December 2, 2022

To: California Air Resources Board

Re: Potential Changes to the Low Carbon Fuel Standard (lcfs-wkshp-nov22-ws)

Submitted via CARB's online Comment Submittal Form with references uploaded as a separate .zip file

To whom it may concern:

The Center for Biological Diversity appreciates the opportunity to comment on CARB's proposed changes to the Low Carbon Fuel Standard (LCFS). We offer several concerns and suggestions.

First, now that California has banned use of carbon dioxide (CO_2) from carbon capture and storage (CCS) for enhanced oil recovery (EOR) within the state, CARB must remove CCS-related EOR from the LCFS. At present, CARB continues to incentivize EOR out-of-state and assume use of this harmful technology in its modeling.

Second, CARB's carbon intensity calculations for fuels made using CCS, such as ethanol with CCS and blue hydrogen, fail to reflect real-world CO_2 capture efficiencies or account for CO_2 and methane emissions across the CCS lifecycle. As a result, CARB significantly underestimates the carbon intensities of fuels made using CCS, and these methodological errors must be corrected.

Third, CARB's CA-GREET model currently underestimates the carbon intensity of fuels made with fossil gas and biogas, such as CNG fuels, factory farm gas, and hydrogen, because it relies on assumptions for methane leakage that dramatically underestimate leakage rates and are inconsistent with the best-available science.

Finally, CARB must consider an alternative with aggressive targets in carbon intensity reductions and rapid phase-down of fossil fuels that incentivizes truly renewable fuels that minimize impacts, rather than alternatives that emphasize technologies like CCS.

Please note that we have attached references cited in this letter in a .zip file titled, "Ctr. Biol Div Refs LCFS 12.2.22," for CARB's consideration and for inclusion in the public record.

I. CARB must end LCFS credits to out-of-state projects conducting EOR associated with CCS

In September 2022, Governor Newsom signed Senate Bill 905 (SB 905) into law.[1] Among other provisions, SB 905 prohibits operators in California from utilizing CO_2 from CCS operations in EOR.[2]

It's easy to see why the legislature listened to communities in California and banned EOR associated with CCS. EOR involves the injection of fluids and/or gases (such as CO_2) underground to extract fossil fuels.[3] EOR threatens drinking water integrity, yet regulations on EOR activities are decades old and fall short of providing sufficient safeguards for groundwater.[4] In addition, all forms of EOR have some risk of blowouts that can result in leakage and/or surfacing of fossil fuels or injection fluids.[5] And throughout the EOR lifecycle—from construction to injection, production, and waste disposal—there are risks to the environment and communities from air, water, and noise pollution.[6] Adding to this is the contribution to climate change caused by extracting and using more fossil fuels via EOR. One study found that for each ton of CO_2 injected for EOR, 2.7 tons of CO_2 are eventually emitted from burning recovered oil.[7]

Yet while California decidedly took a stand against CCS-associated EOR within the State, CARB's LCFS door remains open to incentivizing this same harmful practice *outside* the State's borders. Under the LCFS CCS Protocol, applicable CCS projects are those "that capture carbon dioxide (CO_2) and sequester it onshore, in either saline or depleted oil and gas reservoirs, *or oil and gas reservoirs used for CO_2-enhanced oil recovery (CO_2- EOR)*.[8] Thus, non-California regulated entities conducting EOR will be compensated by CARB for causing environmental and community health damage elsewhere. This asymmetry is simply wrong and must be corrected by removal of CCS-related EOR from the LCFS.

---

[1] SB 905 (Caballero, 2022), https://leginfo.legislature.ca.gov/faces/billStatusClient.xhtml?bill_id=202120220SB905.
[2] *Id.* at Section 4(b), to be codified in Cal. Pub. Res. § 3132(b); *see also* Senate Bill 1314 (Limón, 2022) (also signed into law and prohibiting EOR using CO_2 derived from CCS operations).
[3] Clean Water Action, The Environmental Risks and Oversight of Enhanced Oil Recovery in the United States at 5 (Aug. 2017), https://www.cleanwater.org/sites/default/files/docs/publications/The%20Environmental%20Risks%20and%20Oversight%20of%20Enhanced%20Oil%20Recovery%20in%20the%20United%20States.pdf (CWA EOR Report).
[4] *Id.*
[5] *Id.* at 13.
[6] *Id.* at 12.
[7] *Id.* at 23, citing Banks, Brian et al., *SaskPower's Carbon Capture Project – What Risks? What Rewards?*, Canadian Center for Policy Alternatives at 16-17 (2015) (noting that this calculation "does not even account for carbon dioxide losses in the course of the injection process: a substantial proportion returns to the surface with the oil.").
[8] CARB LCFS CCS Protocol at 7 (Aug. 13, 2018) (emphasis added). CCS projects are eligible for LCFS participation under the Tier 2 pathway. *See* 17 Cal. Code Regs. § 95488.1(d)(7)(B).

