Water Insecurity in Oregon

Water System Nitrate Levels & Social Disparities
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Environmental Public Health
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WATER INSECURITY LITERATURE

DATA COLLECTION

EVIDENCE

- Socioeconomic status, race/ethnicity and drinking water violations
- Water service access
- Water service reliability

METHODS

- Household Water insecurity
- Water scarcity variability mapping
- Safe Drinking Water Act exceedance and compliance mapping (California)

INDICATORS

- Water Poverty Index
- Framework to evaluate human right to water (California)

POLICY

- California Human Right to Water (Assembly Bill 685, 2012)

STEP 1

- Developing the evidence base
- Quantifying the burden of water insecurity

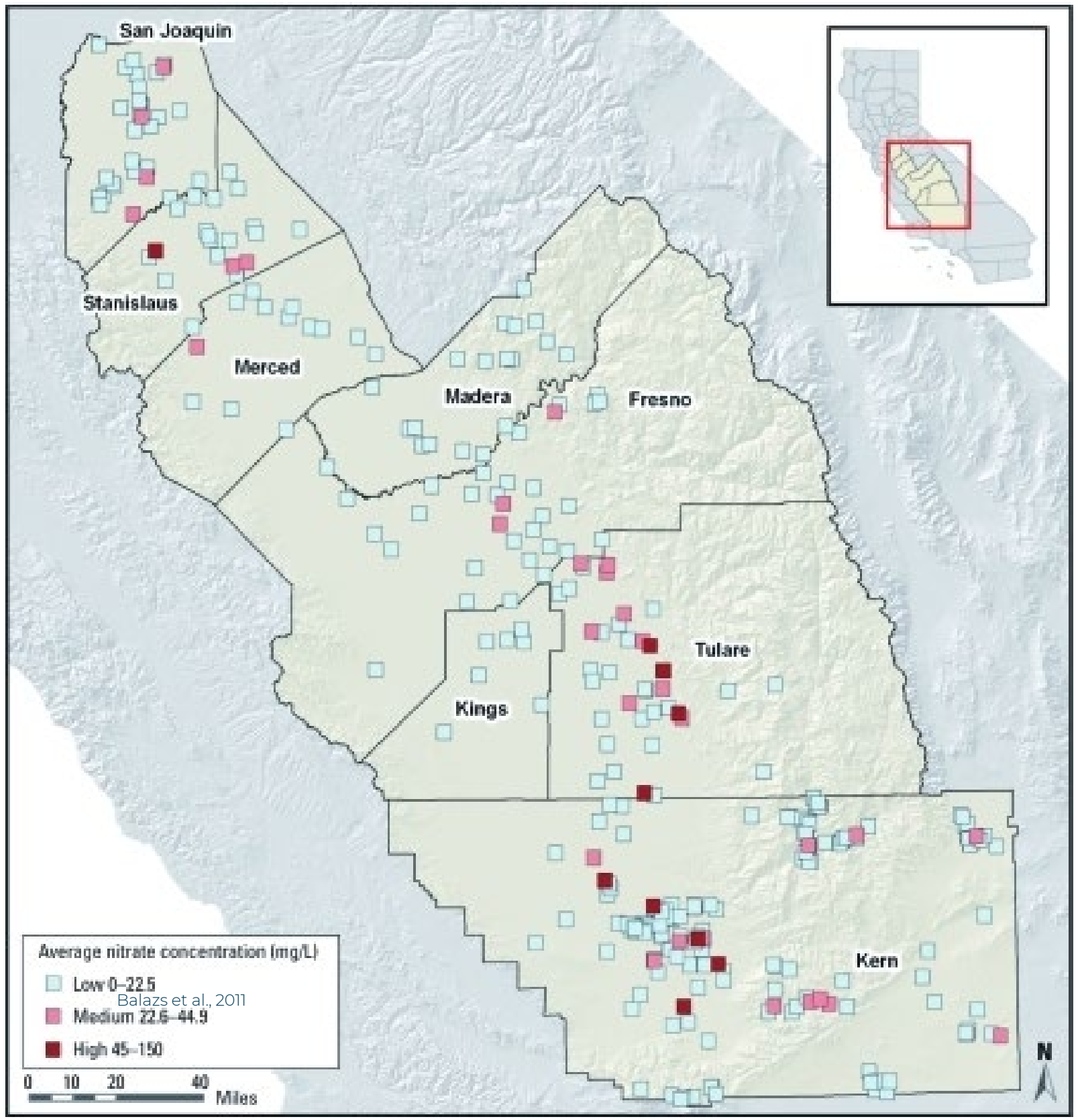
Contaminated Drinking Water and Social Disparities

