



Microsoft carbon removal

An update with lessons learned
in our second year

March 2022

Contents

Foreword	3
Introduction	4
Lessons learned in our second year	6
FY22 additions to our carbon removal portfolio.....	13
Low-durability solutions	17
Medium-durability solutions	20
High-durability solutions.....	21
Looking ahead	22
Acknowledgments.....	24

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Foreword

The burden of climate change is affecting regions around the world more clearly with each passing year, including an increase in the magnitude and frequency of physical climate impacts. The Pacific Northwest—home to our Microsoft headquarters—was hit in 2021 by a punishing heat wave, a spate of wildfires that devastated surrounding forests, and a deluge of rain causing floods and mudslides. Research indicates that the Pacific Northwest heatwaves “[would be virtually impossible without human-caused climate change.](#)”

The global climate reality is sobering. And yet, we have reason for hope:

- There is increased corporate momentum on carbon reduction commitments.
- Demand for carbon removal has never been higher and is growing rapidly.
- In November 2021, COP26 created greater clarity on [Article 6](#), setting out rules for international trade of carbon credits. Global leaders must be vigilant to ensure that the framework delivers climate outcomes, but this advancement was critical.
- In that same month, US President Biden signed into law the bipartisan US [Infrastructure Investment and Jobs Act](#), which includes funding for investments in both natural and technological carbon removal.

Although much remains to be done in both the global and US settings to ensure high-quality carbon removal markets can fulfill the promise of recent climate commitments, these are encouraging milestones.

At Microsoft, we are focused on becoming carbon negative by 2030—prioritizing carbon reductions first, with carbon removal as a critical second component to our strategy. In the coming year, we will focus even more deeply on our dual mission to make deep cuts in our value chain emissions and help scale the market for carbon removal technologies. This paper reflects our candid reflections on lessons learned as a large buyer in this emerging market.



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Introduction

For Microsoft, both carbon reduction and carbon removal are pivotal to achieving [our commitment to be carbon negative by 2030](#). Carbon reduction remains first and foremost in our strategy, and we will only use carbon removal to address any remaining unavoidable emissions.

We strongly believe that addressing the climate crisis requires us all to collaborate and share information to help the world move as quickly as possible toward climate solutions. In January 2021, we published [our first carbon removal white paper](#), communicating our approach and what we learned during our inaugural carbon removal request for proposals (RFP).¹ In September 2021, we shared further observations in a [Nature comment](#).

In this follow-up paper, we provide an update on our second year of progress. We describe our top learnings—from the lack of common standards to the high prices and supply shortage for high-quality removals (with implications for meeting both current and future demand). We also share details on FY22 additions to our carbon removal portfolio.

Global context: a “code red for humanity”

The urgency of scaling the carbon removal market has only increased over the past year. An [August 2021 report from the Intergovernmental Panel on Climate Change \(IPCC\)](#) paints a stark picture and has been called a “[code red for humanity](#)” by the United Nations Secretary-General. The IPCC report reinforces the need for the world to remove on the order of 10 gigatons of carbon dioxide annually in the second half of this century—and to make rapid progress today. Crucially, this must be in tandem with, and not as a replacement for, unprecedented carbon emissions reductions.

In November 2021, Microsoft served as [Principal Partner for COP26](#). One important outcome of the conference was the advancement of [Article 6](#), which provides the option for countries to voluntarily trade credits generated through emissions reduction and removal projects. Article 6 has the potential to be an important driver of climate finance, clean energy development, and carbon removal advancement. However, global leaders must be vigilant to ensure that it delivers meaningful climate outcomes and does not inadvertently drive unnecessary administrative complexity or greenwashing.

¹ We hope that [our first carbon removal white paper](#) offers a valuable foundation for anyone exploring this rapidly developing area.

At COP26, the strength of private sector support for meaningful climate action was unprecedented. We heard widespread acknowledgement that reaching net-zero carbon emissions by mid-century will be critical to avoiding a climate catastrophe—and that carbon removal is a crucial, urgent part of that path. Many companies are already acting, seeking removals right now or citing removals as an important part of their long-term climate strategies. These include [Carbon Direct](#), [GlaxoSmithKline](#), [JPMorgan Chase](#), [Mars Company](#), [Meta](#), [Nestlé](#), [Netflix](#), [Salesforce](#), [Shopify](#), [Stripe](#), [Swiss Re](#), and others.

With more companies setting climate commitments every week, we believe that it is increasingly important for early actors such as Microsoft to convey our perspective on what it means to drive meaningful, measurable climate outcomes. We hope this paper will contribute to that conversation.

