The Climate Restoration Roadmap 2024

Our MVP (minimum viable product) or "The Whole (climate restoration) Enchilada"

Peter Fiekowsky, November 2023

Note: This document is intended for people committing to funding the project of restoring a safe climate for future generations, plus scientists and technologists called on to vet the ideas. It is not intended to convince voters or policymakers to shift attention or funding from their current priorities.

This climate restoration roadmap outlines a minimal, critical set of four programs needed to achieve net-zero emissions by 2030 and a historically safe climate by 2050. We envision these climate restoration programs to proceed in parallel with the thousands of ongoing climate action programs designed to attain net-zero by 2050. Such programs include accelerating the energy transition, emission reductions, carbon removal technologies, reducing consumption, improving agriculture and mariculture, and economic tools (e.g. carbon tax and border adjustments)—all are important concepts, but distinct from this initiative.

Contents

1. What is climate restoration?

Climate restoration means restoring a historically safe climate by 2050 for the benefit of our children and future generations. It calls for restoring historically safe CO2 levels by 2050, and implies returning to *zero* warming, or pre-industrial temperatures, by 2100.

In the climate community, there exists a common confusion that annual GHG *emissions* (about 36 gigatons (Gt) a year) are causing the climate chaos. But in fact, it is the cumulative atmospheric

GHG (now over 1,000 gigatons) that is mainly responsible. Eliminating emissions, as important as it is, will not solve the climate crisis. Only removal of the enormous pool of legacy CO2 from the atmosphere can restore CO2 to levels proven safe for humans (under 300 parts per million) and end the dangerous disruption of our climate.

Thus we need to pull over 1,000 gigatons of accumulated CO2 from the air. Compensating also for new emissions, this works out to removing roughly 60 gigatons (Gt) of CO2 a year for 20 years to reach 300 parts per million (ppm)--the highest level humans and our ancestors have survived long term. Continuing to remove 30 gigatons a year from 2050 to 2100 will restore the pre-industrial norm of 280 parts per million, along with pre-industrial temperatures. See figure 1, top, for the results of modeling CO2 removal in the widely used MAGICC7 climate modeling package.

Boosting nature's methane-oxidation process would accelerate climate restoration (see figure 1, lower graph). According to advanced climate models, doubling the natural methane oxidation rate would lower atmospheric methane to a near-pre-industrial level of 1 ppm by 2030. In addition, If today's methane burst becomes serious, the methane oxidation program could be temporarily tripled in capacity to prevent a catastrophic temperature spike.

