

**GIS Analysis of Nitrate in Oregon  
Domestic Wells:  
Capturing Exposure through Innovative  
Drinking Water Policy**

Brenda Hoppe  
Oregon State University  
Office of Environmental Public Health  
Department of Human Services

# Private Wells in Oregon

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- Over 350,000 private wells in Oregon (DEQ, 2009 Report to the Legislature)
- 23% of Oregon's population
- Given population growth forecasts, will likely increase

# Dilemma of Private Wells

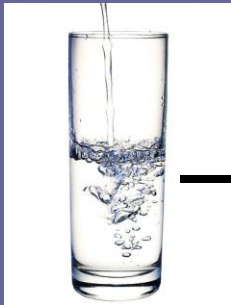


- SDWA ensures quality of public systems ONLY
- Challenge: Private wells are PRIVATE
  - “Off the Grid”
  - Owner resistance to compulsory testing
  - Concerns about property sales
- Concern is warranted due to widely documented GW contamination

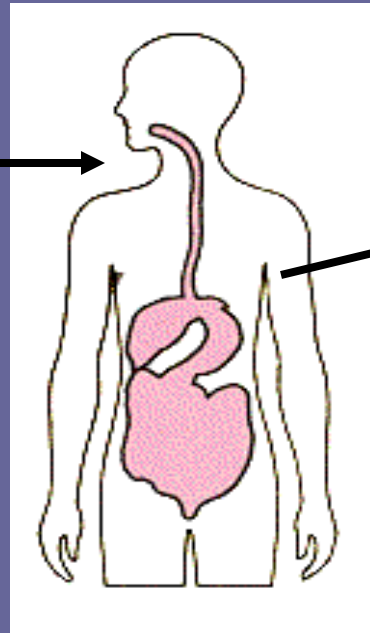
# Nitrate: Most Widespread Contaminant



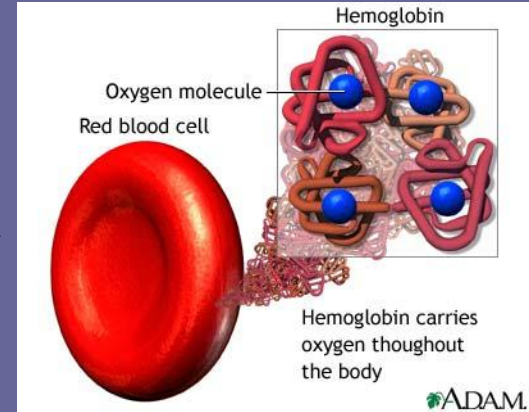
- MCL is 10 mg/L (ppm)
- Established to protect infants from methemoglobinemia
- Other concerns include:
  - Noncancer: thyroid hormone disruptions, diabetes, adverse reproductive outcomes, acute respiratory infections
  - Cancer: non-Hodgkin lymphoma, colon, renal, bladder, ovary



nitrate



Reduced to nitrite



Oxidizes Hb

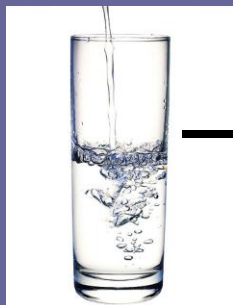


>10%

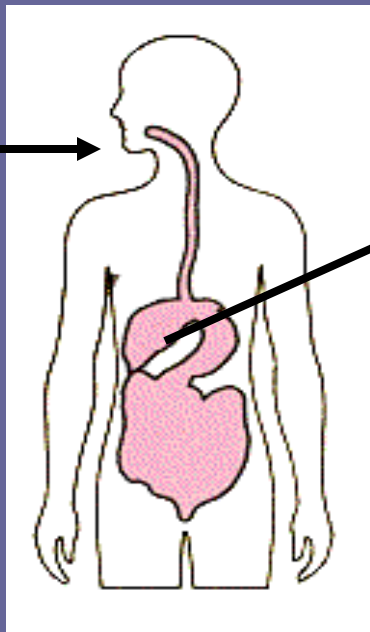
MeHb

Methemoglobinemia



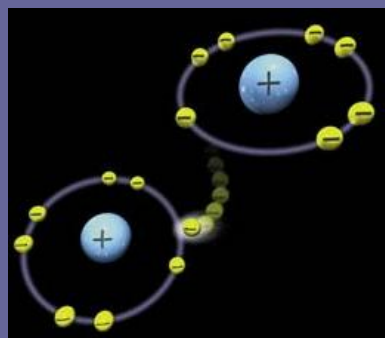
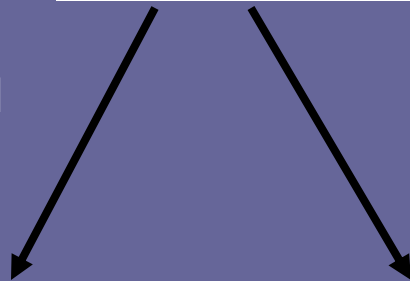


nitrate

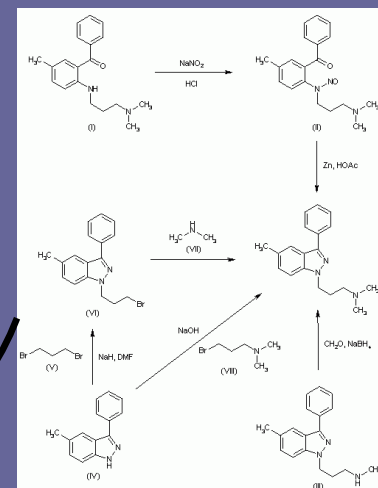


# Nitrosation

Reduced to nitrite



Free radicals of NO and O<sub>2</sub>



N-nitroso compounds

**CANCER**

**BIRTH DEFECTS**

**DIABETES**

**ACUTE RESPIRATORY INFECTIONS**



# Microorganisms: Also Widespread



- Bacteria, viruses, fungi, and parasites
  - GI illness (diarrhea, vomiting, cramps)
- Major source of contamination is fecal material
  - Animals
  - Humans
- Detect fecal contamination by analyzing total coliforms
- **MCL for total coliforms is zero**

# Arsenic (Inorganic)



- Affects most organs
- Noncancer: skin abnormalities, high blood pressure, cardiovascular disease, anemia, diabetes, reproductive effects
- Cancer: skin, lung, bladder, kidney, liver, prostate
- **MCL is 10 ug/L (ppb)**