Lessons learned in our second year

Highlights of our lessons learned

1. The market lacks strong, common definitions and standards. We have developed and communicated our own criteria, and other corporate buyers have done the same. This means that organizations are working in isolation and tracking outcomes in different ways that can't be compared easily. This leads not only to inefficiency but also to inconsistencies in claims.

[Jump to section >>>](#)

2. High-durability solutions are critical, but supply is limited and expensive, and many companies cannot yet afford them at scale. We need expensive, higher durability solutions to become more affordable. Multiyear demand commitments, direct investment, and supportive policies are all critical to drive costs down. [Jump to section >>>](#)

3. Forestry and soil carbon removal face sobering challenges in quality but offer short-term climate value and co-benefits beyond carbon removal. Challenges with nature-based solutions underline the fact that removal is not a uniform commodity that can be compared easily across project types. However, we believe that corporate support for nature-based carbon removal remains essential. We have taken critiques of nature-based solutions seriously and developed our own approaches to mitigating risk with these project types. [Jump to section >>>](#)

The following sections provide a deeper look at these learnings, including a specific call to action for each, reflecting the key steps we believe are required to help foster and grow the carbon removal market.

The market lacks strong, common definitions and standards

One of our key learnings from last year was that no consistent set of standards exists for measuring, verifying, and reporting carbon removal. Removals are not consistently distinguished from offsets that cover avoided or reduced emissions, particularly in the most widely used standards. Moreover, different credit systems

make very different assumptions about the durability (the time that carbon dioxide will remain sequestered from the atmosphere—critical to net climate value) of different solution types.

Removals are not consistently distinguished from offsets that cover avoided or reduced emissions, particularly in the most widely used standards.

Due diligence in the absence of common standards is a heavy burden for corporate purchasers—especially with nature-based solutions, for which it is complicated to prove that carbon removal outcomes are happening. Without clear standards to guide us, we have developed our [own criteria](#), and other organizations have done the same. Not only does the lack of standards to assess carbon removal projects dampen our confidence as we research potential purchases, but it also means that each organization is effectively working in isolation, tracking outcomes in different ways that cannot be easily compared. This is inherently inefficient and introduces the risk of inconsistent claims.

For example, as the [Environmental Defense Fund \(EDF\) reports](#), soil carbon sequestration has the potential to play a valuable role in carbon removal, but lack of standards means that different projects measure, report, and verify their net climate impact differently. This undermines comparability and causes uncertainty for buyers. Moreover, a [CarbonPlan](#) review of common protocols for soil carbon sequestration concludes that none of the protocols can guarantee good climate outcomes, which means buyers must assess individual projects themselves.² Lawrence Livermore National Laboratory (LLNL) explores this topic more fully in [Carbon Negative by 2030: CO₂ Removal Options in the US for an Early Corporate Buyer](#).³

In this context, we are actively advocating for stronger standards. In May 2021, we responded to a request for public comment by the U.S. Department of Agriculture (USDA) on its climate-smart agriculture and forest strategy, calling out the important role that the USDA can take to help address three challenges with nature-based carbon removal: lack of high-quality standards, lack of clear accounting rules, and the need to significantly scale high-quality carbon removal. In August 2021, we also provided input to a European Commission (EC) survey to assess design options for a European Union (EU)–wide carbon removals certification mechanism. We used the opportunity to highlight our perspective that a mechanism could, for example, help ensure strong benchmarks for measuring carbon removal solutions, avoid potential negative externalities (or minimize their impacts), avoid double counting, and promote additionality.

² Microsoft funded CarbonPlan to conduct this review.

³ Microsoft funded LLNL to conduct this study.

Current international policy dynamics create further ambiguity on these topics, as the Article 6 agreement at COP26 left many unanswered questions and laid the task of defining high-quality carbon removal to future working groups. This means that global leaders will now need to build the rulebook for carbon markets, and success will require deep oversight and strong accountability. Strict accounting, governance, contracting, and performance protocols for international trade may take years to complete and even longer to gain wide international acceptance.

CALL TO ACTION:

Corporate purchasers should support strong voluntary standards that adhere to the clearest and latest science and actively advocate for governmental and intergovernmental organizations to adopt a role of independent oversight of carbon removal quality.

