Dear Chair Lively, Co-Chairs Levy and Gamba, and members of the House Committee on Climate, Energy, and Environment,

Thank you for the opportunity for DOGAMI and DSL to present on Geological Carbon Sequestration on January 28, 2025, and thank you to Representative Osborne for the following questions:

1. *What are the consequences of carbon sequestration on the ecosystem, and what impact does carbon sequestration have on trees?*
2. *How long have we been tracking carbon in the air; what percentage has carbon increased; how much of those emissions are produced by Oregon; how much has Oregon sequestered in trees; and what is the net effect of geologic carbon sequestration on the rest of the country and the rest of the world.*

The following letter seeks to address these questions. If you have additional questions, please do not hesitate to reach out the DOGAMI's Legislative Coordinator, Christina Appleby, (christina.appleby@dogami.oregon.gov).

CO_2 concentration and measurement

The annual average for CO_2 surface concentration (i.e., the amount of CO_2 in the air) for 2023 was ~419.3 ppm (parts per million) [Lindsey, 2024]; there is currently no annual average value for 2024. This data comes from the Mauna Loa and Mauna Kea Observatories (Hawai'i), which measure circulated background air within the free troposphere (the lowest layer of Earth's atmosphere) and avoids local sources of CO_2 output or draw-down such as cities or forests.

The earliest measurements from Manua Loa observatory were in 1958, with an annual average CO_2 concentration for 1959 of 315.97 ppm. From 1959 to 2023, CO_2 concentration has increased by 32.7%. This period represents the most reliable direct measurements of CO_2 concentration.

Data on atmospheric CO_2 concentration pre-1958 is an estimate, with the most reliable method based on ice core data. This method uses analysis of gas bubbles locked within ice cores, drilled from ice sheets in Antarctica and Greenland. Ice core data is very accurate, with uncertainty in CO_2 concentration within 1-2 ppm. This includes effects such as measurement precision, sample variability, bubble closure effects, and diffusion (movement) of CO_2. Ice core data extends continuous records for CO_2 concentration back ~800,000 years [Lüthi and others, 2008], as shown in Figure 1, in the context of modern measurements at Mauna Loa Observatory.

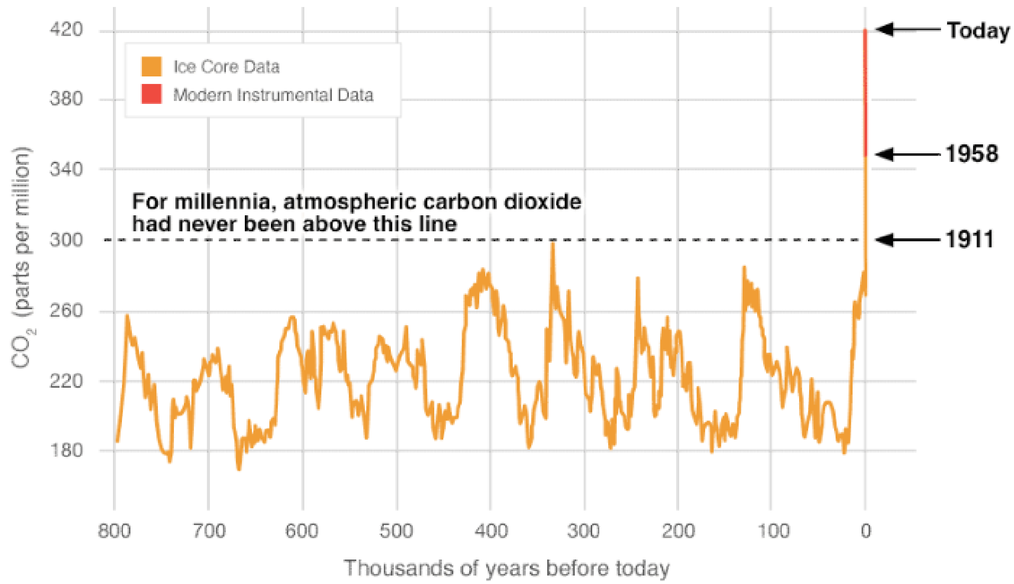

Figure 1. *Atmospheric CO_2 concentration, as measured at the Mauna Loa Observatory in Hawai'i (red portion of curve) relative to CO_2 concentration determined from ice cores [Lüthi and others, 2008]. Credit: NOAA [https://climate.nasa.gov/vital-signs/carbon-dioxide/?intent=121]*

Oregon's CO_2 emissions

The Department of Environmental Quality (DEQ) provides a *Greenhouse Gas Inventory* for years 1990-2021, showing emissions from human activity [https://www.oregon.gov/deq/ghgp/Pages/GHG-Inventory.aspx]. Values are presented in CO_2 equivalent (CO_2e, which includes other greenhouse gases such as methane). Data is drawn from statewide emissions that integrate measured data from the DEQ's *Greenhouse Gas Reporting Program*, and modelled emissions estimates from the Environmental Protection Agency's (EPA) *State Inventory Tool*. It should be noted that since 2010, ~80% of the total emissions data is derived from the DEQ's direct reporting. Taking the period from 2010 to 2021 indicates that Oregon has yearly emissions ranging from 58-64 million metric tons ($MtCO_2e$), with the most recent data indicating 61.4 $MtCO_2e$ emitted in 2021.

