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INTEGRATING NATURAL CAPITAL AND BIODIVERSITY IN THE INVESTMENT PROCESS

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EXECUTIVE SUMMARY

We often take for granted the natural capital and biodiversity that we depend on for much of our lives and livelihoods. We as humans have historically done a poor job of putting a value, much less a price, on the "ecosystem services," such as clean water, air, timber, fisheries, and pollination, that are the foundation for human life on earth.

Investors, companies, policymakers, and civil society are beginning to realize the need to better value and manage these resources as we see the negative impacts natural capital issues, such as climate change, water scarcity, and ocean health, can have on our lives and our investments.

The purpose of this paper is to introduce investment professionals to the key concepts of natural capital, highlight some of the educational resources available, and help investment professionals begin to develop their own frameworks for properly integrating natural capital into the investment process.

Any discussion of natural capital leads to a discussion of the planetary boundaries of the natural world, such as climate change, land use change, and ocean acidification, that serve as canaries in the coal mine for humanity to help us understand how we are or are not adequately managing the natural world. We have already breached the "safe levels" of many of the nine planetary boundaries, a dangerous harbinger for the survival of our markets and even the viability of the society in which we live.

Natural capital has economic, investment, and societal impacts that often overlap. The effects of natural capital issues, such as climate change, mineral use, and water rights, are often systematic in nature, presenting investors with "unhedgeable risks" that have to be addressed because they cannot be diversified away.

Although the necessary data to better understand natural capital and its impact on society exist, such data are rarely presented in an investor-friendly format and often require an understanding of multiple natural capital issues. To better integrate natural capital into the investment process, investors will have to take the data and research pioneered in the scientific and academic communities and make these data fit for investment purposes.

In this paper, we include a few case studies on diverse natural capital issues in order to help investors begin to think of the many facets of natural capital that they will need to understand to properly integrate an understanding of natural capital issues in their decision making.

The effects of natural capital issues, such as climate change, mineral use, and water rights, are often systematic in nature, presenting investors with "unhedgeable risks."

Finally, we address the challenges of "green growth," often seen as a kinder, gentler form of capitalism that simply replaces dirty inputs (fossil fuels) with "green" ones, such as renewable energy. Such an oversimplification of the challenges of energy production and transportation fails to address the problems that remain in the system when you switch from one unsustainable form of development to another unsustainable form of development. The tension between a business-as-usual economic framework and a green growth framework is addressed by the emerging issue of *degrowth*. The degrowth movement advocates moving away from the "growth for growth's sake" ethos exemplified by using GDP as a scorecard for human progress, focusing instead on human well-being and the sustainability of our economic system.

WHAT IS NATURAL CAPITAL?

According to the Scottish Wildlife Trust, "Natural capital can be defined as the world's stocks of natural assets which include geology [metals and minerals], soil, air, water, and all living things. It is from this natural capital that humans derive a wide range of services, often called ecosystem services, which make human life possible."[1]

Unfortunately, humanity has overused our allocation of natural capital, putting some of earth's systems in crisis, threatening not just these natural systems but ourselves as well. If these systems collapse, our ability to survive and thrive on earth will be compromised. This concern is not new. This topic was first explored in a 1972 report from the Club of Rome titled *The Limits to Growth*.[2] The report concluded that the earth's natural systems are unlikely to be able to support existing (as of 1972) economic and population growth rates much further than the year 2100, or even that far into the future, even with technological advances. The research focused on the five basic factors that determine and limit growth on earth: population increase, agricultural production, nonrenewable resource depletion, industrial output, and pollution generation. The report concluded that humankind needs to place limits on growth in order to move to a more sustainable global economic system.

No one will be surprised to find that we have not placed such limits on our growth. As a planet, we are currently using the earth's natural resources as though we had 1.6 earths to use.[3] This number is much higher, up to 4 earths, for the most developed markets.

Exhibit 1 helps illustrate the issue of resource overuse. Earth Overshoot Day marks the date in a given year when humanity's demand for ecological resources and services exceeds what earth can provide. Earth Overshoot Day is hosted and calculated by Global Footprint Network, an international research organization that provides tools to help the human economy operate within the earth's ecological limits.[4] For example, this exhibit shows that by 13 March 2022, the United States and Canada were forecasted to have a year's worth of resources that the earth can provide. In contrast, Jamaica is forecasted to be almost within its resource budget, not overshooting until 20 December 2022.

EXHIBIT 1. COUNTRY OVERSHOOT DAY 2022

Country	Earth Overshoot Day
Qatar	February 10
United States	March 13
Canada	March 13
Republic of Korea	April 2
United Kingdom	May 19
China	June 2
Panama	July 17
Brazil	August 12
Vietnam	September 12
Uzbekistan	October 11
Egypt	November 11
Jamaica	December 20

Notes: Using data for 2018, this exhibit shows when Earth Overshoot Day would occur if the world's population lived like those in a particular country. For a full list of countries, visit https://www.overshootday.org/country-overshoot-days.

Source: National Footprint and Biocapacity Accounts, 2022 edition. data.footprintnetwork.org.

Planetary Boundaries

The planetary boundaries framework was developed in 2009 by Johan Rockström at the Stockholm Resilience Centre to establish the planetary boundaries within which humanity can continue to survive and thrive (see **Exhibit 2**). Crossing these boundaries increases the risk of large and irreversible environmental damages. We have already crossed five of these planetary boundaries: climate change, biodiversity loss, biogeochemical (nitrogen and phosphorus cycles), land use (deforestation), and chemical pollution. Some scientists argue that the boundaries for ocean acidification and freshwater have already been breached or will be soon.[5] If that is the case, of the nine planetary boundaries, only ozone depletion and atmospheric aerosols have not yet been breached.

EXHIBIT 2. PLANETARY BOUNDARIES

System	Description	Safe Level	Current Level
Climate change	Concentration of CO_2 in the atmosphere at less than 350 parts per million (ppm) is considered safe. As of this writing, the concentration is about 419 ppm	Less than 350 ppm	419 ppm[a]
Rate of biodiversity loss	An annual rate of loss of biological diversity of less than 10 extinctions per million species-years	10/Million	Between 100 and 1,000/million[b]
Interference with nitrogen/phosphorus cycles	This includes the nitrogen and phosphorus cycles, both of which are beyond the safe zone. Nitrogen primarily used in fertilizers for food production and phosphorus from mining have seeped into land, waterway, and ocean ecosystems beyond levels that are considered safe	N: 62m tons removed from atmosphere for human use P: 11m tons flowing into the ocean	N: 150m tons P: 22m tons[c]
Stratospheric ozone depletion	Less than 5% reduction in total atmospheric ozone from a pre-industrial level of 290 Dobson units	276 Dobson units	283 Dobson units[d]
Ocean acidification	Global mean saturation of aragonite in surface sea water	2.75	2.90[e]
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000 km^3	Unclear
Change in land use	Percentage of forest intact	75%	62%[f]
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere	TBD	TBD
Chemical pollution	Introduction of novel entities in the environment, including pollutants, plastics, heavy metals, nuclear waste	TBD	TBD

[a]NASA, "Vital Signs" (August 2022). https://climate.nasa.gov/vital-signs/carbon-dioxide/.
[b]O. Mulhern, "The Statistics of Biodiversity Loss [2020 WWF Report]," Earth.Org (4 December 2020). https://earth.org/data_visualization/biodiversity-loss-in-numbers-the-2020-wwf-report/.
[c]Will Steffen, Katherine Richardson, Johan Rockström, Sarah E. Cornell, Ingo Fetzer, Elena M. Bennett, Reinette Biggs, Stephen R. Carpenter, Wim de Vries, Cynthia A. de Wit, Carl Folke, Dieter Gerten, Jens Heinke, Georgina M. Mace, Linn M. Persson, Veerabhadran Ramanathan, Belinda Reyers, and Sverker Sörlin, "Planetary Boundaries: Guiding Human Development on a Changing Planet," *Science* 347 (15 January 2015).
[d]United States Environmental Protection Agency, "Current State of the Ozone Layer." www.epa.gov/ozone-layer-protection/current-state-ozone-layer.
[e]J. Williams, "Planetary Boundaries 8—Ocean Acidification," *The Earthbound Report* blog (30 July 2013). https://earthbound.report/2013/07/30/planetary-boundaries-8-ocean-acidification/.
[f]Steffen et al. (2015).

These planetary boundaries are interconnected. For example, climate change has an impact on the rate of biodiversity loss, ocean acidification, freshwater use, and changes in land use. Land use can contribute to climate change by either emitting excess CO_2 or sequestering carbon in the soil and trees. The more planetary boundaries that are crossed, the harder it is for life on earth to thrive, which of course can have serious environmental, social, and economic costs.

Crossing planetary boundaries has a direct impact on both investments and markets. As it becomes harder for life on earth to survive and thrive, companies will

have a harder time competing for resources that will become scarcer or more protected as society puts more limits on resource use. An investor needs to understand how to value natural capital and biodiversity in order to fully understand any future risks or opportunities that are affected by natural systems.

We tend to take for granted the ecosystem services that humanity has come to enjoy as a given in our modern society. However, these ecosystem services have been developed and nurtured over hundreds and, in some cases, thousands of years. As these services move into and beyond crisis levels, human beings can no longer take their stability for granted. This will have wide-ranging and, in some cases, severe or even catastrophic implications. The following subsections discuss just a small sample of the ecosystem services we get from nature—natural capital—that we often take for granted.

