Presenting:

Supporting Landscape Level Planning and Management with DA-facilitated Integrated Science Modeling

by Tim Nieman and Karen Jenni

DAAG Conference 2016

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Supporting Landscape Level Planning and Management with DA-facilitated Integrated Science Modeling

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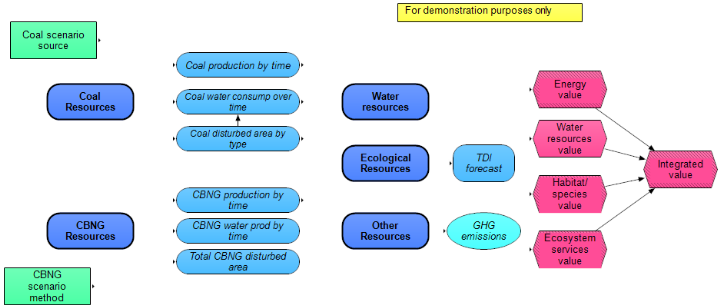
Outline

- **Introduction**
  - Landscape-scale natural resource management as an important "societal decision"
  - Getting started with collaborative framing
- **Moving beyond values clarification**
  - Five modeling challenges
  - Five partial solutions



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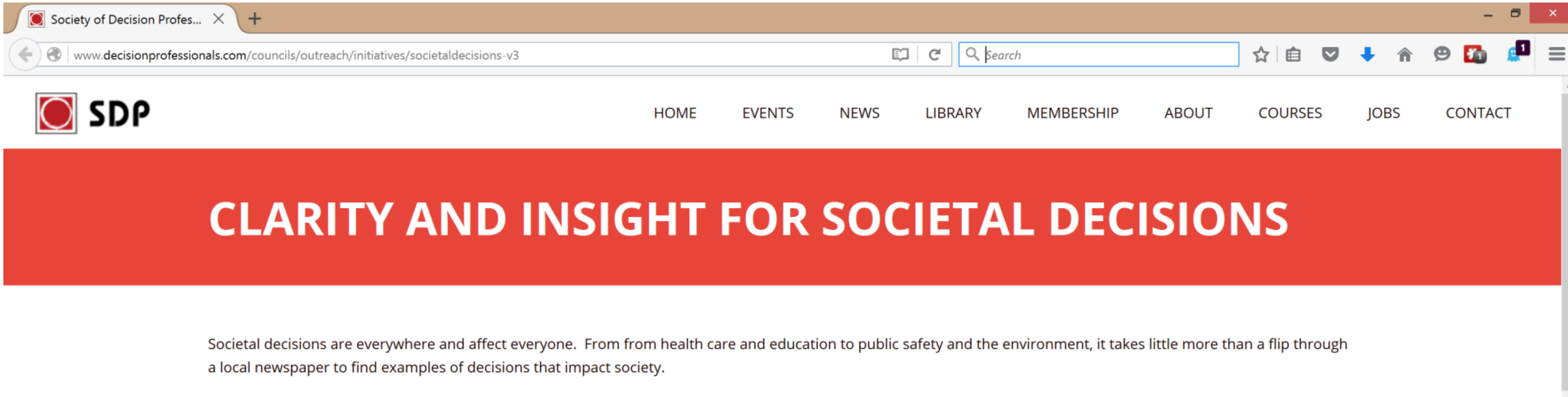
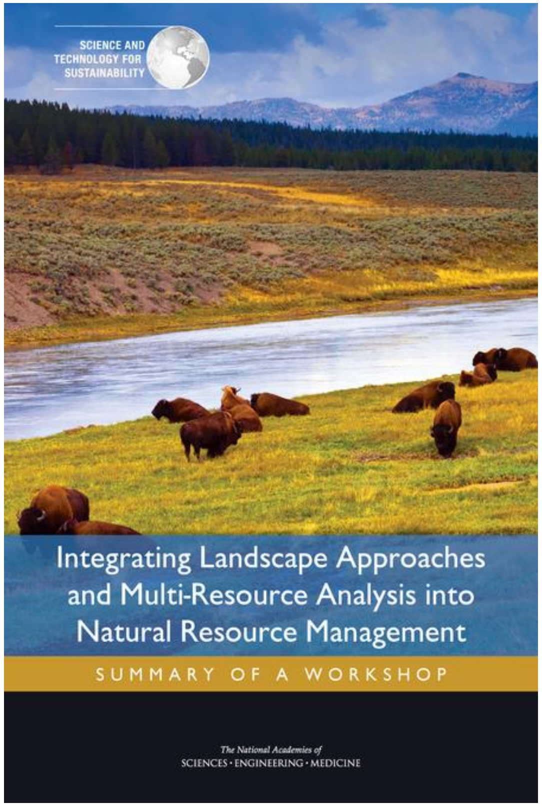


What makes societal decisions unique?

- **Decentralized** decision makers and decision making processes
- **Many stakeholders**, with varying degrees of decision-making authority
- **Multiple and often conflicting values** of varying importance to different stakeholders
- **Stakeholder engagement and participation is critical**
  - May be more important to success than the tradition DA/DQ steps

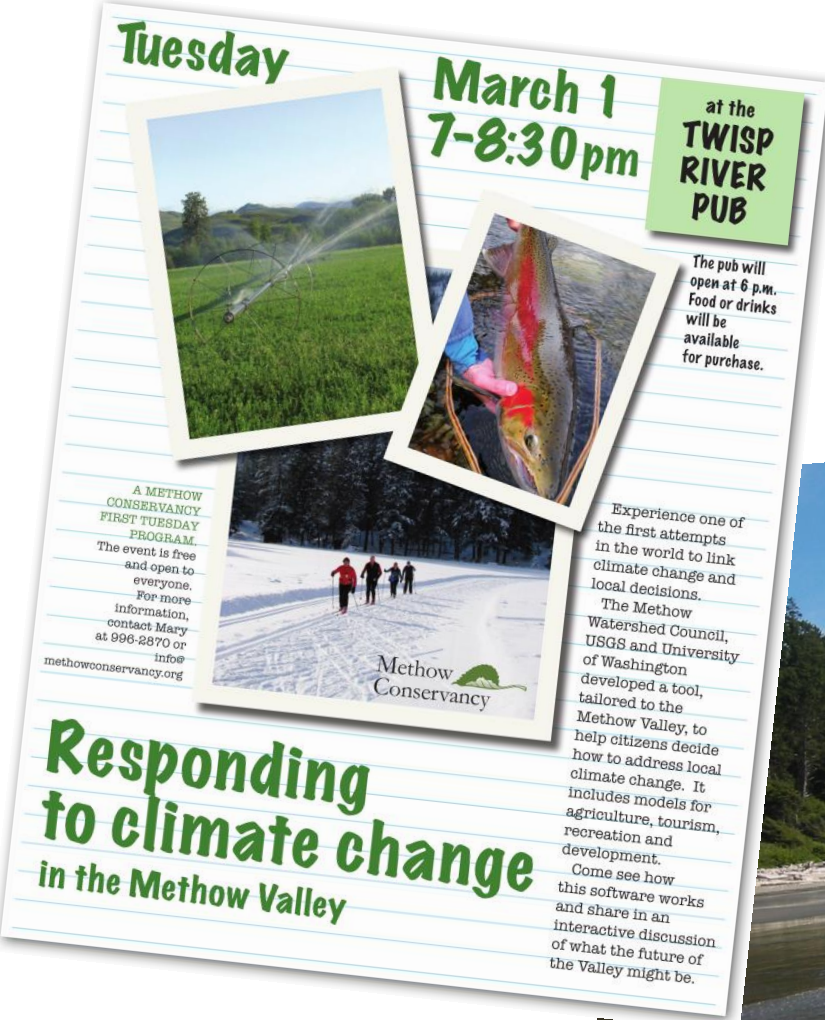
Example: Land and Natural Resource Management

