CARBONDIRECT

2022 Commentary on the Voluntary Registry Offsets Database (VROD)

Executive Summary

Corporations and other organizations are increasingly using carbon credits to offset greenhouse gas emissions as part of their climate goals. Voluntary carbon offset markets continued their growth in 2021, to over $1B[1] in traded credits annually, and volumes are expected to continue rising in coming years due to rapidly-proliferating climate commitments.

The Berkeley Voluntary Registry Offsets Database (VROD) collates data from the four major voluntary carbon offset project registries, representing over one billion tons of carbon offsets, to help provide transparency in this rapidly evolving market. Last April, our Commentary on the Release of the first Voluntary Registry Offsets Database outlined key trends in the voluntary carbon market (VCM) as well as points of caution about the quality of many credits in the market.

These concerning trends have continued in the year since; as low-quality project types grow in number, few developers have issued removal projects, and some parties are retiring credits from the oldest vintages of the surplus. Blockchain has only amplified these challenges over the past year, with the largest protocols retiring swathes of low quality or non-additional projects. Continuing quality issues within the VCM may undermine its ability to direct capital to impactful climate solutions. Left unchecked, this runs the risk of eroding both the confidence in the market and the speed at which the most effective solutions can scale to the gigatonne-level that we need as a global community to meet IPCC targets.

- **Very few credits are removals, and none are durable removals.** In terms of removal offsets, little has changed since 2020. Across 2021 and 2022 year-to-date, pure removal projects made up only 3% of all projects issuing credits, while mixed removal/reduction credits contributed 13% of projects issuing credits. Removals are required to reach major carbon goals, and only durable removals lasting thousands of years can effectively neutralize the impacts of anthropogenic carbon dioxide released into the atmosphere.
- **We saw the continued proliferation of risky project types.** In 2021, avoided deforestation and grid-scale renewable energy credits accounted for the majority of both issuances (71%) and retirements (74%). So far in 2022, this trend has continued in issuances (78%) with a decline in retirements (64%). While it is critical for the world to deploy renewables on a massive scale and to lower deforestation, these are often unreliable project types when it comes to offsets. In many cases, it is not clear that renewable energy credits are dependent

[1] Trove "Voluntary Carbon Market: 2021 in Review and 2022 Outlook", Ecosystem Marketplace report

on carbon finance to move forward, putting them at high risk of non-additionality. Risk is also high for avoided deforestation credits, which have to construct ambiguous counterfactuals about how much deforestation would have occurred without carbon finance (and often underestimate the amount of deforestation that occurs elsewhere as a result).

- **Buyers are purchasing older credits.** The average age of retired credits increased to 6.1 yrs in 2021 as compared to 4.7 yrs in 2019 and 5.3 years in 2020. In 2022 so far, this number has risen to an average of 7.3 years. Retirement of old credits, including avoided deforestation projects older than ten years and renewable energy projects as old as fifteen years, drove this increase. Older projects often come from less mature protocols, have weaker additionality claims, and drive less immediate climate impact.
- **Issuances outpaced retirements.** In 2021 suppliers issued nearly 300 Mt of carbon offsets, while retirers retired 161 M. This signal indicates that supply is growing faster than demand, but is complicated somewhat by nonretirement purchasing. We find that some buyers purchase credits for future use or reselling rather than for immediate retirement; as of April 2022, about half of 2020 purchases on the VCS remained unretired.
- **Blockchain-based applications are increasing low-quality risk.** Blockchain-related activity boomed in the past year. For example, the Toucan Protocol allows users to retire Verra credits and moves these credits onto blockchains. This new retirement type has driven significant retirement volume (representing ~40% of all retirements in Q4). Blockchain retirements in Toucan have been older credits (mean retirement vintage of 2012) and composed primarily of renewable energy and forestry (~78%) and include some instances of mass retirements of industrial manufacturing credits (including significant tonnage from a version of the HFC-23 protocol found to create perverse incentives). Rather than sourcing high quality credits, blockchain buyers have been retiring credit categories at most risk of being low quality.

These findings underscore challenges to a pressing demand. According to the IPCC, global emissions need to peak in the next several years and reduce roughly 43% by 2030 on a path to reach net neutrality by mid-century in order to keep global temperatures below 1.5C above pre-industrial levels. Importantly, and in contrast with the prior 2014 report by the same IPCC group, CO2 removal was declared essential to achieve these goals and for the first time recognized as a necessary complement to other climate mitigation actions.[2] [3]

The continued and expanded use of poor quality offset credits is causing the offset market to undermine these goals instead of being a powerful generator of finances towards achieving them. In 2022 and beyond, actors on the voluntary offset market must take actions to develop, issue, and retire high-quality carbon offsets and with renewed focus on shifting to durable removals. Given the growing urgency for effective carbon removal solutions, carbon offset projects on the voluntary market must shift towards high quality categories of projects, specifically removals with long-lived storage. Blockchain pioneers driving carbon offset demand must also be diligent in the quality of

[2] Friedmann et al., 2022, On the IPCC AR6 WGIII Report: Why Carbon Removal is an Essential Part of Meeting Climate Goals, Carbon Direct Perspective.
[3] IPCC Mitigation Pathways Compatible with 1.5C in the context of Sustainable Development

offsets used in commingled pools. In 2022 and beyond, voluntary offset market buyers, suppliers, and regulators must take actions to develop, issue, and retire high-quality carbon offsets to start reversing the trends we see in the market today of diminishing quality.

Database Orientation

The Berkeley Voluntary Registry Offsets Database (VROD) contains issuance and retirement data on the four major voluntary offset registries (Gold Standard (GS), Verified Carbon Standard (VCS), American Carbon Registry (ACR), and Climate Action Reserve (CAR)). The VROD also identifies active and planned California Air Resources Board (ARB) compliance offset projects. Importantly, the database excludes projects from the Clean Development Mechanism (which includes over 2 bn issuances and 4.5M cancellations, dwarfing the four included registries in issuances) and a longer tail of more nascent registries and protocols (Plan Vivo, puro, etc.)