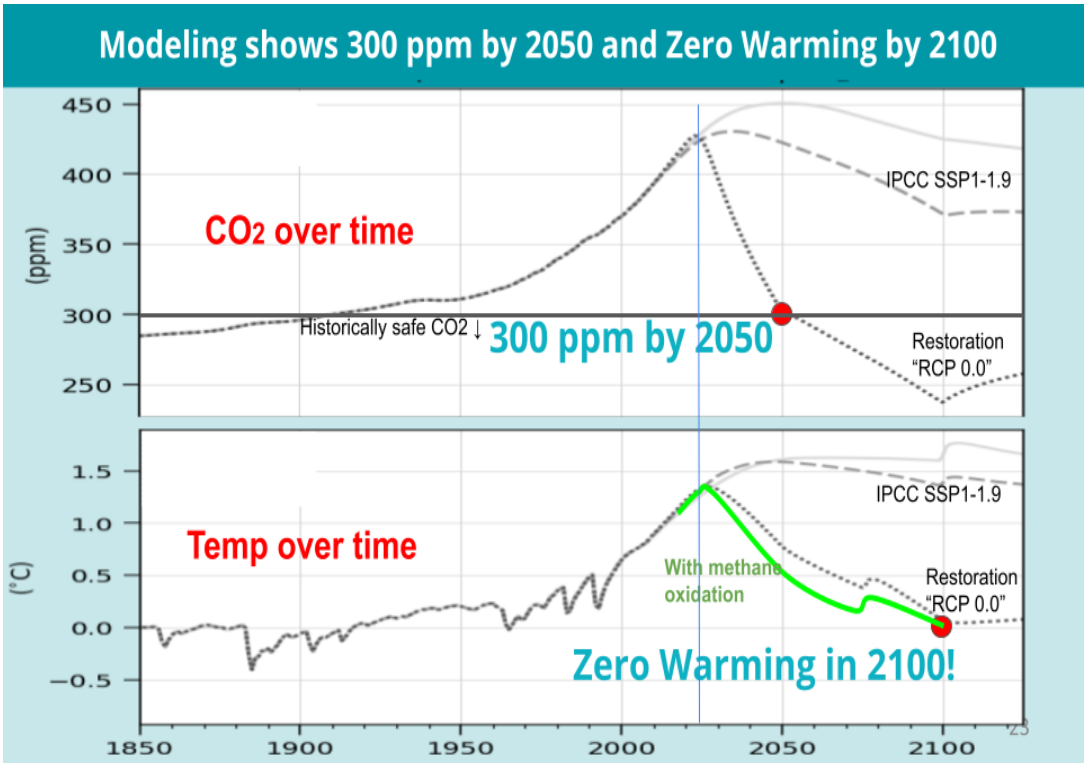

Figure 1. Comparing the IPCC's "very low emissions scenario" (SSP1-1.9) with a climate restoration scenario (RCP 0.0). In the lower graph, methane oxidation is added to CO2 removal, thus accelerating progress toward a pre-industrial climate.

2. Assumptions underlying the roadmap to climate restoration

The roadmap to climate restoration proceeds from the following assumptions.

1. **The cost of restoring the climate is low, and funding can be provided by those** who are naturally concerned for the well-being of their children and grandchildren, and future generations. Funders are likely to include individuals, family offices, foundations, corporations and some governments. This means that **governments, organizations** and individuals with other priorities **do not need to be convinced to contribute or participate**.

2. **Global warming is caused mainly by increased CO2 levels.** Reducing them will rapidly restore temperatures and the climate as it was a hundred years ago. Some scientists argue that climate is affected by complicated interactions between emissions, water vapor, fluorocarbons, solar cycles, Earth's orbit, and more. However, a sharp focus on CO2 and methane levels allows powerful action, right now.

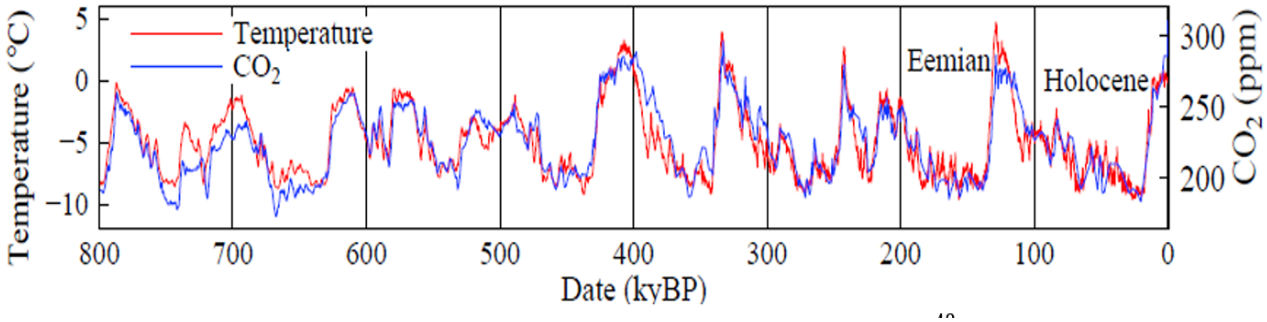

Figure 2. CO2 levels and temperature move in tandem. Periods with CO2 below 250 ppm were ice ages. (Hansen 2023 Global Warming in the Pipeline)

3. **The best solutions are two that Nature has used for at least a million years.** Ocean iron fertilization (OIF) is nature's mechanism for lowering CO2 levels before ice ages, as you can see in figure 2. The oxidation of methane in the atmosphere proceeds continuously, keeping methane from building up dangerously in the atmosphere.