Oregon has made strong efforts to monitor groundwater in our state

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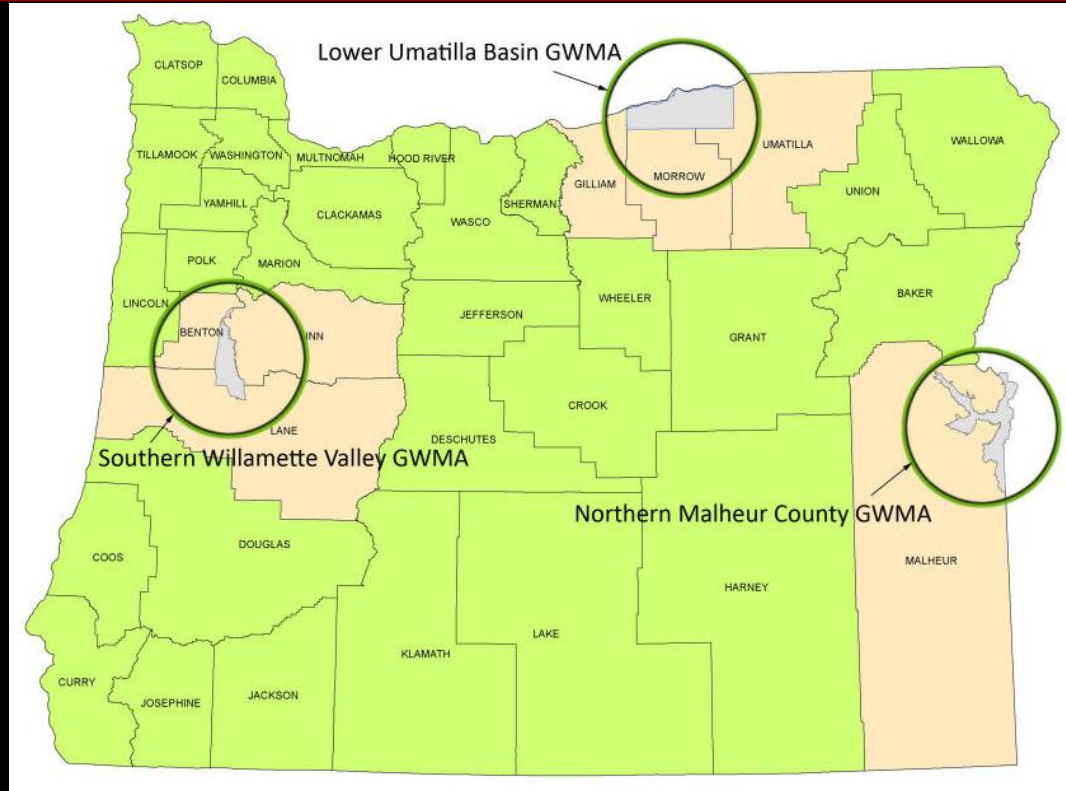


# Groundwater Quality Protection Act

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- DEQ given a range of GW protection responsibilities
- Requires GWMA designation if an area has elevated contaminant levels from non-point sources
  - For nitrate, if concentrations exceed 7 mg/L
  - Stakeholder Committee formed, voluntary action plan developed, some education outreach occurs

# Oregon currently has 3 GWMA's



Declared for widespread nitrate contamination

# Domestic Well Testing Act



- Requires that an owner of a property with a private well must test for **nitrate** and **coliform** if the property is being sold or changing ownership
- 2009 amendment adds **arsenic**
  - Results must be reported within 90 days to buyer and DHS
- Also allows DHS to require additional testing in “specific areas of public health concern”

# Purpose of DWTA



- NOT intended as a Public Health initiative
- “...establishes a program to provide water quality monitoring of underground aquifers...”
- No provision for enforcement
- Sale is NOT contingent on testing

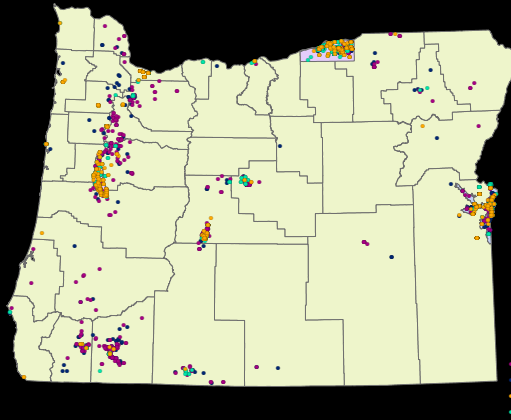
# Testing & Data Submission

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- Seller submits results and reporting form to DHS
  - Property address, owner name, well ID and depth, info on who sampled, and if buyer notified
- DHS sends to DEQ
- DEQ enters data into the RET database (2004)
  - Data available 1989-2008

# Spatial/Statistical Analysis of RET data

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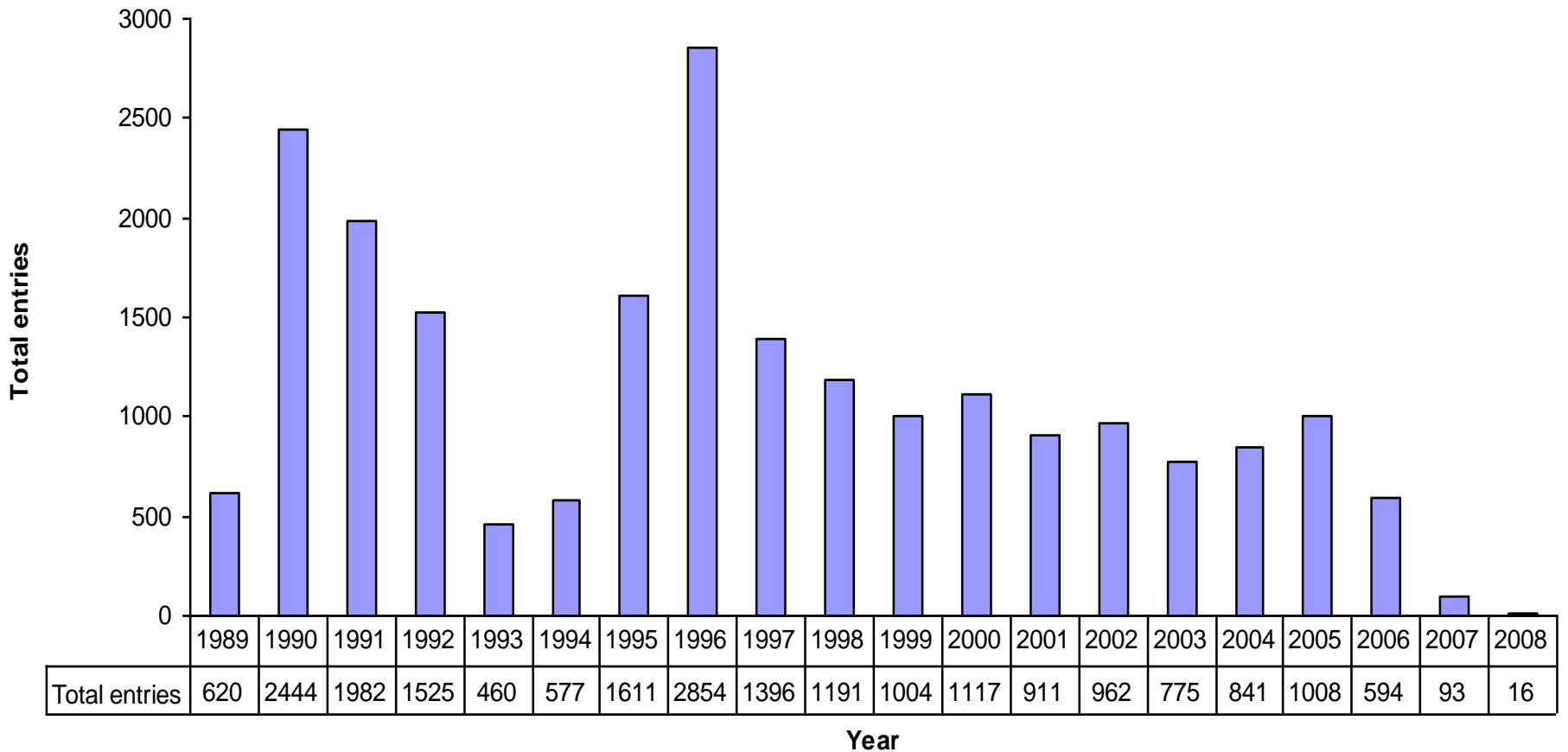
# RET Analysis

