Large-Scale CO_2 Storage Exploration in a Basal Saline System in Canada and the United States

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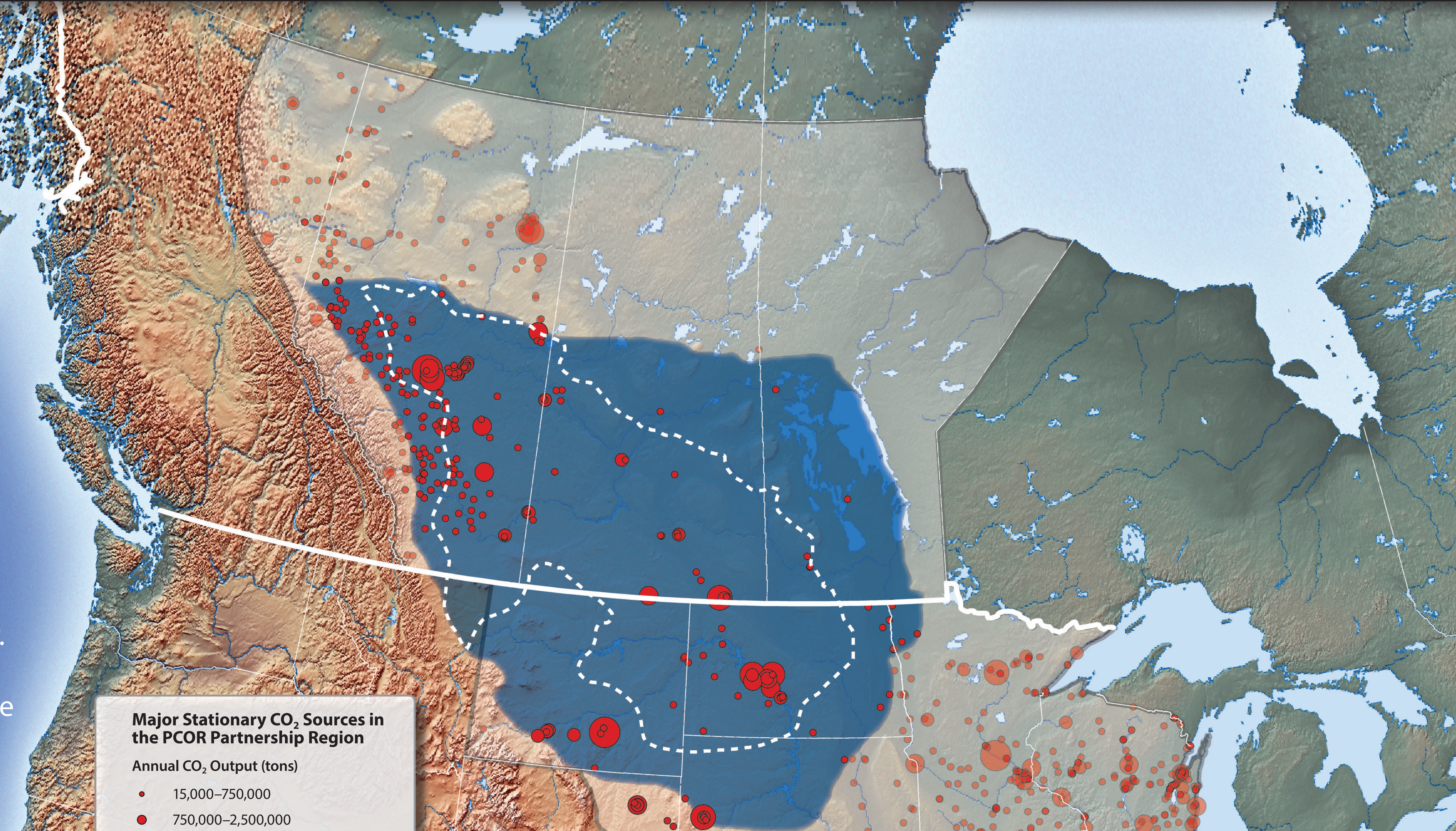
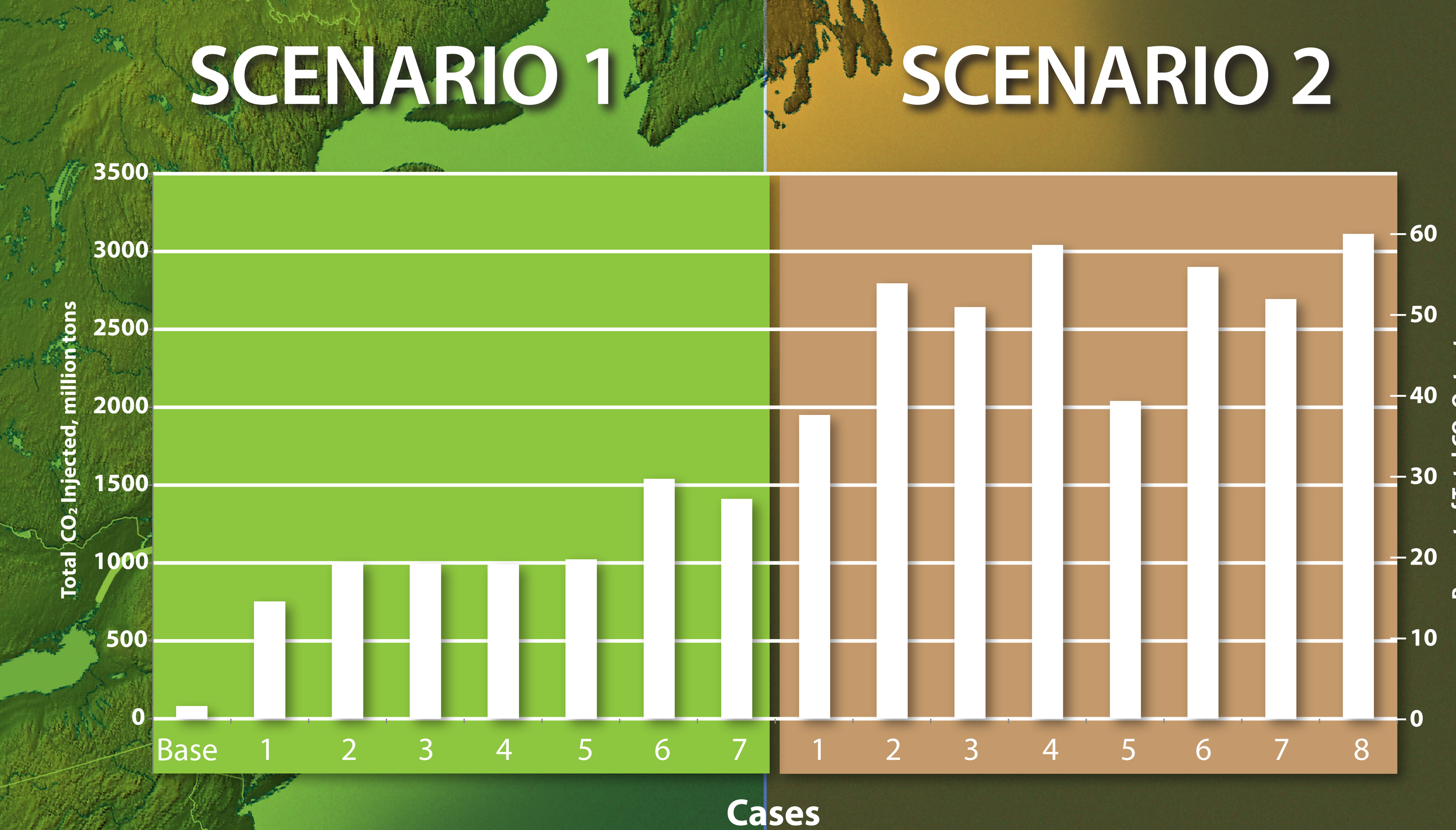
Abstract

