

Nature-Based Approaches to Decarbonization

In our 2020 report “The Largest Investment Opportunity of Our Era: Decarbonizing the Global Economy,” we made the case that investors who price in climate-related risk will be at an advantage relative to those who are too slow to act. The focus was largely on how the public and private sectors might reallocate capital to transitioning and new industries that will help humanity to bring about a cleaner and more equitable future. That is, however, only one side of the coin.

The earth has been endowed with carbon sinks—natural constructs that remove excess CO₂ from the atmosphere. For the better part of the last two millennia, our seas, forests and grasslands have proved to be a most remarkable climate-stabilizing tool. Now, these systems are being overwhelmed. Biodiversity is falling, the ocean is acidifying, and extreme weather is becoming the norm. The consequences are only getting worse.

Often, however, first-order solutions lead to second-order problems, and in our 2020 report we urged investors to support decarbonization solutions that ensure no one is left behind. Today, we would take that maxim a step further to say we should be cognizant of how our solutions affect people *and* the planet.

In this paper we will explore several of Earth’s carbon sinks and how they work together to keep our planet’s natural systems in balance. We will also provide LPs with guidance on how to integrate nature-based sink exposure with their net-zero pledges and impact programs. Furthermore, we will explore how there is opportunity for every GP to consider relevant sink issues within their ESG processes.

Compound Carbon Interest

Carbon dioxide, methane, fluorocarbons and other greenhouse gases (GHGs) survive in the atmosphere for years. Fluorocarbons, for example, are thousands of times more potent than CO₂ and can remain in the atmosphere for up to 60,000 years (Figure 1). Curiously, CO₂, the most well-known GHG, is in some ways the least understood: Scientists are still unsure how long it can remain in the atmosphere. Current estimates suggest that half of every new ton of CO₂ will be eliminated from the atmosphere within 30 years, and the next 30% will be removed within a few centuries. The remainder may stay in the atmosphere for thousands of years. In a sense, even if the world were to be net zero tomorrow, we wouldn't even be close to touching the "carbon principle," some of which we inherited centuries ago. As a result, the GHG concentrations have been growing at a compounded rate since the Industrial Revolution (Figure 2).

If we are fortunate, we will be able to slow the pace of emissions growth enough to keep temperatures from rising 2°C.¹ But we are not even close to reducing the concentration of atmospheric CO₂ to its pre-2010 level.

In our quest to measure emissions, we have gained a good understanding of whence those emissions came. That knowledge has, in turn, led us down our current decarbonization path—to replace those sources with new technologies. We've made remarkable progress on that front targeting the heaviest emitting sectors: In 2020, renewables accounted for 29% of all energy generated worldwide, according to the International Energy Agency. But in our zeal, we may have overlooked an equally important part of the equation: carbon sinks.

Sinks 101

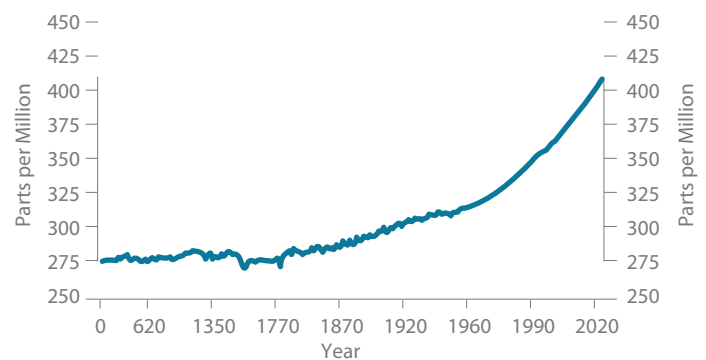
Carbon sinks are defined as any reservoir, natural or otherwise, that accumulates and stores carbon-containing chemical

FIGURE 1 | GLOBAL WARMING POTENTIAL & LIFESPAN OF SELECT GHGS

GHG	100-Year Global Warming Potential (CO ₂ e)	Lifetime (Years)
Carbon dioxide (CO ₂)	1	Hundreds
Methane (CH ₄)	25	12
Nitrous oxide (N ₂ O)	298	114
Hydrofluorocarbon-23 (HCF ₃)	14,800	264
Sulphur hexafluoride (SF ₆)	22,800	3,200
Carbon tetrafluoride (CF ₄)	7,390	60,000

Source: Intergovernmental Panel on Climate Change, 2007.

