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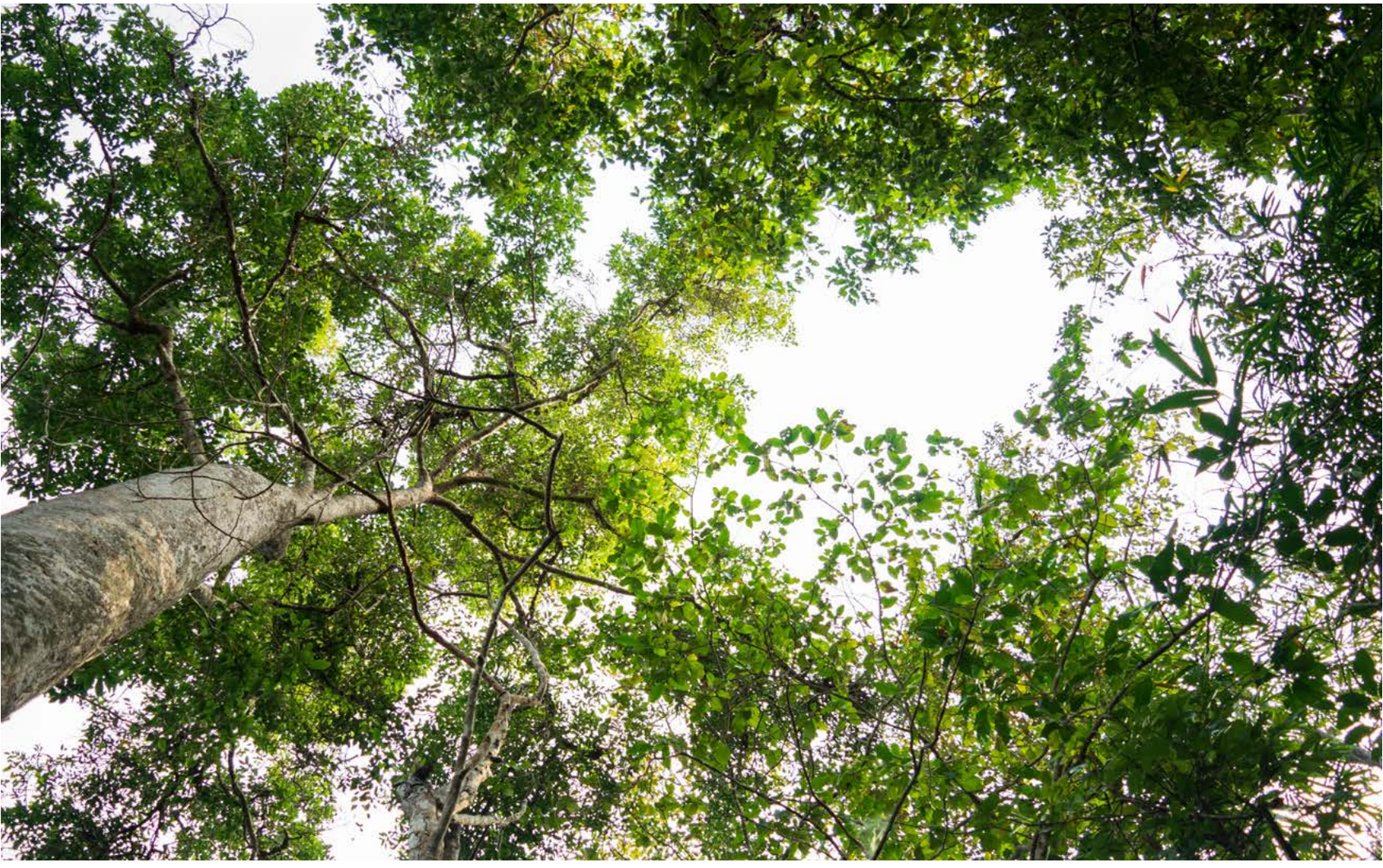

TECHNICAL ADVANCES IN ASSESSING NATURAL CLIMATE SOLUTIONS FOR GLOBAL CARBON MARKETS

NATURE-BASED SOLUTIONS TASKFORCE

SCIENCE WORKING GROUP – TECHNICAL NOTE

NOVEMBER 2021

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EXECUTIVE SUMMARY

The Terra Carta serves as the guiding mandate for HRH The Prince of Wales' Sustainable Markets Initiative (SMI).[1] It calls for urgent action to build a sustainable future for Nature, People and Planet. Investments in natural climate solutions can simultaneously address each of these pillars. The SMI Science Working Group aims to connect nature, science, and technology in addressing root-challenges to scaling natural climate solutions.