NATIONAL STUDY

(Schaider et al., 2019)

- 5.6 million Americans are served by a community water system (CWS) with average nitrate concentrations ≥ 5 mg/L NO_3-N
- Percent of Hispanic residents served by each system was significantly associated with nitrate

Contaminated Drinking Water and Social Disparities



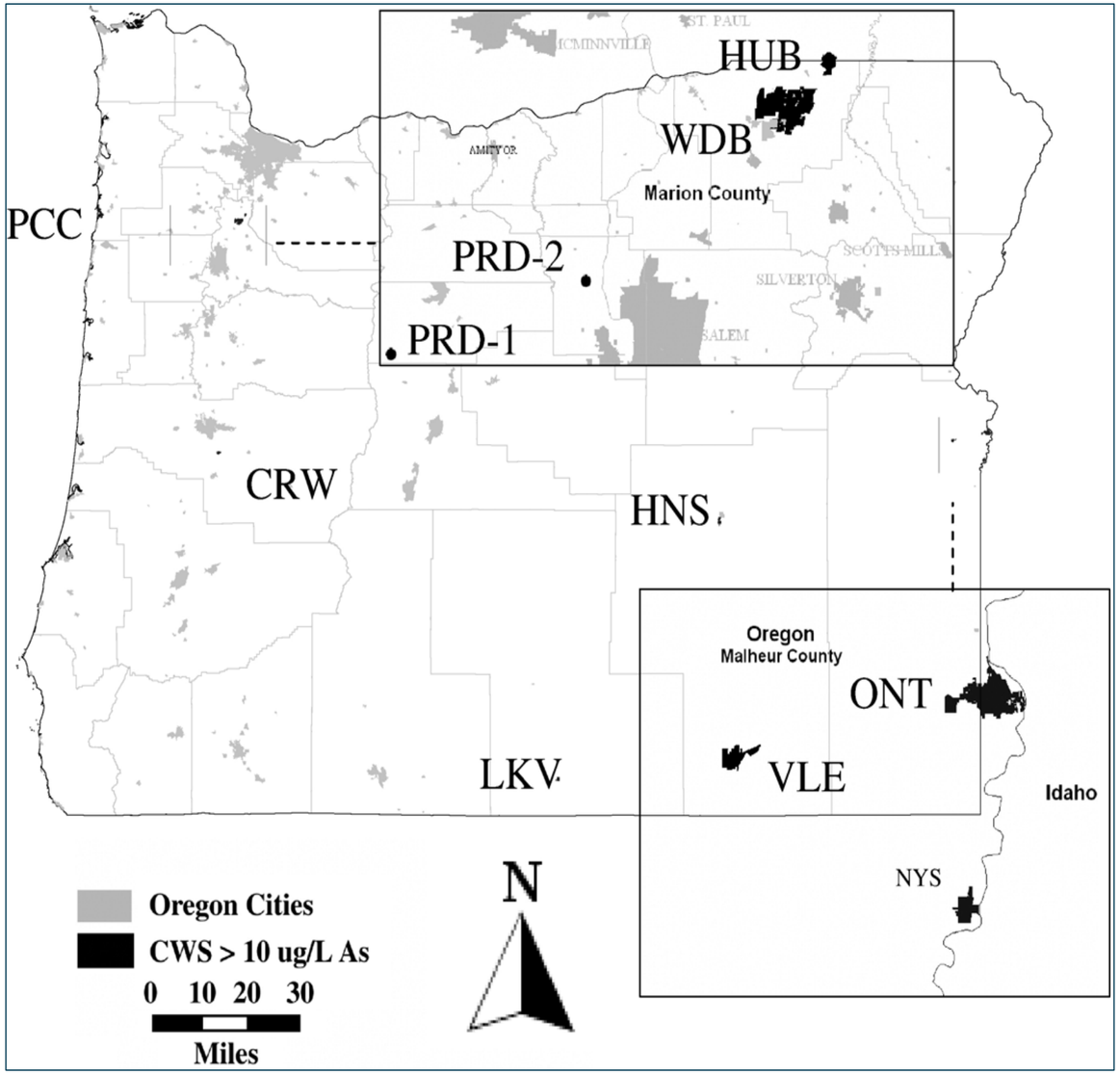
Balazs et al., 2011

SAN JOAQUIN VALLEY

(Balazs et al., 2011)

- Proportion of Hispanic residents is associated with an increase in CWS average nitrate concentrations
