

A settlement currency to finance climate restoration and human prosperity

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A settlement currency to finance climate restoration and human prosperity

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Abstract

Restoring the climate and meeting basic human needs draw on the same scarce public finance. We ask what one settlement mechanism would have to earn to fund both. In the 841-member FaIR ensemble, holding carbon dioxide removal (CDR) at 9.5 GtCO₂ per year after 2183, without global solar geoengineering, returns median atmospheric CO₂ to 280 ppm in 2300. We cost that removal, ending hunger and Gavi's 2026–2030 vaccine target against Carbonite, a hypothetical tree-backed settlement stablecoin whose fees fund a treaty-governed restoration fund. At US\$200 per tonne these commitments need US\$3.1 trillion per year, an effective fee of 13 basis points on all foreign-exchange turnover, attainable only if settlement volume falls by less than 2.9% per basis point of fee. Universal health care fits only if its incremental cost is near published estimates; at US\$2,500 per uncovered person it needs four to five times as much revenue.

Returning the climate towards pre-industrial conditions and securing basic human needs are usually analysed as separate problems, yet they draw on the same scarce public finance. Mitigation pathways consistent with the Paris Agreement rely on carbon dioxide removal (CDR) at the scale of billions of tonnes per year,¹ whereas current deliberate removal is about 2 GtCO₂ yr⁻¹, almost all from conventional land-based methods, and novel methods remove about 1.3 MtCO₂ yr⁻¹.² Estimated costs for engineered removal are commonly of order US\$100–300 tCO₂⁻¹.³ At the same time, an estimated 645 million people faced hunger in 2025,⁴ 4.6 billion people were not fully covered by essential health services in 2023,⁵ and 14.3 million infants received no vaccine at all in 2024.⁶

These needs are rarely costed against a single revenue source. Here we ask what one transparent revenue mechanism would have to earn to finance deep carbon restoration and a defined set of human-service floors simultaneously. The mechanism is Carbonite, a hypothetical settlement stablecoin whose value is backed by a geotagged reserve of planted trees and whose transaction and intermediation revenue is directed to a treaty-governed restoration fund rather than to carbon-credit sales. We do not estimate what Carbonite would earn. Instead we cost each commitment, express the total as the effective fee it implies on a transparent settlement base, global foreign-exchange turnover of US\$9.5 trillion per day in April 2025,⁷ and ask how much fee-driven loss of volume each requirement can tolerate. A reference envelope of US\$6.96 trillion yr⁻¹, 0.29% of that turnover, is carried through the ledger as a scale anchor, not a forecast.

We couple that ledger to a carbon-restoration pathway computed with FaIR 2.2.4 across its 841 calibrated-constrained configurations.^{8,9} Gross emissions fall to a residual 1.5 GtCO₂ yr⁻¹ by 2051, deliberate CDR rises to 15.2 GtCO₂ yr⁻¹ by 2043, and a constant post-2183 removal rate is solved so that ensemble-median CO₂ reaches 280 ppm in 2300. No global solar radiation modification enters the pathway; regional marine cloud brightening appears only as a local reef-cooling sensitivity in the coral screen. Against the ledger we place screens for ending hunger, universal health care with and without AI-assisted ('robot doctor') capacity gains, childhood immunization, AI-assisted legal services ('robot lawyers'), coral-reef recovery and wild-fisheries rebuilding, with cost-basis sensitivities where costs are uncertain. The full framework registers 89 modules (Supplementary Table 1); each result carries its evidence class, and no human-service screen inherits validation from the climate calculations. We also set out how the coin holds its value, how its tree reserve is planted, harvested and kept out of the atmosphere, how participants whose trees grow more slowly or yield less valuable timber are equalized, and how the system operates if the United States does not join.

Results

Deep carbon removal returns median CO₂ to 280 ppm by 2300

In the FaIR ensemble median, atmospheric CO₂ peaks at 435.6 ppm in 2034 (5–95% range 431–439 ppm), falls below 400 ppm in 2057, below 350 ppm in 2105 and below 300 ppm in 2219, and reaches 280 ppm in 2300 (276–284 ppm; Fig. 1a). Median warming peaks at 1.67 °C above 1850–1900 in 2051 (1.22–2.22 °C), returns below 1.5 °C in 2112 and below 1.0 °C in 2230, and is 0.75 °C in 2300 (0.40–1.35 °C; Fig. 1b). Carbon removal alone therefore delivers long-run cooling, but slowly: the median excursion above 1.5 °C lasts about six decades, and in the most sensitive configurations it lasts more than two centuries.

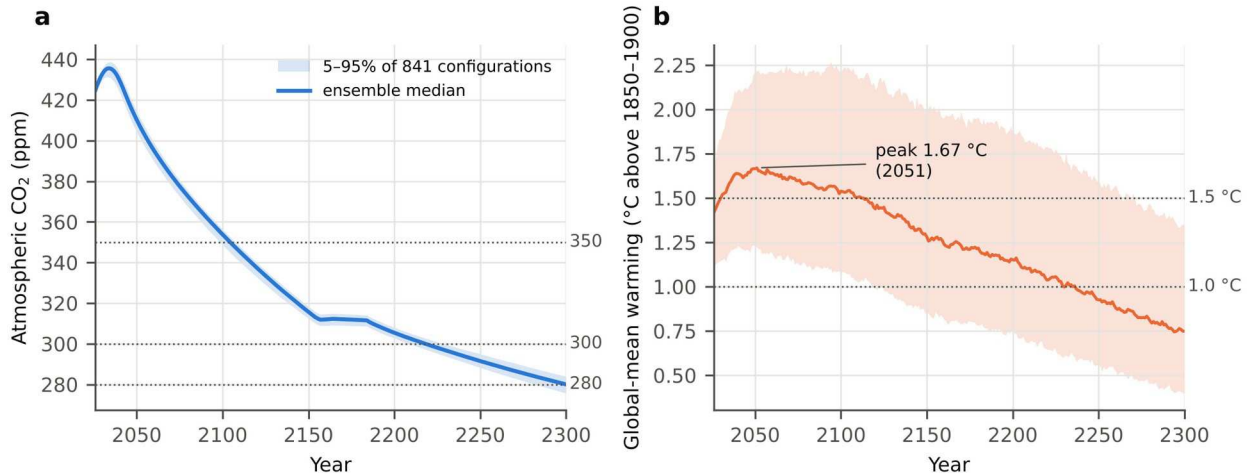


Fig. 1 | Carbon-restoration pathway computed with FaIR, without global solar radiation modification. a, Atmospheric CO₂. **b,** Global-mean warming relative to 1850–1900. Lines give the median and shading the 5–95% range of the 841 calibrated-constrained FaIR 2.2.4 configurations, all forced with the same median non-CO₂ forcing after 2026. Deliberate CDR rises to 15.2 GtCO₂ yr⁻¹ by 2043, is held to 2153 and tapers to 5.3 GtCO₂ yr⁻¹ by 2183, producing the CO₂ plateau between about 2155 and 2185; thereafter it is held at the 9.49 GtCO₂ yr⁻¹ solved for a median of 280 ppm in 2300. Dotted lines mark 350, 300 and 280 ppm and 1.5 and 1.0 °C.