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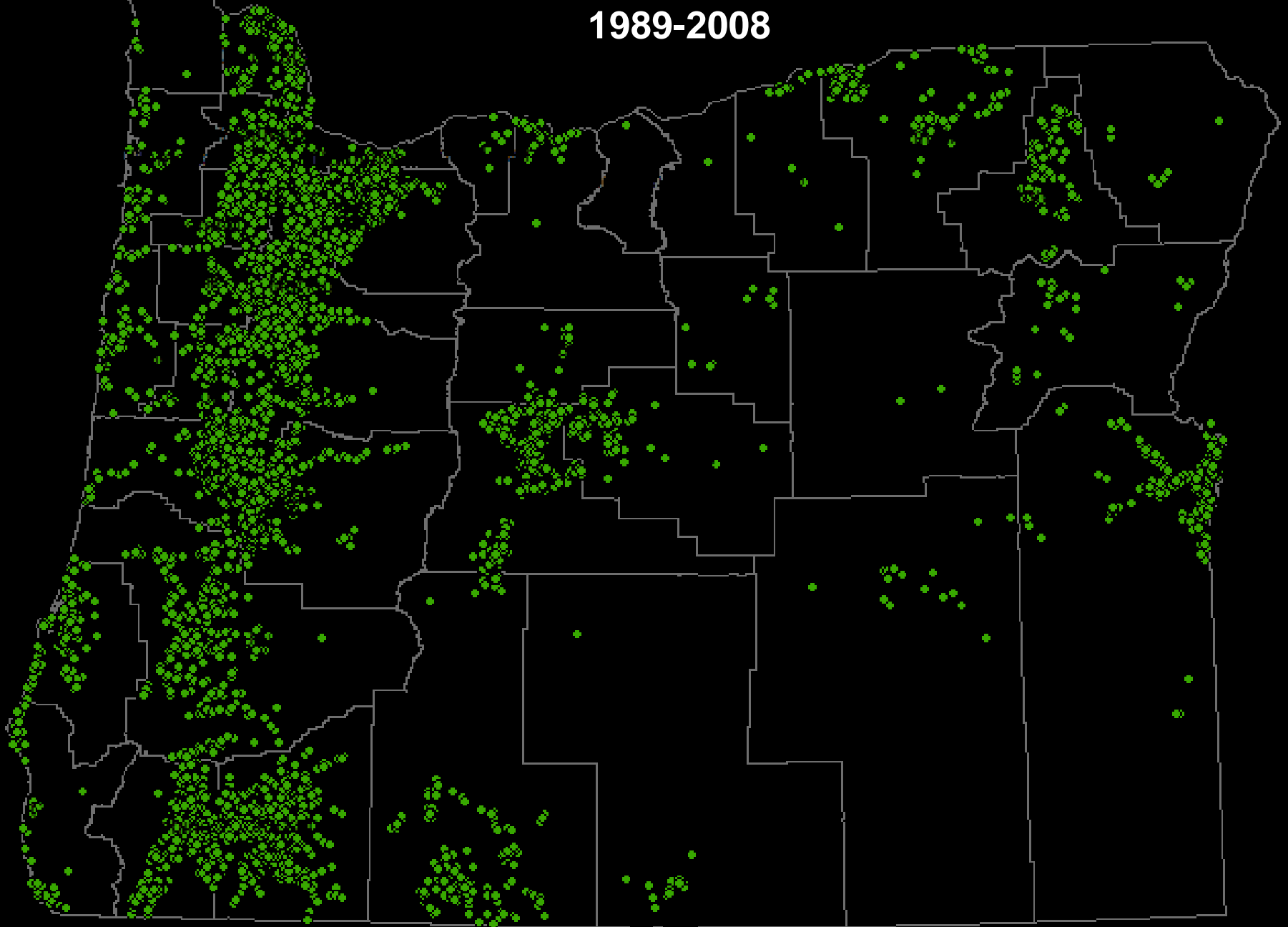
- Data accessed via Pacific NW Water Quality Data Exchange (PNWWQX)
- Nitrate: 2 categories of interest
  - 7-9 mg/L (GWMA trigger level)
  - $\geq 10$  mg/L (MCL)
- Coliform bacteria
- Prevalence, spatial distribution, population growth estimates, demographics



