# Ecological Considerations in Shale Gas Development

Workshop on Risks of Unconventional Shale Gas Development – 31 May 2013

National Academy of Sciences

Washington, DC

Zachary H. Bowen[1] and Aida Farag[2]
[1]*USGS Fort Collins Science Center*
[2]*USGS Columbia Environmental Research Center*

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# USGS Powell Core Team

| | | |
|---|---|---|
| **Aida Farag** | CERC | Fishery Biologist |
| **Bill Kappel** | NY WSC | Hydrologist - GW |
| ★ **Brian Cade** | FORT | Statistician |
| **Chris Potter** | CERSC | Director |
| **Cynthia Melcher** | FORT | Writer/editor |
| **David Mott** | WY WSC | Director |
| **David Susong** | UT WSC | Hydrologist - Research |
| ★ **Gretchen Oelsner** | NM WSC | Hydrologist |
| **Jeff Deacon** | ★ NAWQA | Supervisory Hydrologist |
| **Melanie Clark** | WY WSC | WQ Specialist |
| **Pete Cinotto** | IN WSC | Hydrologist |
| **Suzanne Paschke** | CO WSC | Studies Chief |
| ★ **Tanya Gallegos** | CERSC | Environmental Engineer |
| **Tim Kresse** | AR WSC | Hydrologist - GW |
| **Tim Oden** | TX WSC | Hydrologist |
| **Zack Bowen** | FORT | Supervisory Biologist |

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# Briefing Topics

- Background and issues
- Terrestrial considerations
- Aquatic considerations
- Summary and Discussion

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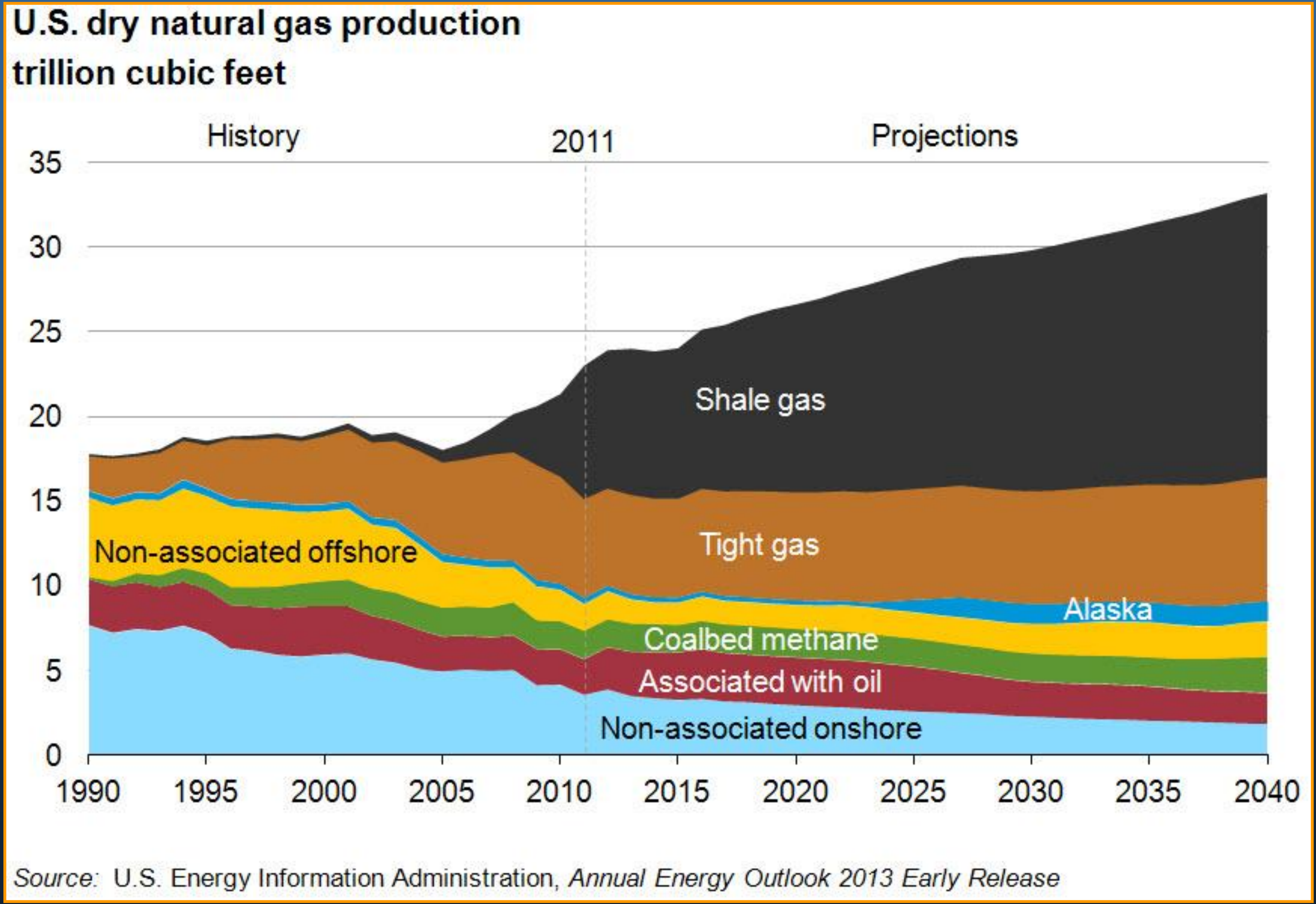
# Unconventional Gas – Key to supply

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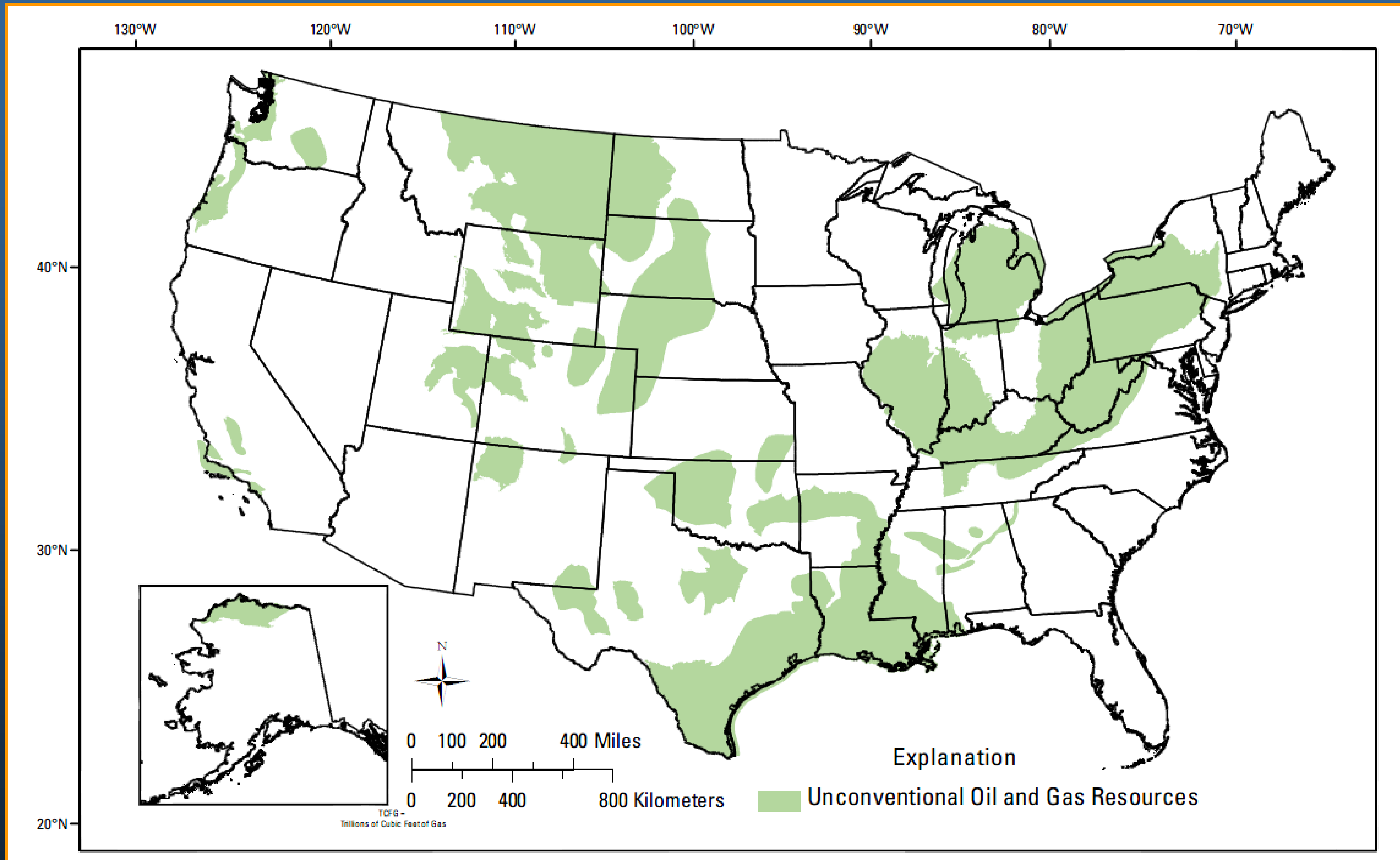
# Areas of Unconventional Oil and Gas

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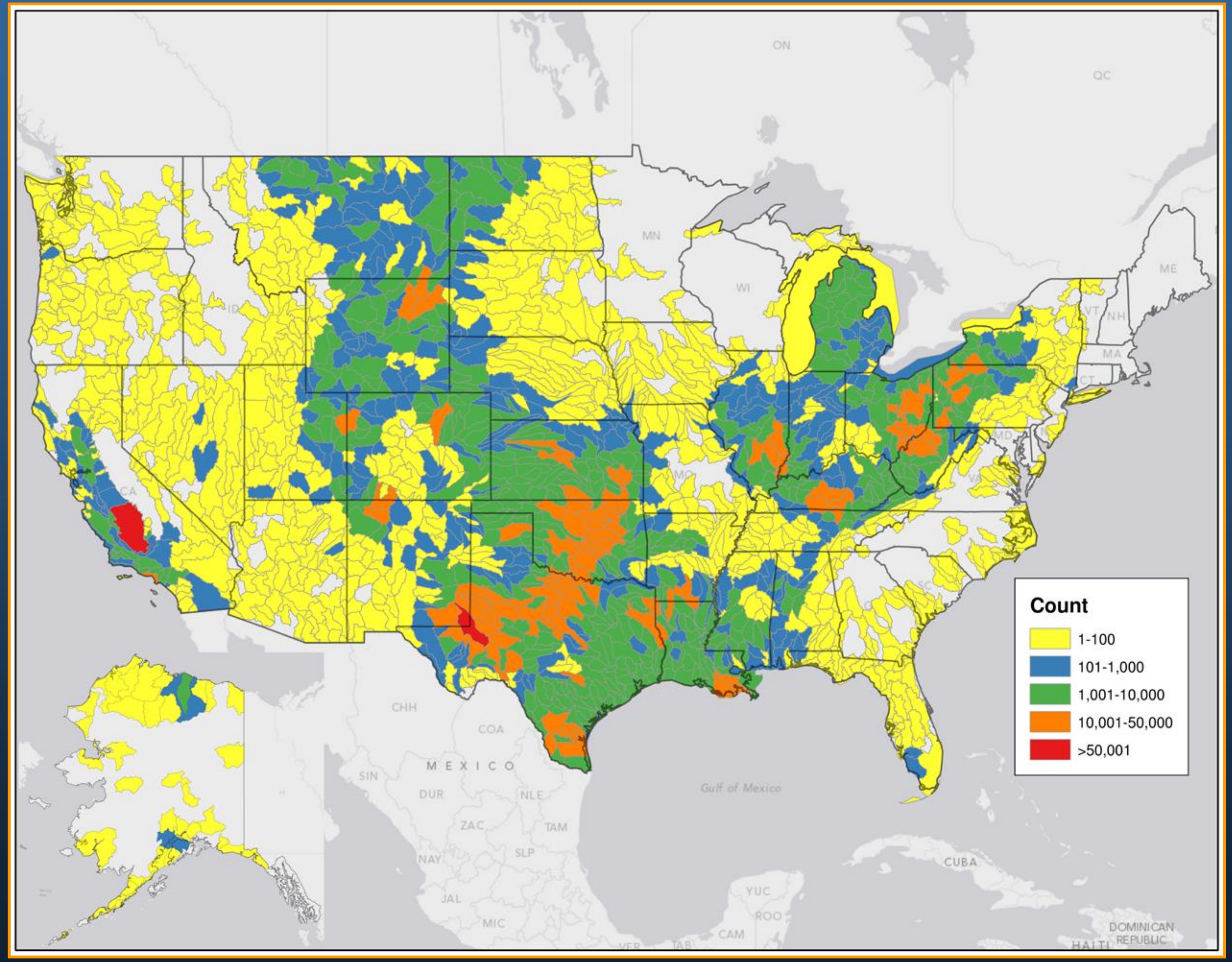
Susong, D.D., Gallegos, T.J., and Oelsner, G.P., 2012, Water quality studied in areas of unconventional oil and gas development, including areas where hydraulic fracturing techniques are used, in the United States: U.S. Geological Survey Fact Sheet 2012–3049, 4 p.