FIGURE 2 | GLOBAL CO₂ CONCENTRATIONS



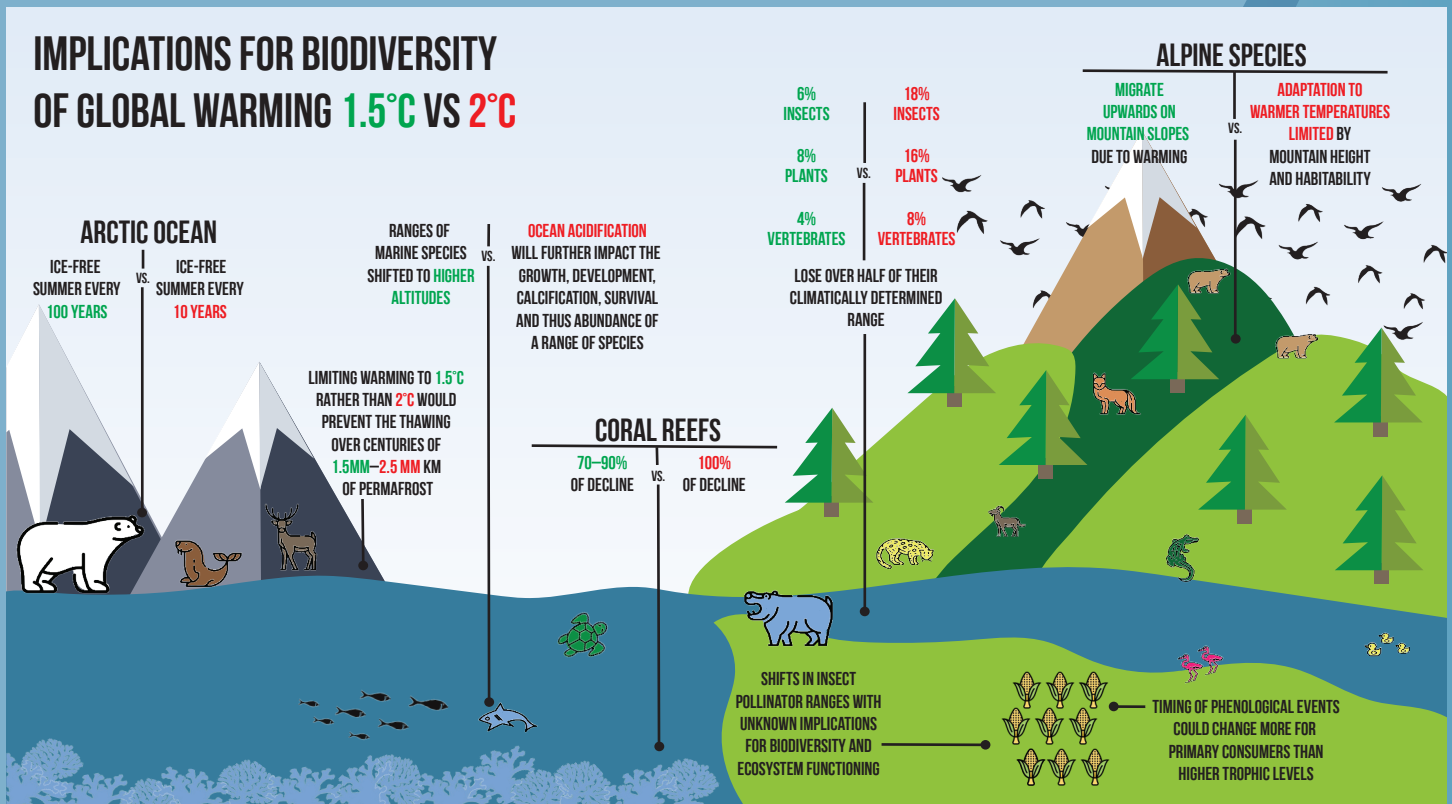
Source: National Oceanic and Atmospheric Administration, 2018.

¹ At this point, 1.5°C seems like wishful thinking.

