

Cleaning up Climate Change

*Carbon Dioxide Removal and
Practical Climate Resiliency*



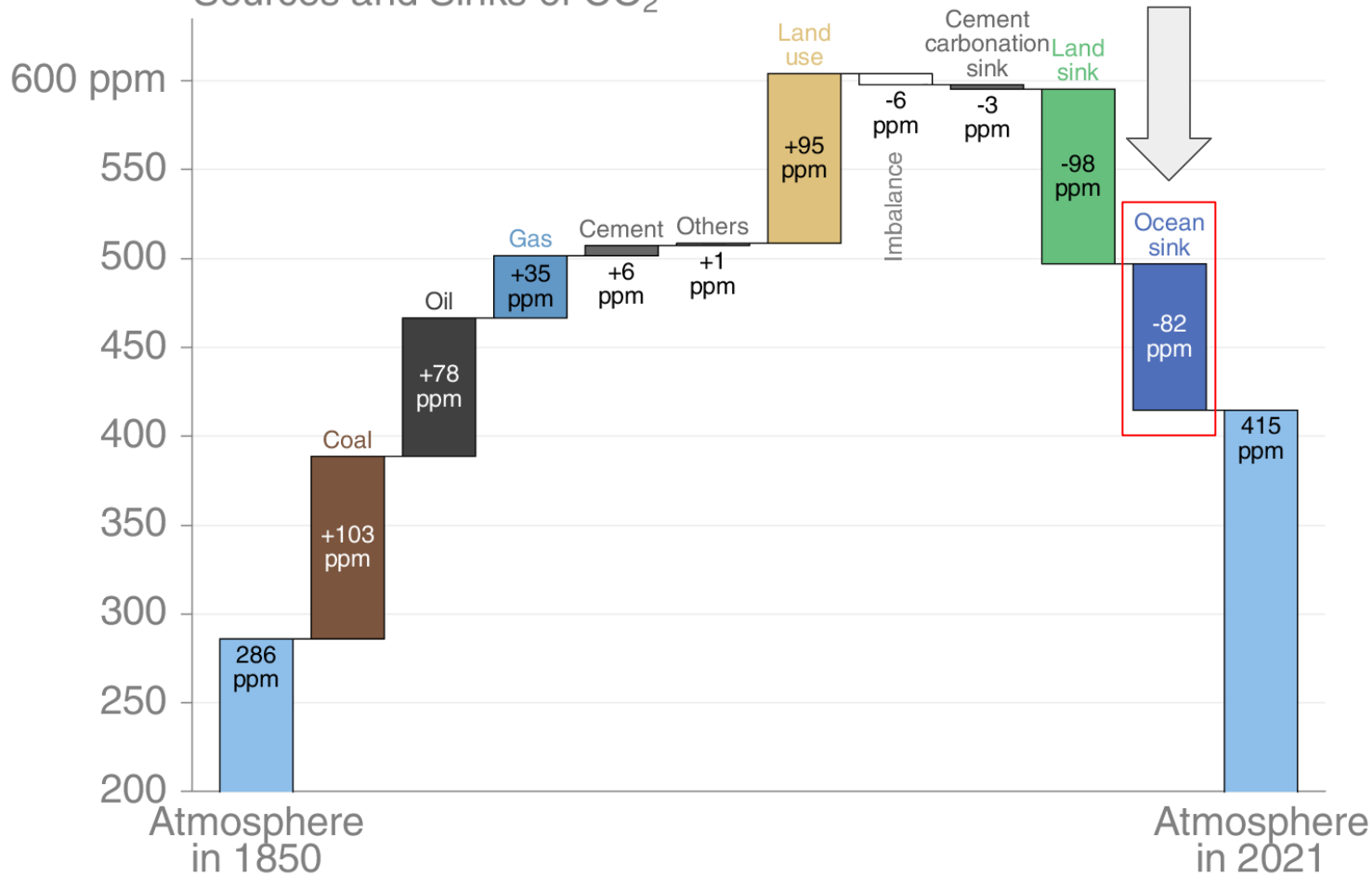
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NOAA Pacific Marine Environmental Laboratory
Seattle WA