# Oil and Gas Wells 1898 - 2010




Susong, D.D., Gallegos, T.J., and Oelsner, G.P., 2012, Water quality studied in areas of unconventional oil and gas development, including areas where hydraulic fracturing techniques are used, in the United States: U.S. Geological Survey Fact Sheet 2012–3049, 4 p.

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# Shale Gas Development - Classes of Decisions

- National policy
- Planning
- Permitting/Disposal
- Siting
- Mitigation/Treatment
- Reclamation/Restoration

Common question: ***What are the effects of the proposed action or decision on other resources?***

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# Terrestrial Considerations

**Direct effects**

- Removal of habitat
- Mortality from collision
- Invasive species

**Indirect effects**

- Avoidance
- Fragmentation of habitat
- Physiological effects

**Cumulative effects**

- Accumulated effects of an action over space and time

# Direct Effect – Surface Disturbance

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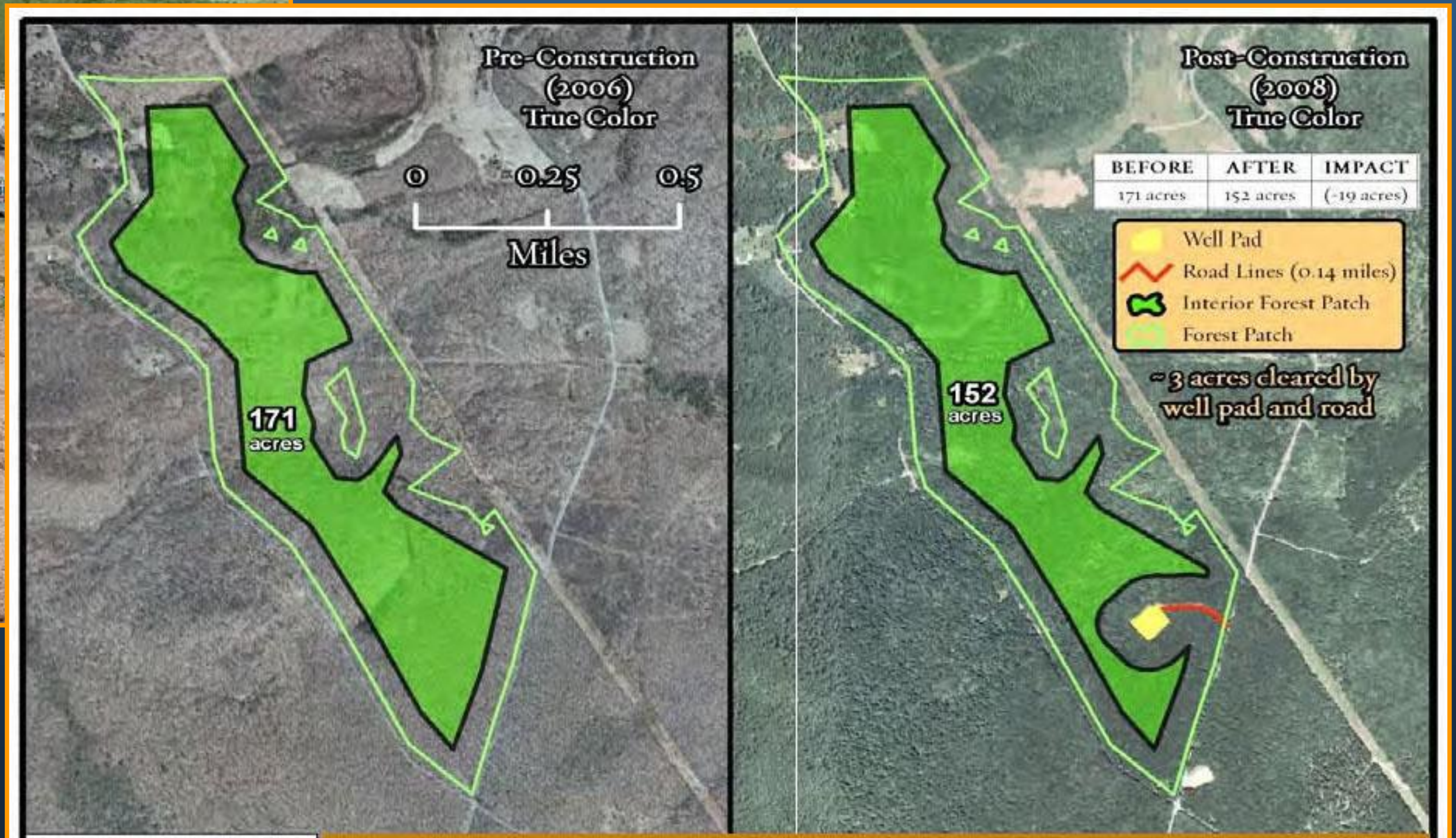
# Indirect Effect – Surface Disturbance




Interior forest habitat before and after development of a Marcellus gas well pad site in Elk County, PA.

New York State Department of Environmental Conservation. 2011. Revised Draft SGEIS on the Oil, Gas and Solution Mining Regulatory Program (September 2011) Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing in the Marcellus Shale and Other Low-Permeability Gas Reservoirs (http://www.dec.ny.gov/energy/75370.html)

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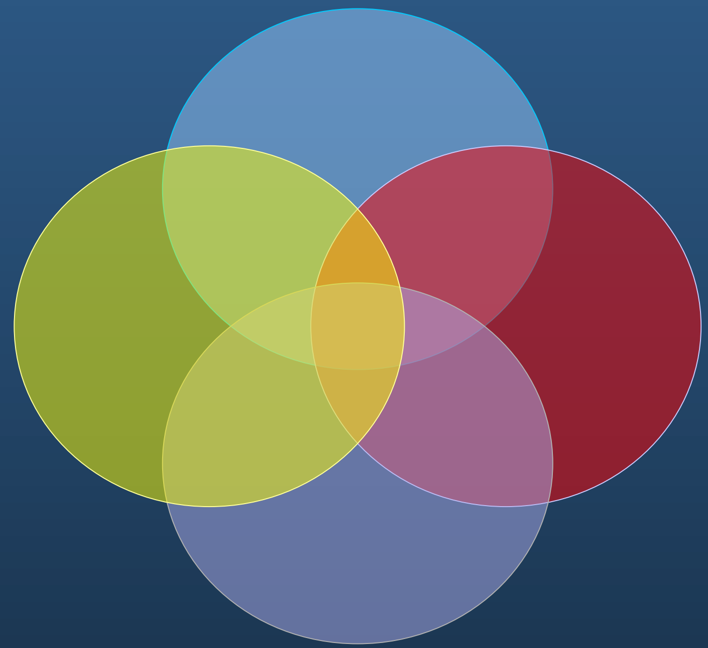
# Approaches to Evaluate Potential Effects

## Spatial Analysis

- Mapping resources
- Estimating development patterns

## Ecoregional Assessment

- Considers multiple species or communities
- Evaluates multiple drivers of change



## Species-based Modeling

- Population biology
- Behavioral studies
- Habitat modeling

## Vulnerability Assessment

- Examining overlap in habitat and potential development

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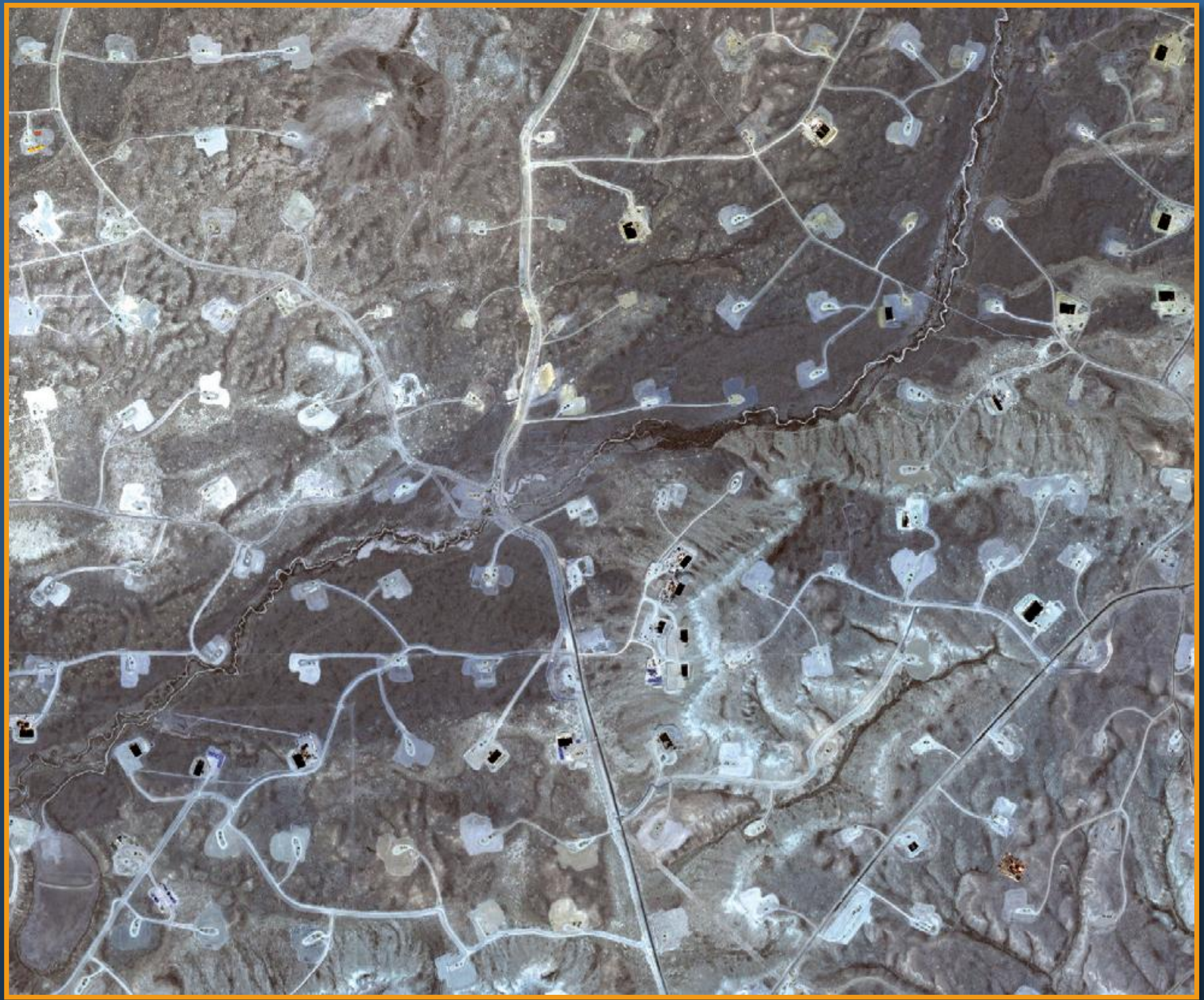
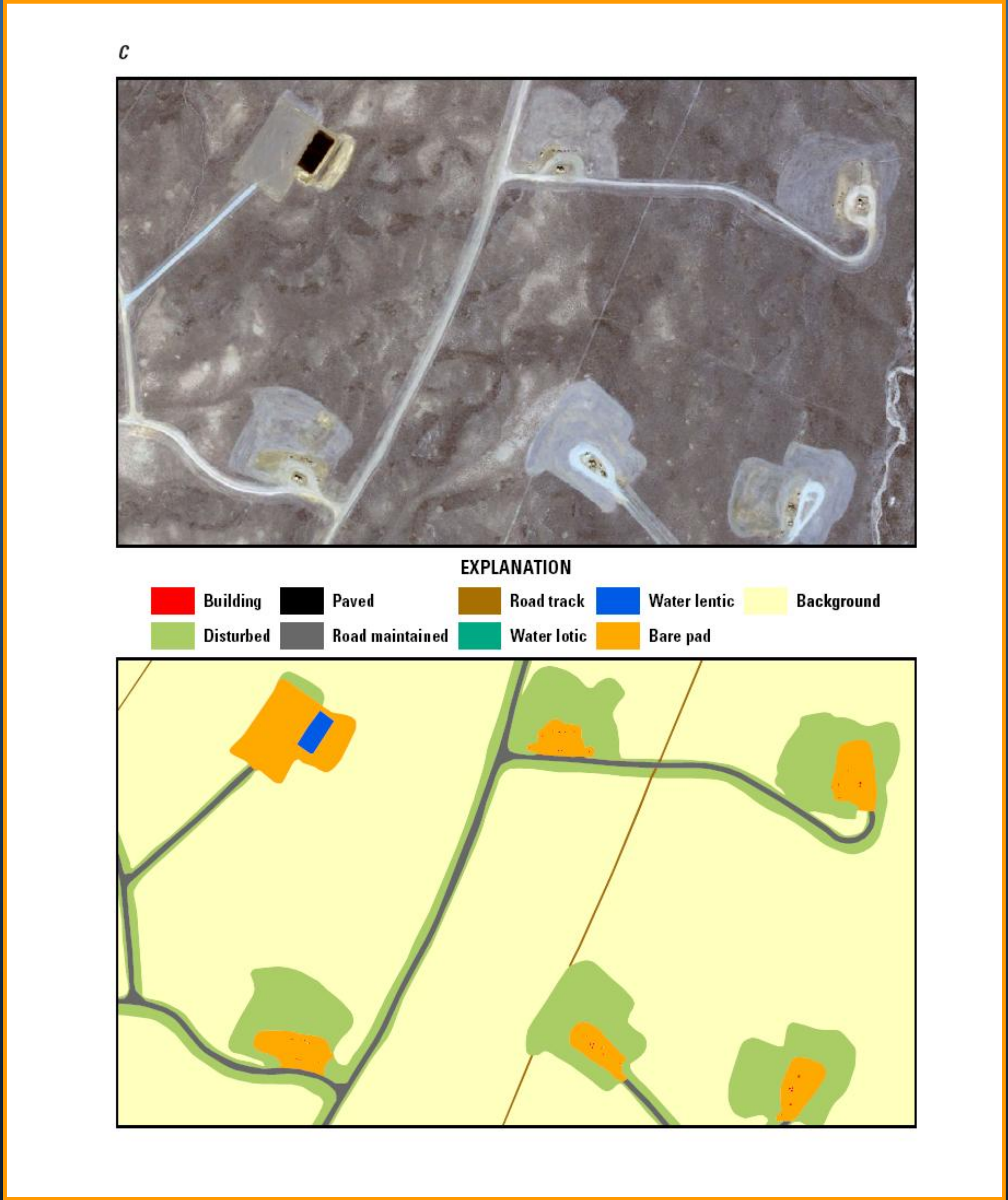
# Surface Disturbance Measurement