Our suggested changes to remove CCS-related EOR are as follows:

1) CARB must remove the bolded language below from the LCFS CCS Protocol:
    - The CCS Protocol applies to projects "that capture carbon dioxide (CO_2) and sequester it onshore, in either saline or depleted oil and gas reservoirs, **or oil and gas reservoirs used for CO_2-enhanced oil recovery (CO_2- EOR)."**
2) CARB must update its regulations with the following changes:
    - In 17 Cal. Code Regs. section 95490(a)(1) (stating that eligible entities include "Alternative fuel producers, refineries, and oil and gas producers that capture CO_2 on-site and geologically sequester CO_2 either on-site or off-site"), make clear that, to be eligible, capture and sequestration of CO_2 does not include EOR.
    - In 17 Cal. Code Regs. section 95490(a)(2) (stating that "If CO_2 derived from direct air capture is converted to fuels, it is not eligible for project-based CCS credits. However, applicants may apply for fuel pathway certification using the Tier 2 pathway application process as described in section 95488.7."), make clear that CO_2 derived from direct air capture may not be used for EOR.

Finally, as it relates to the current workshop, CARB must eliminate any modeling assumptions incorporating use of CCS-related EOR. For example, the November 2022 technical documentation accompanying the CATS model assumes "that the majority of CO_2 captured from ethanol would either be *used* or stored in oil and gas fields."[9] The "use" assumed in this modeling could include EOR. As explained above, because California banned CCS-related EOR, CARB must not assume (or incentivize) its use elsewhere.

II. CARB's methodologies for calculating the carbon intensities for many fuels are flawed and underestimate their true climate impacts.

A. CARB's carbon intensity calculations for fuels made with CCS are flawed.

CARB's carbon intensity calculations for fuels made using CCS, such as ethanol with CCS and blue hydrogen, fail to reflect real-world CO_2 capture efficiencies or account for CO_2 and methane emissions across the CCS lifecycle. As a result, CARB significantly underestimates the carbon intensities of fuels made using CCS, and these methodological errors must be corrected.

i. CARB's assumption of 80 to 90 percent CO_2 capture efficiencies does not reflect the real-world performance of CCS projects.

CARB assumes an 80 to 90% capture efficiency for CO_2 in CCS projects.[10] However, real-world examples show that CCS projects have consistently over-promised and vastly under-

[9] CARB, Draft - California Transportation Supply Model Documentation at 20 (Nov. 2022) (emphasis added).
[10] *Id.* at 18. CARB cites a single report for this premise, and it is unclear how CARB derived the capture efficiency estimates from this report.

performed on capturing CO_2 emissions. For example, seven large-scale CCS projects have been attempted at U.S. power plants, each with hundreds of millions of dollars of government subsidies, but all these projects were canceled before completion or were shuttered due to failure to meet carbon capture targets in addition to technical problems and cost overruns.[11]

Importantly, a recent analysis by the Institute for Energy Economic and Financial Analysis (IEEFA) found that 10 of 13 flagship CCS projects, comprising 90% of the total capture capacity in the sample, failed or are underperforming in their CO_2 capture efficiencies, mostly by large margins.[12] For example, based on real-world data, the Boundary Dam CCS project in the power sector, the Chevron Gorgon CCS project in the gas processing sector, and the Illinois Industrial CCS project in the ethanol production sector are under-performing their designed CO_2 capture rates by ~50% on average.[13] Another study estimated that NRG's Petra Nova CCS project in Texas, the only U.S. fossil-fueled power plant to operate with CCS equipment, vastly underperformed. Although Petra Nova promised a 90% carbon capture rate, in practice it achieved only a 55% CO_2 capture rate from the carbon capture equipment on its pulverized coal boiler.[14] This project was shut down indefinitely in 2020 when it became uneconomic, after costing $1 billion and receiving $190 million from the federal government.

