

Smog is Fertilizer: Implications for California Biodiversity and Grazing Management



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

Rangeland Summit, Stockton, CA
January 13, 2017

Charismatic meso-invertebrate





Hostplants and Nectar Sources



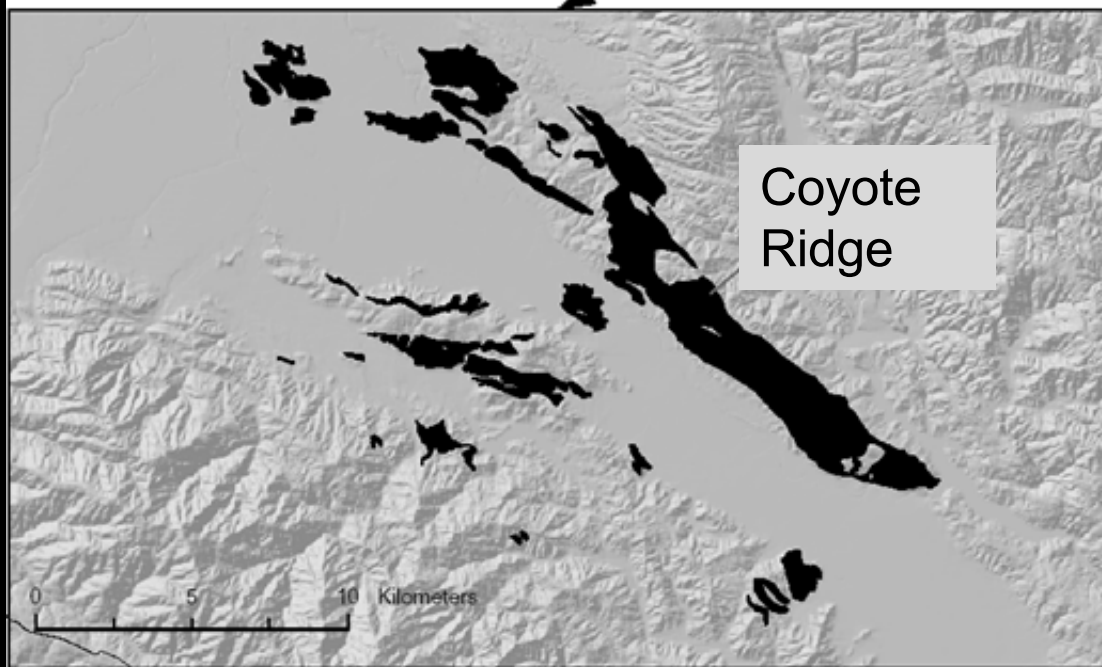
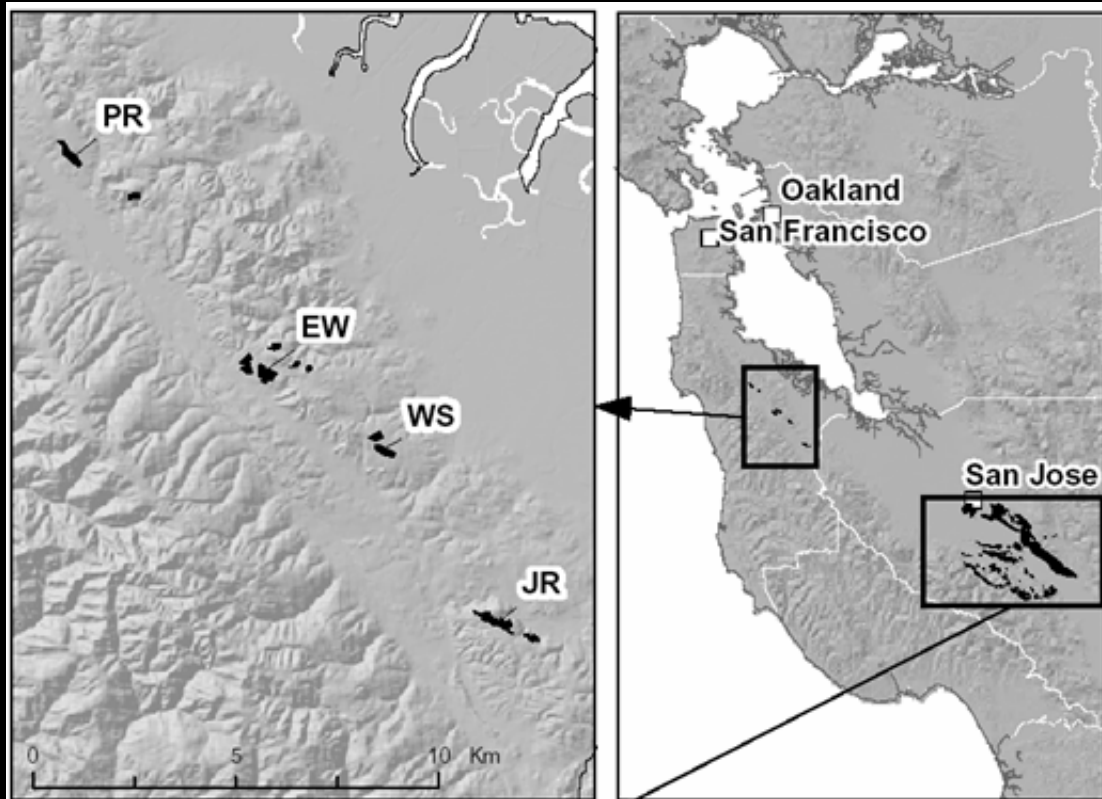
Black, Basking Caterpillars Really are warm and fuzzy