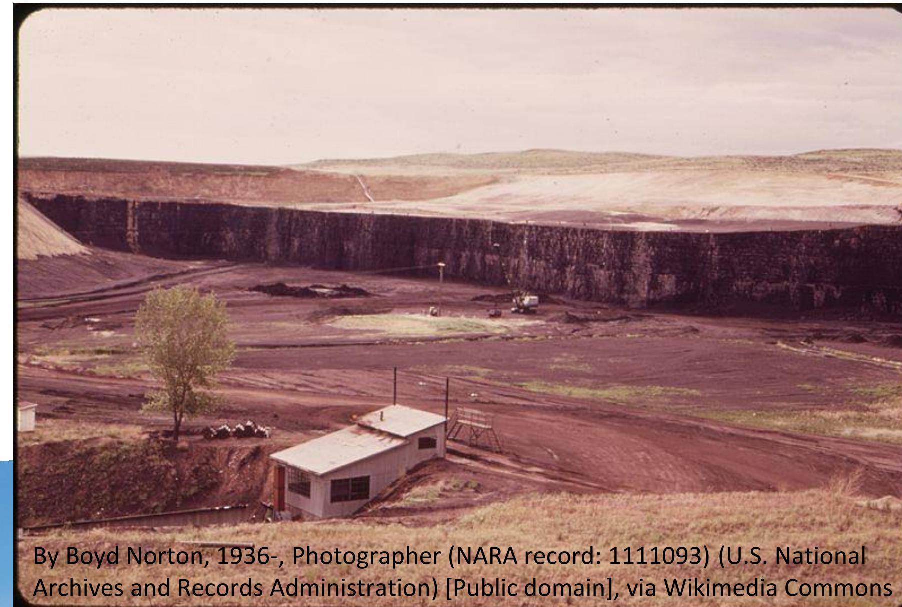


"The responsible management of natural resources for present-day needs and future generations requires integrated approaches that are place-based, embrace systems thinking, and incorporate the social, economic, and environmental considerations of sustainability"

- Technically complex
  - Many uncertainties
  - Resource and stressor relationships are often poorly understood
- Organizationally complex
  - Unprecedented scales
  - Overlapping & conflicting DMs, responsibilities, authorities
  - Need for coordinated action
- Passionate and highly invested stakeholders

A Few Specific Examples





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Getting Started: Lots of People, Lots of Frames, Lots of Perspectives, Lots of Goals…

- In our experience, it helps to bring DMs, stakeholders and scientists together to talk about:
  - Scope of issue
  - Roles, responsibilities, authorities
  - Goals and objectives
    - On the landscape
    - For the analysis process and results
- When this is not possible, the analysis team can serve as "intermediaries"
  - Individual or smaller group discussions
  - Develop a combined framing and offer it back to the stakeholders

Even If You Can Identify Common Objectives…

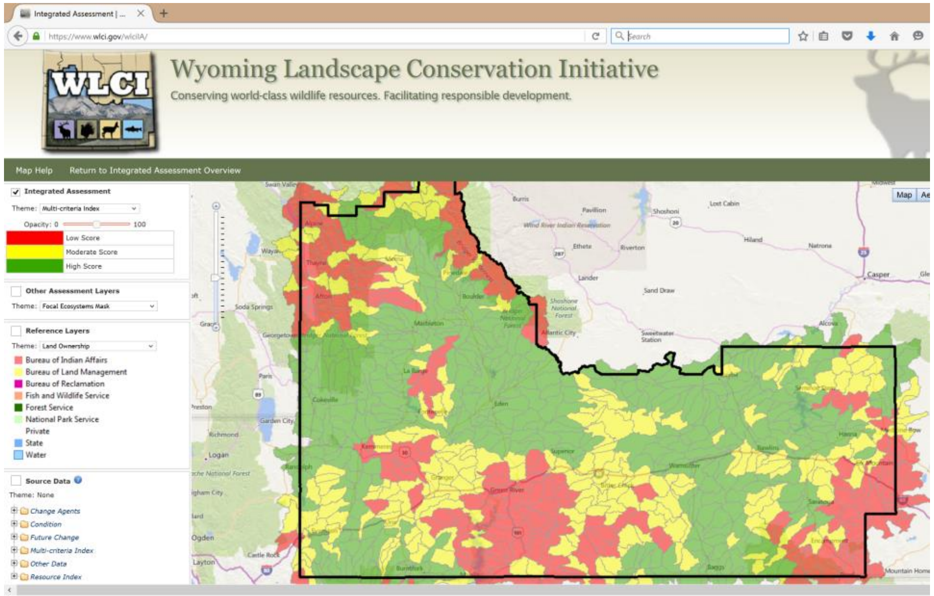
… A lot more may be required before it is even remotely possible to mutually agree on paths forward

- Decision makers and stakeholders need ways to understand and explore the potential impacts of alternative futures
  - That's where modeling comes in
  - Decision-makers and stakeholders may want a role in developing, vetting, and/or reviewing those models

The rest of this presentation will review some of the unique modeling challenges and our (partial and evolving) solutions

Challenge #1: Integration

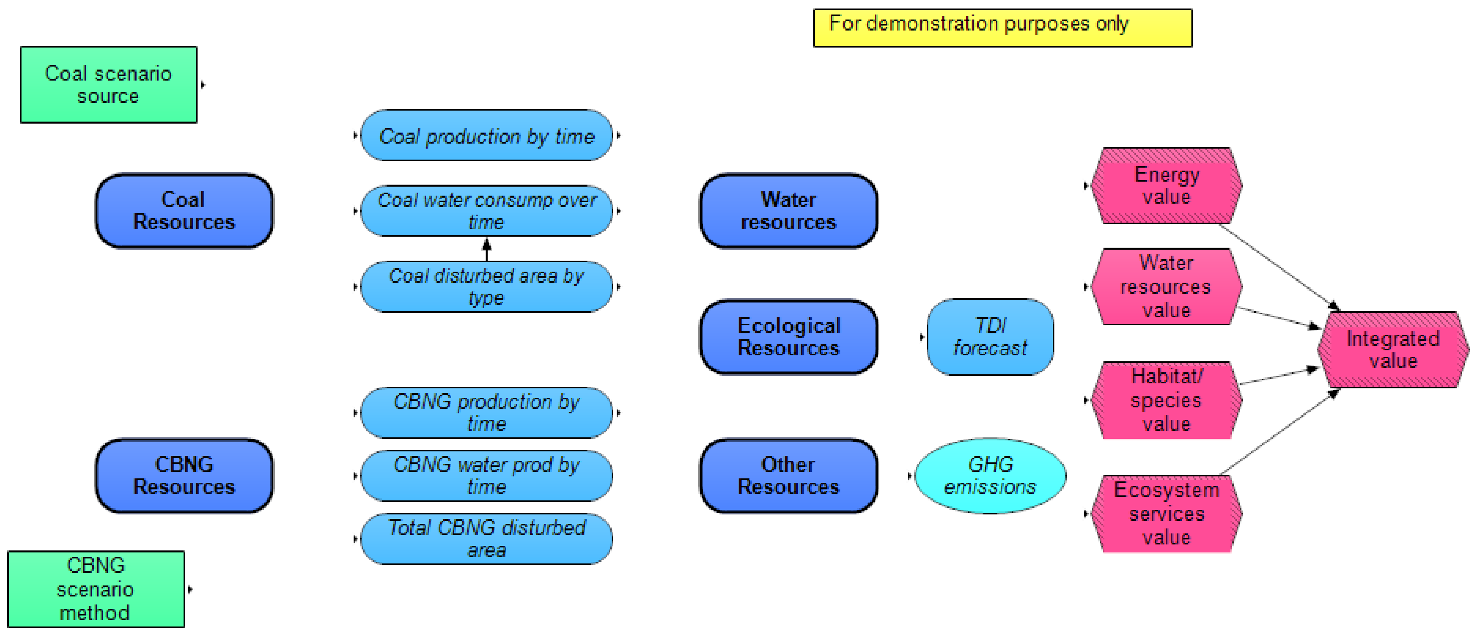
- State of the art appears to be map overlays
  - Of resources, stressors, etc.
  - Sometimes combined into an "index"
- Is this enough?
  - Probably not…



- The models we have been working on aim to
  - Appropriately represent the biophysical relationships between natural resources
  - To model those relationships *dynamically* to project changes over time
- Why isn't this done? What makes it difficult? How do we get to what we need?