High-durability solutions are critical, but supply is limited and expensive, and many companies cannot yet afford them at scale

High-durability solutions—such as carbon mineralization and direct air capture—are those that sequester carbon dioxide for millennia, making them effectively permanent carbon removals. These high-durability, technology-based solutions generally do not present as high a risk of reversal as natural solutions (such as the risk of a wildfire destroying a forestry project). But these solutions are also currently in very short supply and unaffordable for many companies, costing hundreds to thousands of dollars per ton. For our part, Microsoft uses an internal carbon fee that we charge to our business groups to subsidize our carbon removal purchases. But even with these funds, high costs and limited supply mean that high-durability solutions make up only a small fraction of our current portfolio.

One way to help jumpstart affordable supply is for corporate buyers to sign multiyear purchase agreements, as [Swiss Re and Climeworks did](#) in August 2021. This type of contract is analogous to renewable energy power purchase agreements, which Microsoft and other corporate energy buyers have signed over the past decade and which have helped to accelerate mainstream renewable energy supply and adoption. We are actively exploring and soliciting opportunities for multiyear carbon removal purchase agreements.

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Microsoft further helps to develop projects through capital investments via our Climate Innovation Fund. One example is that [we are both a customer of and investor in Climeworks' direct air capture business](#), intending to help them scale their first-of-a-kind commercial-grade, fully renewable carbon removal and mineralization model. We have also made [a \\$100 million grant to Breakthrough Energy Catalyst](#) to accelerate the development of technology solutions needed to reach global net zero, including direct air capture.

We also advocate for government action to create a healthy enabling environment for high-durability solutions. In January 2022, we responded to a request for information from the U.S. Department of Energy (DOE) on carbon removal with comments on the criticality of federal support for these solutions.

As mentioned earlier, we funded Lawrence Livermore National Laboratory (LLNL)—a US government lab—to complete a study of projected carbon removal supply across leading project types in the United States for the year 2030. The LLNL study found that the projected available volume of removal in the United States in 2030 could far exceed our own individual needs and that the scalable removal solutions for 2030 are likely already piloted today. But key questions remain on how quickly the high-durability removal costs will decline and whether the global volume of these solutions will meet the planet's collective needs.

CALL TO ACTION:

Corporate buyers should pursue multi-year purchase agreements, investments, and policy advocacy to help develop affordable high-durability removal.

Forestry and soil carbon removal face sobering challenges in quality but offer short-term climate value and co-benefits beyond carbon removal

Natural solutions currently dominate the carbon removal market—they are the most readily available, at the lowest cost, and remain the mainstay of current carbon markets. However, they are also the most vulnerable to climate risks and human disruptions. We saw this firsthand when a wildfire burned part of a forest carbon project from which Microsoft purchased credits in 2020. This risk of reversal (stored carbon being released back into the atmosphere) is just one underweighted risk of natural solutions; other inherent concerns include greater

risk of leakage (for example, shifting emissions from one timber market to another) and systemic issues such as weak additionality and questionable baselines (true of both forestry and soil projects).

Corporations should especially take caution to ensure sound ecological design of reforestation projects. We are working to incorporate principles such as the Kew 10 golden rules for restoration into our program.⁴

Kew 10 golden rules for restoration

An international group of scientists, led by the Royal Botanic Gardens, Kew, and Botanic Gardens Conservation International (BGCI) have set out [10 golden rules for restoring forests](#), with the aim of protecting biodiversity and removing carbon from the atmosphere to help fight climate change:

1. **Protect existing forest first**—by creating more protected areas and limiting deforestation.
2. **Work with local people**—helping ensure long-term success and the equitable sharing of benefits.
3. **Maximize biodiversity recovery to meet multiple goals**—by restoring native forests.
4. **Select the right area for reforestation**—by planting on previously forested land, not non-forested lands like natural grasslands or wetlands.
5. **Use natural forest regeneration wherever possible**—making it more affordable and effective on some sites.
6. **Select tree species that maximize biodiversity**—using a mix of mainly native species, including rare and endangered species where possible.
7. **Use resilient plant material that can adapt to a changing climate**—by selecting seeds and seedlings that are genetically diverse and sourced from regions that match current and projected environmental conditions.
8. **Plan ahead**—starting early, using appropriate local infrastructure, and providing relevant training to project teams.
9. **Learn by doing**—consulting existing knowledge and running small-scale trials before starting a project.
10. **Make it pay**—for example, by generating income from carbon credits, sustainably produced forest products, and/or ecotourism.

⁴ Republished here with permission.