Food

One of the most self-evident connections between our lives and natural capital is the food the natural world provides us with. Below is a brief and non-exhaustive list of food-related natural capital.

Pollination: Most of the food we eat either directly or indirectly depends on pollination. Pollination from honeybees, native bees, and flies contributes between $235 billion and $577 billion to global food production annually.[6]

Fish stocks: Fish provide 17% of the world's meat consumption, with about 3.1 billion people relying on fish for 20% of their protein; in some coastal communities, this number is closer to 70%.[7]

Plants: Civilization depends on thousands of plants for their diets. These plants are adapted to a climate system that has been stable for thousands of years and cannot adapt as easily as people.

Animals: Heat stresses and other biodiversity challenges will affect the animals we eat and the animals we use to help us harvest crops. In some cases, the industrialization of the food industry exacerbates the problem of crossing planetary boundaries.

Soil: The soil to grow our crops and to feed our livestock depends on a fine balance of moisture, minerals and nutrients and vibrant bug, bacteria, worm, and animal life. Failing to care for or upsetting those systems further challenges our ability to feed humanity.

Plants

Trees and plants absorb CO_2 and lock it away in their own structures and in the soil. Trees and plants also provide us with oxygen to breathe.

Trees and vegetation lower temperatures by providing shade and evapotranspiration. Shaded surfaces can be 20°F–45°F (11°C–25°C) cooler than the peak temperatures of unshaded materials.[8] Evapotranspiration, along with shading, can help reduce peak summer temperatures by 2°F–9°F (1°C–5°C).[9]

Trees and plants help with *stormwater management and water quality:* Vegetation reduces runoff and improves water quality by absorbing and filtering rainwater. This has become a problem in some urban areas where trees and soil have been eliminated. Concrete structures and paved roads cannot absorb or dissipate water as trees and soil can, exacerbating flooding problems.

Trees provide a habitat for innumerable species around the world, and a lack of forest to live in contributes to the loss of biodiversity.

Trees and vegetation also provide an improved quality of life, including aesthetic value and habitat, for many species; they can reduce noise as well. In addition, trees help with mental health and have been shown to alleviate stress and anxiety.[10]

Plants help filter water—for example, by removing heavy metals or excessive levels of nutrients.

Plants affect weather patterns. For example, evaporation from one section of a rainforest leads to life-sustaining rain in other areas of the rainforest and surrounding areas.

Medicine

Plants and animals provide medicine: Many compounds, including aspirin, penicillin, and tetracycline, come from natural resources. The loss of biodiversity will likely deprive humanity of important medicine in the future.

Drinking Water

Transpiration—the movement of water through soil—provides 62% of annual renewable fresh water.

According to the National Ground Water Association, "Groundwater is the world's most extracted raw material, with withdrawal rates currently in the

estimated range of 982 km^3/year. About 70% of groundwater withdrawn worldwide is used for agriculture. Groundwater provides almost half of all drinking water worldwide."[11] Stresses to the availability of groundwater, which are expected to increase as the demand for water increases, are likely to lead to increases in internal and global migration.

Oxygen and Other Gases

Through photosynthesis, plants provide us with the oxygen we need to breathe. This includes phytoplankton and other marine plants. Phytoplankton algae and marine animals produce over 50% of the oxygen we breathe.

Trees and plants absorb harmful gases, such as ground-level ozone, carbon monoxide, and sulfur dioxide.

Decomposition

Bacteria, fungi, worms, insects, beetles, and other living things aid in decomposition. Decomposition recycles carbon, nitrogen, phosphorus, and other minerals. Disrupting these processes would deprive plants of these key nutrients needed to grow.

Civilization Collapse Is on the Table

The recent paper "Global Catastrophic Risk and Planetary Boundaries: The Relationship to Global Targets and Disaster Risk Reduction,"[12] reached the conclusion that if "business as usual" continues and policy changes are not made to address the breaching of planetary boundaries, human civilization is moving toward potential collapse. The report discussed an increasing probability of global catastrophic risk (GCR) events, defined as those that result in over 10 million fatalities and greater than $10 trillion in damages, essentially damages that are extensive and on a global scale.

According to the report,

> the crossing of planetary boundaries is likely to exacerbate GCR risk, with large and complex environmental feedback loops leading to further environmental and social collapse. Depending on the extent of the crossing of the planetary boundaries and the severity of any GCR events that may have occurred, policy interventions that are not drastic are unlikely to improve society and a reactive policy approach will need to be taken. In this scenario international cooperation is extremely limited with a high risk of global or environmental conflict as the environment degrades, with potential forced migrations of people from uninhabitable areas that in turn has the potential to heighten GCR by making events such as pandemic or nuclear war more likely. (p. 12)

This is not one isolated report. There have been many academic papers[13] and books written over the years on the collapse of civilizations.[14] The civilization we currently enjoy will likely eventually collapse; it is more a matter of when than if. Unfortunately, through an overexploitation of earth's resources and a failure to value and protect the natural capital that keeps us alive, we are currently flirting with such a collapse.

It is important for investors to realize what civilization collapse would mean. The property rights and legal structures that protect investment and property would largely disappear. Long-term investments, such as pension plans, would be seriously devalued if not wiped out completely; assets such as housing used to store value would lose monetary value (because the land on which they are built would be devalued) and simply be shelters. Stock markets and bond markets in many countries would face catastrophic declines if they survived at all. Investment depends on the expectation that there is a better future to invest in. In a civilization collapse scenario, all reason for investment would vanish, and the global financial industry would disappear. The pursuit of education or a career would disappear for most people who survived such a catastrophic collapse. The focus of people's lives would become mainly food, water, shelter, and survival. There is a reason that they do not talk a lot about the stock market in *Mad Max* movies.

It is paramount that investors understand that this is not an insignificant risk. Talk of societal collapse is not a scare tactic of the UN Intergovernmental Panel on Climate Change (IPCC) or of this report. It is a real possibility. If our current civilization does not soon change course, the odds of such a collapse will continue to increase. We must do a better job of valuing natural capital and shepherding that capital if we are to avoid such a worst-case scenario.

WHY IS NATURAL CAPITAL IMPORTANT?

Human society and economic activity are fundamentally dependent on biodiversity. According to a recent study by the World Economic Forum, "$44 trillion of economic value generation—more than half of the world's total GDP—is moderately or highly dependent on nature and its services and is therefore exposed," both economically and as a society, to a loss of nature.[15]

We often take these "free" services of nature for granted. They have a profound impact on our way of life in their impact on our economy, our investments, and more broadly on society.

Economic Implications

Ecosystem services can be defined as the direct or indirect contributions ecosystems provide to human welfare. Examples of such services are supplying tangible goods, such as food and firewood; regulation services (benefits that come indirectly from ecological processes, e.g., pest control, soil formation, and water purification); and cultural services (benefits that are intangible, such as ecotourism, either for environmental education or for its aesthetic value).

According to the recent J.P. Morgan Asset Management paper "The Economic Importance of Biodiversity,"[16] the costs relating to recent losses of ecosystem services were between $4 trillion and $20 trillion a year. Land degradation costs were between $6 trillion and $11 trillion a year, and oceanic degradation totaled $200 billion a year.

A recent report from the White House Office of Management and Budget in the United States estimated that damages from climate change alone are $120 billion per year in the United States, a number that could rise to $2 trillion per year by the end of the century and knock off 3%–10% of US GDP annually by 2100.[17]

The depletion of natural capital—for example, such assets as forests, water, fish stocks, minerals, biodiversity, and land—represents a significant challenge to economies in the immediate future. The use of natural capital for economic output is likely to be curtailed in the coming years. As we move further beyond planetary boundaries, pressures will increase from society to limit the activities that push us beyond these boundaries, and the deleterious effects of pushing past these boundaries (e.g., increased heat, flooding, famine, water scarcity, and mass migration) will simply limit the amount of economic activity that can be undertaken.

It is possible that as more investors and society come to better understand the link between natural capital and our economy, economies, markets, and society will move to a more "circular" or regenerative economy. Such an economic model will work to bring balance to resources that can be regenerated, such as timber, fish stocks, and other resources that can "grow back." Finite resources, such as minerals and precious metals, will become the focus of more recycling and efficiency efforts. Materials that cannot be recycled, such as some plastics, will increasingly become replaced by those that can.

Such efforts are already underway in some markets. But as the focus on natural capital and protecting biodiversity becomes more mainstream, we can expect policymakers to put in place rules and regulations that put a greater emphasis on protecting natural capital. This trend will likely increase the cost of doing business for those on the wrong side of certain biodiversity issues and provides opportunities to those who can offer solutions that protect biodiversity.

Investor Implications

Investor focus on natural capital is following a trajectory similar to that of climate change. It is only relatively recently that investors began demanding more data around climate change from companies and policymakers.

Like climate change, natural capital risks can be broken down into physical risks and transition risks. Physical risks simply refer to the availability of the resource in question (water, timber, pollination), whereas transition risks refer to the risks of managing the transition to a time when natural capital is more properly accounted for. Investors who have a better understanding of these risks will be best positioned to take advantage of natural capital opportunities while avoiding unnecessary risks.

Today, investors are increasingly able to track a company's climate change promises and strategy as well as the data that companies disclose. International efforts from the European Union, the Securities and Exchange Commission (SEC) in the United States, and the International Sustainability Standards Board (ISSB) are being made to codify what needs to be disclosed and how it should be disclosed to investors.

