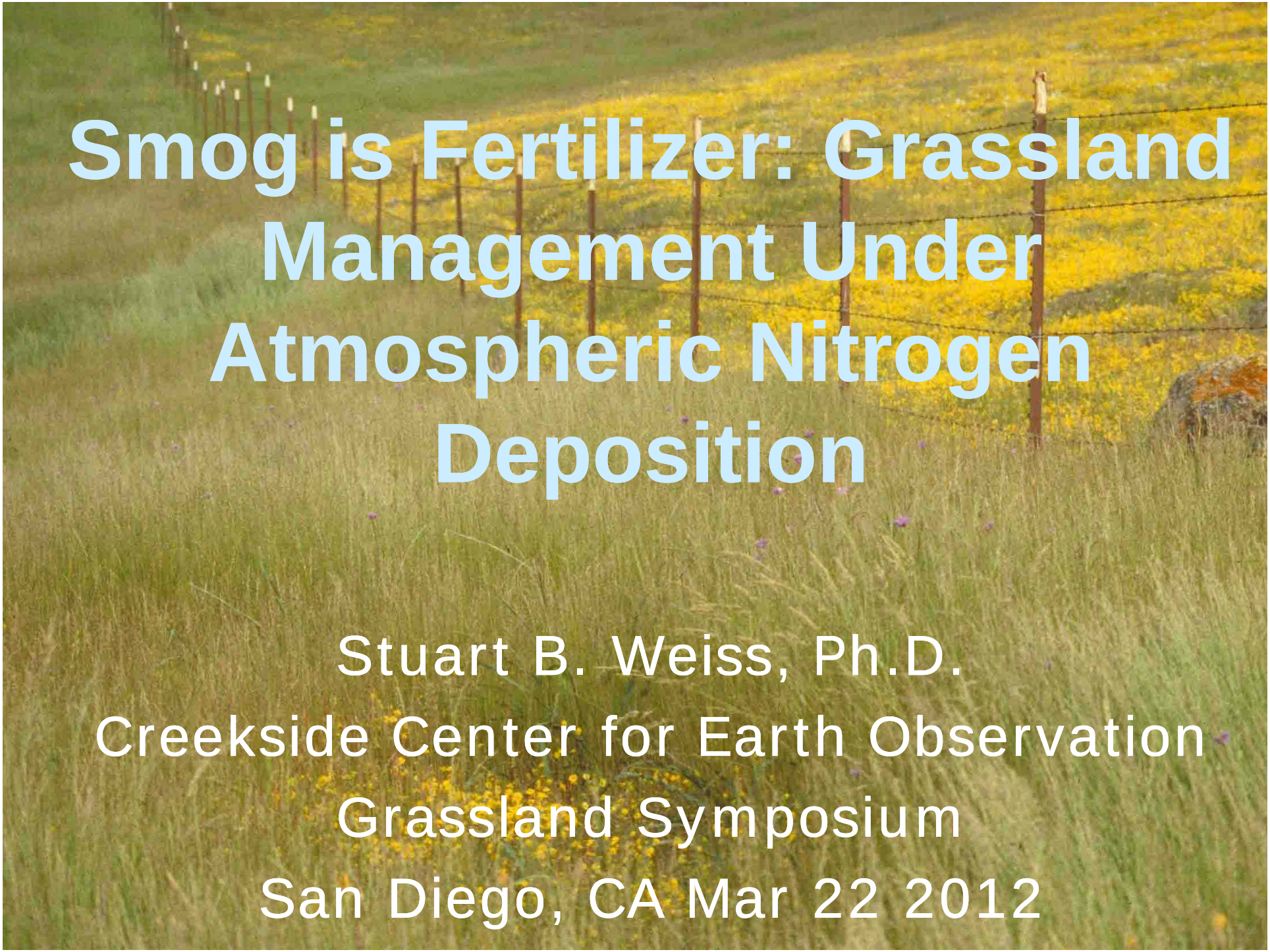


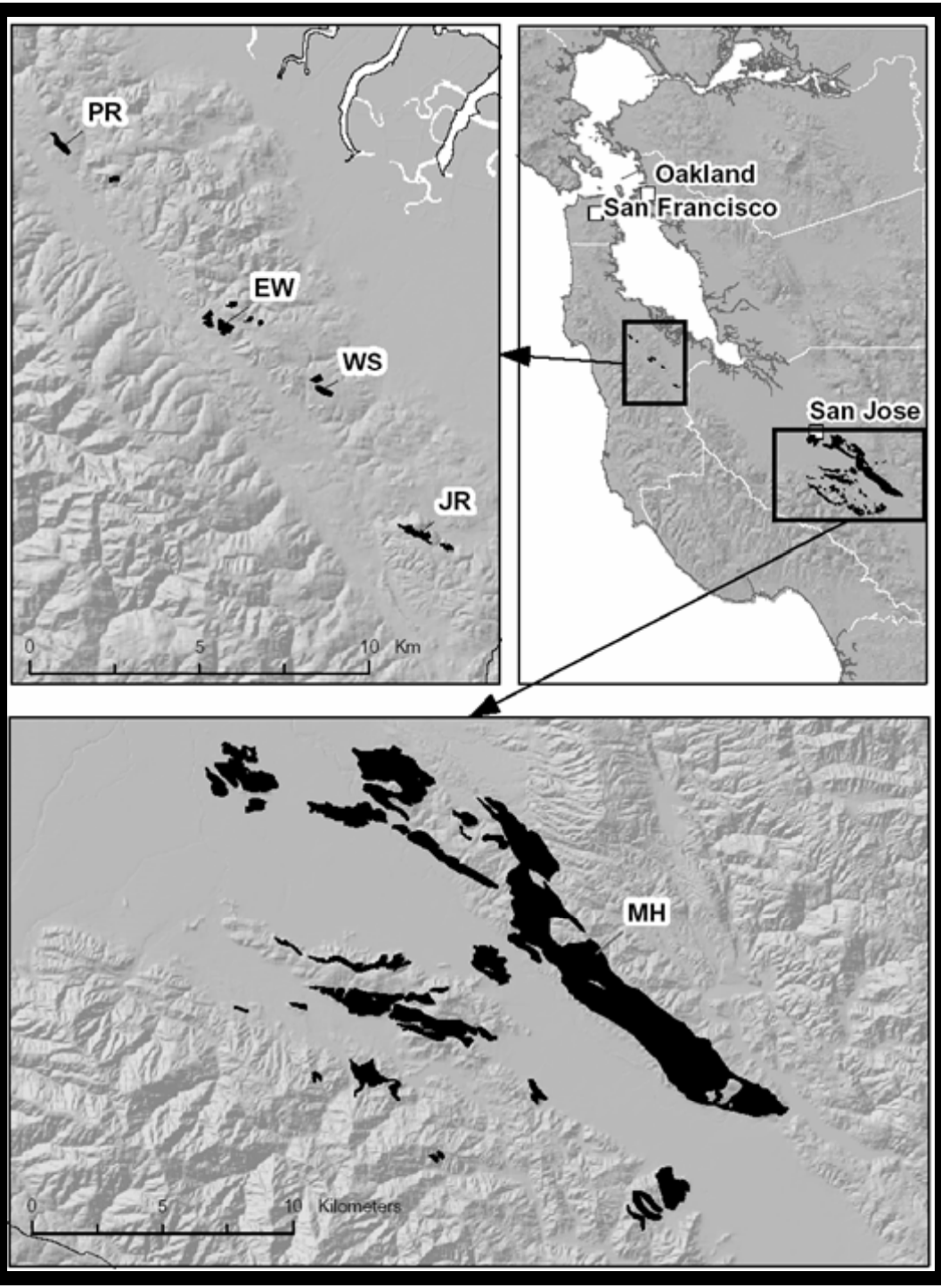
Smog is Fertilizer: Grassland Management Under Atmospheric Nitrogen Deposition