CARB's modeling that ignores the consistent underperformance of CCS projects and assumes that CCS equipment will operate according to idealized specifications ignores the reality of chronic malfunctions, flaring and venting, and shutdowns that substantially increase emissions in practice. By assuming unfounded CO_2 capture efficiency rates, CARB is underestimating the carbon intensity of fuels made using CCS.

ii. CARB must account for CO_2 emissions across the CCS lifecycle for fuels made using CCS.

CARB does not appear to be accounting for the CO_2 emissions across the CCS lifecycle for fuels made using CCS, including the substantial CO_2 emissions from the CCS energy penalty. CCS operations are energy-intensive because they require large amounts of energy to capture, compress, transport, and inject carbon underground, called the "energy penalty." For example, power plants using CCS consume an estimated 15% to 25% more energy to produce the same amount of power than a conventional plant.[15] These energy "penalties" mean that CCS projects emit significant additional CO_2 emissions from burning the fuel to run the CCS equipment as

[11] Congressional Research Service, 2022, Carbon Capture and Sequestration in the United States (Updated October 5, 2022), https://sgp.fas.org/crs/misc/R44902.pdf; For example, the utility Southern Company went $5 billion dollars over budget and three years behind schedule in building a carbon capture facility for a coal-fired power plant in Kemper County, Mississippi, before abandoning the project in 2017, after passing along many costs to its ratepayers, mostly low-income Black residents.
[12] IEEFA, The Carbon Capture Crux: Lessons Learned (September 2022), https://ieefa.org/resources/carbon-capture-crux-lessons-learned.
[13] *Id.* at Appendix 1.
[14] Jacobson, Mark Z, *The health and climate impacts of carbon capture and direct air capture*, 12 Energy Envt. Sci. 3567 (2019), https://doi.org/10.1039/C9EE02709B.
[15] Climate Action Network Int'l, CAN Position: Carbon Capture, Storage, and Utilisation at 9 (2021), https://climatenetwork.org/resource/can-position-carbon-capture-storage-and-utilisation/.

well as the upstream emissions from the extraction, processing, and transport of that fuel.[16] For example, at the Petra Nova coal-fired power plant, the carbon capture equipment covered the coal boiler but not the gas turbine used to power the CCS equipment. When the emissions from the gas turbine were taken into account, the CCS equipment captured only 34% of coal plus gas combustion CO_2 emissions.[17] Furthermore, when the upstream emissions from the extraction and processing of coal used in the boiler and fossil gas used to run the CCS equipment were taken into account, the CCS equipment reduced the coal and gas combustion plus upstream CO_2 a net of only 10.8% over 20 years and 20% over 100 years.[18] The study concluded that when lifecycle CCS emissions are taken into account, CCS "reduces only a small fraction of carbon emissions."[19]

In addition to CO_2 emissions associated with the energy penalty at the industrial facility, CARB must evaluate the other sources of CO_2 emissions across the CCS lifecycle, including the emissions associated with CO_2 transport and injection. CO_2 transport by trucks, rail or barge can significantly increase CO_2 emissions, especially when there are large distances between industrial facilities which are spread across the state, and injection sites which are targeted for the Central Valley. CO_2 transport by pipeline also poses significant CO_2 emissions risks due to inevitable pipeline leaks and blow-outs. At the site of injection, the energy needed to pump CO_2 underground for storage and other purposes has associated CO_2 emissions. CO_2 that is stored underground risks leakage back to the atmosphere, based on the long track record of fossil fuel industry leaks and spills.[20]

iii. CARB must account for methane leakage in its carbon intensity calculations for blue hydrogen.