The landscape around natural capital data is at a much earlier stage. Natural capital covers a broader range of issues than just climate change, so an investor may have to attend to several different natural capital issues in one industry. For example, in the beef and dairy industries, an analyst will have to understand issues around land use, water use, and greenhouse

gas emissions to begin to understand the risks and opportunities facing a company with a material financial exposure to cattle.

Investors will have to educate themselves about natural capital to get ahead of the adjustments to valuations that societies will place on ecosystem services. The development of systems for valuing natural capital are in their early stages. Investors will rightly focus on the risks and opportunities of the companies in which they invest when integrating natural capital into their investment process.

However, investors also need to take into consideration the systemic risks inherent in many natural capital issues. For example, an investor will need to address the systemic risks of climate change to ensure that there are markets to invest in in the future. It does little good to tilt a portfolio so that it is more "climate friendly" than its peers if climate change remains unchecked, eventually leading to market and societal collapse. This will involve investors making the case to policymakers that climate change action is needed to preserve markets so that they are there to serve future generations.

Like climate change, natural capital as a whole presents investors with an "unhedgeable risk."[18] This means that the risks of climate change and natural capital cannot be diversified away, because they will affect all companies around the world. The problems of climate change and natural capital must be addressed by investors, business leaders, and policymakers because they are so all encompassing that they affect all investments, all businesses, and all governments. There is simply nowhere to hide from their impacts.

Societal Implications

We are currently living through the sixth great extinction in the history of our planet.[19] Mass extinctions are distinct periods of geological time during which a large portion of biodiversity—for example, bacteria, fungi, plants, mammals, birds, reptiles, amphibians, fish, and invertebrates—dies off. Earth has experienced five previous mass extinction events, the last one occurring about 65 million years ago, which wiped out the dinosaurs from existence. In the current mass extinction, human activity is causing a high percentage of biodiversity to die off.

The extinction of these species has societal and cultural impacts to the nations where they have disappeared or will disappear in the future. The African lion is the national animal of many African countries in which that lion is no longer found. The Asiatic lion is the national animal of Iran but is now only found in India. The California grizzly, the state animal of the state of California, has been extinct for about 100 years.

These losses, however, go beyond cultural pride. About half of all human pharmaceuticals come from natural sources.[20] The massive loss of plant life that we are currently experiencing is likely limiting the medicines we can offer future generations.

Unless we act to address climate change and our other biodiversity challenges, parts of the earth will become uninhabitable in future decades.[21] In 2020, the Ecological Threat Register, conducted by the Sydney-based Institute for Economics and Peace (IEP), noted that by 2040, about 5.4 billion people will live in the 59 countries under high or extreme water stress, including India and China. The report stated that 3.5 billion people could suffer from food insecurity by 2050. Finally, the report noted that by 2050, about 1.2 billion people around the world could be displaced, causing a mass migration, the likes of which humanity has never seen. For comparison, the Syrian refugee crisis of the past decade saw numbers of just over 4 million displaced persons.[22] Such a mass migration undoubtably would stress systems in nearly every country on earth.

The societal changes that will be brought about by our current and future climate and biodiversity challenges are already daunting. They will be even more so without action to mitigate the worst impacts of climate change and biodiversity loss.

VALUING NATURAL CAPITAL

To properly value something, we need to be able to measure it. We need data. In this section, we discuss the status of data on natural capital.

What Is Not Measured Is Not Managed

In recent years, interest in measuring and therefore managing natural capital has increased among policymakers, companies, and investors. Some of this interest undoubtedly comes from the increased interest in the issue of climate change—which is one aspect of biodiversity and natural capital that intersects with other natural capital issues. Investors should expect a similar interest in natural capital to grow along a similar trajectory.

The Data

As was the case with the issue of climate change, there is currently a dearth of biodiversity information for investors to use in their investment analysis. A joint report from Responsible Investor and Credit Suisse recently emphasized that a lack of actionable data is the main thing keeping investors from integrating natural capital metrics into their investment process. A survey from this report noted that 70% of investors cited a lack of data as a key barrier to making investments that incorporate natural capital into the investment process.[23]

Data on natural capital and biodiversity are currently scarce in both financial reporting and company sustainability reports. But such was also the case with climate change data in recent years. Now, regulators and policymakers have ramped up requirements for climate-related reporting from both companies and investment managers. Natural capital will undoubtedly follow a similar trajectory; the European Commission and the ISSB have already begun work on natural capital or biodiversity standards.

Investors do not have to wait for regulators to give them all the regulation they need on natural capital. Biodiversity systems, such as oceans, land, timber, and fisheries, have been studied by scientists for decades, and interested parties can find hundreds if not thousands of peer-reviewed papers on these specific topics. Such data are not necessarily investor friendly, however, so investors and analysts will need to invest time and resources in digesting this information, develop expertise in these areas, or hire experts to better understand and interpret these data.

Some humility would help as well. A complex natural system cannot be boiled down to one number or indicator that will tell you the whole story. For example, climate change is often represented by the CO_2 parts per million (ppm) metric. This number is helpful to understand the concentration of CO_2 in the atmosphere but does not consider other greenhouse gases, such as methane, which is much more powerful than CO_2 but lasts fractions as long in the atmosphere. Knowing the current ppm number also does not help one understand the physics behind climate change or which climate change solutions are viable and which are not. Understanding climate change takes time to develop expertise on all aspects of the topic. Other natural capital systems are no different. Investors need to invest time and human capital into understanding these systems to adequately integrate this understanding into the investment process.

NATURAL CAPITAL INVESTOR RESOURCES

Some organizations have already begun to provide tools and resources to help investors better integrate natural capital in the investment process. In this section, we examine resources pertaining to natural capital that are available to investors.

Taskforce on Nature-Related Financial Disclosures

The Taskforce on Nature-Related Financial Disclosures (TNFD) was established in 2021 to create a risk management and disclosure framework for organizations to report on nature-related risks and opportunities, with the goal of shifting global financial flows away from nature-negative outcomes to nature-positive outcomes.

The TNFD is modeled on the successful Task Force on Climate-Related Financial Disclosures (TCFD), which has established a model for climate change risk management and disclosure that is widely used by companies and investors:

> The draft disclosure recommendations for nature-related risks and opportunities in this beta version follow the TCFD's four pillars of governance, strategy, risk management, and metrics and targets:
>
> 1. Governance: The ways in which the organization's oversight and decision-making functions take nature-related risk and opportunities into account.
> 2. Strategy: The integration of actual and potential effects of nature-related risks and opportunities on the organization's business model, strategy, and financial planning.
> 3. Risk management: How the organization integrates nature-related risks into its overall risk management approach.
> 4. Metrics and targets: Quantitative and qualitative performance indicators and aims related to nature-related risk and opportunities, based on nature dependencies and impacts.

The TNFD is currently working on its beta framework for nature-related risk and opportunity management and disclosure that will ultimately be used by investors, companies, and policymakers to better measure

and manage natural capital. This work highlights the TNFD's approach to metrics and additional guidance for market participants. Ongoing market feedback will support the further design and development of the TNFD recommendations, which are due in September 2023.

The current framework proposes an internal risk and opportunity assessment approach for use by both companies and financial institutions. This LEAP (locate, evaluate, assess, prepare) approach sets out an initial set of scoping questions to help financial institutions prioritize and focus effort as they assess their financial portfolios (see **Exhibit 3**).

Natural Capital Protocol

The Capitals Coalition is an organization made up of businesses, academics, and professionals that attempts to help organizations understand how their success is directly or indirectly linked to natural capital, social capital, and human capital. The Natural Capital Protocol is a decision-making framework that enables organizations to identify, measure, and value their direct and indirect impacts and dependencies on natural capital.

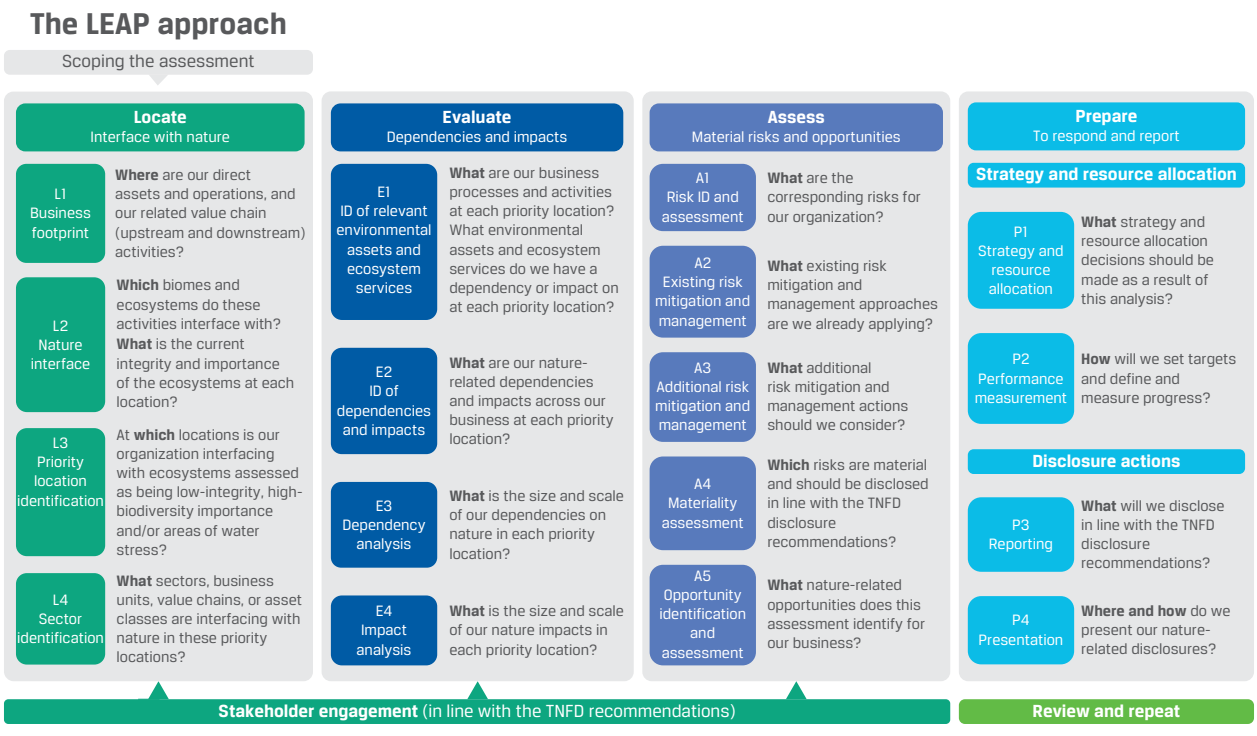
The Protocol Framework focuses on four states centered around the following questions: Why? What? How? What next? (See **Exhibit 4.**)