The need for urgent action on global warming is now widely considered one of the most critical environmental issues of our time, alongside biodiversity loss. While rapid decarbonisation of the global economy is an essential condition for limiting the rise in global temperatures to no more than 1.5°C above pre-industrial levels, it is also increasingly recognised that well-designed natural climate solutions can make an important contribution to limiting climate change, while concurrently providing valuable community and biodiversity benefits, if deployed early enough and at scale.

Despite the potential these solutions offer, investments in natural climate solutions fall far short of that required to make a meaningful contribution to climate change mitigation. The lack of investment can, at least in part, be attributed to uncertainties and risks concerning both the role of natural climate solutions and the integrity of credits traded in voluntary carbon markets.

This paper argues that recent advances in scientific understanding and technological developments have resulted in substantial improvements in the scale, frequency and accuracy with which the extent and condition of natural capital assets and their actual carbon performance can be assessed. This is particularly the case with respect to forests, which is where a lot of the technological assessment improvements have been achieved recently. The full potential of these technology platforms for natural climate solutions assessment cannot be fully realised without the primary field data necessary to support model calibration.

WE THEREFORE RECOMMEND:

1. The mobilisation of an **international taskforce for "ground truthing"** global above- and below-ground carbon stocks i.e. carbon stored in forests and soils. Ground-truthed forest data would provide greater confidence in the performance of individual natural climate solutions, strengthen the integrity and size of the voluntary carbon market, and ultimately support the inclusion of natural climate solutions in the global carbon compliance market. We will be closely monitoring the outcome of Article 6 negotiations at the forthcoming Conference of the Parties of the United Nations Framework Convention on Climate Change (COP26), in this regard.

2. That **methodologies for carbon credits in voluntary carbon markets are updated to reflect both advances in scientific understanding concerning carbon measurement, as well as technological developments** that could revolutionise approaches to monitoring, reporting and verification. These methodologies need to be broadly applicable and supported by clear and consistent guidance in order to eliminate the confusion and uncertainty for potential investors in natural climate solutions. In particular, new approaches are needed to help streamline and accurately account for multiple above- and below-ground carbon pools in existing and new carbon projects. This is especially important given that it could both bring added value and incentives to better understand the carbon dynamics within carbon projects, while also addressing potential issues with long-term (decadal) projects, given the uncertainties introduced by climate change itself.

3. Related to recommendation two, the accounting rules that define the relationship between voluntary carbon market transactions and efforts by countries to reduce national emissions in line with their Nationally Determined Contributions need to be urgently agreed to avoid confusion and in a way that stimulates climate action rather than stifles it. To this end, we recommend **convening an international summit of policy leaders and implementers, including the relevant standards bodies, to resolve outstanding barriers and advance innovation in assessment of natural climate solutions**. We are in discussions with several leading corporate groups who are interested in supporting the MRV campaign financially.

1. INTRODUCTION

The Terra Carta implores that we catalyse science, technology, and innovation for a mutually beneficial relationship between society and nature. The purpose of the Science Group is to set out a snapshot of the best available technologies and techniques for credible assessment of natural assets' carbon sequestration and storage performance. In turn, the ambition is that, with replicable and scalable approaches for measuring and reporting carbon sequestration in natural systems, natural assets can be (re)considered for global carbon compliance markets.

