Source Water Protection: Dairies, Irrigated Agriculture, and Groundwater

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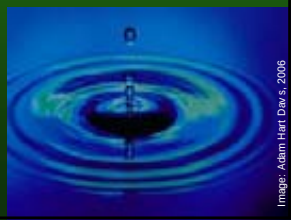
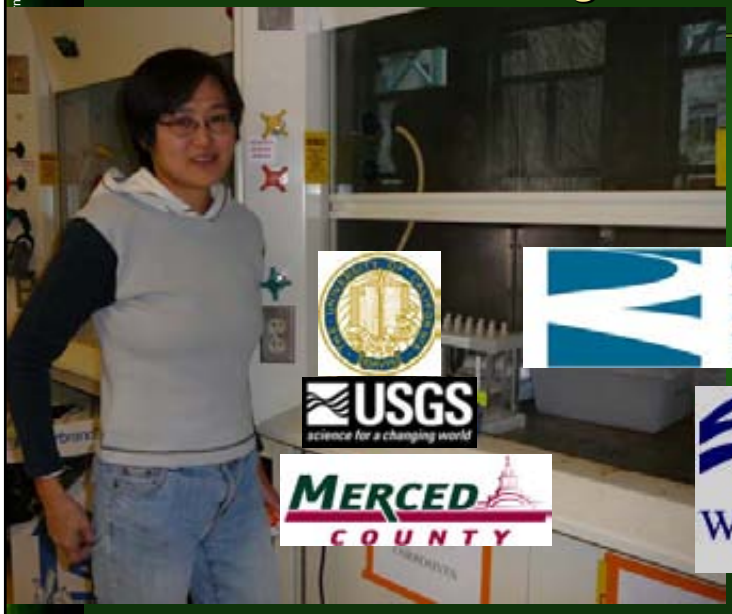


Image: Adam Hart Davis, 2006

nia, Davis, 2009

Acknowledgments



funding provided by:

CALFED BAY-DELTA PROGRAM

USGS science for a changing world

MERCED COUNTY

Water Boards

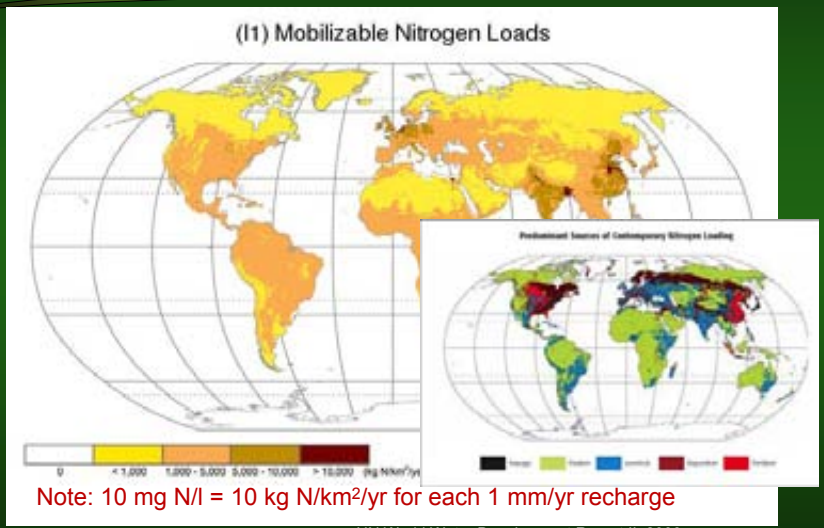
Motivation

- Worldwide dependence on groundwater
  - 2 3 billion people
  - > 60% of gw use towards farming in arid/semi arid regions
- Surge of groundwater use over past 50 years (turbine pump, cheap energy, food demands)
- Increasing intensity of landuse (crops, animals, industry, urban)

↑ dependency on gw & ↑ contamination

SUSTAINABILITY?

