Testimony of Erin Burns, Executive Director, Carbon180
U.S. Senate Committee on Energy and Natural Resources
November 2, 2023
Full Committee Hearing to Examine Opportunities and Challenges in Deploying CCUS and DAC Technologies on Federal and Non-Federal Lands

Introduction

Thank you for the opportunity to testify today on deploying direct air capture (DAC) in the US. I'm Erin Burns, the Executive Director of Carbon180, an independent non-profit organization focused on reversing two centuries of carbon emissions. Specifically, we design and champion equitable, science-based policies that bring carbon removal pathways to gigaton scale to eliminate legacy carbon emissions and create a livable climate in which current and future generations can thrive. We were founded in 2015 as the first and only NGO in the United States dedicated to carbon removal. Our funding comes primarily from philanthropy and individual donors.[1]

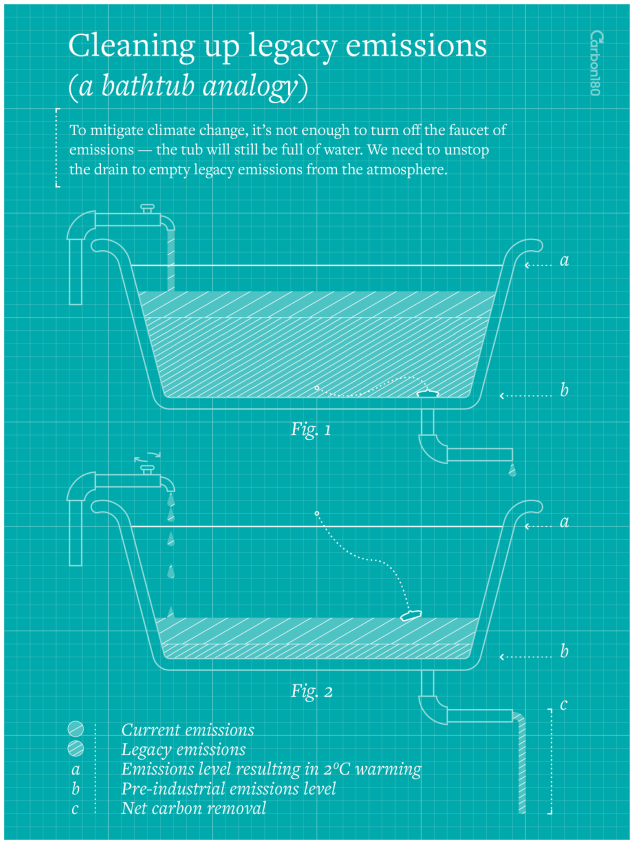
In nearly a decade of working in this field, Carbon180 has seen first-hand the enormous potential of carbon removal and direct air capture. Carbon removal is our only tool to reverse the more than two trillion tons of carbon that's already been emitted into our atmosphere. If deployed responsibly alongside deep cuts to new emissions, carbon removal can be a wellspring of new economic and environmental prosperity for communities. Poised to become a trillion-dollar industry, carbon removal could be a rising tide that lifts all boats — creating high-quality jobs, establishing carbon-negative industries, and activating new sources of revenue for US businesses and communities.

Why Carbon Removal is Necessary

Direct air capture is a form of carbon removal, a set of technologies and practices that remove carbon dioxide (CO_2) from the atmosphere. According to the United Nations Intergovernmental Panel on Climate Change, carbon removal is an essential tool in meeting climate goals and we are expected to need gigaton-scale carbon removal by mid-century.[2]

In our view, the primary goal of all carbon removal, including and especially direct air capture, is to address legacy emissions and not to enable the continued use of fossil fuels. In addition to stopping emissions as quickly as possible, we must also remove billions of tons of CO_2 that has already emitted into the atmosphere.

[1] https://carbon180.org/annual-report
[2] https://www.ipcc.ch/sr15/



What is Direct Air Capture and Where Are We Today?