Despite these cautions, short-term nature-based carbon removal *can* provide important climate and social benefits, helping to decrease peak warming (provided that the world achieves deep decarbonization)⁵ and build local resilience to climate change impacts (for example, helping prevent erosion and flooding with forest and soil restoration and providing coastal storm buffers with mangroves). As a result, we believe that corporate sustainability programs should not pull back on investing in nature but rather make investments with greater awareness, a deeper commitment to improving standards and safeguards, and transparency about actual management and outcomes.

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At Microsoft, we apply internal deductions to projects that have shortcomings but otherwise deliver clear carbon removals. For example, in a hypothetical project in which we detect an issue of questionable carbon baselines, we might deduct 10 percent of the credits we purchase and only count 90 percent against our internal footprint. This does lead to a higher effective price per ton for some projects. As clearer standards permeate the market in this decade, we expect to make fewer such internal deductions.

On another front, guaranteed durability terms tend to be quite short in many soil carbon projects. We would be interested to see a contractual innovation to extend durability, such as deeper risk pools or a rotating carbon facility whereby new enrollments replace old enrollments.

Finally, we also prioritize nature-based projects that advance environmental justice, sustainable livelihoods, and climate goals in tandem. The CommuniTree Carbon Program, Acorn, the TIST Program in Kenya, Jubilación Segura, and Delta Blue Carbon – Phase 1 projects are examples in our current-year portfolio.⁶

⁵ Matthews, H. D., Zickfeld, K., Dickau, M., Maclsaac, A., Mathesius, S., Nzotungicimpaye, C., & Luers, A. In Press. "Temporary Nature-based Carbon Removal Can Lower Peak Warming in a Well-below 2° C Scenario." *Nature Communications Earth & Environment*.

⁶ As part of our criteria for high-quality carbon removals that we published with Carbon Direct in July 2021, we specifically identified [criteria for environmental justice](#) that we use to assess project proposals.

CALL TO ACTION:

When buying credits from nature-based removal projects, corporate buyers should educate themselves about both the risks and the benefits of such projects, advocate for higher standards, and be transparent about their project outcomes.

FY22 additions to our carbon removal portfolio

In response to our FY22 RFP, we received proposals from 67 applicants representing approximately 106 projects in 35 countries. This was considerably fewer than we received for our FY21 RFP, for which there were 79 applicants representing 189 projects. We believe the lower response rate reflects our clearer criteria this year, greater supplier awareness of the distinction between carbon removal and carbon avoidance (despite the lack of common standards), and high demand for projects. Relatedly, some project proponents may not have wanted to complete our lengthy RFP questionnaire and due diligence process.

From the FY22 proposals, so far, we have contracted carbon removal credits from 21 projects representing more than 1.5 million metric tons of carbon dioxide (mtCO₂), meeting our fiscal year goal.⁷ Our portfolio is once again heavily weighted towards low-durability natural solutions, representing more than 99 percent of our total purchase volume:

- **Low-durability solutions:** nine forestry projects, one soil project, and one blue carbon project (total >1.49 million mtCO₂)
- **Medium-durability solutions:** six biochar projects (total >10,000 mtCO₂)
- **High-durability solutions:** one bio-oil project and one carbon utilization (CO₂U) project (total <1,000 mtCO₂)

⁷ Not all this volume will apply to Microsoft's FY22 emissions. We will report details on how we apply these to our emissions in a future release of our annual Environmental Sustainability Report.

Durability definitions and examples

- **Low**—In general, these are solutions that sequester carbon for less than 100 years. Forestry and soil approaches are the main examples. While some forestry projects in our portfolio have a contracted durability of 100 years or more, we categorize them as low durability because of inherent reversal risks.
- **Medium**—In general, these are solutions that sequester carbon for hundreds of years to 1,000 years. Biochar is the main incumbent medium-durability approach.
- **High**—In general, these are solutions that sequester carbon for thousands of years. Biomass approaches with geologic storage (including bio-oil), direct air capture, and mineralization are the best-known approaches in this category.

Our weighted average portfolio price was \$19.40/mtCO₂, compared with a weighted average of \$16.85/mtCO₂ for all applications we received.⁸

For more information on how we approach project selection and the proposals we received, please consult these additional resources:

- To learn more about different project types, our top considerations, and the risks (and remedies) that we have identified, read our [FY21 carbon removal white paper](#).
- For detailed guidance on our selection criteria, review our publication with Carbon Direct, [Criteria for High-Quality Carbon Dioxide Removal](#).
- For an overview of the project proposals we received in FY22, see our [FY22 project submissions dashboard](#).⁹

The following table describes our newly contracted carbon removal purchases, in order of contracted volume.