Stuart B. Weiss, Ph.D.
Creekside Center for Earth Observation

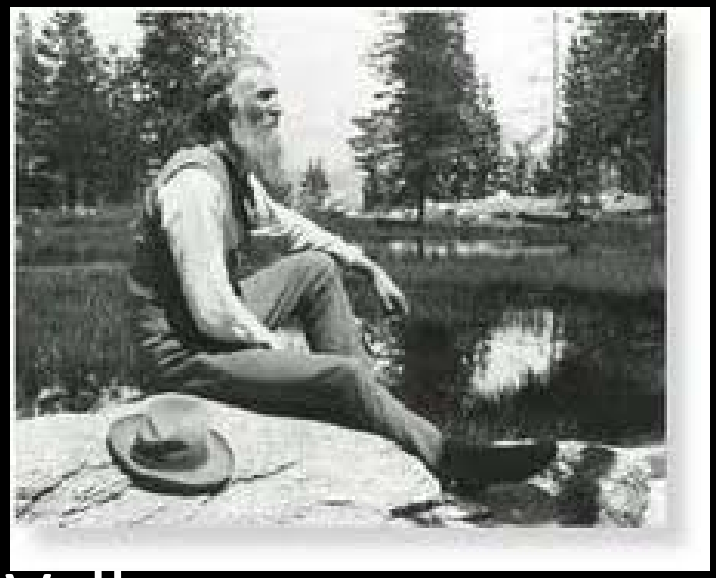
Grassland Symposium
San Diego, CA Mar 22 2012

Charismatic meso-invertebrate

Hostplants and Nectar Sources


PR
EW
WS
JR
0
5
10 Km
Oakland
San Francisco
San Jose
MH
0
5
10 Kilometers

“The last of the Coast Range foothills were in near view all the way to Gilroy. Their union with the valley is by curves and slopes of inimitable beauty, and they were robed with the greenest grass and richest light I ever beheld, and colored and shaded with millions of flowers of every hue chiefly of purple and golden yellow; and hundreds of crystal rills joined songs with the larks, filling all the valley with music like a sea, making it an Eden from end to end…”



---John Muir, 1868 on his walk from San Francisco to Yosemite Valley.


CATERPILLAR
627E

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).

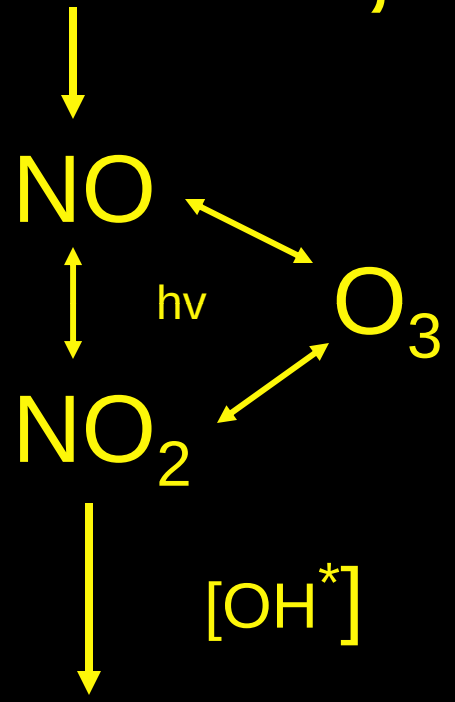
“The goodness of the weather as I journeyed towards Pacheco was beyond all praise and description, fragrant and mellow and bright. The air was perfectly delicious, sweet enough for the breath of angels; every draught of it gave a separate and distinct piece of pleasure. I do not believe that Adam and Eve ever tasted better in their balmiest nook.

---John Muir, 1868 on his walk from San Francisco to Yosemite Valley along Coyote Ridge.


Dry Nitrogen Deposition
Smog is slow release N-fertilizer

"Atmospheric Chemistry 101"

Combustion, soils



$HNO_3 + NH_3 \rightleftharpoons NO_3NH_4(p)$

Fertilizer, animal wastes, vehicles, vegetation,

Weiss (1999) Conservation Biology 13(6):1476-1486

Cars, Cows, and Checkerspot Butterflies: Nitrogen Deposition and Management of Nutrient-Poor Grasslands for a Threatened Species

STUART B. WEISS

Center for Conservation Biology, Department of Biological Sciences, Stanford University, Stanford, CA 94305, U.S.A., email stu@bing.stanford.edu

Abstract: *Nutrient-poor, serpentinitic soils in the San Francisco Bay area sustain a native grassland that supports many rare species, including the Bay checkerspot butterfly (*Euphydryas editha bayensis*). Nitrogen (N) deposition from air pollution threatens biodiversity in these grasslands because N is the primary limiting nutrient for plant growth on serpentinitic soils. I investigated the role of N deposition through surveys of butterfly and plant populations across different grazing regimes, by literature review, and with estimates of N deposition in the region. Several populations of the butterfly in south San Jose crashed following the cessation of cattle grazing. Nearby populations under continued grazing did not suffer similar declines. The immediate cause of the population crashes was rapid invasion by introduced annual grasses that crowded out the larval host plants of the butterfly. Ungrazed serpentinitic grasslands on the San Francisco Peninsula have largely resisted grass invasions for nearly four decades. Several lines of evidence indicate that dry N deposition from smog is responsible for the observed grass invasion. Fertilization experiments have shown that soil N limits grass invasion in serpentinitic soils. Estimated N deposition rates in south San Jose grasslands are 10–15 kg N/ha/year; Peninsula sites have lower deposition, 4–6 kg N/ha/year. Grazing cattle select grasses over forbs, and grazing leads to a net export of N as cattle are removed for slaughter. Although poorly managed cattle grazing can significantly disrupt native ecosystems, in this case moderate, well-managed grazing is essential for maintaining native biodiversity in the face of invasive species and exogenous inputs of N from nearby urban areas.*

Dry deposition

up to 50+ kg-N/ha/year, pre-industrial background is 0.5 kg-N/ha/year

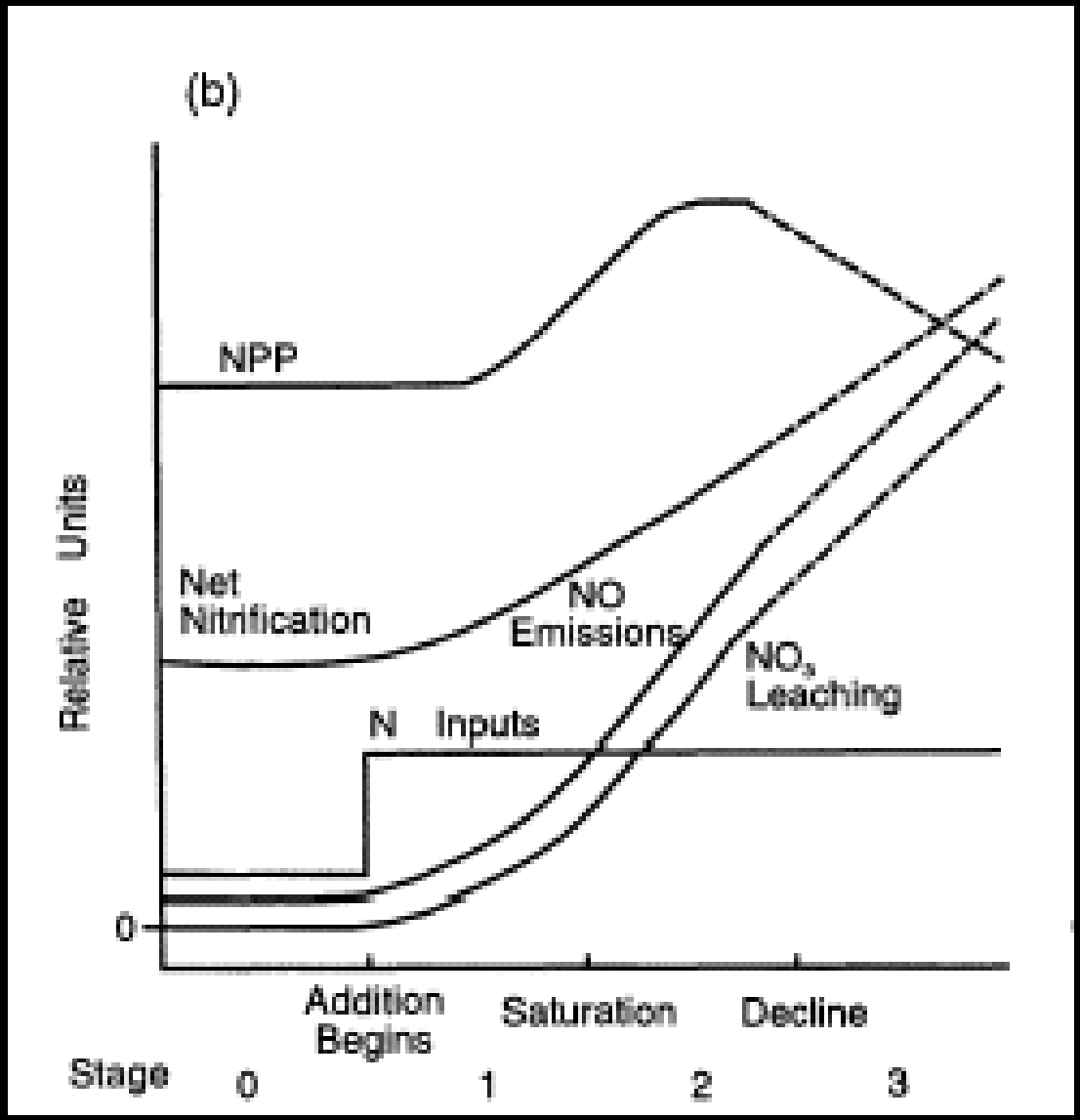
NO_2 and NH_3 gases are taken up through stomata