Direct air capture (DAC) is a suite of technologies that use chemistry to capture CO_2 directly from the atmosphere. The captured CO_2 can be injected deep underground for dedicated geologic storage, or converted into value-added products. Products like concrete provide long-term storage, whereas some applications like beverages or synthetic fuels have short-lived storage.[3][4][5]

Today's DAC technologies rely on large air contactors and chemical sorbents or solvents that selectively react with CO_2, removing it directly from the atmosphere. Because CO_2 only makes up .04% of the atmosphere, DAC plants rely on active air contactors—usually giant fans—to funnel massive amounts of air into their system. From there, CO_2 will come into contact and then bind with sorbents or solvents until they become saturated. At that point, heat is often applied to release a stream of CO_2.[6]

[3] https://www.wri.org/insights/direct-air-capture-resource-considerations-and-costs-carbon-removal

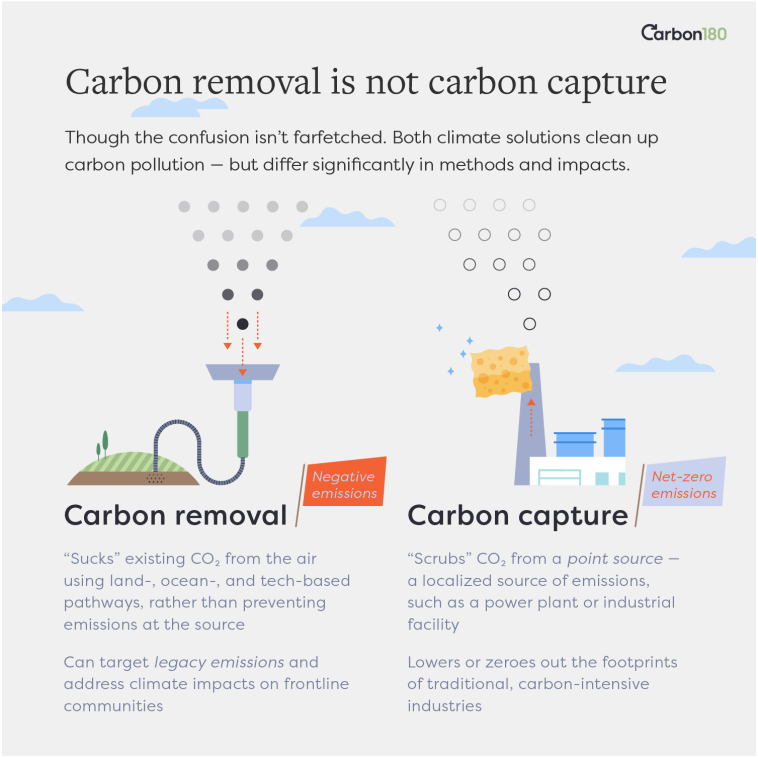
[4] https://static1.squarespace.com/static/5b9362d89d5abb8c51d474f8/t/64e7ca54fd8b1d2622f15daa/1692912213556/Carbon180+Deep+dive+DAC+ENG.pdf

[5] https://static1.squarespace.com/static/5b9362d89d5abb8c51d474f8/t/64e7c87dabd1b503e8a1116e/1692911741602/Carbon180+Fact+sheet+DAC+ENG.pdf

[6] https://cdrprimer.org/read/chapter-2#sec-2-8

Current DAC costs range from $152 to $398 per ton of CO_2, based on technology type, scale, energy source, end-use, and other project-specific components.[7] The passage of the Energy Act of 2020 established the first-ever dedicated carbon removal research and development (R&D) program at the Department of Energy. Federally supported R&D has a proven track record of dramatically decreasing the cost of emerging technologies, in addition to decreases that are expected to come from private sector investments, learning-by-doing, and additional supportive policies. Core developments in DAC technologies include moving towards passive air contacting, modular designs, and alternative capture materials, all of which have significant cost-saving potential.[8]

While DAC and carbon capture utilization and storage (CCUS) have some shared technology and infrastructure, there are also many ways in which they are unique; as a result, they will require some shared and some different policy mechanisms to reach scale. Shared needs include dedicated geologic storage, CO_2 transportation networks, and some similar R&D needs. The chief difference between the two: DAC pulls down CO_2 that's already in the atmosphere, while CCUS scrubs new emissions at their source, which can help decarbonize power and industrial plants. Carbon removal, including DAC, will largely function as a public good.