Half a Degree Can Make All the Difference

When Earth's ecosystems are in equilibrium, it can be difficult to appreciate the complex biological transactions that are working in concert to maintain a Goldilocks position. They are unseen and self-managing. It is only when there's an imbalance that we see the consequences. Ice storms in Chicago, heat waves in the Pacific Northwest, wildfires in Sydney and tornadoes in Tokyo are headline examples of such consequences. There are many more, however, that on their own may seem minor, but on a system-wide basis are quite significant. Declining bee and plankton numbers and the migration of species to new altitudes all are evidence of a system falling out of balance. It is amazing what a difference 0.5°C makes when a system is struggling to maintain equilibrium.

FIGURE A | IMPLICATIONS FOR BIODIVERSITY OF GLOBAL WARMING: 1.5° C VS. 2° C



Source: World Wildlife Fund.

compounds for an extended period, thereby lowering the amount of CO₂ in the atmosphere. The two most important carbon sinks are the oceans and vegetation (land, forests, plants, sea plants)—both of which absorb 25–33% of all CO₂ emitted. While carbon emissions come from the built world, the sinks rest predominantly in the natural world, where we have a disturbingly low level of understanding of the intricate nature of these systems.

It may be easy to conceptualize the important role sinks can play in bringing about a net-zero future; but measuring and reporting on a sinks' capacity to sequester CO₂, however, is easier said than done.² For this reason, the International Energy Agency has opted not to rely on land-based sinks (think: forests or soil) as a core component of its "Net Zero by 2050" road map.

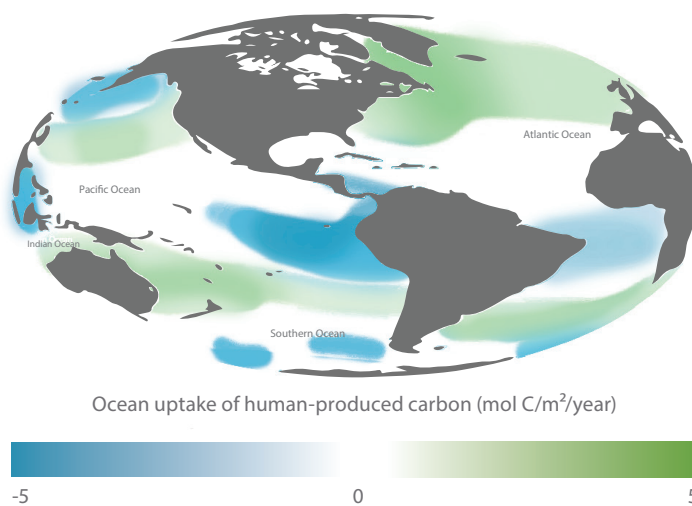
What we do know is that our GHG emissions are overwhelming Earth's sinks. In the past, sinks have been able to keep the built and natural worlds in balance, "fluxing" as needed to either absorb or release carbon dioxide as necessary to hold the planet in carbon equilibrium. Today the GHG concentration is so high that this balance has become harder to maintain. In fact, our sinks may be turning into sources.

OCEAN SINKS

The ocean is a critical sink, absorbing approximately 25–33% of CO₂. Where the concentration of CO₂ is higher in the water than in the atmosphere, the ocean releases CO₂. This transfer of CO₂ from the ocean to the atmosphere is referred to as a positive flux, while a negative flux means the ocean is absorbing CO₂. Historically, at any one time the ocean has had a complicated pattern of both positive and negative fluxes. Prior to the Industrial Revolution, the ocean was in positive flux, keeping the planet in carbon equilibrium by releasing enough CO₂ to offset what was absorbed by plants on land. Today, the reverse is true.

Because colder waters are capable of absorbing more CO₂ than warmer regions, the waters nearest the poles have historically been in negative flux, while allowing warmer waters to be net

FIGURE 3 | CARBON UPTAKE 36% ABOVE AVERAGE IN 2017



Source: National Oceanic and Atmospheric Administration, 2018.

releasers of carbon (**Figure 3**). But when there is too much carbon in the atmosphere, which leads to higher land and ocean temperatures, colder waters lose their temperature advantage. Instead of being a sink, they too become a source.

