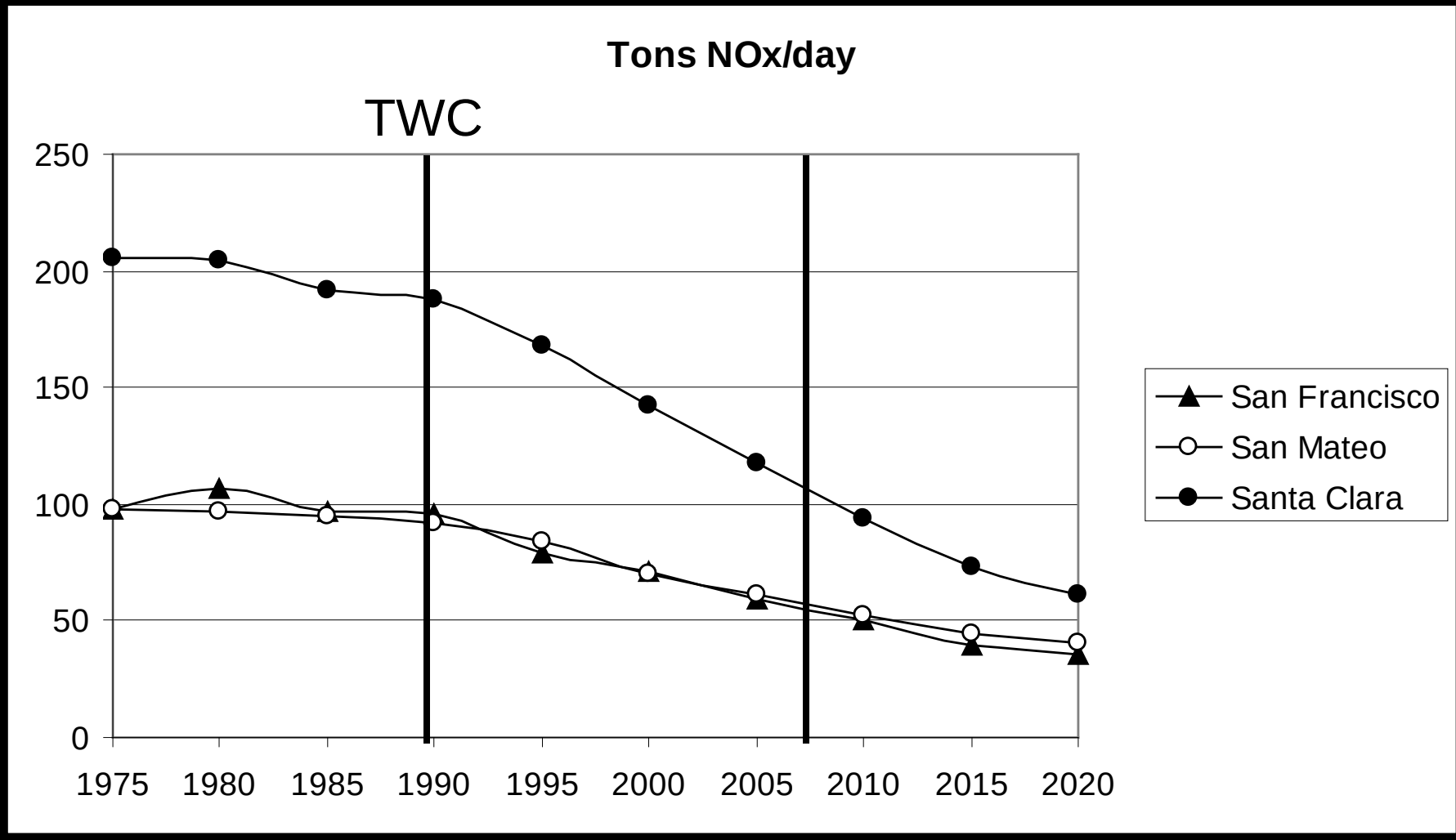
Review

Nitrogen critical loads and management alternatives for N-impacted ecosystems in California

M.E. Fenn [a,*], E.B. Allen [b,c], S.B. Weiss [d], S. Jovan [e], L.H. Geiser [f], G.S. Tonnesen [g], R.F. Johnson [b,c], L.E. Rao [b], B.S. Gimeno [h], F. Yuan [i], T. Meixner [j], A. Bytnerowicz [a]





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