VCS differs from other registries by allowing developers to issue partial credits per verified vintage. The Berkeley VROD makes VCS issuance comparable to other registries by reporting the total vintage quantity if any credits are issued for a successfully verified vintage. Except where noted, we use this value when referring to “issuances'' across all registries.

In our analysis, we have taken advantage of the VROD’s categorization of both California ARB and VCS issuance data. Where noted, we excluded California ARB eligible projects to focus on protocols used exclusively for voluntary commitments. ARB projects retired just over 60m tons in 2020 and 2017, the final year of each three-year compliance period.

1 - Developments in previously identified trends

Removal credits have not entered the market

As of April 2021, most carbon offset projects generated credits through emission reductions (e.g., renewable energy deployment) as opposed to through the removal of carbon from the atmosphere (e.g., direct air capture or reforestation). In all pathways to 1.5°C, the IPCC deems carbon removal projects necessary, sizing the need to between 100-1,000 Gt CO2 in the 21st century[4]; certain emission categories are expensive and difficult to abate, so net negative removal options are required to achieve net-zero[5].

The prevalence of reduction projects did not substantially change in 2021 and 2022 year-to-date, constituting over 80% of all projects issuing credits.

Figure 1: 2021 and Q1 2022 carbon offsetting project types, # of projects[6]

Furthermore, no projects issuing credits in 2021 and 2022 year-to-date offered removal credits with a low risk of reversal[7], which would include projects that have permanent geological sequestration. In last year's commentary covering 2020, we saw six projects issuing credits with lower-risk storage - all enhanced oil recovery projects, which are reduction projects with their own lifecycle accounting issues and a close association with production of fossil fuels. In the assessment of the health of the

[4] IPCC, 2022: Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development, Working Group III, Sixth Assessment Report.
[5] Oxford Principles for net-zero aligned offsetting
[6] Removals include only Afforestation/ Reforestation projects. Mixed includes Improved forest management, Wetland restoration, sustainable agriculture, compost addition to rangeland, REDD+, sustainable grassland management. Avoided/ reduced covers all else. Avoidance/reduction projects with higher-risk storage included avoided forest and grassland conversions.
[7] We define low risk of reversal as geological storage expected to endure on the scale of thousands of years.

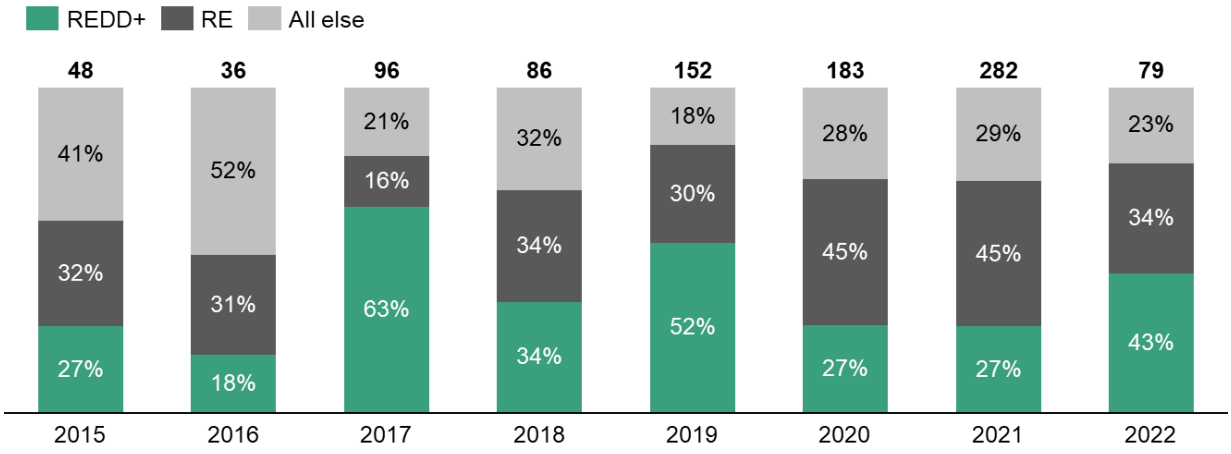
VCM, it is critical to consider one of the key criteria outlined above (durability) and any associated risk of reversal.

We do see removal credits with durable storage in other places in the market; carbon removal options are growing but not yet showing up on the major registries. Some have tracked public purchases of long-lasting, removal options[8]. Many of our clients choose direct procurement of non-registered credits when dealing with nascent technologies like direct air capture. Furthermore, new registries have begun to develop platforms for certifying other emerging technologies like biochar or soil sequestration. **As we approach 2030 and 2050, we must see more suppliers offer removals projects. Offset retirers must also adjust to match long-term climate requirements and preferentially purchase and retire removals.**

The two project categories (REDD+ and RE) with the largest issuances and retirements in 2021 have documented risks

Last year, our report found that 74% of all 2020 offset credits[9] were either forestry or renewable energy (RE) credits. In this analysis, we narrowed the scope to consider REDD+ and grid-connected RE, the most prevalent classes within forestry and RE. In 2021, we found that REDD+ and grid-connected RE made up the majority (71%) of all issuances. Similarly, REDD+ and grid-connected RE made up 74% of all 2021 retirements. Through 2022 year-to-date, we see these project categories at 77% of issuances and a decline in retirements with these project categories at 62% of retirements.