⁸ Statistics represent RFP respondents who consented to Microsoft using their pricing data in aggregate, anonymized form. Some data points were removed from the aggregate statistics based on professional judgment, for data quality reasons.

⁹ For information on the responses to our previous year (FY21) RFP and the subsequent investments we made, please see our [FY21 carbon removal project dashboard](#).

Supplier	Project(s)	Location	Type	Description	Newly contracted volume (mtCO ₂)	Certification	Contracted durability (years)
The Forestland Group, LLC	The Forestland Group CT Lakes	New Hampshire	Forestry	Improving forest management on 146,435 acres protecting the headwaters of the Connecticut River	400,000	ACR, CARB	100
Arbor Day Foundation, Natural Capital Partners	CommuniTree Carbon Program	Nicaragua	Forestry	Reforestation of underused farmland that was historically deforested	250,484	Plan Vivo	30
Cumberland Forest, LP managed by the Nature Conservancy	Cumberland Forest Project	Kentucky, Tennessee, and Virginia	Forestry	Improving forest management on 108,182 acres	210,341	ACR, CARB, CAR	100
Truterra/Land O'Lakes	Soil Carbon Best Practices	United States	Soil	Science-based cropland management	200,000	N/A (under development)	30
Green Diamond	Klamath West Improved Forest Management	Oregon	Forestry	Improving forest management on 185,000 acres	143,965	ACR	100
ClimateCare Oxford and PUR Projet	Jubilación Segura	Peru	Forestry	Agroforestry and reforestation with small-scale farmers	120,000	VCS	29
Natural Capital Partners	TIST Program in Kenya	Kenya	Forestry	Reforestation practice to increase available agricultural land and improve community livelihoods	82,019	VCS	13
Coöperatieve Rabobank U.A.	Acorn	Peru, Colombia, Nicaragua, and Côte d'Ivoire	Forestry	Agroforestry with smallholder farmers in multiple developing countries	39,619	Plan Vivo	20
The Nature Conservancy	Washington Rainforest and Clinch Valley Conservation	Washington and Virginia	Forestry	Improving forest management in Washington on nearly 22,855 acres and in Virginia representing 23,000 acres in the globally important Clinch River Valley	37,330	CARB, CAR, ACR	40 (WA) and 100 (VA)

Supplier	Project(s)	Location	Type	Description	Newly contracted volume (mtCO ₂)	Certification	Contracted durability (years)
Indus Blue Carbon	Delta Blue Carbon – Phase 1	Pakistan	Blue carbon	Mangrove project on 350,000 hectares in southeastern Pakistan	10,000	VCS and Gold Standard	60
ACT Commodities Inc. via Puro.earth	Freres Biochar CO ₂ Removal Certificates	Oregon	Biochar	Biochar from biomass-fired rotary bed boiler producing steam for manufacturing lumber-based products and electricity generation	6,926	Puro Standard	1,000
Carbonfuture GmbH	Pacific Biochar	California	Biochar	Biochar produced from feedstock to directly lower water consumption of drought-stricken agricultural areas or as soil enrichment with compost additives	1,500	European Biochar Certificate	>100
Climate Robotics Inc.	In-field Biochar Production from Crop Waste	Texas	Biochar	In-field waste collection, biochar production, biochar disposition system running first field operations in Texas	1,000	VCS (pending)	200
ECHO ₂ via Puro.earth	ECHO ₂	Australia	Biochar	Diverting green waste from landfill and converting to bio energy and biochar	800	Puro Standard	600
Carbofex via Puro.earth	Carbofex Oy	Finland	Biochar	Biochar from pyrolysis, with the biochar used as horticultural substrates and surplus energy to heat the city of Tampere	600	Puro Standard	800
Carbon Cycle via Puro.earth	Carbon Cycle	Southeast Germany	Biochar	Producing high-quality biochar from sustainable feedstock for use as a soil additive and animal feed	400	Puro Standard	800

Supplier	Project(s)	Location	Type	Description	Newly contracted volume (mtCO ₂)	Certification	Contracted durability (years)
Charm Industrial	Bio-oil geologic sequestration	Kansas	Bio-oil	Storing carbon-containing fluid produced from biomass in deep geologic storage.	200	N/A (under development)	10,000
Neustark AG	CO ₂ Sequestration Cluster Bern	Switzerland	CO ₂ U	Carbon removal by sequestering biogenic CO ₂ from biogas production in demolition concrete	100	N/A (under development)	10,000

ACR = American Carbon Registry; **CARB** = California Air Resources Board; **CAR** = Climate Action Reserve; **CO₂** = carbon dioxide; **CO₂U** = carbon utilization; **CT** = Connecticut; **FY** = fiscal year; **mtCO₂** = metric tons of carbon dioxide; **N/A** = not applicable; **TIST** = International Small Group and Tree Planting Program; **VA** = Virginia; **VCS** = Verified Carbon Standard; **WA** = Washington.

