An Independent Scientific Assessment of Hydraulic Fracturing and Acid Stimulations in California

Joint Legislative Hearing, August 25 2015

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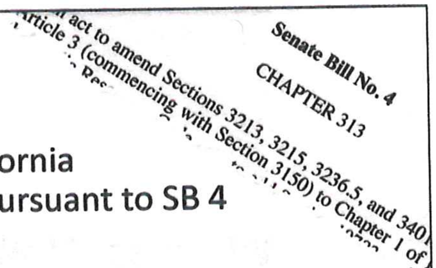
Introduction



- Study commissioned by California Natural Resources Agency, pursuant to SB 4
- Conducted by California Council on Science and Technology & Lawrence Berkeley National Laboratory
  - Pacific Institute, PSE Healthy Energy, University of the Pacific, Stanford University, Don Gautier (USGS retired), CSU Stanislaus
- Extensive peer review
- Led by a balanced steering committee

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For Today's Presentation

- When, where and how well stimulation occurs in California
- Environmental and public health impacts
- Data gaps and how to resolve them
- Data-driven policy recommendations

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What is Well Stimulation and Where Does It Occur in California?

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Well Stimulation

Techniques for increasing flow of oil and gas in low-permeability formations.

Diagram of hydraulic fractures

Hydraulic Fracturing

- About 150 operations/month

Matrix Acidizing

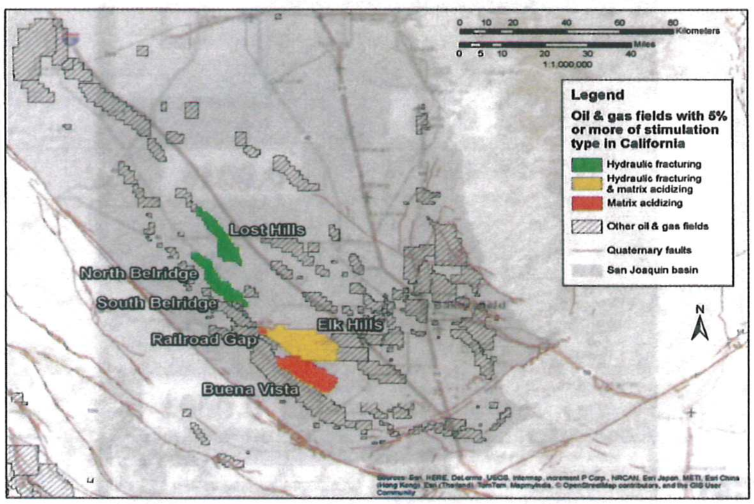
- About 25 operations/month

Acid Fracturing

- Scarcely used in CA

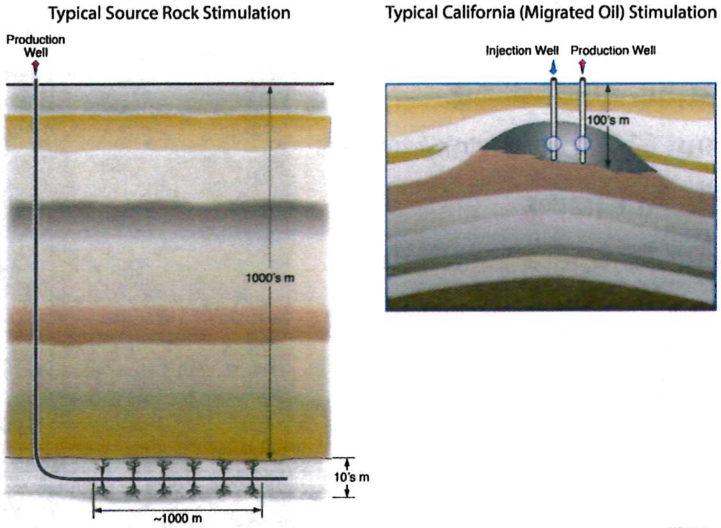
Mostly Hydraulic Fracturing Onshore and for Oil

