Institutional Research Group

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EMERGING TECH RESEARCH

Voluntary Carbon Markets

Investigations into voluntary carbon credit quality have prompted increased focus on high-integrity credits, from both buyers and providers

PitchBook is a Morningstar company providing the most comprehensive, most accurate, and hard-to-find data for professionals doing business in the private markets.

Key takeaways

- Carbon credits offer a way to decarbonize challenging sectors and form a key component of many corporations' decarbonization strategies.

- Recent academic and journalistic investigations into carbon credit quality have found that some credits—particularly nature-based credits—do not represent the carbon reduction/removal that they claim to, which presents a risk for those buying credits of this type.

- VC deal activity for voluntary carbon market companies grew strongly from 2020 to 2022, but current data for 2023 suggests there will be a slight fall in deal value for the year.

- Showcasing integrity has become increasingly important to carbon credit providers, and new independent standards may simplify this need from a carbon credit buyer's perspective.

- This data emphasis means that startups with strong measurement, reporting, and verification capabilities are more likely to generate strong investor value.

Overview

Whilst it is challenging to calculate the future costs of climate change, between 2000 and 2019, the climate change-attributed cost of extreme weather has been calculated at an average of $143 billion per year.[1] The importance of reducing carbon emissions has become widely accepted in recent years, driving a growing industry around decarbonization technology to replace or modify existing hardware and processes and reduce carbon emissions. For some applications, though, these technologies are still in early stages of development and may be expensive to implement or take several years from ideation to operation. Additionally, some processes are very challenging to decarbonize, and some level of overall carbon emission is inevitable even in net-zero scenarios.

Companies are therefore looking to voluntary carbon markets (VCMs), which allow them to buy carbon credits representing emissions reduction or removal from elsewhere, thereby offsetting their own emissions. These carbon credits can enable rapid reductions in an entity's emissions profile and can also be used in the interim whilst internal decarbonization efforts are underway. Though both are examples of carbon emissions trading, VCMs are distinct from compliance carbon markets, in which entities trade carbon allowances—government-issued products that permit the entity to emit a certain amount of carbon. Unlike VCMs, regulated entities are not given a choice as to whether they participate in compliance carbon markets.

In the last two years, uncertainty around the integrity of carbon credits has grown, driven by investigations into historic credit integrity.[2] This has caused several large buyers of carbon credits to withdraw from VCMs in favor of alternative decarbonization strategies.[3] Carbon credits are based on various underlying projects, and the uncertainty does not affect all credit types equally. For the types whose integrity has been challenged most frequently, additional data and transparency, plus adoption of a common set of standards, can be used to prove quality.

1: "The Global Costs of Extreme Weather That Are Attributable to Climate Change," Nature, Rebecca Newman and Ilan Noy, September 29, 2023.
2: "Revealed: Top Carbon Offset Projects May Not Cut Planet-Heating Emissions," The Guardian, Nina Lakhani, September 19, 2023.
3: "Carbon Credit Market Confidence Ebbs as Big Names Retreat," Reuters, Susanna Twidale and Sarah Mcfarlane, September 1, 2023.

VCMs VC activity

VCMs VC deal activity
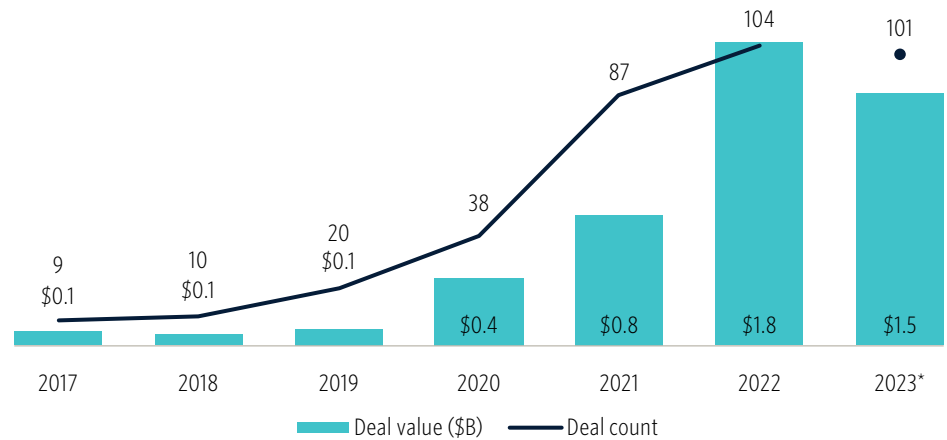
Source: PitchBook • Geography: Global • *As of December 4, 2023

