Carbon Capture and Storage:
How does it work, and is it right for Georgia?

Science Facts and Analysis from Science for Georgia
By Jake Stohr

A lot of fuss has been made about carbon capture and storage. It is being touted as method to combat (and possibly reverse) rising carbon emissions. But it is also being vilified as an energy hog, a false promise, and potential environmental disaster.

Carbon capture is the process of trapping carbon dioxide (CO2) released during industrial processes (i.e. via a smokestack) or extracting carbon already in the atmosphere. The carbon is then stored away, typically underground.

This technology is showing promise in Nordic countries. Their geothermal power is a carbon-free energy source, and their volcanic formations are a ready carbon sink.

But recently, carbon capture and storage has become a topic in the Southeast US. Alabama is a test site for a Direct Air Capture program. And Georgia Tech is involved in researching the technology and its potential impacts. The Floridan Aquifer has been identified as potential carbon storage location.

Herein, we go into detail about the technology, the sequestration methods, and the pros and cons associated with carbon capture and storage. While this technology shows promise, it is currently in its infancy, and in its current state, the cons outweigh the pros in Georgia. The Georgia energy grid is already overtaxed and is a net carbon producer. Most alarmingly, the Floridan Aquifer is a vital source of drinking and irrigation water for millions of people, and sinking carbon into it jeopardizes a pristine water reserve.

How Carbon Capture and Storage Works

Carbon capture and sequestration involves three steps: capturing carbon dioxide (CO2), transporting it via a pipeline, and burying it deep underground.

Capturing the CO_2

Although carbon capture can be indirect via natural processes (i.e. trees breathe in carbon and exhale oxygen), humans capture it directly. To pull carbon out of the atmosphere, chemicals called sorbents, materials that absorb liquids or gases, are put in contact with the air where they absorb or "capture" the CO_2. Then, the captured CO_2 is released from the sorbents and prepared for transportation.

Transportation

Once captured, this carbon dioxide must be transported to wherever it will be buried. In the United States, CO_2 is mostly transported via pipeline. However, these pipelines need to be reinforced heavily to prevent leakage or rupture.

The United States currently has 5,000 miles of pipelines that transport CO_2 for storage. In comparison, it has 74,000 miles of pipeline for carrying other hazardous liquids like ammonia and propane and 80,000 miles for the transport of crude oil. There are no existing CO_2 transport pipelines in Georgia. To scale up carbon capture and burial, the United States would have to invest heavily in pipeline construction. The Biden administration has invested $251 million worth of funding in environmental-focused infrastructure projects that include pipeline construction.

Pipelines are not without dangers. For example, in Satartia, Mississippi, in 2020, CO_2 leaked into the air and caused the hospitalization of 45 people in what locals called "a mass poisoning".

Storage

To bury the CO2, injection wells are drilled as much as a kilometer into the earth. CO2 is primarily stored in sedimentary rocks, but not all formations are created equal. The rock formation must be porous and salty.

Porus rock formations have small, minute spaces through which air or liquid can pass. Example porous rock formations include former oil reservoirs, coal beds that cannot be mined, and saltwater/brackish aquifers.

Salinity of a formation is a critical factor in determining where CO2 can be stored, as it determines the effectiveness of the storage capacity. To be considered saltwater and therefore effective in storage, a formation must have a salinity measured as total dissolved solids (TDS) levels greater than 10,000 parts per million. Fresh water is less than 1,000 TDS and brackish water is anywhere between these two thresholds. Formations with TDS levels above 10,000 parts per million have a good balance of CO2 solubility and long-term stability.

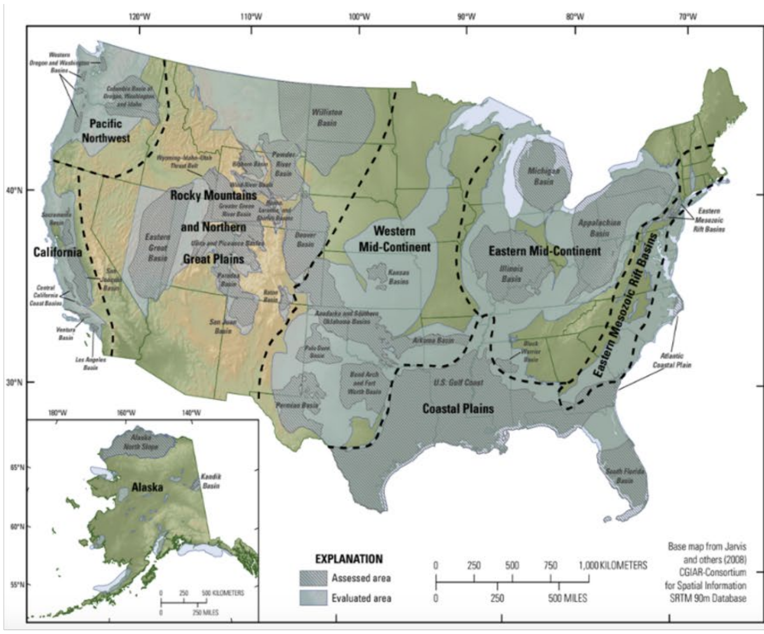
Can carbon capture combat the impact of rising carbon emissions?