As one of the U.S. Department of Energy's Regional Carbon Sequestration Partnerships, the Plains CO_2 Reduction (PCOR) Partnership is studying the feasibility of large-scale underground CO_2 storage in the basal saline system of central North America. The area of investigation encompasses approximately 1,500,000 km^2 of the Alberta and Williston Basins located in the provinces of Alberta, Saskatchewan, and Manitoba in Canada and the states of Montana, North Dakota, and South Dakota in the United States. The calculated static storage resource for CO_2 in this saline system is 480 billion metric tons. However, realistic injectivity is highly dependent on the reservoir pressure buildup, which must be considered during CO_2 injection and postinjection for storage resource estimation and risk assessment.

In the simulation area, the large-scale CO_2 sources emit 104 Mt CO_2/yr. Sixteen cases were designed to address the dynamic CO_2 storage capacity and pressure transient. To increase the injectivity and maximize the storage resource use, various strategies were explored, including injection optimization, multiple well patterns, water extraction during CO_2 injection, modifications to rock compressibility, boundary conditions, and relative permeability. This information summarizes the results of the scenarios and identifies factors playing significant roles in CO_2 storage regarding capacity and pressure buildup throughout a large-scale geologic system. This basic guideline in performing evaluations of large-scale CO_2 storage demonstration projects will specifically answer questions regarding reservoir pressure buildup over the injection and postinjection periods, ultimately tracking the CO_2 as part of the CO_2 monitoring, verification, and accounting process.



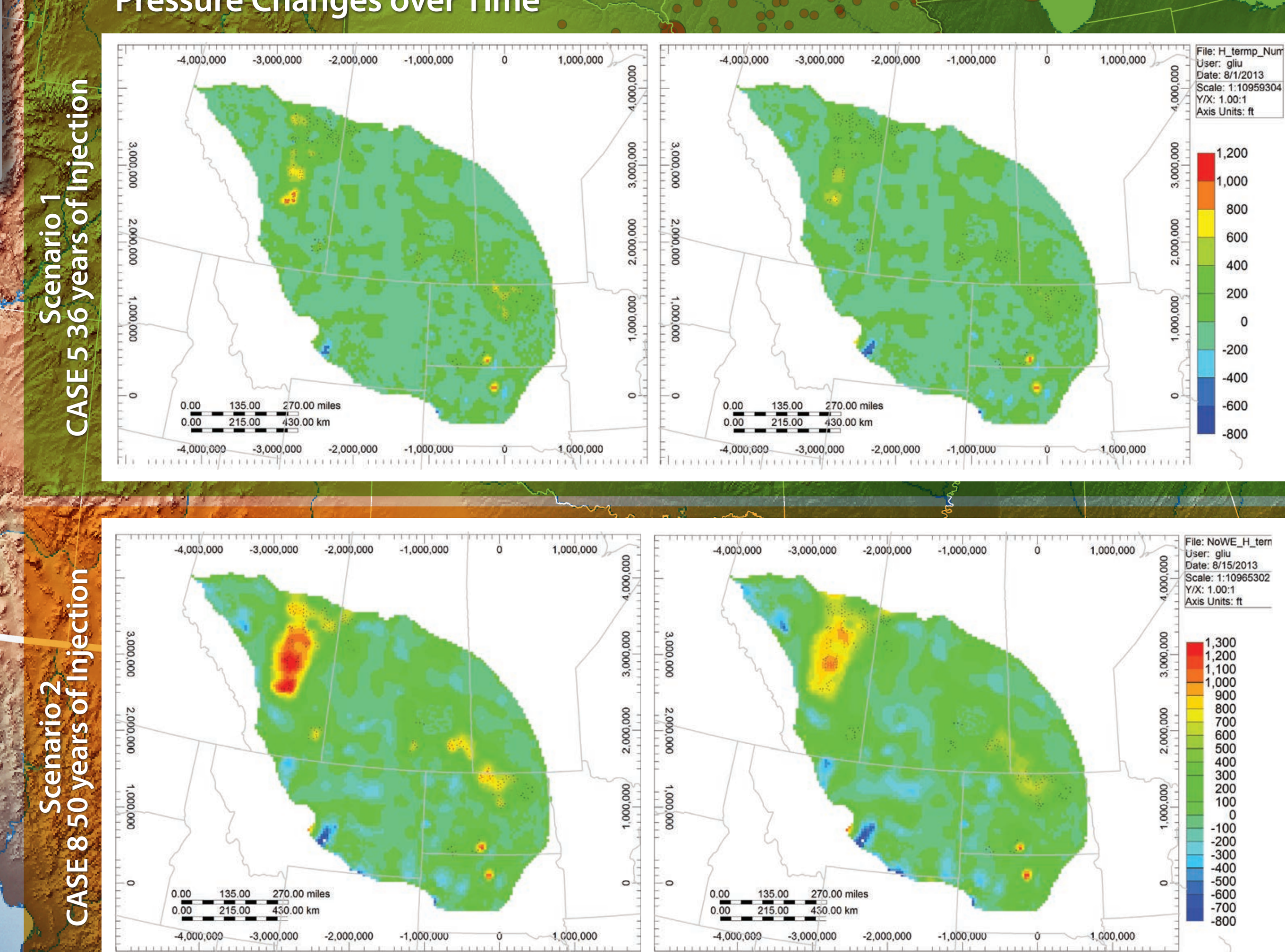
For Case 7 of Scenario 1 and all cases of Scenario 2, the simulations attempted to inject the full targeted annual CO_2 emission rate (90%) at each location for each year of the study time frame. For all other cases in Scenario 1, the annual injection rate was ramped up over a 17-year period.