Sandstone

Serpentinite
California
State Rock



Charismatic micro-flora













“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.







Click to **LOOK INSIDE!**

On the Wings of Checkerspots

A Model System for Population Biology



- 57 years of research
- Hundreds of scientific papers
- In science textbooks
- Heritage of ALL of humanity
- Not just another pretty butterfly

Serpentine Grassland as a Model System for Ecosystem and Community Ecology



Rare Endemic Flora



Charismatic megafauna











In absence of cattle grazing in South Bay, introduced annual grasses overrun habitat within several years. First observed in 1980s





“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.



**“sweet enough for the breath of
angels”?**

Adam and Eve have tasted better.....

Dry Nitrogen Deposition

Smog is slow release N-fertilizer

Deposition 10-20 lbs-N/acre/year

4 lbs-N



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

STUART B. WEISS

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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.*

Metcalfe Energy Center, Tulare Hill 1999 on

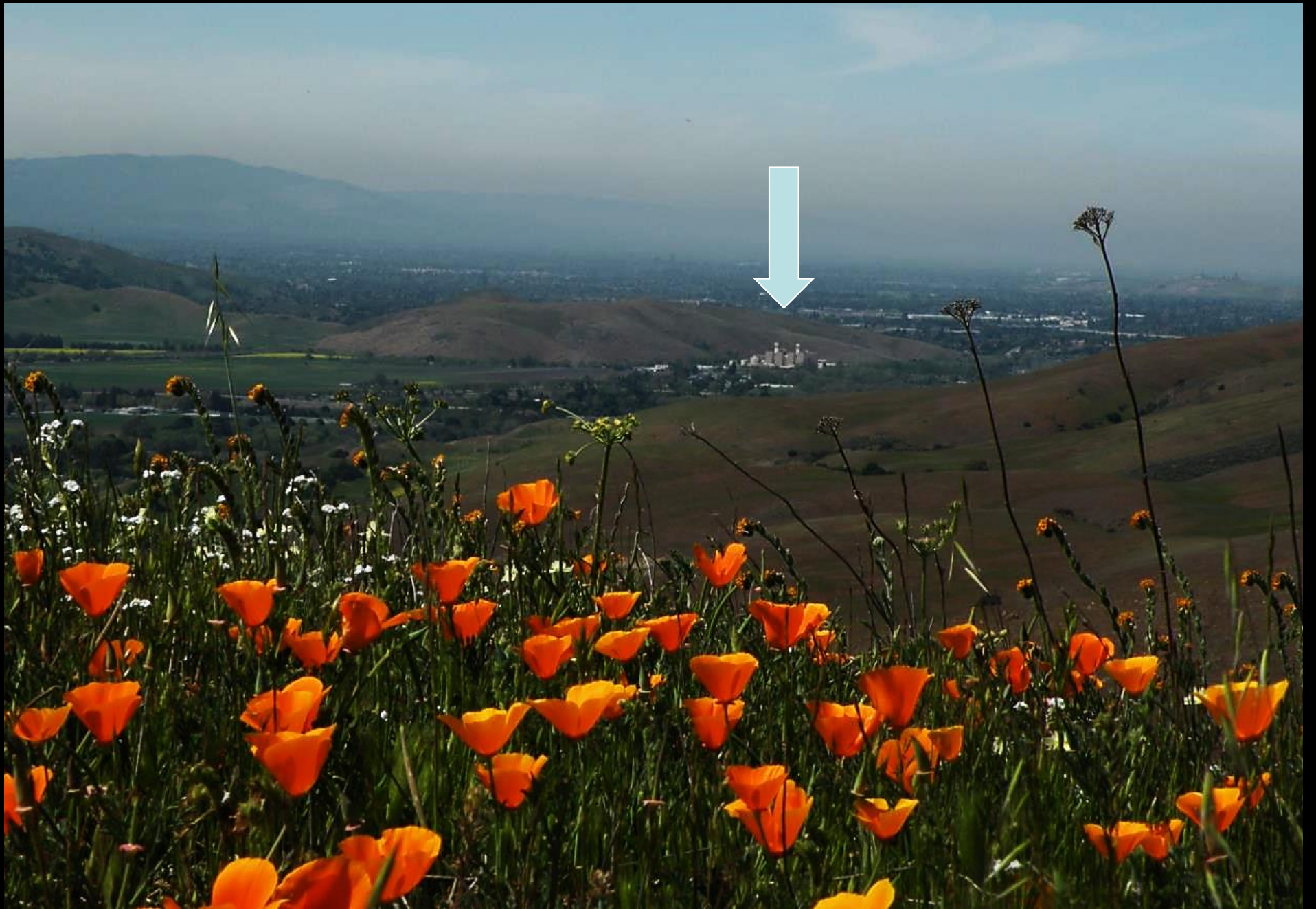
Large point source, but
incremental effects in an
already polluted region