The Natural Capital Protocol is not a reporting standard and does not focus on valuation of a natural resource but instead creates a decision-making framework that offers users of the protocol a way to better understand the risks and opportunities tied up in natural capital and how their business models do or do not support biodiversity.

The Capitals Coalition has put together a Natural Capital Protocol Toolkit.[24] The toolkit, developed by the World Business Council for Sustainable Development, complements the Natural Capital Protocol. The toolkit is meant to help businesses use the protocol by offering tools, methodologies, and approaches available for natural capital measurement and valuation and mapping these against the protocol's framework.

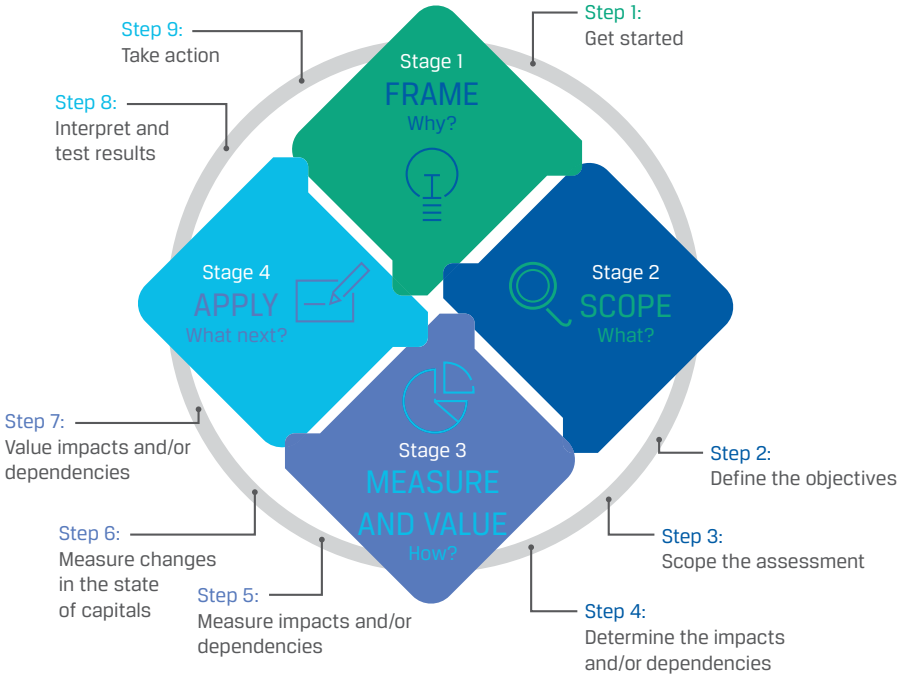
Investors can use the protocol and the toolkit themselves to understand how companies are or are not properly managing natural capital. These tools can also be used in an engagement framework by investors to work with companies to make sure that natural capital risks and opportunities are properly managed.

EXHIBIT 3. TASK FORCE ON NATURE-RELATED FINANCIAL DISCLOSURES—LEAP APPROACH



Source: Task Force on Nature-Related Financial Disclosures.

EXHIBIT 4. NATURAL CAPITAL PROTOCOL FRAMEWORK



Source: Capitals Coalition. https://capitalscoalition.org/capitals-approach/natural-capital-protocol/.

NatureFinance

NatureFinance is a group of 89 financial institutions that aims to raise the profile and materiality of biodiversity in financial decision making while bringing global finance more in line with nature conservation and restoration. The group focuses on the following areas:

- Market efficiency and innovation
- Nature markets
- Public finance
- Strategic liabilities
- Citizen engagement

NatureFinance and its partners are prolific in their writings on biodiversity and natural capital. The company's website offers a great deal of educational and thought-provoking reports for investors looking to better understand the natural capital landscape.

Science Based Targets for Nature (SBTN)

The Science Based Targets initiative has provided guidance to define how companies can assess, prioritize, measure, address, and track their impacts on natural ecosystems and biodiversity. The guidance uses a framework comprising (a) avoid and reduce pressure on nature loss, (b) restore and regenerate ecosystems, and (c) transform underlying systems to address the drivers of nature loss. This guidance shows companies a five-step process for addressing environmental issues or to begin exploring these issues for the first time. These steps are to assess; interpret and prioritize; measure, set, and disclose; act; and track.

World Benchmarking Alliance

The World Benchmarking Alliance recently published its "Methodology for the 2022 Nature Benchmark."[25] In the coming years, the World Benchmarking Alliance will assess the 1,000 companies with the biggest global footprint on nature and biodiversity to see where they stand in their transformation toward becoming "nature positive." This methodology builds on existing natural capital resources. In doing so, it provides a road map for companies and holds those companies that are not moving fast enough accountable.

The Nature Benchmark will require companies to demonstrate they are progressing toward a science-based target (for GHG emissions) and a net-zero deforestation objective or demonstrate how their water withdrawals efforts are effective in water-scarce contexts. The benchmark will also assess companies on other factors that are still being developed by

various organizations, such as resource decoupling, circular economy objectives, and following mitigation hierarchy principles. The methodology is designed to encourage companies to start acting on biodiversity and to measure existing efforts. The benchmark purports to help companies understand where their biodiversity impacts and dependencies are highest and prioritize and act quickly to halt damaging trends.

CASE STUDIES: A SYSTEM, AN INDUSTRY, A NATURAL RESOURCE, AND A FUTURE TECHNOLOGY

To adequately incorporate natural capital analysis into the investment process, investors need to understand the industry that they are analyzing and the impact that natural capital can have on a company and a society. In this section, we will look at four different topics: the ocean, the cattle industry, the role vultures play in our biosphere, and the nascent industry of carbon capture and storage. This section is meant to help investors understand that the knowledge they need to adequately understand natural capital is wide ranging.

A system like the ocean is vast and wide ranging in its impact on our economy, as well as in its impact on other systems. An industry, such as the beef or dairy industry, can have profound impacts on multiple natural systems that may raise challenges for that industry in the future. Natural capital comes in many shapes and sizes, and a relatively small player in the biosphere, such as a vulture, can have a profound impact on human health and well-being. Finally, several industries will appear in the coming years to meet the challenges of our stressed natural capital systems. The carbon capture and storage industry highlights some of the challenges and opportunities that scientists and investors alike will face in the coming years.

A System: The Ocean

The ocean covers about 70% of the earth's surface and offers humanity a broad range of ecosystem services. The following are just some of the important things we get from the ocean:[26]

The air we breathe: Phytoplankton, algae, and bacteria in the ocean produce over half of the world's oxygen.

Climate regulation: The ocean transports heat from the equator to the poles, regulating our climate and weather patterns.

Recreation: From fishing to boating and whale watching, the ocean provides many recreational activities.

Economic benefits: The US ocean economy alone produces $282 billion in goods and services, and ocean-dependent businesses employ almost 3 million people.

Food: The ocean provides more than just seafood; ingredients from the sea are found in thousands of food products.

Medicine: Many medicinal products come from the ocean, including ingredients that help fight cancer, arthritis, Alzheimer's disease, and heart disease.

A 2020 report by the World Economic Forum estimated the value of the earth's oceans at about $24 trillion.[27] This figure includes productive coastlines, valued at about $7.8 trillion; direct output from fishing and agriculture, valued at about $6.9 trillion; trade and transport, valued at $5.2 trillion; and carbon absorption, valued at about $4.3 trillion. According to one estimate, climate-related declines in the health of the ocean could cost the global economy $428 billion per year by 2050.[28] As the health of the ocean is degraded, industries that depend on the ocean will be hardest hit.

Plastic pollution is also damaging to the health of our oceans. The World Economic Forum has estimated that by 2050, the weight of plastic in the ocean could be greater than that of fish.[29] The reason is that as an inorganic material, plastic does not completely decompose and can remain in the ocean for centuries. Plastic pollution can lead to wildlife entanglement, ingestion, alien species transport, and habitat damage. Plastics in the ocean negatively affect tourism, fisheries, and the hundreds of millions of people who depend on the ocean for their livelihood. Microplastics ingested by fish eventually make their way up the food chain and onto the dinner table.