# RET Analysis Results, 1989-2008



# Locations of All Private Wells Listed in the RET Database 1989-2008

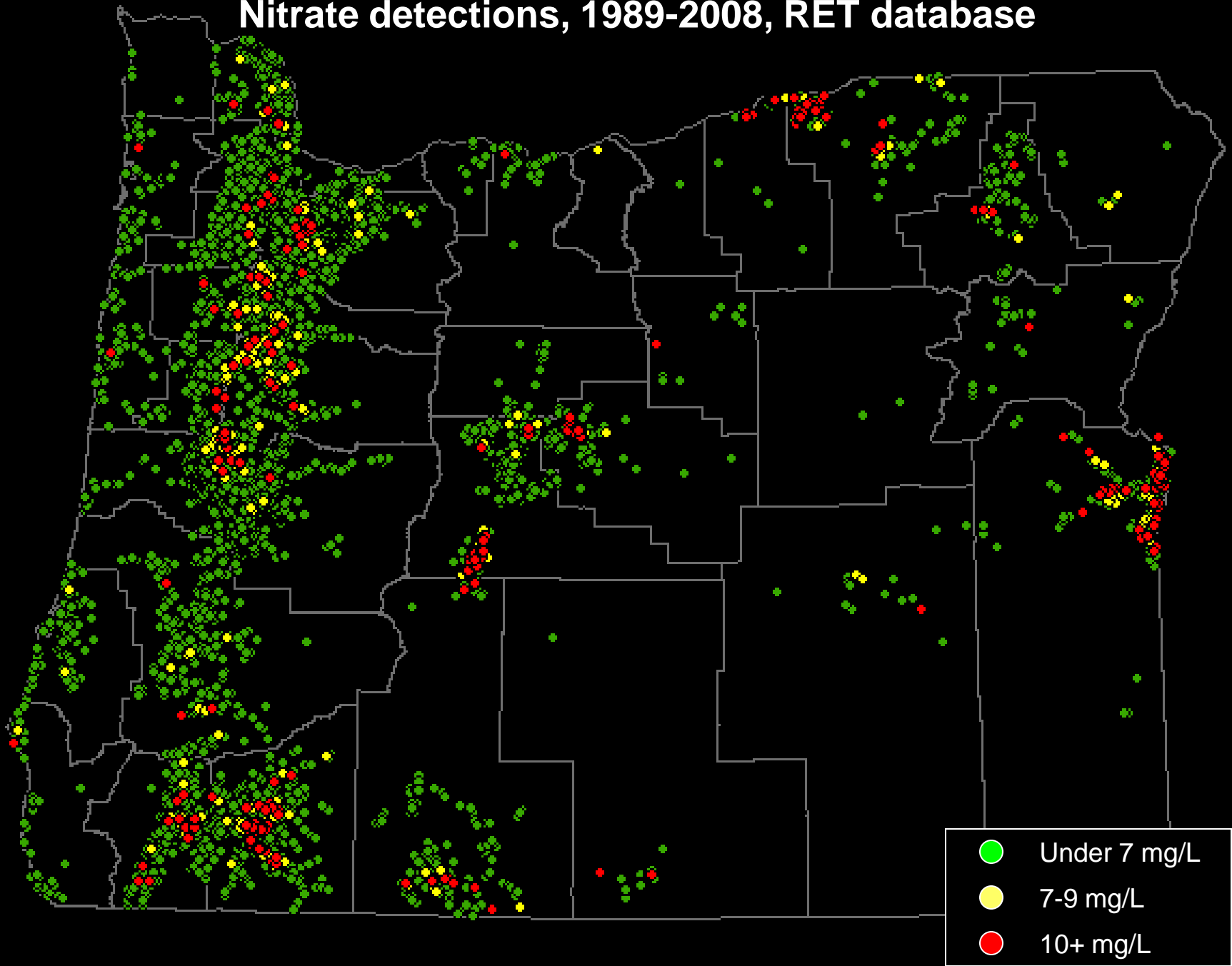


# RET Analysis Results, 1989-2008

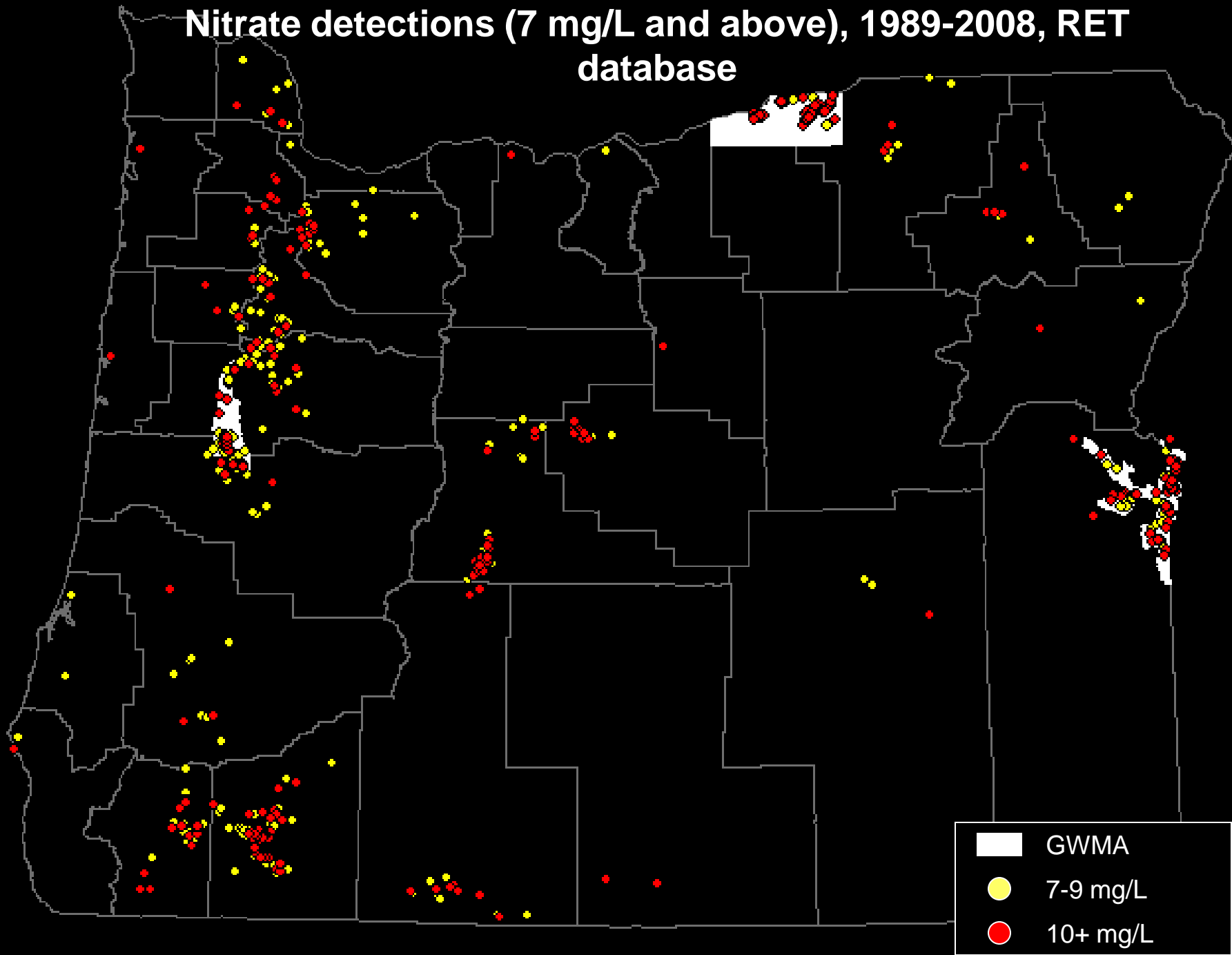
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- 7-9 mg/L: **421 (2.3%)**
  - Range: 6.45 – 9.43
  - Median: 7.52
  - Mean: 7.7
- 10+ mg/L: **343 (1.8%)**
  - Range: 9.47 -118
  - Median: 13
  - Mean: 16.1
- DEQ 2004 summary, 1989-2003
  - 1.7% above 10 mg/L
- Total (positive) coliform: **3551 (19%)**

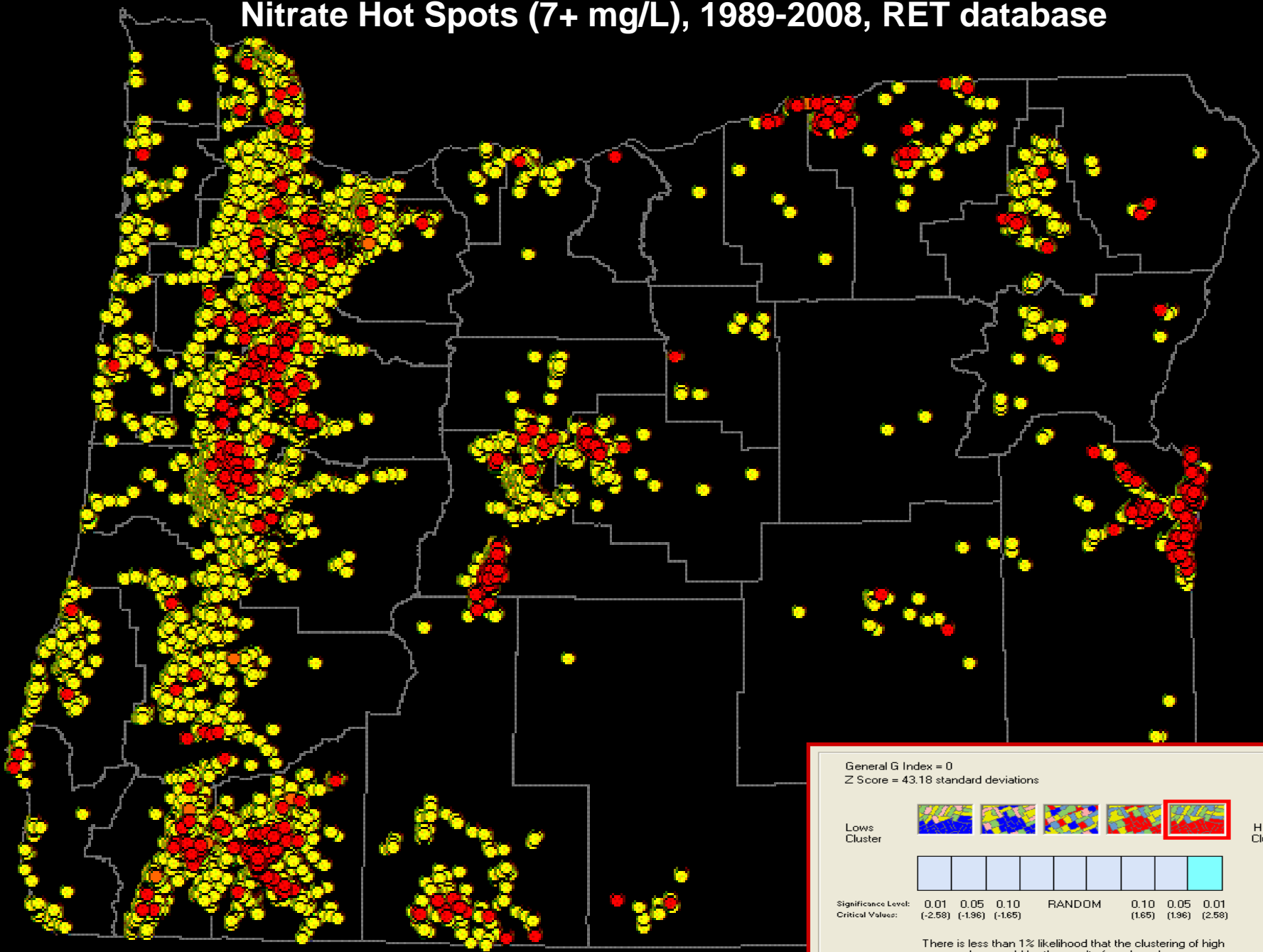
# Nitrate detections, 1989-2008, RET database