96% of hydraulic fracturing in the state occurs in the San Joaquin Valley



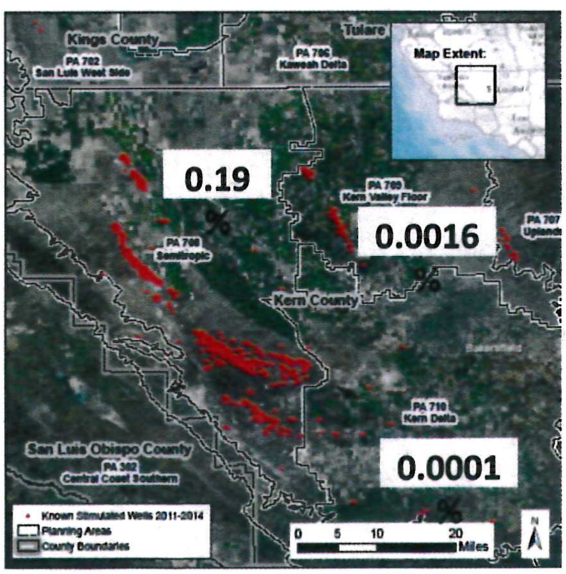
Hydraulic Fracturing in CA is Different

- Shallower, Vertical Wells



Water Use for Hydraulic Fracturing

Relatively small: - per operation - statewide - regionally



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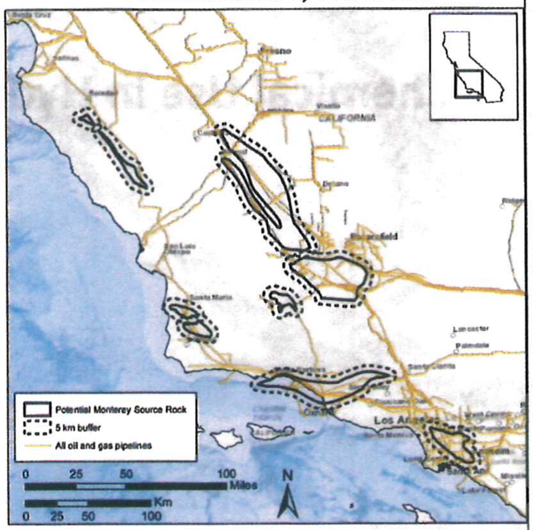
Monterey Formation

- Monterey source rock has not been commercially developed
- Unlikely in foreseeable future

Potential Monterey Source Rock



Impacts of Hydraulic Fracturing vs. Impacts of All Oil and Gas Production

Many impacts associated with hydraulic fracturing are actually general to all oil and gas.

Ventura Oil Field

The biggest impact of hydraulic fracturing is that it enables new production.

Recommendation: Evaluate impacts for <u>*all*</u> *oil and gas development.*

Chemical Use in Hydraulic Fracturing

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Chemical Use in Hydraulic Fracturing

- Identified ~ 300 chemical or chemical mixtures used for hydraulic fracturing
  - Many chemicals were reported infrequently
- Identified ~80 chemical or chemical mixtures used for matrix acidizing
  - ~1/3 were not on hydraulic fracturing list
- Information needed for complete hazard or risk assessment was often not available

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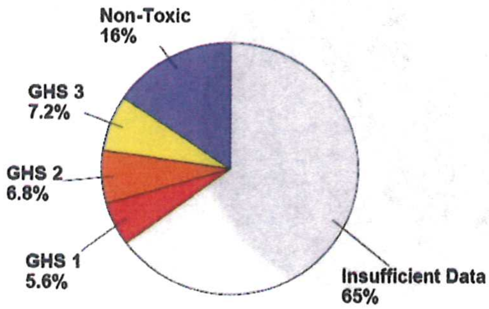
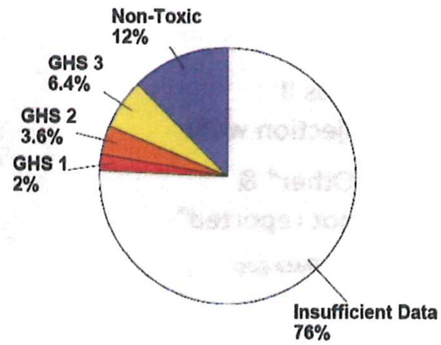
Data Gap: Basic Information on Toxicity Missing

Acute Aquatic Toxicity (*Daphnia magna*)



Acute Aquatic Toxicity (Fathead Minnow)