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

Particulates and other gases are relatively minor contributors

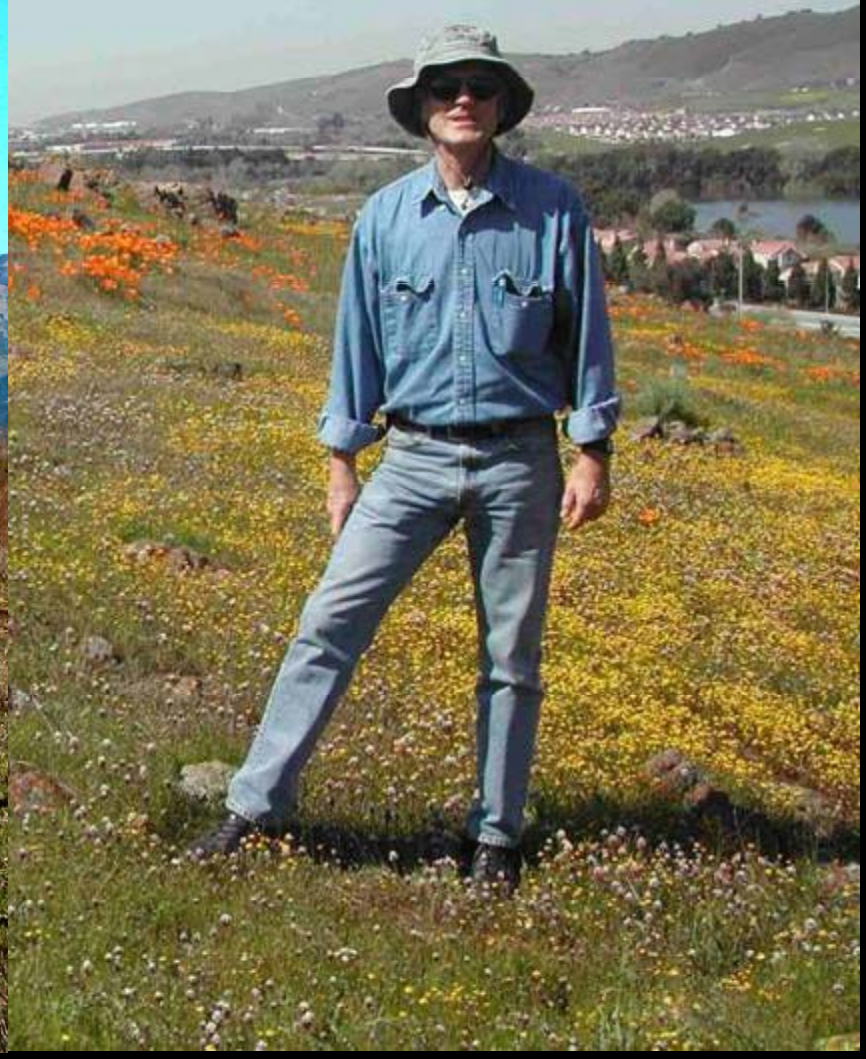
Dry deposition is >80-90% in polluted regions of California, wet deposition is of lesser importance most places

Stages of N-saturation in western xeric forests (Fenn, Poth et al. 1998)
Cumulative Effects