The timing of the 280-ppm target sets the long-run removal burden. Solving the same ensemble for other target years gives post-2183 removal of 31.5 GtCO₂ yr⁻¹ for 2200, 9.49 GtCO₂ yr⁻¹ for 2300 and 7.02 GtCO₂ yr⁻¹ for 2400, against residual sources of 2.39 GtCO₂ yr⁻¹ (Supplementary Note 2). Bringing the target forward by a century more than triples the required rate. At each solution half the configurations remain above 280 ppm in the target year, and the 5–95% range is about ±4 ppm. The pathway's peak removal of 15.2 GtCO₂ yr⁻¹, sustained from 2043 to 2153, is about 7.6 times today's total CDR and exceeds the 7–9 GtCO₂ yr⁻¹ central range for 2050 in the more sustainable mitigation scenarios.² We treat it as a stress-test pathway, not a feasibility forecast.

Carbon-removal cost and the revenue it requires

Removal cost is the largest claim on the ledger (Fig. 2a,b). At US\$200 tCO₂⁻¹, sustaining 9.49 GtCO₂ yr⁻¹ costs US\$1.90 trillion yr⁻¹, 27% of the reference envelope; the 2043–2153 peak of 15.2 GtCO₂ yr⁻¹ costs US\$3.04 trillion yr⁻¹, 44%. At US\$100 tCO₂⁻¹ these shares halve to 14% and 22%. At US\$400 tCO₂⁻¹ the peak period consumes 87% of the envelope, and a 2200 target would require 181%. CDR unit cost and target year, not the human-service floors, decide whether a given revenue suffices.

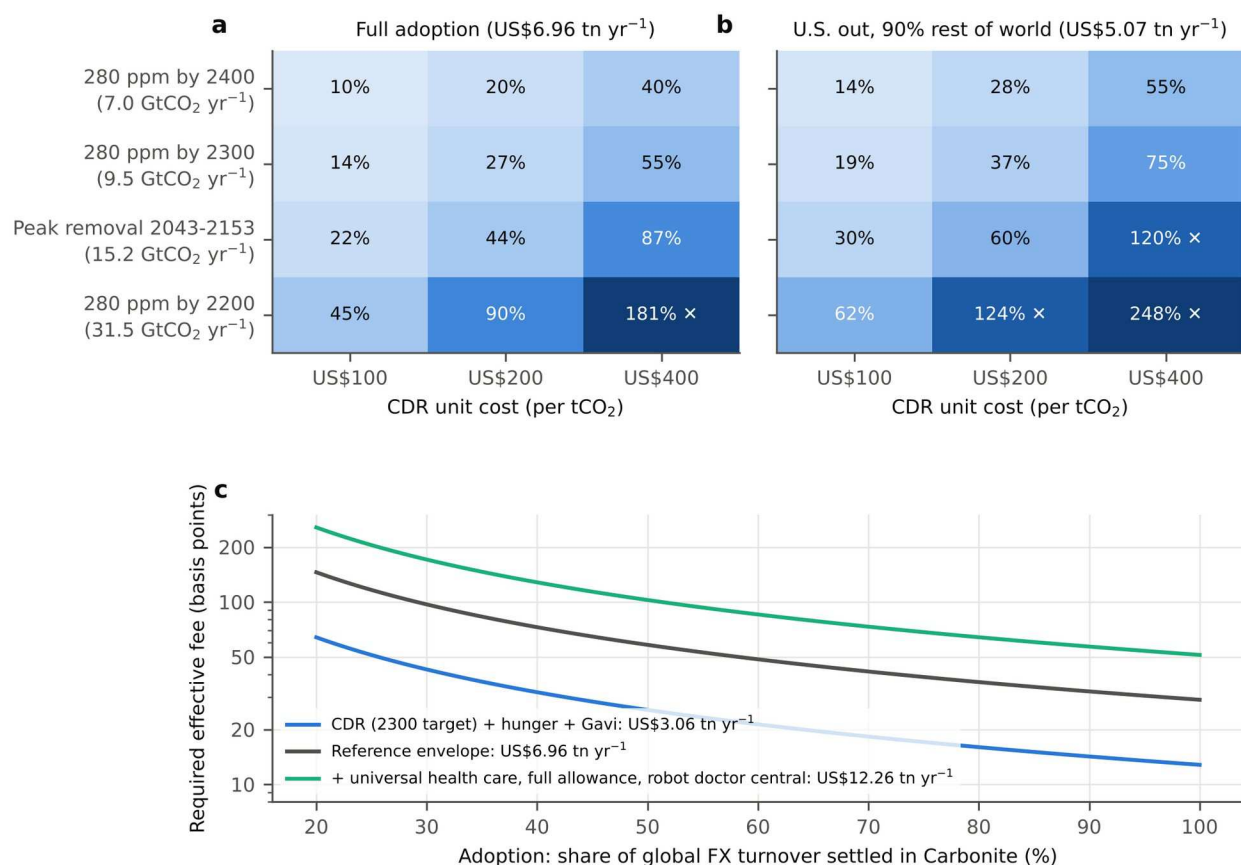


Fig. 2 | Carbon-removal cost and the revenue it requires. **a,b**, Annual CDR cost as a percentage of the reference envelope for four removal rates (rows) and three unit costs (columns), for full adoption (**a**) and for U.S. non-participation with 90% participation elsewhere (**b**). Rows are the FaIR-solved post-2183 rates for 280 ppm by 2400, 2300 and 2200 and the 2043–2153 peak rate. × marks costs that exceed the envelope; shading is capped at 150%. **c**, Effective fee on global foreign-exchange turnover (US\$9.5 trillion per day, 252 trading days) needed to raise each annual requirement, by the share of that turnover settled in Carbonite, assuming no fee-driven loss of volume.