The pH Balance

The pH of the ocean is changing, with increased CO_2 levels making the ocean more acidic. In chemistry, the "potential of hydrogen," or pH, scale is used to specify the acidity or basicity of a solution. Acidic solutions are measured to have lower pH values than basic or alkaline solutions. The pH scale is logarithmic and inversely indicates the concentration of hydrogen ions

in the solution. The pH scale runs from 0 to 14, with 7 being a neutral pH. Anything higher than 7 is basic (or alkaline), and anything lower than 7 is acidic. The more acidic the ocean becomes, the less the ocean can support marine life. The current pH of the ocean is about 8.1, though the ocean is becoming more acidic as it absorbs more and more CO_2.

Ocean acidification will increasingly adversely affect marine life.[30] Such organisms as oysters and corals and any marine life that makes hard shells and skeletons by combining calcium and carbonate from seawater are at risk. As ocean acidification increases, available carbonate ions bond with excess hydrogen, resulting in fewer carbonate ions available for marine life with shells to build their shells and skeletons. If the pH drops too low, shells and skeletons can even begin to dissolve. These small organisms hold an important place in the ocean food web. As they disappear from our oceans, the marine life that uses them as food will suffer, breaking down the food web that eventually leads to humans. An ocean with decreased marine life due to a broken food web can have a catastrophic impact on humanity. As mentioned previously, fish provide 17% of the world's meat consumption, with about 3.1 billion people relying on fish for 20% of their protein; in some coastal communities this number is closer to 70%.[31]

Fish are also directly affected by changes in ocean pH, because changes in the pH of the water they live in can put stresses on a fish's nervous system and internal organs, compromising the ability of some species to thrive or even survive in a more acidic ocean.

The Air That We Breathe

Scientists estimate that 50%–80% of the oxygen production on earth comes from the ocean.[32] This oxygen production comes mainly from phytoplankton, algae, and some bacteria. Both marine life and humans use this oxygen. Oxygen is also consumed when organisms decompose in the ocean. In some cases, oxygen is consumed faster than it can be created, which can cause dead zones in the ocean.

Climate change has increased ocean salinity by about 4%.[33] If total global heating increases to 2°C–3°C, these figures could rise to nearly 25%.[34] Saline water is heavier and sinks deeper into the ocean, which reduces the nutrients available at the ocean surface and, once again, harms the phytoplankton population.

If the phytoplankton in the ocean falls to a low enough level, it could result in the loss of most all marine life on Earth. Phytoplankton loss also reduces the capacity of our oceans to serve as carbon sinks, which would further heat up the planet. Finally, a large-scale phytoplankton die-off could be catastrophic for humanity because we could lose up to half the oxygen we need to breathe, severely limiting humanity's ability to live on earth or perhaps ending our ability to live on earth at all.

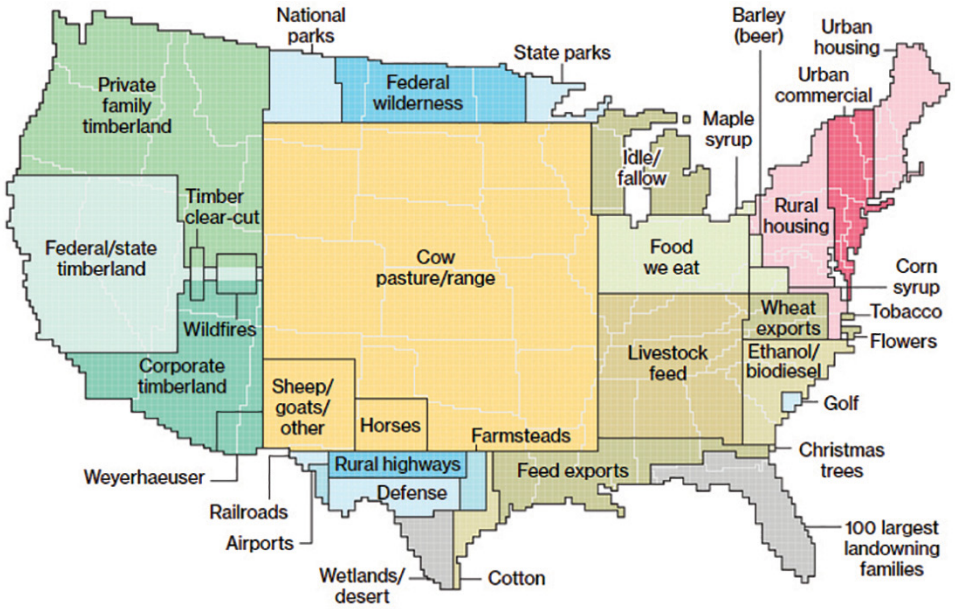
An Industry: Cattle

The environmental footprint of the global beef and dairy industries is well documented. Along with dairy cows, beef cattle have a notoriously high carbon footprint and water use footprint in comparison to other forms of meat. The beef and dairy industries also use a significant amount of land. **Exhibit 5** shows a map of the United States with each major use of land represented. It is easy to see that cow pasture/range is by far the greatest land use in the United States.

According to the Natural Resources Conservation Service, in the United States, "privately owned range and pasture lands make up over 27% (528 million acres) of the total acreage of the contiguous 48 states, and these lands constitute the largest private lands use category, exceeding both forest land (21%) and crop land (18%)."[35] This picture is similar around the world. Beef and dairy cattle represent a huge land use footprint and a large environmental footprint wherever they roam. **Exhibit 6** shows that of the habitable land on earth, about half is taken up by agriculture, and about 75% of that half is devoted to livestock. That means that about 38.5% of all habitable land on earth is used for livestock or feed for livestock. Exhibit 6 also shows that only about 18% of the calories that humanity consumes and about 37% of our protein come from livestock. This highlights the relative inefficiency of livestock as a source of calories we need to survive. Livestock uses well over one-third of the earth's arable land but produces less than 20% of the calories we consume.

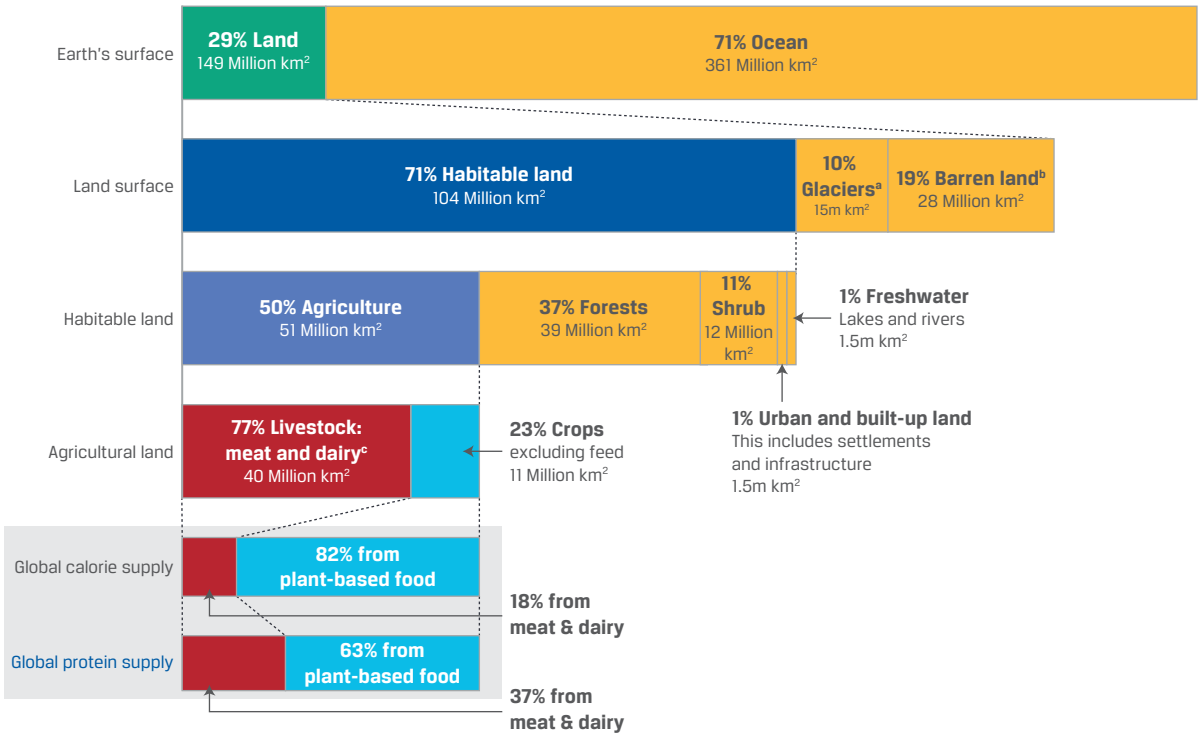
As shown in **Exhibit 7**, humanity currently uses about 4.34 billion hectares of land for cropland and pastureland. If we eliminate beef and mutton from our diets but keep dairy cows, we use only about 2.22 billion hectares of land. In the extreme, if everyone adopted a vegan diet, humanity would use about 25% of the current land used for feeding the world. It is, of course, not feasible to limit all of humanity to a strictly plant-based diet. This information simply illustrates the land use footprint for the beef and dairy industry.

EXHIBIT 5. LAND USE IN THE UNITED STATES



Source: Dave Merrill and Lauren Leatherby, "Here's How America Uses Its Land," Bloomberg (31 July 2018).