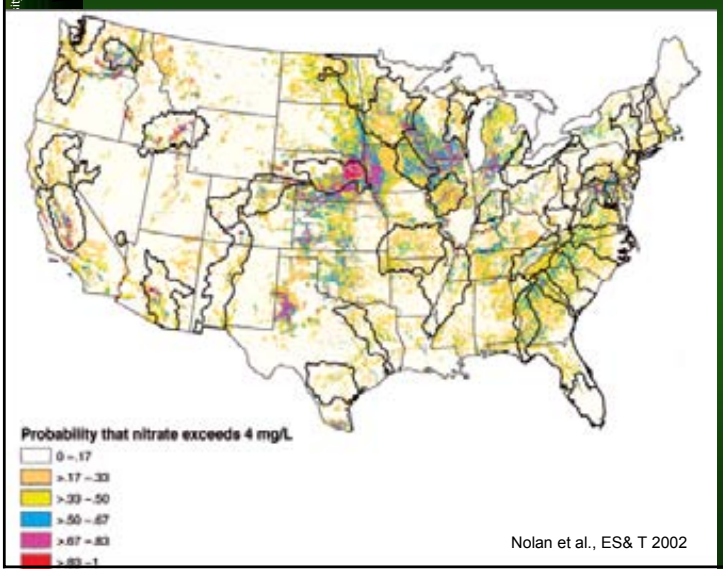
Pervasive GW Pollutant: NO_3



Note: 10 mg N/l = 10 kg N/km²/yr for each 1 mm/yr recharge

UN World Water Development Report II, 2006

Nitrogen Load: Risk Analysis



Nolan et al., ES& T 2002

Based on logistic regression model:

- N loading
- % cropland or pasture
- Human population density
- Well drained soil
- Sand/gravel aquifer
- Depth to gw

Integrated GW Resources Mgmt

LOAD

Education

Technical Measures

- Resource evaluation
- Hazard assessment
- Pollution control
- Pollution assessment
  - Geochemistry
  - Microbiology
  - Transport / Physics & Geology
  - Monitoring

Aquifer Systems:
Quantity
Quality

Institutional Measures

- Water rights
- Discharge regulations
- Landuse planning
- Economic incentives
- Local/regional planning and management
- Stakeholder interests

Ecosystems & Landuse Systems:
Demand (Quantity)
Usability (Quality)

Stakeholder Participation

USE

Perspectives on NPS Pollution for Successful Source Protection

- Understanding NPS Sources
  - here: dairies/(C)AFOs]
  - source control
  - management practices
- Understanding pollutants
  - physics/chemistry of environmental fate
    - Transport
    - Sorption
    - Degradation
  - analytical methods
  - assessment models
- Policy
  - regulatory programs
  - management programs
  - role of monitoring / feedback

Agricultural NPS Pollutants

- Salinity
- Nitrate
- Pesticides
- Emerging contaminants in animal farming:
  - Pathogens (*E. coli* H7 O157, *Campylobacter*, *Salmonella*, *Cryptosporidium*)
  - Antibiotics & other pharmaceuticals
  - Steroid hormones

The Federal Framework in California

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA, 1972)

* registration of pesticides
* use of pesticides

Dep. Pesticide Regulations

Water Well Standards

Dep. Water Resources

California Environmental Quality Act, CEQA;

Porter-Cologne Act

SWRCB / RWQCB / local

Safe Drinking Water Act, 1974

* drinking water standards
* wellhead protection program
* source water assessment
* source water protection
* annual reporting to customers

Dep. Health Services

Clean Water Act, 1972

* point source (NPDES
* nonpoint source regulation
* BMP mandate
* TMDL (total max. daily load)

State Water Resources Control Board & Regional Water Res. Control Boards

[Porter-Cologne Water Quality Control Act]

The Federal Framework in California

Superfund (CERCLA, 1980)

* cleanup and cost recovery program for contaminated groundwater sites

Dep. Toxic Subst. Control & Regional Water Res. Control Boards

Resource Conservation and Recovery Act (RCRA, 1976)

*cradle to grave monitoring of hazardous substances
* guidelines for managing nonhazardous waste facilities
* mandates standards for all handlers of hazardous waste (generators, transporters, and treatment, storage, and disposal facilities ("TSDFs"))

Dep. Toxic Substances Control

Toxic Substances Control Act (TSCA, 1976)

* registration program for toxic substances (other than pesticides)

Dep. Of Toxic Substances Control

Major Water Quality Regulations related to Farming

USDA:
Comprehensive Nutrient Management Plans
(guideline only
farm / field scale

EPA:
Permit Nutrient Plans
(under revised NPDES regulations
farm / field scale

CWA:
Effluent limitation guidelines
(under revised NPDES regulations
farm scale

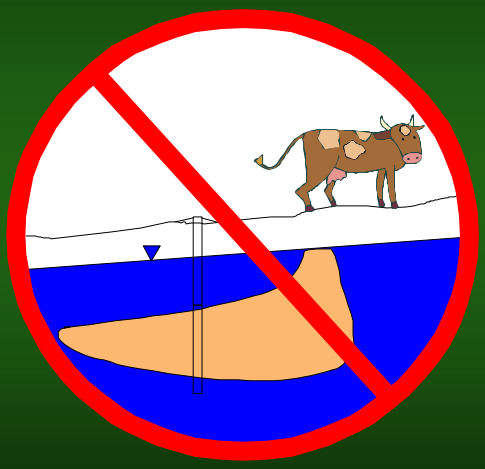
NEPA/CEQA:
EIR process for new permits
field / subfield scale