Expressed as a fee, the requirements are modest per transaction but large in aggregate (Fig. 2c). Removal for the 2300 target, ending hunger at the full food allowance and Gavi's 2026–2030 target together need US\$3.06 trillion yr⁻¹ during maintenance and US\$4.20 trillion yr⁻¹ during peak removal, an effective fee of 12.8 and 17.6 basis points if all foreign-exchange turnover were settled in Carbonite; the reference envelope corresponds to 29.1 basis points, and halving adoption doubles each fee. Fees also reduce volume. If settled volume falls exponentially with the fee, revenue peaks at a fee of $1/\eta$, where η is the fractional volume loss per basis point. At full adoption the US\$3.06 trillion tier is attainable only if η is below 2.9% per basis point, the reference envelope only if it is below 1.3%, and a tier including universal health care at a full allowance only if it is below 0.7% (Supplementary Note 3). No elasticity of this kind has been measured for settlement fees, so the mechanism's feasibility rests on an empirical quantity that this analysis can bound but not supply.

Hunger and vaccine finance are small claims on the residual

After removal at US\$200 tCO₂⁻¹, the reference-envelope residual is US\$5.06 trillion yr⁻¹ during 2300-target maintenance and US\$3.92 trillion yr⁻¹ during peak removal (Fig. 3). A full healthy-food allowance of US\$1,800 person⁻¹ yr⁻¹ for the 645 million people facing hunger⁴ costs US\$1.161 trillion yr⁻¹, 23% of the maintenance residual and 30% of the peak residual; without U.S. participation the shares rise to 37% and 57%. A quarter of the residual covers this allowance 1.09 times during maintenance but 0.84 times during peak removal (Fig. 4a). A full allowance is an upper bound on the public cost of ending hunger, because most people facing hunger already obtain much of their diet. Allowances of US\$300–1,200 person⁻¹ yr⁻¹ need 4–15% of the maintenance residual, and the Ceres2030 estimate of about US\$33 billion yr⁻¹ of additional public spending to end hunger sustainably by 2030¹⁰ needs under 1% (Supplementary Note 5). These are resource equivalents; they assume

that delivery succeeds and say nothing about logistics, prices or governance in food-insecure states. The framework retains omnivore, mixed and vegetarian-plus-aquatic diet pathways and does not require eliminating meat.

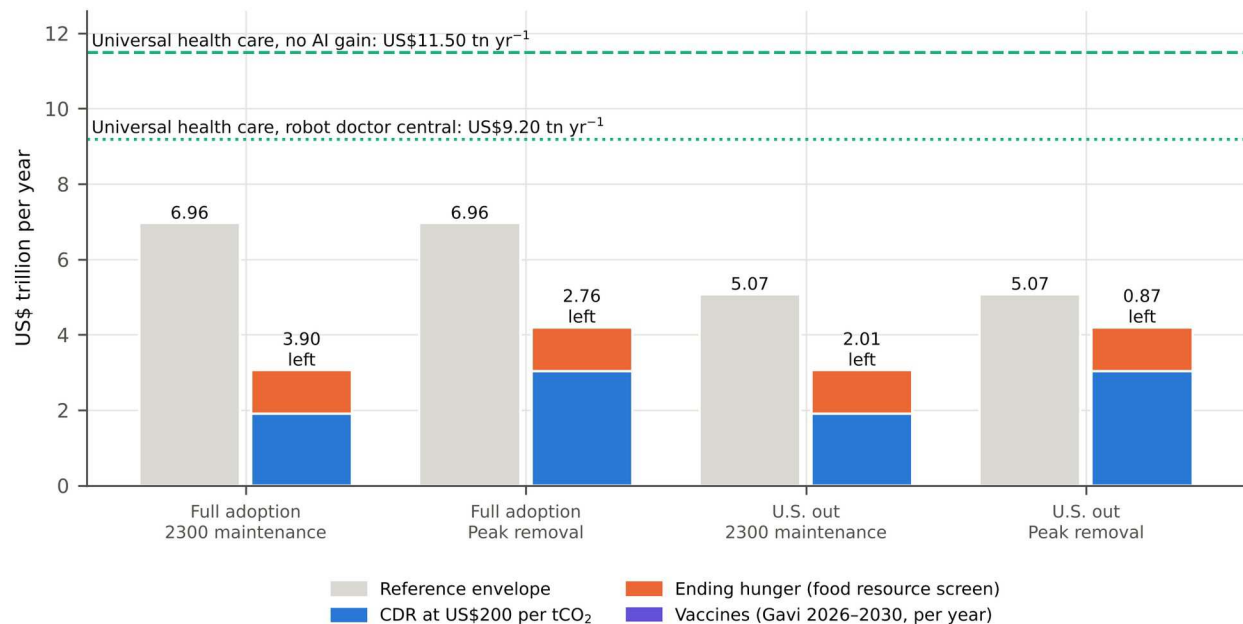


Fig. 3 | Carbonite allocation ledger at US\$200 tCO₂⁻¹. Grey bars give the reference envelope for full adoption and for U.S. non-participation, each during 2300-target maintenance (9.49 GtCO₂ yr⁻¹) and during peak removal (15.2 GtCO₂ yr⁻¹). Stacked bars give CDR cost, the hunger screen at the full food allowance and annualized Gavi 2026–2030 vaccine funding (US\$0.0024 trillion yr⁻¹, too small to be visible); numbers give the residual left. Horizontal lines mark the universal-health-care resource equivalent at US\$2,500 per uncovered person without AI capacity gain and with the central robot-doctor multiplier.

Immunization is small by comparison. Gavi's 2026–2030 funding target of US\$11.9 billion¹¹ corresponds to US\$2.38 billion yr⁻¹, or 0.05% of the maintenance-period residual; with more than US\$9 billion pledged in June 2025, the remaining gap of less than US\$2.9 billion is about 0.01%. This compares Carbonite revenue with Gavi's financing target and gap; it is not a costing of universal immunization or of global vaccine finance as a whole. Reaching the 14.3 million zero-dose infants⁶ is limited by health-system reach as much as by money, which is why the vaccine and health-care screens are linked (Supplementary Note 6).