March 2023
ICR23, Columbus, OH

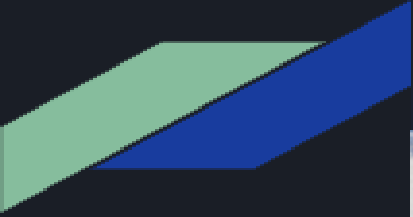
2009:
389 ppm



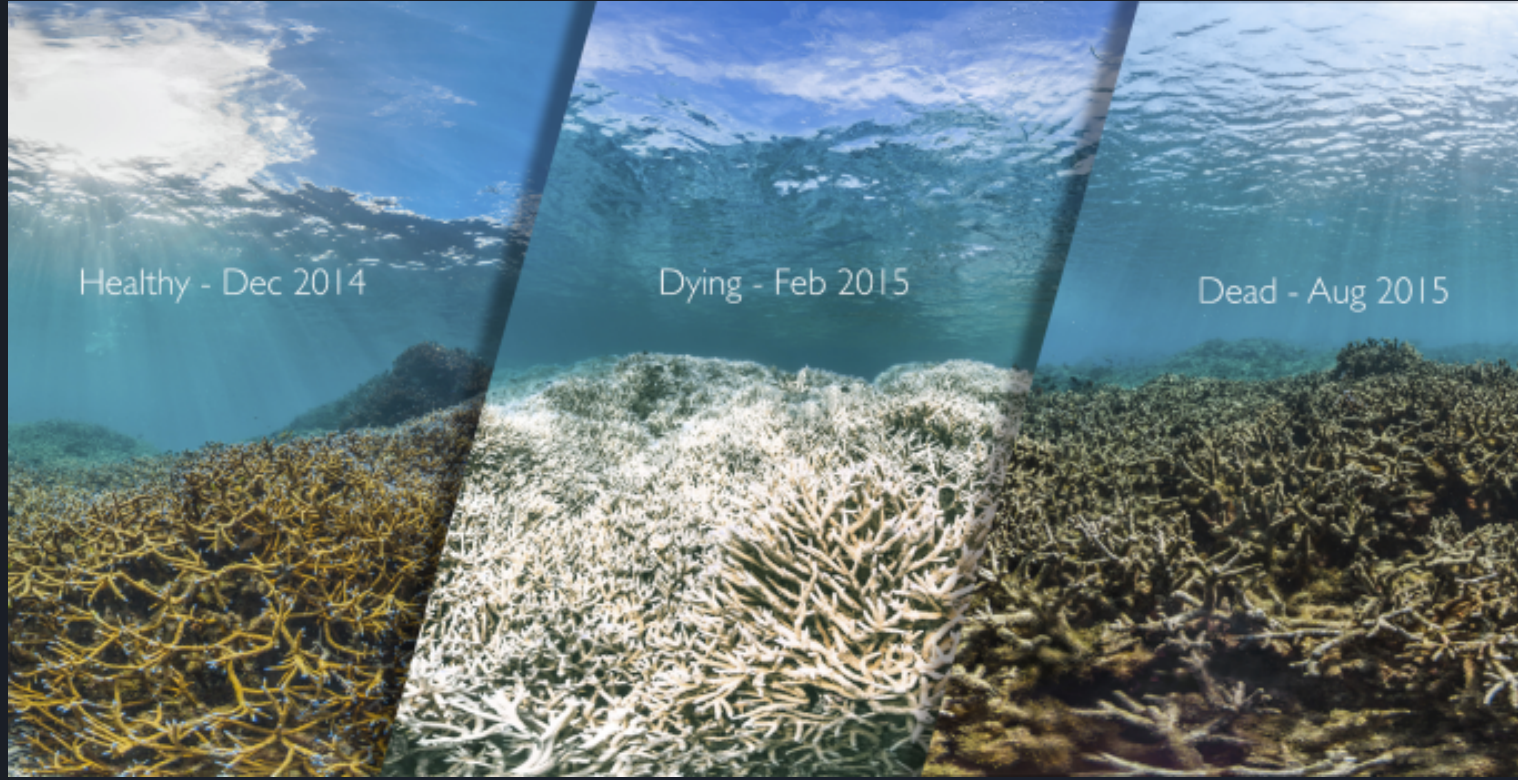
Sources and Sinks of CO₂



**The Ocean is
an asset to
our
atmosphere.**



**A key
consequence
of that service
is ocean
acidification.**





2015:
401 ppm

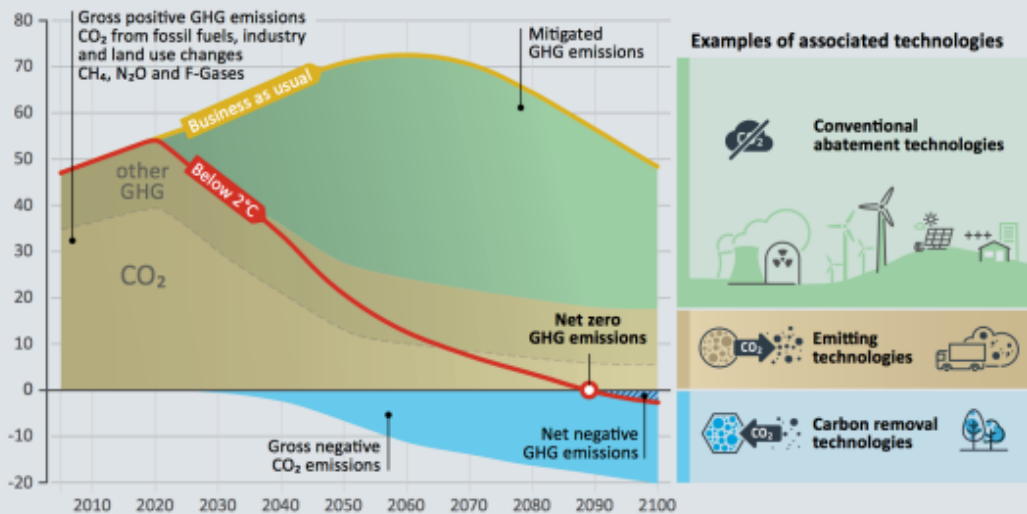
What do we
do?

What can we do?

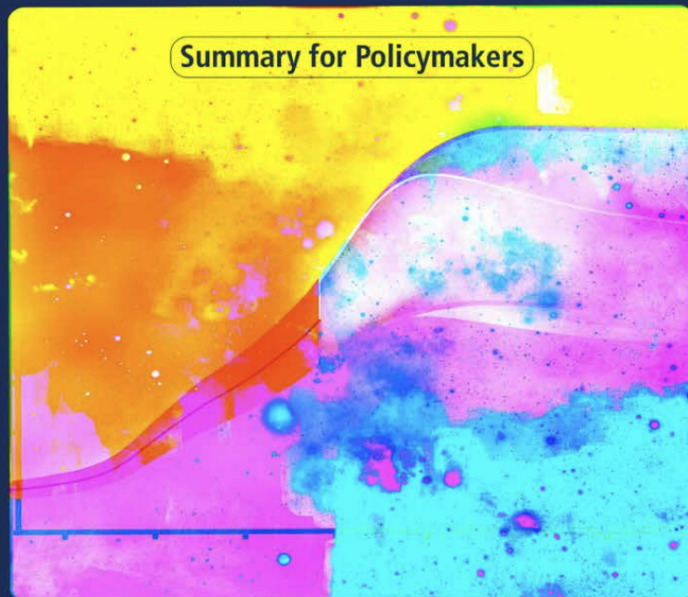
Global Warming of 1.5°C

An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

GHG emissions (GtCO₂e/year)



