Nitrogen deposition impacts on a nutrient-poor grassland ecosystem: conservation, management and restoration

> Stuart B. Weiss Creekside Center for Earth Observations



## Serpentinite forms discrete patches of habitat



# Serpentinite weathers to thin, rocky, nutrient-poor soils:

high Mg, Ni, and Cr, low Ca, N, P, and Mo







## **Hostplants and Nectar Sources**



# Rare Endemic Flora







## Problem

In absence of cattle grazing in South Bay, introduced annual grasses overrun habitat within several years (repeatable).

#### Dry deposition – Dominant in California

## Air Pollution Chemistry Simplified





# $HNO_3 + NH_3 - NO_3NH_4(p)$

#### **Fertilizer**, Vehicles

## **Dry Deposition**

- Complex process
- Resistances: Aerodynamic, boundary layer, and surface
- Surface resistance function of composition, wetness, plant cover, and N-species
- Deposition directly to surfaces and/or through stomata
- > Up to 45 kg-N ha<sup>-1</sup> yr<sup>-1</sup> in San Bernardino Mtns, 20-30 kg-N ha<sup>-1</sup> yr<sup>-1</sup> in Riverside

Flux = Dep Velocity X Concentration

## **Passive Sampling**









#### Dr. Andrzej Bytnerowicz, USDA FS Riverside, CA







June Ν 40 NNW NNE NW NE 30 20 WNW ENE W E WSW ESE sw SE SSŴ SSE S Calm 2.1%

December Ν 40 NNW, NNE NE NW 30-20 WNW ENE W Е \_ WSW ESE sw SE SSW SSE s

Calm 11.1%



200 0 200 400 600 800 Feet

Highway 280 carries 100,000 cars per day, often at capacity southbound in AM July 9 2002 - Mar 11 2003



Monthly differences (not shown) follow wind and temperature

July 9 2002 - Mar 11 2003



mm/s	Dry	Wet
HNO <sub>3</sub>	16	16
NH <sub>3</sub>	10	16
NO <sub>2</sub>	0.5	2

## Ammonia from Cars

 $\succ$  Catalytic converters over-reduce NO, when running fuel rich Emissions factor of ~ 0.05 g/km > 1.8 Mg/km for Highway 280 N<sup>15</sup> isotope signature? > Tahoe impacts > Byron lunch



#### **Conservation targets are well-defined**



## Impacts



## Environmental "Train Wreck"

Silver Creek Hills 1990-2000 Extinct Bay checkerspot populations Heavily degraded habitat > Political pressure on USFWS > Lawsuits Development delays Redesign of reserve > Ongoing restoration



## **Metcalf Energy Center Site**



# Metcalf Energy Center (Calpine Corp.)

- > 600 MW gas-fired combined cycle electricity plant
- Emissions ~124 tons NO<sub>x</sub>, ~119 tons NH<sub>3</sub> per year
- Mitigation strategy– Preserve habitat through purchase/easements (131 acres), graze cattle
- > Adaptive management, funded by endowment
- Precedent setting!

#### Worst-case scenario modeling, all emissions as HNO<sub>3</sub>









# Former-future Cisco World Headquarters (now just another office park, CVRP) 230 tons NO<sub>x</sub>/year, ?? ammonia



## Widening Highway 101





Range: 25-60 Mg (metric tons) NO<sub>x</sub> km<sup>-1</sup> yr<sup>1</sup> ~1.8 Mg NH<sub>3</sub> km<sup>-1</sup> yr<sup>1</sup> 669 acres of serpentine for CVRP and Highway 101 Purchase being negotiated (not simple)

Habitat Conservation Plan/Natural Communities Conservation Plan HCP/NCCP for Santa Clara County Process starting, MOU signed

## Local impacts of a freeway





Bay checkerspot habitat (blue outlines) bisected by Highway 280, carrying 100,000 vehicles/day

Prevailing NW winds carry emissions onto core habitat

What effects on habitat and butterfly?

## 9,000 larvae in 1997, The last larva in 2003?





Plant transects established in 2001

Percent cover of all species in 0.5x0.5m quadrats (10/transect)

Soil depth (4) in each quadrat



## Edgewood Patterns 2001

Lolium cover higher on thicker soils (more nutrients/water available), Plantago opposite





Range: 25-60 Mg (metric tons) NO<sub>x</sub> km<sup>-1</sup> yr<sup>-1</sup> ~1.8 Mg NH<sub>3</sub> km<sup>-1</sup> yr<sup>-1</sup>

## **Restoration Experiments**

- Small-scale (700 m<sup>2</sup>), replicated
- > Fire Cancelled twice, sorry
- Mowing Effective, known costs and technology
- > Goat grazing Expensive, not as effective

Seeding Plantago appears unecessary

> Reintroduction of butterfly in 3 -5 years



White-rayed Pentachaeta at long-term risk? Only known occurrence West of 280 across from Edgewood Preserve, avoids first 75 meters from freeway



## Problem is not going away soon

NO<sub>x</sub> Emissions



2001 California Almanac of Emissions and Air Quality Ammonia emissions likely to get worse

## Problem is across California



#### 2001 California Almanac of Emissions and Air Quality

#### Other unique CA habitats at risk?

> Annual Grass Invasions – CSS, Desert, Serpentine grassland > Other grasslands > Lake Tahoe, alpine lakes Vernal pools –Lolium invasions in unmanaged vernal pools Forests and shrublands Statewide screening – CEC funded project







## Acknowledgements

- Calpine Corporation
- Waste Management, Inc.
- National Fish and Wildlife Foundation
- Center for Conservation Biology
- > USFWS
- San Mateo Co. Parks and Recreation
- California Native Plant Society, Santa Clara Valley Chapter
- Generations of checkerspot butterfly researchers
- Generations of serpentine grassland researchers
- > Air pollution scientist community