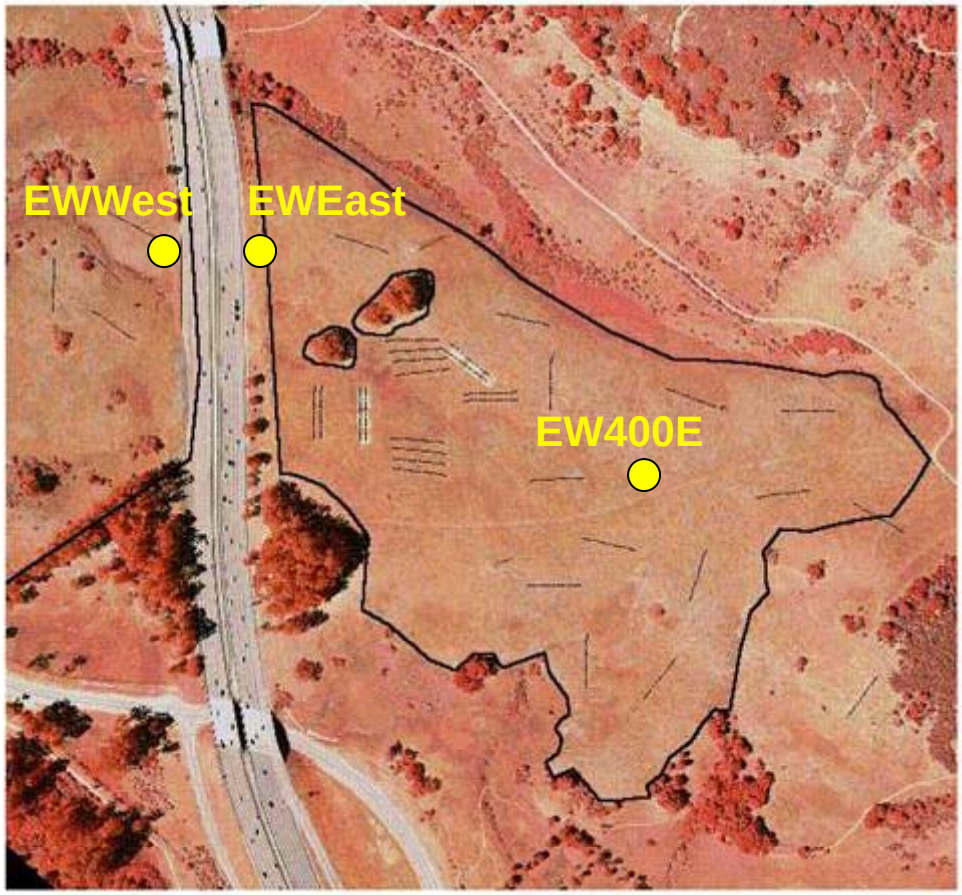


Dr. Andrzej Bytnerowicz

USDA FS Riverside, CA




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

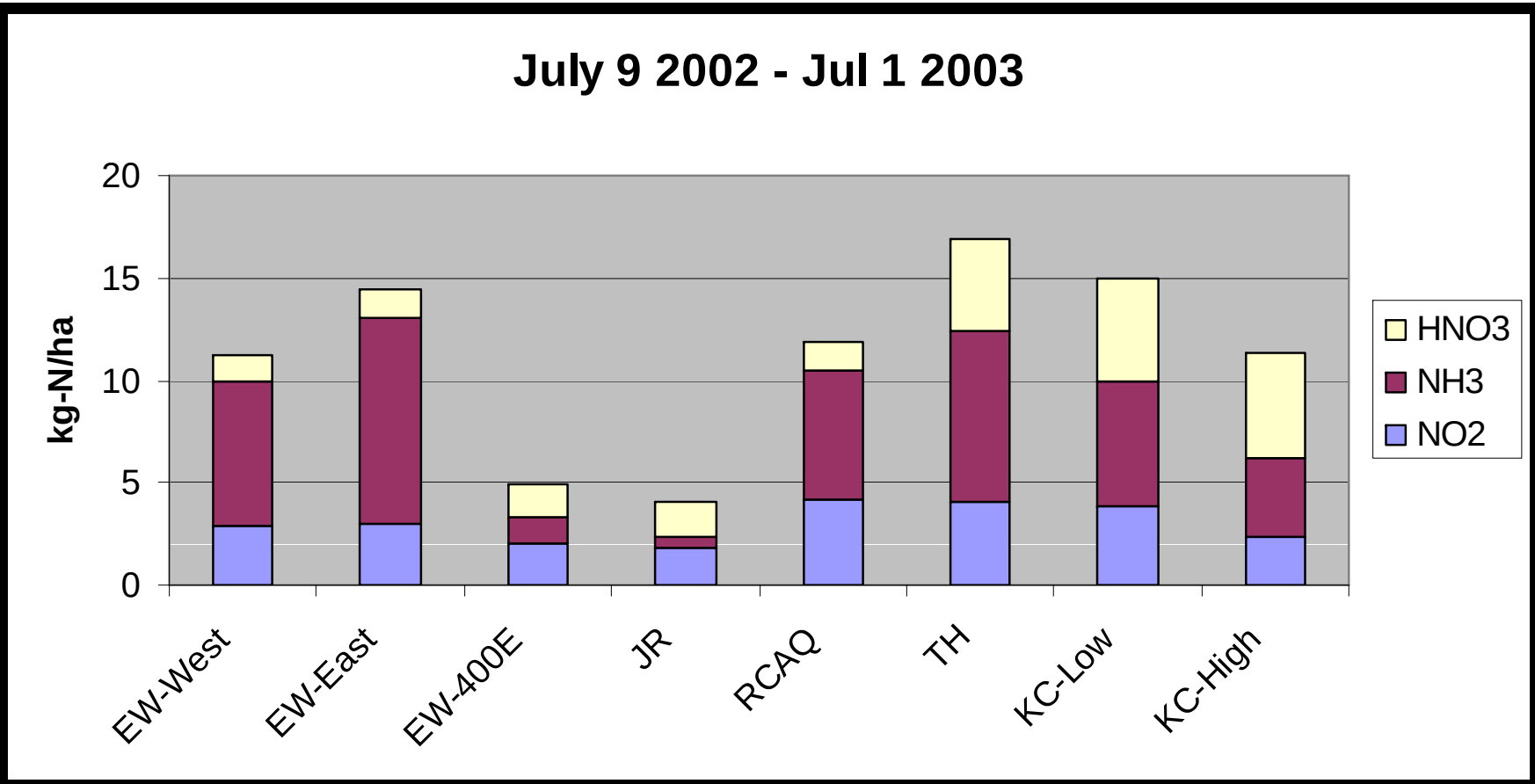


200 0 200 400 600 800 Feet

50 0 50 100 150 200 Meters

N

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.

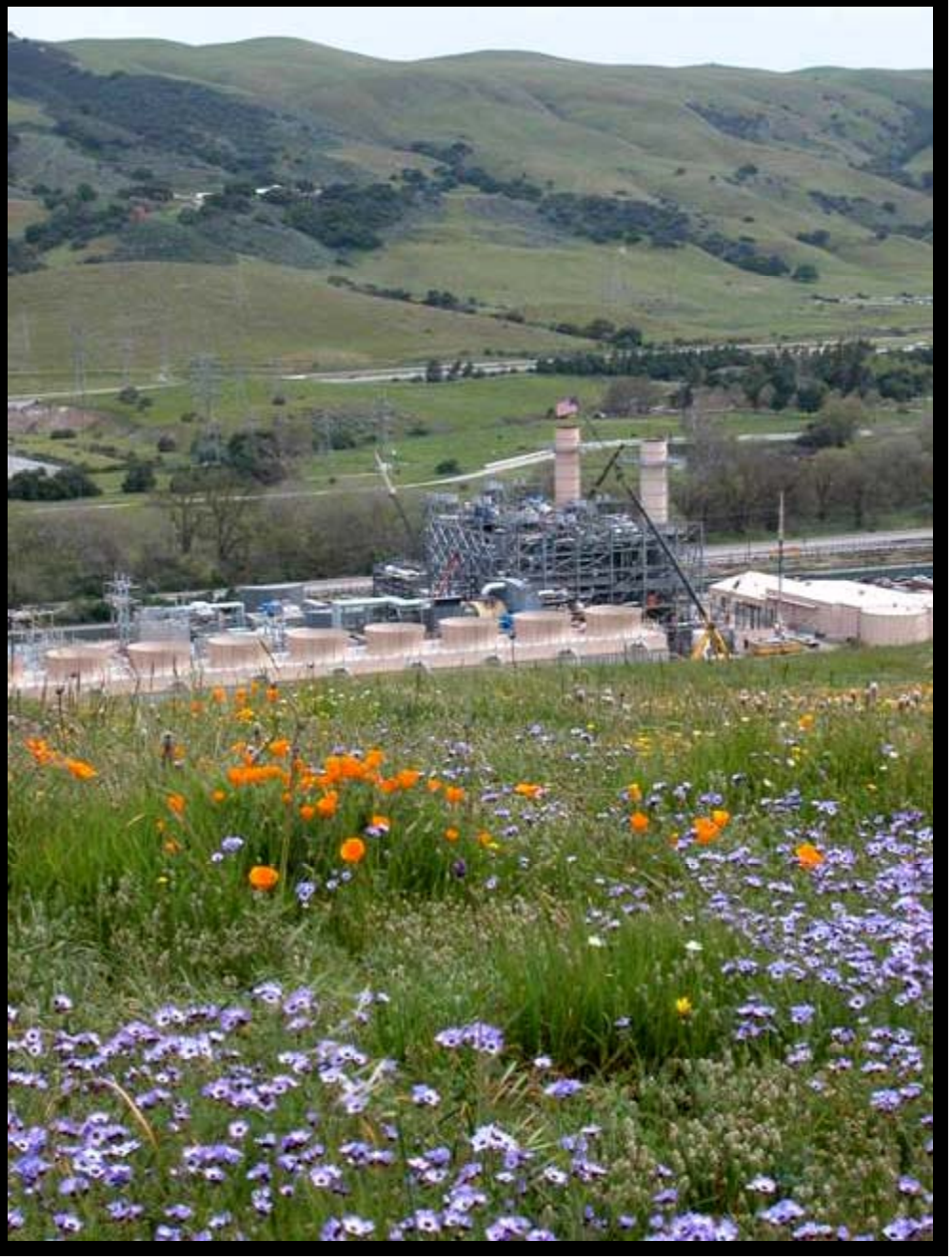
Metcalf Energy Center, Tulare Hill

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



2001 - widening Highway 101 – 540 acres mitigation + commitment to HCP

Santa Clara County HCP/NCCP

Comprehensive plan to protect imperiled species in southern Santa Clara County

Address cumulative impacts of N-deposition and development, one-stop permitting

Habitat acquisition/easements + MANGEMENT MONEY

Long-term (50 years), >$650,000,000 ($13,000,000 per year)