Universal health care depends on its cost basis

Whether universal health care fits depends almost entirely on what it is assumed to cost (Fig. 4b). About 4.6 billion people were not fully covered by essential health services in 2023,⁵ but many already receive some care, so the incremental cost per uncovered person is well below a full allowance. After CDR, food and vaccines, the maintenance-period residual of US\$3.90 trillion yr⁻¹ covers up to US\$848 per uncovered person per year (US\$599 during peak removal; US\$438 and US\$189 without U.S. participation). At a full allowance of US\$2,500 it covers 34% of the need during maintenance and 24% during peak removal. We represent AI-assisted and robotic 'robot doctor' services, covering triage, documentation, decision support, remote monitoring, pharmacy logistics, scheduling and translation under mandatory human clinical oversight,¹² as capacity multipliers of 1.10, 1.25 and 1.50, which raise these coverages to 37–51% and 26–36%. At the other extreme, the additional spending projected to move 67 low- and middle-income countries towards the health Sustainable Development Goals, about US\$371 billion yr⁻¹ by 2030 in the ambitious scenario,¹³ is a tenth of the residual (Supplementary Note 6). The full-allowance case is therefore an upper bound, and the multipliers are scenario assumptions, not measured productivity effects.

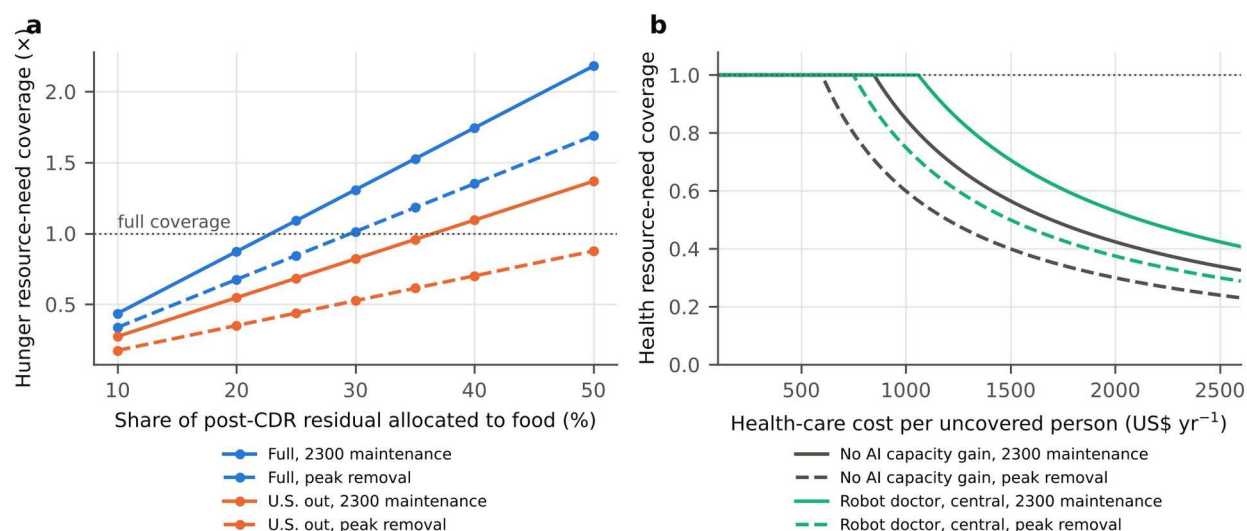


Fig. 4 | Human-service coverage. **a**, Coverage of the hunger screen at the full food allowance (1.0 = full coverage) by the share of the post-CDR residual allocated to food, for full adoption and U.S. non-participation during 2300-target maintenance (solid) and peak removal (dashed), with CDR at US\$200 tCO₂⁻¹. **b**, Coverage of universal health care for the 4.6 billion people not fully covered, by the assumed cost per uncovered person, without AI capacity gain and with the central robot-doctor multiplier (1.25), from the full-adoption residual after CDR, food and vaccines during maintenance (solid) and peak removal (dashed).

Access to justice is treated in the same way. The robot-lawyer scenarios assume that 20%, 40% or 60% of routine legal-service volume (triage, legal information, research, drafting, form completion, document review, translation and mediation support) is eligible for AI assistance, with verification by a lawyer or judge wherever the law requires it. This gives a normalized public legal-access capacity index of 110, 120 or 130 (Supplementary Note 7). These are capacity assumptions without a costed ledger and are reported for completeness rather than as findings.

Coral and fisheries recovery follow ecological clocks

Carbon removal alone restores coral reefs late (Fig. 5). In the screen, coral recovery requires ten consecutive years with a reef hot-season temperature proxy at or below 1.2 °C and CO₂ at or below a chosen gate, followed by a 10–15-year hard-coral recovery clock consistent with observed recovery times after mass bleaching.¹⁴ Under CDR alone the window opens in 2181 for CO₂ gates of 400, 350 or 320 ppm, so hard-coral cover re-establishes between 2191 and 2196; a 300-ppm gate delays the window to 2219. The thermal proxy exceeds the 1.2 °C gate in all 66 years from 2035 to 2100. Seasonal local reef cooling of 40 W m⁻² by regional marine cloud brightening, which reduced peak sea-surface temperature by about 0.5 °C in a Great Barrier Reef simulation,¹⁵ removes those exceedance years and opens the window in 2057 under a 400-ppm gate and in 2105 under a 350-ppm gate; the 20 and 60 W m⁻² cases scale that single anchor linearly and are sensitivity assumptions. At 300 ppm all cases converge on 2219, because local cooling neither lowers CO₂ nor reverses acidification. Regional cloud brightening is a radiative intervention, but a local one, evaluated here only as a reef-scale sensitivity separate from the global pathway. These are screening results, not reef-ecosystem projections.