In the following sections, we provide a description of each of these projects, organized by carbon removal durability ([low durability](#), [medium durability](#), or [high durability](#)).

Low-durability solutions

We selected the following low-durability projects this year (in order of contracted volume, with supplier names in parentheses):

- **The Forestland Group CT Lakes** (The Forestland Group, LLC) is a 146,435-acre improved forest management (IFM) project protecting the headwaters of the Connecticut River, developed in conjunction with Finite Carbon. Most credits are for carbon removals achieved through tree growth, with a small portion for emissions reductions from carbon stored in long-term wood products through Forest Stewardship Council (FSC)-certified sustainable harvesting. (Microsoft does not claim the emissions reductions.) The project supports conservation of productive forests; sustains traditional forest uses, including forest management and permitted recreational activities; conserves water resources, biological diversity, fish and wildlife habitat, and rare plants and animals; and conserves high-elevation mountain spruce-fir forest, which supports rare animals and pockets of mature forest stands located above 2,700 feet.
- The **CommuniTree Carbon Program** (Arbor Day Foundation, Natural Capital Partners), managed by Taking Root, is the largest reforestation initiative in Nicaragua. It helps farming families to grow native tree species and build forest-based enterprises on underused farmland, creating sustainable livelihoods for the long term. The project team is made up of cross-disciplinary local and international experts in forestry, business,

smallholder economics, computer science, and remote sensing, and the project has been used as a best practice reforestation model by organizations including the United Nations and European Union.

- **Cumberland Forest Project** (The Nature Conservancy) is a 253,000-acre conservation impact investment located in the Central Appalachian region of Kentucky, Tennessee, and Virginia, of which Microsoft's purchase supported 108,182 acres. It aims to improve the health of working forestland to benefit local economies, wildlife habitat, clean water, and climate resilience in a globally significant biodiversity hotspot. Managed through The Nature Conservancy's NatureVest impact investing team, the project seeks to achieve financial returns for investors and environmental outcomes generated by sustainable timber management, carbon sequestration, recreational access, and nature-based local economic development.
- The **Truterra/Land O'Lakes Soil Carbon Best Practices project**, based in the central United States, focuses on building an innovative and best-in-class soil carbon program. The project leverages existing infrastructure, sociological insights, and an innovative portfolio approach to create a more reliable supply of high-quality, durable carbon removal.
- The **Klamath West Improved Forest Management (IFM) project** (Green Diamond), located in Oregon, addresses impacts of overharvesting by previous owners. This legacy left the forest carbon stocks significantly below the common practice baseline set by the California Air Resources Board (CARB). Forest thinning and other silvicultural tools are being used to improve forest health, manage fire hazard, and maximize long-term forest growth. Atmospheric carbon removal is achieved through incremental tree growth as evidenced by increases in baseline carbon stocks for the project areas.
- **Jubilación Segura** (ClimateCare Oxford and PUR ProjeT), a grouped afforestation and reforestation project within the Amazon Andean foothill forest in the San Martin region of Peru, addresses widespread deforestation caused by the expansion of agriculture, typically driven by international demand, degraded lands, and low farmer income. Small-scale farmers increase land productivity and diversify incomes through agroforestry and reforestation on previously degraded land. The project is certified under the Verified Carbon Standard (VCS), with timber harvesting certified under the Forestry Stewardship Council Certification.
- The **Kenya Community Reforestation project, or International Small Group and Tree Planting Program (TIST) in Kenya** (Natural Capital Partners), organizes hundreds of small, community-based tree-planting initiatives on lands owned by smallholder and subsistence farmers. Under traditional practices, farmers clear trees to increase available agricultural land and for firewood. Forestry projects such as this combine carbon sequestration with sustainable development, helping to improve community livelihoods through education and training and create additional sources of income. The program helps to break the local cycle of deforestation, drought, and famine by reducing erosion, stabilizing and

enriching the soil, and providing shade. Once mature, the trees provide other benefits, including edible fruits and nuts, medicines, windbreaks, firewood, and timber.