[7] These costs are adjusted for inflation; original costs from the report are are $124 to $325 per ton in 2018 dollars https://rhg.com/wp-content/uploads/2019/05/Rhodium_CapturingLeadership_May2019-1.pdf
[8] https://carbon180.medium.com/the-future-of-dac-is-knocking-168326270d33

Today, there are 18 currently operational DAC plants located in Canada, Europe, and the United States.[9] Orca, located in Iceland, is the largest-scale operation, removing 4,000 tons of carbon dioxide annually.[10] There are also many planned DAC plants across the US. 1PointFive, a development company owned by Oxy Low Carbon Ventures, is currently constructing a DAC facility in Ector County, Texas, and once complete, will remove 500,000 tons of carbon dioxide annually.[11] Awards for the Department of Energy's Regional DAC Hubs program are expected to be dispersed in early 2024 and will include the deployment of two additional million-ton scale DAC hubs.[12]

There has also been significant private sector investment in DAC. Frontier is an advance market commitment to purchase more than a $1 billion of permanent carbon removal between 2022 and 2030; this strong demand signal has already accelerated the deployment of durable carbon removal pathways. It was founded by Stripe, Alphabet, Shopify, Meta, McKinsey, and tens of thousands of businesses using Stripe Climate.[13] In April 2022, the Swiss direct air capture company Climeworks signed an equity round amounting to about $650 million.[14] [15] Similarly, Heirloom, a US-based DAC start-up received a $53 million investment in a Series A round of funding.[16] [17]

Opportunities in Direct Air Capture Deployment

DAC can play an essential role in meeting climate goals through addressing legacy emissions. It can also bring enormous benefits beyond climate. US federal policies such as The Energy Act of 2020, the Infrastructure Investment and Jobs Act, the Inflation Reduction Act, and annual Energy and Water Development Appropriations Acts have bolstered support for DAC technologies in the US. The Rhodium Group estimates that these policies will result in between one and eight million tons of DAC capacity deployment in 2030.[18] Those tons can help drive continued American leadership, propel economic growth, and realize benefits across the country.

- **Continued US leadership on carbon removal.** The majority of DAC companies are headquartered in the US and while some of the largest companies are not US-based, they have planned their first full-scale deployments here. Federal policy support — a 45Q tax credit that provides $180 per ton, the Direct Air Capture Hubs program, robust R&D

[9] https://iea.blob.core.windows.net/assets/78633715-15c0-44e1-81df-41123c556d57/DirectAirCapture_Akeytechnologyfornetzero.pdf
[10] https://climeworks.com/plant-orca
[11] https://www.1pointfive.com/ector-county-tx
[12] https://www.energy.gov/oced/regional-direct-air-capture-hubs-selections-award-negotiations
[13] https://frontierclimate.com/
[14] https://www.bloomberg.com/news/articles/2022-04-05/climeworks-raises-650-million-in-largest-round-for-carbon-removal-startup?embedded-checkout=true
[15] https://climeworks.com/uploads/documents/climeworks-press-release-finalized_05.04.22_.pdf
[16] https://www.prnewswire.com/news-releases/direct-air-capture-startup-heirloom-raises-53mm-series-a-among-the-largest-investments-in-new-carbon-removal-technologies-301505399.html
[17] https://carbonherald.com/new-53-million-in-funding-for-heirloom-ensures-further-growth/
[18] https://rhg.com/research/direct-air-capture-workforce-development/

support — has meant that the US is far and away leading the world in planned DAC projects.

The US can also play a central role in derisking new technologies, including DAC, enabling further global deployment and supporting climate justice.[19]

- **Economic Growth**. DAC has strong potential to create new jobs and businesses, promote market and economic growth, and provide long-term wealth-building opportunities. According to an analysis released this month from the Rhodium Group, a 500,000 ton DAC plan could generate 1,215 jobs in construction, engineering, materials, and equipment and 340 jobs in operations and maintenance over the facility's lifetime. Importantly, 37% of the jobs identified by the Rhodium report are in supply chains. To fully realize the economic opportunity in building a robust DAC sector in the US, we must invest in domestic supply chains. The Rhodium Group's estimate of one to eight million tons of capacity deployment by 2030 could mean up to 19,000 jobs in the next several years.[20] These benefits are even more promising for historically fossil fuel-dependent communities, whose workforces have many overlapping skill sets with those required in the construction, operation, and maintenance of a DAC facility.

  There is also enormous private sector demand for DAC that can be unlocked by policy support. Voluntary carbon removal markets are estimated at a $10 to $40 billion market by 2030, but in that same year, demand is expected to exceed projected supply.[21] Policy support can help realize the full economic benefits of DAC.