- Home Ownership increases associated with lower levels of nitrate

Contaminated Drinking Water and Social Disparities



OREGON

(Stone, Sherman and **Hofeld**, 2007)

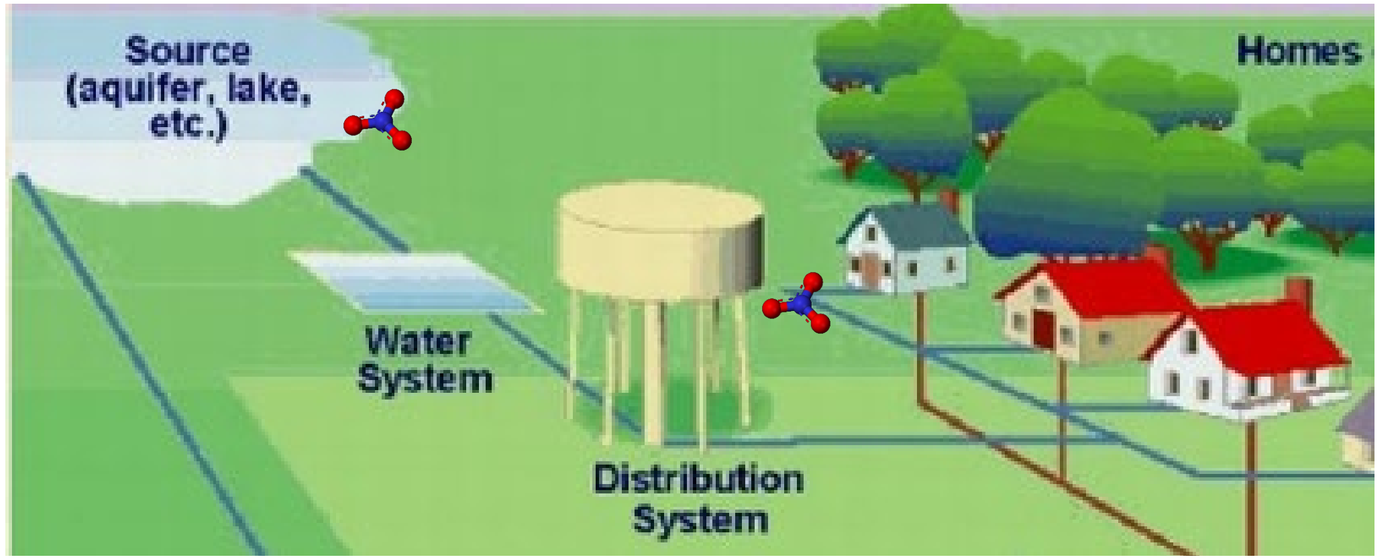
- Arsenic exposure 10 ppb in CWSs
- 35% were of Hispanic origin
  - statewide average: 8% in yr 2000
- Lower median household income and median age
- Higher % of residents who spoke a second language at home compared to statewide average