Germaine, S.S., M. O'Donnell, C.L. Aldridge, L. Baer, T. Fancher, J.L. McBeth, R.R. McDougal, R. Waltermire, Z.H. Bowen, J. Diffendorfer, S.L. Garman, and L. Hanson. 2012. Mapping surface disturbance of energy-related infrastructure in southwest Wyoming - an assessment of methods: U.S. Geological Survey Scientific Investigations Report 2012–5025. 42 p.

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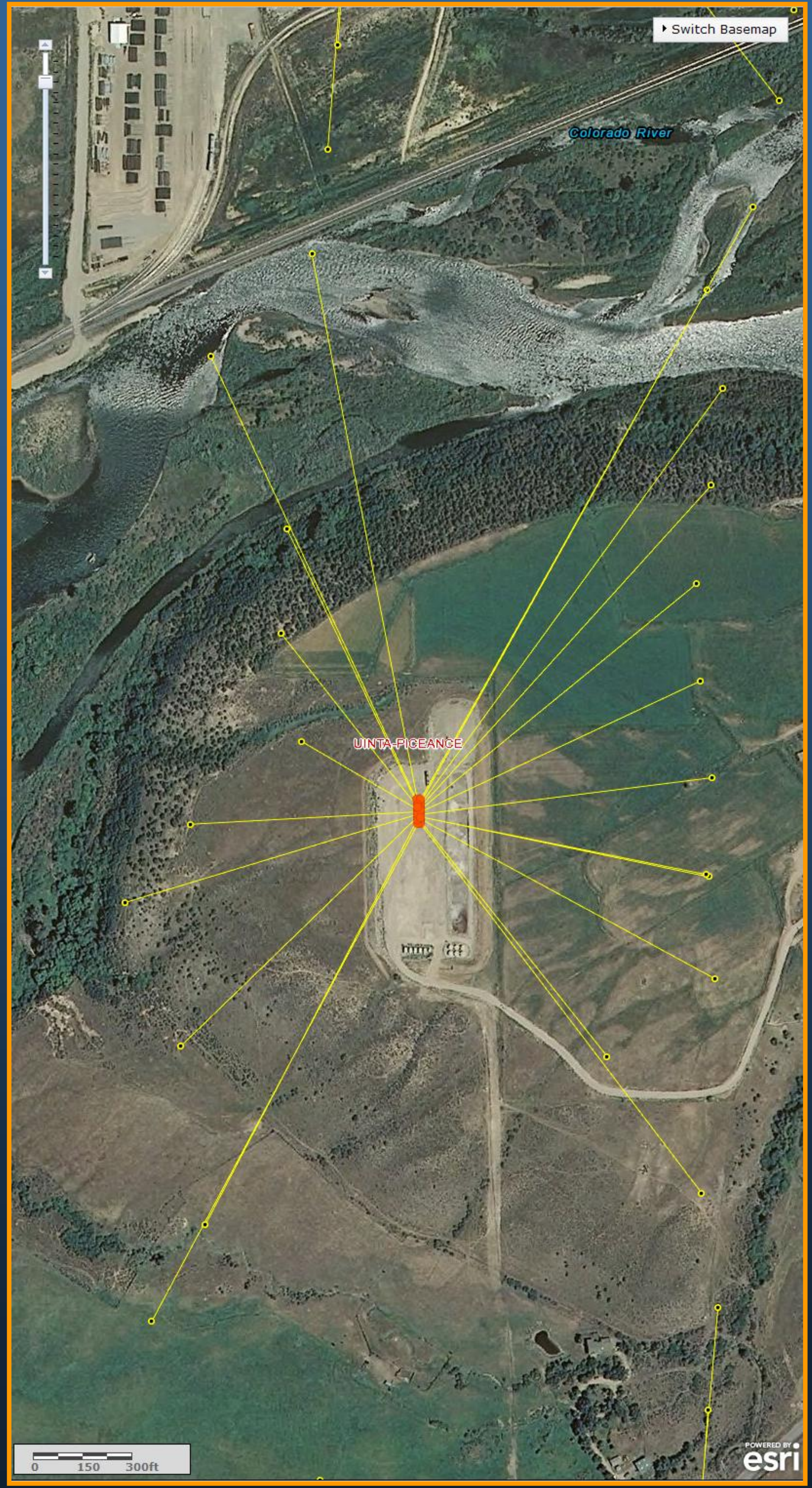
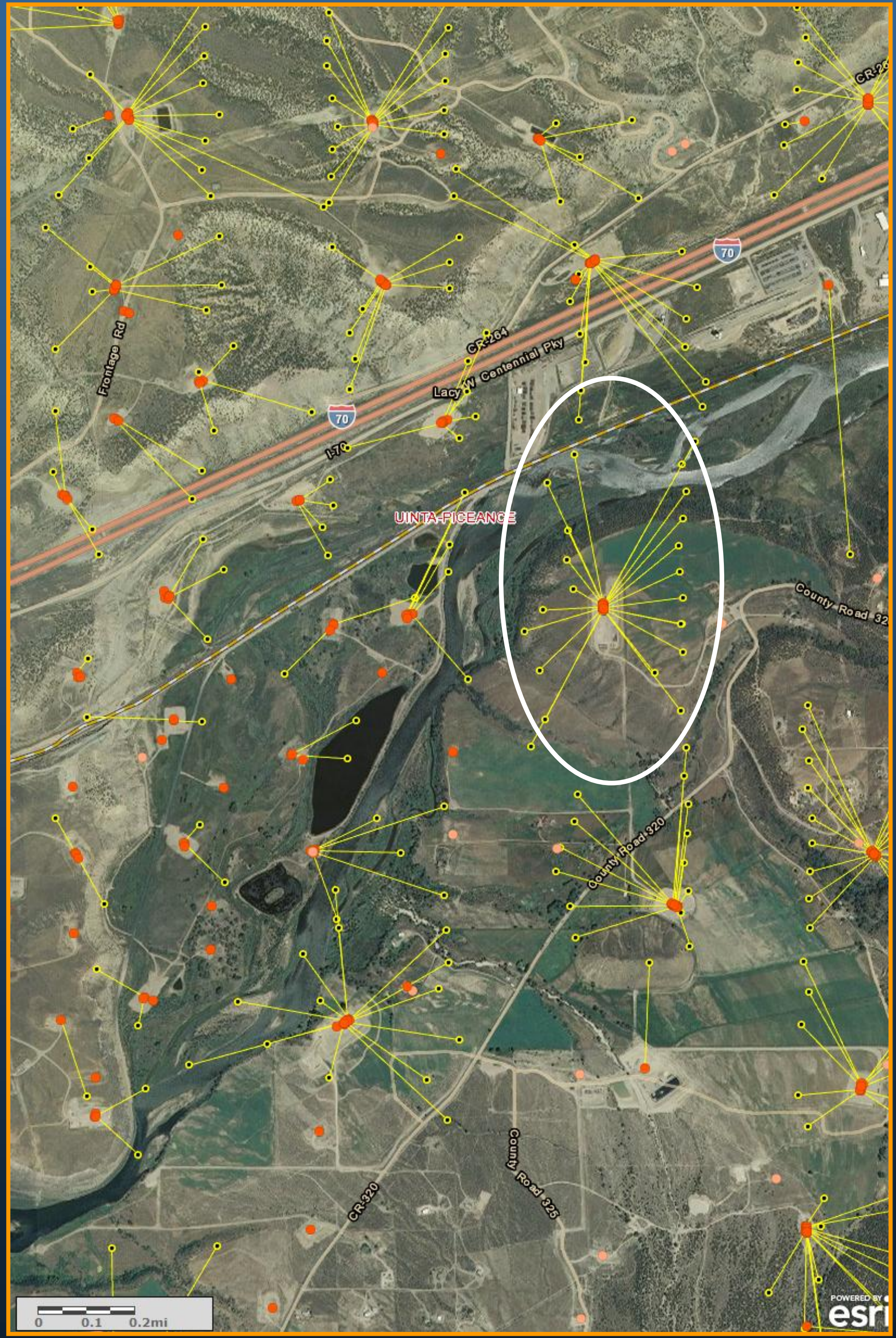
# Multi-well Pads and Directional Drilling

Reduced density of well pads within a project area

Reduces the cumulative disturbance of development over large areas




Carr, N.B., N. Babel, J. Diffendorfer, S. Hawkins, D. Ignizio, N. Latysh, K. Leib, J. Linard, and A.M. Matherne. 2012. Interactive Energy Atlas for Colorado and New Mexico [Website]. U.S. Geological Survey, Fort Collins Science Center: Fort Collins, CO. (http://my.usgs.gov/eerma/)