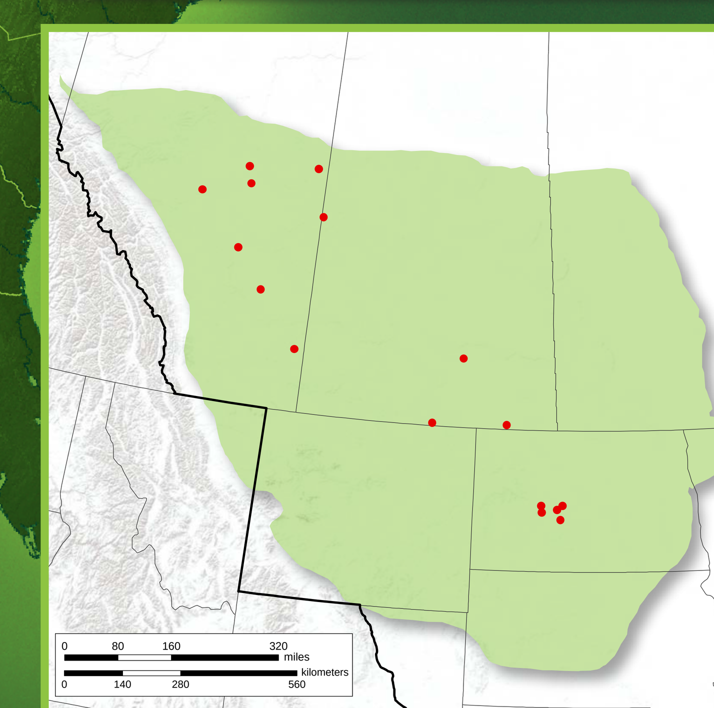
Case	Number of Injectors	Years of Injection	Postinjection Years	Water Extraction Area	Kv/Kh Ratio	Relative Perm. Curves
Base	16	36	50	None	0.1	No Change
1	210	36	50	None	0.1	No Change
2	210	36	50	Duffield-Warburg	0.1	No Change
3	210	36	50	Duffield-Warburg	0.4	No Change
4	210	36	50	Duffield-Warburg	0.6	No Change
5	210	36	50	Duffield-Warburg	0.1	Changed
6	210	50	36	Duffield-Warburg	0.1	Same as Case 5
7	210	50	36	Duffield-Warburg	0.1	Same as Case 5