- **Regional distribution of benefits.** Importantly, DAC projects can be sited in many regions, including those that are navigating an economy impacted by a reduction in the production and use of fossil fuels. Support for workforce development and close alignment with unions, including those who have regional representation in fossil fuel areas like the United Mine Workers of America, can help these communities realize the full economic benefits of high-paying DAC jobs.

  Flexibility in siting can also provide opportunities for communities to opt in to hosting DAC projects, helping to build public support and social license for deployment. DAC can also unlock opportunities including long term local wealth and ownership.

Current Barriers to Direct Air Capture Deployment

While recently enacted legislation has made major strides in addressing the immediate needs of DAC, barriers to deployment at scale remain. These include demand signals, access to geological storage, performance standards, insufficient research and transparency, and the need for additional clean energy.

- **Reliable demand signals.** Reliable demand signals, including offtake agreements, are necessary to finance large-scale projects. These signals from the private sector, most

[19] https://www2.itif.org/2014-federally-supported-innovations.pdf
[20] https://rhg.com/research/direct-air-capture-workforce-development/
[21] https://www.bcg.com/publications/2023/the-need-and-market-demand-for-carbon-dioxide-removal

notably the Frontier advance market commitment, have helped drive the current wave of deployment. Reaching million- and then billion-ton scale will require robust demand signals from the US federal government.

- **Secure geologic storage.** We need to capture billions of tons of CO_2, which will then need to be safely and securely stored. A key part of that process is the Environmental Protection Agency's Underground Injection Control program, which oversees the permitting, siting, operation, and monitoring of Class VI wells. While the US has enormous geologic storage potential (around 2,400 gigatons), an historically under-resourced Class VI program has resulted in functionally no new permits for saline storage.[22] [23]

- **Monitoring, reporting, and verification (MRV)**. To operate at scale, the carbon removal industry, including DAC companies, need rigorous, science-based standards for the quantification of net carbon removed from the atmosphere. Standards bring clarity, consistency, and transparency across the market, de-risking investment and enabling the development of legally enforceable offtake agreements that protect both the buyer and the supplier of carbon removal services. Standards also enable independent validation of DAC project or facility performance. Independent validation allows for unbiased comparisons between technologies and investment in those solutions that work best. [24]

- **Transparent, accessible, and relevant information.** As DAC deployment rapidly scales, community engagement and social license are essential to the sector's success. One of the immediate barriers to strong community engagement is a lack of transparent, easy-to-access, and unbiased educational materials. Additionally, there are significant research gaps on issues important to environmental justice organizations.

- **Additional clean energy**. Meeting climate goals requires rapid decarbonization. DAC requires clean energy to operate. To ensure that scaling DAC doesn't in any way slow decarbonization, the US will need additional clean energy build out.[25]

Policy Recommendations for Direct Air Capture Deployment

Over the past 6 years, the US has passed the world's most ambitious carbon removal and DAC policies and we are poised to move to megaton scale plants in the coming years. Additional policy support is necessary to maintain our leadership and trajectory on scaling DAC. These policies can also help unlock additional private sector capital, ensure the full benefits of the technology are realized, and help the US meet climate goals.

- **Research, development, and demonstration (RD&D).** Continued and increased funding of the Department of Energy's RD&D work will be necessary for continued innovation and improvement of DAC. Considerations for the future of this R&D work can include:

[22] https://www.usgs.gov/faqs/how-much-carbon-dioxide-can-united-states-store-geologic-sequestration
[23] https://www.epa.gov/uic/table-epas-draft-and-final-class-vi-well-permits
[24] https://carbon180.medium.com/a-buyers-guide-to-high-accountability-mrv-2435fd8e5681
[25] https://cdrprimer.org/read/chapter-2#sec-2-8

- Ensuring R&D includes a diverse portfolio of DAC pathways, supporting emerging technologies alongside those being deployed today. This can increase learnings, drive innovation, and prevent technology lock-in. Carbon180 has endorsed S. 2812, the Carbon Dioxide Removal Research and Development Act, which would "direct federal agencies to support research on technology-based, land-based, and ocean-based approaches to remove carbon dioxide from the atmosphere. The bill takes a whole-of-government approach and includes specific research provisions across solutions such as DAC, carbon mineralization, agroforestry and perennial agriculture, forestry, and more."[26]
- DAC requires additional clean electricity. Coordination across DOE's applied offices can support research on key questions at the intersection of carbon removal and renewable energy.
- The Department of Energy's work on carbon storage should receive increased attention and support. This could include R&D on offshore storage and more research on subsurface mineralization as a storage mechanism.
- Additional support for R&D on monitoring, report, and verification will be essential for ensuring accountability in DAC projects and building public trust.
- There are key research gaps on questions raised by environmental justice experts and organizations around DAC and CCUS. The Department of Energy should ensure that R&D efforts include addressing these gaps. [27]
- The Direct Air Capture Hubs program has included requirements for community benefit plans (CBPs). The Department of Energy could explore utilizing CBPs for other agency funding opportunities and mechanisms to better center community engagement and buy-in.