Figure 2: All issuances by credit type, Mt[10]

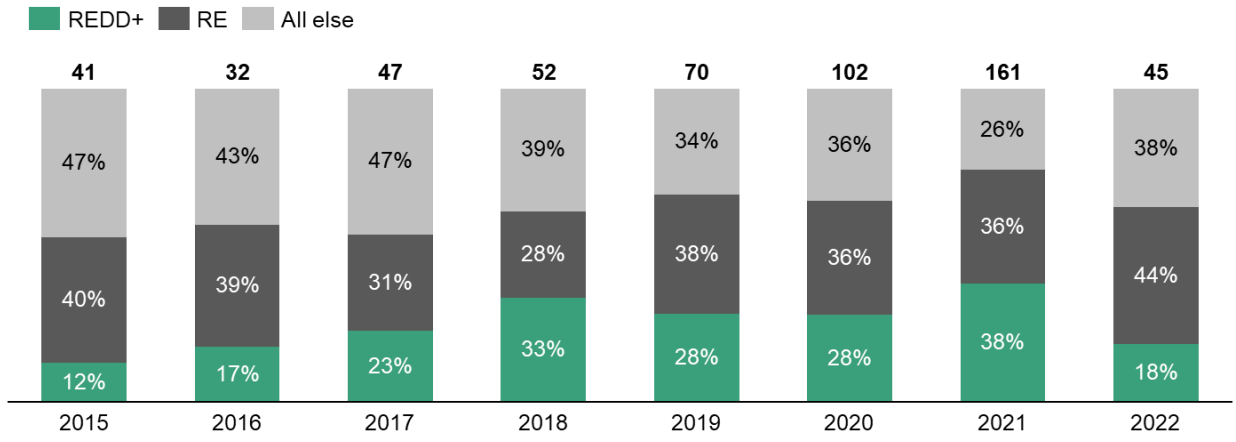


[8] List of known CDR purchases

[9] Issued through December 8, 2020.

[10] ARB credits excluded from analysis. ARB credits are largely (>80%) IFM and contributed to large retirement events in 2017 and 2020. Because these credits are used in the California compliance markets, we've excluded them from this look into credit composition in the VCM. Though some ARB credits are used for voluntary retirements, ARB credits accounted for ~.1% of all retirements in 2021.

Figure 3: All retirements by credit type, Mt[10]



The scale of renewable projects generating and retiring credits is cause for concern. As highlighted in our previous update, credits from renewable energy largely derive from utility-scale wind, solar, and hydro projects. A number of studies have called into question the additionality of these projects[11]. Studies have documented the inaccuracy of the financial and barriers assessments used to demonstrate additionality[12]. Assumptions used in financial assessments can be strategically chosen to show that cost effective projects are not cost effective, especially in the context of support policies and programs, and it is easy to document barriers even if they would not have prevented projects from going forward. As costs of wind and solar power decline and these technologies become even more cost competitive with conventional power, the financial additionality of these projects also weakens[13]. If credit generation follows the math on the lowering cost of energy, grid-connected renewable energy contributions to the VCM should decline over time, rather than increase to nearly half of issuances we saw in 2021.

Furthermore, forestry projects, predominantly REDD+ represented 30% of 2021 issuances. Analyses of REDD+ projects and protocols highlight the risk of over-crediting due to baseline uncertainties and risk of negative impact on smallholders which are the focus of most REDD+

[11] Cames, M., Harthan, R. O., Füssler, J., Lazarus, M., Lee, C. M., Erickson, P., & Spalding-Fecher, R. (2016). How additional is the Clean Development Mechanism? https://ec.europa.eu/clima/system/files/2017-04/clean_dev_mechanism_en.pdf
Fearnside, P. M. (2013). Credit for climate mitigation by Amazonian dams: Loopholes and impacts illustrated by Brazil's Jirau Hydroelectric Project. Carbon Management, 4(6), 681–696. https://doi.org/10.4155/cmt.13.57
Haya, B. (2010). Carbon Offsetting: An Efficient Way to Reduce Emissions or to Avoid Reducing Emissions? An Investigation and Analysis of Offsetting Design and Practice in India and China [(Doctoral dissertation) Energy & Resources Group, University of California]. https://escholarship.org/content/qt7jk7v95t/qt7jk7v95t.pdf
Haya, B., & Parekh, P. (2011). Hydropower in the CDM: Examining Additionality and Criteria for Sustainability (Energy and Resources Group Working Paper, ER-11-001). University of California, Berkeley.
He, G., & Morse, R. (2014). Addressing Carbon Offsetters' Paradox: Lessons from Chinese Wind CDM. Energy Policy, 63, 1051–1055. https://doi.org/10.1016/j.enpol.2013.09.021
[12] Cames, M., Harthan, R. O., Füssler, J., Lazarus, M., Lee, C. M., Erickson, P., & Spalding-Fecher, R. (2016). How additional is the Clean Development Mechanism? https://ec.europa.eu/clima/system/files/2017-04/clean_dev_mechanism_en.pdf
Haya, B. (2010). Carbon Offsetting: An Efficient Way to Reduce Emissions or to Avoid Reducing Emissions? An Investigation and Analysis of Offsetting Design and Practice in India and China [(Doctoral dissertation) Energy & Resources Group, University of California]. https://escholarship.org/content/qt7jk7v95t/qt7jk7v95t.pdf
[13] Reback, S., 2019. Solar, Wind Provide Cheapest Power for Two-Thirds of Globe. Bloomberg.

projects.[14]" Carbon Direct has seen similar risks of overcrediting in a high proportion of REDD+ forestry projects we have vetted due to baselines and leakage. Offset purchasers should vet REDD+ projects carefully and offset developers should design projects to avoid inadvertent harm or incorrect carbon accounting.

Our findings here on quality risks with the most prevalent project types on today's market echo findings of other efforts to track quality issues in carbon offset markets. Studies have found very high rates of over-crediting by all major offset programs that have developed offset protocols with credits available on the VCM, including the UN's Clean Development Mechanism[15], California's offset program[16], and a range of project types developed by the voluntary market registries, including soil carbon, improved cookstoves, and improved forest management[17].

Overall across the market, registries and offset suppliers need to tighten their standards to certify and create offsets credits with clear additionality and avoiding other carbon accounting issues. Similarly, offset purchasers should carefully vet offset projects and choose projects that demonstrate high quality standards.

The average vintage of credits has increased, driven by purchase of older credits

Retired credits have grown significantly older over the past two years, largely driven by the increasing retirement age of VCS projects in particular. Credits have risen from an average retirement age of 4.7 years in 2019 to 5.3 years in 2020 and again to 6.6 years in 2021. In 2022 so far, this average has risen to 7.3 years.

