Land Impacts from Shale Oil and Gas Development

Forrest S. Smith, Fred C. Bryant and Eric G. Grahmann

Caesar Kleberg Wildlife Research Institute

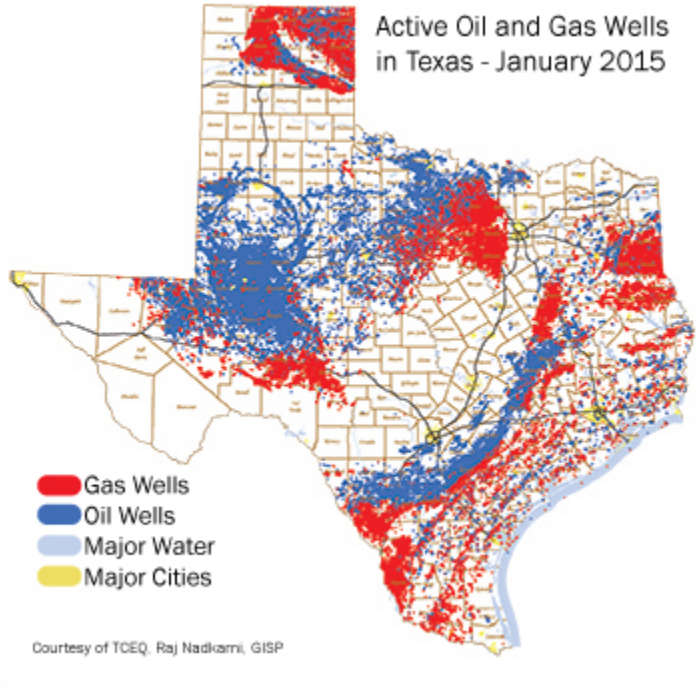
Texas A&M University-Kingsville

LAND Impacts from Shale Oil and Gas Development in Texas

- Interrelated issues with other topics
- Realize all impacts are SPATIAL and TEMPORAL
  - At small spatial scales, many of these issues are not issues
  - Many issues are just becoming known; even historic effects of oil and gas activity on land and vegetation may just be becoming apparent

Knowledge of Land Impacts

- Very limited despite a century of oil and gas production
- Amount of peer-reviewed literature is poor
- Case-study methodology is varied
- Most available research deals with traditional E&P



Three major areas of concern:

- Soil erosion and contamination
- Landscape fragmentation and habitat loss
- Vegetation: plant community effects, invasive plants, and restoration

Soil

- Erosion concerns
- Interrelated water issues
  - Altered hydrology, especially from road and creek disturbances
  - Water quality impacts
- Spills & contamination

  Ex. : USDA Oil field waste land range site

Literature: Erosion

Selected case studies:

1. Gas well sites in NC TX had significant erosion & sediment loading, *until revegetation.* Up to 49x higher than that seen on rangelands. (Williams et al. 2007).
   - *Note: Inference based on 3 pad sites.*
2. Erosion and runoff significantly greater on gas well pad sites in E TX in comparison to clear cutting forestry operations; water quality was minimally impacted (McBroom et al 2012)
   - *Note: Inference based on 2 pad sites.*

Literature: Erosion

3. Eagle Ford development and soil characteristics in La Salle County indicative of 51% increased potential for soil loss on disturbed sites because of higher surface runoff, and greater wind erodibility (Pierre et al. 2013).
    - *Note: County level assessment; however, in early stages of Eagle Ford development (data only up to 2012).*

Conclusions:

- Pad development is indicative of increased erosion potential, but limited study at large spatial scales has been done. Soil diversity is inherent, particularly in the Eagle Ford, thus scope of inference is limited.
- Studies characterizing the impacts of pipeline infrastructure were not found.
- Erosion in relation to shale oil and gas road developement is poorly studied; impacts elsewhere are significant in similar contexts.