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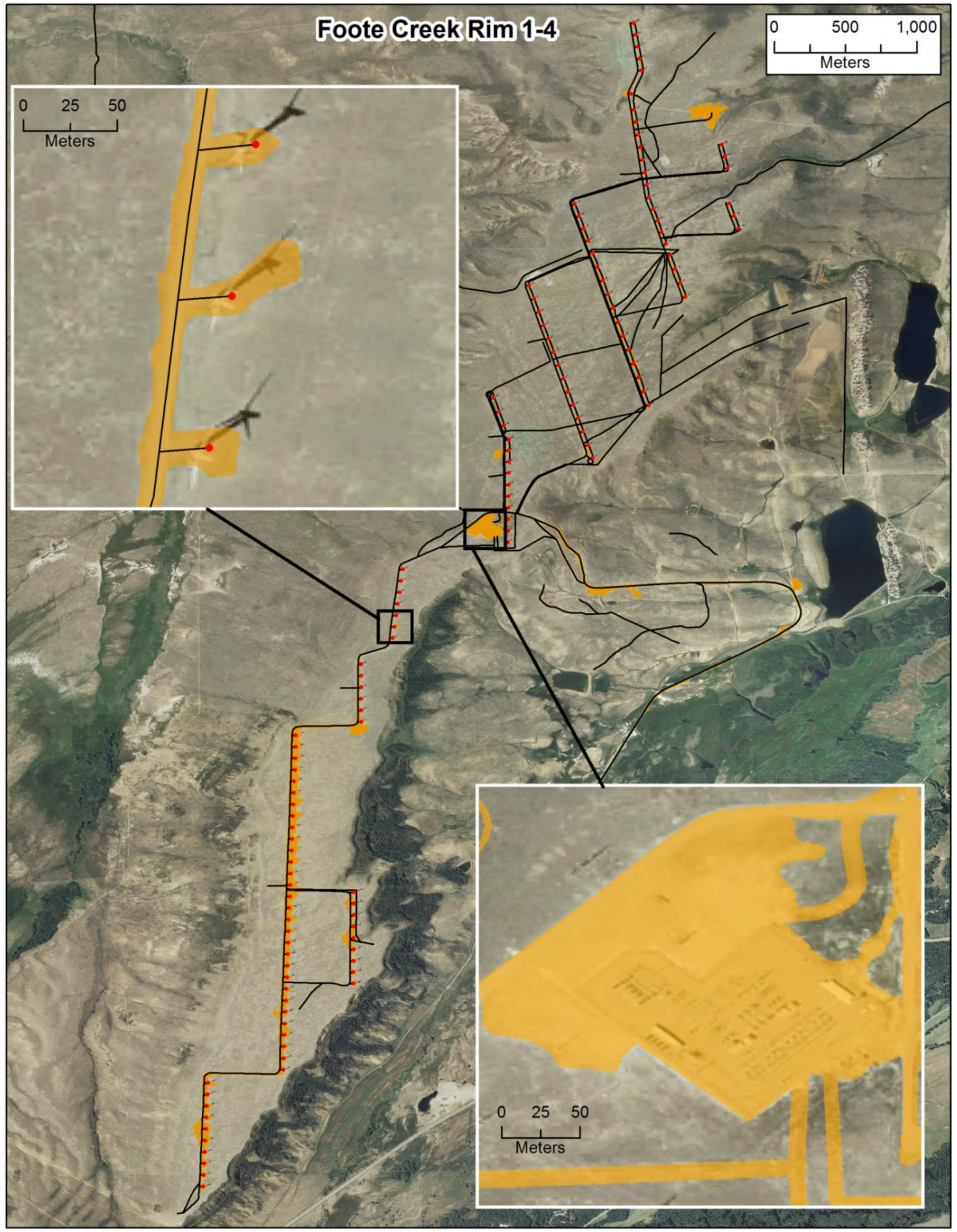
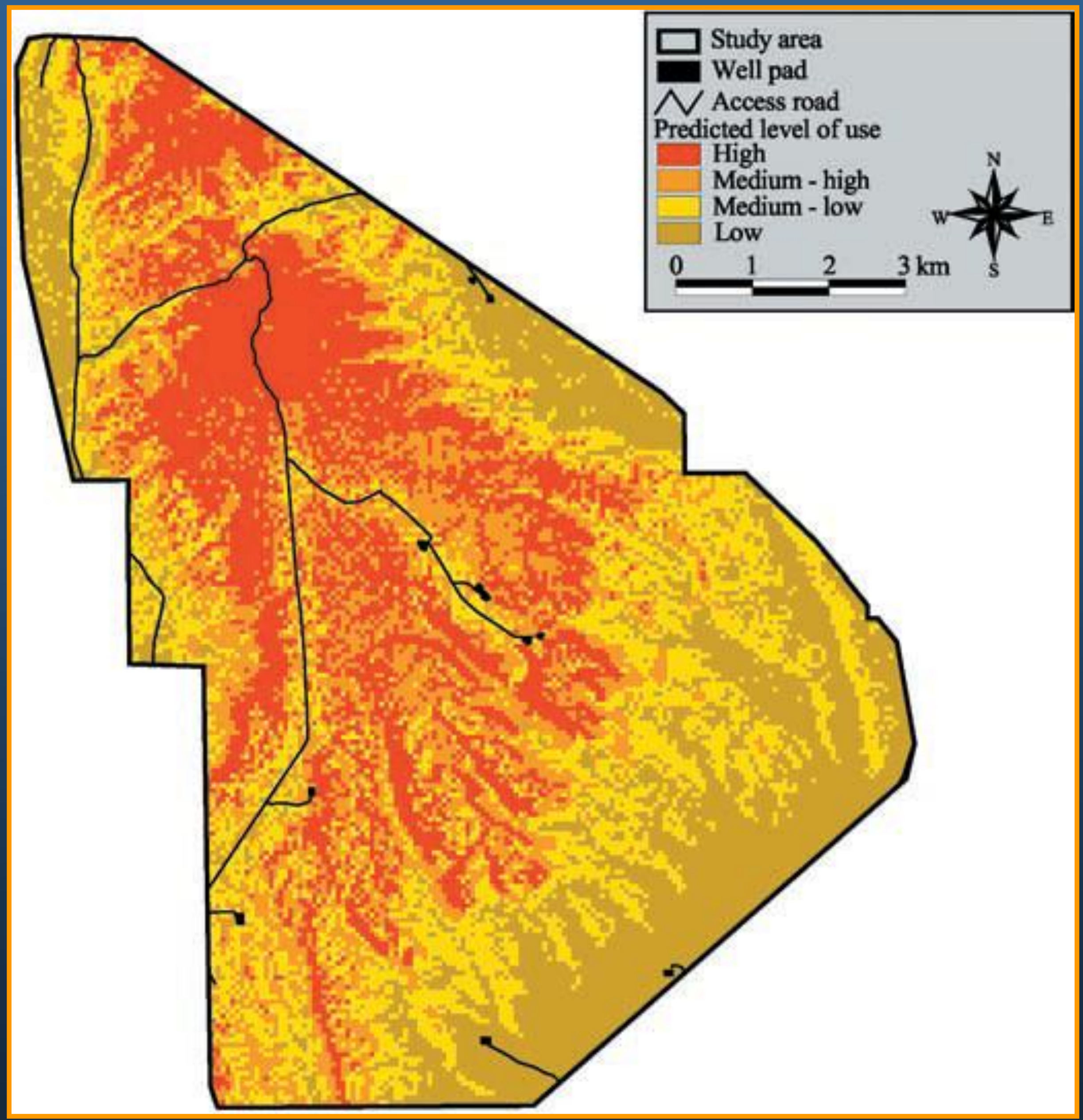
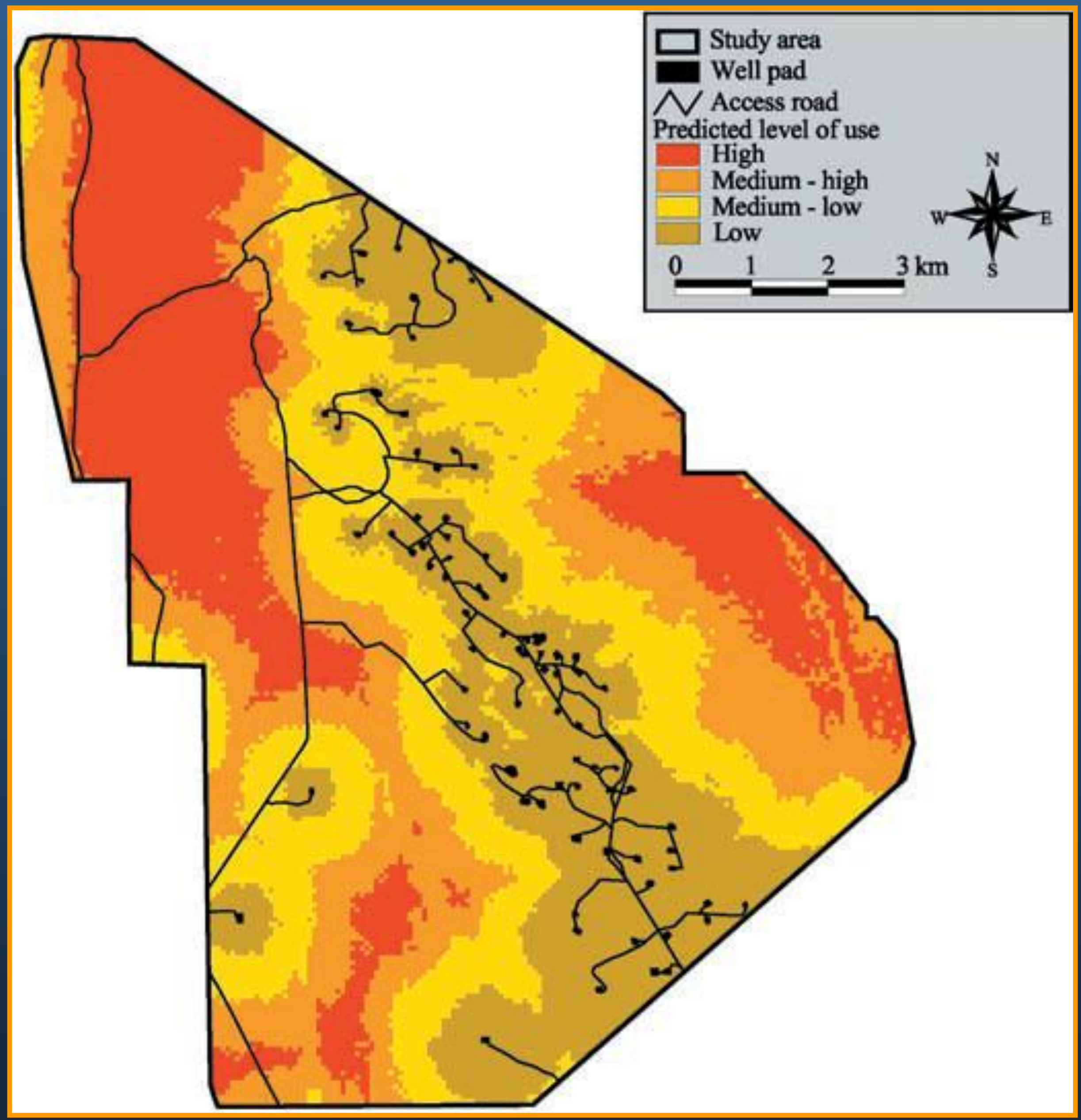
# Wind Energy – Surface Disturbance

# Indirect Effects – Habitat selection studies

Sawyer, H., Nielson, R. M., Lindzey, F. and McDonald, L. L. (2006), Winter Habitat Selection of Mule Deer Before and During Development of a Natural Gas Field. The Journal of Wildlife Management, 70: 396–403.

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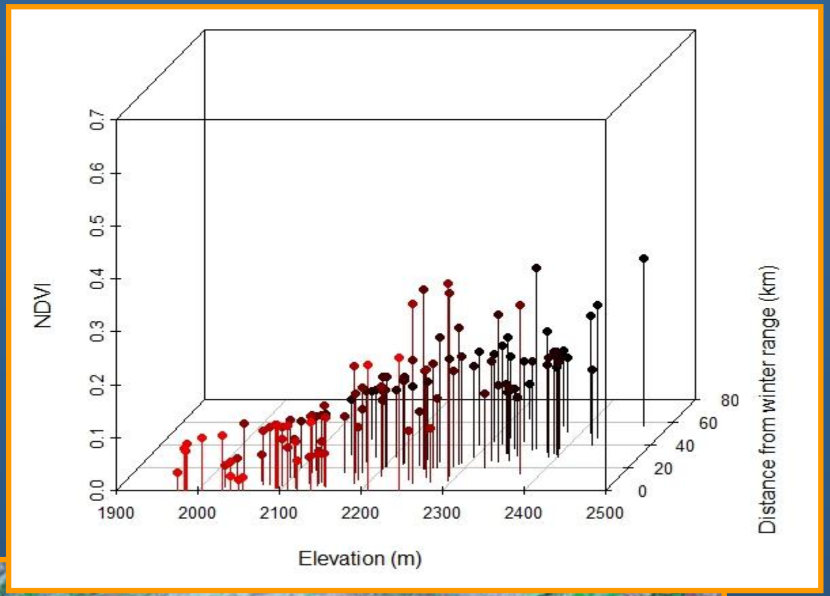
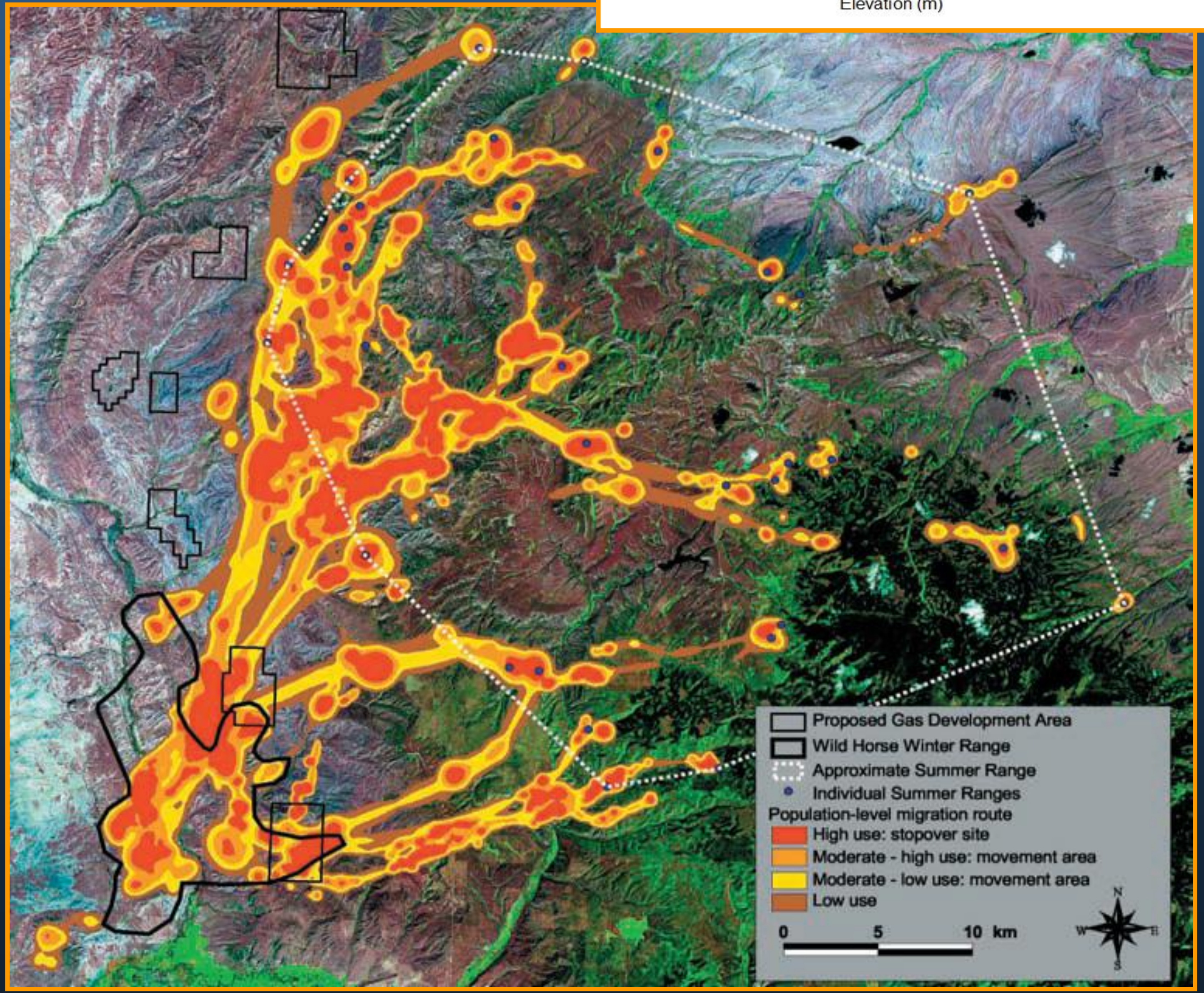
# Indirect Effects – Migration studies




Sawyer, H. and Kauffman, M. J. (2011), Stopover ecology of a migratory ungulate. Journal of Animal Ecology, 80: 1078–1087.