- **Acorn** (Agroforestry Carbon removal units for the Organic Restoration of Nature) (Coöperatieve Rabobank U.A.) provides long-term food security for developing countries with indigenous agricultural practices by helping smallholder farmers in their transition to agroforestry with the help of local partners. The benefits of agroforestry for the farmer include a more diversified and higher yield, improved soil health, and better resilience against climate change and weather events. The project uses scalable, transparent, and inexpensive remote sensing technologies to measure yearly biomass increase. Acorn measures the carbon storage yearly, sells ex-post carbon credits, and pays the farmers 90 percent, enabling access to the voluntary carbon market for those who need it most.
- The **Washington Rainforest** project (The Nature Conservancy) is based in the lowland areas of the Washington coast—areas heavily affected by more than a century of industrial forest management that has almost eliminated old-growth forests. By managing Conservancy-owned forests to restore old-growth forest habitat and function, this project can sequester a significant amount of carbon and at the same time restore habitat for wild salmon and other wildlife. It aims to connect forests from summit to sea through a combination of philanthropic capital and proceeds from carbon sales, supporting restoration efforts in the Olympic Rainforest and Willapa Bay.
- **Clinch Valley Conservation** (The Nature Conservancy) is a project in southwestern Virginia. The Clinch River is one of the last free-flowing tributaries of the Tennessee River system and harbors the nation's highest concentrations of globally rare and imperiled fish and freshwater mussels. The Nature Conservancy has protected its lands and waters since 1990. It launched the Conservation Forestry Program in 2002 and now manages 22,000 acres to model sustainable forestry practices. Its on-the-ground operations are designed to provide economic opportunity for forest owners and enhance forest resources such as soil and water quality, high-value timber, sensitive wildlife habitat, and carbon storage.
- The **Delta Blue Carbon project** (Indus Blue Carbon) is a mangrove forest restoration project covering 350,000 hectares in southeastern Pakistan. Over several decades, the region's mangrove forests have experienced massive-scale deforestation and degradation, due in part to their use as a local source of fuel wood, fodder, and open-range grazing by livestock. The project's climate, community, and biodiversity objectives include large-scale mangrove reforestation, access to education, sustainable fisheries, access to safe drinking water and healthcare, and promotion of gender development and income-generating activities for women. The entire project (including but not limited to the credits Microsoft is buying) will sequester an estimated 142 million mtCO₂ over its 60-year lifetime.

Medium-durability solutions

We selected the following medium-durability projects this year (in order of contracted volume, with supplier names in parentheses, where applicable):

- The **Freres Biochar project** (ACT Commodities Inc.), run by Freres Lumber based in Lyons, Oregon, produces biochar through a biomass-fired rotary bed boiler that generates steam used in the manufacturing of lumber-based products and for electricity generation. The biochar is a byproduct of the steam production. The boiler is fed with a wide range of biomass feedstocks sourced from the local region, including bark and waste from the onsite production of timber products. The biochar is either shipped to a landfill, where it becomes a carbon sink, or used for material purposes. The project issued CO₂ Removal Certificates (CORCs) through the Puro.earth marketplace, and the proceeds of our purchase will be used to drive enhanced biochar production in Freres's system.
- California-based **Pacific Biochar** (Carbonfuture GmbH) harvests biochar from existing biomass power plants. The biochar is then used in soil applications, mainly to decrease water consumption in drought-stricken agricultural areas or enrich soil with compost additives. Through Carbonfuture, Pacific Biochar has the carbon sink for each of these applications independently certified and audited by European Biochar Certificate (EBC), ensuring that the biochar ultimately reaches the soil, so the carbon remains sequestered. The sink portfolio tied to Microsoft's carbon removal credits is based mainly on feedstock from high-risk wildfire areas; credit revenue will allow Pacific Biochar to expand operations in California and convert two additional existing biomass energy plants.
- **Climate Robotics** is developing a biomass-to-biochar conversion project on 5,000 acres of agricultural and ranch land in and around Houston, Texas. The company has developed a patent-pending tow-behind agricultural implement—similar to a planter or harvester—that is moved across agricultural fields to continuously collect and convert agricultural waste biomass into biochar in the field. The system incorporates the biochar into the upper 10 cm of topsoil (qualifying as conservation tillage). The design allows for repeated, seasonal applications of biochar, maximizing the long-term carbon storage potential of the land. This project will generate annual credits of 2.2 mtCO₂ per acre.
- **ECHO₂**, based in Australia, focuses on developing and supplying modular systems to transform biomass residues to energy and biochar. It tackles the issue of green waste from food, agriculture, and wood processing that is burned or landfilled each year, converting it into high-carbon biochar and clean syngas. The additional revenue from CORCs allows the next ECHO₂ modules to be commissioned and new biochar commercial products to be developed, increasing the volume of carbon dioxide that is removed and stored in biochar. The project issued CORCs through the Puro Standard.