(Partial) Solution: Respect *Separate* Expertise and Focus on Connections

- Bring scientists from different disciplines together:
  - Create *linked* models and move towards *integrated* models
- Example: Energy development scenarios flow through to impacts on other resources



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Challenge #2: Choosing a Spatial and Temporal Scale

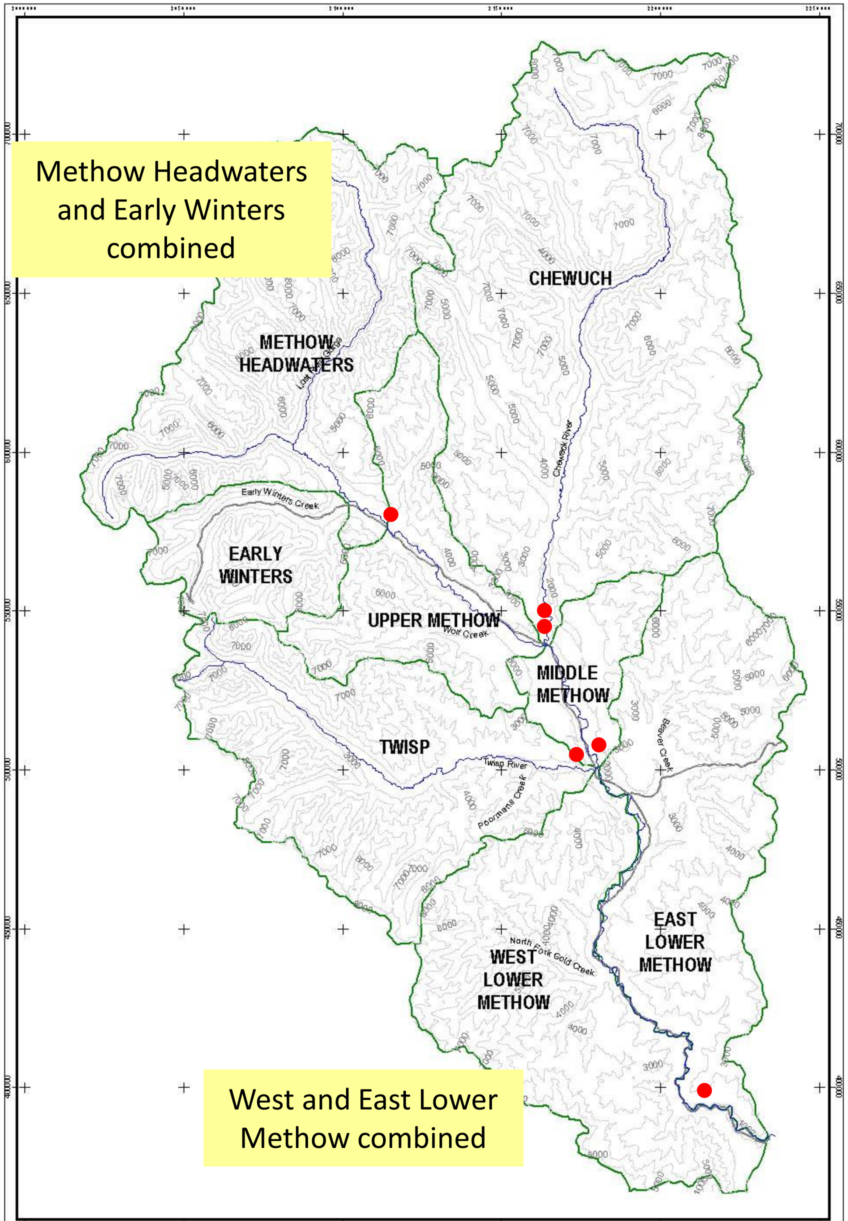
- "Landscape scale" implies a large geography
  - Different disciplines define their "large geographies" differently

- Land and resource management plans are often prepared for 5 to 20-year time horizons
  - Managing for climate resilience implies even longer time horizons
- The scale of existing data rarely aligns. E.g.,
  - Energy and groundwater data defined by subsurface geology; surface water data is defined by surface hydrology
- How do we define a useful scale and scope for modeling?
  - What scales have we used?

(Partial) Solution: Remember That You Can’t Solve Everything All At Once

- Stay focused on the initial choices about which decision makers and which decisions the models aimed to inform
- “Too small” scale makes it overwhelming in terms of data and detail
- “Too large” makes it uninformative

Example of a “small” scale



ACRES	SUB-BASIN
52,424	Early Winters
180,570	Methow Headwaters
88,165	Upper Methow
331,831	Chewuch
156,716	Twisp
35,850	Middle Methow
155,077	West Lower Methow
160,468	East Lower Methow

- **Methow Basin = 1,800 sq mi**
- **Spatial scale is at the sub-basin level**
  - Water availability and water use aggregated within each sub-basin
  - Size of a sub-basin averages about 150K acres
- **Time scale is monthly**
  - Sufficient to see seasonal impacts

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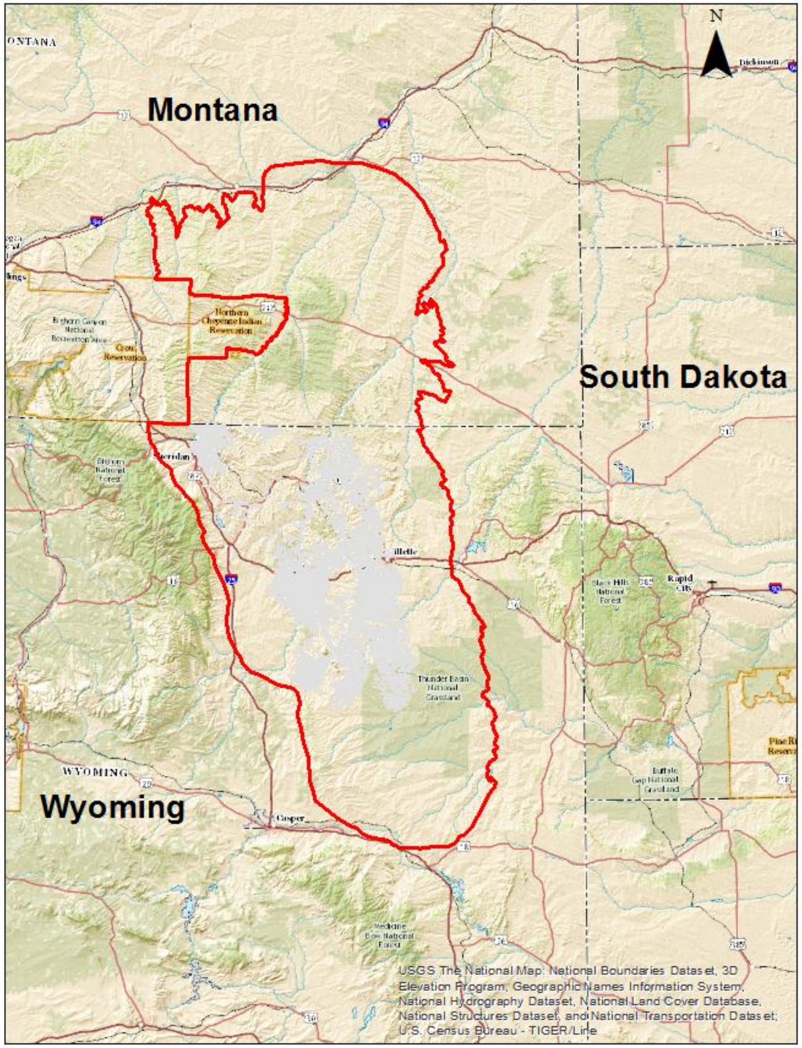

Example of a "large" scale

- **PRB = 22,000 sq mi**
- **Spatial scale is the entire Powder River Structural Basin in NE Wyoming and SE Montana**
  - Matches the scale of energy data
  - Spans geopolitical boundaries
  - Modeled using a 600m x 600m grid size
- **Time scale is a 5-year increment**
  - Sufficient to see long-term impacts

Challenge #3: Defining / modeling scenarios of change

- A major “selling point” for integrated models is to allow end-users to explore the implications of future changes
  - E.g., new management plans, different environmental policies, different climate conditions, etc.
- Many possible scenarios could be defined, yet we can’t model everything
- How do you identify an appropriate set for a particular region?