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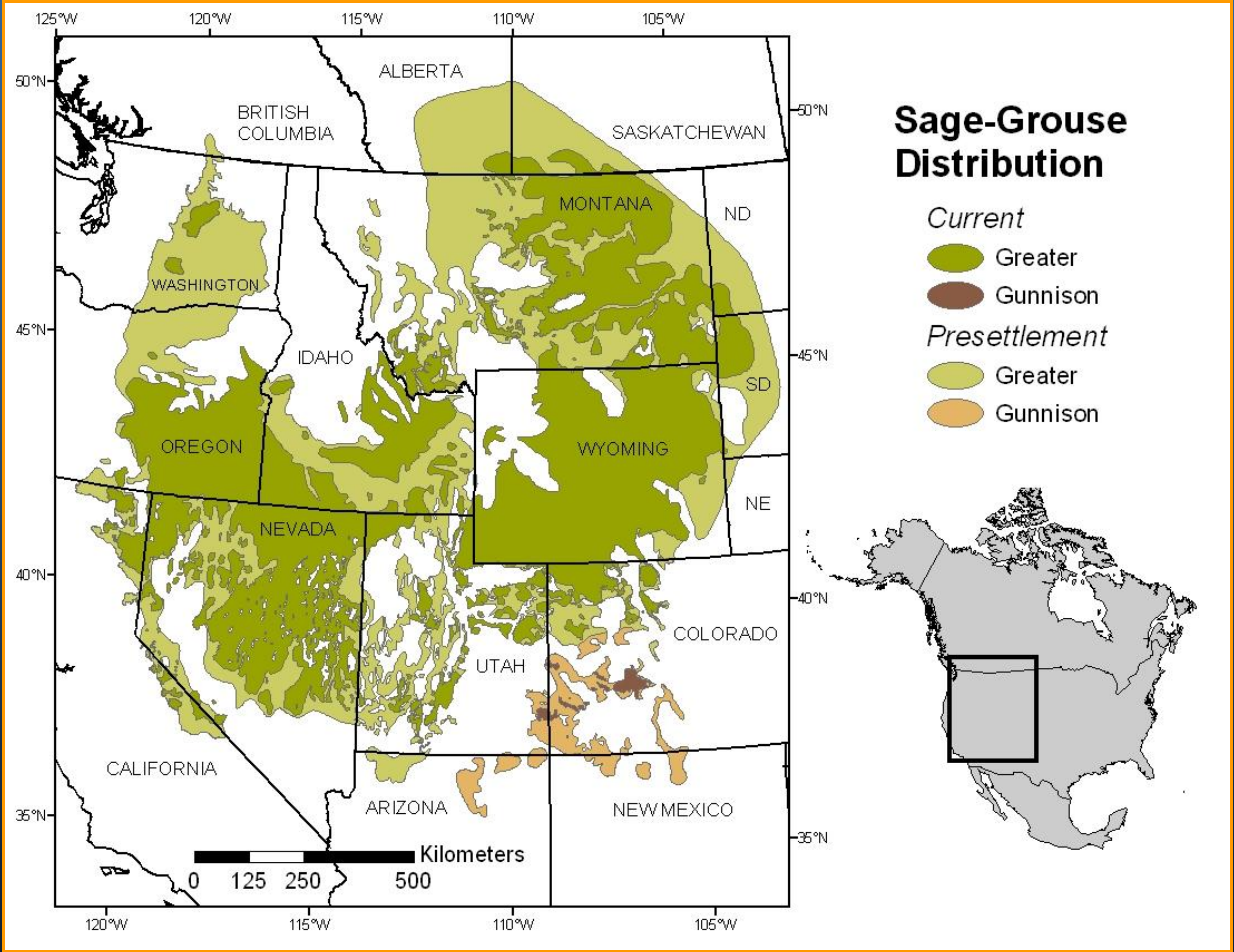
# Indirect and Cumulative Effects




Aldridge, C.L., S.E. Nielsen, H.L. Beyer, M.S. Boyce, J.W. Connelly, S.T. Knick, and M.A. Schroeder. 2008. Range-wide patterns of greater sage-grouse persistence. Diversity and Distributions 14(6): 983-994.

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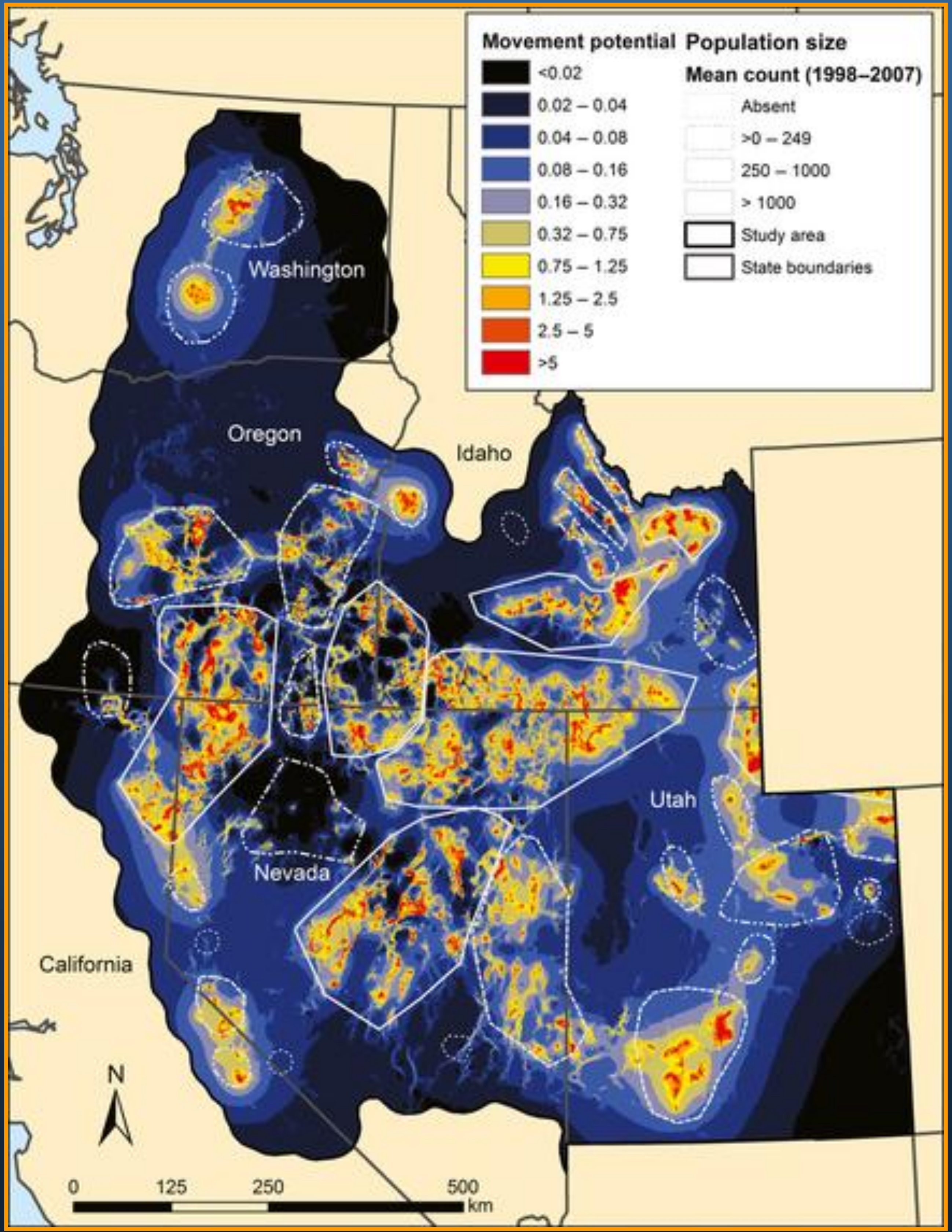
# Habitat Connectivity Modeling




Knick, S. T., Hanser, S. E. and Preston, K. L. (2013), Modeling ecological minimum requirements for distribution of greater sage-grouse leks: implications for population connectivity across their western range, U.S.A. Ecology and Evolution.