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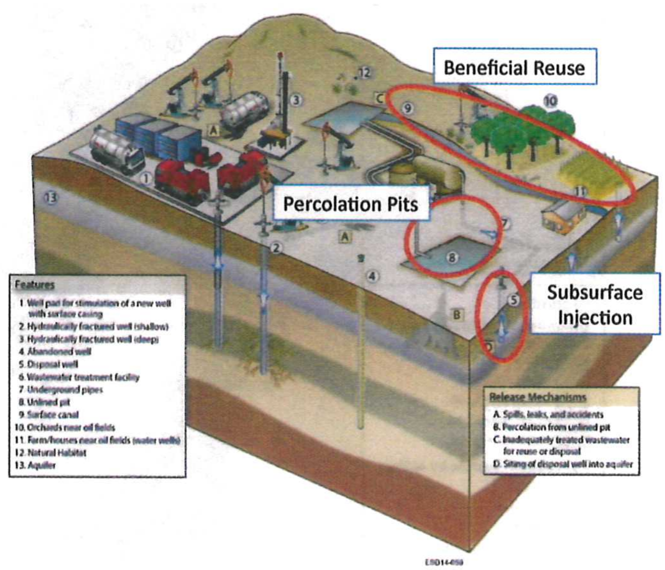
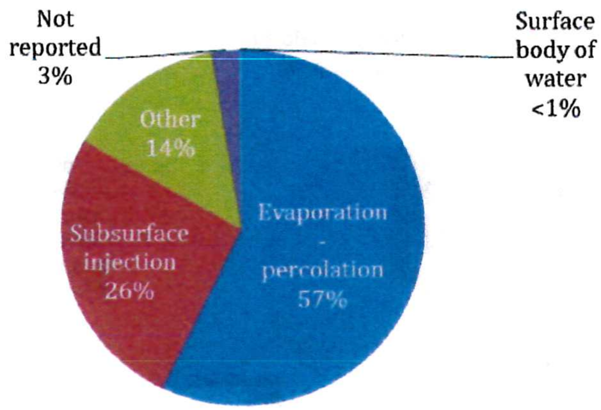
Produced Water Management

- Produce more than ten times as much water as they produce oil
- Produced water from fractured wells may contain stimulation chemicals



Produced Water Disposal: Fractured Wells

- Percolation pits
- Class II injection wells
- "Other" & "not reported"
  - Data gap



Produced water disposal as reported during the first full month after stimulation

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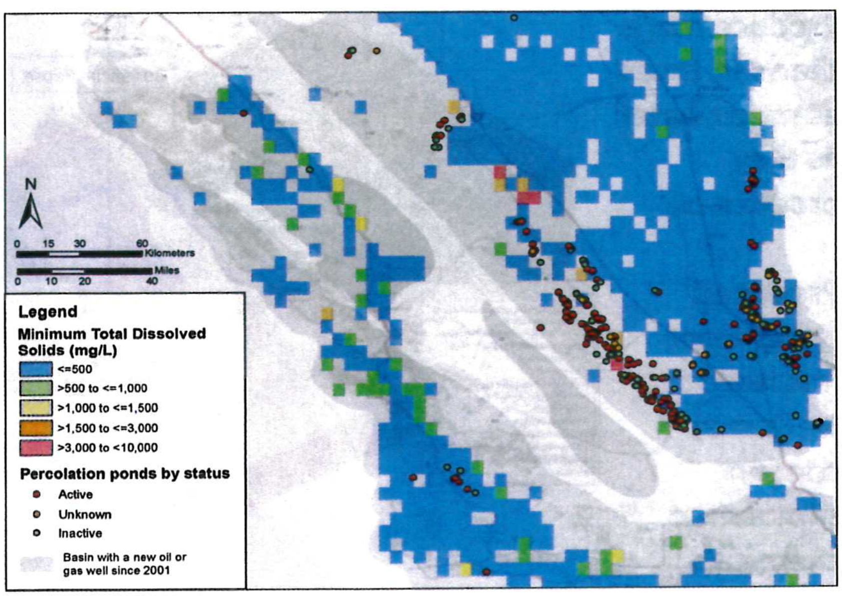
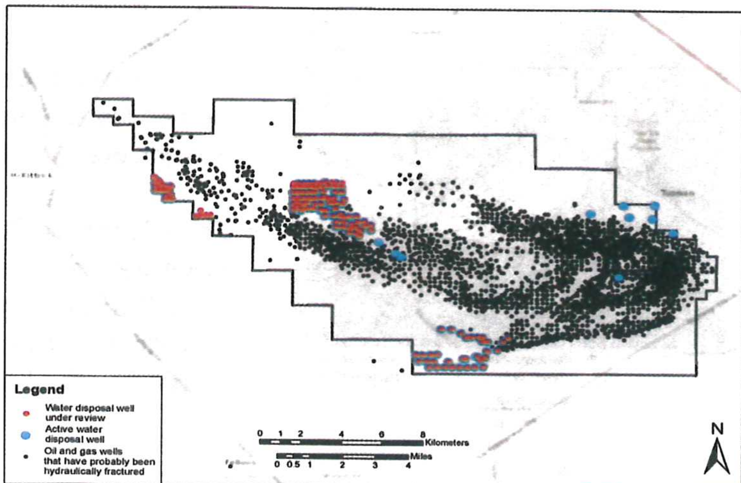
Disposal to Percolation Ponds