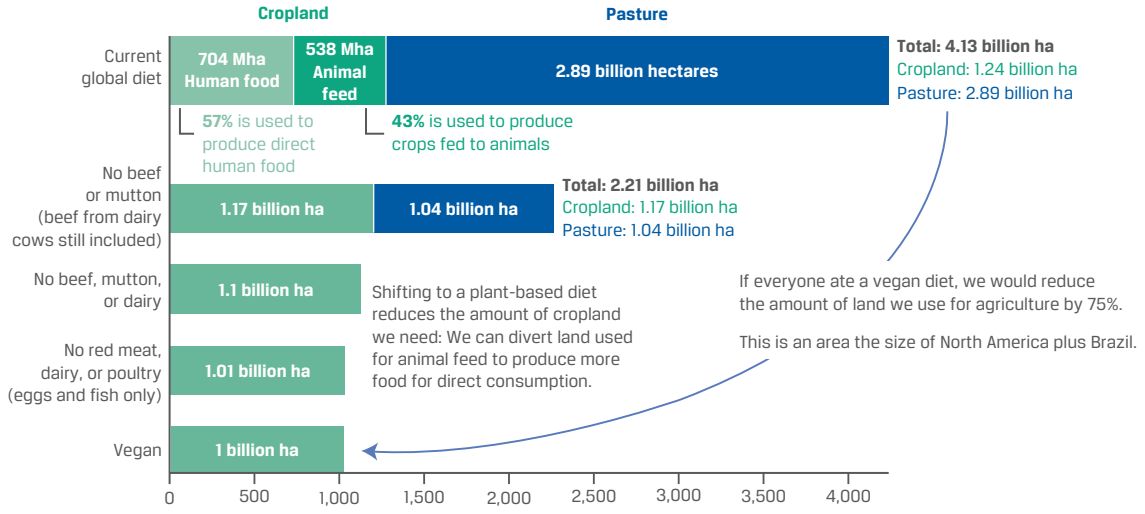
EXHIBIT 6. GLOBAL LAND USE FOR FOOD PRODUCTION



[a]14m km² of which is the land area of Antarctica.
[b]This includes the world's deserts, salt flats, exposed rocks, beaches, and dunes.
[c]This includes grazing land for animals and arable land used for animal feed production.

Sources: Hannah Ritchie and Max Roser, "Land Use," OurWorldinData.org (2019). https://ourworldindata.org/land-use. The data are from the UN Food and Agriculture Organization.

EXHIBIT 7. GLOBAL LAND USE FOR AGRICULTURE ACROSS DIFFERENT DIETS



Notes: Global agricultural land use is given for cropland and pasture for grazing livestock assuming everyone in the world adopted a given diet. This assumption is based on reference diets that meet calorie and protein nutritional requirements. Mha = million hectares; ha = hectares.

Sources: Hannah Ritchie, "If the World Adopted a Plant-Based Diet We Would Reduce Global Agricultural Land Use from 4 to 1 Billion Hectares," OurWorldinData.org (2021). https://ourworldindata.org/land-use-diets. The data are from J. Poore and T. Nemecek, "Reducing Food's Environmental Impacts through Producers and Consumers," *Science* 360 (1 June 2018).

According to the World Economic Forum, "Global agricultural production is responsible for about 25% of greenhouse gas emissions and about 70% of freshwater withdrawals."[36] Greenhouse gas emissions from the livestock supply chain are estimated to be responsible for about 14.5% of human-caused greenhouse gas emissions.[37] The livestock industry is also a large user of water. A recent academic study of global water use estimated that livestock feed alone accounts for about 41% of total agricultural water use.[38]

It is feasible that we will see a shrinking of the livestock industry due to several factors discussed previously, along with a growing awareness by the public of the environmental footprints of the foods they eat. The production of livestock is a relatively inefficient way to produce the calories that humanity needs, with other forms of protein and other foods providing the same calories for a much smaller environmental footprint. Add to this equation the vast land use of the industry, and it is not hard to imagine a world in the near future in which the dairy and beef industries have shrunk in size, with some of that vast land use savings deployed to "re-wild" or reforest areas in the effort to absorb carbon dioxide.

A Natural Resource: Vultures

Now let's talk about something most people value very little: vultures.

Vultures are one of the most, if not the most, valuable bird species to humankind because of the service they provide. Vultures do a great job of keeping the world safe from deadly pathogens by cleaning the carcasses of dead animals. When a dead animal begins to decompose, bacteria that cause diseases, such as swine flu, botulism, leprosy, and anthrax, develop. These bacteria can be picked up by other animals and pests and spread life-threatening diseases to humans. But vultures are designed to handle this problem. Their stomach acids are strong enough to tolerate pathogens that would make humans incredibly sick or even kill us. Vultures do the dirty work of eliminating these pathogens from the environment.

In 1993 in India, there were about 40 million vultures. But by 2007, the population of the long-billed vulture had dropped by about 97%. The population of oriental white-backed vultures dropped by about 97%.[39] This massive die-off of vultures was caused by the introduction of an anti-inflammatory drug diclofenac, which was used extensively on livestock. Unfortunately, diclofenac made the carcasses of animals treated with it poisonous to vultures, causing the extreme increases in vulture mortality.

Other scavengers, mostly dogs, took the place of vultures in India in the job of cleaning carcasses. It was estimated that that the dog population in India increased by about 7 million because of the loss of

vultures as a competitor for food. These dogs were mostly feral, with little or no veterinary care. This situation led to an explosion in the cases of rabies in India, and estimates show that about 50,000 people in India perished from rabies from feral dog bites because of the disappearance of vultures.

As we lose vultures from our world, we should expect the rates of the diseases that they help moderate to increase. This increase will lead to higher mortality rates linked to these diseases, increasing medical costs and all the costs that come with the loss of life. Humans can, of course, take the job of finding and safely disposing of every single dying animal carcass in the world. But such an effort would add enormous costs to a service that nature currently provides for free through the work of the humble vulture. A recent study noted that all but 7 of the 23 vulture species are now considered nearly threatened, vulnerable to extinction, endangered, or critically endangered.[40] These losses are mainly due to habitat loss, poisoning, and hunting.

A Future Technology: Carbon Capture, Utilization, and Storage

There are only a few carbon capture, utilization, and storage (CCUS) power plants currently operational in the world. These plants capture about 40 metric tons of CO_2 per year[41]—only about 0.1% of the yearly global emissions of CO_2. The International Energy Agency (IEA) has estimated that between 2018 and 2060, CCUS can capture 115 gigatons of CO_2, delivering about 13% of the cumulative emission reduction in that period. So, there is a role for carbon capture and storage, but it is no silver bullet. And it is currently very expensive.

CCUS is not profitable as a process by itself at this time. It is often added on as an option to power plants or to process CO_2 from power production. There are also a limited number of sites where CCUS is viable.

There is increasing interest in the "U" of CCUS, utilizing CO_2 for other processes. Some of these uses are less green than others, such as injecting CO_2 into oil wells to aid in oil recovery. Other uses include adding CO_2 to concrete to lock that CO_2 away in the life of structures that are being built and using CO_2 in greenhouses, carbonated beverages, and other processes.

CO_2 utilization will likely grow in the future as more CCUS operations are brought online. However, not all uses of CO_2 are as sustainable as others, so some may be looked on more favorably than others. Policies that reward companies for using CCUS will likely help this industry grow.

Direct Air Capture

Direct air capture sucks CO_2 directly out of the atmosphere, but the cost is currently uneconomical compared with other carbon capture technologies, such as tree planting. However, the promise of direct air capture lies in its physical footprint, which is much smaller than a forest that can capture the same amount of CO_2.

The output of direct air capture is CO_2. The direct-air-capture business model necessitates an end use for this output: A business needs to get paid for the CO_2 it has removed from the atmosphere. In some cases, companies, individuals, or governments will pay a direct-air-capture company to permanently sequester that CO_2 safely deep underground, but in many cases, that CO_2 is used for commercial processes—whose own carbon footprint needs to be considered. Next, we will look at two companies currently operating in the direct-air-capture landscape to better understand the business: Carbon Engineering and Climeworks.

Carbon Engineering[42] has a pilot plant in British Columbia that captures about 1 metric ton of CO_2 per year. It has a plant in the Permian Basin that is scheduled to open in 2024 that can capture 1 million metric tons of CO_2 per year, which is equivalent to 40 million trees. This is a very energy-intensive process, so the power source matters if the aim is to lower atmospheric CO_2 levels. One use that Carbon Engineering is exploring is creating synthetic fuels that can be used in both land-based transport and aviation. When such fuels are burned, they do release CO_2—which will be captured by Carbon Engineering to begin the process again. Sequestration is not quite economical yet. The current cost of Carbon Engineering's air capture ranges from $94 to $232 per metric ton of CO_2.[43]

Climeworks[44] operates 14 plants across Europe that together currently capture 2,000 metric tons of CO_2 per year. The company's new plant in Iceland will capture 4,000 metric tons per year. At the end of the process, the CO_2 is mixed with water and injected deep underground. The cost is currently about $600–$800 per metric ton. The company has predicted the cost will drop below $250 per metric ton by 2030.[45]

Both Carbon Engineering and Climeworks are unprofitable currently and would need policy changes to become profitable. Note also that current emissions of CO_2 per year stand at about 36 billion tons.[46] So, direct air capture or carbon capture utilization and storage will need to scale up considerably to make a meaningful impact. As with other natural systems that remove CO_2 from the atmosphere, direct air capture is no silver bullet but, rather, is part of a larger effort to draw down CO_2 from our atmosphere.