Elected officials voting in 2011-2012

N-side Tulare Hill 2002

N-side Tulare Hill 2007

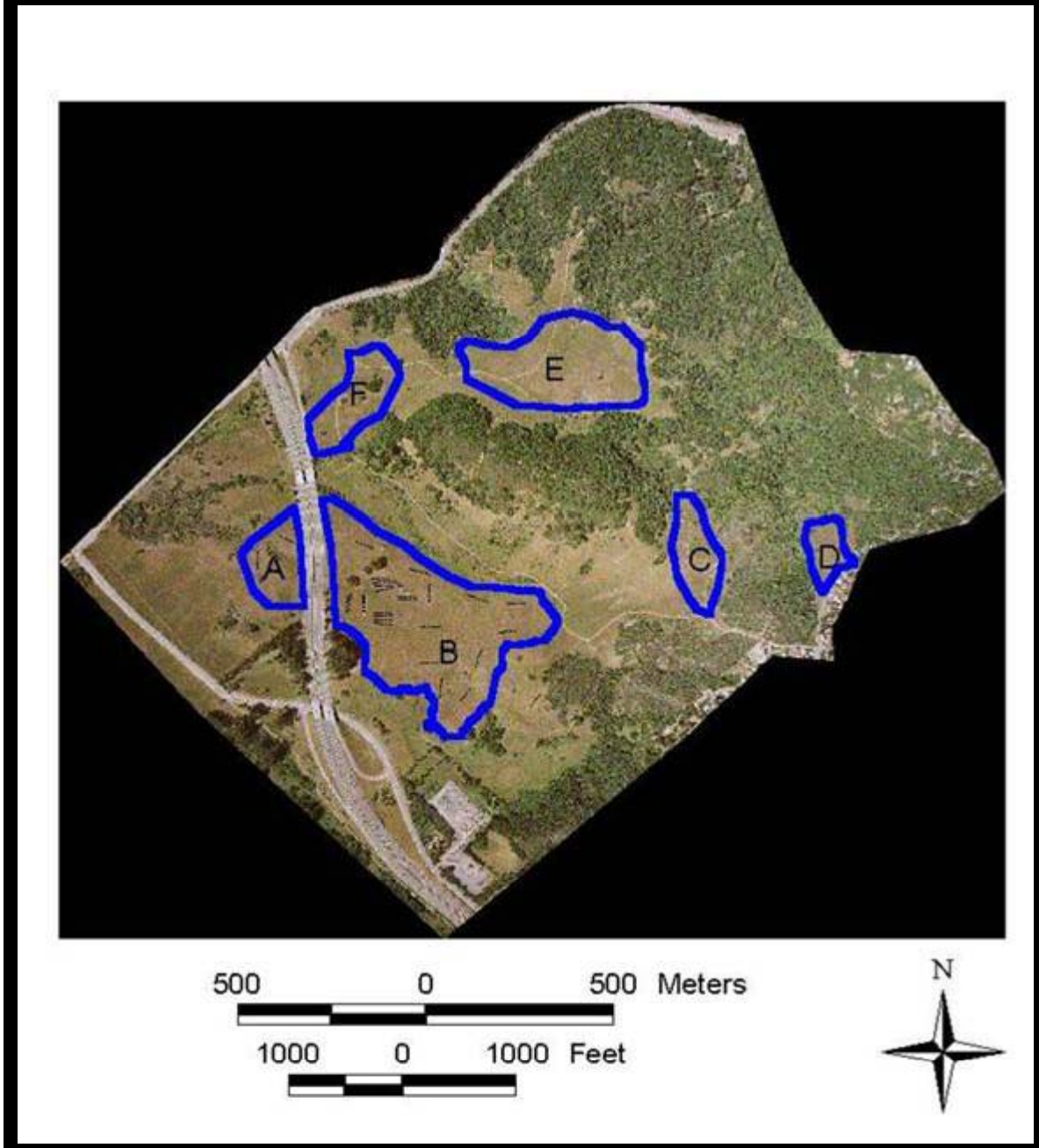
The return of grazers

- PG&E Safe Harbor Agreement
- Cows returned on June 25, 2008
- Habitat is recovering, 5+ years

Keystone Species: Ranchers

The Case of the Drive-by Extinction: Search for the Subtlety Smoking Tailpipe

CSI Redwood City



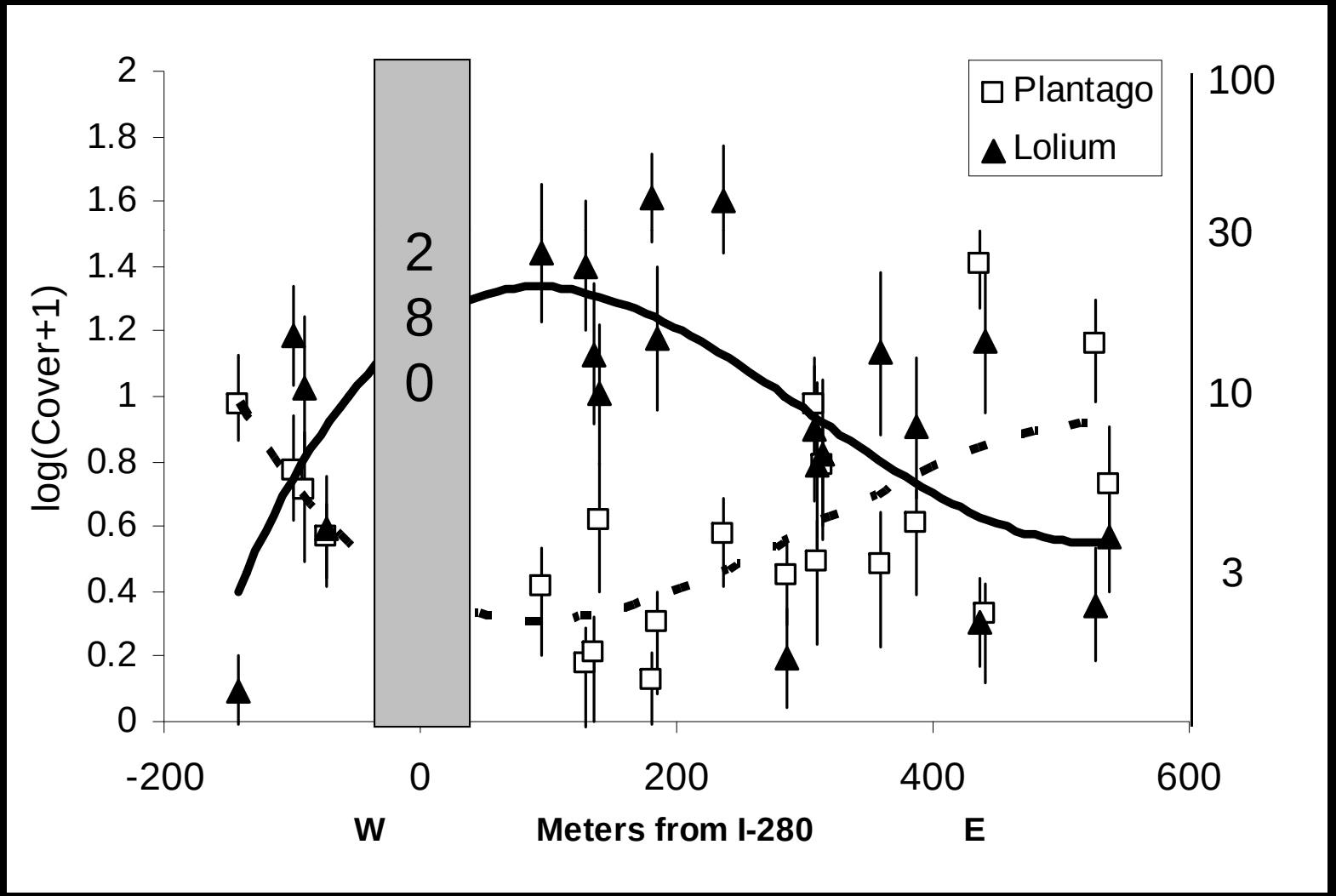
Bay checkerspot habitat (blue outlines) bisected by Highway 280