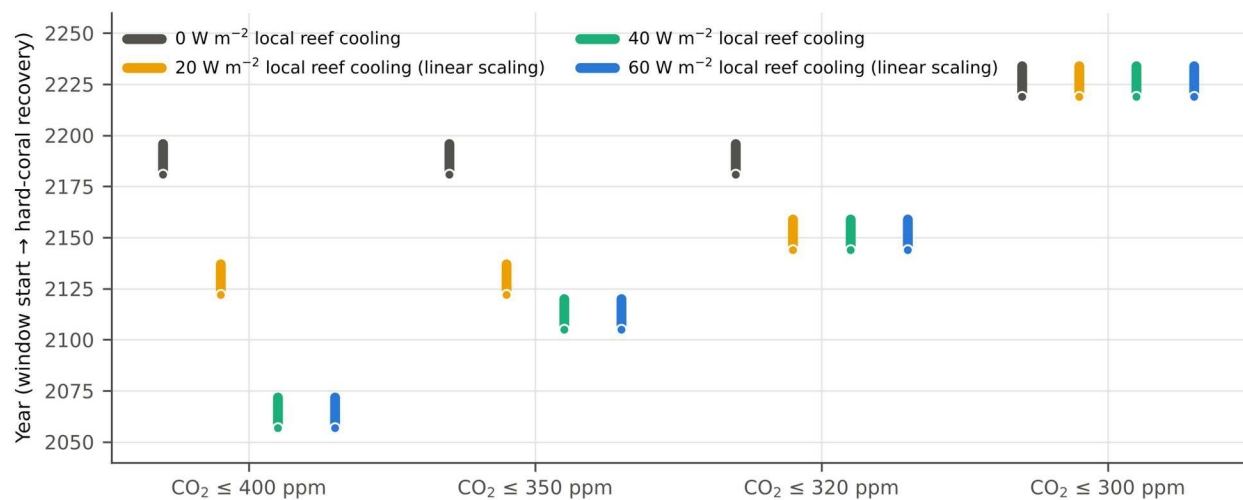


Fig. 5 | Coral recovery windows under the FaIR restoration pathway. For each CO₂ gate, bars run from the first year of ten consecutive years meeting both the 1.2 °C thermal gate and the CO₂ gate (circle) to the latest hard-coral recovery year (window start plus 15 years), for seasonal local reef cooling of 0, 20, 40 and 60 W m⁻² by regional marine cloud brightening. Only the 40 W m⁻² case (about 0.5 °C) is anchored to a published simulation; 20 and 60 W m⁻² assume linear scaling. Local cooling is a reef-scale sensitivity; no global solar radiation modification is applied.

Wild fisheries recover on faster, management-driven clocks. The literature-bounded screen retains a median rebuilding time of about ten years after effective management reform and the published scenario in which reform makes about 98% of modelled fisheries biologically healthy by 2050.¹⁶ These are external literature results rather than outputs of this framework.

A tree-backed stablecoin keeps the settlement unit stable

A settlement currency must hold its value. Unbacked cryptocurrencies such as Bitcoin have no claim on any asset, and their prices swing widely, which makes them poor units of account for contracts, wages or a fund that must pay for carbon removal over centuries. Stablecoins are the class of cryptoasset designed to avoid this. Most hold fiat-currency reserves, and as money they still face open questions of singleness, elasticity and integrity.¹⁷ U.S. law now requires payment stablecoins issued in the United States to be backed one-to-one by dollars, Treasury securities and similar liquid assets.¹⁸ Carbonite takes a different route (Fig. 6a). Each coin is backed by timber rights in a geotagged reserve of planted trees. A newly mined coin can be registered only after its miner pays a registration fee that pays for planting on land contributed by land stakers, who operate validating nodes in return; mining and validation are restricted to verified clean or otherwise wasted electricity. The species, location and planting date of every tree are recorded on the blockchain, and drones carrying multispectral, LiDAR and thermal sensors, supported by field crews, survey the reserve and report growth and losses to fire, drought, disease and windthrow.

Two rules keep each coin's backing stable. First, the reserve is pooled. An equalization algorithm reassigns trees among coins as stands grow, are revalued or are lost, so that every coin carries the same intrinsic value whatever the species, age or location of the trees first planted for it; a coin issued over seedlings is interchangeable with one issued a decade earlier over maturing stands. Second, a share of every planting is left unassigned in a stability pool. When timber prices fall, pool trees are assigned to coins; when they rise, trees return to the pool. A pool holding a share b of planted trees fully offsets a timber-price fall of up to b . With the reference pool of 20% (two of every ten trees planted), a 30% fall in timber prices reduces backing per coin by 12.5% rather than 30% (Fig. 6b and Supplementary Note 12). Issuance is throttled so that backing per coin rises slowly rather than falling: if the reserve's value grows by 4% yr⁻¹ through biomass accumulation and maturation and new issuance dilutes it by 1.5% yr⁻¹, backing per coin rises by 2.5% yr⁻¹ in real terms. Current and projected backing values are published continuously.