The ocean doesn't just store solar radiation, it also helps to distribute heat around the globe. Ocean water is constantly evaporating, increasing the temperature and humidity of the surrounding air to form rain and storms that are then carried by trade winds. That almost all rain that falls on land starts off in the ocean explains why land-based sinks are so dependent on the oceans to work efficiently. When they don't, rainfall patterns are disrupted. Studies have found that rising sea temperatures in the Atlantic are affecting rainfall over the Amazon.³

FROM SEA TO LAND

Land-based sinks include all soil and plants. Of these, soil is the largest sink, holding many times more carbon than all

² Several groups are working to develop better accounting guidelines for sinks. The Partnership for Carbon Accounting Financials and GHG Protocol are two such groups.

³ Source: Xinyue Wang et al. 2018. "The strengthening of Amazonian precipitation during the wet season driven by tropical sea surface temperature forcing." *Environmental Research Letters* 13 (9): 094015.

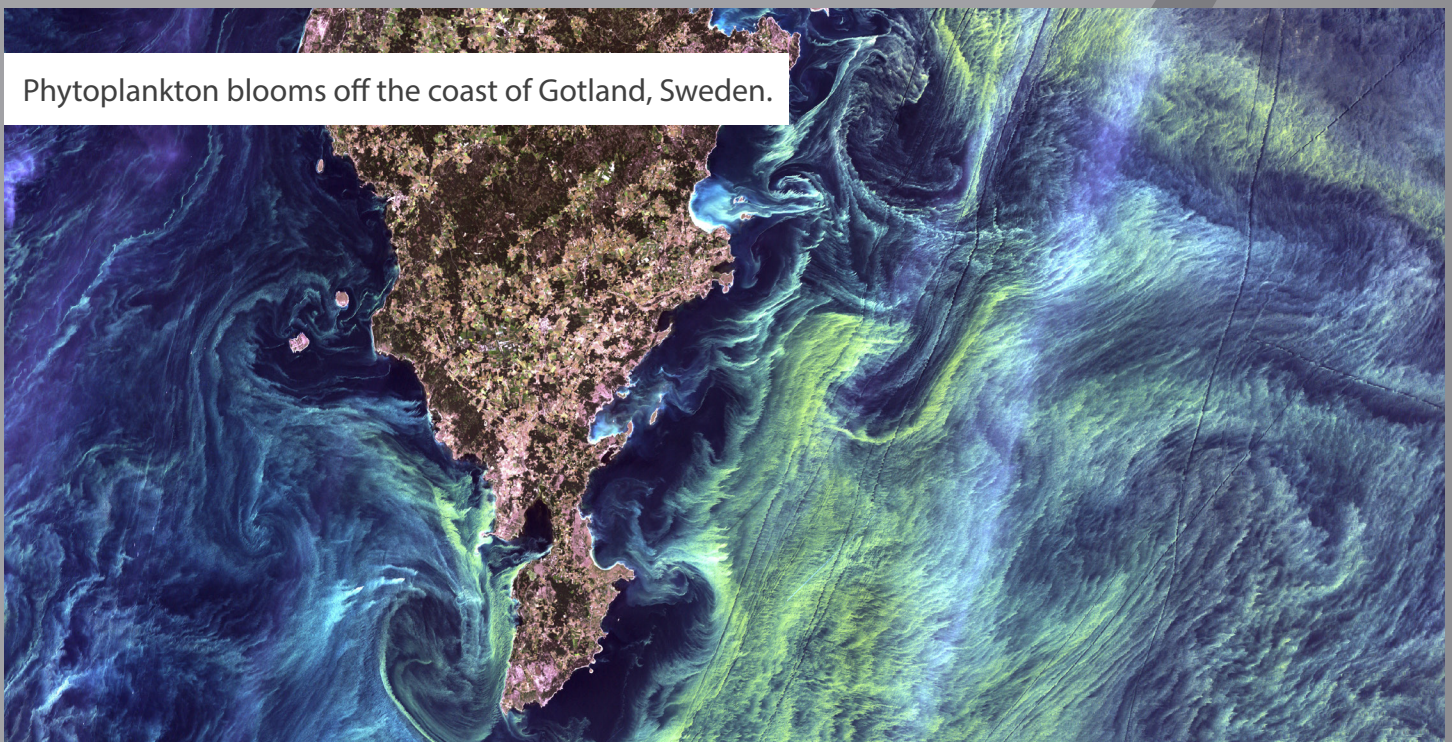
Ocean Acidification

When CO₂ is absorbed by the ocean, a series of chemical reactions take place that cause the water to become more acidic. Because the ocean's natural defense mechanisms against acidification are being overwhelmed by the overabundance of CO₂, our oceans are more acidic than they have ever been.