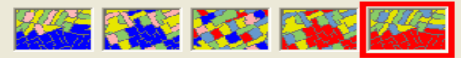
# Nitrate detections (7 mg/L and above), 1989-2008, RET database



# Nitrate Hot Spots (7+ mg/L), 1989-2008, RET database



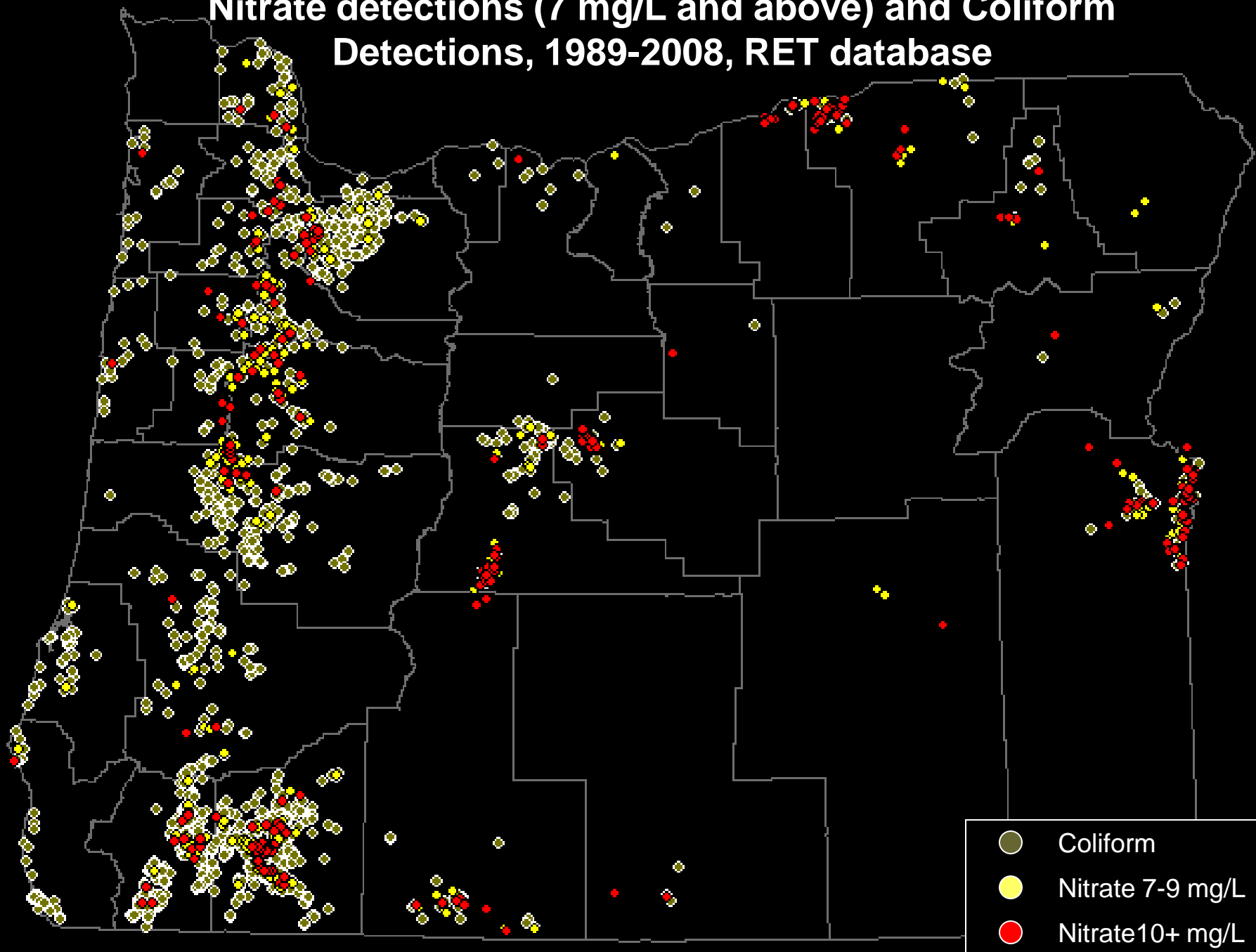
General G Index = 0  
Z Score = 43.18 standard deviations