CWA: TMDLs
watershed scale

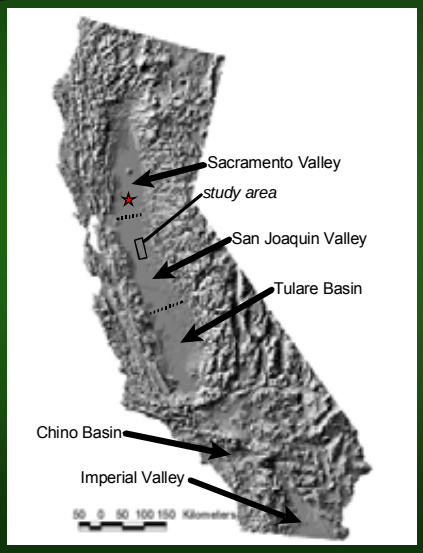
FIFRA:
pesticide use
farm / field scale

12/2002 sunset of 1982 CEQA a effluent waiver (Porter-Cologne
* waste dicharge requirements (e.g. dairy WDR)
* waiver of waste discharge (e.g. Irrigated Lands Conditional Waiver
* salt / nutrient basin plans
farm / field scale

Understanding GW NPS Pollution: The Challenge



Farm Contaminant Sources: Basin Scale



- Geology
- Landuse
- Climate

Irrigated Agriculture as N Source

Irrigated Acreage (Year 2000): 9.5 million acres

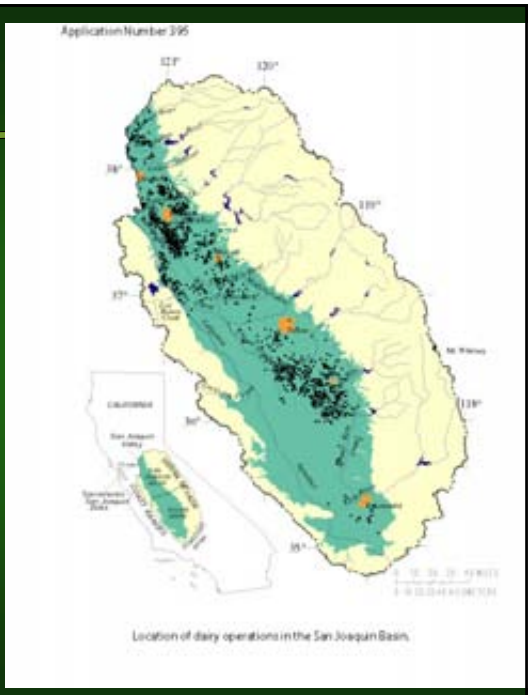
Water Use: 27 – 35 MAF

N fertilizer Use (2007): 740,000 tons On 6.7 million acres + 240,000 tons field applied from dairy animal manure

MAF = million acre feet

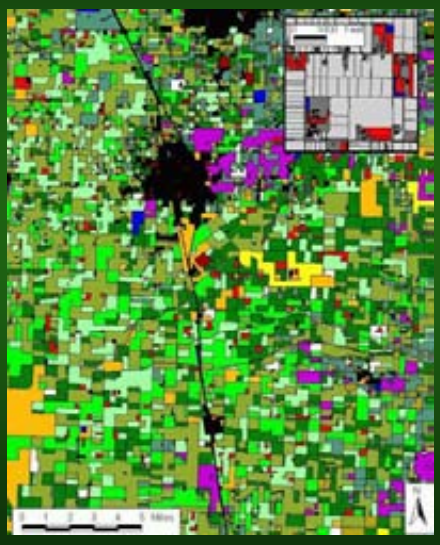
Dairies in the San Joaquin Valley

- ~1,500 dairies
- ~1.5 million milking cows
- trend to > 2 million milking cows
- additional support stock: 1.5 million
- 1 cow = 20 – 40 humans in waste production (solids, BOD, N)



Location of dairy operations in the San Joaquin Basin.