Estimated CO_2 sequestered in Oregon's forests

Based on the U.S. Forest Service's Forest Inventory and Analysis (FIA) program, and for the 10-year reporting cycle 2007-2016, there were ~3.2 billion metric tons of CO_2 ($GtCO_2$) sequestered in Oregon's forests [Christensen and others, 2019]. This value is in constant flux, with tree growth resulting in carbon sequestration (positive flux), and tree death, decay, and fires resulting in carbon emission (negative flux). Based on changes in forestlands between 2001-2006 and 2007-2016, the total forest net flux has been estimated at 31.4 $MtCO_2e$ per year, indicating a net increase in carbon sequestered into forest. Forests are part of the "short" carbon cycle, and wildfires are a major disruption to this sequestration. Although not limited to forests, wildfire burn acreage for 2024 is estimated to have exceeded 1.9 million acres (7,689 km^2), with a fire season cost of $318 million [McDonald, 2024]; this fire season breaks the previous record for burn area, set in 2020.

Consequences of the proposed *Research Well*

The aim of the proposed *research well* is to collect data to assess the CO_2 storage potential of basaltic rocks in the subsurface, in Oregon. The proposed research well falls within Oregon's existing regulatory framework, as a Class V underground injection control (UIC) well. The research well is not a CO_2 injection well (a Class VI UIC). There are currently ~44,000 UIC wells registered with the Oregon Department of Environmental Quality (DEQ) UIC program, of which the vast majority are Class V, and include stormwater disposal, geothermal, aquifer storage, and dewatering wells. The potential for environmental impact, or consequences related to the research well, such as potential for groundwater contamination during drilling, are mitigated by adherence to the existing rigorous regulatory framework within Oregon.

The scale and consequences of carbon sequestration

The principal aim of carbon sequestration is to counteract greenhouse gas *emissions* from human activity: specifically, we are referring to the sequestration of CO_2 here. Although there is no single globally agreed target on reducing the amount of CO_2 in the atmosphere (also known as the *concentration*) a commonly cited aim is to achieve "*net-zero* *emissions*" by 2050 [see e.g., the United Nations climate action: https://www.un.org/en/climatechange/net-zero-coalition]. The International Energy Agency (IEA) estimates that global CO_2 emissions from fossil fuels, transportation, and industrial processes was ~37.4 $GtCO_2$ for 2023 [IEA, 2024]; as above and for comparison, Oregon emits ~61.4 $MtCO_2e$ per year, Oregon's forests sequester ~31.4 $MtCO_2e$ per year, and the U.S. emits ~6.343 $GtCO_2$ per year [EPA, 2024]. A global *net-zero* policy would aim to balance emissions caused by human activities, by removing ~37.4 $GtCO_2$ from the atmosphere, but this would have the effect of stabilizing CO_2 concentrations, rather than reducing the current atmospheric CO_2 concentration.

Geologic carbon sequestration in the Columbia River Basalt Group (CRBG) of Oregon and Washington has the potential to balance U.S. current rate of emissions for 15 years, or Oregon's emissions for more than 1600 years. Taken as a whole, the CRBG covers more than 210,000 km^2 (81,081 mi^2) with a total volume in excess of 210,000 km^3 (50,382 mi^3). Taking average porosity values, and without elevating pore fluid pressures, the estimated CO_2 sequestration potential for the CRBG is >100 $GtCO_2$ [McGrail and others, 2006]. These calculations have been supported recently by well characterization, and injection of CO_2 at the Wallula Basalt Pilot project in Washington [Cao and others, 2024]. The pilot project focused on the *Grande Ronde Basalt*, which is one of four formations that make up the CRBG, and spans the entire width of Northern Oregon. Based on direct measurement of rock properties in the test project, Cao and others [2024] estimate that the Grande Ronde Basalt has a storage potential of 40 $GtCO_2$, providing more than 1000 years of storage capacity at the current emission level for all point sources in the PNW.

Elevated atmospheric CO_2 can increase the rate of carbon fixation by photosynthesis, potentially increasing plant growth [Ainsworth & Rogers 2007]. Studies of mixed plant systems subjected to elevated atmospheric CO_2 conditions show a variable response, with some species experiencing decreased growth, probably due to competition within the ecosystem [Poorter & Navas 2003]. Notably, there has been a long record of global deforestation due to human activity, including clearing land for other uses such as agriculture, infrastructure, and mining, and as a source of fuel. It is estimated that since the last ice age (~10,000 years ago), deforestation has removed about one third of the world's forest land, with about half of that deforestation occurring in the last 100 years [Kump and others, 2004]. In that same period (~100 years), CO_2 concentration has risen from ~300 ppm, to ~419.3 ppm (e.g., Figure 1). Net global deforestation is ongoing [FAO, 2020]. The effects of reducing atmospheric CO_2 concentration will need to be considered in the context of a decreasing forest ecosystem, while noting that a net-zero goal does not decrease atmospheric CO_2 concentration.

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