Summary for Policymakers



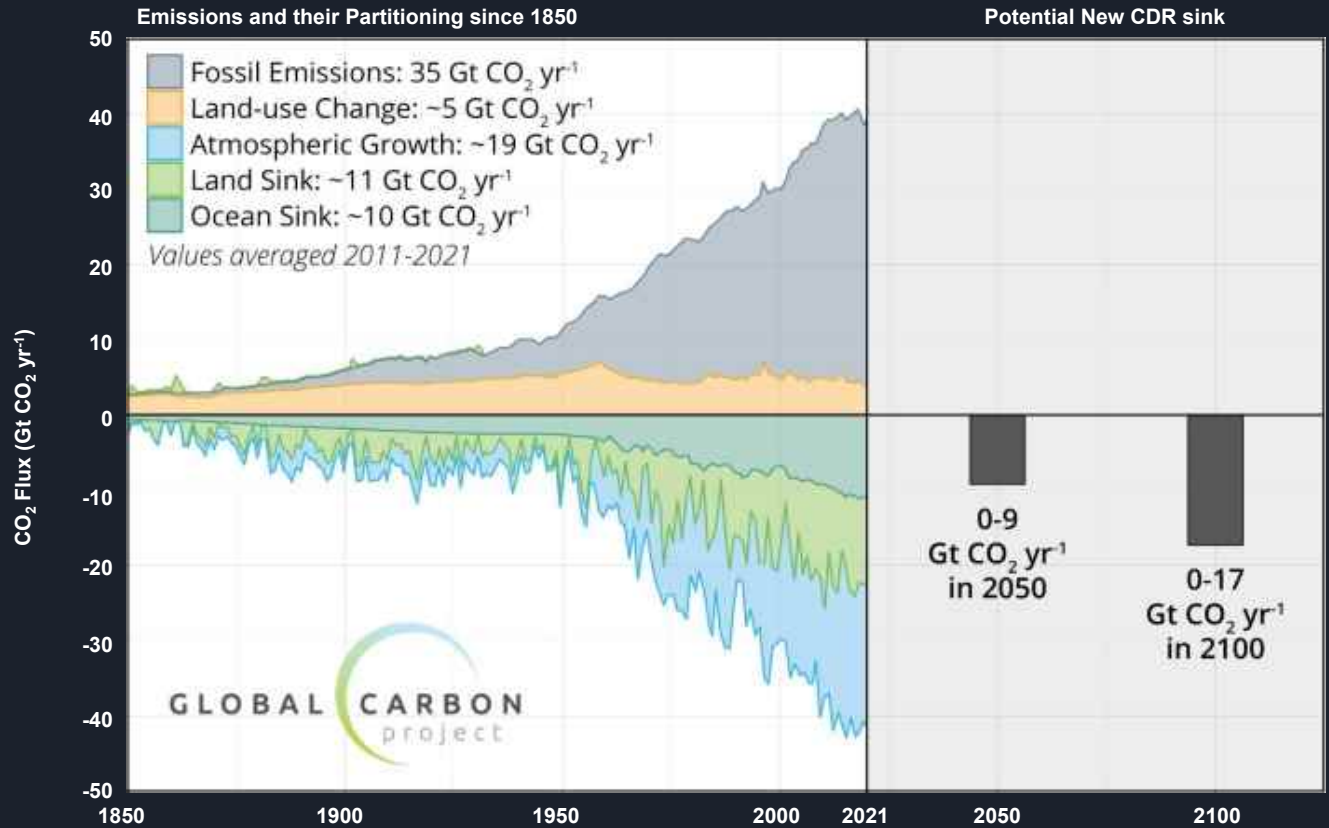


Can Kelp
Help?



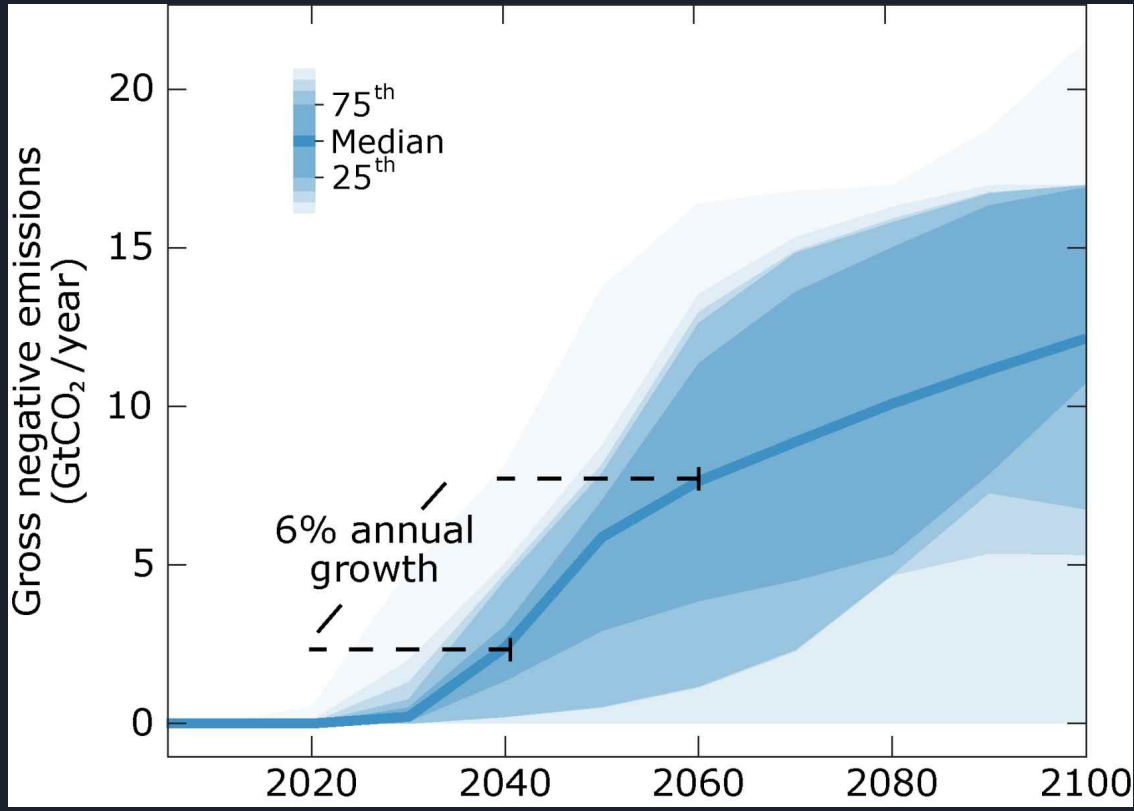
UNITED
FISHERMEN
OF ALASKA

It will be very *difficult* to double the land and ocean sinks for carbon.