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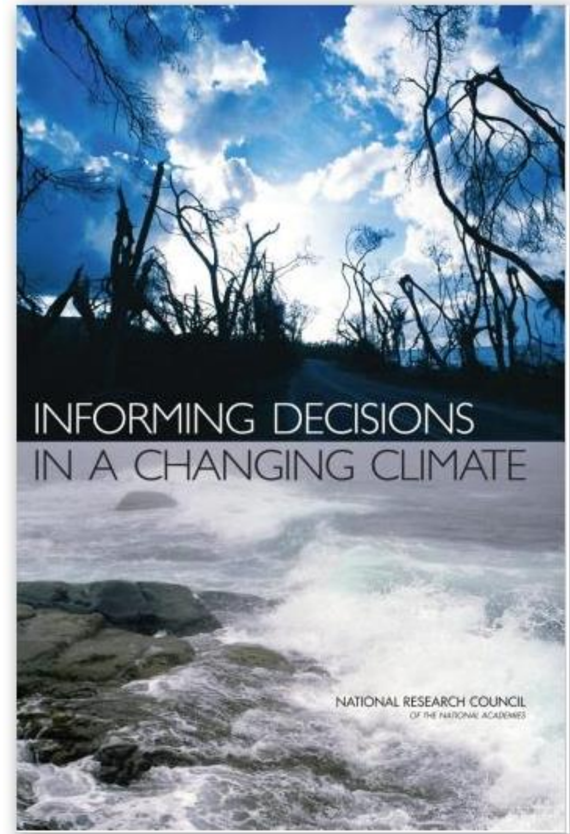
(Partial) Solution: Focus on Interests of Stakeholders and DMs

- Two key principles of effective decision support:
  - Begin with user's needs
  - Link information producers and users
- Common in this arena for scientists to focus on their technical interests
  - Focusing on the drivers of changes most relevant to DMs and stakeholders increases the likelihood of the science influencing decision-making

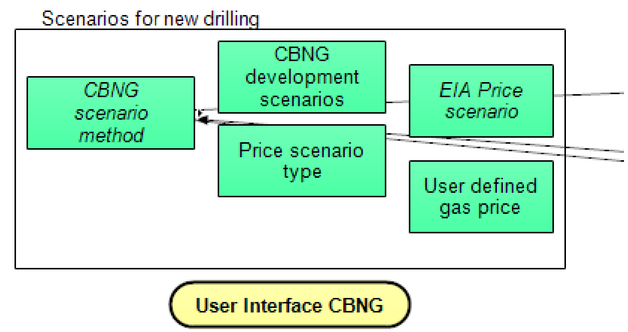


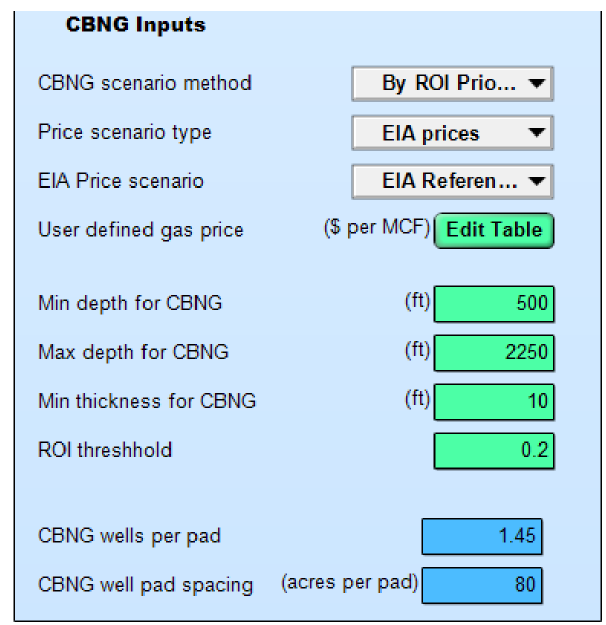
Report available on:
http://www.nap.edu/catalog.php?record_id=12626

Example: CBNG Development Scenarios

Several elements must be specified:

- Price for PRB CBM gas, e.g.,
- Development approach
  - Random well locations within the basin
  - Economic screening with random or prioritized well locations
- We then model a development trajectory that will
  - Meet the production target, if specified, or
  - Develop economically attractive locations only
- Models would also function with direct specification of the quantity, location and timing of gas development, but no such scenarios are readily available





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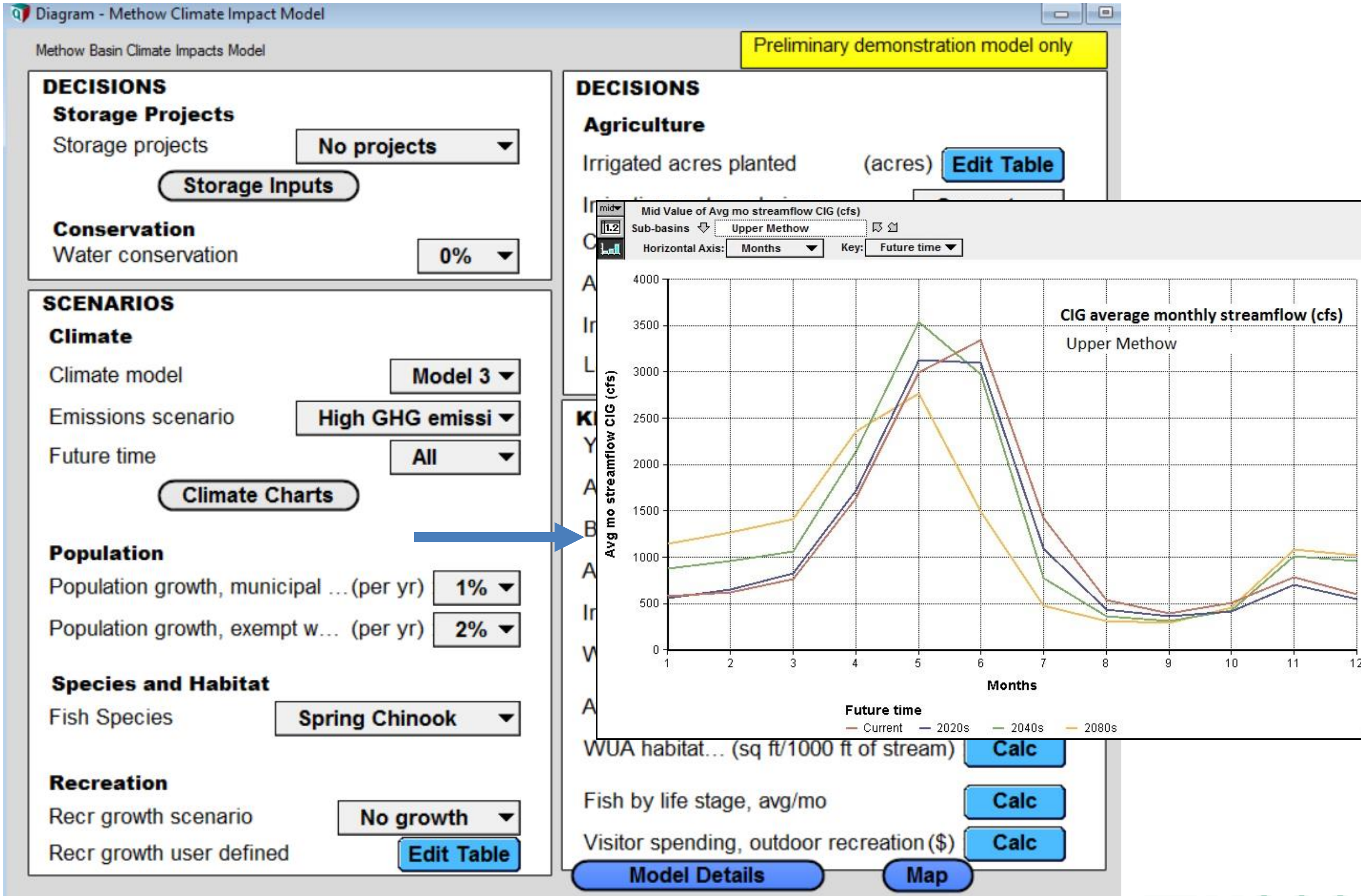
Example: Climate Change Scenarios

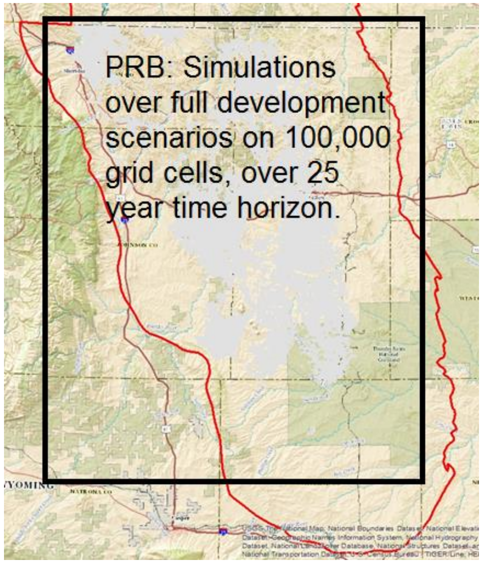


Challenge #4: Modeling Uncertainty

- These models are big
- The underlying science is uncertain
- How do you incorporate uncertainty into such large models?