Literature: Contamination

1. Sixteen of 18 historic oil pad sites on Padre Island had contamination agents (metals, sodium, higher salinity, pH or hydrocarbons) present, with no pattern of contamination; levels were not immediate threats, but may have cumulative significance environmentally (Carls et al. 1995).
   - *Note: These were historic, conventional well sites; techniques differ substantially today.*
2. Soil salinity (1 site) and nutrient availability (3/4 sites) differed on historic pad sites in S TX in comparison to surrounding areas (Falk et al. In Press). Even so, restoration of native plants was not inhibited.
   - *Note: Historic sites, techniques for pad development differ today. Only 4 study pads.*

Literature: Contamination

3. On 4 W TX sites with on-site disposal of drilling fluids in subsequently covered reserve pits, rangeland soils had severe, substantial increases in SARs and soluble salt concentrations. Revegetation technique choice was dictated by these conditions (McFarland et al. 1987).
   - *Note: Just four study sites were characterized.*

Conclusions:

- Contamination of soils is possible, but has not been well characterized across regions, soils, or plays.
- Diversity in soils, operator procedures, and measurement of impacts varies widely.
- Pipeline and road impacts on soils contamination are unreported, but associated literature, and literature from other regions supports contention that impacts are substantial.
  - Studies ongoing on “mixed soils” on ROWs (Wester et al.)
  - Implications of fracking on soil issues?

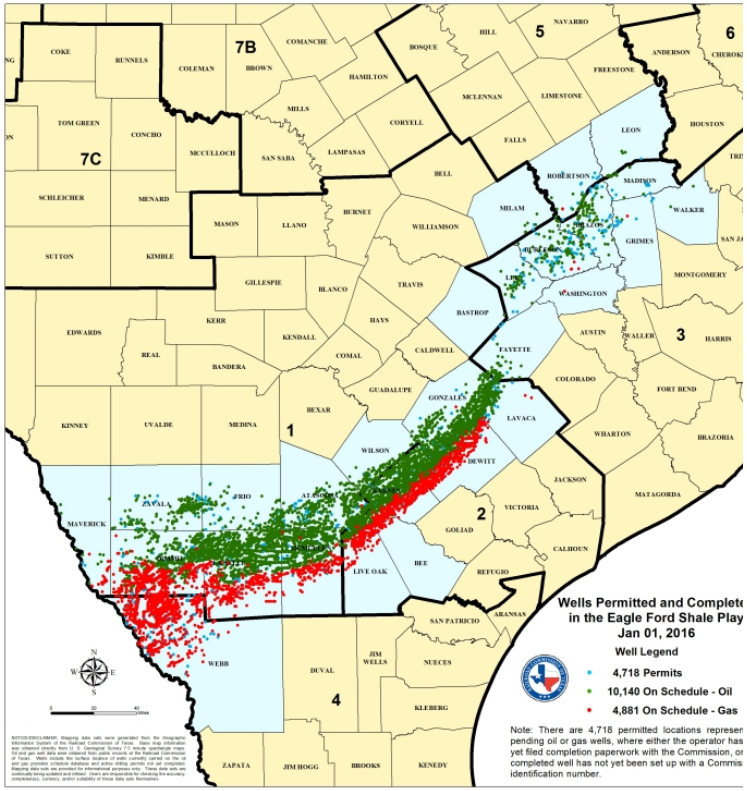
Fragmentation and Habitat Loss

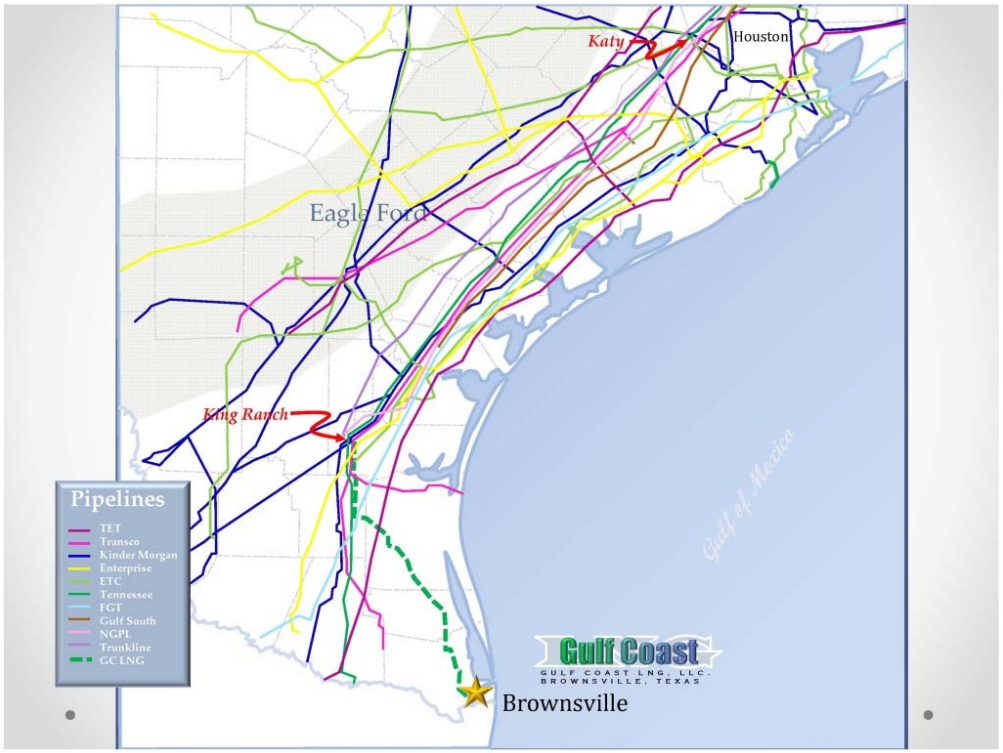
- Habitat amount and quality concerns
- Productivity for other land uses
- Texas A&M Land Trends (Lopez 2014)
  - Eagle Ford Shale region 1993-2014
  - 23,000 well pads accounted for 84,000 acre footprint
  - Roads and pipeline impact not estimated