Case	Number of Injectors	Number of Extractors	Water Extraction	Horizontal Injection	Rock Compressibility
1	211	None	No	No	Low
2	211	None	No	No	High
3	211	163	Yes	No	Low
4	211	163	Yes	No	High
5	211	None	No	Yes	Low
6	211	None	No	Yes	High
7	211	163	Yes	Yes	Low
8	211	163	Yes	Yes	High

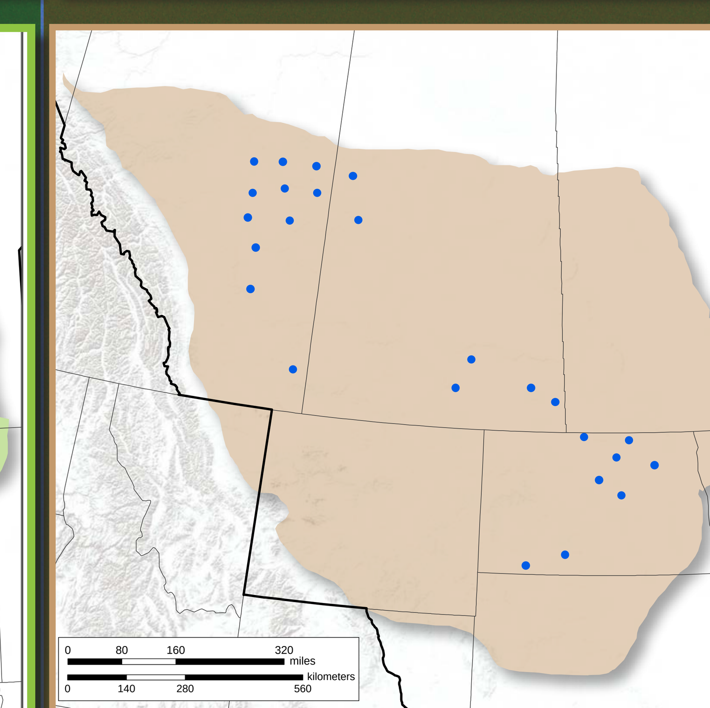
Pressure Changes over Time



Left images illustrate pressure change after initial injection period; right images illustrate pressure change after a 36-year postinjection period.



Sixteen aggregated injection clusters based on the actual locations of the CO_2 emission sources in the study area.



Twenty-five aggregated injection clusters distributed for "better injectivity" regions.

Summary

- Increasing number of injectors, adding water extractors around the injectors, using horizontal injectors, and changing relative permeability show a moderate to significant role in increasing the injectivity and, ultimately, the total amount of injected CO_2.
- Rock compressibility plays the most important role for the injectivity for the cases without water extraction. However, this effect is reduced by adding water extraction because of the balance of the injection and production in the system.
- In Scenario 2, some of the injection clusters were able to accommodate the required CO_2 injection volumes. The heterogeneity of the system with regard to several factors (even in areas of connected geobody and "high permeability") was a limiting factor for many of the clusters.
- All expected CO_2 from resources might be injected with more wells (injectors and extractors), perhaps as many as 500 wells in the areas with "good" transmissibility (thick, connected, high-permeability).
- As would be expected, reservoir pressure increases are lower in cases involving water extraction. This reinforces the role that water extraction plays in reservoir management and risk assessment.

PCOR Partnership 2003 – Present