OBJECTIVES

1) Characterize inequities among residents served by CWSs and non-EPA (NP) state-regulated systems with higher nitrate concentrations

2) Inform Oregon water insecurity policy development

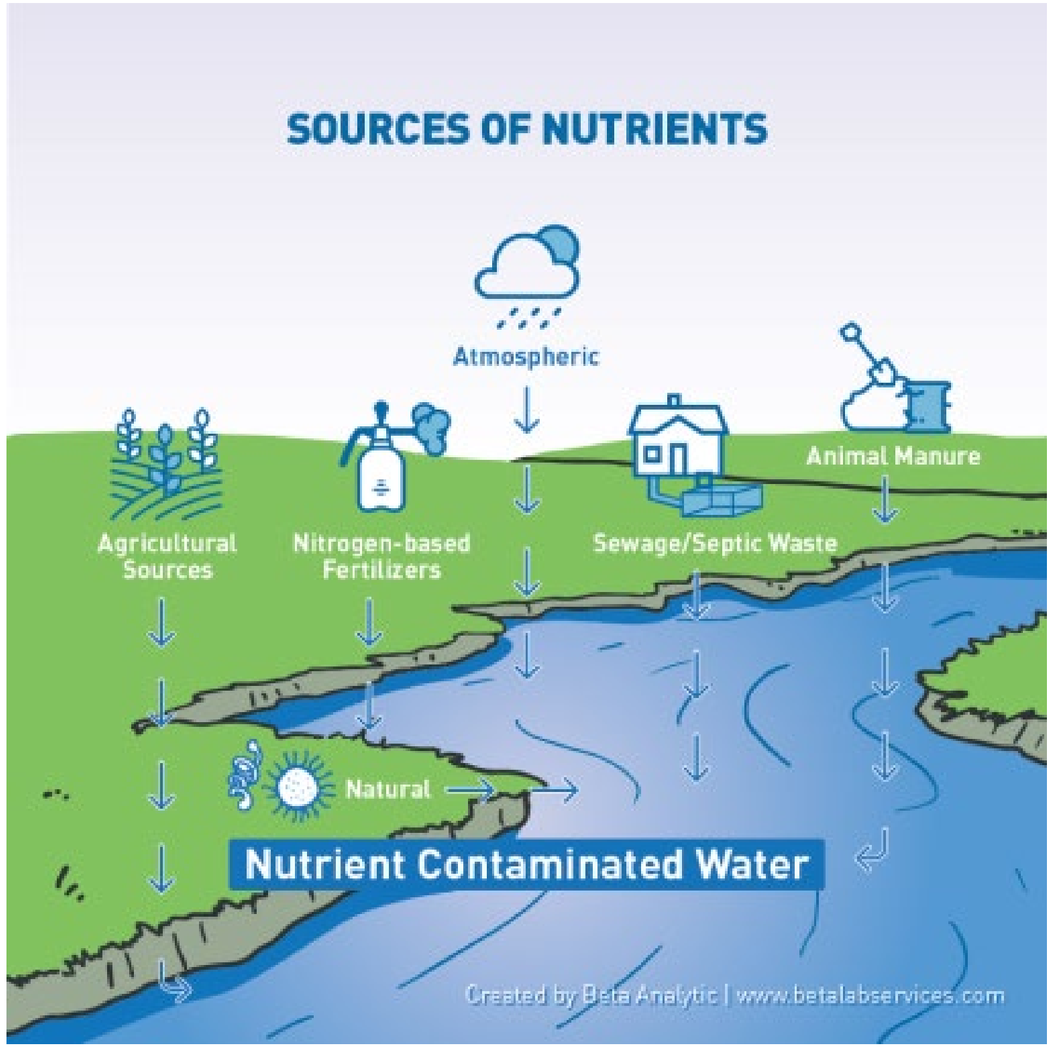
HYPOTHESIS



Higher nitrate levels in:

- CWSs serving a higher proportion of Hispanic residents
- communities with low home ownership rates
- smaller systems, including non-EPA systems

NITRATE (NO_3-N)



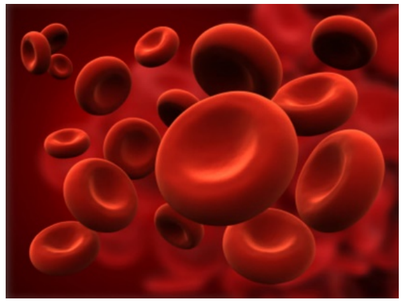
CAUSES

- Human-caused above 2 mg/L
- Human-caused sources: runoff from fertilizer-use, leaking septic tanks and sewage

REGULATION

- EPA maximum contaminant level (MCL) is 10 milligrams per liter (mg/L) or 10 parts per million (ppm)

HEALTH OUTCOMES



Methemoglobinemia or “blue baby syndrome”

Thyroid disfunction

Negative reproductive outcomes

Certain cancers (e.g. stomach, bladder cancer)

TARGET POPULATION: WATER SYSTEMS

COMMUNITY WATER SYSTEMS

- 15 or more service connections
- 25 or more year-round residents
- System size range from very small to very large

STATE-REGULATED SYSTEMS, NON-EPA (NP)

- 4-14 or more service connections
- 10-24 a day for at least 60 days a year
- System size very small

MOBILE HOME PARKS (MHP)

OREGON

- 1,065 MHPs serving 296,683 residents
- Half need infrastructure repair
- Construction regulation: 1976
- 47% built before 1980

MEDIAN HOUSEHOLD INCOME

- MHP owners: $38,466
- All homeowners: $72,519 (2019)

MHPs and CWS

- 18% are CWSs with their own water source
- Very small or small systems serving 22,604 people

METHODOLOGY

STUDY SAMPLE

- CWSs and non-EPA systems active between 2017-2019 with entry point nitrate sample data

ANALYSIS

- **Analysis 1:** Characteristics of 816 CWSs and 665 non-EPA systems

- **Analysis 2:** Demographic and regression analysis

NITRATE CATEGORIES (NO_3-N)

- **low** (< 5 mg/l)
- **Medium** (5 mg/l to 10 mg/l)
- **high** (> 10 mg/l)

SYSTEM SIZE CATEGORIES

- **very small** (≤ 500 people)
- **small** (501-3,300)
- **medium** (3,301-10,000)
- **large** (10,000 -100,000)
- **very large** (> 100,000)

MEASUREMENTS

THREE MEASURES

a) Average nitrate concentrations for each CWS

a) Potentially Exposed Populations (PEP) to three nitrate levels

$$PEP = \sum_{i=1}^{n} [(X_i \times s_{il} \,/\, S_{it})]$$

b) Areal weighting to estimate CWS demographics of 132 out of 816 systems

$$Areal\ based\ weight = (\sum_{j=1}^{j=n} [(x_j/X_j) * p_j] \,/\, \sum_{j=1}^{j=n} [(x_j/X_j) * P_j]) * 100$$

ANALYSIS 1: CWS CHARACTERISTICS

POTENTIALLY EXPOSED POPULATIONS TO THREE NITRATE CATEGORIES BY SYSTEM SIZE

Characteristics	All Systems (n= 816)	Very Small (n= 582)	Small (n= 139)	Medium (n= 50)	Large (n= 41)	Very large (n=4)
Population Served (%)	3,283,658	81,029 (2.47)	211,605 (6.44)	301,449 (9.18)	1,317,747 (40.13)	1,371,828 (41.77)
Average Nitrate (NO_3-N)	0.91	**1.02**	**0.71**	0.66	0.39	0.11
PEP low (%) (< 5 mg/L)	3,262,268 (99.35)	79,026 (97.53)	205,713 (97.22)	291,594 (96.73)	1,314,107 (99.72)	1,371,828 (100.0)
PEP medium (%) (5 to 10 mg/L)	21,325 (0.65)	1,938 (2.39)	5,892 (2.78)	9,855 (3.27)	3,640 (0.28)	0 (0)
PEP high (%) (> 10 mg/L)	65 (0.00)	**65** (0.08)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)