Overall VC investment in VCMs has increased from less than $100 million in 2017 to 2019, to a peak of $1.8 billion in 2022, with deal count growing every year from 2017 to 2022. As of December 2023, deal count was close to that of 2022—101 deals, compared to 104 in 2022—though deal value dropped to $1.5 billion from 2022's $1.8 billion, likely due to a decline in total VC dollars invested, the increased uncertainty in VCMs, and the effects of this on carbon-credit buyer confidence. Looking at quarterly VC deal value, VC investment into VCM companies has exceeded $100 million every quarter since Q3 2021. Prior to this, only Q2 2020 saw more than $100 million, and this was due to two $100 million-plus deals for Climeworks and Aspiration. Megadeals have a strong influence on the total VC funding for individual quarters, and the two quarters with the highest deal value by a significant margin were Q2 2022 and Q1 2023, with $869.1 million and $828.9 million, respectively, driven by Climeworks' $634.4 million Series F and Xpansiv's $525.0 million late-stage VC funding.

In the market map, VCM-focused companies are broken into several categories. VCM infrastructure & services includes companies that perform a range of activities in VCMs, such as acting as carbon credit marketplaces, connecting prospective buyers to projects, aggregating projects and credits, and integrating VCMs with other products. Carbon credit generation is also highly varied; some companies that help to generate carbon credits focus on a specific credit type, whereas others support a wider range. Nature-based credit developers in particular commonly support both ecosystem protection and ecosystem restoration projects. The "Other" category in the market map contains companies that use less common methods to generate carbon credits, including sequestration of high-carbon biological matter in soils or ocean environments, carbon dioxide mineralization, and ocean carbon capture. Finally, a relatively small category of companies focuses on developing measurement, reporting, and verification (MRV) technologies and processes. Most other VCM participants include elements of MRV, but those that focus solely on MRV do so with either a greater overall level of depth or a strong focus on a specific element of MRV, such as remote sensors or other physical hardware.

Voluntary carbon markets market map
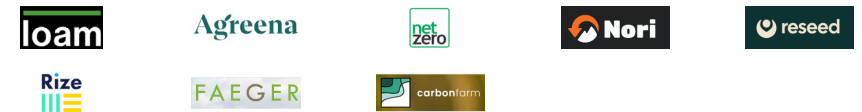
VCM infrastructure & services

X	Aspiration	Watershed	SWEEP	Patch
BeZero	Carbon Direct	Key Carbon	SINAI	Flowcarbon

Carbon credit generation

Reforestation & restoration

MOMBAK	Mast REFORESTATION	KOMAZA		the future forest company
LAND LIFE	HIGHLANDS REWILDING	EARTHLY		

Ecosystem protection

CARBONEXT	MOSS	FiniteCarbon	SINGLE.EARTH	OCELL
CarbonDrop	BOREAL Carbon Corporation	PINA EARTH		

Agriculture

loam	Agreena	netzero	Nori	reseed
Rize	FAEGER	carbonfarm		

Direct air capture

climeworks	CarbonCapture	Carbon Engineering	GLOBAL THERMOSTAT	Avnos
DEEP SKY	Heirloom	ebb carbon		

Other

CHARM	Climate Robotics	worldtree	UNDO	FOREVER BAMBÙ
Carbonfuture	vaulted	CUR8		

MRV

Sylvera	Pachama	SUSTAINCERT	EARTHOPTICS	YARD STICK Soil Carbon Revealed
Ecosystem Restoration Standard	BX	Terradot	OPEN FOREST PROTOCOL	varaha

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From 2020 onward, when VC funding started to grow, the largest segment by deal value was typically VCM infrastructure & services (other than 2022, due to Climeworks' large Series F). As of December 4, 2023, the VCM infrastructure & services category represented 47.2% of the total VC deal value for VCM companies. 2023 represents peak VC funding for dedicated MRV technologies and agricultural carbon credit generation, at $161.2 million and $149.9 million, respectively.

Categorization of VCM companies is complicated by variation in companies' business models, such that some companies carry out several VCM functions. Where this occurs, we segmented them based on primary value proposition.