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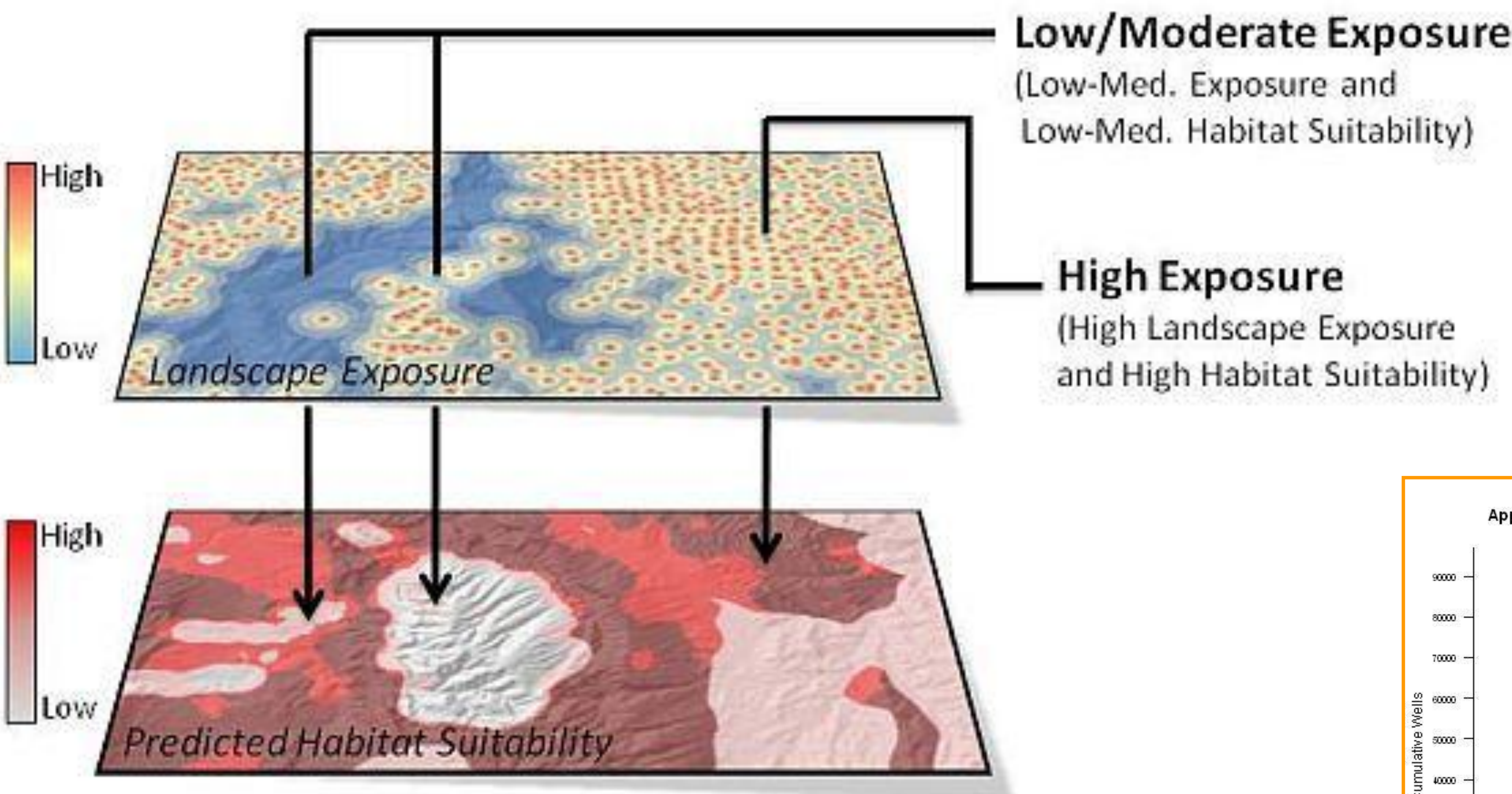
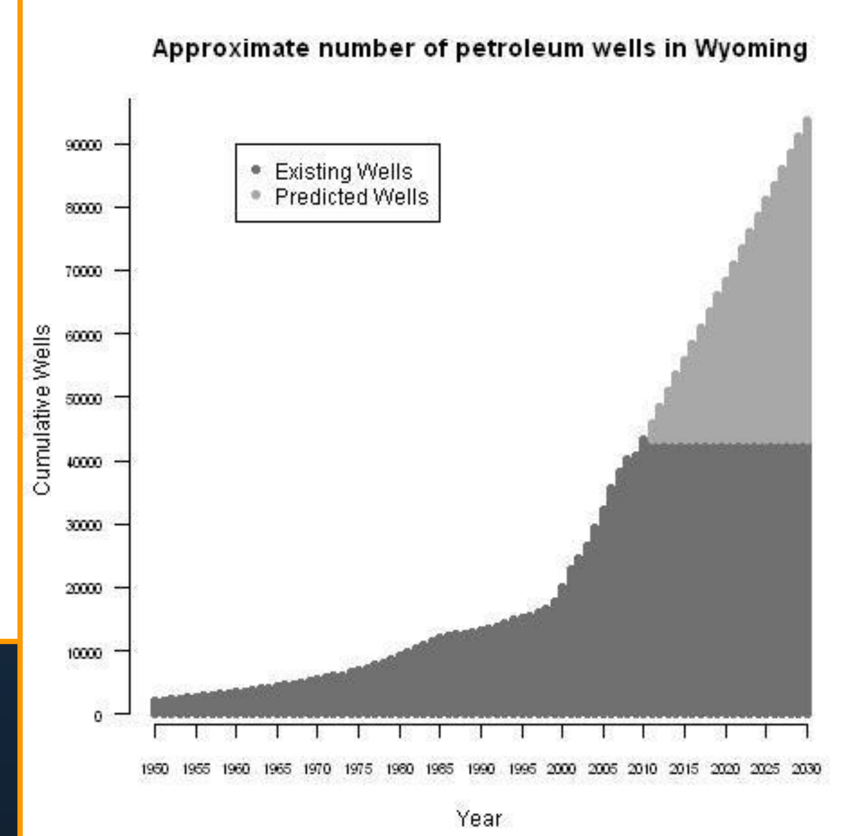
# Vulnerability Assessment




Keinath, D., Copeland, H., Posewizc, A., Kauffman, M., Doak, D., and Andersen, M., (in prep.) Assessing landscape-scale exposure of wildlife resources to domestic energy activities: Ecological Applications.

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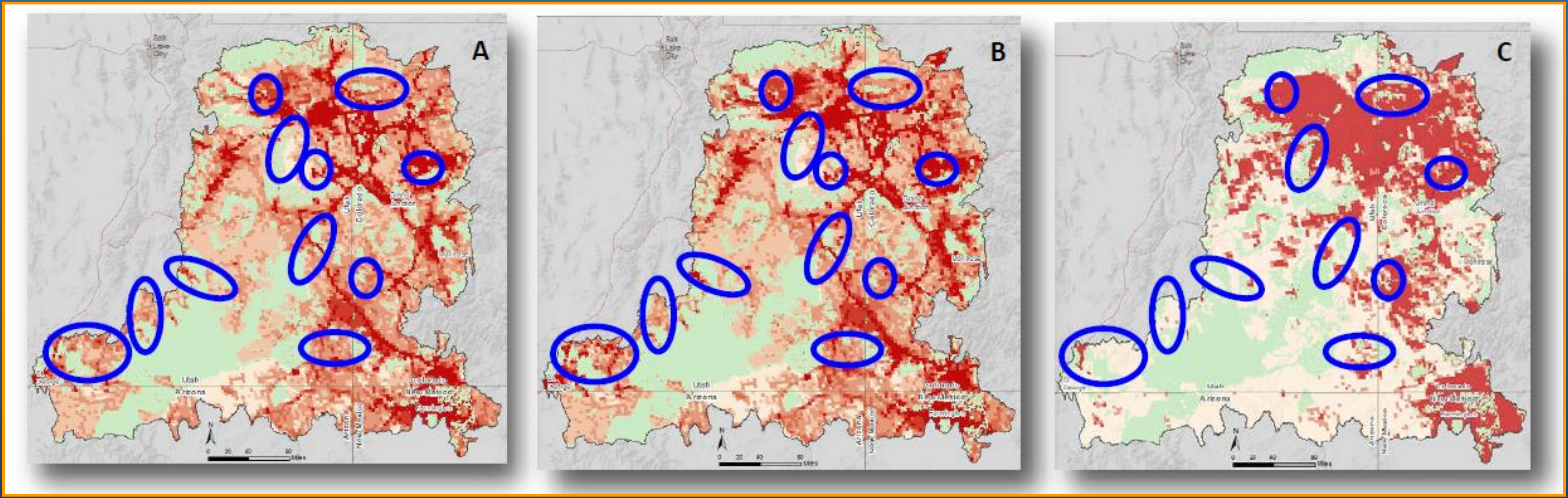
# Ecoregional Assessment – CO Plateau




Concentrations of species or communities

Bryce, S.A., J.R. Strittholt, B.C. Ward, and D.M. Bachelet. 2012. Colorado Plateau Rapid Ecoregional Assessment Report. Prepared for the U.S. Department of the Interior, Bureau of Land Management, Denver, Colorado. (http://www.blm.gov/wo/st/en/prog/more/climatechange.html)

# Summary – Terrestrial

- The distribution of shale gas resources and the methods used to develop the resource determine potential surface disturbance
- Habitat requirements and behavioral responses to development are species specific
- Species responses must be known or estimated to predict responses to development but population responses are difficult to predict precisely
- Vulnerability of species, communities, or ecosystems to potential development is typically assessed by examining areas of overlap and optimally considers sensitivity of the affected species
- Ecoregional assessments examine multiple natural resources and are potentially useful in identifying priority areas for development or conservation

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# Water Cycle

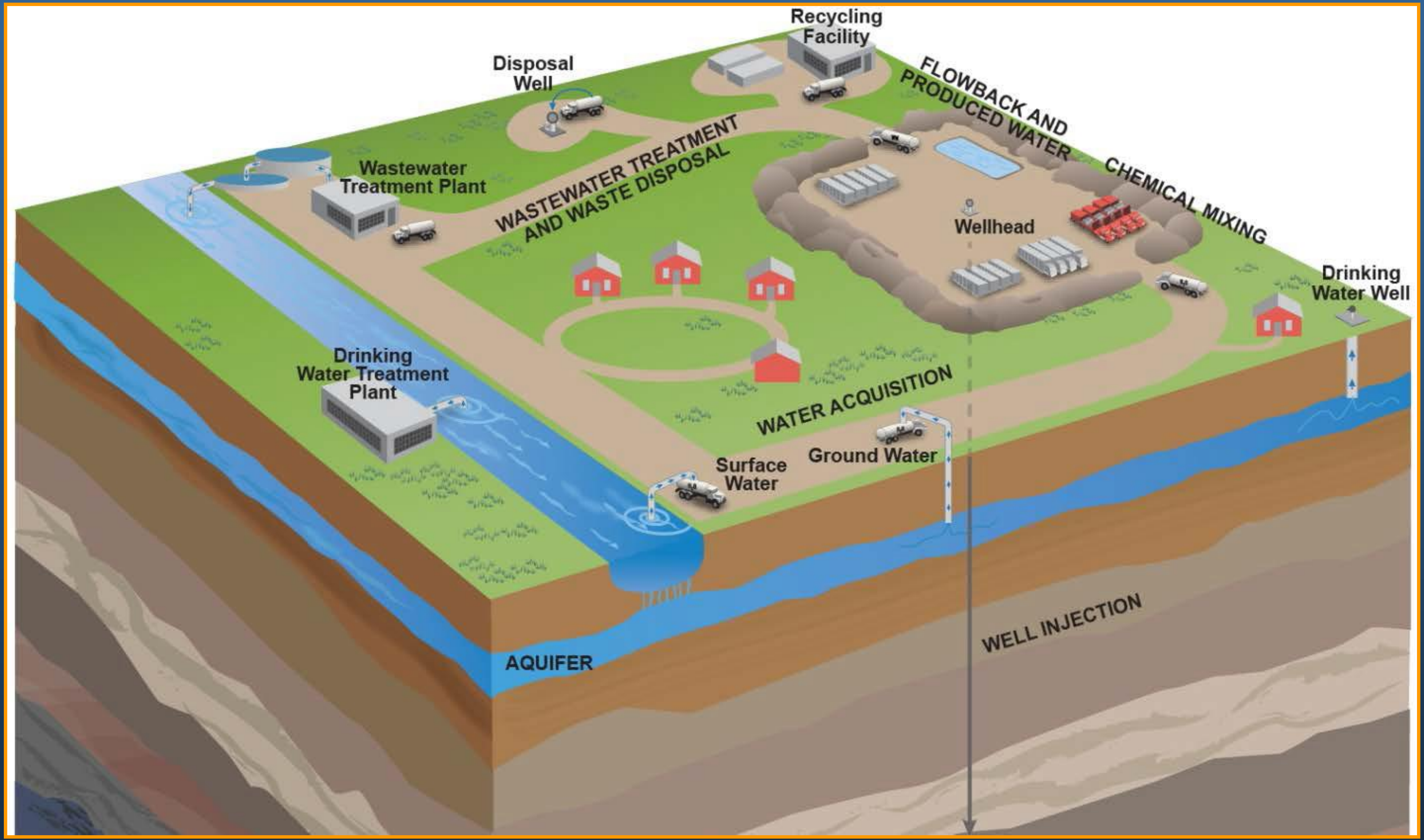


Illustration of the five stages of the hydraulic fracturing water cycle. The cycle includes the acquisition of water needed for the hydraulic fracturing fluid, onsite mixing of chemicals with the water to create the hydraulic fracturing fluid, injection of the fluid under high pressures to fracture the oil-or gas-containing formation, recovery of flowback and produced water (hydraulic fracturing wastewater) after the injection is complete, and treatment and/or disposal of the wastewater. Taken from EPA 601/R-12/011 | December 2012 | www.epa.gov/hfstudy

# Water Source

# Disposal and Treatment Options



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# Aquatic Considerations

**Direct effects**

- Quantity (erosion and habitat loss)
- Quality (beneficial use vs. toxicity)
- Infiltration
- Produced waters (salts) vs. flowback (trace organics)

**Indirect effects**

- Runoff (SAR and TDS)
- Alteration of flow rates and seasonal cycles
- Reduced diversity of habitat patches, increase non-natives
- Trace metals

**Cumulative effects**

- Accumulated effects of an action over space and time

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# Direct Effect – Surface Disturbance

Jerry Rodriguez, FWS

Quantity (erosion and habitat loss)

Dave Harper, USGS

Produced waters (salts) vs. flowback (trace organics)

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# Direct Effect – Water Quality

Potential toxicity/aquatic health

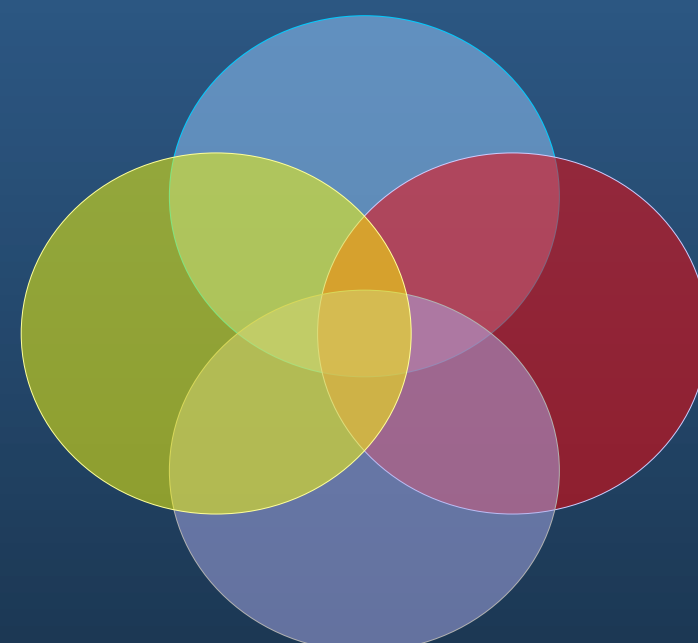
Beneficial use

Aïda Farag, USG

# Approaches to Evaluate Potential Effects

## LABORATORY

- Acute (96 hrs)
- Chronic



## INDIVIDUAL (Quality)

- Physiological Malfunction
- Growth

## POPULATION (Quantity)

- Population Structure
- Death

## FIELD

- In Situ
- Mixing Zone

# Individual to Population

- Growth
- Deformaties
- Mechanisms of toxicity
  - Na/K ATPase
  - ionoregulation
  - Histology
  - Estrogen and androgen receptors