Habitat Issues

- Direct and Indirect impacts
- Direct: “Actual Footprint”-numerically small
- Indirect: “Ecological footprint”-larger than actual
- Generalizing the effects of landscape change:
  - Species specific responses apparent in wildlife
  - Northern bobwhite vs. scaled quail as examples
  - Raw habitat loss and corresponding effects on populations of wildlife, grazing animals, leasable acres is relevant and poorly studied in Texas

Two footprints:





Literature: Fragmentation

1. In La Salle County, pipeline construction was the dominant landscape change feature, followed by drilling and injection pads; at the county level, core areas decreased 8.7%; patch number increased 0.2%; and patches, edges, and perforated areas increased; overall habitat fragmentation increased 62% (Pierre et al 2014).
   - *Note: Early stages of Eagle Ford development only.*
2. In the Barnett Shale, patch, edge, and small core landscape conditions increased with development, especially where roads cross. Effects differ by drilling intensity (Pradhananga 2014).
   - *Note: 3 sample areas used in estimates.*

Conclusions: Fragmentation and landscape characteristics were greatly altered in shale plays; corresponding effects are not known.

Literature: Habitat Loss

- 3-7 acres consumed/pad in shale plays (Brittingham et al. 2014)
    - 23% of well pads in La Salle Co. were multi-well pads in 2012 (Pierre et al 2014).
    - TAMU INR (Lopez 2014) estimated avg loss of 3.65 acres per pad in the Eagle Ford as of 2014 (23,000 wells).
- Each new well results in 7-9 acres associated acreage consumption (Brittingham et al 2014)
    - LaSalle County: 3% of the county directly impacted by 2012
- Grey literature:
    - Private ranch observations: ranch wide avg. of 10 acres of vegetated land per well lost (Hehman pers comm.)
    - Pipelines: 16,000 miles new ROWs in TX 2010-2013 (Garcia 2014)
        - 200,000 ac of new impact at est. 100’ width
        - Not inclusive of flow lines and unregulated ROWs
    - TX has 431,997 miles of regulated pipelines (Railroad Commission of Texas 2016)
        - LNG-associated pipelines could expand this impact to new areas.

Conclusions: Fragmentation and Loss

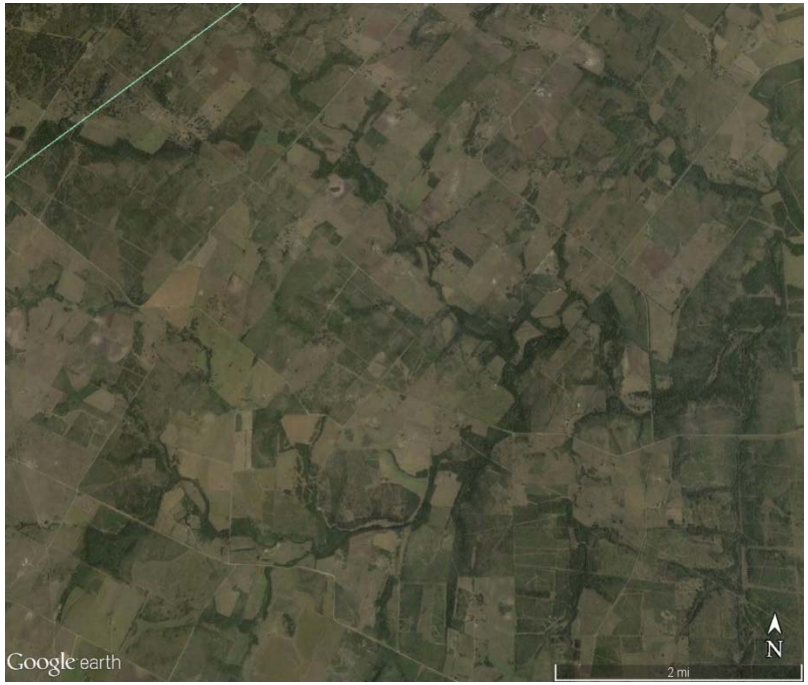
Published effects on landscape characteristics indicate substantial fragmentation occurs in shale plays.