Generating carbon credits

Highly varied physical projects form the foundation of carbon credits. They include:

- Restoration of damaged or destroyed ecosystems, commonly through reforestation, but also through restoration of other ecosystems such as wetlands or marine ecosystems.

- Creation of new carbon-storing ecosystems, usually through establishment of forests or wetlands where historically there were none.

- Protection of ecosystems from damage or degradation, including REDD+ projects.[4]

- Carbon storage of either high-carbon biological matter or via CO_2 storage from carbon-capture technology.

- Agricultural change through either adoption of regenerative agricultural practices or through soil carbon sequestration.

- Community programs to replace devices and fuels, typically in developing nations and involving replacement of high-carbon fuel hardware.

- Waste management projects that typically reduce the release of methane, which is a more potent—if shorter-lived—greenhouse gas.

- Installation of low-carbon energy hardware.

4: According to the UN, "REDD" stands for "reducing emissions from deforestation and forest degradation in developing countries," while the "+" stands for "additional forest-related activities that protect the climate, namely sustainable management of forests and the conservation and enhancement of forest carbon stocks."

Different underlying projects influence several elements of the carbon credits they generate. Cost is one of the most significant elements, and the price of a carbon credit representing 1 ton of reduction/removal ranges from single-digit figures up to approximately $1,000/ton CO_2 equivalent (CO_2e) for some direct air capture technologies. Nature-based credits tend to have lower costs per ton on average, with removal-based credits selling for a premium at an average of approximately $15/ton CO_2e,[5] including landfill gas capture, afforestation, and carbon capture. Carbon capture, utilization, and storage approaches are typically on the more costly end—even amongst removal-based credits—partially due to the lower technological maturity of some of these approaches, but also the substantial energy inputs. As the technologies for carbon capture become more energy efficient and as installation scales up, the overall cost of carbon capture is projected to fall to $125 to $335/ton CO_2e for large-scale facilities. Buyers might initially look for the lowest-cost credits, but these can be lower quality than more expensive credits of the same type, and thus represent risk to the company if they are later found to not match their carbon reduction/removal claims.

The process for measuring and reporting quality of carbon credits and their underlying projects similarly depends on the type of credit/project in question. This is known as MRV and essentially involves performing due diligence on carbon projects to make sure they accurately represent the carbon reduction or removal that they claim to. This process is frequently combined into the workflows of companies that facilitate carbon credit generation, and carbon credit trading platforms, though dedicated MRV companies can provide additional coverage for project types with niche carbon measurement requirements. Soil carbon projects—whether they are linked to improved agricultural practices or simply soil carbon storage—are an example of this; they typically require distributed in-ground sensing to measure carbon levels.

When evaluating carbon projects/credits, certain elements are used across most credit types. These include governance criteria that typically involve review of project documentation, covering how credits will be tracked, how data concerning the credits will be released, and review of land ownership documents. Evaluation of the physical site and surrounding area is also important, and satellite imaging is commonly used for monitoring and measurement of ecosystem-wide or agricultural carbon projects, though it cannot be applied to certain marine projects.

The process of evaluating carbon credit emissions impacts can involve many criteria, though these can generally be assigned to one of several requirements:

- **Additionality:** To generate valid credits, carbon projects must be based on activity that would not have occurred otherwise. This is generally simple to show for certain project types, such as direct air carbon capture and storage, as this is not an activity that otherwise would be carried out. For projects such as ecosystem protection, to meet additionality requirements, a project must protect an area that otherwise would be damaged or destroyed, and providing sufficient evidence of this can be challenging.

5: "Publication: State and Trends of Carbon Pricing 2023," Open Knowledge Repository, World Bank, May 2023.

Add-on benefits

Credit quality is influenced by factors other than just carbon credit integrity. Many credits provide add-on benefits that do not necessarily increase the quantity of carbon emissions reduced/removed, but still provide tangible improvements to the surrounding area. Some carbon projects bring social benefits, supporting local communities through improved local air quality, access to energy and resources, training and education, or simply economic and employment benefits. Ecological benefits are a common add-on for many nature-based carbon projects, which typically sequester carbon and protect biodiversity simultaneously by preventing habitat destruction or by restoring damaged ecosystems. In some cases, buyers seek out specific biodiversity credits to reduce their negative impacts on biodiversity in much the same way that they use carbon credits. Other benefits include additional environmental resilience to flooding, soil erosion, and storm damage that mature ecosystems can provide.