(Partial) Solution: Modularization and Multiple Approaches to Uncertainty

- Overall modular structure allows a combination of approaches to be used
  - Some uncertainty is dealt with probabilistically (e.g., stochastic energy resources) and propagated through simulation.
  - Some is included via scenarios (e.g., mining scenarios; climate uncertainty)
- This is a challenge with such large spatial models. We have to be judicious to manage computer limitations



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Challenge #5: Communicating Models and Results

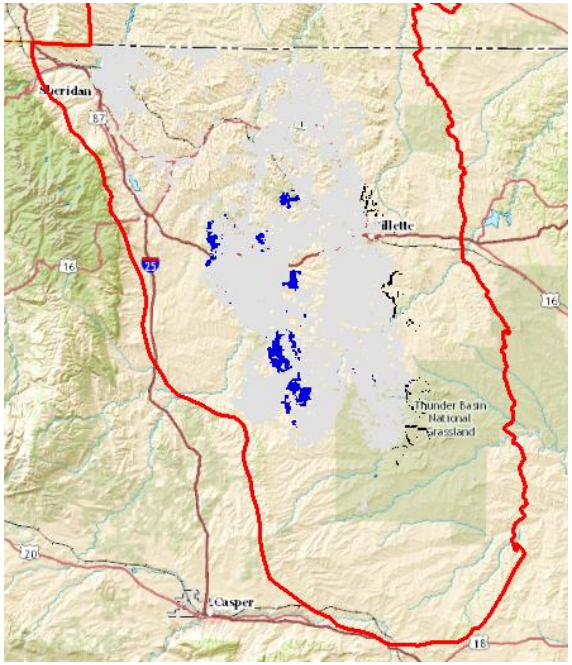
- There are lots of interrelated outputs, extending over a large area, potentially over a long time horizon, with different “outputs” of interest to different decision-makers and stakeholders, with uncertainty.
- How can end-users make sense of all of that?

(Partial) Solution: *Use multiple displays and modes*

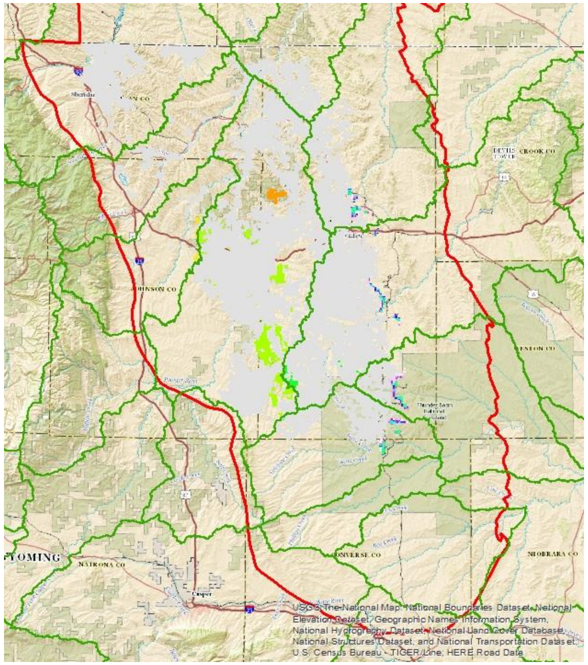
- This is one of our biggest challenges
- We try to provide users multiple ways to view outputs. E.g.,
  - For spatial representations, we use GIS, and animations of GIS maps to bring in changes over time.
  - For aggregated outputs, or those for a specific location, we generate a wide variety of graphs and charts to show impacts.

2015

Coal/CBNG Development



Groundwater Extracted



Terrestrial Devel. Index

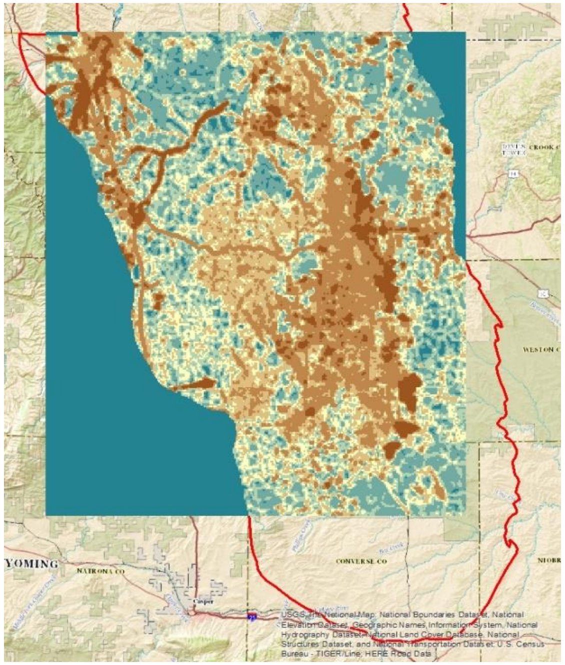


Illustration: GIS display of CBNG/Coal development & impacts over time

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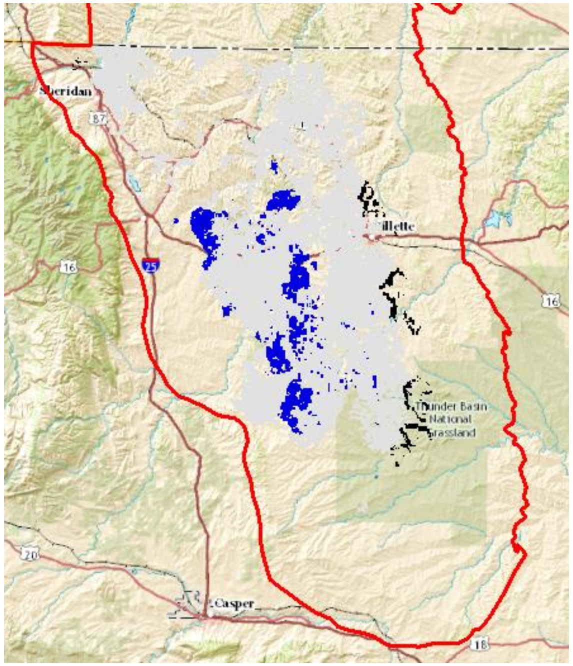
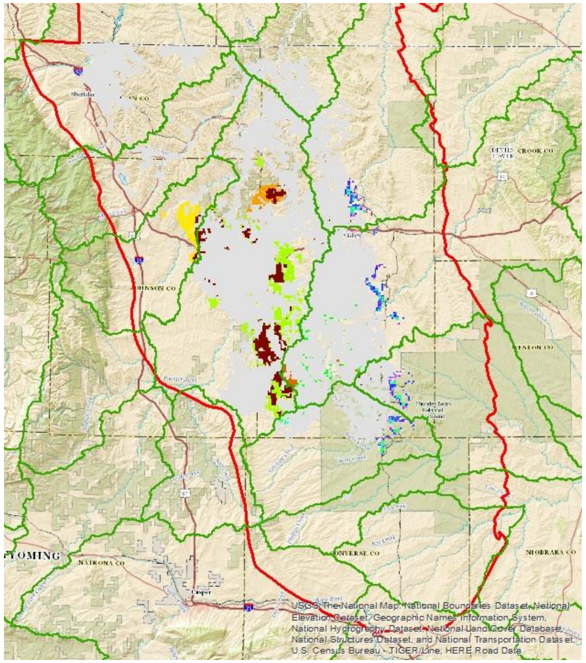
2020