# Laboratory to Field – Study Area Broadens

- Toxicity thresholds in laboratory
- Fish kill - Kentucky
- Watershed - Brook trout Marcellus
- Structural Basin – Powder River
- Brine contamination – Prairie Pothole Region
- United States - Powell

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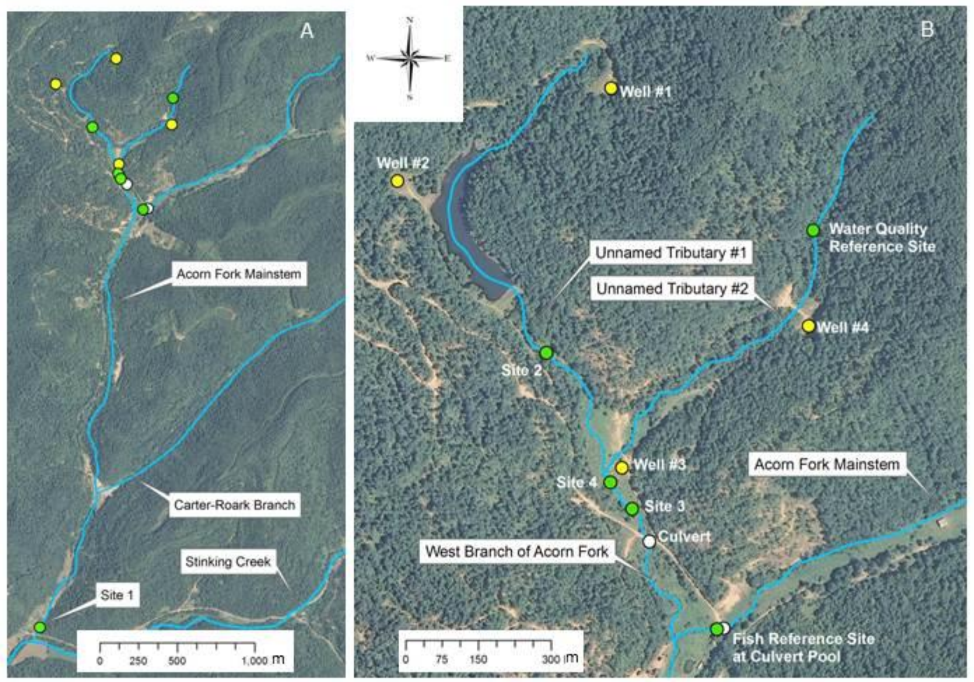
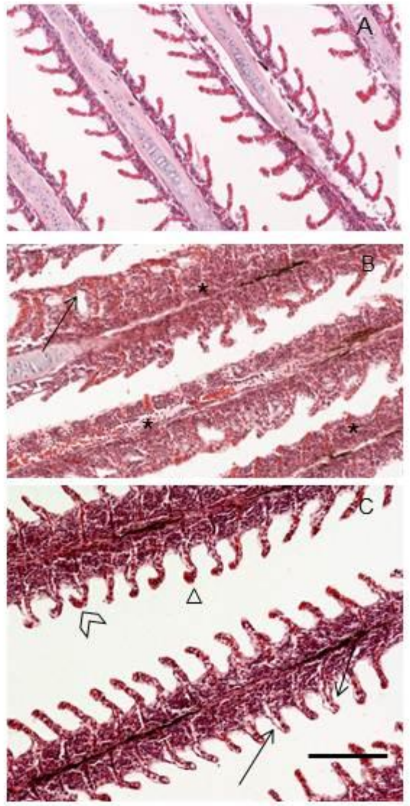
# Fish Kill – Limited Area



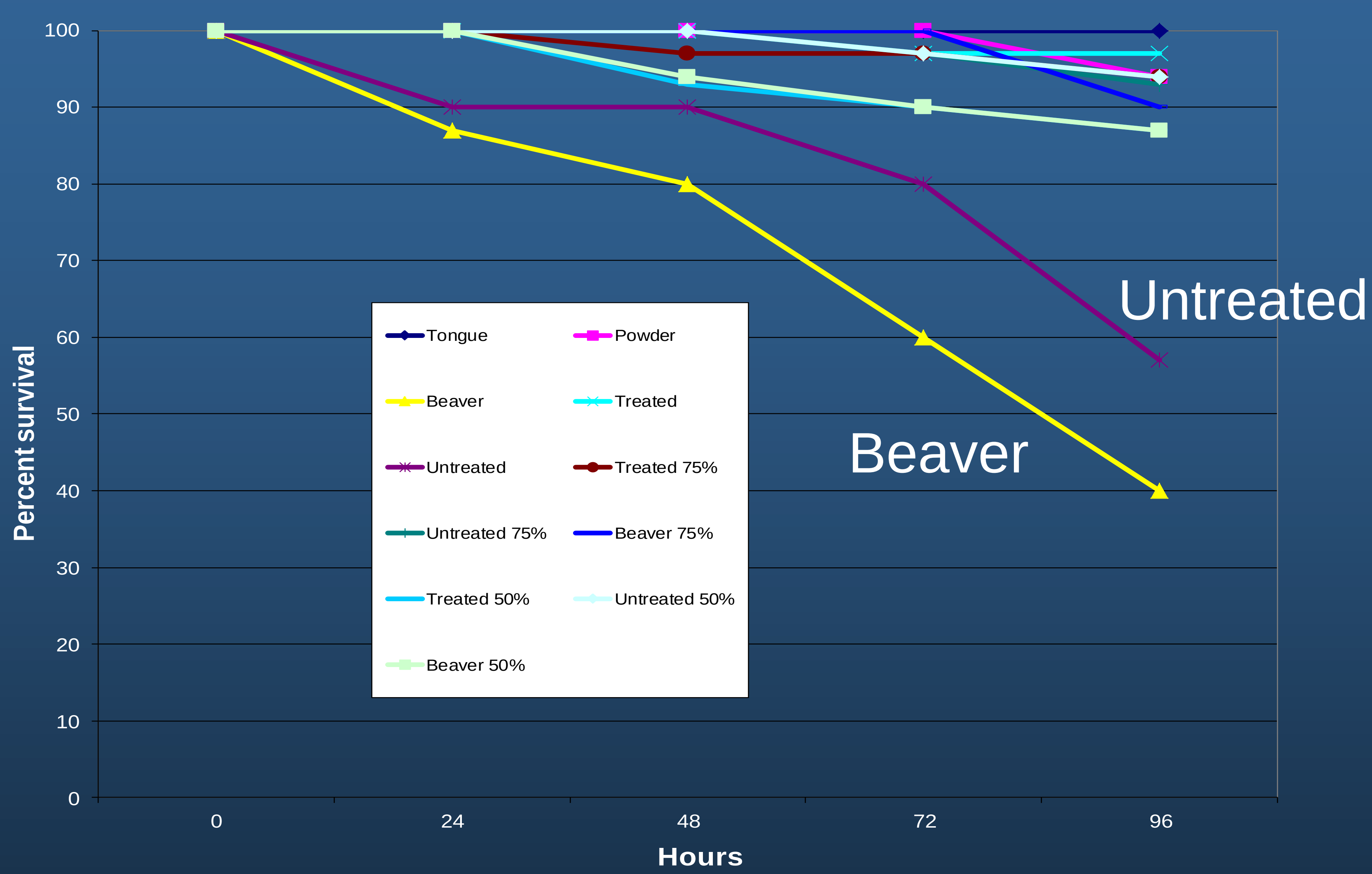

In situ and streamside

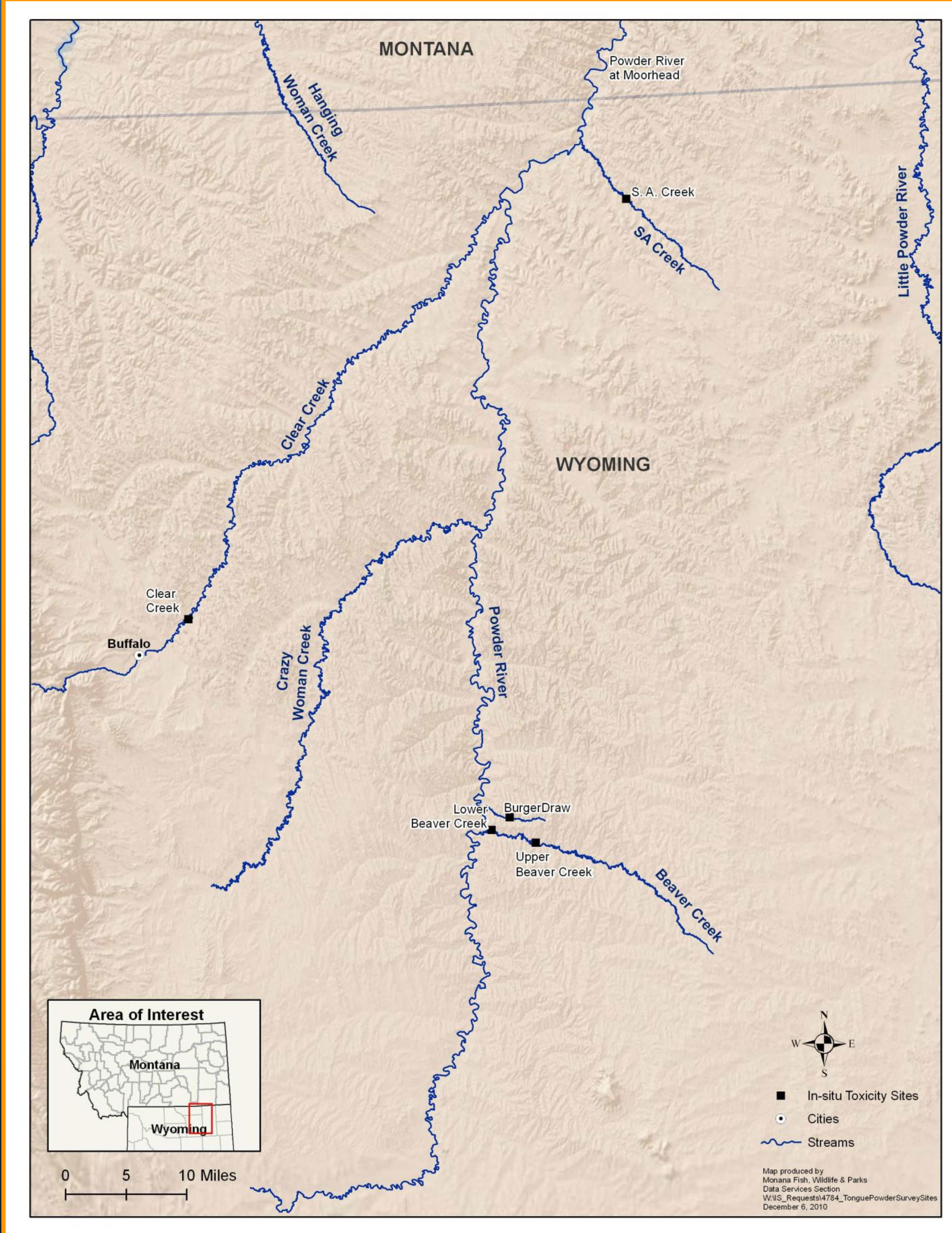



- pH decreased to 5.6
- Epithelial lifting, hyperplasia
- Conductivity increased to 35,900 µS/cm

Papoulias, D.M, and Velasco , J.L., 2013 , “Histolpathological Analysis of Fish from Acorn Creek, Kentucky, exposed to Hydraulic Fracturing Fluid Releases” (in Press)

# Discharge – Basin Wide




Farag, A.M., and Harper, D.D., eds, 2012, “The potential effects of sodium bicarbonate, a major constituent from coalbed natural gas production, on aquatic life” U.S. Geological Survey, Scientific Investigations Report 2012–5008, 101 p.