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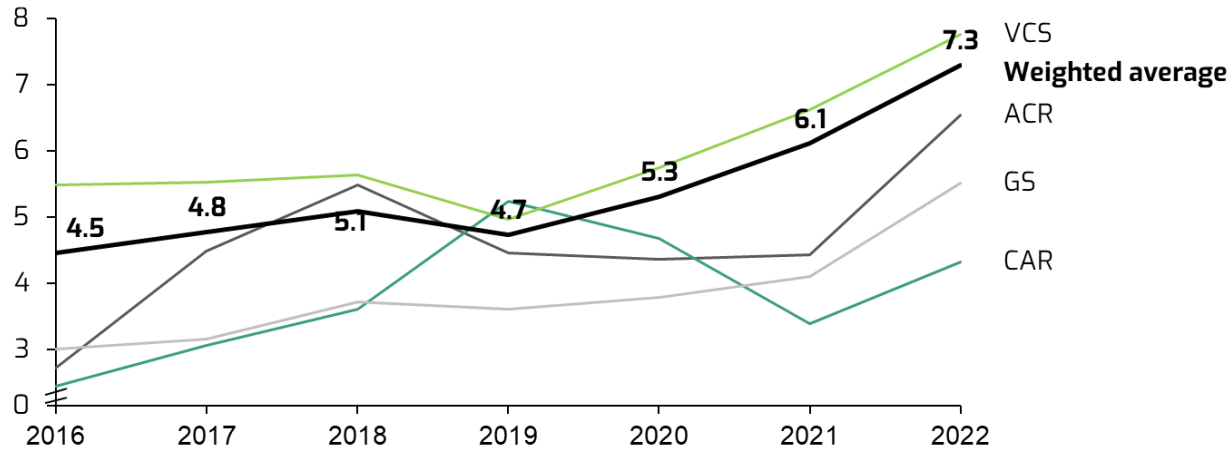
[14] Berk, N., & Lungungu, P. (2020). *REDD-Minus: The Rhetoric and Reality of the Mai Ndombe REDD+ Programme*. APEM & Rainforest Foundation UK. https://www.rainforestfoundationuk.org/media.ashx/redd-minus.pdf; Devine, J. (2014). Counterinsurgency Ecotourism in Guatemala's Maya Biosphere Reserve. *Environment and Planning D: Society and Space*, *32*(6), 984–1001. https://doi.org/10.1068/d13043p; Mertz, O., Grogan, K., Pflugmacher, D., Lestrelin, G., Castella, J.-C., Vongvisouk, T., Hett, C., Fensholt, R., Sun, Z., Berry, N., & Müller, D. (2018). Uncertainty in establishing forest reference levels and predicting future forest-based carbon stocks for REDD+. *Journal of Land Use Science*, *13*(1–2), 1–15. https://doi.org/10.1080/1747423X.2017.1410242; Milne, S., Mahanty, S., To, P., Dressler, W., Kanowski, P., & Thavat, M. (2019). Learning From "Actually Existing" REDD+: A Synthesis of Ethnographic Findings. *Conservation and Society*, *17*(1), 84. https://doi.org/10.4103/cs.cs_18_13; West, T. A. P., Börner, J., Sills, E. O., & Kontoleon, A. (2020). Overstated carbon emission reductions from voluntary REDD+ projects in the Brazilian Amazon. *Proceedings of the National Academy of Sciences*, *117*(39), 24188. https://doi.org/10.1073/pnas.2004334117.

[15] Cames, M., Harthan, R. O., Füssler, J., Lazarus, M., Lee, C. M., Erickson, P., & Spalding-Fecher, R. (2016). *How additional is the Clean Development Mechanism?* https://ec.europa.eu/clima/system/files/2017-04/clean_dev_mechanism_en.pdf

[16] Badgley, G., Freeman, J., Hamman, J. J., Haya, B., Trugman, A. T., Anderegg, W. R. L., & Cullenward, D. (2021). Systematic over-crediting in California's forest carbon offsets program. *Global Change Biology*, gcb.15943. https://doi.org/10.1111/gcb.15943; Haya, B. (2019). *The California Air Resources Board's U.S. Forest offset protocol underestimates leakage*. University of California, Berkeley. https://gspp.berkeley.edu/assets/uploads/research/pdf/Policy_Brief-US_Forest_Projects-Leakage-Haya_4.pdf

[17] Zelikova, J., Chay, F., Freeman, J., & Cullenward, D. (2021). A buyer's guide to soil carbon offsets. CarbonPlan. https://carbonplan.org/research/soil-protocols-explainer; Bailis, R., Wang, Y., Drigo, R., Ghilardi, A. & Masera, O. (2017). Getting the numbers right: Revisiting woodfuel sustainability in the developing world. *Environmental Research Letters,* 12(11). https://doi.org/10.1088/1748-9326/aa83ed; Van Kooten, G. C., Bogle, T. N., & de Vries, F. P. (2014). Forest Carbon Offsets Revisited: Shedding Light on Darkwoods. *Forest Science*, *61*(6), 370–380. https://doi.org/10.5849/forsci.13-183

Figure 4: Average years from vintage to retirement by registry



Credit age presents a challenge within the carbon market as older credits have a greater likelihood of disqualifying or low quality factors. Older projects that have operated without selling carbon credits bring with them the implication that carbon finance was not truly required to operate the project, and therefore purchases now would not create financial additionality. Furthermore, credits developed with older protocols may have been issued under less stringent requirements, or with a less developed understanding of the science involved[18]. Some advanced buyers also have a preference for newer vintages, given the more direct applicability to recent emissions. In addition, some standards, such as CORSIA and Article VI have specific vintage cutoffs; for example, to apply offset credits against your CORSIA obligations they must be issued at least at a vintage of 2016.

Moreover, the carbon offset market should seek to facilitate real climate impact by driving capital to new carbon projects - if older credits make up the bulk of retirements, it is a signal the market is failing to develop and scale the carbon solutions that we need to meet our climate goals.