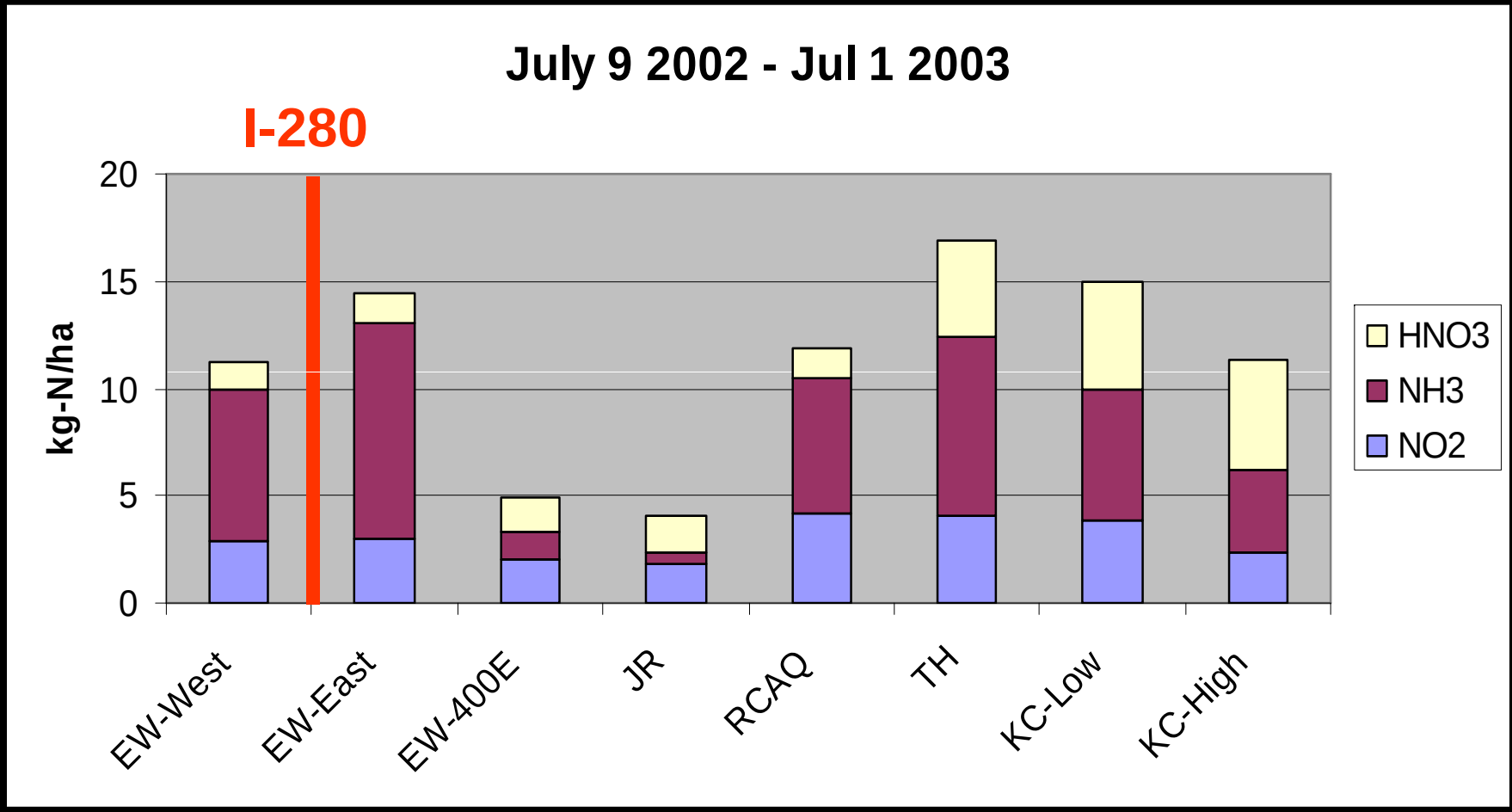
113,000 vehicles/day

35 acres in the main habitat area “B”

9,000 larvae in 1997
The last larva in 2002

Edgewood 2001





NH_3 from catalytic converters!

"The subtlety smoking tailpipe"

Mowing

Early May Timing

Mowing passes the “O-test”

Rotational Mowing 4-5 year cycle

Reintroduction in 2007
“Navigating the Regulatory Ecosystem”

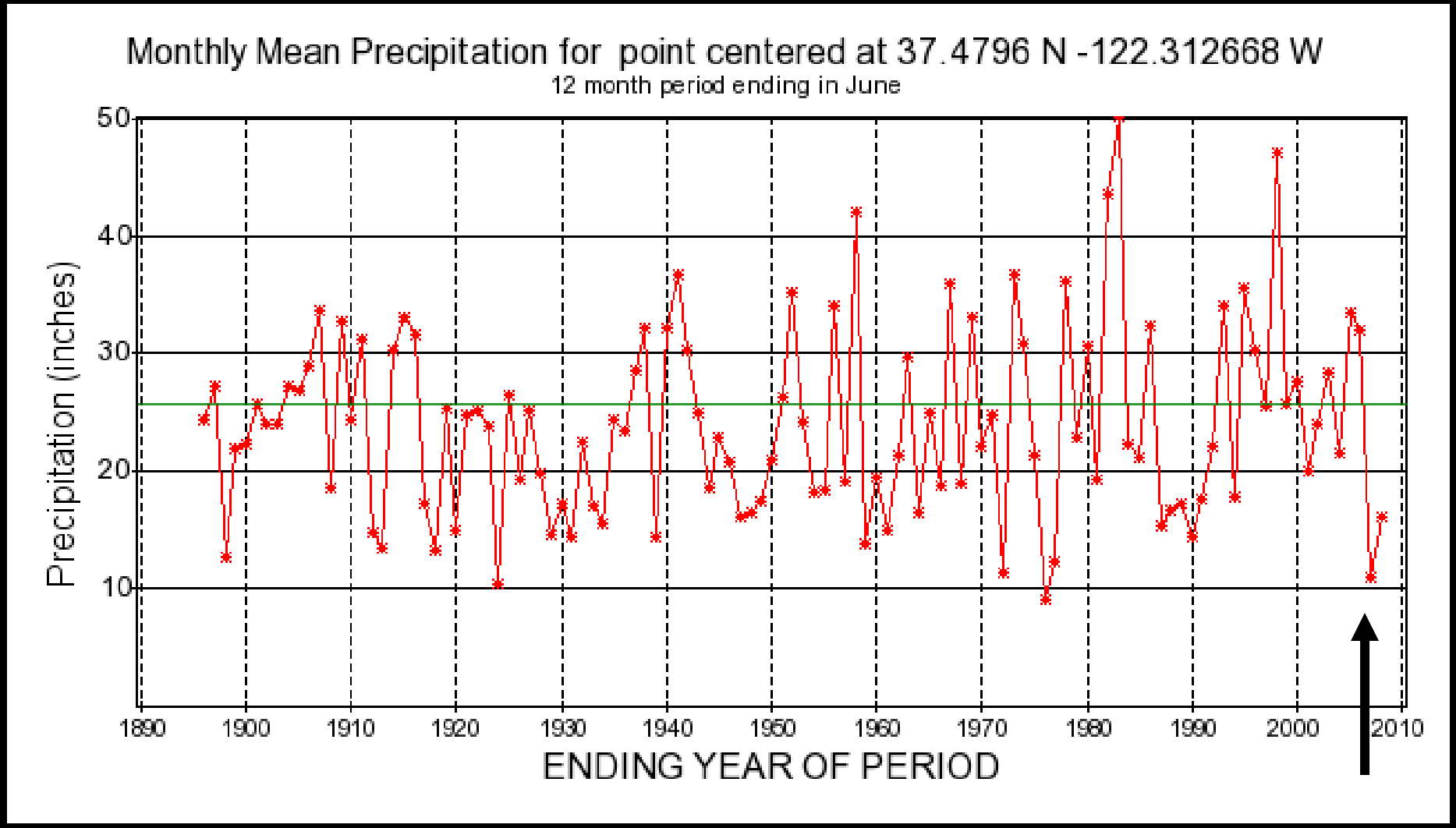

AREA CLOSED
FRAGILE WILDFLOWER
& BUTTERFLY HABITAT
DO NOT ENTER


Sulfate
21-0-0
Sulfato de Amonio
For Trees, Shrubs, Hedges, Evergreens and in Flower & Vegetable Gardens
Ammonium Sulfate 21-0-0

What Happened in 2007 and 2008

- We saw adult butterflies in 2007: not as many as hoped
- We found 1 larva in 2008
- No adults seen
- Not a “total failure” but disappointing

