Energy Development in the Great Plains: Ecological Implications and Restoration Opportunities

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Energy Use
Energy Use
Sources of Energy Consumption

- Petroleum and other liquids
- Natural gas
- Coal
- Nuclear
- Hydro
- Liquid biofuels
- Other renewable energy

Energy (quadrillion BTUs)

EIA 2018
Energy Resources on our Grasslands: Coal

[Map showing coalbed methane fields in the Lower 48 states, with a focus on the Powder River Basin and the San Juan Basin.]

Source: Energy Information Administration based on data from USGS and various published studies
Updated: April 8, 2009
Energy Resources on our Grasslands: Conventional Oil and Gas

Gas Production in Conventional Fields, Lower 48 States

Gas Production, Last Reported Year (Billions of Cubic Feet)
- • 0 - 5
- • 5.1 - 20
- • 20.1 - 50
- • 50.1 - 290

Basins and OCS Areas
Inter-Basin Areas

Source: Energy Information Administration based on data from HPDI, IN Geological Survey, USGS
Updated: April 8, 2009
Energy Resources on our Grasslands: Wind

## Energy Production: Consumption Ratios

<table>
<thead>
<tr>
<th>US</th>
<th>CO</th>
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<tbody>
<tr>
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<td>2.2</td>
<td>0.8</td>
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<td>3.0</td>
<td>2.4</td>
<td>0.6</td>
<td>1.4</td>
<td>17.3</td>
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> 1 exporting energy  
< 1 importing energy

EIA 2018
### Energy Production: Consumption Ratios

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EIA 2018, Pipeline Safety Trust
# Energy Resources on our Grasslands

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## Oil and Gas Pipeline Mileage (%)

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<tbody>
<tr>
<td>2.8</td>
<td>2.7</td>
<td>0.8</td>
<td>1.2</td>
<td>1.5</td>
<td>1.9</td>
<td>3.0</td>
<td>0.4</td>
<td>12.8</td>
<td>1.0</td>
</tr>
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1.8 million miles of O&G pipeline in the US
28% occurs in our grassland states

EIA 2018, Pipeline Safety Trust
Ongoing and Increasing Energy Harvest

Oil and gas wells drilled in central Canada and USA

Allred et al. 2015
Energy Production and Land Ownership

Wells Drilled (million)

Private: 0.34
Federal: 0.01
Native American: 0.005
State: 0.001

Allred et al. 2015
Impacts of Energy Development: Historical Disturbances

Grazing

Fire

Climate

Kevin Ebi/Living Wilderness

Cristi Painter

Eva Horne
Comparing Energy Development to Historical Disturbances

**Historical Disturbances**
- Small to mid-sized soil disturbance
- Removal of aboveground vegetation
- Disturbance timing driven by biology/phenology
- Creates local and landscape scale habitat heterogeneity

**Energy Development**
- Mid-sized to large and deep soil disturbance
- Removal of aboveground and belowground vegetation
- Disturbance timing driven by economics
- Heterogeneity in infrastructure density
- Alters vertical structure
- Introduces new substances
Potential Impacts and Opportunities of Energy Development

I. Potential Impacts
   1. Atmosphere
   2. Water
   3. Soils and Vegetation
   4. Wildlife
   5. Social

II. Opportunities
Potential Impacts of Energy Development: Atmosphere

Power Plant Emissions in the Great Plains

Emissions (million tons)

- Red line: SO₂
- Black line: NOₓ

EPA 2018
Potential Impacts of Energy Development: Atmosphere

- Emissions (VOCs, NO$_x$, SO$_2$, BC)
  - Venting
  - Flaring
  - Equipment Leaks
Potential Impacts of Energy Development: Atmosphere

- Emissions (VOCs, NO\textsubscript{x}, SO\textsubscript{2}, BC)
  - Venting
  - Flaring
  - Equipment Leaks
- Local climate change

Local warming effect of 0.724°C per decade in TX (Zhou et al 2012)
Potential Impacts of Energy Development: Water

- Competing water use
Potential Impacts of Energy Development: Water

- Competing water use
- Surface water contamination
  - Reserve pits are no longer legal in many states
  - Reinject into the wells
  - Still opportunities for spills
Potential Impacts of Energy Development: Soil and Vegetation

- Soil disturbance during construction and harvesting
Potential Impacts of Energy Development: Soil and Vegetation

- Soil disturbance during construction and harvesting
- Soil compaction and erosion
Potential Impacts of Energy Development: Soil and Vegetation

- Soil disturbance during construction and harvesting
- Soil compaction and erosion
- Soil alterations
  - Mixing horizons
  - Changes in microbial and soil seed bank during long-term storage
  - Opportunities for invasive species
Potential Impacts of Energy Development: Soil and Vegetation

Non-native species

- Soil disturbance creates open niches for weeds
- Movement of equipment can transport their seeds
- Linear developments (Roads, pipelines, and transmission lines) create opportunities for weed movement
Potential Impacts of Energy Development: Soil and Vegetation

Simmers and Galatowitsch 2010
Potential Impacts of Energy Development: Soil and Vegetation