Disposal to Injection Wells

- Preferred practice to percolation
- Must be properly sited and constructed

Disposal wells in proximity to fractured wells



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Beneficial Reuse & Alternative Practices

- Regulations do not test for or prevent hydraulic fracturing chemicals from entering irrigation water
- Need appropriate monitoring, treatment, & other safeguards

Photo credit: Lauren Sommer

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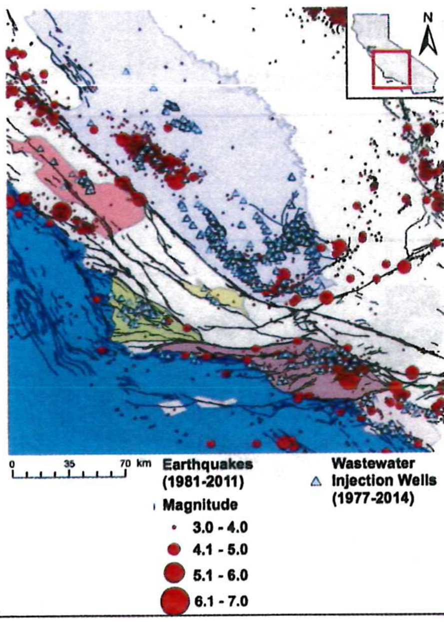
Seismicity and Wastewater Disposal Wells



- Fluid injection for hydraulic fracturing unlikely to cause earthquake of concern
- Wastewater disposal has caused felt or damaging earthquakes in other states
- Since California has so much natural seismicity, difficult to determine if any earthquakes may have been induced by fluid injection

Recommendation: Chemical Use

- Limit the use of hazardous and poorly understood chemicals
  - Disallow the use of chemicals with unknown environmental profiles
- Apply "green chemistry" principles
  - Reduce the overall number of different chemicals
  - Use the least hazardous chemicals
  - Discourage use of chemicals with poor environmental profiles

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Recommendation: Produced Water Management

- Characterize the chemistry of produced water from hydraulically fractured and acid stimulated wells
  - Determine how this chemistry changes over time
  - Active monitoring programs & reporting requirements
- Ensure safe disposal of produced water in percolation pits with appropriate testing and treatment
  - Or phase out this practice

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Recommendation: Produced Water Management

- Protect water designated for beneficial reuse from contamination by hydraulic fracturing chemicals and byproducts
  - Appropriate treatment, monitoring, management
- Investigate legacy impacts from improper disposal practices
  - Hydraulic fracturing chemicals & by-products may be present in improperly disposed produced water

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Recommendation: Produced Water Management

- Determine if there is a relationship between wastewater injection and earthquakes in California
- Evaluate tradeoffs in wastewater disposal practices
  - If California phases out percolation pits will use of injection wells increase other risks?
  - What are the opportunities for beneficial reuse?