This Interim Technical Note is the first output of the SMI Nature-Based Solutions Taskforce Science Group. We set out the need to integrate carbon sequestration by natural systems into compliance markets in the context of intensifying global warming. It goes on to outline the rapid improvements in technology and data collection platforms that are enabling a revolution in the precision and accuracy of remotely sensed information collection on the functional attributes of natural systems and their ability to capture and store carbon. The Group is aware of the important work being done by the Taskforce on Scaling Voluntary Carbon Markets (TSVCM) and others to develop, curate, host and enforce a set of core carbon principles to accelerate the scale-up of high-quality natural climate solutions. The intention of this Group is not to duplicate those efforts but rather to address the scientific and technical components and platforms that are fundamental to ensuring the environmental integrity of carbon markets.

The note highlights the importance and urgency of addressing the remaining challenges with regards to both understanding the size of the contribution that natural climate solutions may make to global climate change mitigation and how scientific advances and technologies may support the rapid scaling up of nature-based emissions reduction projects. We find a continuing need for ground-truthing at varying sampling intensities dependent on the type of biome or natural habitat being assessed. Furthermore, we recognise the challenge of complex socio-ecological systems and the need to advance our ability to integrate and universally measure co-benefits to host communities. Finally, we understand that the increasing pace of climate change brings with it an inherent increase in scientific uncertainty due in large part to the complexities of interacting socio-economic and environmental factors. Increasing our global investment in monitoring and evaluation is essential for understanding the actual impacts of carbon projects designed to address the very causes of this uncertainty.

2. THE CHALLENGE – A CLIMATE AND ECOLOGICAL CRISIS

The correlation between atmospheric carbon dioxide (CO_2) and average global surface temperature is well established from deep polar ice cores. Over the last two centuries, a period of fossil fuel burning at a global industrial scale has fundamentally transformed Earth and its climate. By 1958, atmospheric CO_2 had risen to 315 ppm from a pre-industrial level of around 280 ppm. Since then, it has increased by about an additional 100 ppm, taking it to around 415 ppm by summer 2021.[2] The corresponding rise in global temperature since the Industrial Revolution is approximately 1.2°C, the global sea level is about 20 cm higher and both are rising ever more quickly. Article 6 of the Paris Agreement does not rule out 2 m of global sea-level rise by 2100.[3]

At the same time, growing demands for food, timber, energy, water and minerals have placed substantial pressure on natural capital assets and their ability to continue providing the services on which our economies ultimately depend. The size of global GDP today is estimated to be about 120 trillion international dollars, 60 times the size of the economy in 1900. Whilst remarkable,

this growth has contributed to a situation where around three-quarters of the world's land area and most of the world's oceans have been severely and adversely impacted by human activities. Sixty per cent of the world's large mammals are now listed as threatened with extinction. Over 80 per cent of tropical and sub-tropical grassland and savanna habitats had been converted to anthropogenic land uses by 2000.[4] The pace of change is accelerating, especially in the tropics, where it is estimated that the rate of loss of intact forest landscapes has increased threefold in ten years due to industrial logging, agricultural expansion, fire and mining.

In temperate zones, habitat loss often predates industrialisation such that little remains. Natural resource extraction and global warming remain threats to ecosystems.

3. NATURAL CLIMATE SOLUTIONS CAN HELP

The need for urgent action on the climate has become accepted globally and is now widely considered to be one of the most critical environmental issues of our time, alongside biodiversity loss. Furthermore, the links between land degradation and both climate change and biodiversity loss are now evident and direct.[5] For this reason, there is growing interest in the potential of so-called natural climate solutions – conservation, restoration and improved land management actions that increase carbon storage or avoid greenhouse gas emissions across forests, grasslands, wetlands and oceans. While estimates vary depending on the model assumptions, timeframes and objectives, the studies concur that, where ambitious and carefully designed, natural climate solutions can provide an important contribution towards efforts to maintain global temperatures below 2°C of pre-industrial levels. Sustainable land management and the reversal of land degradation are therefore of common interest for current global efforts to combat land degradation, climate change and loss of biodiversity, as well as facilitating land-based adaptation to climate change and achieving the Sustainable Development Goals (SDGs).