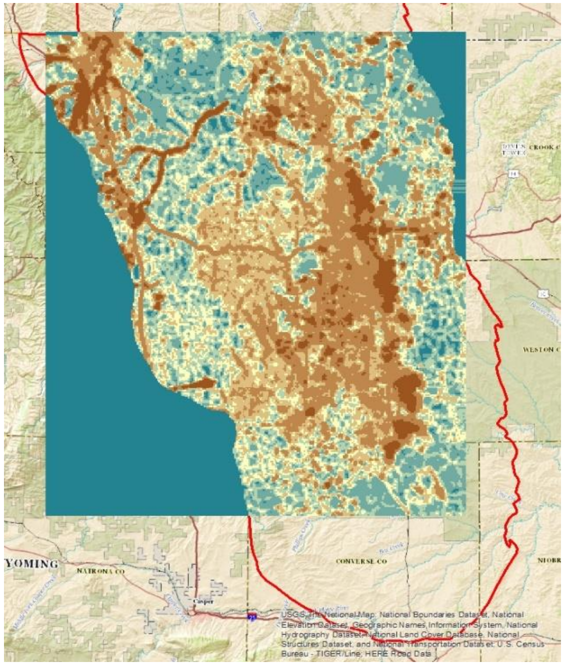
Coal/CBNG Development



Groundwater Extracted



Terrestrial Devel. Index



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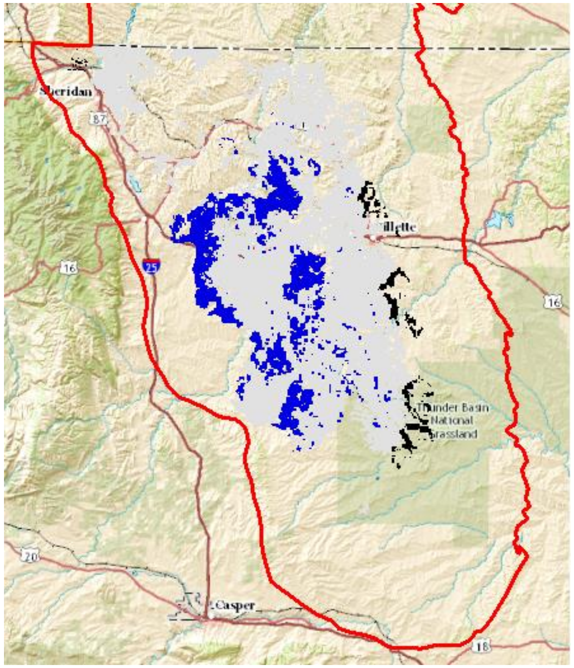
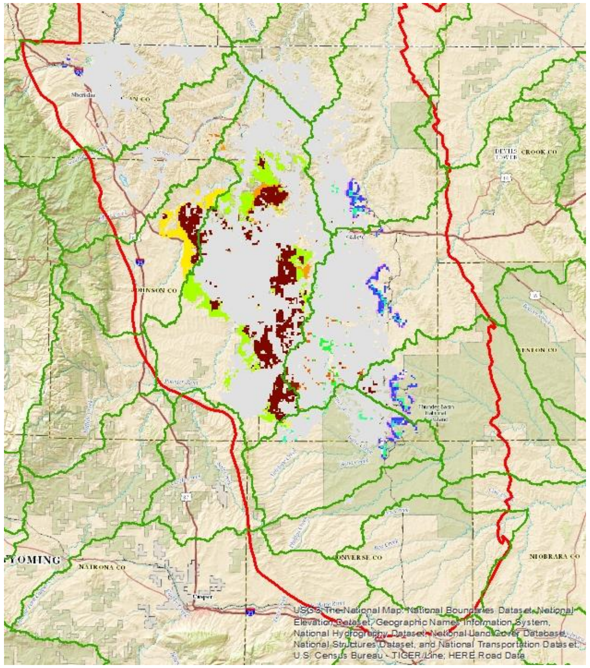
2025

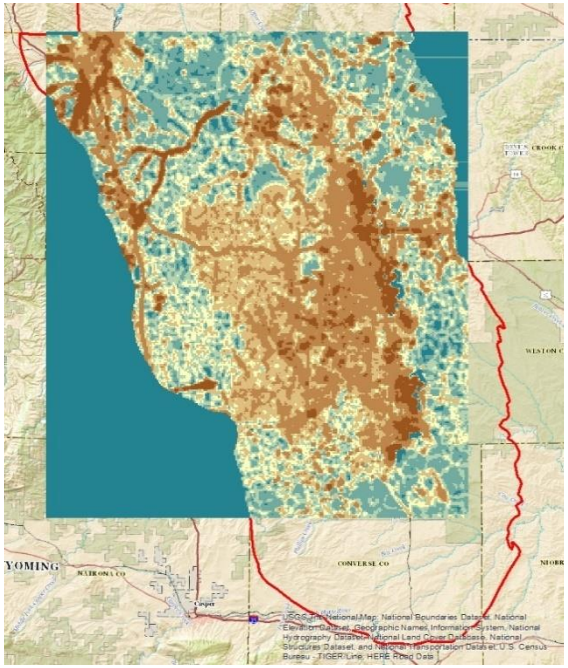
Coal/CBNG Development



Groundwater Extracted



Terrestrial Devel. Index



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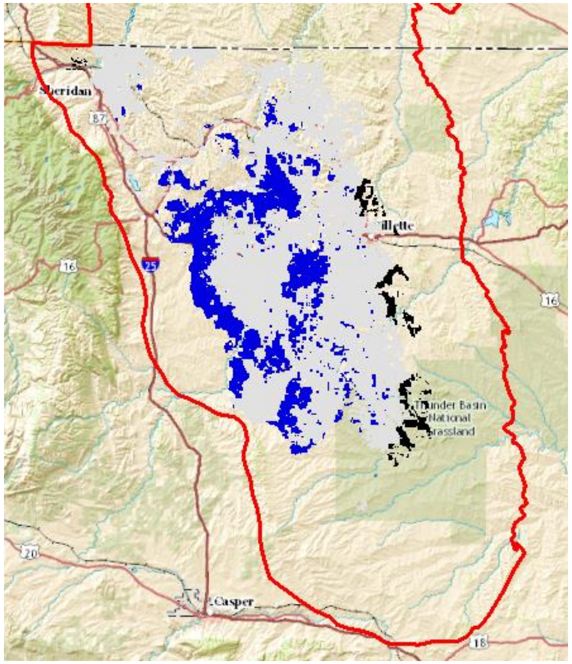
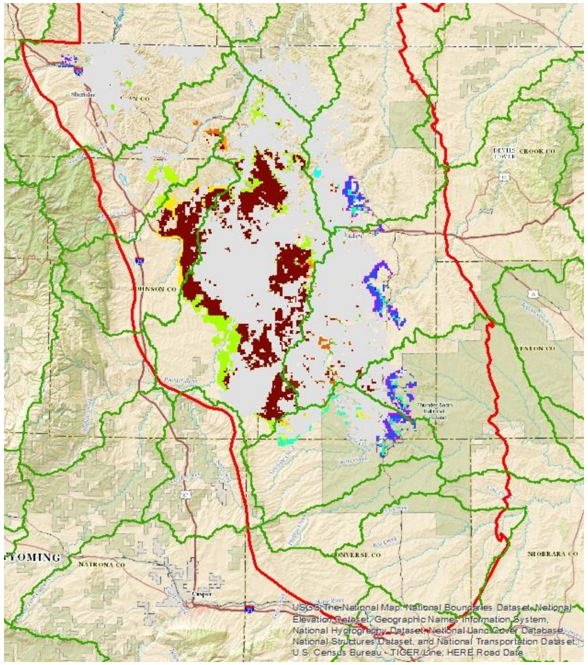
2030