In its calculations for the carbon intensity of blue hydrogen, CARB must account for the inevitable methane leakage from the production, processing, and transport of fossil gas used to produce the hydrogen and run the CCS equipment. A Cornell study that evaluated the lifecycle emissions of blue hydrogen, accounting for emissions of both CO_2 and unburned fugitive methane, concluded that the greenhouse gas emissions from the production of blue hydrogen are very high, at only 9%-12% less than for gray hydrogen made without CCS.[21] This is because the methane leakage emissions for blue hydrogen are higher than for gray hydrogen due to the increased use of fossil gas to power the CCS equipment. An analysis by the Natural Resources Defense Council found that "upstream leakage at average rates reported in the United States would add another 2.1 CO_2 per kg H_2 to the carbon intensity of blue hydrogen — roughly double

[16] *Id.*
[17] Jacobson, Mark Z, *The health and climate impacts of carbon capture and direct air capture*, *supra* note 14.
[18] *Id.*
[19] *Id.*
[20] Conley. S. et al., *Methane emissions from the 2015 Aliso Canyon blowout in Los Angeles, CA*, 351 Science 1317 (2016), https://science.sciencemag.org/content/351/6279/1317.
[21] Howarth, Robert W. & Mark Z. Jacobson, *How green is blue hydrogen?*, 9 Energy Sci. and Engineering 1676 (2021), https://doi.org/10.1002/ese3.956.

the onsite emissions for SMR with 90% carbon capture."[22] At present, CARB is underestimating the carbon intensity of blue hydrogen by failing to factor in methane leakage.

B. CARB must update the CA-GREET model with accurate assumptions for methane leakage for fuels made with fossil gas and biogas.

The CA-GREET model currently underestimates the carbon intensity of fuels made with fossil gas and biogas, such as CNG fuels, factory farm gas, and hydrogen, because it relies on assumptions for methane leakage that dramatically underestimate leakage rates and are inconsistent with the best-available science. The CA-GREET model assumes that the upstream leakage rate for conventional natural gas is 1.14% and the leakage rate for shale gas is 1.21%.[23] These are considerable underestimates at odds with the best-available science on methane leakage from gas production, handling, and transportation. The majority of scientific literature estimates average U.S. methane leakage rates at 1.6 times to more than two times the rates used in the CA-GREET model.[24]

Making the situation worse, fossil gas produced in California has a methane leakage rate that is much higher than the U.S. average, making CARB's estimates even more out of step. A recent analysis found that the methane leakage rate for gas sourced from the San Joaquin Valley is 4.8%,[25] making this gas not only worse than coal in terms of its carbon intensity but also the worst leakage rate in the continental United States. The fossil gas consumed in California has an overall leakage rate of 2.8%,[26] which is also much higher than the leakage rates used in the CA-GREET model.

CARB must also account for the leakage of factory farm gas during all stages of production, transport, and refining. For example, a study of methane leakage from biogas plants found that leaked methane can be as high as 14.9% of total methane production.[27] Importantly, one recent study concluded that renewable natural gas from intentionally produced methane—as

[22] Earthjustice, Reclaiming Hydrogen for a Renewable Future (August 2021), https://earthjustice.org/sites/default/files/files/hydrogen_earthjustice_2021.pdf.
[23] CARB, CA-GREET3.0 Lookup Table Pathways Technical Support Documentation, at 20, Table C.2. (Aug. 13, 2018), https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/lut-doc.pdf?_ga=2.244773765.1612320332.1659372127-1168559359.1580157486.
[24] Alvarez, R.A. et al., *Assessment of methane emissions from the U.S. oil and gas supply chain*, 361 Science 186 (2018); Howarth, Robert W. & Mark Z. Jacobson, *How green is blue hydrogen?*, *supra* note 21.
[25] Burns, Diana & Emily Grubert, *Attribution of production-stage methane emissions to assess spatial variability in the climate intensity of US natural gas consumption*, 16 Envtl. Research Letters 4 (2021), https://doi.org/10.1088/1748-9326/abef33.
[26] *Id.*
[27] Scheutz, Charlotte & Anders M. Fredenslund, *Total methane emission rates and losses from 23 gas plants*, 97 Waste Mgmt. 38-46 (2019), https://doi.org/10.1016/j.wasman.2019.07.029.

is the case with factory farm methane—is always a net greenhouse gas emitter unless total system leakage is zero.[28]

Methane is a super-pollutant more than 80 times more powerful than CO_2 at warming the atmosphere over a 20-year period,[29] second only to CO_2 in driving climate change.[30] Recognizing this, a recent report by the United Nations Environment Program concluded that "methane emissions globally from all sources need to be reduced by 40%-45% by 2030 in order to achieve the least cost pathway for limiting the increase in the Earth's temperature to 1.5°C."[31] Therefore, it is imperative that CARB properly factor methane leakage into the carbon intensity of fuels made with fossil gas and biogas, so as not to unfairly incentivize these polluting fuels.