- **Infrastructure and Domestic Supply Chains.** DAC at the megaton and gigaton scale will require a build out of CO_2 infrastructure and related supply chains. It is our view that infrastructure barriers are one of the most significant barriers to deploying DAC and should be a priority for policymakers. In addition to permitting challenges that the DAC sector has increasingly highlighted, the first questions we get on DAC from environmental justice and community organizations are often on the safety of CO_2 transport and storage.[28][29] There is an enormous opportunity to build public trust and realize the full potential of DAC jobs, but this will require getting it right on infrastructure on multiple dimensions. Our recommendations include:
  - To the greatest extent possible, the Department of Energy should leverage the capacities of the Office of Fossil Energy and Carbon Management's Carbon

[26] https://carbon180.org/policy-tracker

[27] https://www.federalregister.gov/documents/2023/09/12/2023-19608/white-house-environmental-justice-advisory-council-notification-of-virtual-public-meeting

[28] https://carbon180.medium.com/regranting-for-just-carbon-removal-one-year-later-dd06a7955a3b

[29] https://static1.squarespace.com/static/5b9362d89d5abb8c51d474f8/t/6115485ae47e7f00829083e1/1628784739915/Carbon180+RemovingForward.pdf

Storage Program to pair DAC hubs with Carbon Storage Assurance Facility Enterprise Initiative projects, to facilitate permitting and technical assistance.[30]
    - The Department of Energy should coordinate with the Environmental Protection Agency to ensure a timely and thorough Class VI review for DAC Hubs projects in order to appropriately schedule project milestones and support application development, including providing technical assistance to projects.[31]
    - Congress should explore opportunities for investment in the domestic supply chains for DAC deployment at scale to ensure there can be US production of materials and components, including steel and chemicals. This should include coordination with the Made in America Office to ensure compliance of all federally funded projects.[32]
    - The Department of Energy and Environmental Protection Agency could explore more ambitious cross-agency work, such as pre-permitting carbon storage hubs where communities opt in to hosting geologic storage.

- **Building the Carbon Management Workforce.** As the Department of Energy plays a central role in deploying DAC, we believe that publicly funded carbon management projects should prioritize jobs for local residents. The Department of Energy's Office of Economic Impact and Diversity and the Department of Labor should ensure that project developers are connected with "recognized apprenticeship programs to encourage local economic development and skilled training opportunities." [33]

- **More transparency.** Communities need clear, accessible, and trustworthy information on DAC projects, especially those receiving federal funding. There should be transparency in decision making and accessibility to data, including comprehensive maps listing all proposed, planned, in-process, and completed projects. The Department of Energy should use specific terminology for projects, rather than the umbrella term carbon management.[34]

- **Markets and Procurement.** Corporate purchases have helped drive the current market for durable carbon removal, including DAC. At the same time, the market for carbon removal faces a near-term supply crunch, with even large and dedicated corporate purchasers struggling to find high-quality and durable tons to purchase and nascent carbon removal companies seeking early investment to move along the innovation curve. Given the unique purchasing power of the government, there is agreement across industry, climate advocates, and policymakers on both sides of the aisle that establishing direct public purchasing of carbon removal services could be catalytic. The carbon removal industry and voluntary corporate procurement initiatives like Frontier see federal

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[30] https://static1.squarespace.com/static/5b9362d89d5abb8c51d474f8/t/6261d1890b76863f1047a2dd/1650577901659/Carbon180-SettingDAConTrack.pdf

[31] Ibid.

[32] Ibid.

[33] Ibid.

[34] https://www.federalregister.gov/documents/2023/09/12/2023-19608/white-house-environmental-justice-advisory-council-notification-of-virtual-public-meeting

procurement as critical to supporting innovation, expanding the portfolio of available solutions, unlocking additional private capital, and driving down costs.