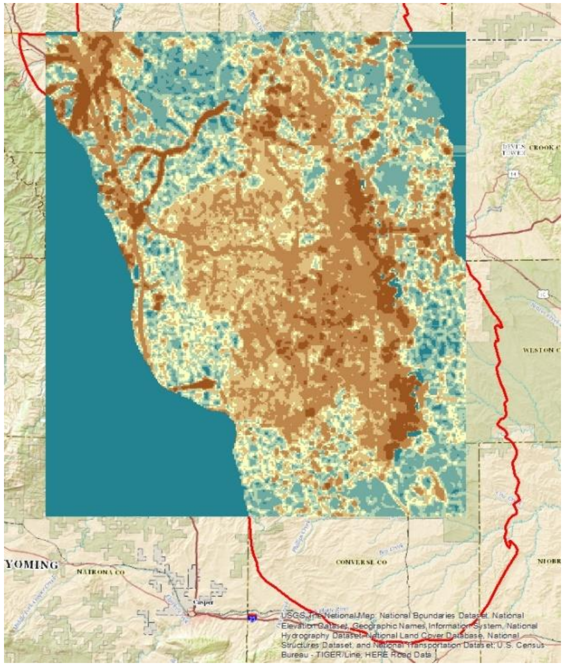
Coal/CBNG Development



Groundwater Extracted



Terrestrial Devel. Index



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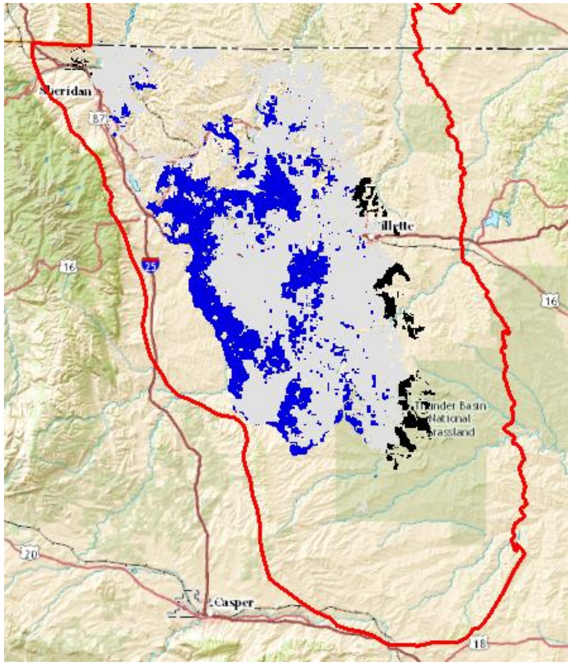
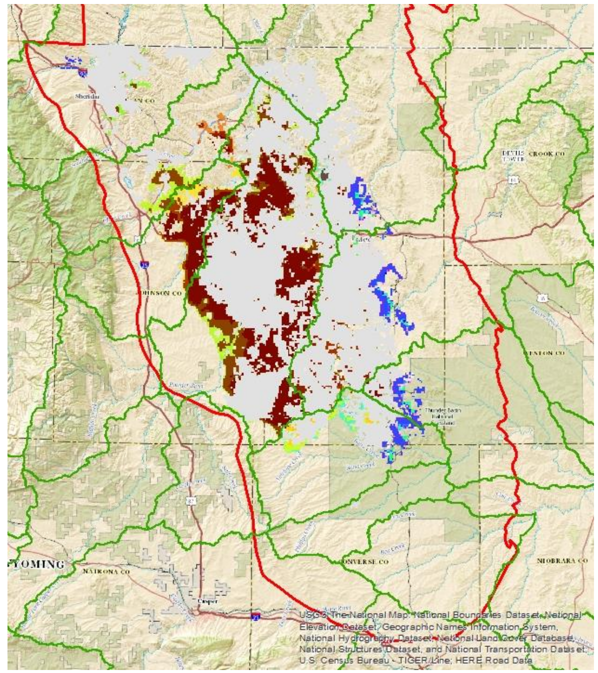
2035

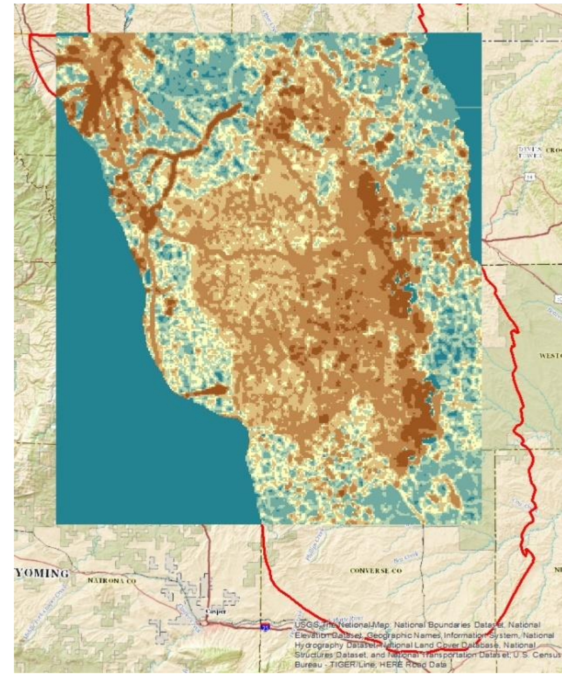
Coal/CBNG Development



Groundwater Extracted



Terrestrial Devel. Index



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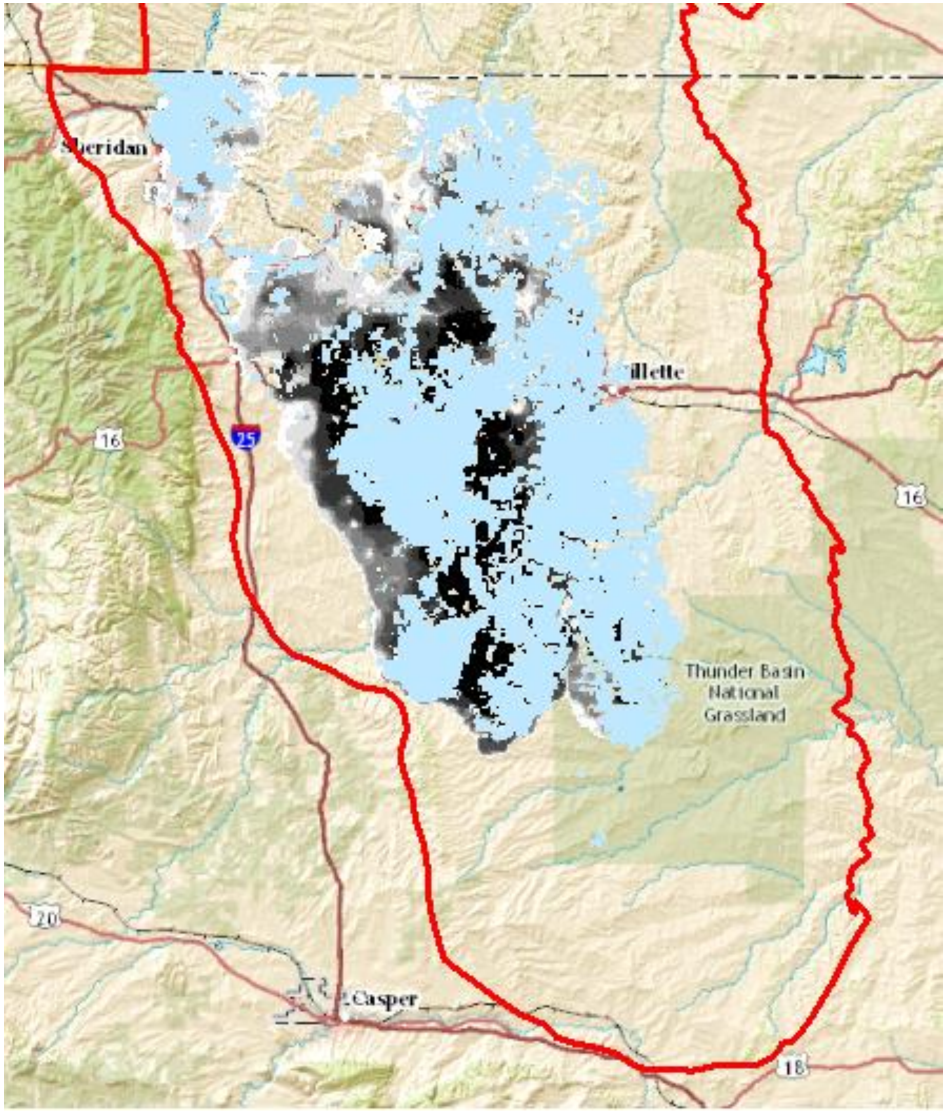
Example Uncertainty Illustration: Probability of CBNG development