- **Carbofex** produces high-stability biochar manufactured with spruce thinnings from sustainably managed Finnish forests that would otherwise decompose. Examples of use include city plantations in Stockholm, Sweden, and landfill leachate water filtration in Tampere, Finland. The additional income from CORCs will allow Carbofex to grow its production and develop biochar-based carbon removal projects. The project issued CORCs through the Puro Standard.
- **Carbon Cycle**, a sustainable agriculture company based in southeast Germany, produces high-quality biochar from untreated wood chips sourced locally from forests certified by the Programme for the Endorsement of Forest Certification (PEFC). The biochar is used both for animal feed and as a soil additive. The product helps reduce the loss of nutrients and nitrate leaching from the soil, reduces the need for fertilizers, helps protect groundwater, and improves soil fertility, all while binding carbon dioxide for centuries. As Carbon Cycle is a small operation, income from carbon removal helps expand its production. The project issued CORCs through the Puro Standard.

High-durability solutions

We selected the following high-durability projects this year (in order of contracted volume):

- US-based **Charm Industrial** has created a novel process for preparing and injecting bio-oil and other carbon-containing liquids into geologic storage. The process takes atmospheric carbon dioxide captured in biomass, converts the biomass to a carbon-containing liquid, and injects it into deep geologic storage. The company has reported completion of its first year of demonstrations, sequestering 5,450 mtCO₂, and is rapidly scaling up to meet demand.
- In Bern, Switzerland, **Neustark** has established a negative emission value chain that sequesters carbon in demolition concrete. The value chain makes use of existing concrete recycling processes, which collect, crush, and screen demolition concrete to produce new concrete. Biogenic carbon dioxide, sourced from biogas plants, is liquefied and transported to concrete recyclers in the vicinity. There, the carbon dioxide mineralization plant—a silo retrofitted to treat the concrete aggregate with carbon dioxide while it is temporarily stored—fixes the carbon dioxide permanently in demolition concrete. The carbon dioxide undergoes a chemical reaction with the cement phases to form calcium carbonate, a natural, highly safe, and permanent way of storing carbon.

Looking ahead

To develop a healthy future global carbon market, stakeholders must work to ensure clear standards, high-quality oversight, supporting policies, and continued corporate demand.

In the second year of our carbon removal program, we have continued to experience the challenges of being a large buyer in a nascent removal market—specifically in the absence of common standards and limited supply of high-quality projects. We have found it difficult to value the durability and reversal risk of nature-based removal, and we share stakeholder concerns about the permanence and additionality of many nature-based projects on the market today.

Despite these imperfections, we continue to purchase nature-based removals not only because we have a volumetric commitment, but also because we want to help jumpstart important market improvements. We also continue to procure and invest in high-durability removals, aiming to ensure the permanence of our own purchases and to drive affordable supply.

To develop a healthy future global carbon market, stakeholders must work to ensure clear standards, high-quality oversight, supporting policies, and continued corporate demand, specifically:

- Common definitions of and protocols for what removal really means, as well as more consistent differentiation of removal durability.
- Stronger measurement, validation, and oversight of climate outcomes, especially from nature-based solutions.
- Public policies and investment from both public and private sectors to help develop high-durability technologies.
- Increased corporate demand, especially through multiyear contracts.

Looking ahead to the coming year and beyond, at Microsoft we plan to focus on securing an increasing volume of tons to meet our 2030 commitment; advocate for standards to help ensure high-quality removals; innovate contractually to mitigate our risk as a purchaser; and invest to help drive cost reductions, especially in promising medium- and high-durability technologies.

Our work on carbon removal is fundamental to achieving our climate commitments, and we recognize that this is not something we can do alone. Sharing our learnings and collaborating closely with others around the world will be vitally important, both to help ensure our own progress and to contribute to the building of a market that can reach the scale needed for the net-zero transition.

Please visit aka.ms/carbonremoval for more information.

Acknowledgments

In the past year, Microsoft's carbon removal program and development of this white paper were directly supported by:

- Bridge Partners: Carson Wright, Catherine Martini, Kaycee Keegan, Gordon Smith
- Machtley Group: Ken Machtley, Sarah Carson, Claudia Richey, Philip LaRose
- Microsoft: Lynne Andersen, Amy Luers
- WSP: Bridget Venne, Lakmini Senadheera