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Potential Underground Leakage

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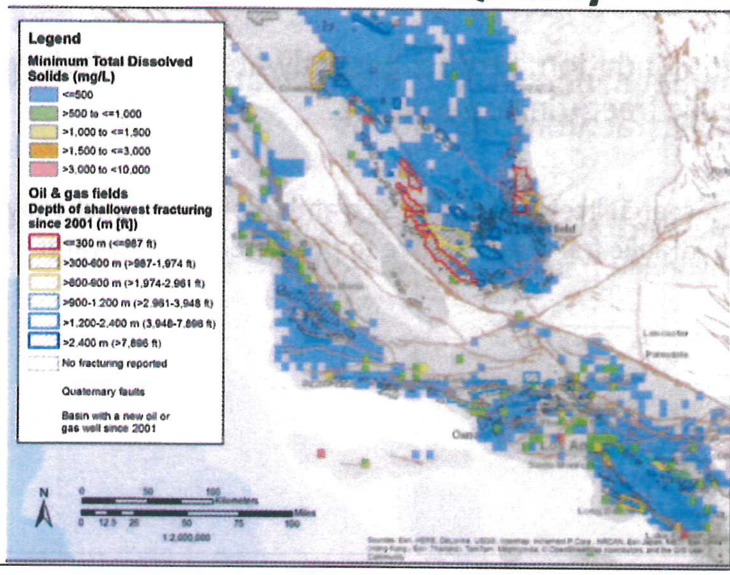
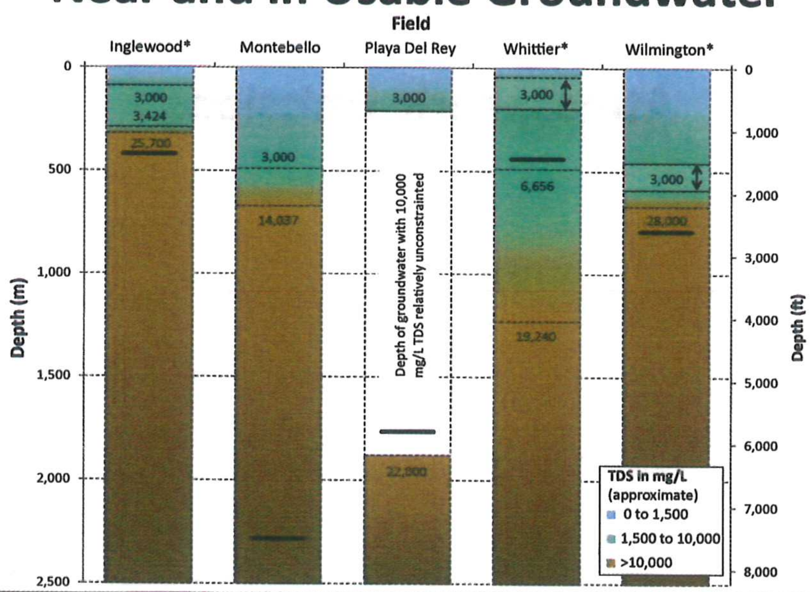
Shallow Fracturing Locations and Groundwater Quality



Shallow Hydraulic Fracturing Happens Near and In Usable Groundwater



Shallow Fracturing Raises Concerns About Potential Groundwater Contamination

Recommendation: Protect groundwater from shallow hydraulic fracturing operations

- Research likely maximum size and orientation of shallow hydraulic fractures relative to protected groundwater

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Atmospheric Emissions

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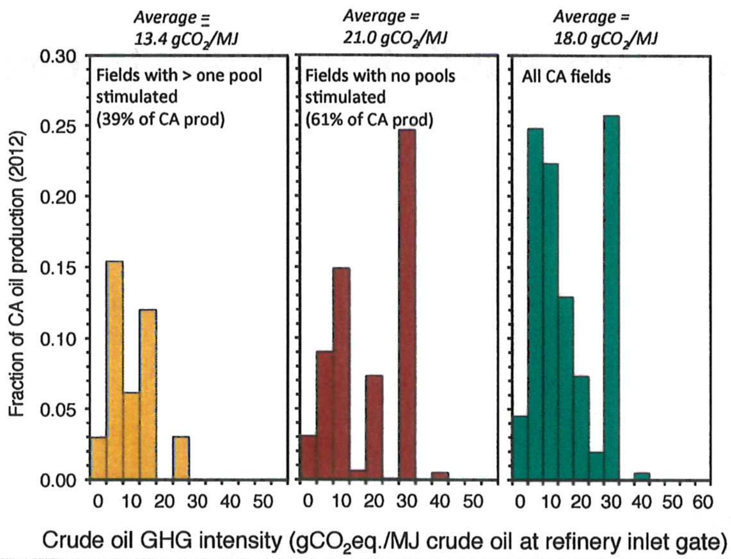
Comparison of Crude Oil Greenhouse Gas Intensity