Suppliers should develop new carbon offset projects that generate climate impacts, and offset retirers should seek to retire newer projects in order to drive greater additionality and higher quality carbon offsetting projects.

2 - Issuances outpace retirement and blockchain impacts

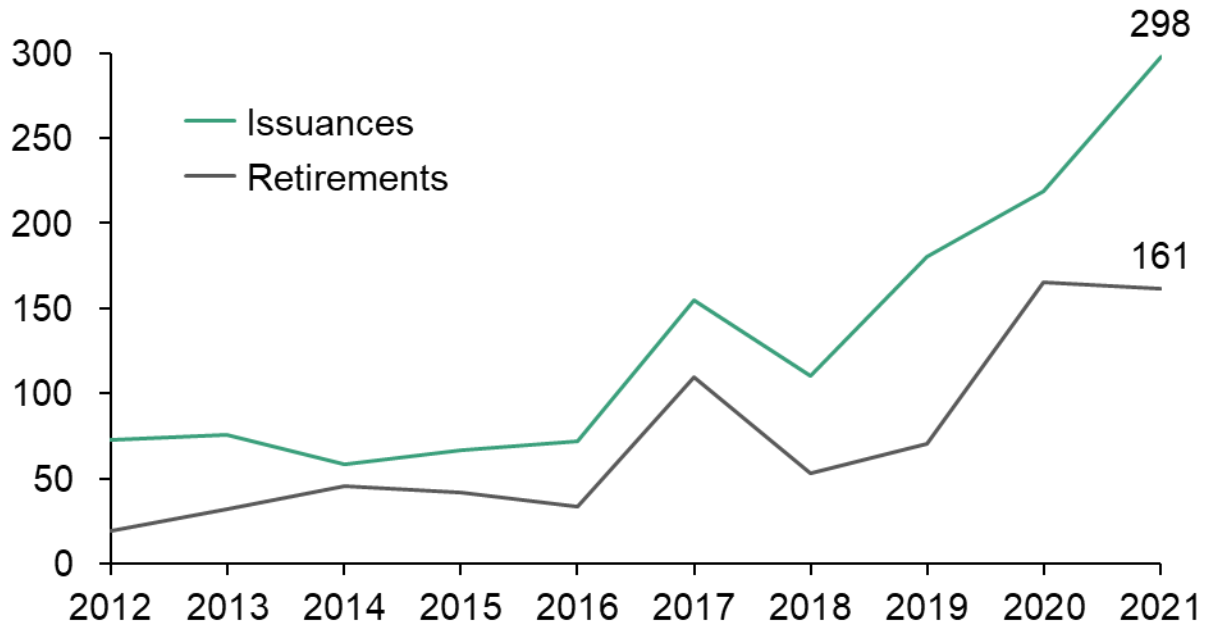
Issuances continue to outpace retirements and we observe nonretirement purchasing

Overall, issuances have continued to outpace retirements - meaning that overall carbon offset supply has grown faster than demand. In 2021, we saw nearly 300 Mt of offset issuances, with only

[18] https://e360.yale.edu/features/is-the-legacy-carbon-credit-market-a-climate-plus-or-just-hype, https://www.nature.com/articles/s41558-019-0415-y

161 Mt of offset retirements. Issuances continuing to outpace retirement comes in spite of rapidly increasing demand signals from the market.

Figure 5: Issuances vs. retirements, Mt/ year



However, more purchasing occurs than what is reflected in the retirement data. While registry retirement data can serve as a demand signal, information in the VROD indicates that many purchased credits are not used for retirement.

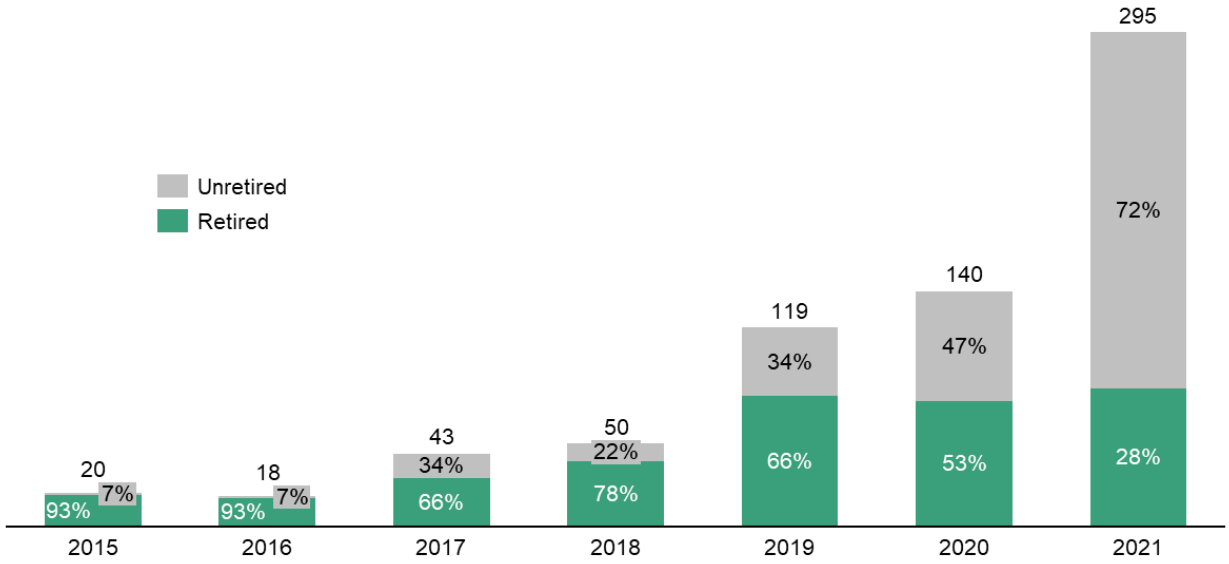
Due to the opaque nature of carbon offset trading, it is relatively difficult to track if registered credits are purchased; registries do not track when credits change hands, only when they are retired. However, Verra's approach to accreditation provides additional transparency; the registry charges suppliers a cost on a per-credit basis (rather than per MRV issuance), and allows partial accreditation of projects. The VCS platform therefore incentivizes developers to issue partial vintages of credits just before they sell them. As a result, it's likely that all or almost all credits listed as "issued" on the VCS registry have been purchased from the developer. This creates an opportunity to examine the volume of non-retired, purchased credits by assessing the pool of credits that have been issued but not retired within VCS. It is important to note that the "missing" issuances due to this method are included in preceding charts. The following discussion will isolate the analysis to those credits listed as "issued' by VCS itself, and not the VROD's displayed issuances[19].