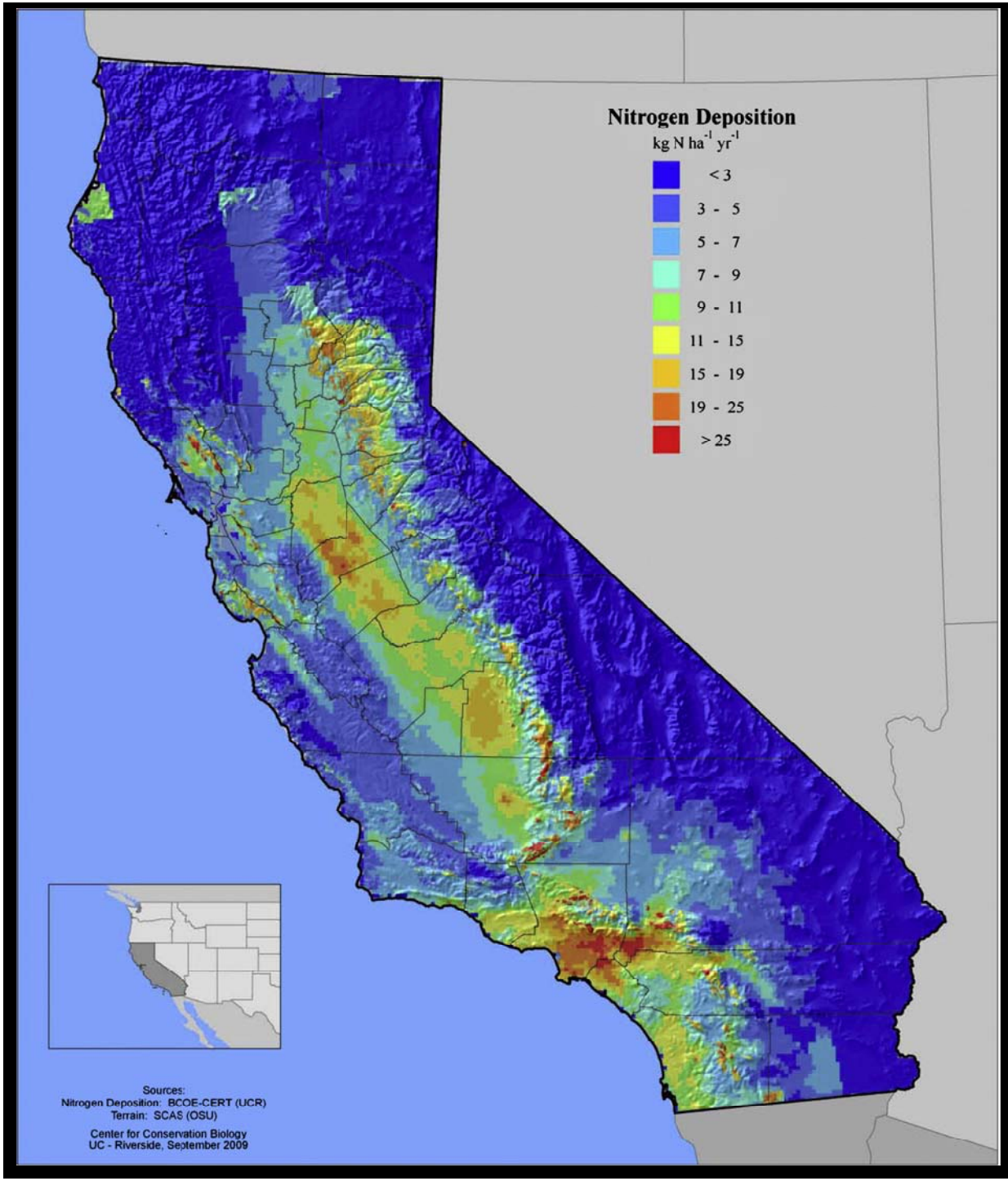
Drought year: luck of the draw



Re-reintroduction in 2011
“Navigating the Regulatory Ecosystem”
again, bigger hammer, better year”

x4000 2011

x4152 2012



Chemical Climate of California

2002

Contact Edie Allen

UC Riverside

CCB

Google Earth

KNOW YOUR

N-DEP!

Weiss, S.B. 2006. Impacts of nitrogen deposition on California ecosystems and biodiversity. *California Energy Commission Report.*

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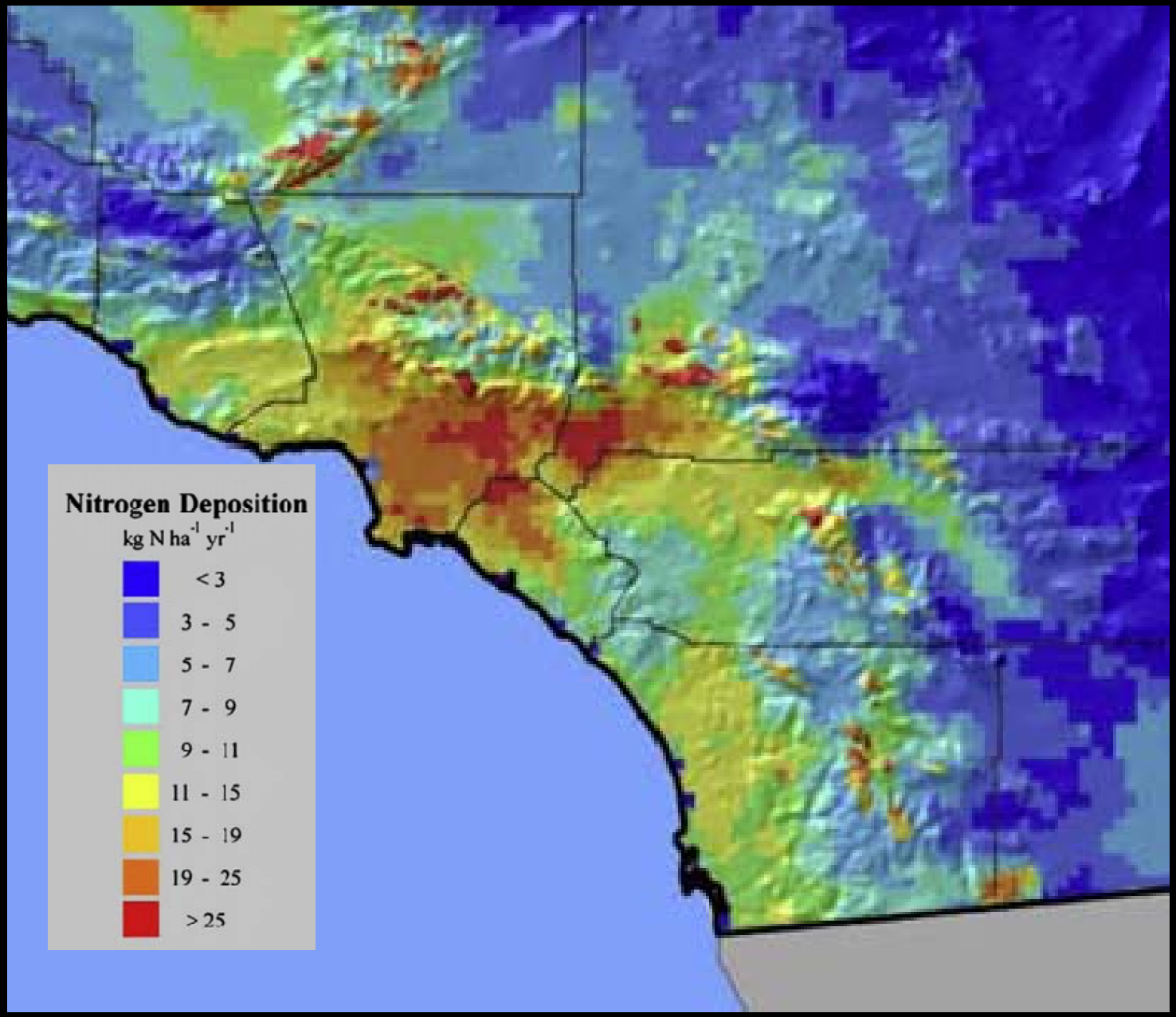
journal homepage: www.elsevier.com/locate/jenvman

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]

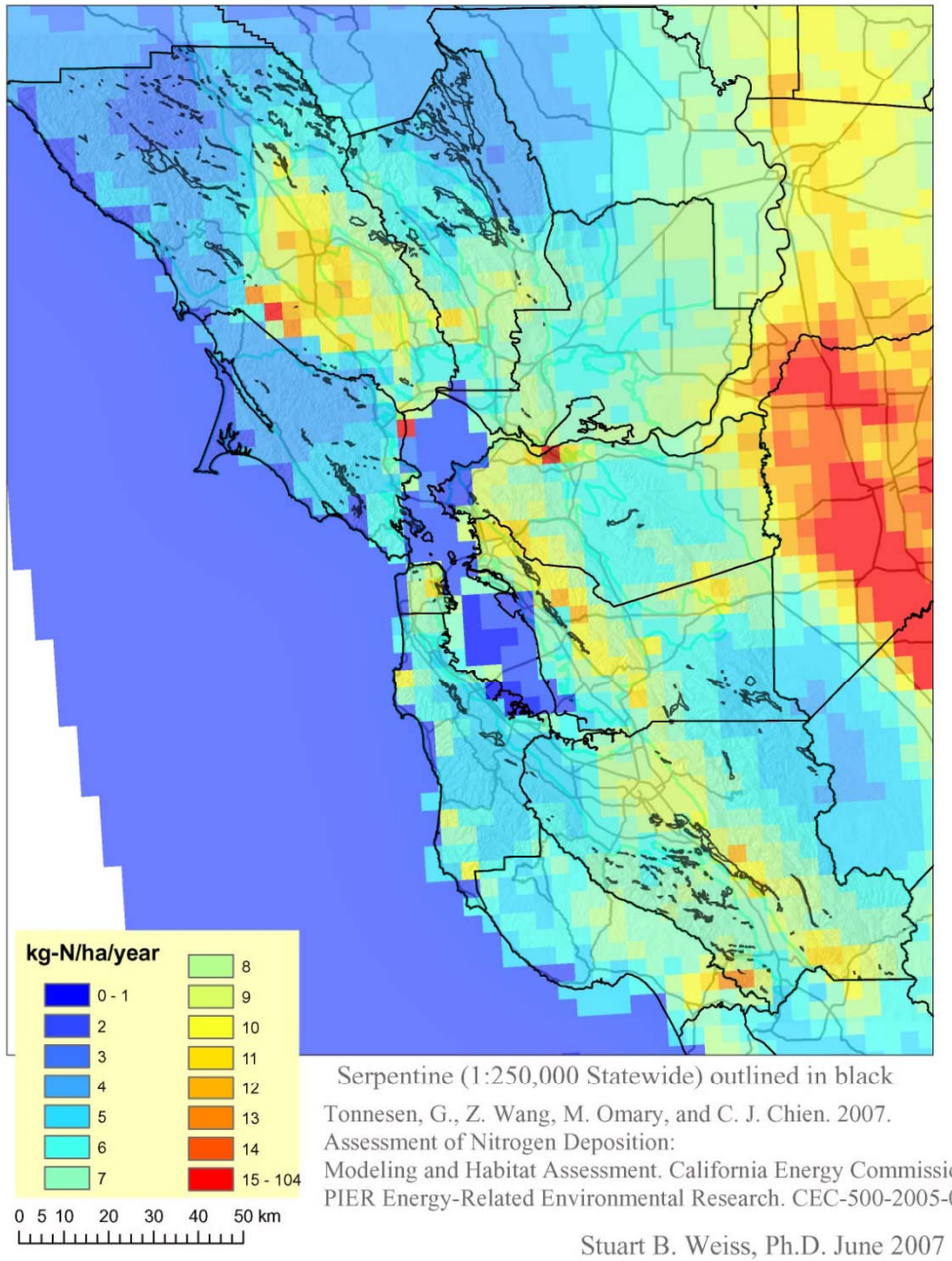
Pardo et al. 2011 Assessment of Nitrogen deposition effects and empirical critical loads of Nitrogen for ecoregions of the United States Gen. Tech. Rep. NRS-80. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 291 p.