Lows Cluster  Highs Cluster

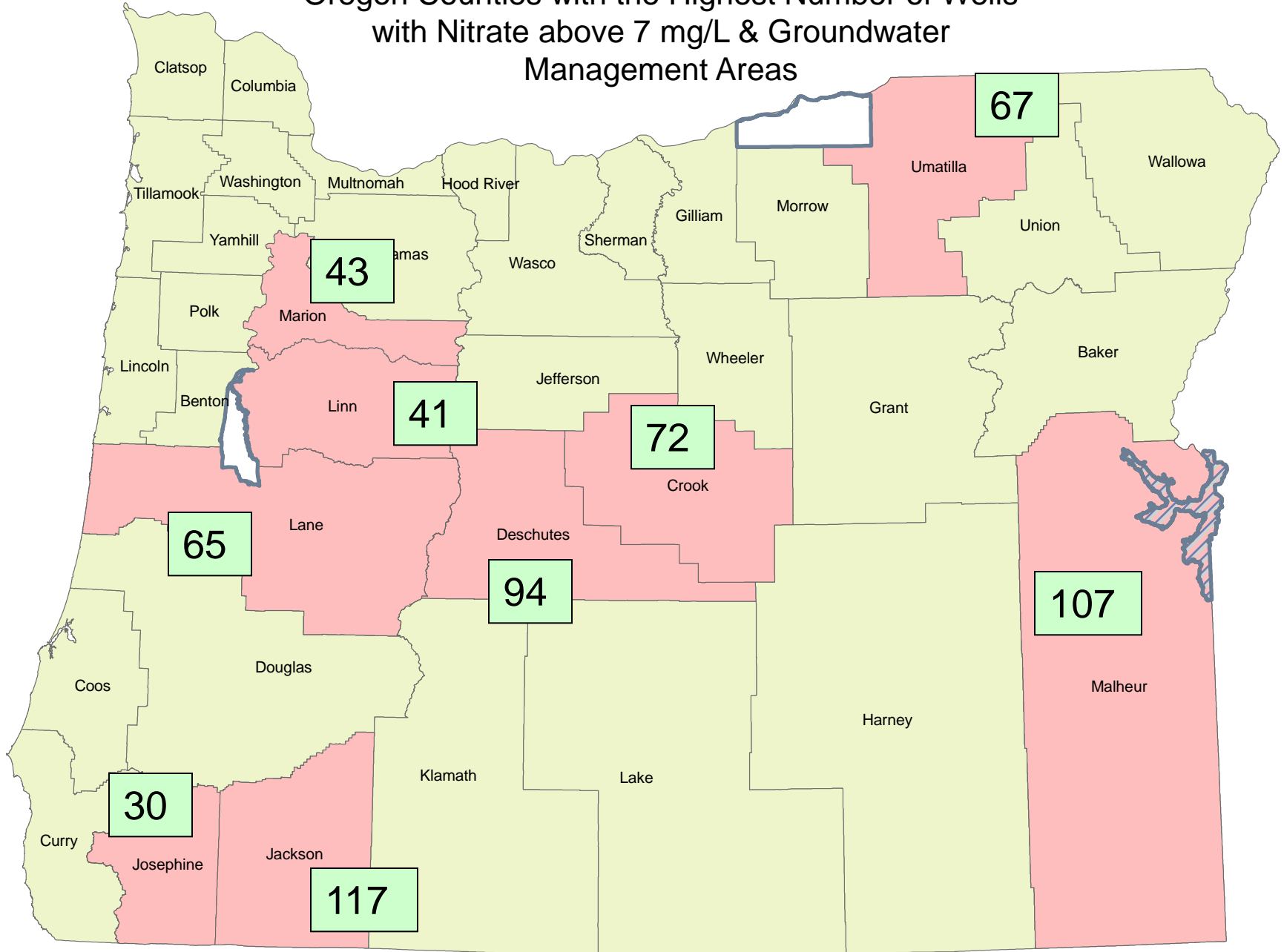
Significance Level: 0.01 0.05 0.10 RANDOM 0.10 0.05 0.01  
Critical Values: (-2.58) (-1.96) (-1.65) (1.65) (1.96) (2.58)

There is less than 1% likelihood that the clustering of high values could be the result of random chance.