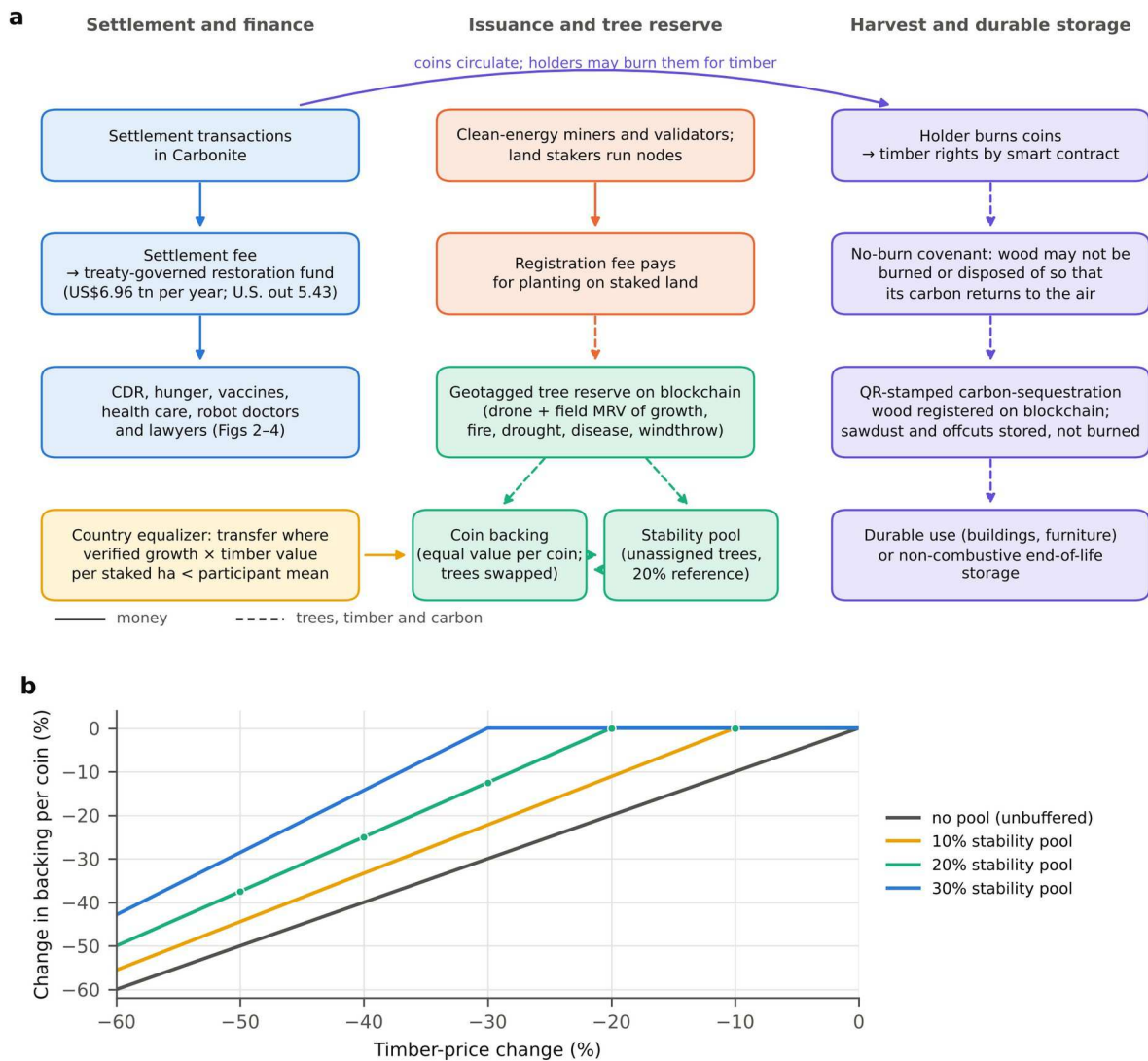


Fig. 6 | Carbonite's tree-backed stablecoin architecture. **a**, Flows of money (solid arrows) and of trees, timber and carbon (dashed). Settlement fees fund the restoration fund analysed in Figs 2–4; registration fees pay for planting on staked land; the geotagged reserve is split between coin backing, equalized so that every coin carries the same value, and an unassigned stability pool. Burning a coin releases harvest rights under a no-burn covenant, and harvested wood is QR-stamped and registered as carbon-sequestration wood. The country equalizer offsets lower growth or timber value in participating countries. **b**, Change in backing per coin after a fall in timber prices, for stability-pool shares of 0, 10, 20 and 30%; dots mark the 20% reference pool. Design arithmetic, not a projection of the coin's market price.

The reserve is designed to keep carbon out of the atmosphere, not to cycle it. A holder who wants timber burns (permanently retires) coins and receives, by smart contract, harvest rights to the corresponding trees, but only after agreeing that the wood will not be burned or disposed of in any way that returns its carbon to the atmosphere. Each harvested log and piece of sawn timber is stamped or engraved with a QR code and registered on the blockchain as carbon-sequestration wood, so that its custody can be traced from stump to end use. Sawdust and offcuts are dried and stored underground or in trenches rather than burned. Long-lived timber in buildings is a recognized carbon store,¹⁹ and burying wood under conditions that slow decay can retain most of its carbon for centuries.²⁰ Land stakers may keep fruit, nut and syrup harvests from standing trees. The restoration fund costed above draws only on settlement revenue: carbon-credit income from the reserve, where national rules allow it, accrues to coin backing rather than to the fund, and the reserve's carbon is not credited against the deliberate removal costed in the ledger.

Pooling also protects participants whose trees grow slowly or yield lower-value timber. Because staked land is graded by expected growth and timber value, a hectare in a boreal or semi-arid country backs less value than a hectare of fast-growing tropical hardwood, so such countries would otherwise gain less from planting. A country equalizer offsets the difference: a participant whose verified value increment per staked hectare, v_i , falls below the participation-weighted mean receives a transfer proportional to the shortfall and to its verified staked area (Methods). Minimum suitability standards and drone and field verification prevent the equalizer from rewarding planting on unsuitable land. Neither the equalizer nor the tree reserve is costed in the ledger.

Participation shapes both revenue and carbon

U.S. non-participation is a central design case, not a tail risk. On 20 January 2025 the United States ordered its withdrawal from the Paris Agreement,²¹ which took effect in January 2026, and on 7 January 2026 it ordered withdrawal from the UN Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change, among 66 international bodies.²² Its stablecoin law ties payment stablecoins issued in the United States to dollar reserves.¹⁸ Carbonite is therefore designed to work without the United States: issuance, the tree reserve, the country equalizer and the restoration fund operate among participating states, trees are planted only on land staked in those states, and accession remains open at any time.

Non-participation by the largest economy affects both sides of the ledger. Removing the 19% of global foreign-exchange turnover booked by U.S. sales desks²³ and assuming 90% participation elsewhere lowers the reference envelope by 27%, to US\$5.07 trillion yr^{-1} , and raises the fee needed for any requirement by 37%. On the physical side, the archived central refusal pathway adds 308 GtCO₂ of excess emissions through 2183, equivalent to about 20 years of peak removal and to a screening penalty of about 15 ppm in 2183. Joining in 2036, 2046 or 2056 instead adds 23, 59 or 92 GtCO₂ (Supplementary Note 11), so each decade of delayed accession adds about 35 GtCO₂ to the removal burden.

The physical cost of refusal outweighs the revenue loss. The central refusal case adds the equivalent of about 20 years of peak removal, which must be funded from 27% less revenue; at US\$400 tCO₂⁻¹ the peak period already exceeds the U.S.-out envelope (Fig. 2b). Without the United States, removal for the 2300 target still absorbs only 19–37% of that envelope at US\$100–200 tCO₂⁻¹, but the margin for universal health care narrows (Supplementary Table 7). Treaty sanctions and border measures for non-participants are registered in the framework but not modelled.

Discussion

What settlement-fee finance can and cannot pay for

The ledger separates two tiers. Carbon removal for a 2300 target, ending hunger at the full food allowance and full Gavi funding together need US\$3.06 trillion yr^{-1} , or US\$4.20 trillion yr^{-1} during peak removal: 12.8–17.6 basis points on all foreign-exchange turnover. Adding universal health care at US\$2,500 per uncovered person raises the requirement to US\$10.7–15.7 trillion yr^{-1} (45–66 basis points), depending on the robot-doctor case and removal period (Supplementary Note 8). The first tier is within reach of a settlement fee if adoption is broad and volume is not highly fee-sensitive; the second is not, unless the incremental cost of health coverage is closer to published estimates than to a full allowance, or national health budgets co-finance it. The binding uncertainties are the fee elasticity of settlement volume, the CDR unit cost and target year, and the incremental cost of health care, not the food or vaccine commitments.