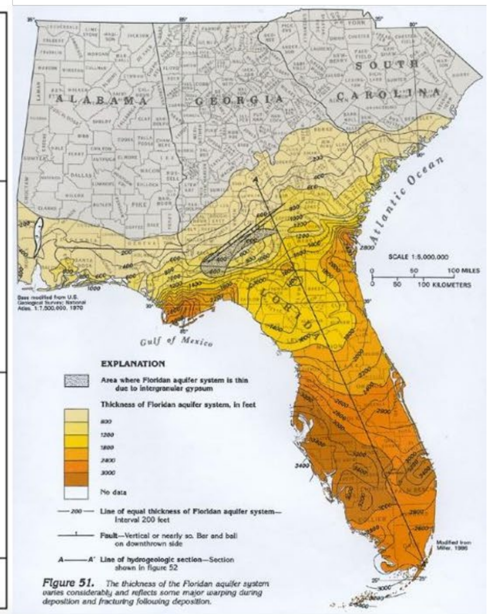
For as long as it has existed, debates have raged over the environmental impact of carbon capture. In dealing with climate change, proponents argue that carbon capture can reduce emissions enough to avoid the most dangerous effects of climate change and that it is useful for industries that have no alternative methods of CO_2 emissions reduction. However, some climate activists say carbon capture serves to permit harmful industries to continue emitting greenhouse gases and that investment in carbon capture often happens at the expense of investment in renewable energy. Environmentalists have also sounded alarms about chemical waste and groundwater pollution from carbon capture storage sites.

Carbon capture is also extremely energy intensive. The British Geological Survey estimates that carbon capture increases the energy needs of the average coal-fired power plant by 25 to 40%, also increasing the electricity cost to the plant. While these energy needs decrease the net climate benefit of carbon capture, new technologies offer intriguing solutions. A team at Georgia Tech has created a process that would convert captured carbon into raw materials with a variety of potential uses (such as fuel manufacturing, building materials, and enhanced oil recovery), saving on cost and energy usage. Other researchers have found lean sorbents that require less energy to capture carbon out of the air.

Could Georgia host CO_2 sequestration sites?

In 2013, the United States Geological Survey (USGS) assessed the potential of different geologic formations throughout the United States to store CO_2 deep underground. The study concluded that the Atlantic Coastal Plains, which stretch from the Texas gulf coast to Cape Cod, Massachusetts, have the optimal conditions for storing CO_2.