Gray scale shows likelihood of being drilled by 2035



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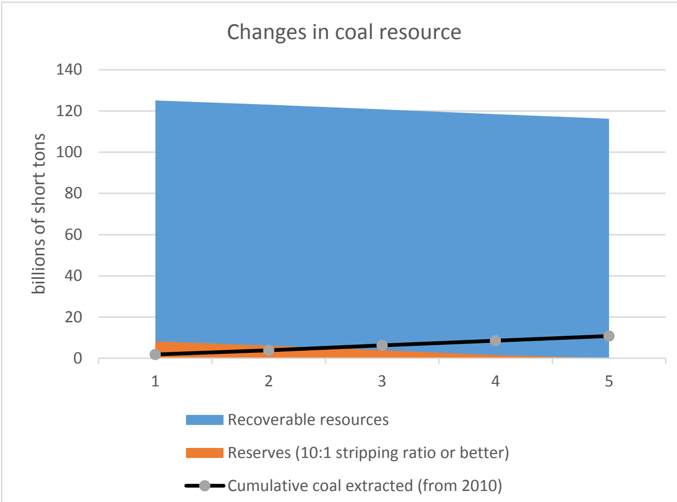
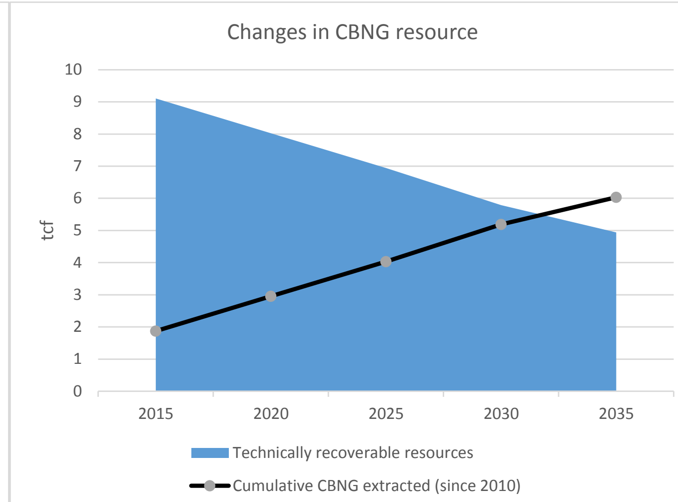
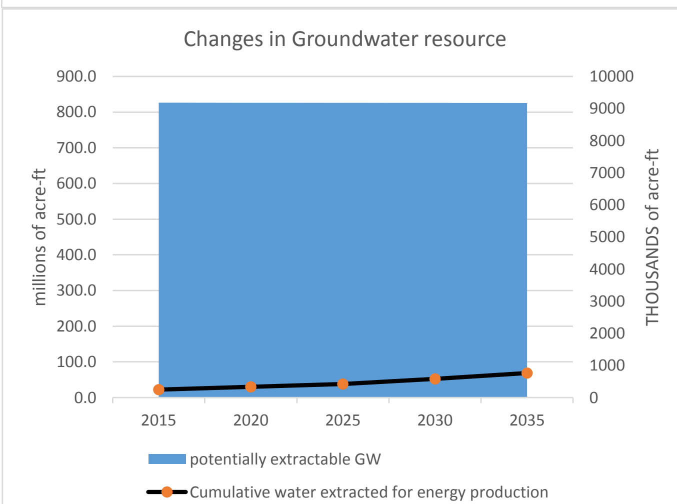
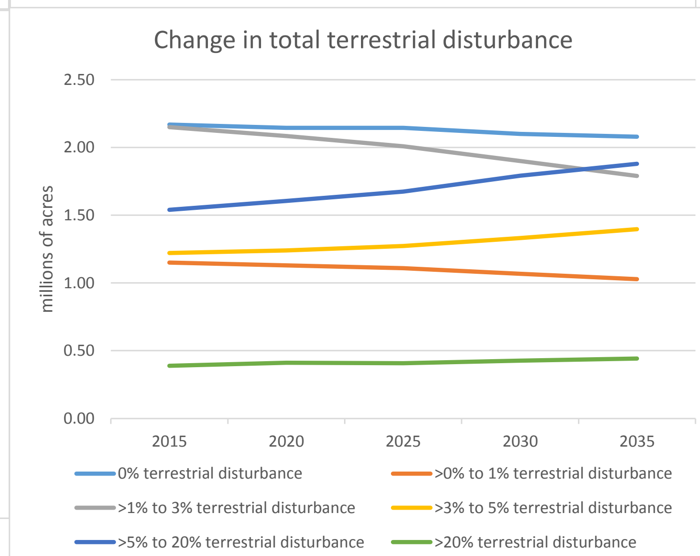
Example: Graphical/Numeric Summary of Regional Impacts









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Impact summary table

	Scenario: EIA reference case for both coal and CBNG production						
	CBNG development driven by ROI						
	No restrictions based on water use or habitat						
		2015	**2020**	**2025**	**2030**	**2035**	
Energy							
Coal	**Recoverable resources**	125.1	123.054	120.764	118.457	116.23	billion short tons
	Reserves (at 10:1 stripping ratio or less)	8.2	6.154	3.864	1.557	0	billion short tons
	Cumulative coal extracted (since 2010)	1.9	3.946	6.236	8.543	10.77	billion short tons
CBNG	**Technically recoverable resources**	9.106	8.024	6.943	5.788	4.94	TCF
	production (mid)	1.869	1.082	1.081	1.155	0.848	TCF
	Cumulative CBM extracted (since 2010)	1.869	2.951	4.032	5.187	6.035	TCF
Water							
Ground water	**Total Quantity**	4591.4	4591.0	4590.9	4590.8	4590.6	millions of acre-ft
	Quantity potentially recoverable	826.4	826.1	826.0	825.9	825.7	millions of acre-ft
	Cumulative water removed for energy extraction (since 2010)	246	335	427	586	767	thousands of acre-ft
	Quality?						
Surface water	**Perennial streams**	2800					km
	Impaired streams	810					km
Ecology and Biology							
Air quality	**Cumulative greenhouse gas emissions from delevoment activities**	50	101	157	214	268	million tons of CO2
Habitats and terrestrial disturbance	**0% terrestrial disturbance**	2.17	2.14	2.14	2.10	2.08	million acres
	>0% to 1% terrestrial disturbance	1.15	1.13	1.11	1.07	1.03	million acres
	>1% to 3% terrestrial disturbance	2.15	2.09	2.01	1.90	1.79	million acres
	>3% to 5% terrestrial disturbance	1.22	1.24	1.27	1.33	1.40	million acres
	>5% to 20% terrestrial disturbance	1.54	1.61	1.67	1.79	1.88	million acres
	>20% terrestrial disturbance	0.39	0.41	0.41	0.43	0.44	million acres
Sage grouse core areas	**Not impacted**	1.38E+06	1.38E+06	1.37E+06	1.30E+06	1.24E+06	acres
	Violation of restriction	0.00E+00	2.67E+02	1.67E+04	7.90E+04	1.45E+05	acres
	% of SG core area impacted	0.0%	0.0%	1.2%	5.7%	10.5%	
Sage grouse connectivity areas	**Not impacted**	3.19E+05	3.19E+05	3.19E+05	3.12E+05	3.01E+05	acres
	Violation of best practices	0.00E+00	0.00E+00	0.00E+00	6.05E+03	1.77E+04	acres
	% of SG connectivity area impacted	0.0%	0.0%	0.0%	1.9%	5.6%	
Conservation areas for "species of greatest conservation need"	**Not impacted**	2.85E+06	2.85E+06	2.83E+06	2.75E+06	2.69E+06	acres
	Moderate impact	0.00E+00	1.78E+03	6.85E+03	2.24E+04	3.44E+04	acres
	High impact	0.00E+00	3.29E+03	1.59E+04	7.67E+04	1.33E+05	acres
	Extreme impact	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	acres
	% of total area with moderate or worse impact	0.0%	0.2%	0.8%	3.5%	5.9%	
Habitat adjacent to Critical Stream Corridors	**Not impacted**	8.34E+04	1.38E+06	1.38E+06	1.38E+06	1.38E+06	acres
	Impacted (wells within the same 80-acre parcel as the critical stream corridor)	0.00E+00	0.00E+00	0.00E+00	8.90E+01	2.05E+03	acres
	% of potential habitat affected	0.0%	0.0%	0.0%	0.1%	2.5%	

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Questions?

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