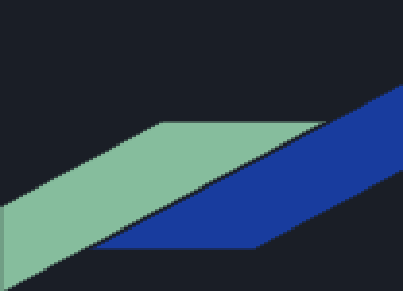


From [Friedlingstein et al., 2021](#)

From [Minx et al., 2018](#)



Doing so will require 6% annual growth per year in negative emissions, in addition to emissions reductions.




**2020:
413 ppm**

**“I want to
make
Alaska the
mariculture
capital of
the world.”**

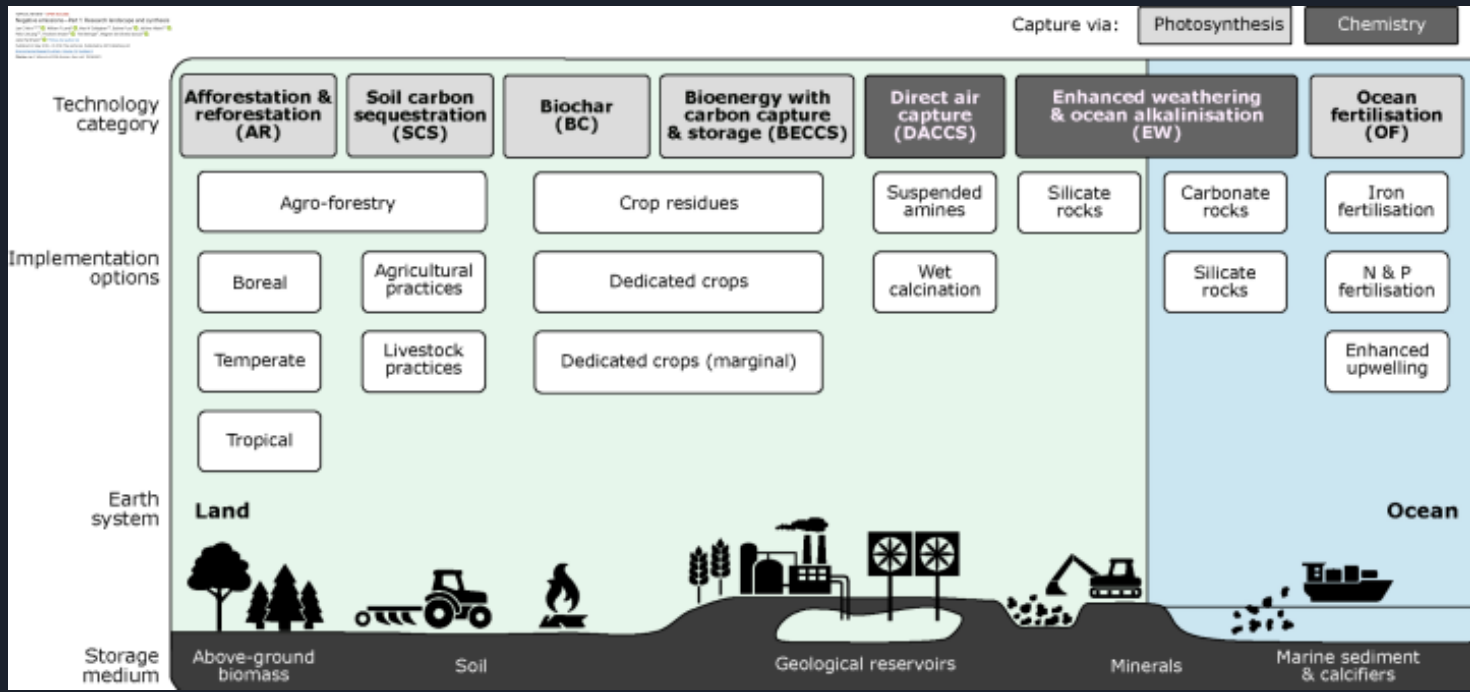
–Gov. Dunleavy





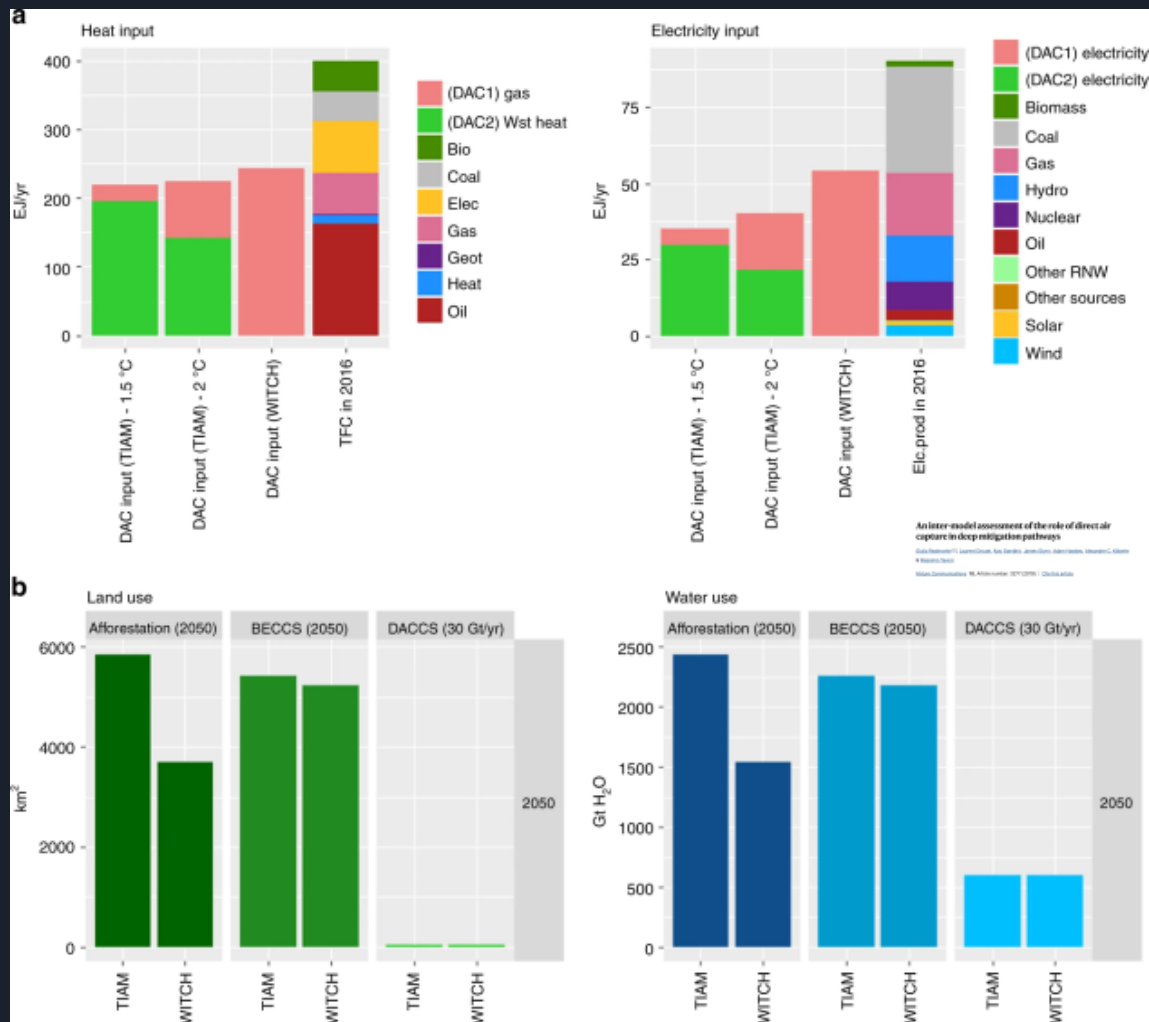
**How can we remove
enough carbon from
the atmosphere?**

**Can CDR be safe,
sustainable, and fair?**



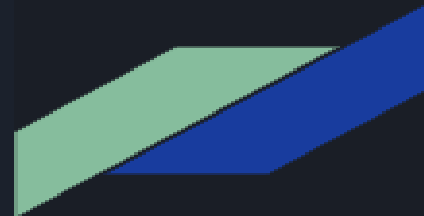
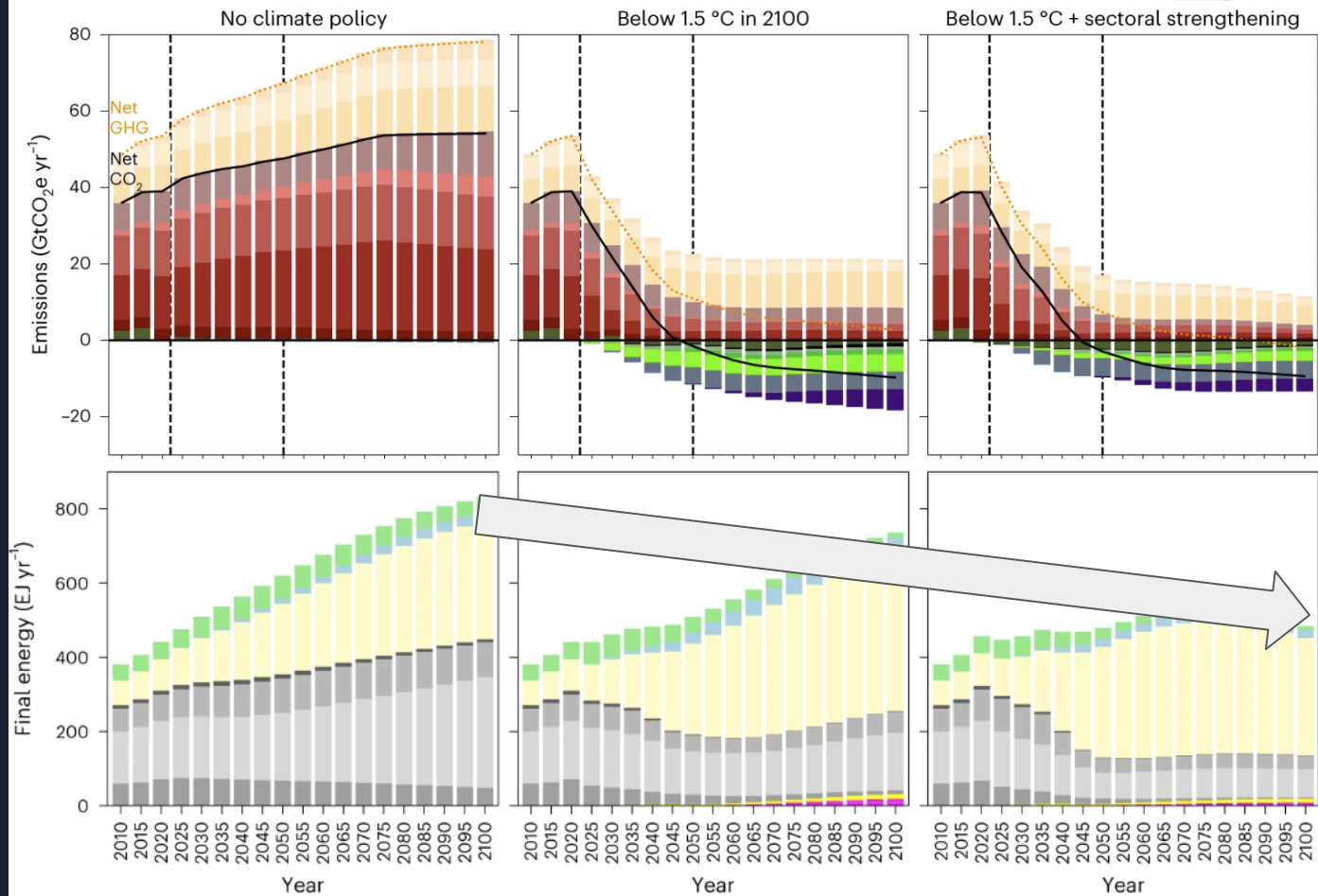
There are many ways to remove carbon from the atmosphere