A WORD ABOUT GREEN GROWTH

Much has been written about how we only need to substitute clean sources of energy for fossil fuel energy to solve the climate crisis and other planetary boundary problems linked to climate change. If only it were so simple.

The materials needed for such a green energy transition are mainly things that we dig up from the earth, some of them quite rare. The mining that will be needed for such a ramp up in the use of these materials is often underappreciated by those touting a clean energy transition.

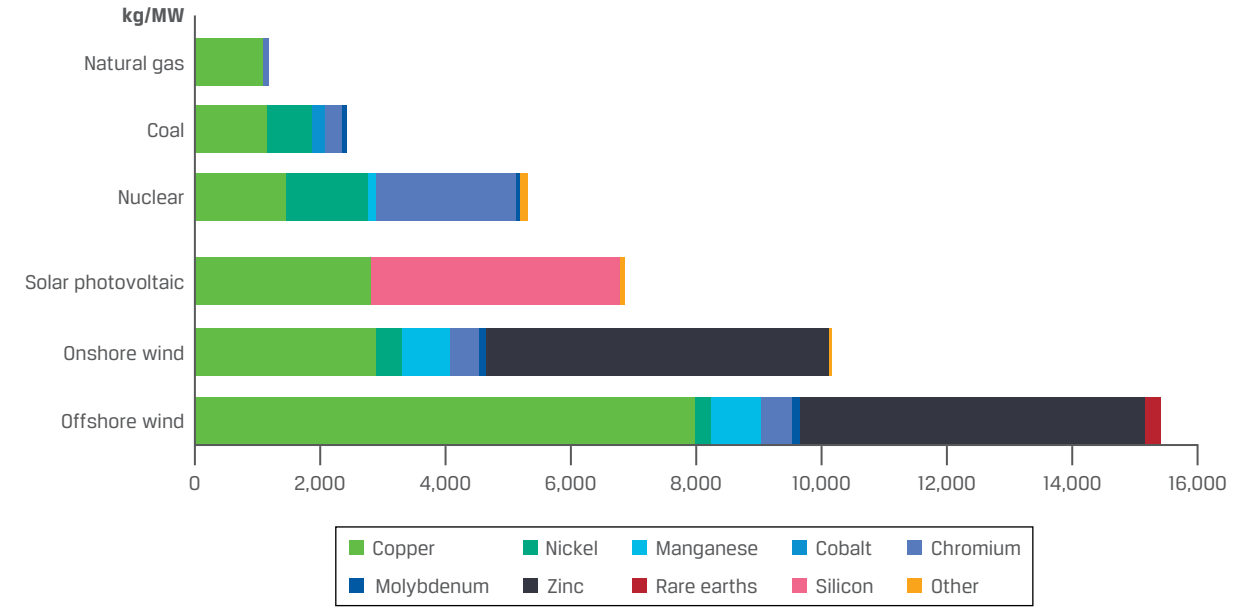
Take copper, for example. Currently, around 60% of copper demand comes from wind and solar technology, electric vehicles, and infrastructure.[47,48] The mining of copper requires a large amount of water and energy and often leaves behind toxic waste that must be safely managed. The main sources of copper are concentrated in a few countries, mainly in South America, which could limit the resource if political instability arises in any of the main suppliers of the metal. Energy transition technologies use up to 12 times more copper than current conventional uses for copper, such as electronic goods—which threatens to exhaust the supply of copper needed for a clean energy transition. Mining all the metals and rare earth elements for a "green" energy transition comes with its own environmental, societal, and economic challenges.

Exhibit 8 details the mineral intensity of many of the metals, minerals, and rare earth elements that are heavily used in transport and power generation. It demonstrates just how much more mining and invasive extraction will be required to ramp up such things as solar and wind power, not to mention electric vehicles (EVs), which are high users of lithium, graphite, copper, nickel, aluminum, cobalt, and titanium for EV batteries. As the mining for these minerals increases, which surely will occur, we will face environmental concerns about land use, water use, and other health and safety concerns.

Simon Michaux, the senior scientist at the Geological Survey of Finland, recently published a detailed study of the metals required to phase out fossil fuels in favor of renewables.[49] The findings from his paper are summarized in **Exhibit 9**. The study leads to a sobering conclusion. Currently, there are nowhere near the adequate reserves of metals needed to transition away from fossil fuels completely. In some cases, only a small fraction of the metals needed are available, requiring a rigorous ramp up in mining or a search for substitutes.

Solar and wind energy can currently supply power at rates that are competitive with traditional sources and,

EXHIBIT 8. MINERAL INTENSITY IN TRANSPORT AND POWER GENERATION



Sources: IEA and Schroders Economics Group (June 2022).

EXHIBIT 9. TOTAL METALS REQUIRED FOR ONE GENERATION OF TECHNOLOGY TO PHASE OUT FOSSIL FUELS

Metal	Required Production (tons)	Known Reserves (tons)	Comment
Copper	4,575,523,674	880,000,000	Reserves cover 20% of requirements
Cobalt	218,396,990	7,600,000	Reserves cover 3.48% of requirements
Graphite	8,973,640,257	320,000,000	Reserves cover 3.57% of requirements
Lithium	944,150,293	95,000,000	Reserves cover 10% of requirements
Manganese	227,889,504	1,500,000,000	Adequate reserves
Nickel	940,578,114	95,000,000	Reserves cover 10% of requirements
Silicon (metal)	49,571,460		Adequate reserves
Silver	145,579	530,000	Adequate reserves
Vanadium	681,865,986	24,000,000	Reserves cover 3.52% of requirements
Zinc	35,704,918	250,000,000	Adequate reserves
Zirconium	2,614,126	70,000,000	Adequate reserves

Source: Data from RCDEA (2022). https://rincrude.com/?p=1762.

in some cases, below the costs of traditional power generation. But the materials that go into solar and wind generation are not currently being recycled or reused in any meaningful way. Communities that have invested heavily in rooftop solar are starting to come to grips with the problem that there are currently no good recycling options for rooftop solar arrays, with many of these solar cells ending up in landfills.[50] The same is true for wind turbine blades.[51] Recycling industries for rooftop solar and wind turbine blades will have to develop to make these energy sources sustainable in the long term.

A transition to "green" energy comes with its own environmental challenges. We should not pretend otherwise.

A WORD ABOUT DEGROWTH

Natural capital has become an issue on investor dashboards because we can see how mismanagement of our natural systems has put investments, markets, and even the future of our civilization in peril. We must acknowledge that these stresses to our natural world are inextricably linked to an economic system that demands ever-expanding growth.

In the 1930s, the US Department of Commerce asked economist Simon Kuznets to establish more suitable economic metrics than those that were previously used. This project gave birth to the term *gross domestic product* (GDP). GDP has been used to measure progress and success ever since. However, Kuznets himself warned that GDP would not be able to measure the welfare of a nation because it simply measures economic output, ignoring all the factors that contribute to that output.

The resources that help fuel an ever-growing economy are finite, which means that without changes to resources, the economic system will reach an end. We very well may be in or approaching that moment. Humanity is using the earth's resources as though we have 1.6 earths to use. We have passed multiple planetary boundaries that are putting human economies and civilization at risk. This system is unsustainable.

Degrowth is a term increasingly heard in economic circles to describe a world in which we live more within the limits of the natural world. This economic philosophy involves shrinking an economy to a size that is manageable, one that keeps us within the guardrails of the planetary boundaries.

The degrowth movement asks, What if we just slowed down development and got back to using resources as though we had only 1.0 earth to use? What if we throttled back on development so that we are again on the safe side of planetary boundaries? Advocates of degrowth posit that humanity needs to do exactly this: move from a focus on GDP growth to measuring the success of humanity with a different set of indicators. Some countries, such as New Zealand, Canada, and Finland, have already done so, using a dashboard of such metrics as life expectancy, education, and human happiness to measure human progress. Iceland, for example, has experimented with a four-day work week, while keeping pay the same, to lighten the stress on resources and improve the well-being of its citizens.

The genuine progress indicator (GPI) is an alternative to GDP that uses GDP as an input but also considers negative externalities that GDP does not. For example, if a cigarette company sells $1 billion in cigarettes, GDP grows by $1 billion, without taking into effect any of the negative medical implications of smoking. Net domestic product (NDP), which adjusts for loss of assets, including natural assets, is another benchmark indicator that economists have used to measure progress in the place of GDP.

Degrowth is about intentionally limiting the size of our economy so that it does not push us over planetary boundaries, such as climate change, that ultimately threaten our civilization. A degrowth world would, of course, entail drastic changes to our economy and how we live and work. But it is sustainable. The current system we are operating under is not.

RECOMMENDATIONS

A better understanding of natural capital and how it can affect company valuations will help investors make decisions based on natural capital risks and opportunities. Given that over half of global GDP can be traced back to natural capital and ecosystem services, a better understanding of natural capital and better methods of measuring and managing these resources is imperative. Because natural capital and ecosystem services are a systemic issue, collective action is required to effect change. Investment firms have a shared interest in pushing for better disclosures and corporate engagement issues on natural capital, and they will need to work together to effect positive change.

The following six recommendations should be considered relative to the size and resources of investors. No investors can ignore these issues, but not all will be able to devote the same level of resources to natural capital analysis and integration.