Evidence classes and limits

The quantities in this analysis have different standing. The CO₂ and temperature pathway and the inverse CDR requirements are computed with FaIR across 841 configurations and are reproduced end to end by Supplementary Code 1; they inherit FaIR's structural limits and have not been repeated here with a second carbon-cycle model. The coral and fisheries results are literature-bounded screens. The reference envelope, participation and adoption shares, fee elasticities, diet and service allowances, and robot-doctor and robot-lawyer multipliers are scenario inputs, and the results are framed as thresholds on them rather than estimates of them. The participation stress reuses archived excess-emission cases converted to ppm with a screening factor. Monetary policy, liquidity, financial stability and anti-money-laundering controls are registered in the framework (Supplementary Table 1) but not quantified here. The permanence, land, energy and water constraints of removing 15.2 GtCO₂ yr^{-1} are likewise outside this ledger.^{1,2} The resource screens convert people in need into

money; they do not model delivery, which depends on workforce, infrastructure, prices and governance. The stability-pool and backing-growth figures are design arithmetic. They show how the reserve's rules respond to price shocks, not that markets will trade the coin at its backing value. Standing trees are illiquid, so under heavy redemption the coin's market price would depend on redemption rules and liquidity buffers that are not modelled here.

Priorities for testing

Three steps would turn these thresholds into a testable policy design: measurement of how settlement volume responds to fees, the quantity on which every revenue result here turns; repetition of the inverse solves in carbon-cycle models other than FaIR; and delivery-cost evidence for food, immunization, AI-assisted care and AI-assisted legal services in low-income settings. The present result already narrows the design space. The binding costs are carbon removal and health care, not hunger or vaccines, and solvency depends more on fee elasticity, removal cost and target year than on any single human-service commitment. A field pilot of the tree reserve, linking drone and field measurement, QR-registered harvest and end-of-life storage of carbon-sequestration wood, would test the chain of custody on which the coin's backing depends.

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Methods

Restoration pathway and inverse solves

The carbon pathway for 2026–2183 is the archived Planetary Restoration annual trajectory (Supplementary Data 1, D10): gross anthropogenic CO₂ declines from 42.2 GtCO₂ yr⁻¹ in 2026 to 1.5 GtCO₂ yr⁻¹ by 2051 and is then held; permafrost and stored-carbon-reversal terms are added; and deliberate CDR rises from zero in 2026 to 15.2 GtCO₂ yr⁻¹ in 2043, is held through 2153 and tapers to 5.28 GtCO₂ yr⁻¹ in 2183. Net CO₂ emissions replace FaIR's fossil and land-use CO₂ inputs from 2026. We run FaIR 2.2.4⁸ with all 841 calibrated-constrained configurations of fair-calibrate 1.4.1⁹ and the medium-extension background for other species. To remove differences in future non-CO₂ forcing as a source of spread, every configuration is forced after 2026 to the ensemble-median non-CO₂ effective radiative forcing of a no-removal run, through an additive forcing-only bookkeeping species converged to 10⁻⁷ W m⁻². After 2183 the gross, permafrost and stored-carbon sources are held at their 2183 values (2.39 GtCO₂ yr⁻¹ in total) and deliberate removal is held at a constant rate R . For target years 2200, 2300 and 2400 we solve by bisection for the R at which the ensemble-median CO₂ concentration equals 280 ppm (tolerance 0.01 ppm), re-converging the forcing harmonization at the solution. The 2300 solution, $R = 9.49$ GtCO₂ yr⁻¹, defines the pathway; Fig. 1 shows its median and 5–95% range. With R held at the 2183 rate, the same code reproduces an archived FaIR run of this schedule exactly to 2300. FaIR runs deterministically here, so no random seed is involved. Threshold-crossing years are the first year after the respective peak in which the median falls below the threshold.

Carbonite envelope and participation

Carbonite is modelled as a hypothetical settlement stablecoin whose transaction and intermediation revenue funds a treaty-governed restoration fund independent of carbon-credit sales. The reference envelope, $E = \text{US\$}6.960714$ trillion yr⁻¹, is an author-defined scale anchor. The settlement base is global foreign-exchange turnover, $B_0 = T \times 252$ trading days with $T = \text{US\$}9.5$ trillion per day in April 2025⁷ ($\text{US\$}2,394$ trillion yr⁻¹), so $E/B_0 = 0.291\%$. For a requirement Q and adoption share a , the effective fee with no volume response is $f = Q/(aB_0)$. If settled volume falls with the fee as $aB_0 \exp(-\eta f)$, with f in basis points, revenue is maximized at $f = 1/\eta$ and cannot exceed $aB_0 \times 10^{-4}/(\eta Q)$; a requirement is attainable only if $\eta \leq aB_0 \times 10^{-4}/(eQ)$. We report $\eta = 0, 0.5, 1, 2$ and 5% per basis point and $a = 25\text{--}100\%$ (Supplementary Note 3). The U.S.-out envelope is $E \times (1 - 0.19) \times$

$0.90 = \text{US\$}5.074 \text{ trillion yr}^{-1}$, where 0.19 is the share of global foreign-exchange turnover booked by U.S. sales desks²³ (a location-of-trading proxy, not a measure of U.S. payment flows) and 0.90 is rest-of-world participation.

Carbon-removal costing

Annual CDR cost is the removal rate multiplied by the unit cost, for rates of 7.02, 9.49, 15.2 and $31.5 \text{ GtCO}_2 \text{ yr}^{-1}$ and unit costs of US\$100, 200 and 400 tCO_2^{-1} , spanning commonly cited ranges for engineered removal.³ US\$200 tCO_2^{-1} is the central value. Costs are undiscounted annual flows in constant US dollars. The residual R is the envelope minus CDR cost, evaluated separately for the maintenance period ($9.49 \text{ GtCO}_2 \text{ yr}^{-1}$) and the peak period ($15.2 \text{ GtCO}_2 \text{ yr}^{-1}$).

Human-service screens

Hunger: $645 \text{ million people}^4 \times \text{an allowance of US\$}300, 600, 1,200 \text{ or } 1,800 \text{ person}^{-1} \text{ yr}^{-1}$; the central full-allowance case gives US\$1.161 trillion yr^{-1} , and coverage at allocation share s is $sR/1.161$. The Ceres2030 estimate of additional public spending, US\$33 billion yr^{-1} ,¹⁰ is reported as an incremental anchor. Health care: $4.6 \text{ billion people}^5 \times \text{US\$}250, 500, 1,000 \text{ or } 2,500 \text{ person}^{-1} \text{ yr}^{-1}$, divided by a robot-doctor capacity multiplier $m \in \{1.00, 1.10, 1.25, 1.50\}$; coverage is $(R - \text{food} - \text{vaccines})/\text{need}$, and the break-even cost per person is $(R - \text{food} - \text{vaccines})/4.6 \text{ billion}$. The additional health spending projected for 67 low- and middle-income countries, US\$371 billion yr^{-1} by 2030 in the ambitious scenario,¹³ is reported as an incremental anchor; it covers a different population and is not directly comparable. The robot-doctor cases assume that 15%, 30% or 50% of routine clinical task volume is eligible for AI or robotic assistance, with mandatory human oversight of regulated diagnosis, treatment and prescribing unless applicable law and a validated safety case permit otherwise. Vaccines: Gavi's 2026–2030 funding target of US\$11.9 billion¹¹ is annualized over five years (US\$2.38 billion yr^{-1}); the gap uses pledges of US\$9.0 billion, a lower bound on the more than US\$9 billion pledged, so the gap is an upper bound. Legal access: the normalized capacity index is $100 \times (1 + f/2)$ for eligible routine-volume fractions $f = 0.2, 0.4 \text{ and } 0.6$. The required envelope for each tier is the sum of CDR cost, food, vaccines and, where included, capacity-adjusted health care.