[19] VROD displays VCS issuances based on MRV history in order to make 1:1 comparisons to other registries.

Given Verra has so far issued ~60% of all issued credits on the VROD, an analysis on VCS credits alone provides significant insight into purchasing dynamics as a whole in the VCM.

Unretired purchases are, in-year, the majority of 2021 purchases in VCS. Furthermore, about half of credits issued in 2020 remain unretired.

Figure 6: VCS purchases by retirement status, Mt



Although this data is only available for the VCS registry, the results show that actual purchase demand for credits across the VCM outstrips retirement volumes; buyers or intermediaries are purchasing credits but not retiring them.

It is important to note here that non-retirement purchases may be made for a variety of reasons, and likely involve a number of types of market actors. This type of purchasing includes a broker purchasing credits to secure supply for the upcoming year. It also includes corporate buyers purchasing for their 2022 commitments that have not yet retired their purchases. It may be large, well-capitalized buyers - both corporate buyers or financial institutions - securing and holding credits to either hedge against a potential upswing in price or with a view that the credit can be resold at a higher price for a profit.

The ramp in non-retirement purchasing while issuance continues to outpace retirement demand points to a number of potential possible outcomes depending on the rationale for non-retirement. If issuances continue to outpace retirement demand from compliance and corporate retirement, it's possible the value of purchased credits would drop as supply continues to exceed demand. However, if retirements grow to exceed issuances and the supply of available carbon credits dwindles, the value of purchased credits are likely to rise.

No quality issues necessarily arise from the volume of unretired purchasing, but the volume of these purchases highlights that retirement volumes on the VROD are not the sole demand signal to pay attention to.

Users of Toucan Protocol, the largest platform for tokenized carbon offsets, have retired 20M+ tons of offset credits from VCS, representing a new type of high-volume demand

Blockchain-based applications claiming to focus on climate and ESG benefits have added demand for credits in the VCM during 2021. Frequently, these projects attempt to connect capital from blockchain networks like Polygon to environmental benefits by using carbon credits as a proxy for positive environmental outcomes. The volume of demand they are adding for carbon offsets in the VCM make them a key topic of discussion for 2021 developments in the VCM.

Recent articles have highlighted examples of these projects delivering fewer environmental or carbon-reducing benefits than they claimed[20]. Simply using public blockchains to track carbon offsets do not provide any direct environmental benefits–these benefits are delivered entirely by associated CO_2 removal or reduction projects. However, the idea of using blockchain ledgers for tracking carbon credit issuance and retirement has been explored from groups ranging from the World Bank to these more decentralized, crypto-native applications.

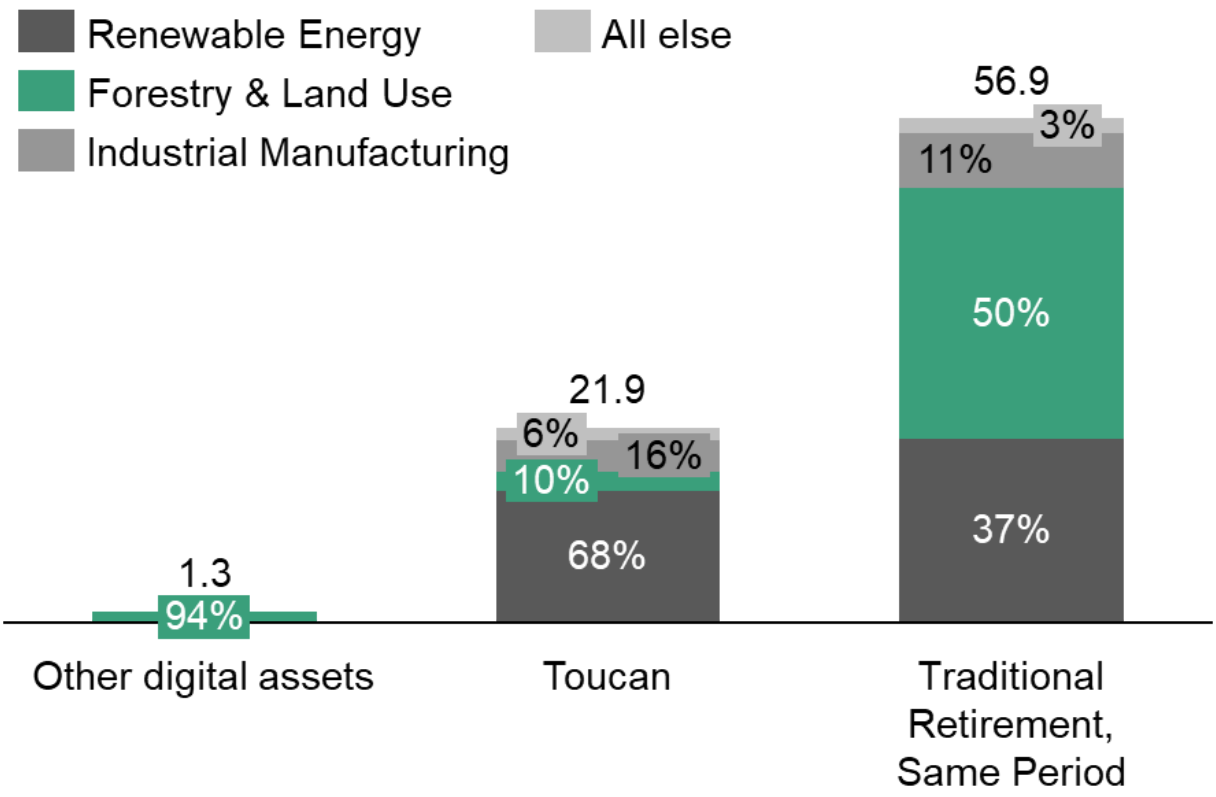
Toucan Protocol users have led this on-chain carbon demand, purchasing 4.6% of Verra's registry between Q4 2021 and Q1 2022. Toucan's protocol allows users to purchase Verra offsets, bridge them to the Polygon blockchain, and then represent them on-chain as fungible tokens that can be used by any application building on top of the network.Toucan launched its protocol in mid-October, and by the end of 2021, users had purchased and retired 16.63 million tonnes from Verra registry. As of this writing, Toucan protocol users are responsible for bridging over 21.9 million tonnes. When users bridge credits by the Toucan protocol, the credits are retired on the Verra registry.