As a result, carbonate, a mineral essential to many organisms, is growing more scarce. Without it, coral cannot build their skeletons, and oysters, clams and other mollusks cannot maintain their shells.

Acidification also adversely affects phytoplankton. These minuscule algae photosynthesize the same as other plants, converting sunlight and CO₂ into oxygen. Phytoplankton absorb more carbon than all other plant life combined, and when they die, they take their absorbed carbon down to the abyss, locking away CO₂ for millennia.

Beyond the implications to the food chain, acidification presents a serious risk to the job and food security for millions of people around the world. More than one billion people depend on fish and shellfish for their primary source of protein.⁴



Phytoplankton blooms off the coast of Gotland, Sweden.

Source: United States Geological Survey, 2020.

⁴ National Oceanic and Atmospheric Administration. 2021. "What is Ocean Acidification?"

plants combined (Figure 4). Like the ocean, land-based sinks flux to help the earth remain in carbon equilibrium, and like the ocean, terrestrial sinks can be overwhelmed by excessive amounts of carbon in the atmosphere. One study found that when temperatures rise above a certain threshold, plants photosynthesize less and become sources of carbon rather than the sinks we have come to know them as.⁵

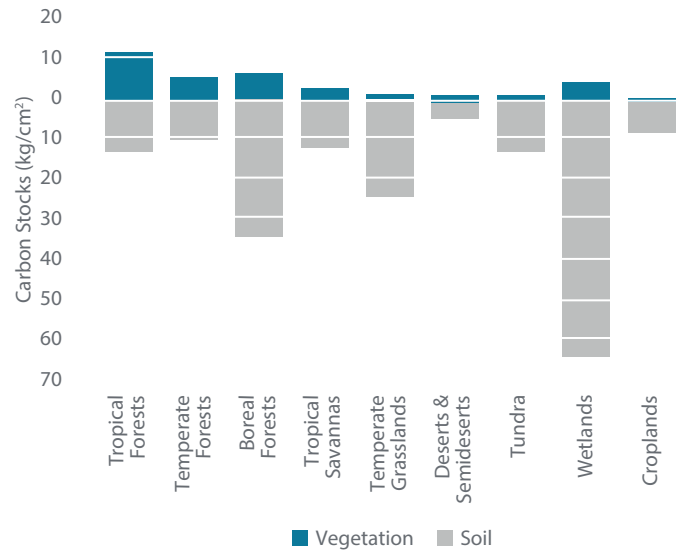
Perhaps the bottom line is that terrestrial sinks have the potential to absorb close to 40 gigatonnes of CO₂e annually.⁶ Currently, land use, including agriculture, generates 10–12 gigatonnes of CO₂e per year so net terrestrial sink capacity is approximately 30 gigatonnes per year. But sinks' capacity is finite and at risk. Without intervention, we are in danger of turning our sinks into permanent sources.

Sink Resiliency

The earth is nothing if not resilient. It's a complex adaptive system that has given rise to and sunk whole continents, survived asteroids and super volcanoes, evolved life, and gone through several periods of "glacierization" and thaw. Along the way it also evolved a decarbonization mechanism. It may be hardy, but it is not indestructible. Experts have identified several strategies for shoring it up (Figure 5).

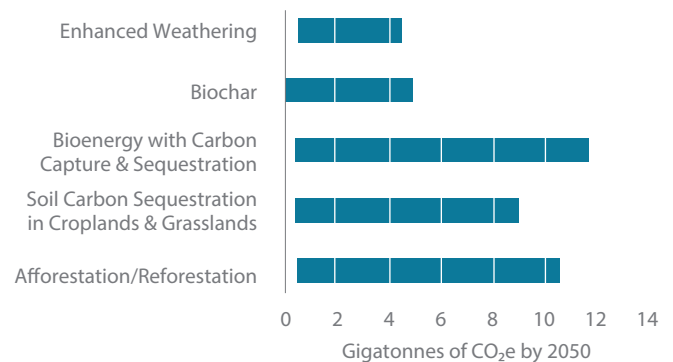
- » **Reforestation** is the replenishing of jungles, woodlands and kelp forests that have been depleted. Beyond sequestering CO₂, reforestation provides habitat, enhances soil fertility, controls floods and improves air and water quality. It's opposite, deforestation, is the largest cause of CO₂ release from land use and land cover change. Our understanding of the carbon absorption capacity of different types of trees has increased, which can be used to enhance reforestation programs.
- » **Afforestation** refers to turning land being used for other purposes into forests. It may be best regarded as a complement to sustainable agriculture. For context, afforesting around 170 million hectares of land (roughly half the size of India) would sequester about 1 gigatonne of CO₂ annually by 2050.