Coral and fisheries screens

The reef hot-season proxy is the FaIR median warming minus a local peak-season cooling $c = \min(1, F/80) ^\circ\text{C}$ for seasonal regional forcing $F \in \{0, 20, 40, 60\} \text{ W m}^{-2}$, with $0.7\times, 1.0\times$ and $1.3\times$ response sensitivities. Only the 40 W m^{-2} case is anchored, to the approximately $0.5 ^\circ\text{C}$ seasonal cooling reported for a Great Barrier Reef regional marine-cloud-brightening simulation;¹⁵ the 20 and 60 W m^{-2} cases assume linear scaling, which that study does not establish. This local intervention is a reef-scale sensitivity, not global solar radiation modification. A recovery window opens in the first year that begins ten consecutive years in which the proxy is at or below the thermal gate (1.2 or $1.0 ^\circ\text{C}$) and CO_2 is at or below the CO_2 gate (400, 350, 320 or 300 ppm); hard-coral recovery follows 10–15 years later.¹⁴ The screen is recomputed from the FaIR pathway by Supplementary Code 1. Fisheries values are taken from published global management-reform scenarios.¹⁶

Participation stress

Excess cumulative emissions through 2183 for delayed-accession and refusal cases are taken from the archived model. The ppm penalty is a screening conversion pending a rerun with positive-emissions forcing in a calibrated carbon-cycle model.

Tree reserve, stability pool and country equalizer

Of the trees planted with each registration fee, a share b is held unassigned in the stability pool and $1 - b$ is assigned to coins. After a fractional fall f in timber prices, pool trees are assigned to coins until backing is restored or the pool is exhausted, so the change in backing per coin is 0 for $f \leq b$ and $(1 - f)/(1 - b) - 1$ for $f > b$; when prices rise, trees are returned to the pool and backing is held constant. The reference design uses $b = 0.20$ (two of every ten trees); Supplementary Table 18 gives $b = 0, 0.1, 0.2 \text{ and } 0.3$. If the reserve's value grows at rate g per year and issuance dilutes it at rate δ , backing per coin grows at $(1 + g)/(1 + \delta) - 1$; the reference case $g = 0.04$ and $\delta = 0.015$ gives $2.46\% \text{ yr}^{-1}$ (Supplementary Table 19).

For the country equalizer, participant i has verified staked area A_i and value increment per hectare $v_i = G_i P_i$, where G_i is verified merchantable growth ($\text{m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$) and P_i the timber value (US\$ m^{-3}). With the participation-weighted mean $\bar{v} = \sum A_i v_i / \sum A_i$, the annual transfer is $Q_i = \theta A_i \max(0, \bar{v} - v_i)$, where $\theta \in [0, 1]$ is the equalization share set by treaty and only land meeting minimum suitability standards counts towards A_i . Transfers would be

paid from settlement revenue; they are not costed here because verified country-level growth and value data are not part of this analysis. Coin-level equalization reassigns trees among coins so that every coin carries the same backing value to the nearest whole tree.

Evidence classification

Each of the 89 registered modules carries one evidence class (Supplementary Table 1): externally executed, legacy mechanistic, literature screen, engineering scenario, policy scenario, service-capacity scenario, diagnostic only or open science gate. Supplementary Table 1 also states each module's role in this Article; Hector, OSCAR and paired-attribution modules belong to related archived work and are not used here. Results do not inherit validation across classes.

Use of large language models

OpenAI ChatGPT and Anthropic Claude were used under the authors' direction for literature discovery, code drafting, quantitative cross-checks, language editing and document preparation. The authors retain responsibility for all claims, assumptions, code, data and references.

Data availability

The input carbon trajectory, the FaIR restoration pathway with ensemble percentiles, the inverse solutions, the CDR cost grid, allocation ledger, revenue-threshold and fee-elasticity tables, cost-basis sensitivities, hunger, health, vaccine, legal-access, coral, fisheries and participation tables, stability-pool and backing-growth tables, and the complete 89-module registry are provided as Supplementary Data 1. A permanent archive with a DOI will be deposited on acceptance.

Code availability

Supplementary Code 1 contains `run_fair_restoration_inverse.py`, which runs FaIR 2.2.4 with the 841 fair-calibrate 1.4.1 configurations from the input carbon trajectory and solves the inverse removal rates, and `restoration_finance_screen.py`, which reproduces every other table and every figure; exact package versions, the Python version and run instructions are included. The FaIR calibration files are distributed with FaIR v2.2.4 (<https://github.com/OMS-NetZero/FAIR>). The input trajectory and the archived FaIR and Hector workflows from which it derives are public at <https://github.com/bcjohnjr/Planetary-Restoration-Version-62.2> (commit 89a0f4a). A permanent archive with a DOI will be deposited on acceptance.

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Author contributions

J.K.B. conceived the Planetary Restoration and Carbonite framework, defined the restoration-finance and human-service questions, directed the modelling and led manuscript preparation. C.P. contributed physics and quantitative-model review. P.V.B. contributed to integrated-restoration concept development, seaweed-harvesting technical analysis, and review and editing of the social and ecological framing. All authors reviewed and approved the submitted manuscript and author-contribution statement.

Competing interests

J.K.B. previously filed Canadian and international (PCT) patent applications on elements of the Carbonite settlement architecture; these applications have been abandoned, and no author holds or has applied for any current patent right, or holds equity or another financial interest, related to this work. C.P. and P.V.B. declare no competing interests.

Additional information

Supplementary Information is available for this paper. Correspondence and requests for materials should be addressed to Jonathan Karl Bily.

Supplementary Files

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