Some have important costs, such as high energy, water, or land use requirements.



aPositive and negative CO₂ emissions

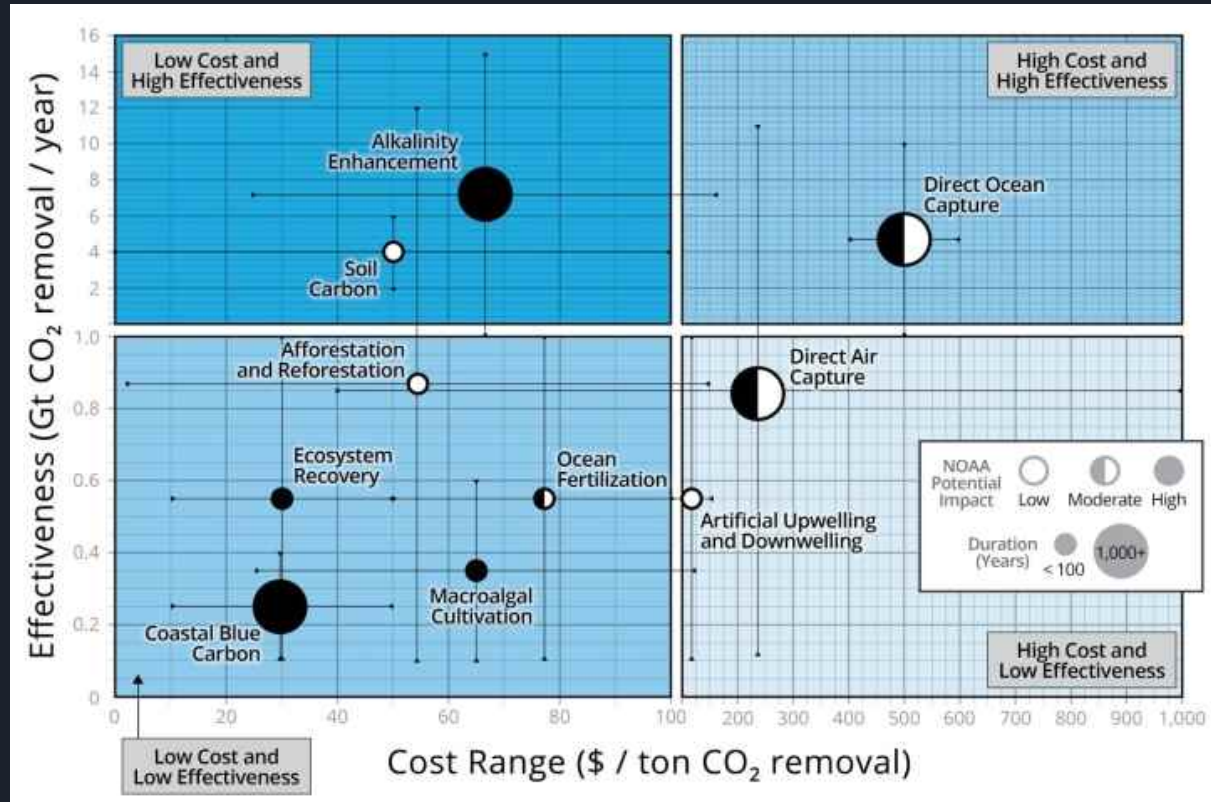
International Institute for Applied Systems Analysis
 Institute for Energy Economics and Energy Policy Studies
 Institute for Global Energy Transformations Studies
 Institute for Sustainable Energy and Environment Policy Studies
 Institute for Technology and Design
 Institute for Technology and Innovation Policy Studies
 Institute for Technology and Innovation Policy Studies



**A diverse portfolio—
and the right incentives—
can limit these pressures.**



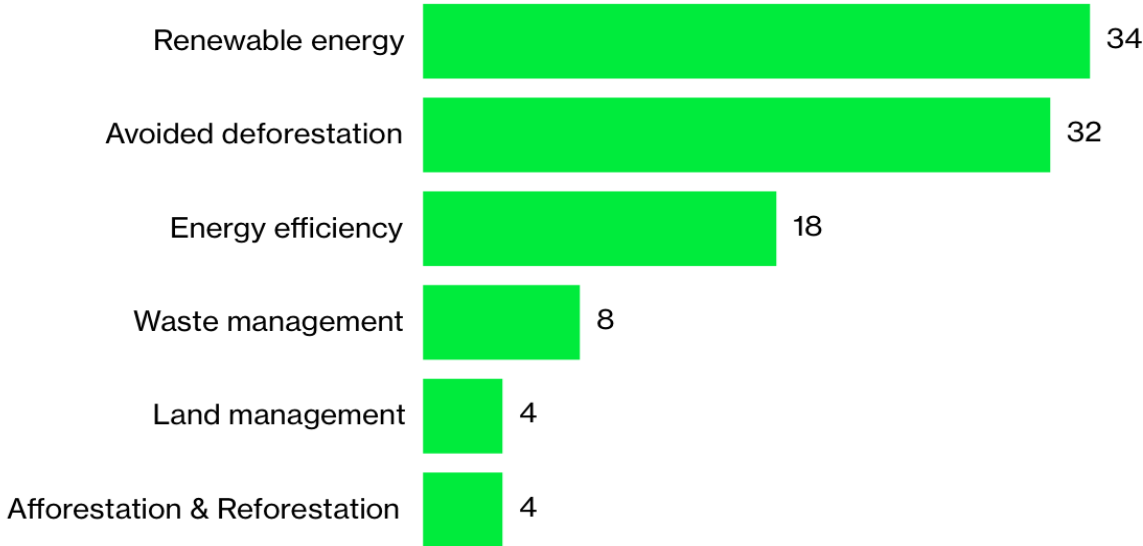
Cheap,
effective,
and durable
methods
could have
the highest
potential
impact.