Farm Contaminant Sources: Regional Scale



- Source of N (2007):
  - Fertilizer use (varies with farm / farming practices) *740,000 tons*
  - Animal Manure *240,000 tons*
  - Septic leach fields *27,000 tons*
  - Irrigation water source & mgmt.
  - Treated municipal effluent *31,000 tons*

Farm Contaminant Sources: Dairy Farm Scale

Sources of N:

- Feedlot
- Lagoon
- Storage areas
- Manured fields
- Fertilized fields
- Various crops
- Septic system

Overview of dairy farms

Milking parlor

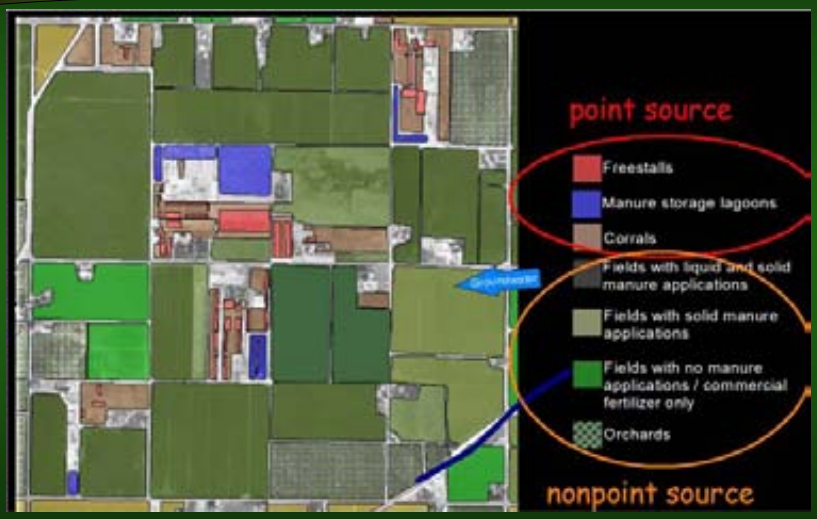
hutches

Figu

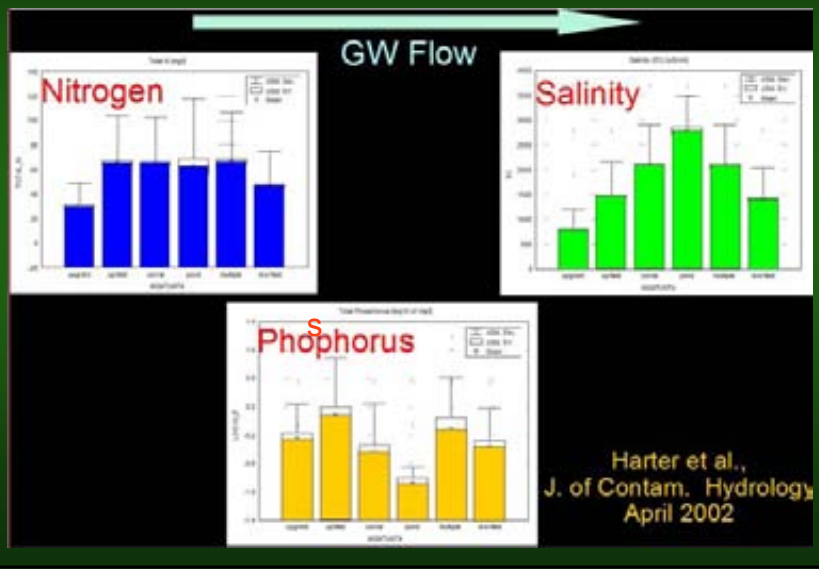
Dairy Nutrient Cycling

- http://www.youtube.com/watch?v=G6QliWbvBwI
- http://ucanr.org/spotlight/groundwater.shtml