- CWS nitrate concentrations are higher in very small and small systems

- Very small to medium systems have a higher percentage of residents who are exposed to nitrates > 5mg/L

ANALYSIS 1: CWS CHARACTERISTICS

POTENTIALLY EXPOSED POPULATIONS:
MOBILE HOME PARKS VS ALL OTHER TYPES OF COMMUNITY WATER SYSTEMS

Characteristics	MHPs (n=173)	All OTHER CWSs (n=643)
Population Served (%)	19,165 (0.58)	3,264,493 (99.42)
Average Nitrate (NO_3-N)	**1.47 mg/L**	0.76 mg/L
PEP low (%) (< 5 mg/L)	17,772 (92.73)	3,244,496 (99.39)
PEP medium (%) (5 to 10 mg/L)	**1,328 (6.93)**	19,997 (0.61)
PEP high (%) (> 10 mg/L)	**65 (0.34)**	0 (0.00)

- MHPs have higher average nitrate concentrations than other types of systems
- MHPs have a higher % of residents exposed to nitrate concentrations > 5mg/L

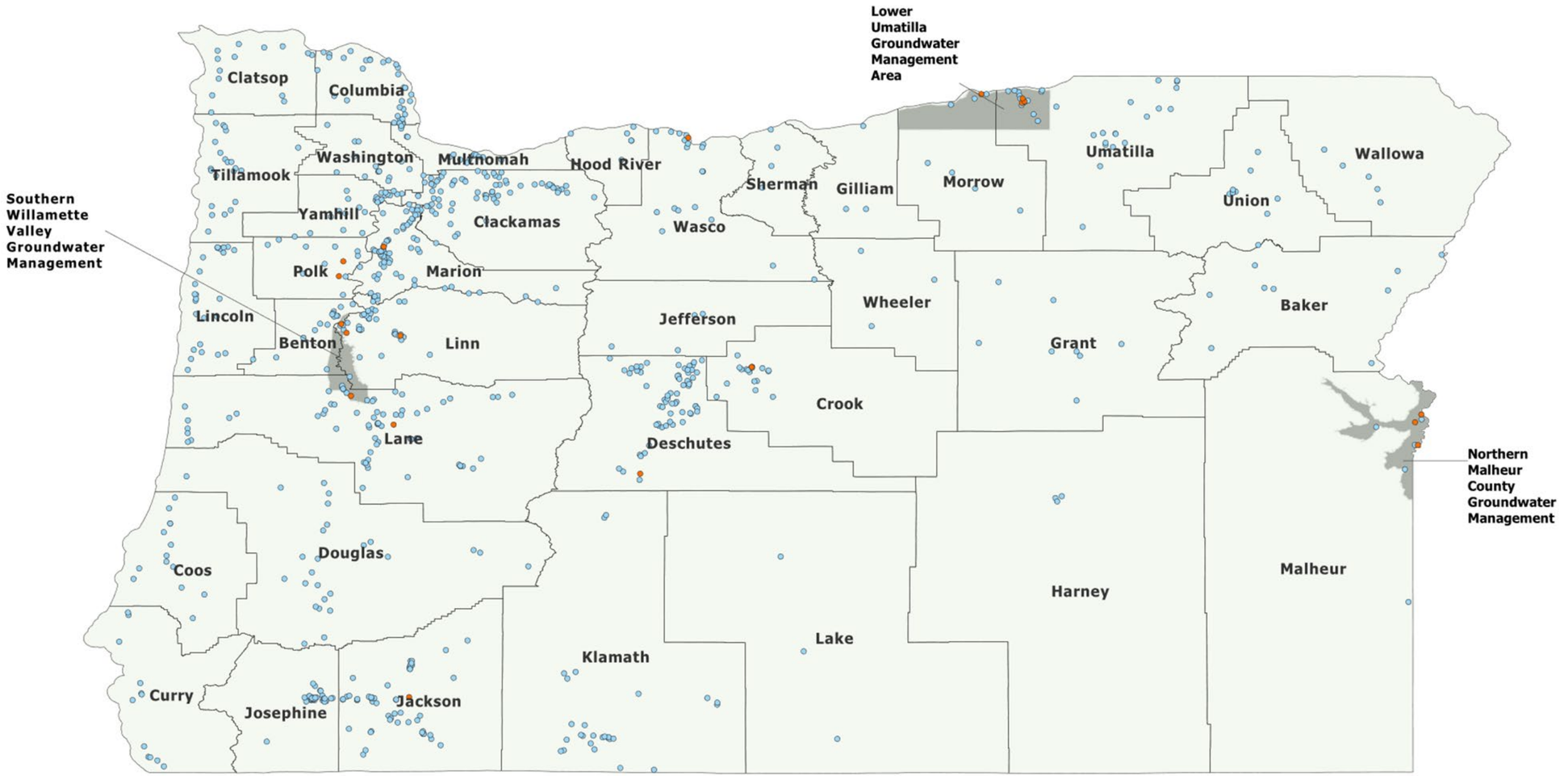
ANALYSIS 1: Non-EPA SYSTEM CHARACTERISTICS