Nitrogen Deposition
kg N ha-1 yr-1
< 3
3 - 5
5 - 7
7 - 9
9 - 11
11 - 15
15 - 19
19 - 25
> 25

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!**

CMAQ 4 km Total Nitrogen Deposition
2002



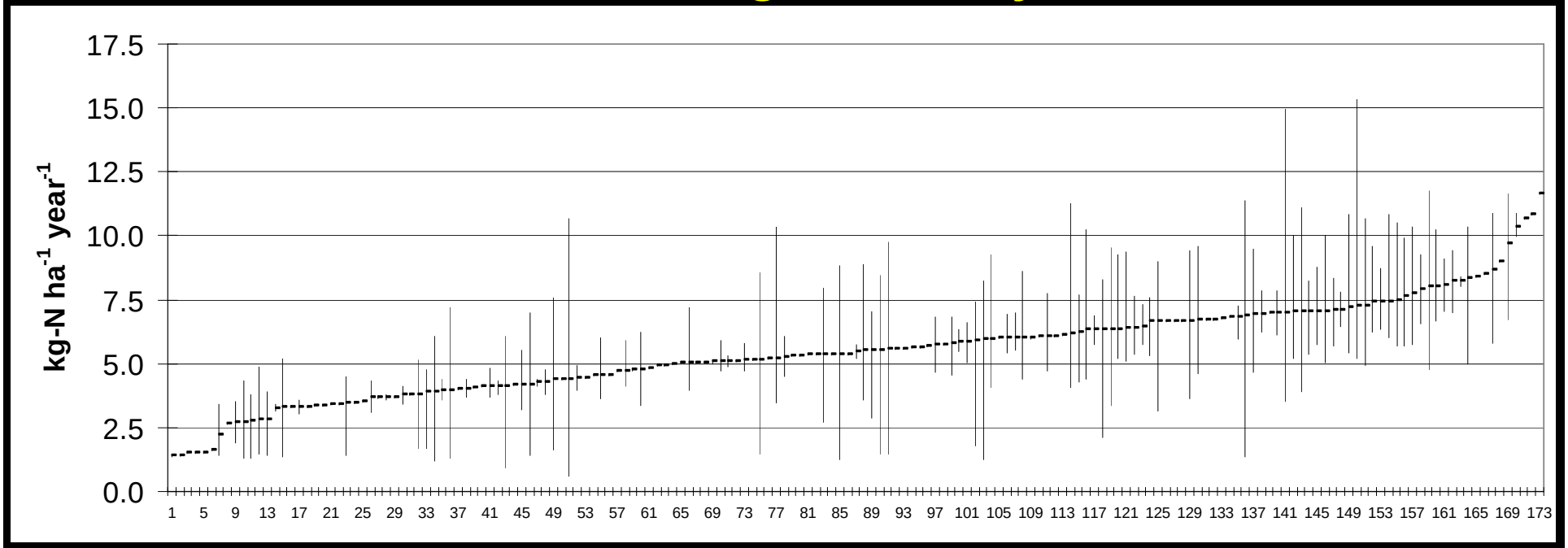
Serpentine (1:250,000 Statewide) outlined in black

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

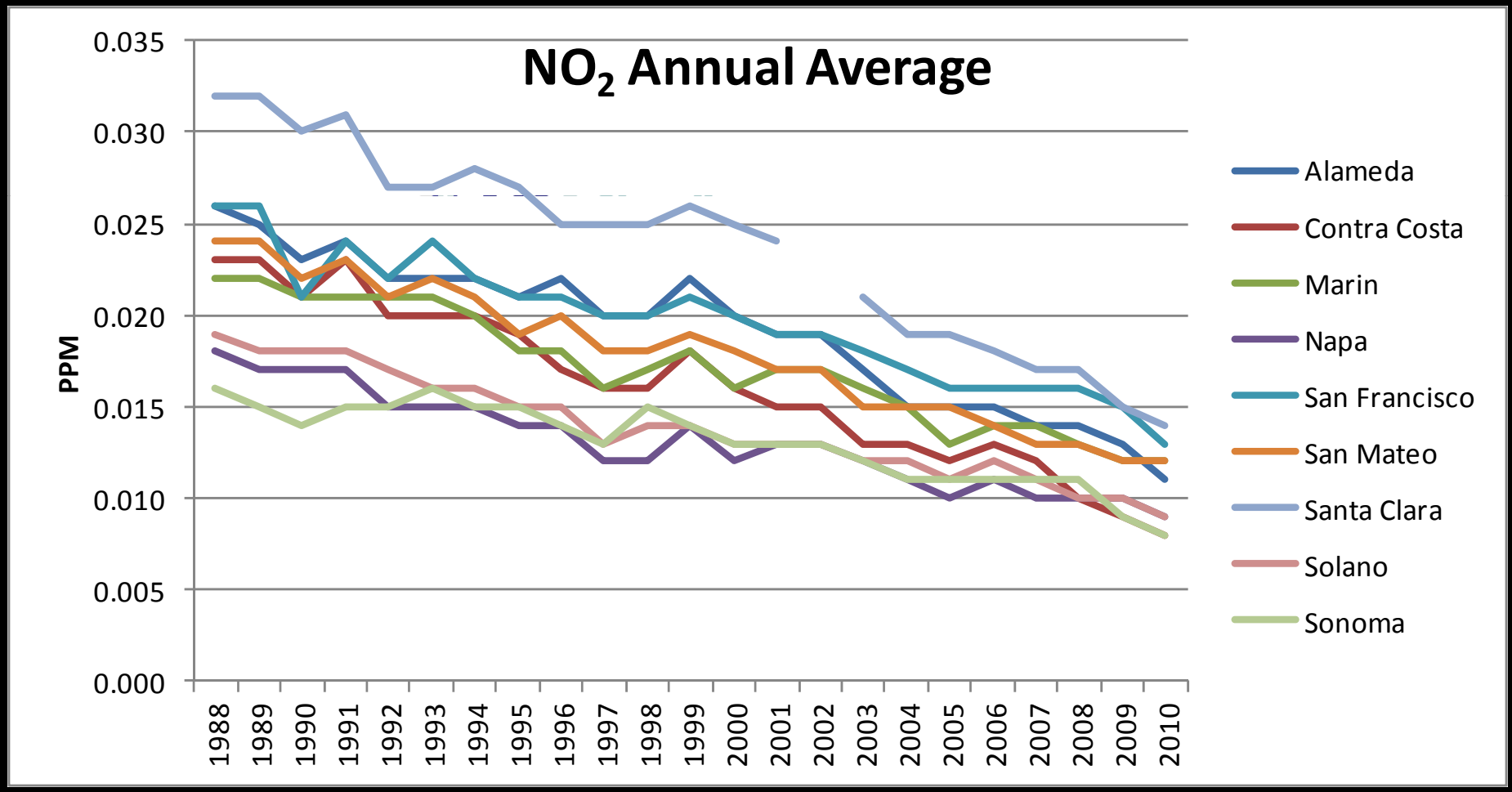
110 > 5 kg-N ha^{-1} yr^{-1}



Conservation Land Network

www.bayarealands.org

Air Quality Regulations Working (Thank you CARB!)



Operation Flower Power: Grassroots Lobbying

Docents led 2000+ people on tours 2001-2011