- Efforts to expand characterization should continue- especially as development matures.
  - Degree and types of development widely vary by play/operator; guidance on siting should be available.

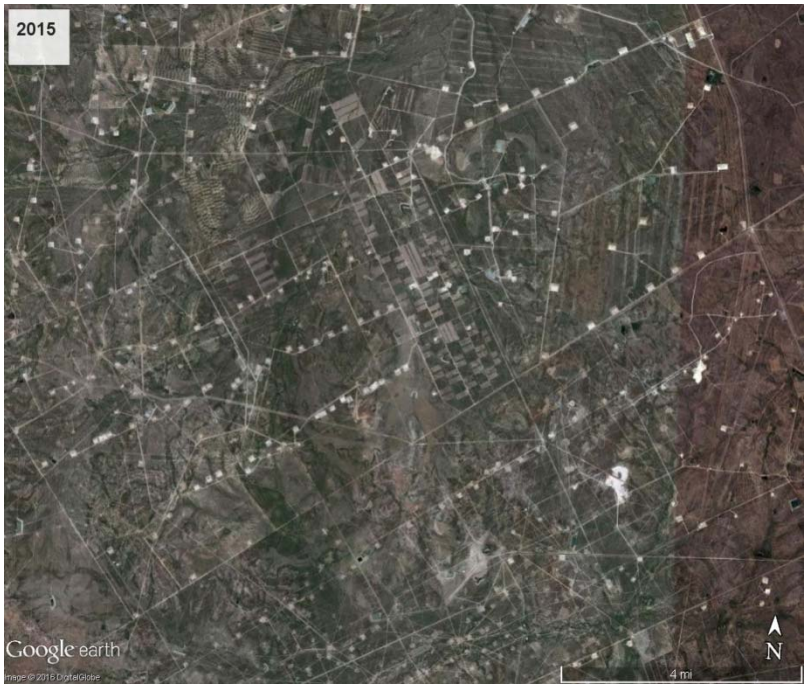
Habitat loss is pronounced and impactful at the landscape scale, as measured and evidenced by satellite imagery

- Efforts to identify wasteful land use, and guide future operations should be studied
  - Private ranch “development corridors” as an example