POTENTIALLY EXPOSED POPULATIONS:
NON-EPA (NP), STATE REGULATED WATER SYSTEMS

Characteristics	Non-EPA Systems (n=665)
Population Served (%)	11,389
Average Nitrate (NO_3-N mg/L)	0.85
PEP low (%) (< 5 mg/L)	11,106 (97.52)
PEP medium (%) (5 to 10 mg/L)	283 (2.48)
PEP high (%) (> 10 mg/L)	0 (0.00)

- The PEP estimates showed no exposure to nitrate concentrations over the MCL
- No particular type of NP system was disproportionately impacted by higher nitrate levels

NITRATE LEVELS



ANALYSIS 2: NITRATE CONCENTRATIONS ≥5

LOGISTIC REGRESSION: LIKELIHOOD OF NITRATE CONCENTRATIONS ≥5 mg/L. (N= 816)

Variables	*B*	*SE B*	*OR*
Constant	-5.428***	0.54	0.004
Agricultural Land %	0.51**	0.02	1.053
MHP	2.252***	0.51	9.504
[a]All Other CWSs	-2.252***	0.51	0.105

Note: [a] We ran a separate analysis with all other types of CWSs as a reference group.
*p< .05.**p< .01.***p < .001.

Agriculture

- Each 1% increase in agricultural land led to a 5.3% increase in the odds of a system having ≥5 mg/L nitrate concentration.

MHPs

- The odds of a MHP having an average systemwide nitrate concentration ≥5 mg/L were 9.5 times higher than other system types.

ANALYSIS 2: CWS DEMOGRAPHICS

COMMUNITY WATER SYSTEMS AND DEMOGRAPHICS (N=132)

Variables	Mean (95% CIs)
Average Nitrate (NO_3-N)	0.70 mg/L (0.51-0.90)
Hispanic/Latino %	11.40 (9.42-13.39)
People of Color %	17.88 (15.81-19.95)
White (Non-Hispanic) %	78.49 (76.23-80.71)
Home Ownership %	66.85 (65.05-68.66)

ANALYSIS 2: CWS DEMOGRAPHICS

POTENTIALLY EXPOSED POPULATIONS & CWS DEMOGRAPHICS (N=132)

PEP Categories (NO_3-N)	Total Population % (n= 1,991,996)	White, Non-Hispanic % (n= 1,495,119)	Hispanic/Latino % (n= 213,316)	People of Color % (n= 431,532)
PEP low (< 5 mg/L)	1,972,609 (99.03)	1,483,205 (99.20)	206,437 (96.78)	423,313 (98.10)
PEP medium (5 to 10 mg/L)	19,387 (0.97)	**11,914 (0.80)**	**6,879 (3.22)**	**8,219 (1.90)**
PEP high (> 10 mg/L)	(0) 0.00	0 (0.00)	(0) 0.00	(0) 0.00

- Hispanic residents and people of color have greater exposure to nitrate concentrations 5-10 mg/L than the total population.