Paltry Offering

Less than 5% of offsets actually remove carbon dioxide from the atmosphere

■ Share of total %



Carbon removal technologies

0

TheVerge

Climeworks says a third-party auditor has verified its carbon removal for Microsoft, Stripe, and Shopify.

Jan 13 2023

Bloomberg
Green

Source: TSVCM inventory analysis for 2020

One key challenge
of CDR
implementation is
measuring the
actual removal
part.

This is especially true for ocean or marine CDR, and this is reflected in market settings.

Snapshot of the Carbon Dioxide Removal certification and standards ecosystem (2021–2022)
Snapshot from the Annual Report on the Implementation of Article 6

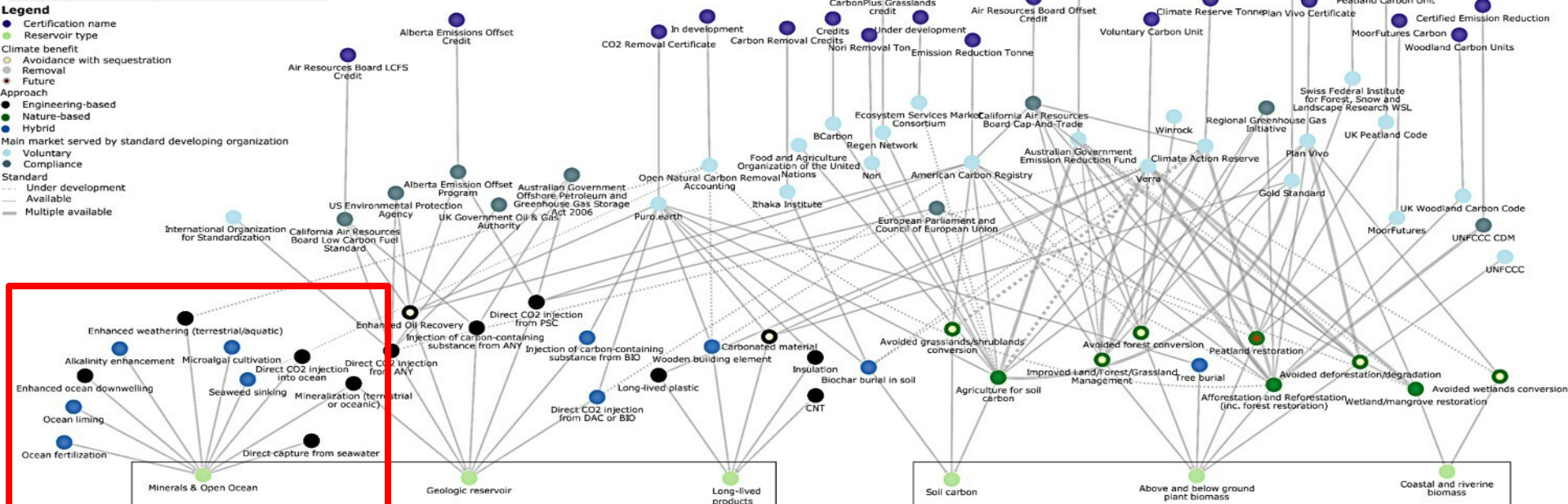
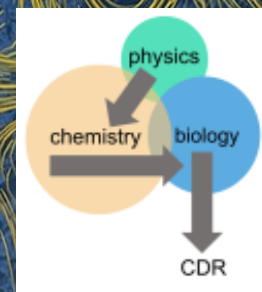
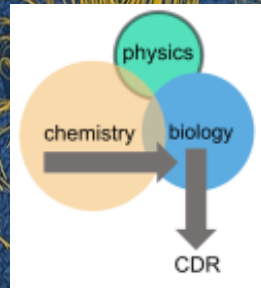
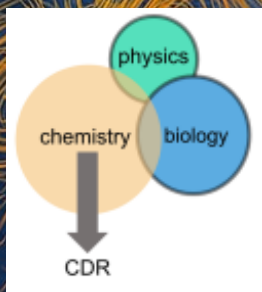