FIGURE 4 | LAND-BASED SINKS



Source: World Resources Institute, 2019.

FIGURE 5 | ESTIMATED POTENTIAL OF VARIOUS CARBON REMOVAL APPROACHES



Source: Intergovernmental Panel on Climate Change, 2019.

- » Some **sustainable agriculture** techniques seek to ensure that soil retains a maximum amount of carbon. This may involve refined tilling techniques, smarter chemical use and better water management. Though the most abundant

⁵ Katharyn A. Duffy and Christopher R. Schwalm, et al. 2021. "How close are we to the temperature tipping point of the terrestrial biosphere?" *Science Advances* 7(3).

⁶ To put this in perspective, one gigatonne equals 2.2 trillion pounds or 10,000 fully-loaded US aircraft carriers, per NASA.

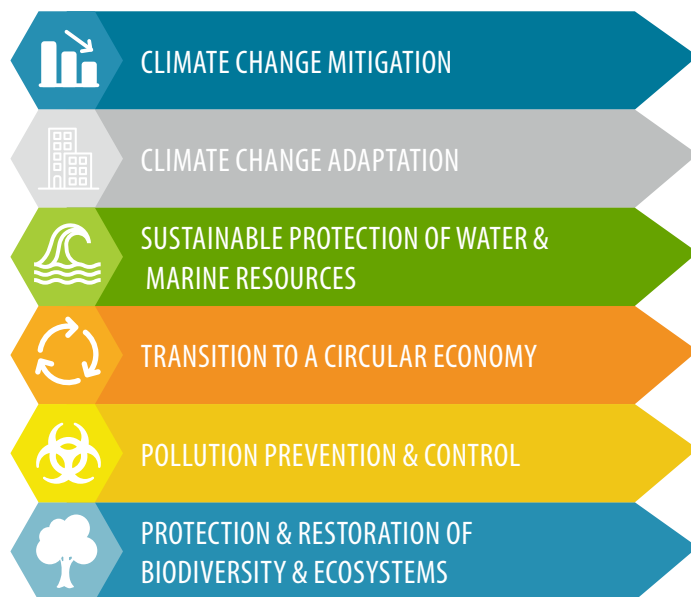
land-based sink, soil can reach carbon saturation. Most operations run well below this level.

- » Though it has not yet been executed on a large scale, scientists regard **bioenergy with carbon capture and sequestration** (BECCS) an essential ingredient in the zero-carbon future. This renewable energy source burns organic material and captures and stores the carbon emissions.
- » **Biochar** is charcoal that is created in an oxygen-limited environment in a process known as pyrolysis. The resulting biochar can then be added to soil, providing essential nutrients enhancing the carbon sink. Like BECCS, biochar has not been executed at scale.
- » **Iron fertilization** involves dumping iron particles in the ocean to stimulate the growth of phytoplankton—an absorber of CO₂. This has been conducted only at a pilot scale, and there are doubts about the absorption capability of this strategy.
- » **Enhanced weathering** capitalizes on the natural reaction between water and certain types of rocks to create carbonate—literally accelerating the natural process of rocks absorbing CO₂. These rocks can then be crushed and added to soil, replenishing nutrients and making the soil less acidic, all while retaining the CO₂.

LP Implementation Perspective

Though nascent, sink resiliency investments (or nature-based solutions) present an exciting opportunity set for LPs to consider.⁷ For the most part, these opportunities (e.g., forestry and agriculture) have lain within the realm of real assets. But for a number of reasons, many LPs have historically limited their exposure to these types of investments. But this is changing, as more investors and asset owners prioritize sustainability, make the net-zero pledge and seek to align their portfolios with SDGs. To maximize carbon revenue streams would be too singular a purpose. In our estimation, the nature-based investment programs must account for biodiversity and appreciate that land has many competing uses: It is not straightforward to argue for afforestation over housing or farmland. And while there is no formal guidance on how LPs, as responsible

FIGURE 6 | THE SIX SUSTAINABILITY OBJECTIVES



For illustrative purposes only.

investors, might reconcile these competing objectives, several frameworks may provide direction.