Greenhouse Gas Emissions

Oil and gas production from hydraulically fractured reservoirs emits less greenhouse gas per barrel of oil than other forms of oil production in California

Recommendation: Assess and compare greenhouse gas signatures of different types of oil and gas production in California

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Land Use, Public Health and Habitat

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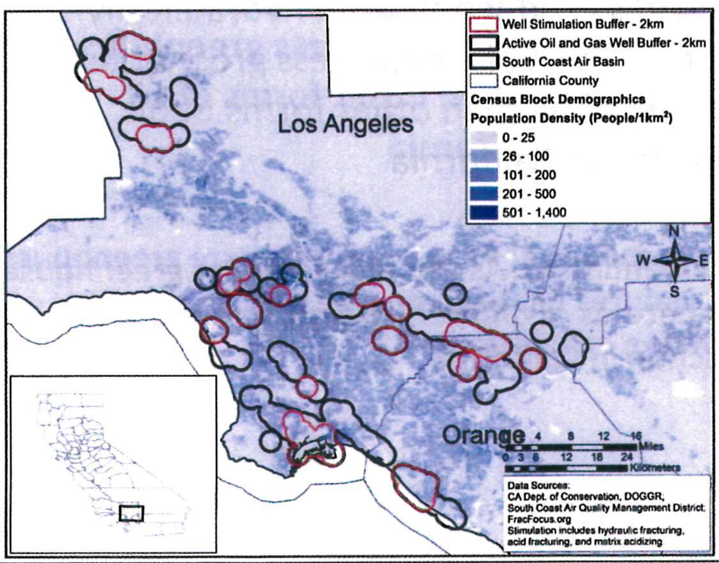
Population Density Within 2,000 m of Active Oil Wells



Air Pollution

Air pollutants and toxic air emissions from hydraulic fracturing are mostly a small part of total emissions, but pollutants can be concentrated near production wells.

Recommendation: Control toxic air emissions from oil and gas production wells and measure their concentrations near productions wells

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Air Pollution

Emissions concentrated near all oil and gas production could present health hazards to nearby communities in California

Recommendation: Assess public health near oil and gas production, not just stimulated wells, and develop policies such as science-based surface setbacks, to limit exposures

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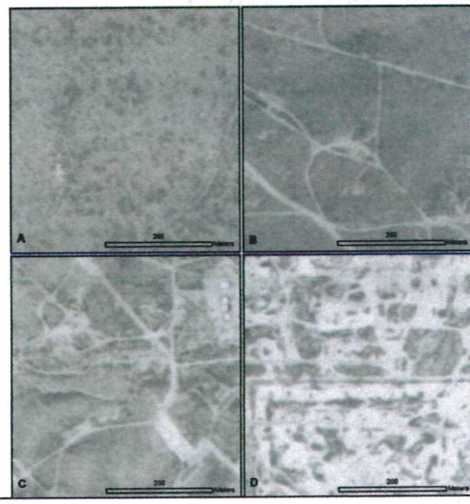
Wildlife and Vegetation Impacts

Oil and gas development *in general* causes habitat loss and fragmentation.

No wells



High well density >77 wells/km^2

Wildlife and Vegetation Impacts

Recommendation: Minimize habitat loss and fragmentation in oil and gas producing regions

- Enact regional plans to conserve essential habitat and dispersal corridors for native species in Kern and Ventura Counties
- A program to set aside compensatory habitat in reserve areas when oil and gas development causes habitat loss and fragmentation should be developed and implemented

Data and Knowledge Gaps

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Data Gaps

Data reporting gaps and quality issues exist

Examples:

- Well depths, casing type and cementing in a searchable format
- Inaccurate data regarding how produced water was disposed

Recommendation: Improve and modernize record keeping for oil and gas production

- Implement data quality assurance and control
- Future as well as past data in publicly-available normalized, relational databases
- Graphical search interface for non specialist public access

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Data Gaps

Future research would fill knowledge gaps

Examples:

- Location and depth of protected groundwater
- Well integrity statistics, such as frequency of ongoing gas leakage
- Produced water disposal by injection and seismicity

Recommendations:

Conduct integrated research to close knowledge gaps

Establish a scientific advisory committee on oil and gas development.

Thank you for this opportunity to present our findings.

Questions?