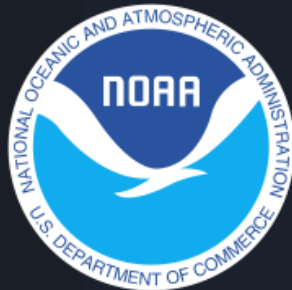
Figure S1

Figure S2

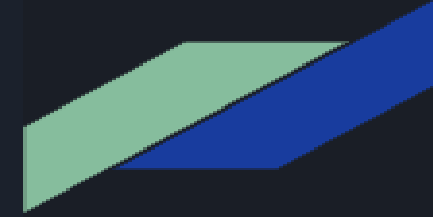
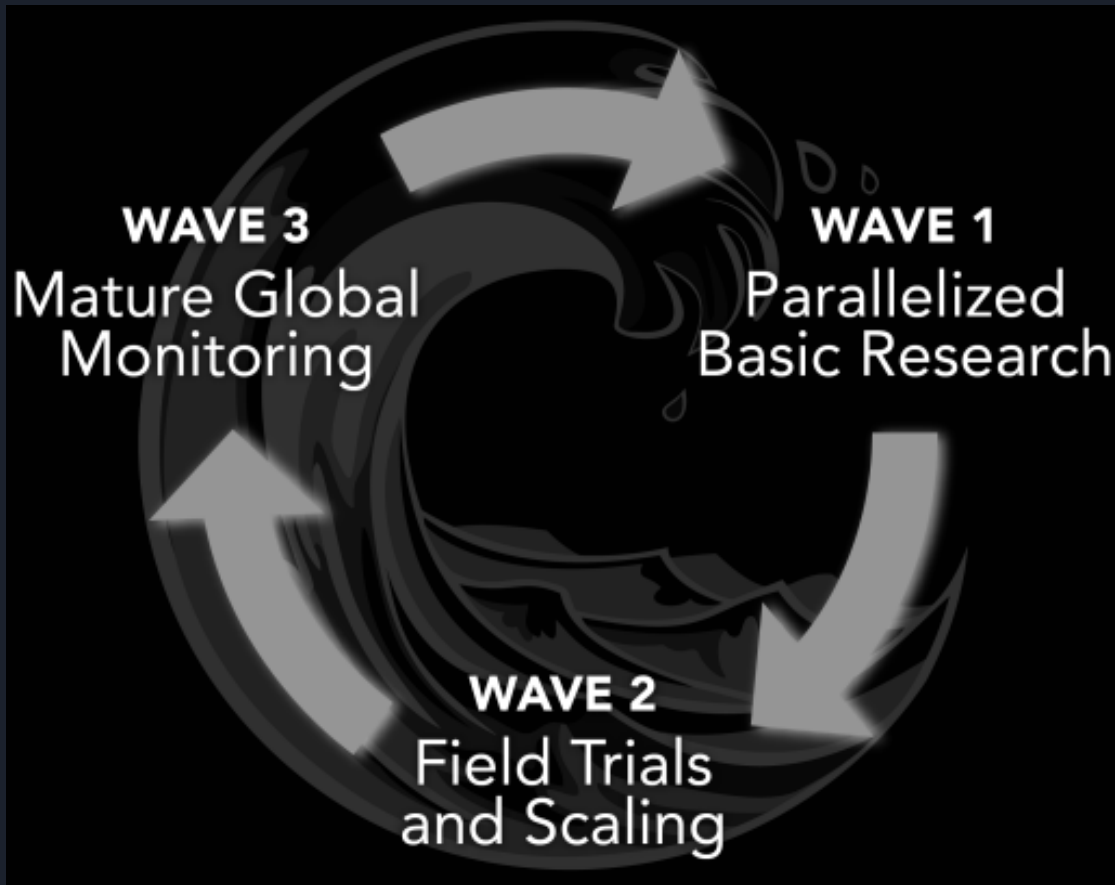
Why is it so difficult to measure carbon removal?



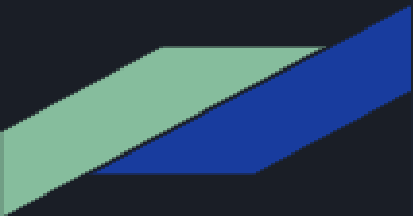
If we're going to learn how to measure CDR, we need new tools.



Current NOAA Assets	Development Necessary for CDR	Potential Impact of new NOAA CDR Research	
Observing Networks	Global Atmospheric and Ocean Observing (e.g., GGRIN; GO-SHIP; Argo; GOA-ON)	Fill regional gaps; develop deep-sea monitoring network	NOAA continues to verify global Carbon Budget at necessary scales to identify CDR
	Local Atmospheric and Ocean Observing (e.g., CarbonTracker; IOOS RA; NOAA-ON)	Expand to many more sites for comprehensive local-scale monitoring at CDR installations	NOAA verifies, monitors impact of single CDR projects
	Technology Development Programs (e.g., DART; ITAE)	Early investment and partnerships with industry, other agencies	NOAA catalyzes global CDR monitoring and verification potential (e.g., trading, accredited offsets)
Modeling, Scaling, and Projection of CDR Pathways	Earth System Models (e.g., CMIP6) and regional models (e.g., ROMS)	New CDR-specific modeling packages	NOAA projects near-term and long-term CDR impacts to identify changes, risks, cobenefits for earth system
	Process study models	Development of virtual "testbeds" for CDR research	NOAA designs quality process studies for investigating the impacts of experimental CDR methods
Environmental impacts	National ecosystem monitoring programs	Expand to many more sites for comprehensive local-scale monitoring at CDR installations	NOAA verifies, monitors environmental impacts of single CDR projects
	Ecosystem modeling	Modify ecosystem models to evaluate the effect of CDR	NOAA projects impacts of CDR on marine ecosystems
	Laboratory research	Design and implement CDR-specific experimental studies for key species	NOAA identifies environmental risks, cobenefits of single CDR projects
Decision Support	Data management and synthesis (e.g., NCEI, OCADS)	Data preservation, interoperability and compatibility, discovery and access, quality control and synthesis	Bridging the gap between observations and subsequent research, MRV efforts to account for carbon credits, and decision support based on these data
	Marine Spatial Planning (e.g., NCCOS, OCM)	Apply new CDR knowledge using existing spatial planning tools	NOAA resolves use conflicts, enhances decision support for CDR implementation requests
	Aquaculture Research, Development, and Policy	Development of sustainable farming methodology; expanded permitting support	NOAA maximizes sustainable coastal marine services
	Collaborative Research and Stakeholder Engagement (e.g., SeaGrant)	Improve pathways for stakeholder participation in NOAA CDR Research	Research reflects stakeholder needs
	Blue Carbon Conservation (e.g., CCAP)	Fill local gaps; conserve existing natural carbon storage sinks	NOAA protects and restores existing natural carbon sinks



Creating the right space for CDR to flourish will require new models for research and partnerships.




**Safe,
sustainable, fair
CDR will keep
people at the
forefront.**

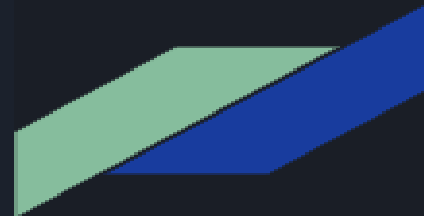
Guiding principles for just carbon removal



1. The benefits of carbon removal solutions must be equitably distributed.
2. Public engagement must be robust and involve seeking input from groups throughout the development and deployment of carbon removal solutions.
3. Safeguards are needed to ensure adverse impacts are not borne by disadvantaged communities.
4. The socioeconomic consequences and distributional impacts of carbon removal solutions need to be evaluated alongside their technological and economic attributes.
5. Carbon removal is seeking to address a challenge that is both local and global, and therefore should incorporate justice across temporal and spatial scales.



**That means we need
You.**



**2022:
417 ppm...**

**...Still not
too late.**





Questions and Discussion