The first is the EU Taxonomy, which has adopted the concept of Do No Significant Harm (DNSH). This maxim ensures that progress toward one sustainability objective does not come at the expense of another. Within the context of the EU Taxonomy, this means an investment in climate change mitigation—one of six sustainability objectives identified in the Taxonomy (**Figure 6**)—is not made at the expense of protection and restoration of biodiversity and ecosystems.

The Taxonomy specifies that pursuing an objective should be interpreted as making *substantial contribution* to its gain; while DNSH is the mirror of causing material negative impact. The completion of the EU Taxonomy framework will help cement the role of sinks within broader sustainability discussions. Over the next two years, the substantial contribution thresholds for water and biodiversity will be spelled out. Both will be important for LPs to monitor. As they take shape, capital may begin to shift toward nature-based solutions.

⁷ The International Union for Conservation of Nature defines nature-based solutions “as actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.”

The newly minted Taskforce on Nature-related Financial Disclosures (TNFD) will similarly deliver important content for sink resiliency investments. This corollary to the Task Force on Climate-Related Financial Disclosures, the TNFD reckons that by broadening the concept of “climate-related financial disclosures” to include sinks, it can help shift capital away from anything that generates a “nature negative outcome.”⁸ The group aims to deliver a framework for reporting nature-related risks by 2023. It seems likely it will draw on work already conducted by the seminal Convention on Biological Diversity (CBD).⁹ In July 2021, the CBD published a draft of the post-2020 global biodiversity framework as a stepping stone toward living in harmony with nature by 2050. This framework, which will be debated by CBD’s governing body (COP15) in October 2021, sets out clear targets that will be reviewed in 2030 to assess whether the global community is on track to becoming “nature positive,” underscoring the importance of nature-based solutions.

Any investors worried about having to come up to speed with yet another list of definitions and requirements may find solace in the fact that in many instances, they will not need to dramatically modify their approaches. If they already have an ESG framework in place or are aligning with the Paris Agreement or SDGs, or are invested in real assets, then there’s a good chance they have already touched at least one of the gateways into nature-based solutions and natural carbon sinks.

1 Organizations with an explicit climate policy or that have made a net-zero commitment will come to regard sinks and emissions as two sides of the same coin as the TCFD and TNFD refine and align their credos.

2 LPs that are positioning themselves around SDGs 13, 14 and 15 will inevitably incorporate natural sinks and nature-positive investing into their agendas.

3 Any organization that must comply with any of the EU’s sustainability rules (e.g., the Sustainable Finance Disclosure Regulation) will over time adopt a more expansive definition of sustainability that includes biodiversity.

4 Finally, investors in farmland, timberland, aquaculture and related sectors are increasingly aware of the carbon revenue stream these assets can generate. The many investments that are monetizing their carbon streams are using national, regional or even voluntary pricing mechanisms to realize value; a global emissions trading scheme would make these much more efficient and comprehensive.

The Cutting Edge

Although many of the opportunities to invest in natural sinks can be found in forestry and sustainable agriculture (read: real assets), the keys to maximizing the biodiversity profile and amount of carbon sequestered lie in the systems and technologies (e.g., AI and robotics) that have been developed by private equity-backed companies. This underscores the role private equity—especially, venture capital and growth equity—can play in an LP’s sink-resiliency program. As these solutions become scalable, they will allow real assets to play a larger role in nature-positive portfolios. As the TNFD picks up steam, all GPs, not just those focused on nature-based solutions, will eventually need to disclose how they regard biodiversity as both an investment risk and opportunity. Just as the TCFD has pushed climate change into mainstream investing, the TNFD hopes to do the same with biodiversity. GPs that move earlier may perceive a new set of investment opportunities; over time we would expect dedicated, specialist funds to emerge. The following section looks at some of the exciting low- and high-tech solutions that are making an impact.