The chart below compares the types of Verra projects that have been bridged or retired in 2021 by Toucan users, other digital asset market participants[21],and traditional participants during the period in which Toucan launched.

Figure 7: Retirements by source and project type in Q4 2021/Q1 2022 on Verra

[20]Crypto bubble: The hype machine behind a $70,000 carbon credit; The Biggest Crypto Effort to End Useless Carbon Offsets Is Backfiring;Zombies on the blockchain

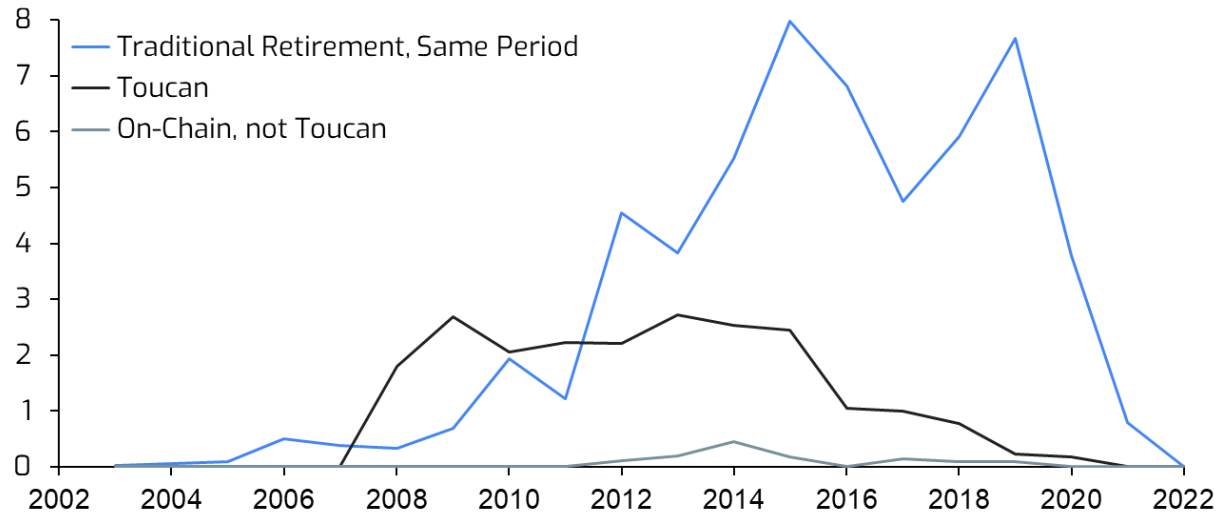
[21] Identified in retirement details or as the retirement beneficiary.



Toucan users have retired 21.9 MT of carbon credits, compared to a total of 56.9 MT of carbon credits retired by traditional users during the same six-and-a-half-month period. Relative to traditional retirements, Toucan users had a greater preference for retiring Renewable Energy and Industrial Manufacturing credits, totaling 14.8 Mt and 3.5 Mt tons, respectively. This represents 42% of all Renewable Energy credits retired in that time period. These projects have the same issues covered in the previous sections on additionality.

While demand for carbon credits for use on blockchain is relatively new, the approach taken by bridging protocols like Toucan bear similar issues to the criticisms we leveled in Part 1 of this document. Because they optimize for secondary liquidity of the tokenized carbon credits, there is a willingness to commingle carbon sourced from a wide spectrum of project types, with a range of project qualities, in particular, those stemming from carbon avoidance projects or older vintages. Rather than helping promote high quality carbon solutions, as proponents claim, the data suggests that Toucan has facilitated the greenwashing of otherwise unattractive offset sources present within the VCM.

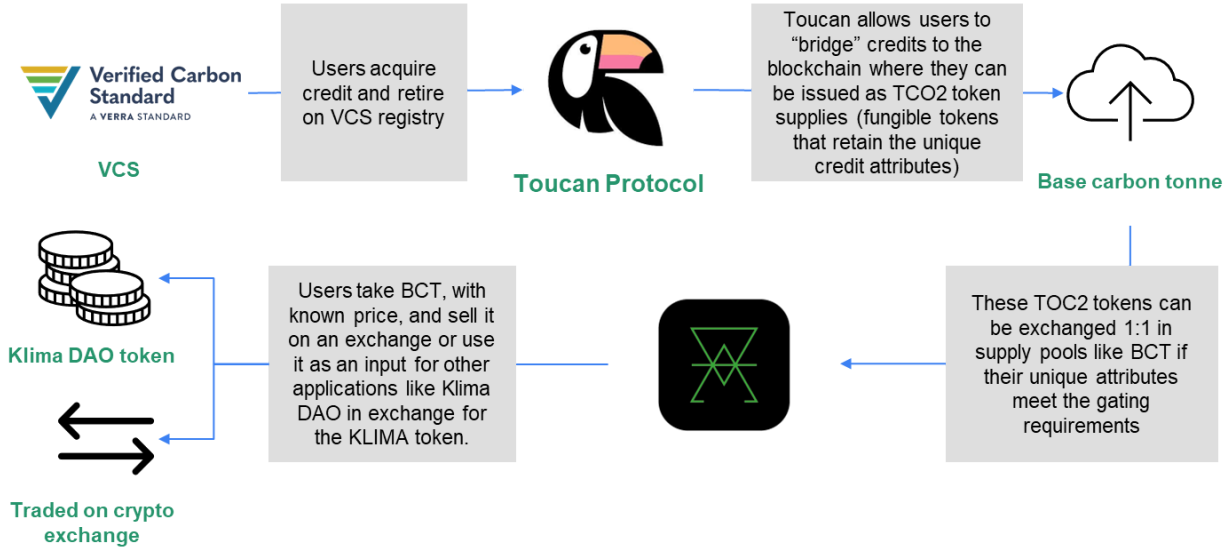
Figure 8: Retirement demand by vintage and category over Q4 2021/ Q1 2022, Mt