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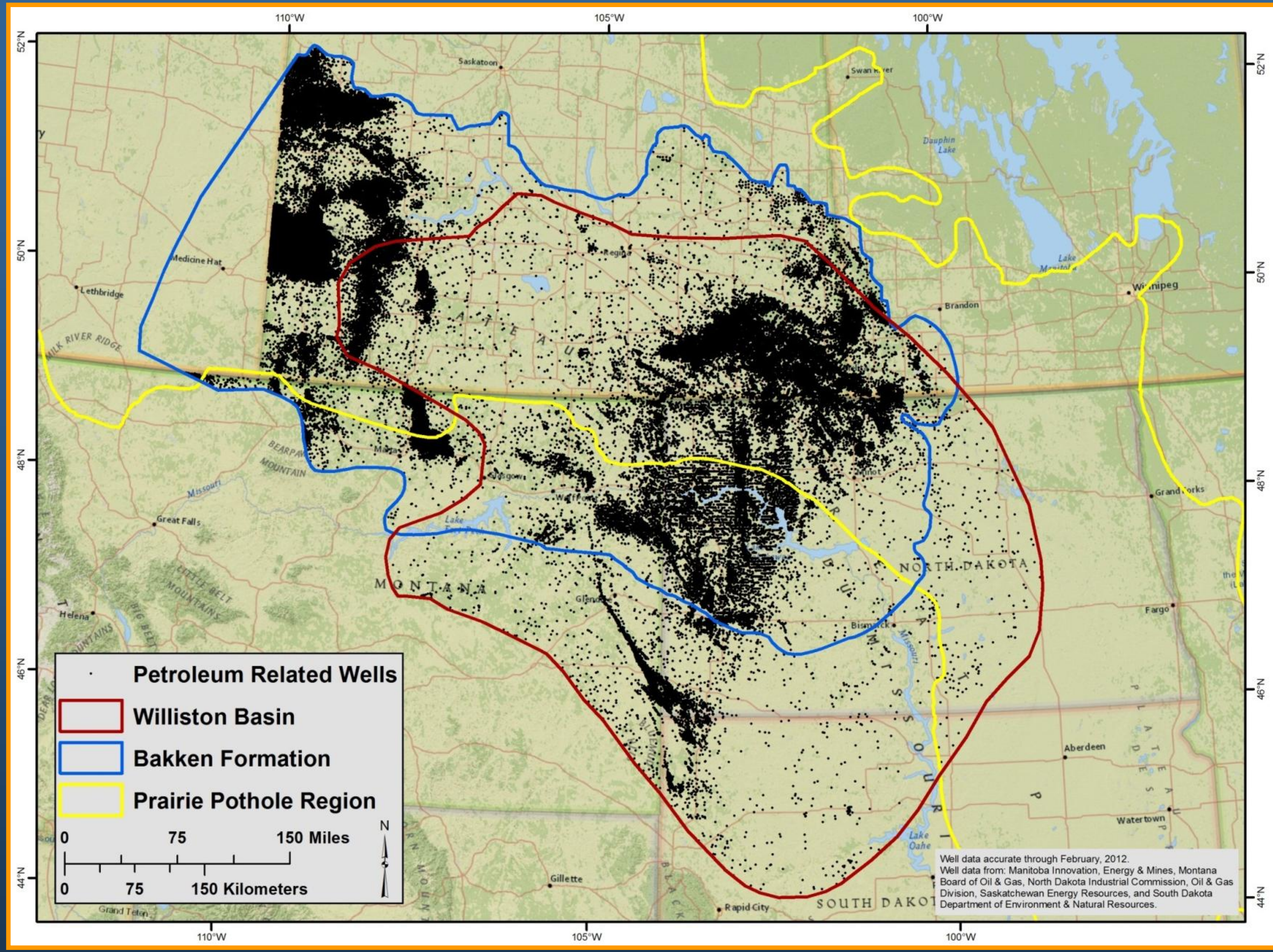
# Proximity to Water Sources

## Wetland Proximity Analysis

- 33% within 1 mile buffer
- 17% within ½ mile buffer
- 7% within ¼ mile buffer
- Need information on potential biological impacts

## EPA

- Study of potential infiltration into test wells
- Study ecological implications at similar locations




Gleason, R.A., Thamke, J.N., Smith, B.D., Tangen, B.A., Chesley-Preston, T., Preston, T.M., 2011, Examination of brine contamination risk to aquatic resources from petroleum development in the Williston Basin: U.S. Geological Survey Fact Sheet 2011-3047, 4 p.

# Summary – Aquatic

- Mitigation of surface disturbance can maintain diversity of aquatic habitat patches
- Integrated scientific approach balances beneficial use with potential toxicity
- Defining mechanisms of toxicity at the individual level provides explanations and early warning
- Establishing toxicity thresholds and field studies expands the study area focus
- Long-term water quality monitoring data are essential

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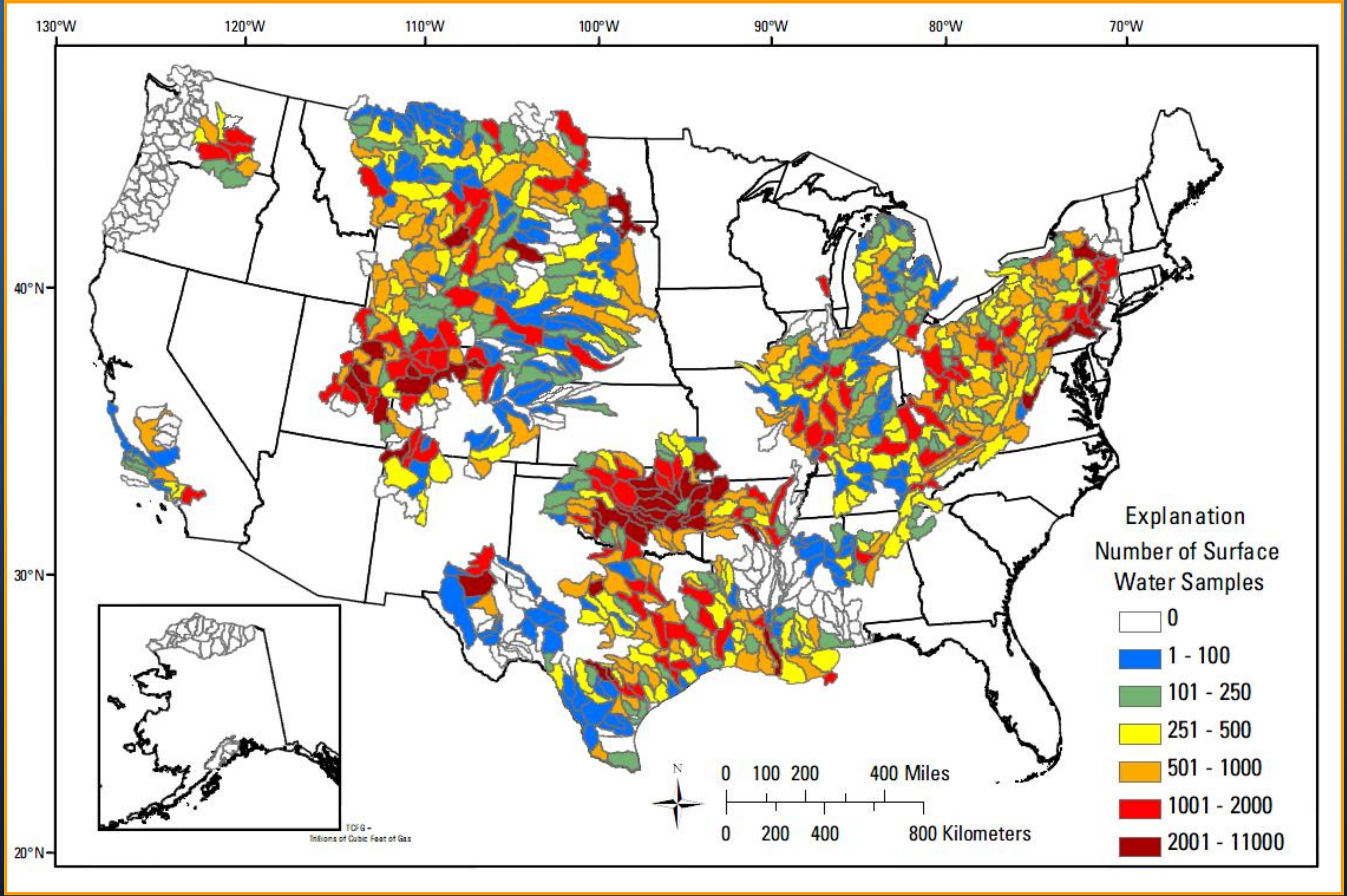
# Retrospective Study - Unconventional Energy and Water Quality

- Watersheds in areas with unconventional energy resources
- 11,401,883 results from over 110,000 sites
- Surface water and ground water quality data from NWIS and STORET
- Completing analyses now

Susong, D.D., Gallegos, T.J., and Oelsner, G.P., 2012, Water quality studied in areas of unconventional oil and gas development, including areas where hydraulic fracturing techniques are used, in the United States: U.S. Geological Survey Fact Sheet 2012–3049, 4 p.

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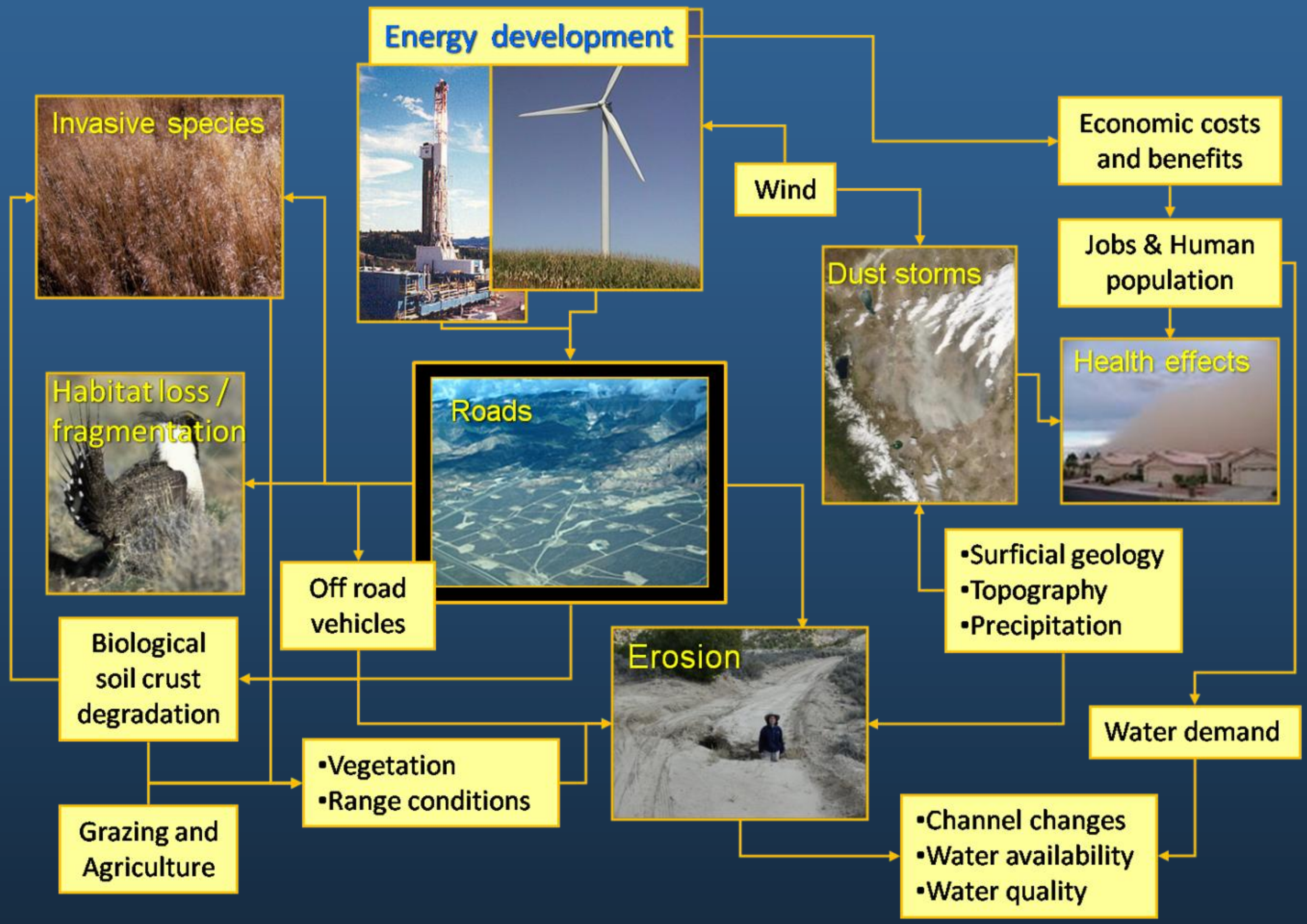
# Integrated Assessment

Common characteristics include:

- Collaboration between policymakers or managers and scientists
- Consideration of multiple resource values and societal needs
- Development of relevant products based on the best available information

Approaches or methods include vertical integration, decision analysis, and ecosystem services valuation

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# Opportunities

- Improve our understanding of the needs of decision makers and managers – multiple resource use
- Focus effort and technical assistance on helping managers make better use of existing high-quality science (now)
- Develop better data and understanding of the basics – distribution and abundance of shale gas, water, vegetation, and fauna
- Continue improving frameworks, methods, and analytical approaches for assessing potential effects of shale gas development on other natural resources