Indisputable evidence?
Dewitt County 2008-2015

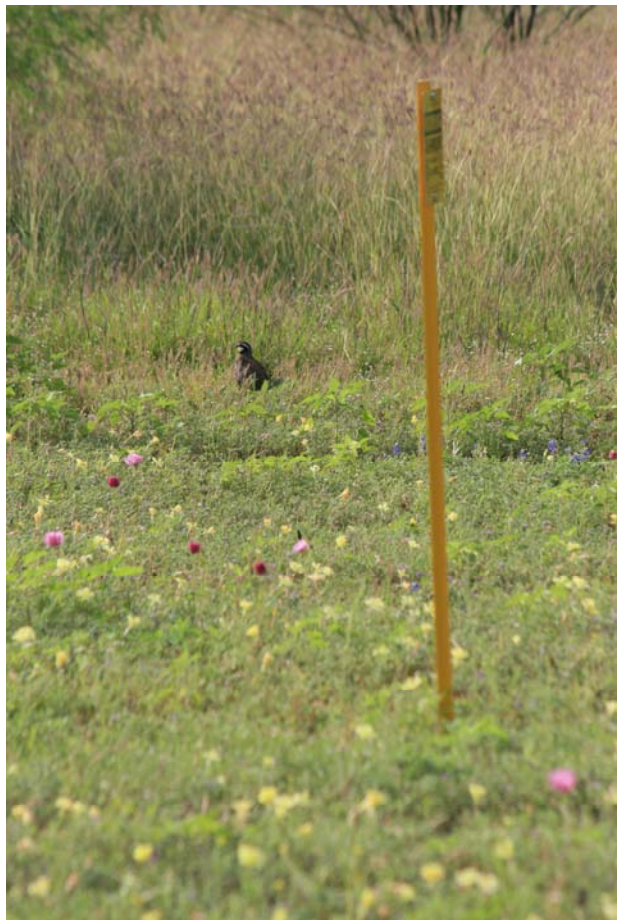


Indisputable evidence?
Dimmit County: 2002-2015



Vegetation

- Plant community
- Invasive species
- Restoration



Literature: Plant community

1. Raw plant diversity was higher on disturbed sites; however vegetation cover was lower; vegetation is dissimilar on Padre Island, even years later. Changes relate to hard surfacing of oil and gas sites, and alteration of natural relief (Carls et al. 1990).

Conclusion: Despite over 400,000 miles of pipelines, and 200,000 well pads, almost no information on the effects of oil and gas infrastructure development on vegetation communities exists.

Literature: Invasive Plants

1. Non-native grass cover higher at historic pad sites than in adjacent landscape; effects were species specific; two species were only present in association with well pads; invasion effects were limited to within 60 m of pads (Cobb et al. 2016).
    - *Note: Research limited to single study site and soil series.*
2. Historic roads and pipelines ROWS are supported as vectors for exotic grass invasions, and those areas support near-monoculture stands of exotic grasses (Goertz 2013).
    - *Note: Research limited to single ranch, albeit with a long term data set*

Literature: Invasive Plants

Conclusions:

- Literature available indicates invasive plant occurrence is influenced by oil and gas related disturbance.
- However, despite the level of oil and gas development both historically and in current shale plays, very little information exists in scientific literature.
- Effects of invasive plants on wildlife in other contexts are well-studied and clear (reviewed by Fulbright et al.).

Invasive Plants of Concern:

Buffelgrass

Lehman lovegrass

Old World bluestems

Literature: Restoration

1. Various seeding techniques were effective for restoration of native plants using ecotypic native seeds on three ecological sites impacted by Eagle Ford Shale pipeline (Pawelek et al. 2015).
    - *Note: Research limited to single study site.*
2. Various seeding methods and high levels of seed mix diversity resulted in successful reclamation of Eagle Ford pipeline ROWS using ecotypic native seeds (Falk et al 2015).
    - *Note: Research limited to two study sites.*
3. Ecotypic native seed mixes were successfully used to reclaim historic oil pad sites with typical soil limitations of pad sites, even with continuous livestock grazing in S. TX (Falk et al. In Press)
    - *Note: Research limited to four pad sites*
4. Plant choice, mulching, irrigation, and grazing deferment were impactful in revegetation of W. TX pad sites (McFarland et al. 1987).
    - *Note: Research limited to four pad sites*

Literature: Restoration

Conclusions:

- Results from South Texas and the Eagle Ford Shale indicate ecotypic native seeds can be successfully used to restore impacted areas
- Research on long-term performance of restored sites is lacking
- Information from other areas of Texas is nonexistent

Restored Pad Site-King Ranch, Texas

Restored Eagle Ford Pipeline ROW

Putting it all together:

- An obvious dearth of knowledge of impacts on Texas' land resources
- Tangible effects of development are poorly studied
  - Wildlife: effects vary by species
  - Effects on land use for ranching, farming, or land values are poorly documented
  - Long term and cumulative environmental effects on land resources are poorly studied.
- The interrelationship of problem areas is undeniable:
  - Soil erosion issues can be mitigated with better restoration
  - Need for restoration can be minimized with better landscape-level planning
  - Fragmentation and habitat loss may be alleviated with good restoration

Recommendations

- Characterize land and habitat change at the oil and gas "play" level
  - Effects on wildlife: so far we know (something) about these effects on just a few species
- Evaluate *actual* erosion and soil contamination at meaningful scales, and across a diversity of operators, sites, and ranches
  - Not just the one Federal Land in Texas impacted by oil and gas exploration
  - Is there (or will there be) a cumulative environmental impact?

Recommendations

- Determine the effects of shale oil and gas exploration on vegetation
  - Invasive vegetation-one study done- with fairly convincing results.
  - Native plant restoration-a real solution?
  - Impact size: could logically be as much as 1/10 of the non-urbanized land mass of Texas (!)
- Even a single, long-term case study with solid methodology would be superior to available information
- Soil, landscape, and vegetation impacts are intuitive: our treatise is that restoration has potential to alleviate land impacts where exploration is done

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