Recommendation 1: Increase education. Natural capital is a new topic to many investors. This report is only a first step in educating investors about natural capital. Investors and financial professionals need to educate themselves on these issues to better integrate natural capital considerations in the investment process. CFA Institute calls on the investment management industry to support staff training and development in systems thinking and natural capital issues. Financial professionals will need to understand the broader implications of an interconnected world for estimating and managing risks.

Recommendation 2: Enhance natural capital expectations in analyst reports. Natural capital touches every sector and every industry in the market, yet discussions of the risks and opportunities that arise from natural capital rarely make their way into financial research and writing. CFA Institute recommends that investment professionals account for natural capital in their risk analysis. Natural capital has value. The more that value is reflected in analyst reports, the more investors can place a proper value on natural capital.

Recommendation 3: Increase development and disclosure of natural capital metrics. Natural capital covers many natural systems and ecosystem services. Specialized data for each of these areas already exist to some extent but often are not presented in investor-friendly ways or do not lend themselves to easy inclusion in a valuation model. Investors should, therefore, work with those already setting standards for ecosystem services, as well as issuers, researchers, and policymakers, to settle on the metrics that matter when assessing a company's climate change strategy. CFA Institute also encourages investors to work with researchers, standard setters, and policymakers to expeditiously develop standard disclosures for natural capital in order to better assess investment risk and opportunity.

Recommendation 4: Bring in experts. The ecosystem services that make up the natural capital landscape have been well researched for decades by scientists and professionals around the world, but to this point, investors have rarely researched these services. CFA Institute recommends that investment managers partner with these experts and bring them into the analysis process where appropriate and practical. Such expertise cannot be expeditiously replicated in house by investment managers or analysts and can offer a fresh perspective on what is practical and possible when evaluating natural capital investments.

Recommendation 5: Engage with companies on physical and transition risks around natural capital issues. CFA Institute believes investors should engage with issuers to ensure that climate data, scenario analysis, and related disclosures are sufficiently thorough to support robust climate risk analysis in the investment process.

Recommendation 6: Advocate for policy that complements investor efforts. Investors need to continue to meet with policymakers to ensure that they have the tools and data they need to support the efficient allocation of capital and that they can account for natural capital concerns.

SUGGESTED READINGS

Additional Draft Guidance for Corporates on the 'Evaluate' Phase of the TNFD's LEAP Approach for Dependency and Impact Analysis (2022)[52]

> "The report highlights the synergies and interconnection between the Natural Capital Protocol and TNFD's LEAP approach, which sits at the heart of the TNFD framework." —Capitals Coalition

Banking on Natural Capital (2022)[53]

> The report imagines what integrating natural capital into financial markets should look like: "building on the foundation of the evolving carbon market, the growth in sustainable finance, and emerging payments for ecosystem services, and how to bring these together into a single shared platform of action and investment in nature."

CDSB Framework: Application Guidance for Biodiversity-Related Disclosures (2021)[54]

> "The CDSB Framework application guidance for biodiversity-related disclosures (the Biodiversity Application Guidance) has been produced by CDSB to assist companies in the disclosure of the material information about the risks and opportunities that biodiversity presents to an organisation's strategy, financial performance and condition within the mainstream report (biodiversity-related financial disclosure). It is designed to supplement the CDSB Framework for reporting environmental and climate change information to investors (CDSB Framework)."

The Changing Wealth of Nations 2021: Managing Assets for the Future (2021)[55]

> "It is now clear that a narrow focus on the growth of gross domestic product (GDP) is insufficient to achieve humanity's aspirations for sustainable prosperity. Wellfunctioning ecosystems and educated populations are requisites for sustainable wellbeing. … This report—and the accompanying global database—firmly establishes comprehensive wealth as a measure of sustainability and a key component of country analytics."

The Economic Importance of Biodiversity (2022)[56]

> "Biodiversity—the world's varied wildlife, plants and habitats—is bound up with the viability of human life, especially food production (both farming and aquaculture). Rising levels of pests, extinctions, habitat loss, heat waves, wildfires and other human impacts are harming biodiversity, including by diminishing soil and water quality, pollination and disease resistance around the world. Nature's effectiveness as a carbon 'sink' (storing CO_2) is also waning."

The Economics of Biodiversity (2021)[57]

> "The Dasgupta Review is an independent, global review on the Economics of Biodiversity led by Professor Sir Partha Dasgupta (Frank Ramsey Professor Emeritus, University of Cambridge). … The Review calls for changes in how we think, act and measure economic success to protect and enhance our prosperity and the natural world. Grounded in a deep understanding of ecosystem processes and how they are affected by economic activity, the new framework presented by the Review sets out how we should account for Nature in economics and decision-making."

Environmental Water Regimes and Natural Capital (2017)[58]

> "The value of natural capital and *ecosystem services (ESs)* is widely acknowledged, but the application

of the concept to environmental water is still in its infancy. This chapter argues for the need to adopt the natural capital and ESs concept and to underpin environmental flows assessments. It also highlights the numerous challenges that lie ahead in applying the concept. In particular, the importance of identifying hot spots and hot moments of ES delivery in relation to rivers and flow is presented, and the importance of stakeholder engagement and dialogue as part of proactive water allocation is stressed. The value and associated challenges are highlighted using the example of the Ganges River in India and a number of East African rivers."

Exploring Degrowth Policy Proposals: A Systematic Mapping with Thematic Synthesis (2022)[59]

The authors "conducted a systematic mapping of the degrowth literature from 2005 to 2020. … Out of a total of 1166 texts (articles, books, book chapters, and student theses) referring to degrowth, [they] identified 446 that include specific policy proposals. … Following this, [the authors] assess the precision, frequency, quality, and diversity of this agenda, reflecting on how the degrowth policy toolbox has been evolving until today."

Global Assessment Report on Biodiversity and Ecosystem Services (2019)[60]

"The overall scope of the assessment is to assess the status and trends with regard to biodiversity and ecosystem services, the impact of biodiversity and ecosystem services on human well-being and the effectiveness of responses, including the Strategic Plan and its Aichi Biodiversity Targets. It is anticipated that this deliverable will contribute to the process for the evaluation and renewal of the Strategic Plan for Biodiversity and its Aichi Biodiversity Targets."

Global Catastrophic Risk and Planetary Boundaries: The Relationship to Global Targets and Disaster Risk Reduction (2022)[61]

"The scenario analysis considers worlds where global catastrophic risk is high and low, and planetary boundaries have not been crossed and have been crossed respectively. This gives rise to four scenarios: Earth Under Uncertainty, Global Collapse, Stable Earth, and Earth Under Threat. In all of these scenarios except for Stable Earth the achievement of global targets and accompanying frameworks is negatively impacted. Furthermore, in the absence of change, scenarios Earth Under Uncertainty and Earth Under Threat tend towards that of Global Collapse."

How to Handle Natural Capital within the Context of the Green Economy? (2019)[62]

"Natural capital is one of the most controversial measures in current models of economic development. Sustainability challenges of our time are related with measuring Nature as economic value. How to measure the inputs that do not have a clear market price? How to measure ecosystems and noncultivable land? How to introduce these elements in our National Accounts? In this chapter, the main elements of the theory behind natural capital are reviewed, and the available measures are presented and criticized. The chapter concludes with some suggestions to adequate wealth measures with the inclusion of natural capital as economic input."

Is Green Growth Possible? (2019)[63]

"The notion of green growth has emerged as a dominant policy response to climate change and ecological breakdown. Green growth theory asserts that continued economic expansion is compatible with our planet's ecology, as technological change and substitution will allow us to absolutely decouple GDP growth from resource use and carbon emissions. … But empirical evidence on resource use and carbon emissions does not support green growth theory. … [The authors] find that: (1) there is no empirical evidence that absolute decoupling from resource use can be achieved on a global scale against a background of continued economic growth, and (2) absolute decoupling from carbon emissions is highly unlikely to be achieved at a rate rapid enough to prevent global warming over 1.5°C or 2°C, even under optimistic policy conditions."

The Limits to Growth (1972)[64]

"The earth's interlocking resources—the global system of nature in which we all live—probably cannot support present rates of economic and population growth much beyond the year 2100, if that long, even with advanced technology. In the summer of 1970, an international team of researchers at the Massachusetts Institute of Technology began a study of the implications of continued worldwide growth. They examined the five basic factors that determine and, in their interactions, ultimately limit growth on this planet-population increase, agricultural production, nonrenewable resource depletion, industrial output, and pollution generation."

Natural Capital Accounting: Revisiting the Elephant in the Boardroom (2019)[65]

> "This research is motivated by a growing belief that Natural Capital Accounting (NCA) can assist organisations in increasing their stewardship over the ecological elements they effect and in some cases control."

Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy (2020)[66]

> "[T]his report provides a deep dive into how nature loss is material to businesses in all industry sectors and makes a clear argument for nature-related risks to be regularly identified, assessed and disclosed by business—as is now increasingly the case for climate change risks. This will help prevent risk mispricing and inaccurate capital buffers, as well as guiding action to mitigate and adapt business activities that degrade and destroy nature."

Planetary Boundaries: Guiding Human Development on a Changing Planet (2015)[67]

> "The planetary boundary (PB) approach aims to define a safe operating space for human societies to develop and thrive, based on our evolving understanding of the functioning and resilience of the Earth system. Since its introduction, the framework has been subject to scientific scrutiny and has attracted considerable interest and discussions within the policy, governance, and business sectors as an approach to inform efforts toward global sustainability."

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