GETTING A CLEARER PICTURE

The most accurate way to measure how much CO₂ a tree has absorbed is to chop it down, weigh it, dry it out and weigh it again. Hardly viable on a large scale. As such, the most common approach is to estimate the amount of carbon stored by making several assumptions based on a tree’s species, age, height and diameter. Therefore we have only a rudimentary and inaccurate understanding of forests’ ability to absorb and store carbon.

⁸ TNFD also introduces the concept of moving the world back into nature-neutral by 2030 and then further shifting to nature positive by 2050.

⁹ See the Convention on Biological Diversity. 2021. “First Draft of the Post-2020 Global Biodiversity Framework.”

Increasingly, lidar (radar's sister) is being used to gain a more accurate estimate of the CO₂ stored in the world's forests. By deploying the technology to drones and satellites, scientists are developing a living database of carbon absorption. Some of the technology is now so accurate that it can give a complete tree-by-tree analysis, including stem diameter. Obviously, a live database can account for the effects of climate change and fires. The information is critical for deciding which trees to plant to maximize CO₂ storage and improve biodiversity; it will help forest managers more accurately price any assumed carbon streams.

WEATHER FORECASTING GETS ACCURATE!

(Re)insurance is a notoriously bland topic. But as climate change redefines actuarial tables, a spate of tech companies that promise better risk pricing is emerging. For example, there are companies using machine learning, a network of sensors and lidar to create hi-res microgrids so they can evaluate wildfire risk for tracts of land as small as 0.5 square mile (130 hectares). Better prediction entails better detection and faster responses—all of which help to save lives, preserve wealth and minimize the amount of carbon that gets released each time a tree is burned.

Startups often begin by focusing on one type of problem (i.e., wildfires), before expanding into another (such as floods). So it's not hard to imagine how this technology might be applied to other industries. Farmers are keen to know the best planting or harvesting days; car dealers don't want their shiny new wares getting dinged in a hailstorm.

KELP VS. URCHIN

Kelp and seagrass are critical to the ocean's ability to absorb CO₂. However, like most marine life, kelp is sensitive to increasing water temperature. It has also been affected by regulations that have allowed sea urchin populations to explode. These spiky critters love nothing more than munching through kelp, turning kelp forests into urchin barrens in a matter of weeks. Normally, sea stars keep urchins in check, but a combination of warmer waters and disease have killed off 91% of the global sea star population.¹⁰

To correct this imbalance, groups are developing low- and high-tech approaches alike. Marine-tech companies are building

robots that remove and destroy urchins, and researchers along America's West Coast are figuring out how to raise sea stars (urchin's natural predator) in captivity. These efforts are being dovetailed with those to map and better understand why certain areas sustain seagrass and kelp forests more effectively than others. With luck, this knowledge will help us to one day manage kelp forests the same way we manage their terrestrial counterparts.

THE GRIND

When certain magnesium-rich minerals are exposed to CO₂, they solidify, locking away the GHG for millennia. Kimberlite is one such mineral. Named for the South African town of Kimberley, this rock is often found in diamond mines. By filling abandoned mines with kimberlite gravel, mining companies like De Beers reckon they can give new life to mine reclamation, potentially sequestering enough CO₂ to offset a mine's emissions. Similar efforts are underway to change the composition of cement, another notoriously dirty industry. By either injecting CO₂ into wet cement, forcibly sequestering CO₂, or supplanting conventional cement ingredients with carbonate, cement manufacturers hope they can turn over a new leaf.

Conclusion

Impressive though the earth's sinks are, they are finite. And despite the important role they play in balancing global CO₂ levels, we know little about them. Though many of us aren't aware of the sinks and the role they play, we see daily what happens when they falter. Ocean acidification, losses in biodiversity and the normalization of extreme weather are but a few of the reminders.

In investments, early movers are often rewarded, and waiting until there is a global carbon market may be too late. There are opportunities across the private markets to focus on people and the planet without forgoing profits.

Even as the investment community begins to embrace concepts like nature positive and expands the due diligence process to include biodiversity implications, we are falling behind. To keep pace with climate change, investors need to go further, to allocate more capital to nature-based sinks and the projects that aim to make these sinks more resilient.

¹⁰ Todd Woody. 2021. "Scientists Are Breeding Sea Stars in a Lab to Rehabilitate Warming Oceans." Bloomberg Green, May 3.

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