4. **We can cooperate with nature to intentionally replicate and accelerate both processes and thus end the climate crisis.** Triggering natural removal of CO2 and methane can be done easily, safely and quickly.

5. **Climate restoration calls for standard project management practices:** Establish specific outcomes, target dates and budgets. This allows Gantt charts to be used to optimize scheduling.

6. **Parallel operation**: Each of the four programs listed below are critical, low risk, and they are mutually reinforcing. We assume they will all be successful, attracting additional resources as needed.

7. **Restoring safe GHG levels can be achieved with or without a carbon tax** or punishing oil companies. No sacrifices necessary: Only organizations and individuals committed to future generations flourishing need to engage.

8. **Climate restoration does not interfere with conventional climate action.** It does not compete for budgets, focus, or scientific resources.

9. **Key actors will soon choose to restore a safe climate** rather than adhere to the outdated goal of eliminating 'harmful' human interference in the climate system.".

3. How will climate restoration be funded?

Climate restoration solutions are so economical that public funding, while useful, is not necessary. Instead, funding for climate restoration is expected to come mostly from private sources, such as the Grandparents Fund for Climate Restoration. In fact, the billion dollars per year could be crowdfunded by individuals in the top 1% in the U.S. each contributing a dollar a day ($365 per person per year). We prefer not to depend on public funding in any case: it is an unreliable source, since the government must prioritize its voters, taxpayers, and lobbyists—and our grandchildren do not vote, pay taxes or lobby.

Politically, it is important to note that activists and politicians often prioritize shutting down fossil fuel production over making sure our children have a livable climate. As much as we hope this will change, it may not. **Climate restoration can and must progress at the same time as activists call for shutting down fossil fuel production.**

4. Four simultaneous programs to restore the climate

1. **The Biden Project**: Strategy leading to President Biden's declaring that the U.S. is committed to restoring a historically safe climate for future generations.

2. **Long-term funding**: The Grandparents Fund for Climate Restoration is designed to crowdfund these four programs while building popular support. A groundswell of public support can then also trigger government and commercial funding.

3. **Safety, Governance & Social license**: The Climate Restoration Safety and Governance Board is designed to ensure the social license and effectiveness of restoration programs.

4. **CO2 and methane removal programs**: Implement ocean iron fertilization (OIF) to remove atmosphericCO2, and iron salt aerosol (ISA) to oxidize atmospheric methane.

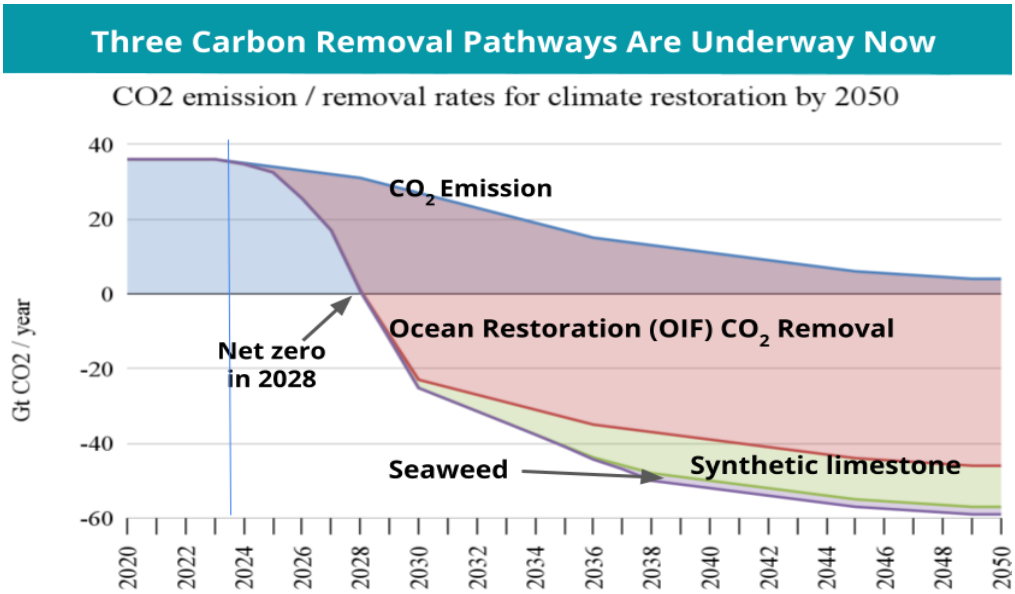

Figure 3. This schematic shows relative contributions to climate restoration expected from four nature-based approaches. Initially, the Grandparents Fund will support only OIF and methane oxidation (not shown).