- **Leakage:** Most applicable for ecosystem protection projects, leakage refers to the relocation of damage to another, unprotected location, such that the same amount of damage ultimately occurs. For example, a high quality project must prove that protecting an area of forest from logging does not simply push the logging activity to an unprotected location nearby.

- **Permanence:** Projects must result in a carbon reduction for a meaningful period, and for projects with a material risk of reversal, such as wildfire risk for reforestation projects, measures must be put in place to mitigate this risk.

- **Accurate quantification:** The quantity of carbon reduction/removal claimed by the carbon credits must be an accurate representation of the reduction/removal that the project creates. For nature-based projects, this can require complex measurements of carbon sequestered in an ecosystem.

- **Exclusivity:** The carbon reduction/removal of a project can be counted only once, thus preventing multiple credits from being issued based on the same greenhouse gas reduction. This also covers instances in which two entities both claim the climate benefits of the same carbon credit. For example, the emissions reduction characteristics of a carbon credit based on emissions reduction at an energy generation facility cannot also be claimed by the facility as its own independent emissions reduction.

Evaluating projects based on reducing emissions from deforestation and forest degradation (known as REDD+) can be particularly challenging. In addition to proving that leakage will not occur—which can be challenging in large environments with multiple sources of deforestation occurring at different rates—accurately quantifying the avoided emissions is complex. Quantification is calculated based on ex ante deforestation rates, which are based on nearby or similar sites. Incorrect or changing forecasts can result in later discovery that these carbon projects do not represent the deforestation reduction—and therefore the carbon reduction—that they claim to.[6] Addressing this requires improving the methodologies used to calculate deforestation baselines, such that they are more in line with actual deforestation rates.

Many companies that provide carbon credits to buyers work with physical asset holders and help them generate carbon reduction/removal, in turn creating carbon credits. This involves substantial evaluation of project sites, and often assistance to help the asset holders to optimize their assets' transition to carbon projects. Some companies limit their focus to a few carbon project types, given the expertise required for this evaluation and guidance. Others seek out and buy physical assets to develop into carbon projects owned and operated by the company, rather than working with third-party asset holders.

6: "Action Needed to Make Carbon Offsets From Tropical Forest Conservation Work for Climate Change Mitigation," Arxiv, Cornell University, Thales A. P. West, et al., n.d., accessed December 15, 2023.

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Carbon insurance

Awareness is growing that carbon credits might not deliver on their claims, and this presents a risk to buyers, which might suffer financial and reputational damage in addition to falling short in their decarbonization goals. Facing this risk, firms might opt for carbon credits they deem lower risk, such as those with more integrity data behind them or those based on carbon projects that are easier to quantify and validate. Another option is available via carbon insurance, which provides coverage of carbon credits in case of invalidation, whether due to catastrophic natural events, nonadditionality, over-crediting, or other causes. In the event of carbon credit invalidation, the buyer receives either financial compensation to purchase replacement credits, thereby maintaining their decarbonization position, or equivalent carbon credits. Alternatively, carbon credit sellers can also insure the credits they sell, thus increasing buyer confidence. Carbon insurance is a relatively new concept, though carbon insurance products are being developed both by existing insurance companies and startups such as Oka and Kita.[11, 12]

The current state of VCMs

The use of carbon credits into corporate decarbonization strategies has grown rapidly in the last two years.[7] Many of these companies are simultaneously developing decarbonization technologies to reduce internal emissions, but these technologies can take years to put in place. In the interim, carbon credits can be used to accelerate decarbonization and show early commitment to emissions reduction. In the longer term, many companies will continue to use carbon credits to decarbonize certain elements of their operations that are otherwise hard to decarbonize. High-profile carbon credit purchases include Microsoft's recent agreement to purchase 1.5 million tons of carbon removal credits from Mombak;[8] JPMorgan Chase's agreement to spend $200 million on carbon removal credits from both Climeworks and Charm Industrial;[9] and agreements from Stripe, Shopify, and H&M to purchase removal credits from a range of companies.[10]

Recently, trust in certain elements of VCMs has fallen, particularly around certain carbon credit types. Investigations from media outlets and academics into the carbon projects underlying credits showed that several projects—particularly those underlying nature-based carbon credits—did not represent the carbon reductions or removals they claim to, falling short in one or more of the evaluation categories (additionality, leakage, permanence, accurate quantification, and exclusivity). Firms risk reputational damage when using low-integrity credits, which can result in higher carbon emissions than the expected, reported figure.