- Soil disturbance during construction and harvesting
- Soil compaction and erosion
- Soil alterations
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- Fugitive dust
Potential Impacts of Energy Development: Soil and Vegetation

- Soil disturbance during construction and harvesting
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- Soil alterations
  - Mixing horizons
  - Changes in microbial and soil seed bank during long-term storage
- Invasive species
- Fugitive dust
- Contamination from spills
Potential Impacts of Energy Development: Wildlife

- Increased mortality
Potential Impacts of Energy Development: Wildlife

- Increased mortality
- Habitat fragmentation and reduction
  - Attraction or avoidance of infrastructure
  - Affect migration routes and stopover sites
- Noise
- Altered behavior/movement
- Life history timing

Sawyer et al. 2013
Potential Impacts of Energy Development: Wildlife

Intercapture Distance

- **Males**
- **Females**

Distance (m)

<table>
<thead>
<tr>
<th>Year</th>
<th>Distance (m)</th>
</tr>
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<tbody>
<tr>
<td>1979</td>
<td>100</td>
</tr>
<tr>
<td>1980</td>
<td>250</td>
</tr>
<tr>
<td>1981</td>
<td>150</td>
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Dana 1991
Potential Impacts of Energy Development: Wildlife

Butler et al. In press.
Potential Impacts of Energy Development: Wildlife

- Increased mortality
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  - Affect migration routes and stopover sites
- Noise
- Altered behavior/movement
- Life history timing
- Altered fecundity/breeding success
Potential Impacts of Energy Development: Wildlife

Higher O&G development

Burr 2014
Potential Impacts of Energy Development: Wildlife

- Increased mortality
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  - Life history timing
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Principles
- Species specific
- Site Specific
- Scale
- Trophic Levels
- Time period of study
Potential Impacts of Energy Development: Social

- Boom-Bust Cycles in rural locations
  - Stress on community resources and investment on the grasslands
- Increased grassland use
- Shadow flicker and noise
I. Potential Impacts
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   2. Water
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   4. Wildlife
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II. Opportunities
Opportunities to avoid and minimize impacts: Atmosphere

**Current opportunities**
- Build pipelines or develop storage capabilities for natural gas production to reduce the need for flaring

**Needed research**
- Determine the critical loads and monitoring needs of the various emissions
Opportunities to avoid and minimize impacts: Water

Current opportunities

• Develop and use risk assessments for areas with oil and gas activity to focus monitoring efforts
Opportunities to avoid and minimize impacts: Water

Current opportunities
• Develop and use risk assessments for areas with oil and gas activity to focus monitoring efforts

Research needs
• More knowledge on the effects of using surface vs groundwater for unconventional oil and gas development
Opportunities to avoid and minimize impacts: Soil and Vegetation

Current opportunities
• Have in mind reclamation and restoration plans from the beginning of the project
  • Eliminate weed populations prior to disturbance
  • Collect seeds from native ecotypes prior to development
  • Use high numbers of native plant species
  • Minimize disturbance
Opportunities to avoid and minimize impacts: Soil and Vegetation

Current opportunities
• Have in mind reclamation and restoration plans from the beginning of the project
  • Eliminate weed populations prior to disturbance
  • Collect seeds from native ecotypes prior to development
  • Use high numbers of native plant species
  • Minimize disturbance
• Lessons from other disciplines (O&G learn from coal and CRP)
• Project siting
  • Overlap with existing development
  • Locate in areas that need vegetation improvement
  • Colocation available due to horizontal drilling
Opportunities to avoid and minimize impacts: Soil and Vegetation

Needed research/technology
• Opportunities with future linear developments (focus on new restoration techniques)
• Better understanding of the biological processes occurring in stockpiled and salvaged topsoil (e.g. microbial responses) to produce new technology and improve methods for storing topsoil for long periods of time
• Determine methods that favor succession from weedy species to perennial natives
• Link aboveground and belowground restoration
• Seed provenance
  • Find or develop reasonably priced seed supplies of native species (especially forbs)
  • How far can we move seed?
Opportunities to avoid and minimize impacts: Wildlife

**Current opportunities**
Goals: Reduce noise, road traffic, fragmentation, vertical structure, and direct mortality

- Enlarge blades to lower rotational speeds of wind turbines
- Paint patterns on turbines to increase visibility/ Acoustical deterrents
- Project siting
  - Colocation (multiple wells on a single pad, battery tanks near roads)
  - Map key areas of wildlife use and group infrastructure leaving wildlife corridors
- Timing restrictions (minimize disturbance during key life history periods of certain species)
- Training reduction (consolidate visits to energy development sites)
Opportunities to avoid and minimize impacts: Wildlife

**Needed research/technology**

- Improve technology for running quieter operations (blade design, pump design)
- Conduct research that is species and site specific, takes in multiple geographic scales, looks at both the short and long term effects while considering effects on various trophic levels
- Knowledge of effects on pollinators and amphibians
Opportunities to avoid and minimize impacts: Social

Current opportunities
• Use socio-economic analyses to develop strategic investments to aid communities in the boom and bust cycles of energy development

Research needs
• Examine how human perceptions of oil and gas development are formed
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Cristi Painter

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Rocky Mountain Research Station