5. Risk factors for achieving 300 ppm by 2050

In contrast to existing climate projects that attempt to slow our climate disaster, the climate restoration by 2050 project has a clearly defined outcome: Restore historically safe CO2 and methane levels, similar to or better than 100 years ago. When those are achieved our weather and crop patterns will return to the norms that allowed our civilizations to develop over the last 10,000 years (see figure 2 above).

What risks might keep us from succeeding, and how are we dealing with them?

1. **Technology development**: The two technologies are tested by nature at full scale. However, we must develop protocols to duplicate nature's scale intentionally. This will require funding above $20 million in 2024.
2. **Business development:** The finance, marketing, supply chain development, agreements and corporate governance are starting to be developed, and need funding above $20 million in 2024.
3. **Governance**: There are no enforceable laws preventing or requiring the technology's implementation. However the UN set its climate goal in 1992, before warming was visible, to eliminate harmful human interference in the climate. Because any interference is considered harmful by some people, this is widely interpreted to disallow action for restoring a safe climate. Restoration projects are disparaged as geoengineering by rigid followers of this UN rule. We need an authority such as President Biden or Pope Francis to declare explicitly that we (US and humanity) have an obligation to give future generations and nature a safe climate. A campaign to introduce a Congressional resolution declaring this is underway.
4. **Funding**: Costs are low, and can be paid by wealthy families committed to ensuring that future generations flourish. We need from each US millionaire an average of $5 per month.

However we need to organize to raise the funds. Government funding is currently unauthorized, so it is considered a future option which is being developed.

5. **Social license:** Groups affected by climate restoration need to have a seat at the table, or they will assume they're being victimized by these actions and block them. The Climate Restoration Safety and Governance Board needs funding to organize protocols and convenings for representatives from affected groups including first nations, faiths, islanders, scientists, entrepreneurs and investors.
6. **Competing interests:** This climate restoration project is entirely separate from and parallel to the various climate and energy transition projects discussed at the UN and in US and other governments. The Climate restoration project will not compete with them for funding.

Looking at risk from another angle: If we failed, what would be the reasons, from most likely least?

1. **Stopped politically, in the media**, by opposing interests (as previous climate restoration attempts have been): Anti-oil groups, Pro DAC groups, pro-CDR technology, Pro-nuclear, pro-forest, emission reduction groups such as EDF, carbon offset market traders afraid that $.03 / ton offsets from OIF or methane oxidation will collapse their market. If we expect that to get support from groups whose income depend on us failing, we'll likely fail.
2. **Our business operations were not up to** the global scale and quality needed (the team doesn't yet have the experience required).
3. **Funding failed** (only because of #1, #2)
4. **We lost social license** (developed public opposition). (possible, but not likely)
5. **Technology could not achieve what nature did randomly** in the Pinatubo pause. (unlikely)

Overall, simply maintaining good operations should ensure success.

6. Three phases for program implementation

These three phases are designed to result in restoring CO2 and methane to levels last seen 100 years ago. Methane is to be restored below 1 ppm by 2030 and CO2 below 300 ppm by 2050.

Phase 1. Establish legitimacy, funding & pilots by Q2 2024

1. **Achieve a Biden declaration** for climate restoration, similar to the California resolution. HIs support can override the implied policy that we're not 'allowed' to intentionally intervene in climate—and increase demand that we restore the climate for our children's future.

2. **Grow the Grandparents Fund for Climate Restoration.** This fund reminds people of why we're pursuing climate restoration. And it funds the projects.