Images from: https://pubs.usgs.gov/circ/1386/

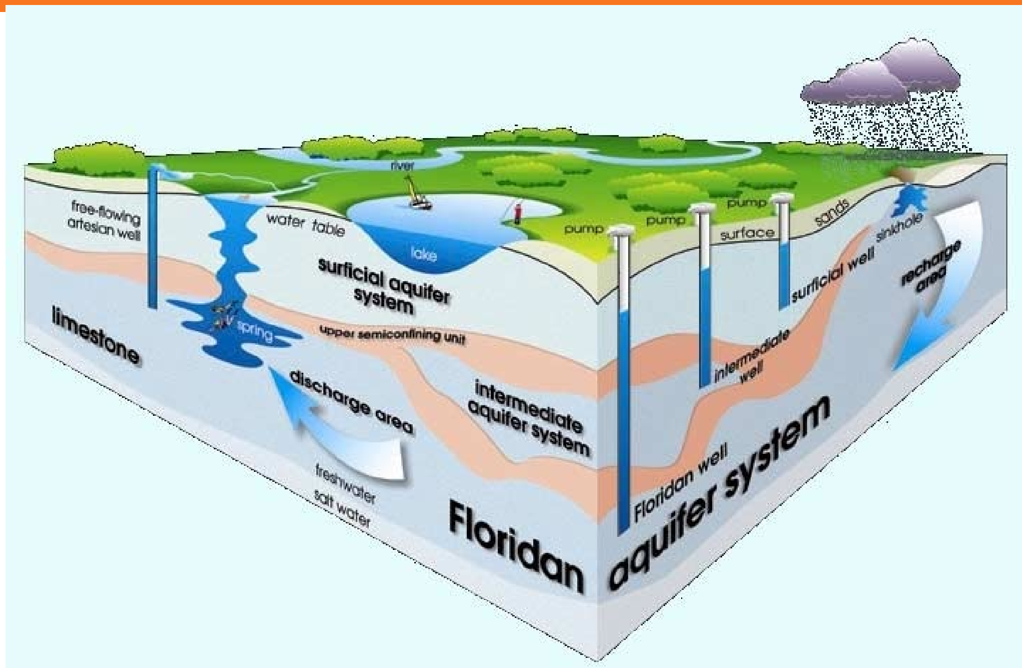
However, much of the area in Georgia demarcated by the USGS as Coastal Plains is also home to the Floridan Aquifer, which stretches from coastal Mississippi to South Carolina while also covering all of Florida. While south Florida has saline water in the aquifer, in northern Florida and southern Georgia the aquifer is mostly freshwater or brackish. In fact, TDS levels only reach 1,900 parts per million in the upper aquifer regions.

What happens when CO_2 is buried in freshwater aquifers?

As depicted in the image below, many aquifers are layered with fresh water on top and salty brackish water sinking to the bottom. For household and agricultural use, the wells tap into the top layer of the aquifer. Since CO_2 cannot be buried in this fresh water, it must go deeper into the aquifer where the water becomes brackish or salty.

The pipe through which the CO_2 is transported must also run through the freshwater and runs the risk of leaking. If leakage occurs, it could release trace metals like iron and manganese into the aquifer, which can turn the freshwater salty and make it unpotable. It is uncertain to what extent an aquifer can recover from CO_2 leakage.

While CO_2 is used for potable sparkling water, leaks into an aquifer would cause high levels of contamination and render water unpotable. However, researchers say that the technology exists to mitigate this risk and ensure that any potential leaks are caught early. It's likely that any leakage would happen slowly, giving overseers enough time to catch and address it before it badly contaminates drinking water supplies.



A cross section of the Floridan Aquifer. (from https://edis.ifas.ufl.edu/publication/FR445)

How important is the Floridan aquifer?

The Floridan Aquifer supplies fresh drinking water to over 10 million people in the southeastern United States. It is essential to the livelihood of Georgia, is already stressed, and demand will only continue to increase. The City of Savannah, which draws part of its water supply from the Floridan aquifer, says it will need an additional 42 million gallons a day in water to meet its future growth. In addition, a proposed Hyundai plant near Savannah hopes to draw 6.6 million gallons per day from the aquifer. If the aquifer is contaminated, it would be catastrophic for household and agricultural water supplies in Georgia.

Learn more about Floridan Aquifer: Our Water Supply - Water on Campus - UF Clean Water Campaign

Are there plans for carbon capture in Georgia?

Well, kind of. Georgia Power has launched three test bore sites in Georgia, two of them on top of the Floridan Aquifer, to investigate their suitability for CO_2 burial. The sites in Wayne and Brantley County in southeast Georgia will bore as deep as 6,000 feet underground, drilling through the freshwater level of the Floridan Aquifer. While this testing is only preliminary, emissions limits and funding for carbon capture projects make the possibility of carbon capture more of an eventuality. As of yet there is no concrete plan for industrial scale carbon capture and storage in Georgia, but preliminary plans are well underway above the Floridan Aquifer.

Can you do anything else with captured carbon aside from storing it?

Captured carbon can theoretically be put to productive use for a number of things outside of storage. Captured carbon can be used in fuel manufacturing, building materials, and enhanced oil recovery (C2ES). However, currently, due to cost and technology barriers, these uses are not widely practiced aside from enhanced oil recovery, which can have problematic environmental effects such as groundwater pollution and biodiversity loss in nearby ecosystems.

About Science for Georgia

Science for Georgia is a 501c3 dedicated to bridging the gap between scientists and the public through training, outreach opportunities, and direct contact with the public, policymakers, and the press. Science for Georgia highlights how science can impact people's lives and advocates for the responsible use of science in public policy.

Please reach out with any questions or comments info@sci4ga.org

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