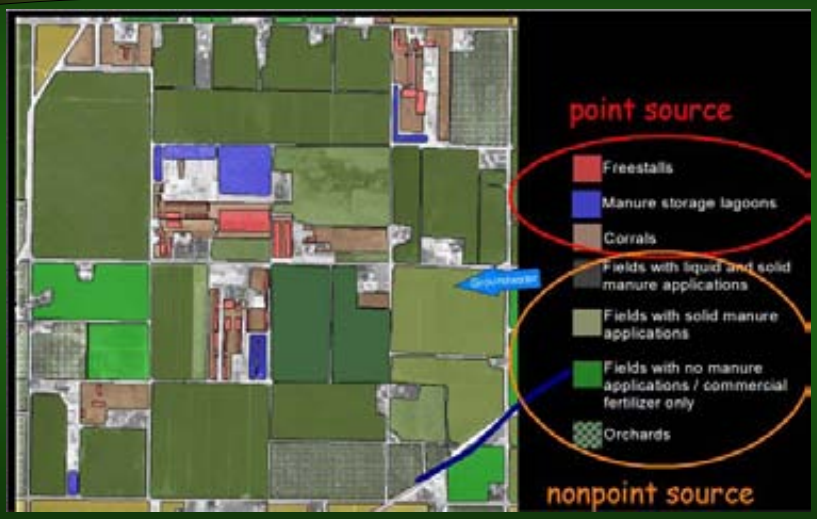
Dairy Farm Contaminant Sources: Management Units



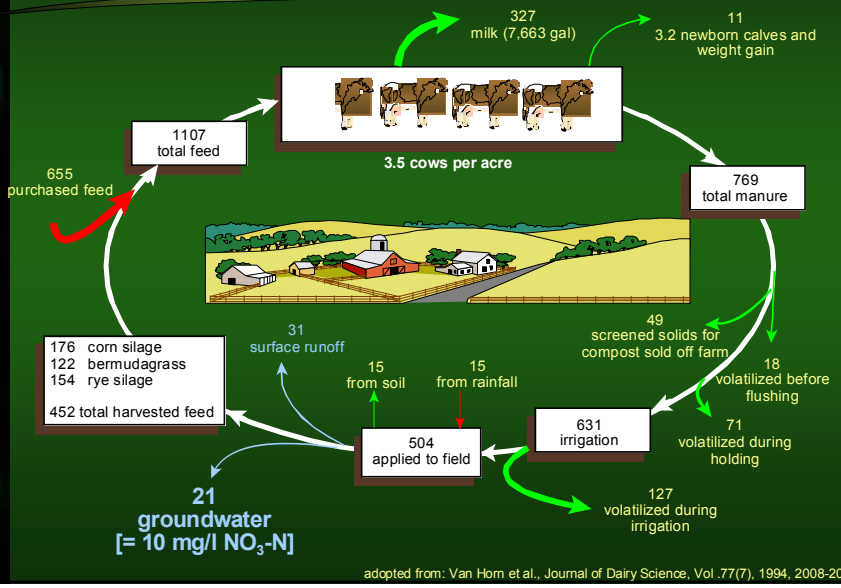
Statistical Analysis: By Management Unit



Dairy Farm Contaminant Sources: Management Units



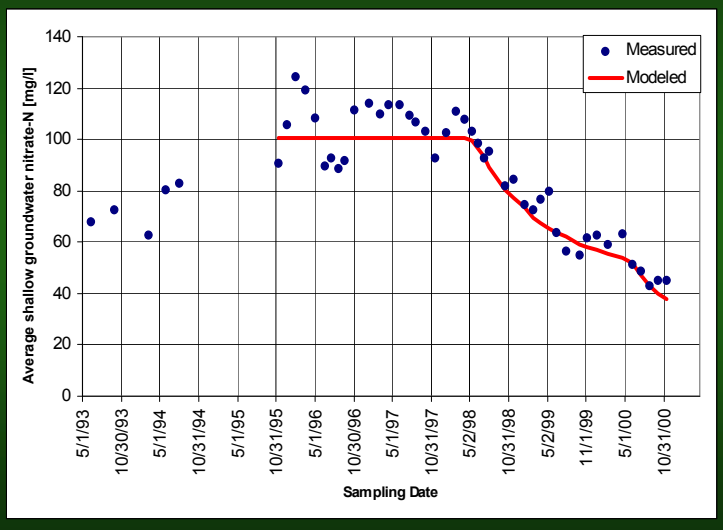
Farm Nutrient Management



adopted from: Van Horn et al., Journal of Dairy Science, Vol .77(7), 1994, 2008-2030

Nitrogen Management Case Study

NMPs: Balancing Nitrogen Application and Uptake



for publications: http://groundwater.ucdavis.edu/gw_201.htm

Central Valley Regional Water Quality Control Board
Dairy Waste Discharge Requirements

- Preliminary Dairy Facility Assessment
  - Existing nutrient management
  - Existing waste management conditions
  - Existing water quality conditions
- Nutrient management plan (crop land)
- Waste management plan (animal facilities, waste storage facilities)
- Groundwater monitoring