*Precedent setting
mitigation:*

131 acres + \$1.4 million
endowment + 30-year
operating expenses

2 more powerplants, 80
acres + \$\$\$\$





Widening Highway 101 in 2001

540 acres mitigation + commitment to HCP



Operation Flower Power: Grassroots Lobbying



**Docents led
2000+ people
on tours 2001-
2012**

April 13, 2011
CRCC





Habitat Conservation Now



October 3, 2013 Anderson Dam



Implementing Agreement

by and among the
United States Fish and Wildlife Service, California Department of Fish and Wildlife,
Santa Clara Valley Habitat Agency, County of Santa Clara, City of San Jose,
City of Gilroy, City of Morgan Hill, Santa Clara Valley Water District,
and Santa Clara Valley Transportation Authority regarding the

Santa Clara Valley Habitat Plan

This Implementing Agreement governs the implementation of the joint habitat conservation and natural community conservation plan for the Santa Clara Valley as of the Effective Date. The SCVHP is a plan to protect and enhance ecological diversity and function in a substantial portion of Santa Clara County, while allowing appropriate and compatible growth and development to occur in accordance with certain environmental laws.

Signed on this day, Thursday, October 3, 2013.



SANTA CLARA VALLEY

HABITAT AGENCY

- HCP/NCCP (Federal/California)
- Grew out of powerplant and highway mitigation for N-deposition impacts
- Acquire and manage ~46,000 acres for 19 covered species (10/19 are serpentine, ~10,000 acres serpentine)
- \$665,000,000 over 50 years (\$13 million/year)
- **N-deposition fee. \$4.47 per new daily vehicle trip, \$44.69 per new single family residence, one time (~\$10,000,000 over plan lifetime)**