III. CARB must consider an alternative with aggressive targets in carbon intensity reductions and rapid phase-down of fossil fuels that incentivizes truly renewable fuels that minimize impacts.

There is an overwhelming scientific consensus that we need to make immediate, deep reductions in CO_2 and other greenhouse gases across all sectors to avoid devastating climate change-driven damages. This includes the need for immediate, deep reductions in methane emissions are critical for lowering the rate of global warming in the near-term, avoiding dangerous tipping points, and delivering important health and economic benefits from reducing ground-level ozone.[32] CARB's 2022 Scoping Plan calls for proposing accelerated carbon intensity targets pre-2030 and post-2030 for LCFS, while monitoring for and ensuring that the production of low-carbon fuels does not result in unintended consequences, such as on vulnerable communities.[33] None of the LCFS alternatives meet the demands of the climate crisis while also avoiding serious unintended consequences.

Alternative C sets the most aggressive target with a 35% decrease in carbon intensity by 2030. However, it does so by relying heavily on unproven solutions such as direct air capture and high-polluting fuels, while phasing out fossil fuels more slowly than the other alternatives. It also relies more heavily on the generation of credits instead of on actual, direct emissions reductions.

---

[28] Grubert, Emily, *At scale, renewable natural gas systems could be climate intensive: the influence of methane feedstock and leakage rates*, 15 Envtl. Research Letters 8 (2020), https://iopscience.iop.org/article/10.1088/1748-9326/ab9335.
[29] Forster, P. et al. 2021: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, doi:10.1017/9781009157896.009, at Table 7.15.
[30] United Nations Environment Programme and Climate and Clean Air Coalition, Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions, Nairobi: United Nations Environment Programme (2021), https://www.unep.org/resources/report/global-methane-assessment-benefits-and-costs-mitigating-methane-emissions, at 11.
[31] *Id.*
[32] *Id.*
[33] CARB, 2022 Scoping Plan at 192.

Meanwhile, Alternative A more rapidly transitions California off of fossil fuels but results in the slowest decline in greenhouse gas emissions.

These tradeoffs are untenable; we must rapidly phase out fossil fuels while scaling up truly renewable energy, such as that derived from solar and wind. Recent reports have found that there can be no new fossil fuel development if we are to limit temperature rise to 1.5°C, with wealthier countries (and states) leading the way.[34] Oil production in the U.S. must be cut by 74% by 2030 with zero production by 2034 to have a 66% chance of 1.5°C.[35] Any alternative that fails to rapidly phase down fossil fuels is not a plausible alternative.

We urge CARB to revisit the metrics and tradeoffs to analyze an alternative that accelerates the targets while reducing reliance on accounting devices and "solutions" that fail to decelerate warming and have other unintended consequences on health and the environment. These include fuels such as: methane or fossil-derived hydrogen fuels and use of hydrogen fuels for light-duty vehicles; highly polluting fuels such as woody biomass and crop-based fuels that drive harmful land-use changes,[36] ethanol and dairy manure-derived biomethane;[37] and engineered carbon removal technologies.[38] The LCFS should incentivize truly renewable resources without relying heavily on credits schemes and on technologies such as engineered carbon removal that prolong the life of fossil fuels and other dirty combustion, create safety risks, and have never lived up to their promises.[39]

Moreover, any hydrogen should not be incentivized as a low-carbon fuel for the light-duty vehicle fleet because it is much less efficient than electric battery technology. Because so much energy is lost in producing, compressing, and transporting hydrogen to fuel cell vehicles, those vehicles, when factoring in the fuel's full lifecycle, require two to three times more energy than an EV to travel the same distance.[40] For this reason, several automakers have chosen to abandon the technology entirely, after realizing that hydrogen fuel cell vehicles will never be