# Nitrate detections (7 mg/L and above) and Coliform Detections, 1989-2008, RET database

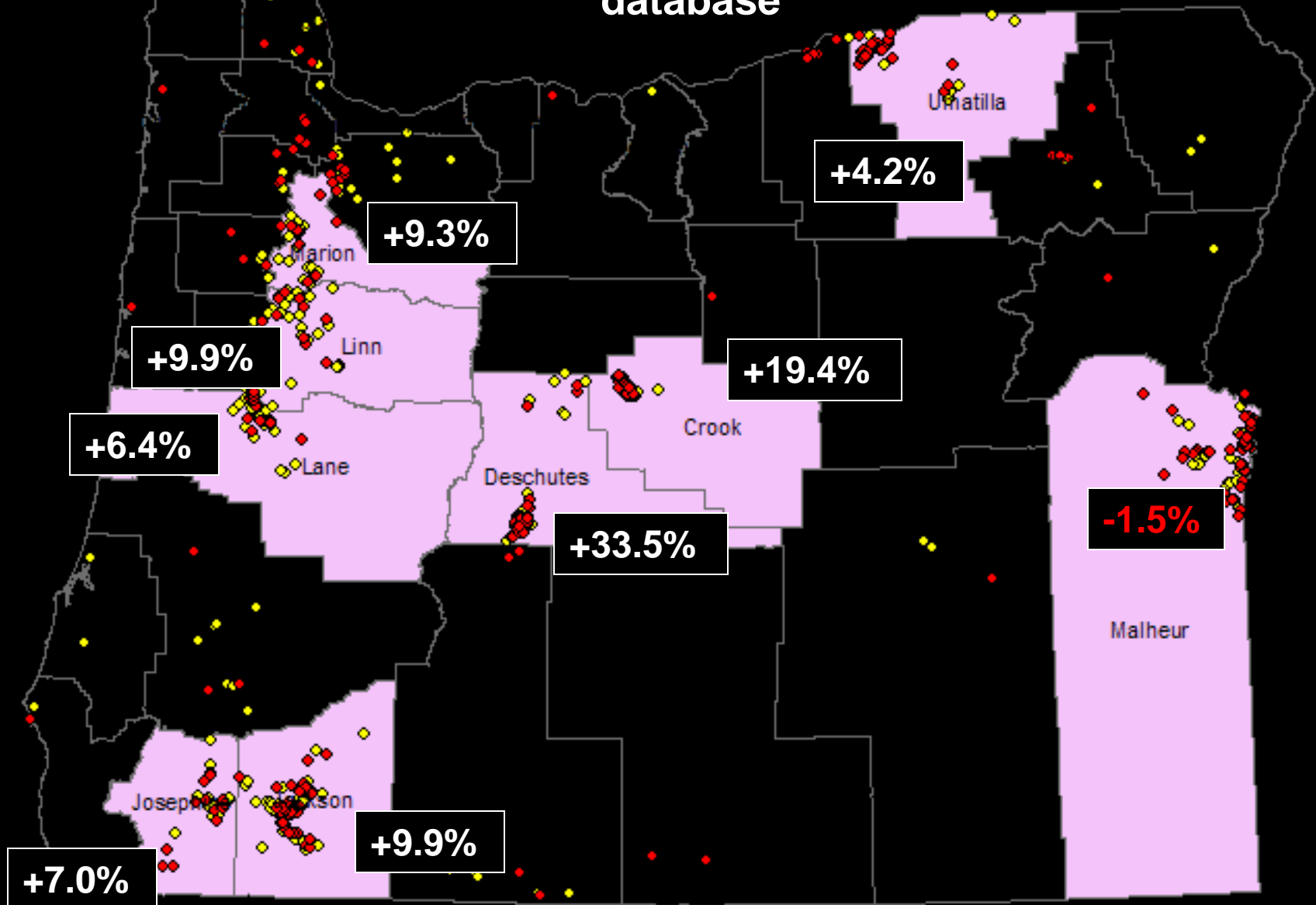


# Oregon Counties with the Highest Number of Wells with Nitrate above 7 mg/L & Groundwater Management Areas



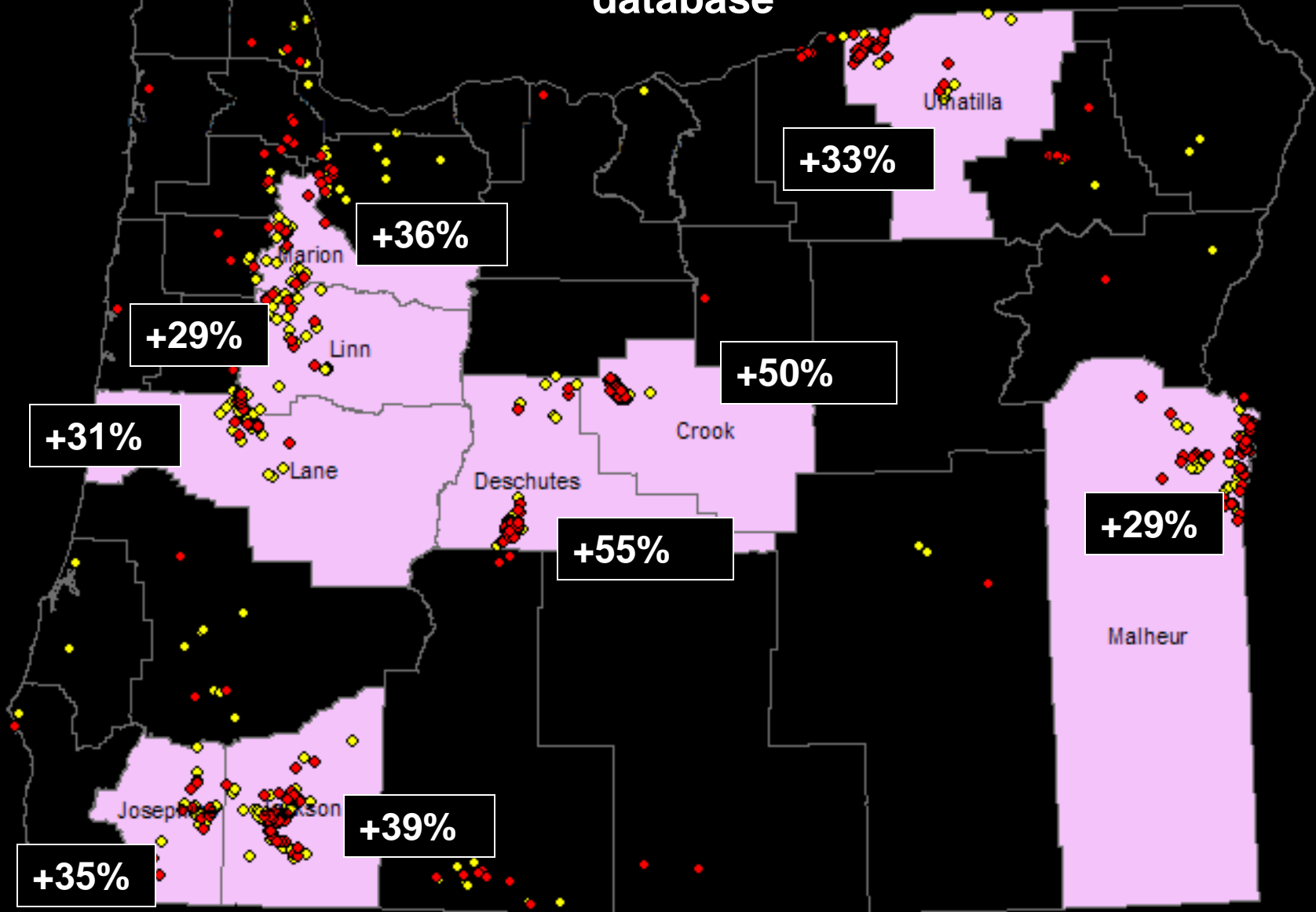


# Nitrate detections (7 mg/L and above), 1989-2008, RET database



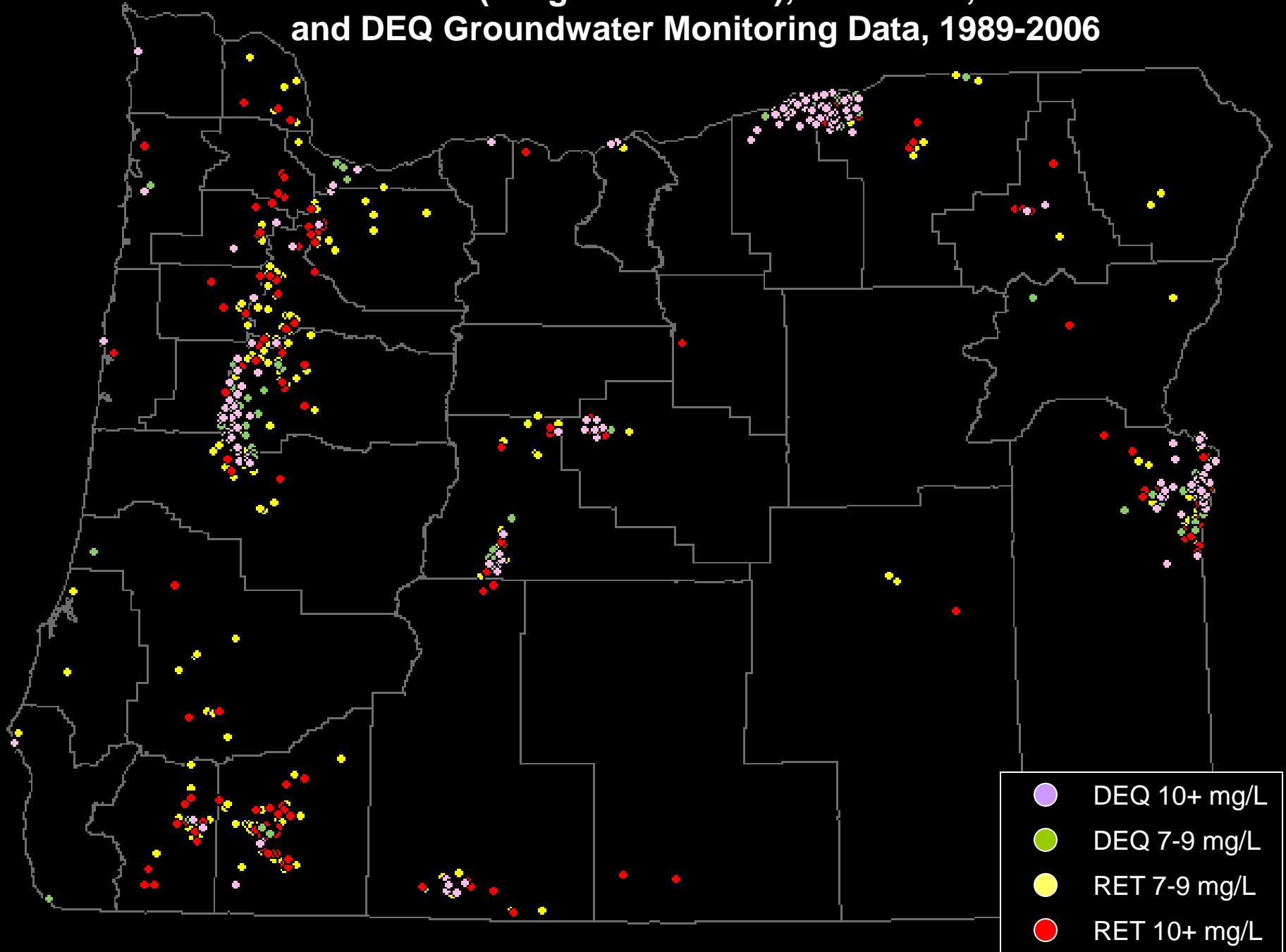
**% Population Growth, 2000-2007 (State average = 9.5%)**