Coyote Ridge Open Space Preserve 1800+ acres, March 18, 2016



Keystone Species: Ranchers



N-side Tulare Hill 2002



N-side Tulare Hill 2007





Cattle reintroduced in 2008



N-side Tulare Hill 2014





Photo: Lech Naumovich



Photo: Lech Naumovich





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

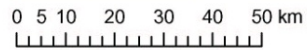
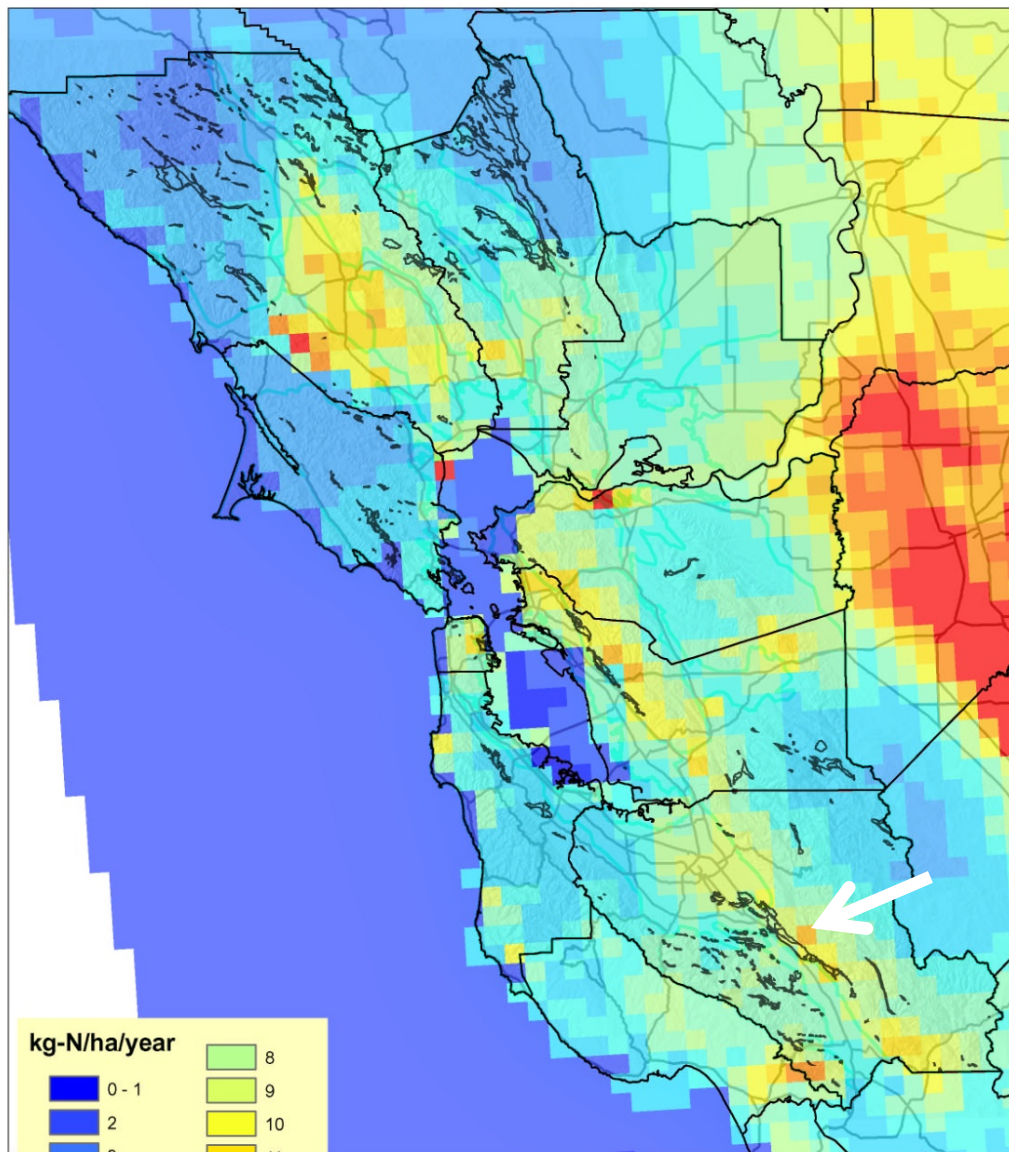
STUART B. WEISS

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~\$700,000,000 paper

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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

Nitrogen Deposition

kg N ha⁻¹ yr⁻¹



Sources:
Nitrogen Deposition: BCOE-CERT (UCR)
Terrain: SCAS (OSU)

Center for Conservation Biology
UC - Riverside, September 2009

Chemical Climate of California

2002

Vernal Pools: grass invasion in absence of grazing (Jaymee Marty TNC) 10 lbs-N/ac/yr