With the $35 million Carbon Dioxide Removal Procurement Pilot Prize, announced as part of the Department of Energy's Carbon Negative Shot, the federal government can play a unique role in establishing high standards for DAC and other long-duration carbon removal pathways. Specifically:

- Federal procurement policy should set a high bar for MRV while also creating a glide path for future inclusion of new approaches. Near-term emphasis on adopting robust, performance-based standards across a portfolio of durable carbon removal technologies and solutions will help drive the market towards quality and consistency, de-risking investment, crowding in private funding, and setting the stage for more robust policy support.
- Procurement policy should also establish high standards on labor and community engagement, as well as social and environmental safeguards, including but not limited to requiring applicants to adopt the agency's Responsible Carbon Management Principles. Procurement policies can and must be designed to ensure that local, social, and non-CO_2 pollution impacts, including but not limited to air quality, water quality, traffic, seismic impacts, and adverse land use impacts, are controlled, and that just and equitable community engagement is a prerequisite for understanding those priorities.

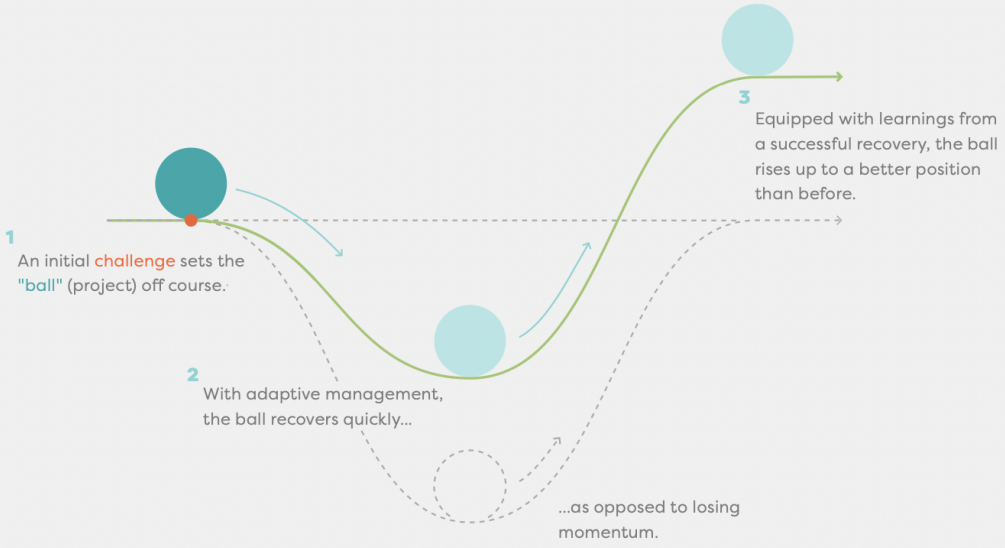
With these standards established, Congress should build on the current Carbon Dioxide Removal Procurement Pilot Prize.

- **DAC Hubs.** The $3.5 billion Direct Air Capture Hubs program is the single most significant DAC policy in the world. It can set the foundation for an equitable, just, and thriving DAC industry in the US and success of the program is critical. In our report from earlier this year, *How Direct Air Capture Succeeds: A Framework for Effective DAC Hubs*, we make the case that "success is dynamic across time and perspectives […and that] as civil society and policymakers evaluate the DAC Hubs program, it will be important to consider not just *what* to evaluate but also *when* to evaluate it, *who* is evaluating it, and *how* a project responds to and evolves from challenges."[35]

[35] https://static1.squarespace.com/static/5b9362d89d5abb8c51d474f8/t/63c6b2a3ad67251500e487a4/1673966245209/Carbon180-HowDirectAirCaptureSucceeds.pdf

The Resilience Function for DAC Hubs

A resilient DAC Hubs program will successfully adapt to and recover from challenges, sustaining climate and non-climate benefits through changing political environments. Targeted investments, flexibility, and responsiveness to internal and external demands can put the ball back on track and potentially lead to growth from the baseline. The program may be more or less resilient depending on stakeholders' capacity, preparation, and reactions to a given challenge.



SOURCE:

Adapted from Ratcliff, N. J., Nair, D. T., Goldstein, J.R. (September 2019). The Area of Resilience to Stress Event (ARSE): A New Method for Quantifying the Process of Resilience. *The Quantitative Methods for Psychology, 15*(2), 148-173. 10.20982/tqmp.15.2.p148