# Nitrate detections (7 mg/L and above), 1989-2008, RET database

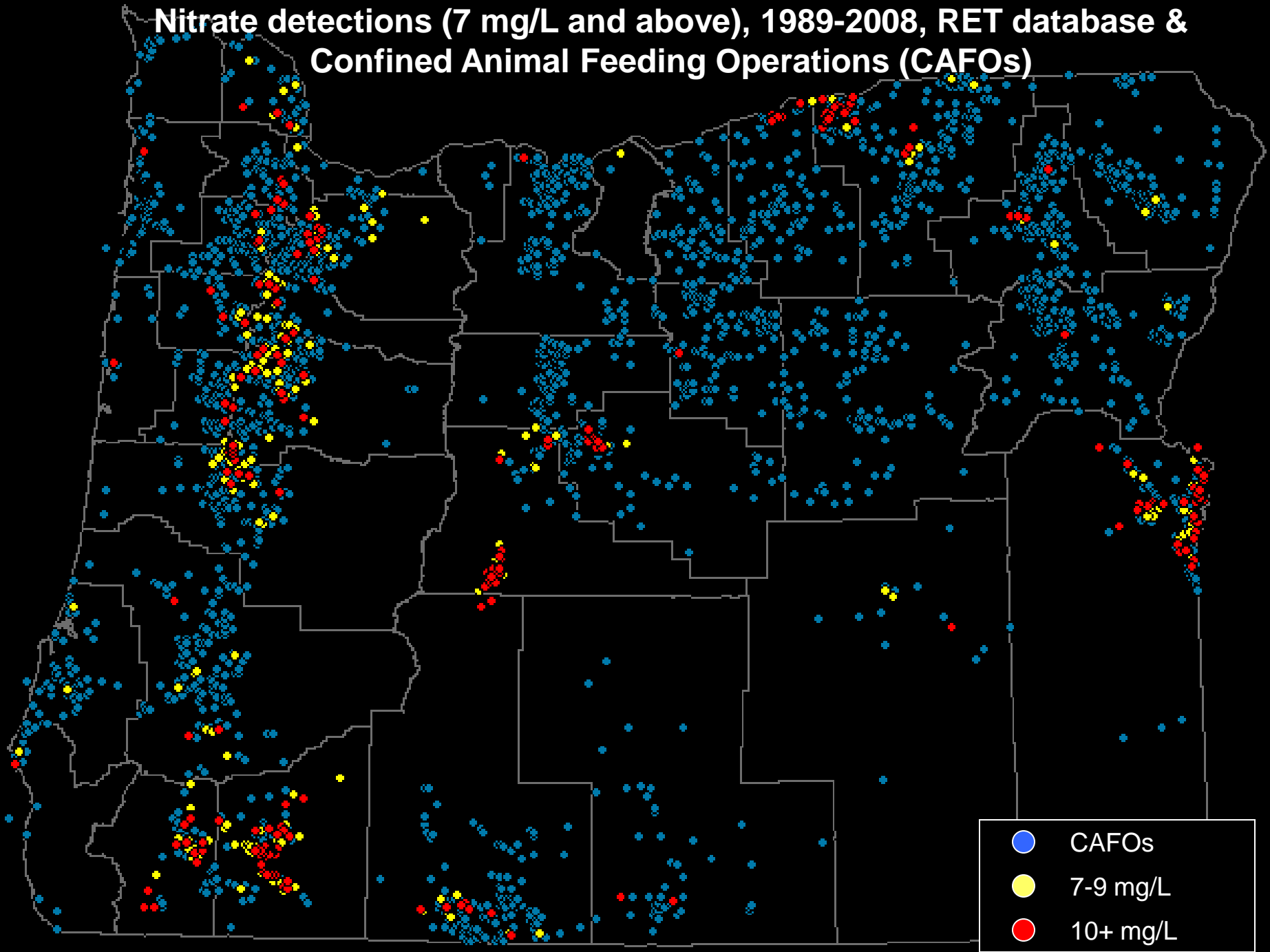


**% Population Forecast, 2000-2040 (State average = 37%)**

**Nitrate detections (7 mg/L and above), 1989-2008, RET database  
and DEQ Groundwater Monitoring Data, 1989-2006**



# Nitrate detections (7 mg/L and above), 1989-2008, RET database & Confined Animal Feeding Operations (CAFOs)



# Are we getting our money's worth out of this policy?

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- If each sampling/testing effort costs ~\$80, averages out to 93K per year since 1989
  - Is the cost worth the benefit of having this data?
  - Cost will increase with As



# New Jersey's PWTA: Gold Standard

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- Passed in 2001, rules amended 2008
- Fundamental difference is in underlying goal of the two laws
  - GW quality monitoring vs Consumer right-to-know



# New Jersey's PWTA

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- Sale IS contingent on testing
- Flexible: seller or buyer takes responsibility
- Results are confidential (subject to discretion of local agencies)
- Electronic submission to database direct from labs
- Relevant to landlords as well
- No requirement to remediate but NJDEP will respond with information
- Much longer analyte list (includes lead and VOCs)
- Analytical reports released every four years

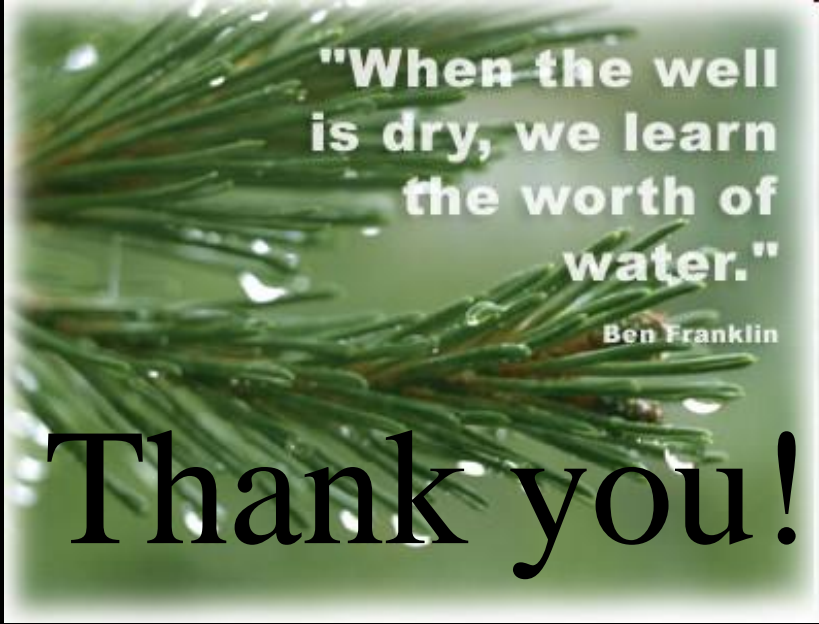
# Lessons learned for Oregon

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- New Jersey's RET law and program = greater compliance = more reliable monitoring data
  - Can focus outreach to affected areas
  - DHS can investigate link between exposure and disease

**DHS relies on good quality data to focus agency efforts and resources to do the best job we can of protecting the health of Oregonians.**





"When the well  
is dry, we learn  
the worth of  
water."

Ben Franklin

Thank you!

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Brenda Hoppe

[Brenda.hoppe@state.or.us](mailto:Brenda.hoppe@state.or.us)

Questions?