23 T&E, 22 Rare in Vernal Pools



Blennosperma bakeri



Orcuttia pilosa



Pogogyne abramsii



Limnanthes vinculans



*Limnanthes gracilis
parishii*



Lasthenia conjugens

+Fairy Shrimp, CTS, CRLF



Review

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

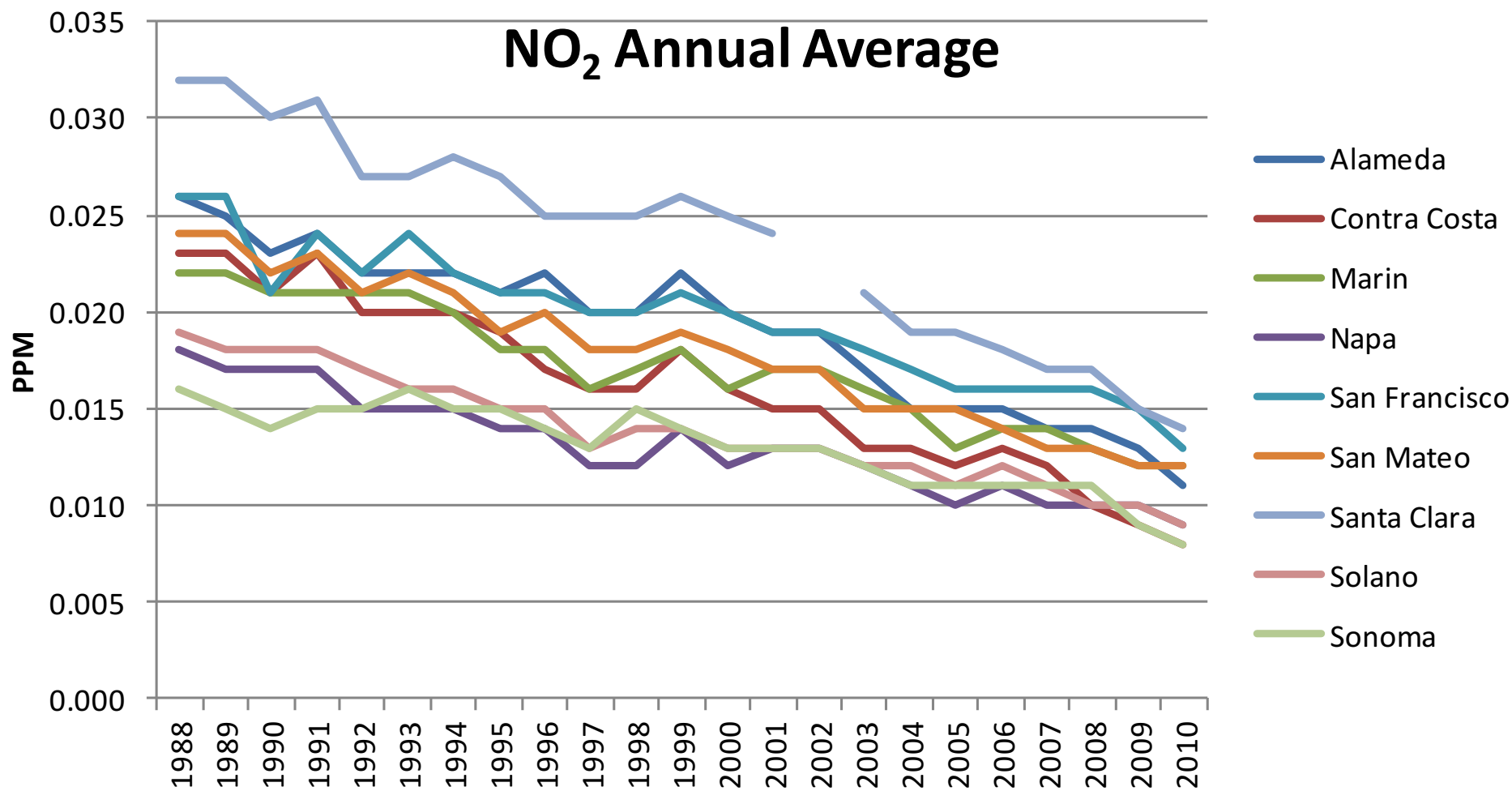
M.E. Fenn^{a,*}, E.B. Allen^{b,c}, S.B. Weiss^d, S. Jovan^e, L.H. Geiser^f, G.S. Tonnesen^g, R.F. Johnson^{b,c}, L.E. Rao^b, B.S. Gimeno^h, F. Yuanⁱ, T. Meixner^j, A. Bytnerowicz^a