---

[34] Trout et al, *Existing fossil fuel extraction would warm the world beyond 1.5 °C*, Envtl. Research Letters (2022), https://iopscience.iop.org/article/10.1088/1748-9326/ac6228/pdf.
[35] Calverley, D., & Anderson, K., Phaseout Pathways for Fossil Fuel Production Within Paris-compliant Carbon Budgets (2022), https://www.research.manchester.ac.uk/portal/files/213256008/Tyndall_Production_Phaseout_Report_final_text_3_.pdf.
[36] *See* Earthjustice, Comments on July 7, 2022 LCFS Workshop (April 8, 2022); *see also* Ctr. for Biological Diversity, Comments on Draft 2022 Scoping Plan Update (June 24, 2022) at 30-33.
[37] *See* Ctr. for Biological Diversity et al., Comments on the Recirculated Draft Environmental Analysis for the 2022 Draft Scoping Plan (Oct. 24, 2022) at 26-27.
[38] *Id.* at 5-21.
[39] *See supra*, Section II. For more information on carbon capture and storage and direct air capture technologies, *see* Ctr. for Biological Diversity, Comments on the 2022 Scoping Plan Update – Engineered Carbon Removal Technical Workshop (Aug. 26, 2021); *see also* Ctr. for Biological Diversity, Comments on Draft 2022 Scoping Plan Update (June 24, 2022) at 24-34.
[40] Volkswagen, Battery or Fuel Cell, That is the Question (2020), https://www.volkswagen-newsroom.com/en/stories/battery-or-fuel-cell-that-is-the-question-5868.

cost-competitive with electric vehicles.[41] The price disparity becomes more apparent when considering the cost of providing hydrogen to consumers. According to the Department of Energy there are only 54 hydrogen refueling stations—all in California—compared to over 48,000 EV stations. As most hydrogen is currently fossil fuel-derived, it makes little sense to offer credits that incentivize expansion of an underutilized, expensive, and polluting fuel for use in light-duty vehicles.

Pursuant to the Scoping Plan, CARB must also monitor and avoid unintended consequences. For example, in the LCFS, CARB must account for increased groundwater contamination from expansion of dairy herd sizes in the production of biofuels and associated water supply impacts; the health and safety costs of hydrogen produced from steam methane reformation, gasification, or pyrolysis of biogas and biomass;[42] and the economic and ecological damages caused by crop-based biofuels that increase emissions while worsening global food insecurity.[43]

The LCFS program has significantly more credits than deficits. Instead of providing even more credits for technologies and fuels that carry health and safety risks, damage ecosystems, and include high lifecycle costs and emissions, CARB should analyze alternatives that rapidly phase out fossil fuels and incentivize truly renewable fuels.

Thank you,

Victoria Bogdan Tejeda
Staff Attorney, Climate Law Institute
vbogdantejeda@biologicaldiversity.org

Shaye Wolf, PhD
Climate Science Director, Climate Law Institute
swolf@biologicaldiversity.org

---

[41] *See, e.g.*, Morris, Charles, Charged Electric Vehicles Magazine, Daimler Becomes the Latest Automaker to Abandon Hydrogen-Powered Passenger Cars (2020), https://chargedevs.com/newswire/daimler-becomes-the-latest-automaker-to-abandon-hydrogen-powered-passenger-cars/.

[42] *See e.g.* American Med. Ass'n, Resolution 438 Informing Physicians, Health Care Providers and the Public About the Dangers of Fossil-Fuel Derived Hydrogen (2022), https://www.ama-assn.org/system/files/a22-refcmte-d-report-annotated.pdf; *see also* Ctr. for Biological Diversity, Comments on Draft 2022 Scoping Plan Update (June 24, 2022) at 33-34.

[43] *See* Earthjustice, Comments on July 7, 2022 LCFS Workshop (April 8, 2022) at 8-9; Rulli, M.C. et al., *The water-land-food nexus of first-generation biofuels*, 6 Nature Scientific Reports (2016); Fleming, John, Ctr. for Biological Diversity, The Biofuels Myth: Why Sustainable Aviation Fuels Won't Power Climate-Safe Air Travel (2022) at 7, https://biologicaldiversity.org/programs/climate_law_institute/pdfs/2022_The_Biofuels_Myth_Center_for_Biological_Diversity.pdf.