3. **Start OIF and methane pilot projects.** We plan to pilot OIF projects starting with the restoration of fisheries for developing countries. About $1 million is required to launch the pilots. Full-scale implementation is expected to cost $100-200 million a year.

   The methane oxidation projects are designed to provide protection against a potential extinction-level methane burst in the near future. They will share many resources with the

OIF program. They both will take place over international waters, will be monitored by existing satellites, and are each expected to cost one or two hundred million dollars a year.

4. **Further develop the Climate Restoration Safety and Governance Board** for quality and safety assurance, and to boost political acceptance of climate restoration projects.

Phase 2: Build momentum by Dec 31, 2024

1. Establish discussion in the media and at the UN for climate restoration
2. Develop commitments for $1 billion / year for long-term operation
3. Safety & Governance Board is expected to eventually become part of an intergovernmental organization such as the International Maritime Organization.
4. OIF and ISA are operating at half-scale

Phase 3: Operation at scale by Dec 31, 2025

1. Climate restoration is accepted globally as our collective goal, in parallel with existing emission reduction, ecosystem regeneration, regenerative agriculture, circular economy, and other sustainability initiatives.
2. Funding commitments are secured from a wide range of sources, protecting against local downturns.
3. Safety & Governance Board is accepted and performing successfully
4. OIF and ISA are in full operation: Removing 30-60 Gt CO2 / year and doubling the natural methane oxidation rate.

Appendix 1: Biden Project Milestones

2024 Outcome: President Biden declares a U.S. commitment to restoring a historically safe climate for future generations on Earth Day (April 22, 2024). This declaration will allow scientists and funders to justify restoration work that would otherwise be dismissed as “geoengineering.” We would expect the UNFCCC, to follow suit eventually. Total 2024 cost: $250K.

1. California Senate Climate Restoration Resolution (SR34) passed without opposition in July 2023.
2. Introduce a similar Congressional climate restoration resolution to induce public and media discussion of the ethics of restoring a safe climate (or not). It does not need to be passed. It might be introduced by a senior Democrat (Pelosi or Eshoo?), and a senior Republican (John Lewis?). Target: January 5, 2024
3. The U.S. Secretary of Energy announces potential funding for climate restoration science. January 15, 2024
4. A university president (MIT’s Sally Kornbluth?) announces a research program for climate restoration science. March 2024
5. President Biden signs an executive order declaring a national commitment to a safe climate for future generations, calling on EPA, NOAA, DOE, and DoD to collaborate on the needed research and implementation.Earth Day, April 22, 2024
6. COP29 declares a UNFCCC commitment to restoring and stabilizing safe GHG levels for future generations and nature. December 1, 2024

Appendix 2: Long-term funding (Grandparents Fund) milestones

2024 Outcome: Donations totaling $100 million per year or more are committed to by at least a million donors globally, by December 31, 2024. At least 25% of funding comes from governments, foundations and corporations in 2024.

1. The Grandparents Fund was incorporated and has been granted full 501C3 status. October 10, 2023.
2. Raised $70,000. December 1, 2023.
3. Contracted a satellite data company to develop CO2 and methane removal measurement and reporting using existing satellite data. November 2023
4. Fundraiser in California, to raise $1 million, February 2024
5. Donated PR campaign starting Feb 15 produces 20,000 new donors / month
6. Contracts signed with companies to implement ocean restoration and methane oxidation pilot programs by April 1, 2024
7. Galas following the Biden announcement, to raise $20 million each, June 2024
8. Crowdfunding develops 50,000 new donors per month by May 2024, and 100,000 per month by July 2024
9. One million monthly or annual donors reached by December 1, 2024

Appendix 3: Safety, Governance, and Social License

2024 Outcome: Two pilot projects are evaluated in 2024. Citizens, Environmental groups, scientists and policymakers are clear that specific climate restoration projects are designed to be safe and ethical for concerned parties. An annual conference builds a sense of community. Total 2024 cost: $1 million.