California Nitrogen Deposition Initiative

Mitigation \$\$\$\$\$\$\$...
for Weed Management

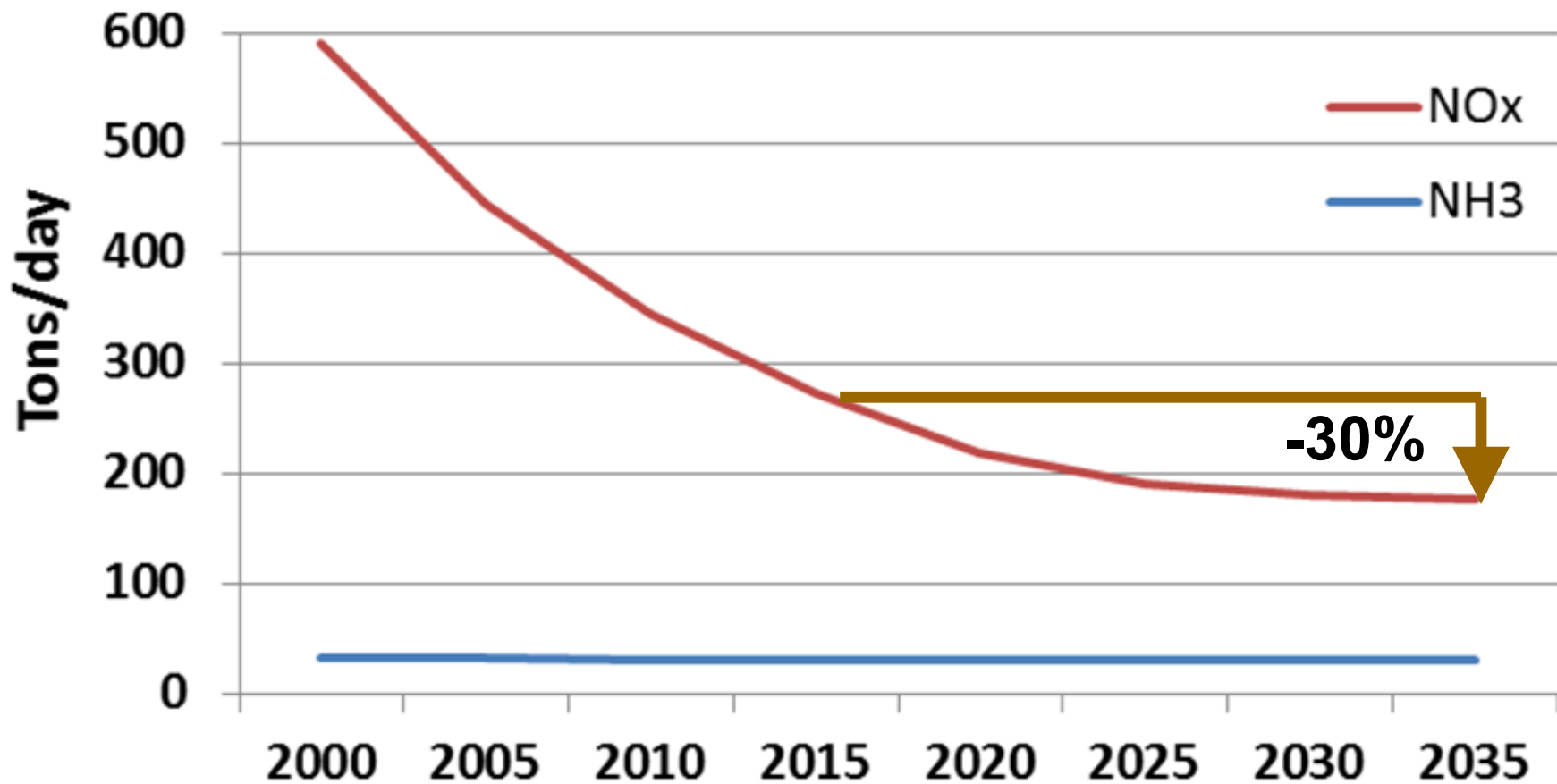
Good News!

Air Quality Regulations Working (but not fast enough)



CARB Almanac of Air Quality

NO_x and NH₃ Trends Bay Area



N

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



Success?
Locally! Regionally? Onward!



Photo: Lech Naumovich