Looking to avoid this risk, companies are taking care to avoid low-integrity carbon credits, whether by reducing use of carbon credits overall, choosing credits based on projects that are easier to prove integrity for, or choosing credits that have additional data available to support their carbon claims. Ultimately, many projects and credits are available to choose from, with varying levels of due diligence and data behind them. Uncertainty has favored high-integrity credits backed by data, and this benefits credit providers that focus on removal-based credits, those that have strong data collection and management capabilities, and companies providing dedicated MRV services.

7: "Net Zero Stocktake 2023," Net Zero Tracker, June 11, 2023.
8: "Microsoft Goes Big in Brazil's Voluntary Carbon Credit Market," Bloomberg, Peter Millard, December 5, 2023.
9: "JPMorgan Chase to Spend $200 Million on Carbon Dioxide Removals," Reuters, Susanna Twidale, May 23, 2023.
10: "Stripe, Shopify, H&M Spend $7 Million on Carbon Removal From a Dozen New Companies," CNBC, Catherine Clifford, September 7, 2023.
11: "Howden Offers First Insurance Against Fraud in Voluntary Carbon Markets," Reuters, Simon Jessup, Carolyn Cohn, and Susanna Twidale, September 6, 2022.
12: "Enabling the Offset; What Role Can Insurance Play in Offsetting Emissions," AXA XL, November 16, 2022.

Showcasing integrity

A core issue in VCMs is their unregulated nature, which has led to the establishment of multiple sets of standards for what constitutes high-integrity carbon credit. Though many of these share common themes, the specific metrics used and the weighting toward certain areas differ. This in turn creates confusion for buyers, requiring them to carefully evaluate the criteria and standards used by prospective carbon credit sellers.

In March 2023, the Integrity Council for Voluntary Carbon Market (ICVCM), an independent body seeking to create and maintain global standards for VCM integrity, published a new set of Core Carbon Principles (CCPs) for VCMs,[13] aiming to provide a fundamental set of international standards that others can follow to show the quality of carbon credits. Following this, the ICVCM announced ongoing collaboration with the Voluntary Carbon Markets Integrity Initiative, an independent initiative aimed at increasing VCM integrity. The ICVCM then published its full framework in July 2023, updating the previous documentation and adding criteria for assessing the categories of credits that should be approved to use the CCP label.[14]

These new standards are a potential answer to one of the core challenges VCMs face: a lack of standardization. If adopted, they could reduce the burden for carbon credit buyers, which otherwise must go to additional efforts to evaluate the standards used by carbon credit providers to ensure they do not face reputational risk from low-integrity credits.

The second element to showcasing integrity is in the development of data-capture technologies. Detailed MRV is increasingly necessary, whether through dedicated MRV technology developers or companies that incorporate internal MRV into their processes. Traditional MRV techniques for agricultural and nature-based carbon projects relied on ground surveying and sampling, which are costly to scale and do not translate well to all environments. Replacing and supplementing these techniques is a combination of remote sensing, drone and aerial surveillance, satellite monitoring, and AI technologies.

Soil carbon measurements for agricultural or nature-based carbon projects involve either in-ground sensors or scanning devices. Agrology develops in-ground sensors that are left in place for real-time soil monitoring, plus metrics such as moisture and temperature, whilst companies like Yard Stick and Carbon Asset Solutions develop scanning hardware that can be used to measure soil carbon over large areas.

Satellite and aerial imaging are also key components of MRV, and companies like CarbonCrop and CarbonFarm use AI to evaluate the data that this imaging produces, allowing ongoing monitoring of large project areas.

13: "Quality Standards to Hold Carbon Offsetting Industry Accountable," The Guardian, Patrick Greenfield, March 29, 2023.
14: "Global Benchmark for High-Integrity Carbon Credits Aims to Mobilize Climate Finance at Speed and Scale," The Integrity Council for the Voluntary Carbon Market, n.d. accessed December 15, 2023.