ANALYSIS 2: NITRATE & SOCIAL FACTORS

LINEAR REGRESSION WITH BETA COEFFICIENTS, (95% CIs), AND LEVELS OF SIGNIFICANCE

Variables	Model A	Model B	Model C
Constant	0.42 (0.12 to 1.51)	0.33 (0.086 to 1.26)	3.46 (0.82 to 14.5)**
Hispanic (%)	1.03 (1.01 to 1.57)*		
[a]White (non-Hispanic)			0.98 (0.97 to 1.00)**
People of Color		1.03 (1.01 to 1.04)**	
Home Ownership rate	0.98 (0.96 to 1.00)	0.98 (0.96 to 1.00)	0.98 (0.96 to 1.00)
Groundwater	1.99 (1.37 to 2.88)**	2.07 (1.44 to 3.00)**	2.05 (1.42 to 2.97)**
Small System	1.79 (1.21 to 2.63)**	1.80 (1.22 to 2.67)**	1.80 (1.22 to 2.67)**

Equation 1: $\ln\text{nitrate}=\beta_0+\beta_1$ (Hispanic)$+\beta_2$ (home ownership)$+\beta_3$ (groundwater)$+\beta_4$ (small)$+\epsilon$

Equation 2: $\ln\text{nitrate}=\beta_0+\beta_1$ (People of Color)$+\beta_2$ (home ownership)$+\beta_3$ (groundwater)$+\beta_4$ (small)$+\epsilon$

Equation 3: $\ln\text{nitrate}=\beta_0+\beta_1$ (White, non-Hispanic)$+\beta_2$ (home ownership)$+\beta_3$ (groundwater)$+\beta_4$ (small)$+\epsilon$

Hispanic & people of color residents

- Each 1% increase in Hispanic residents is associated with a 3% increase in nitrate concentrations.

System size

- Among smaller systems, average nitrate was 80% higher than larger systems.

Groundwater

- Average nitrate concentrations among groundwater systems was 99% higher than non-groundwater systems.

SES

- Home ownership did not have a statistically significant association with nitrate in all three models.

LIMITATIONS

- Small sample size
- Units (mg/L) lost in log-transformed linear regression model
- Limited data on the racial/ethnic demographics of residents served by MHPs and very small systems

SUMMARY

CWS and SOCIAL DISPARITIES

- Increases in CWS average nitrate concentrations is associated with the proportion of Hispanic residents and people of color
- MHPs and small systems have higher average nitrate concentrations than other types of CWSs and larger systems
- Agriculture land increases the odds of a system having ≥5 mg/L average nitrate concentrations.

POLICY IMPLICATIONS

Environmental Justice Research Opportunities

- Increase data collection of MHP systems and small systems (demographics, household water insecurity surveys, infrastructure assessments)
- Build knowledge of MHP infrastructure risks, including MHP customers of water utilities
- Improve accessibility of MHP data

POLICY IMPLICATIONS

Racially Equitable Solutions in Water Policy

- Include residents of MHPs and small systems, low SES communities and people of color in water management strategies
- Develop anti-racist and culturally inclusive resources
- Consider the inequities presented in this research as a potential threat to a community's capacity to prepare for and recover from climate events and public health emergencies
- Hold a water insecurity summit in Oregon
- Develop an Oregon drinking water disparities framework to outline how the natural environment, built environment and sociopolitical environment drive drinking water disparities within the household, community, county and state level

Thank you

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