Relative to traditional retirement uses, Toucan users retired older vintages, with a mean the most frequently retired vintage age 2009, compared to the more frequently retired vintage ages of 2015 and 2019 for traditional retirement demand in the same time period. The other non-Toucan retirements more closely resemble the vintages used by traditional retirements.

The preference for older vintages and Renewable Energy and Industrial Manufacturing project types Toucan is driven by the largest demand segment, Klima DAO. Klima DAO is a non-discriminating buyer of tokenized carbon credits that allows users to sell fungible tokenized carbon credits like BCT to their treasury as the value backing their KLIMA token. The rate Klima DAO purchases more carbon credits dictates how quickly they can issue rewards to existing token holders. Purchasing large volumes of credits is necessary for maintaining a high rate of rewards back to the token holders. Klima DAO launched in tandem with Toucan in mid-October 2021 with few restrictions on accepted credit project types and vintages and has driven most of the 2021 demand for the Toucan Protocol bridge. How Klima acquired carbon credits from users bridging Verra credits on Toucan is as follows:

Figure 9: Illustrative flow for typical VCS credit to Klima token



Given the bare minimum requirements on what types of carbon offsets would be accepted for BCT and the demand for credits from Klima users, some users bridged Chemical Process credits like HFC-23 projects, a methodology Verra stopped approving or accepting new projects for in 2014 due to concerns that it was creating perverse incentives[22]. After over 500,000 credits from HFC-23 projects were bridged, Toucan responded to concerns about these credits in December 2021 by blocking this methodology from being bridged or accepted for BCT. While this represents progress from an extremely low bar, Toucan's subsequent purchases have done nothing to improve quality on the market. In the database, we found over 870,000 tons of these HFC-23 projects retired on behalf of Toucan. These credits that were bridged prior to being banned remain in the system and can be exchanged for one tonne of carbon in the on-chain application ecosystem[23].

This digital asset market has broadened audiences for the VCM while also simplifying exchange and purchase, with a net effect of driving larger demand. However, the source of this demand has largely drawn from categories with questionable additionality claims, facilitating a predictable race to the bottom in terms of bridged credit quality. In 2022, Toucan has launched a second pool for fungible tokens called Nature Carbon Tonnes (NCTs), accepting only nature-based credits like Forestry and Land Use projects with a 10-year rolling vintage cut off[24]. Since the launch of NCT in mid-February, forestry and land use projects still remain a small proportion of the types of credits that have been retired and bridged from Verra's registry by Toucan users.

A Toucan core-team member has also proposed increasing the cutoff year for the Base Carbon Tonne pool to 2012 or 2014 in a community governance forum as a way of improving on-chain credit quality[25]. In 2022, we actually observed a decrease in the most frequently retired vintage age relative to Toucan user's retirements at the end of 2021, from 2014 to 2010. Finally, even if there

[22] https://verra.org/major-win-climate-voluntary-market-closes-door-hfc-23-projects/
[23] https://docs.toucan.earth/protocol/bridge/carbon-bridge/blocklist
[24] https://docs.toucan.earth/protocol/pool/pool-parties/nct-pool-party-report
[25] https://governance.toucan.earth/t/increase-quality-of-the-base-carbon-tonne-bct/39

was an increase on the vintage cutoff for BCT pool, the aforementioned older vintages or lower quality sources will remain available for trading on-chain.

If public blockchain networks are to be an effective long-term tool in managing carbon, the approach must evolve to ensure that carbon offsets involved are of high quality. The retirements recorded in the database indicate issues in the age and type of credits demanded by these new market participants. Pioneers in this category must start seriously acting on improving credit quality they accept in commingled pools. It is currently driving significant capital to non-additive carbon projects.

3 - Looking ahead: how to improve the VCM to support global climate goals

The voluntary market has seen rapid growth, but remains plagued by systemic issues in project quality and vintage demand. With deep penetration by controversial credit types, aging vintage retirements, and slow uptake of removal credits, there is evidence that the VCM currently trends away from high quality as a group. This does not undermine the existence of high-quality projects on the VCM, but does indicate a trend on the overall market.

Carbon removal is recognized by the IPCC as **essential in all pathways to a 1.5C world**. Many nascent removal pathways require offset credit revenues to drive their economic feasibility; continued access to these revenue streams require customer faith in the offset system. If the market breeds widespread distrust due to quality concerns, carbon markets cannot operate. An offset market based on poor quality credits will erode the VCM's long-term ability to turn voluntary purchasing into an engine for effective carbon management.

In order to support the growth of a robust VCM that will help us reach our climate goals:

- We must see protocols and registries on the VCM adapt to provide a platform for nascent removal offset categories. Furthermore, offset retirers must also adjust to match long-term climate requirements by seeking to retire more removals with long-term durability.
- Registries and offset suppliers need to tighten their standards to certify and create offsets credits with clear additionality, while avoiding other carbon accounting issues. Similarly, offset purchasers should carefully choose projects that fulfill high-quality standards.
- Offset developers should develop new carbon projects that generate climate impacts and retirers should seek to retire newer projects in order to drive greater additionality and higher quality carbon offsetting projects.
- Pioneers in blockchain retirements must improve the credit quality they accept in commingled pools, so as to not support non-additive carbon projects.

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