Select company highlights

Xpansiv

Founded: 2016

Employees: 277

Total VC raised: $703.0 million

Last financing: $525.0 million late-stage VC funding

Last financing valuation: N/A

Lead investor(s): Blackstone, The Goldman Sachs Group, Bank of America

California-based Xpansiv acts as an exchange for a range of climate-relevant commodities, including several types of carbon products, renewable energy certificates, low-carbon fuel certificates and contracts, and water entitlements/allocations. Its flagship carbon product is the Global Emissions Offset (GEO), which is traded on Xpansiv's exchange platform and represents a standardized offset contract, based on several underlying projects. In addition to the GEO, the company also offers more specific versions, including one that focuses on nature-based projects and one that aligns with the CCP set by the ICVCM. Xpansiv's platform and business act as an exchange for standardized environmental commodity products and operate a spot exchange in addition to futures contracts.

Founded in 2016, Xpansiv is one of the largest VC-backed VCM-focused companies, with $703.0 million raised to date. In January 2023, the company raised $525.0 million in late-stage VC funding in a deal led by Blackstone, The Goldman Sachs Group, and Bank of America. This is one of the largest deals in the VCM space and is Xpansiv's sixth VC funding round. PitchBook's VC Exit Predictor gives Xpansiv a 98% probability of a successful exit, with a 61% probability of an IPO and a 37% probability of an exit via M&A.

Earthly

Founded: 2018

Employees: 35

Total VC raised: $11.0 million

Last financing: $2.0 million in early-stage VC funding

Last financing valuation: $12.4 million

Lead investor(s): N/A

Earthly provides a project marketplace for environmental protection services, including both nature-based carbon and biodiversity credits. The company uses its own project assessment and scoring methodology, dividing criteria across three pillars: carbon, biodiversity, and people/social impacts. Buyers can review a project assessment report for each project that Earthly features, which are updated as new data is available, and Earthly's assessments are also shared with its project development partners to improve their existing and future projects. The company's dedicated biodiversity credits are much less common than carbon credits but can be used to demonstrate commitment to environmental protection and to reduce the impacts of the biodiversity crisis.

Earthly raised $2.0 million in early-stage VC funding in June 2022, its fifth VC funding round to date. PitchBook's VC Exit Predictor gives Earthly a 73% probability of a successful exit, with a 2% probability of an IPO and a 71% probability of an exit via M&A.

Sylvera

Founded: 2020

Employees: 172

Total VC raised: $97.7 million

Last financing: $57.3 million Series B

Last financing valuation: $187.8 million

Lead investor(s): Balderton Capital

Mast Reforestation

Founded: 2015

Employees: 87

Total VC raised: $73.4 million

Last financing: $30.0 million Series B

Last financing valuation: $165.0 million

Lead investor(s): Carbon Streaming

Sylvera

Sylvera provides ratings for carbon credit projects, assessing the likelihood that credits based on a given carbon project will deliver on their claims. These ratings are used to validate carbon credits and increase trust, thereby increasing buyer confidence. The company uses a range of data inputs into its ratings methodologies, including lidar data from ground, drone, high-altitude, and satellite sensors to measure variables such as forest biomass, canopy height, and tree cover. Due to the size of the datasets involved, machine learning is used to evaluate the data, and these outputs are checked against remote sensing data to ensure accuracy. Different carbon project types require different metrics to calculate useful ratings, and Sylvera uses different methodologies for each category of project, including REDD+; agriculture; reforestation/revegetation; carbon capture, utilization, and storage; direct air capture; cookstove improvement; and renewable energy.

Sylvera raised $57.3 million in Series B funding in July 2023, with a pre-money valuation of $130.5 million. PitchBook's VC Exit Predictor gives Sylvera a 96% probability of a successful exit, with an 8% probability of an IPO and an 88% probability of an exit via M&A.

Mast Reforestation

Based in Seattle, Mast Reforestation offers a range of services aimed at allowing landowners to restore their damaged land and generate carbon credits in the process. The company initially uses satellite imaging to map out the damaged land, and then creates a reforestation plan based on the site in question. After this, Mast Reforestation carries out site preparation and seedling cultivation, followed by planting and monitoring. The carbon benefits of reforestation are then measured and sold as carbon credits. Formed as a parent company of DroneSeed, with expanded reforestation services, Mast acquired Cal Forest Nurseries in March 2023, a major tree seed and seedling nursery in California.

PitchBook's VC Exit Predictor gives Mast Reforestation a 91% probability of a successful exit, with a 16% probability of an IPO and a 75% probability of an exit via M&A.