1. Established Climate Restoration Safety and Governance Board, June 2023.
2. Incorporated the CRSGB as a fiscal project of the Grandparents Fund. November 2023.
3. A first ocean restoration / fishery restoration project for evaluation is identified and engaged. Q1 2024
4. Establish a team including the environmental impact evaluator, Ethics board manager, Ethics board members and coordinator Q1 2024
5. Ethics board protocols are written and approved Q2 2024
6. Test evaluation of the first application is run, Q3 2024
7. Report to COP29, December 2024

Appendix 4: Ocean Fertilization Pilot Projects

2024 Outcome: Two pilot projects are implemented in 2024, to demonstrate that the Pinatubo Pause can be replicated, and fisheries restored. Total 2024 cost: $6-10 million

1. Three projects are proposed in different regions, likely Gulf of Alaska, tropical Pacific, northern Atlantic, and African Union. Approval MOUs from national governments are signed. Q1 2024
2. Science / Data / Reporting and training group is established, working with methane oxidation too. Q1 2024
3. An operations company or companies are created. Q2 2024
4. First 2 projects are funded and initiated. Q3 2024

Appendix 5: Atmospheric Methane Oxidation Projects

2024 Outcome: Pilot tests in two hemispheres are run (Pacific Ocean near Baja California; S. Pacific off of Chile) Total 2024 cost: $8 million.

1. Optimize lab testing. Q4 2023
2. Specify local methane-removal measurement. Q4 2023
3. Specify / design ship-borne nebulizer. Q1 2024
4. Build & test ship-borne nebulizer. Q2 2024
5. Acquire ship & crew for Baja California. Q2 2024
6. Perform pilot tests in Baja. Q3 2024
7. Set up pilot in Chile. Q3 2024

8. Perform pilot test in Chile. Q4 2024

Appendix 6: Why is OIF practical? Experts say OIF can only remove 20% of what was actually removed after the Pinatubo eruption in 1991. Should funders believe models or the actual Keeling curve data?

1. **The Iron hypothesis** (OIF)[1] is the only known hypothesis that fits the observed multi-decadal CO2 data (Fiekowsky 2023). Of the 15 billion tons (5 cubic km)[2] of volcanic dust released, at least one millionth is likely to have been usable iron compounds, such as iron sulfate (and this would be sufficient to explain the results). The ash was deposited into the South China Sea in a 600 km arc west of the volcano. In addition, phosphorous would be expected to be at least one thousandth of the dust coming from apatite. The pre-eruption availability of nitrogen and phosphorus in that ocean area is said to be insufficient for the amount of carbon sequestration observed. However, adequate amount of those minerals can be explained by nitrogen-fixing cyanobacteria, and phosphorus in the volcanic ash.[3] (Quimbo 2020). The recent article, "Vertically migrating phytoplankton fuel high oceanic primary production" offers another pathway that might provide sufficient N and P for phytoplankton growth.

2. The observed rate of CO2 removal works out to 14 grams of carbon removal per square meter per day (14 g C/m^2/day).[4] While high, this rate lies within the range observed in high "primary productivity" nutrient-rich areas of the Pacific Ocean such as the Humboldt current (up to 20 g C/m^2/day). (Danieri et al. 2000). There were no satellites available to observe the bloom at the time. The SeaWiFS satellite currently used to measure chlorophyll and blooms was launched in 1997.

3. Implementation of a "Pinatubo pause replication" program is estimated to cost $50 million over three years, and reveal the pathways that allowed nature to achieve net-zero in 1992. Such a program could provide real data to help advance current ocean models.

[1] 30 years of the iron hypothesis of ice ages
[2] The Cataclysmic 1991 Eruption of Mount Pinatubo, Philippines, Fact Sheet 113-97
[3] Quimbo 2020 thesis. The impact of the 1991 Plinian eruption of the Mt. Pinatubo, Philippines on soil development, phytolith accumulation, phosphorus status, and crop productivity
[4] Danieri estimates that roughly 1 million km^2 received significant volcanic ash, roughly ⅓ of the South China Sea. 20 Gt CO2 is 5.3 Gt carbon. Divide by 365 days and 10^6 km^2 corresponds to 14 g C/m^2/day.