4. WHAT ARE NATURAL CLIMATE SOLUTIONS?

Natural climate solutions are conservation and management actions that reduce greenhouse gas emissions from ecosystems, harness their potential to store and sequester carbon and which can also provide important climate adaptation benefits.[i] Studies suggest that natural climate solutions are critical and time-sensitive components of climate change mitigation and delivering on global climate goals[6] [ii] but to be sustainable and equitable, they need to be designed and implemented with the full engagement and consent of local communities.

While we recognise the need for investment in a wide range of ecosystems to fulfill the potential of natural climate solutions (Table 1)[iii], this paper primarily focuses on forests because that is where technologies we discuss have been most widely deployed and tested.[7] Other ecosystems store significant amounts of carbon, however, the technology and technical platforms for assessing these ecosystems are at a less mature stage of development than those for forests.

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i Although most carbon standard methodologies currently neglect the removals aspect of natural climate solutions, improved science and assessment technology will help to solve this problem.

ii 'Natural climate solutions can provide 37% of cost-effective CO2 mitigation needed through 2030 for a >66% chance of holding warming to below 2 °C. One-third of this cost-effective natural climate mitigation can be delivered at or below 10 USD $MgCO_2^{-1}$ (Griscom et al., 2017).

iii Relevant examples include these three natural climate solutions projects:
Northern Kenya - Northern Rangelands Trust. Available to access here: https://www.nrt-kenya.org/
Southern Kenya – Chyulu Hills Carbon Project. Available to access here: https://biglife.org/what-we-do/habitat/redd-carbon-project
Zambia – BioCarbon Partners. Available to access here: https://biocarbonpartners.com/

5. THE VOLUME OF EMISSION REDUCTIONS WE NEED TO ACHIEVE, AND THE CONTRIBUTION NATURAL CLIMATE SOLUTIONS CAN MAKE

By 2050, the world needs to sequester and store eight gigatonnes of carbon dioxide ($GtCO_2e$) annually on average, removing more emissions than the total U.S. greenhouse gas emissions in 2015 (6.6 $GtCO_2e$), to meet global Paris Agreement targets[8].

Some of that carbon could be sequestered using terrestrial natural climate solutions. Natural forests represent a huge store of carbon that must be protected. The carbon storage and sequestration capacity of forests can also potentially be enhanced through restoration of degraded forests and reforestation. Some commentors estimate that up to 0.9 billion hectares (~2.2 billion acres) of land worldwide would be suitable for afforestation, with there being a global capacity for 4.4 billion hectares (~10.9 billion aces) of canopy cover in total.[9] [iv] Being able to assess the height, diameter, density, and number of these trees, and the carbon content within the soil, is crucially important to establish how much carbon is actually stored.[10]

iv Forests play a crucial role sequestering carbon and are seen as the conventional way to address climate change. However, it should be noted that, 'soil carbon represents 25% of the potential of natural climate solutions' offering significant carbon sequestration potential (Griscom et al., 2017).

TABLE 1: The mitigation potential of different ecosystems for addressing climate change.[11]

ECOSYSTEM	PURPOSE	MITIGATION POTENTIAL[v] ($GtCO_2e\ yr^{-1}$)	IMPACT SUMMARY
FOREST	Deforestation and degradation	0.4–5.8 (Higher level includes peatlands)	Conservation of existing carbon pools in vegetation and soil through protection in reserves, controlling disturbances such as fire and pest outbreaks, and changing management practices.
	Degradation only	1.0–2.18	
	Afforestation / reforestation	0.5–10.1 (medium confidence)	Can increase carbon sequestration in both vegetation and soils.
	Forest management	0.4–2.1 (medium confidence)	Can alter productivity, turnover rates, harvest rates carbon in soil and carbon in wood.
	Wood products to replace construction materials	0.25–1 (medium confidence)	Global mitigation potential from wood products can represent a store that can sometimes be from decades to over a century, while the wood can also substitute for intensive building materials, avoiding emissions from the production of concrete and steel.
PEATLAND	Reducing annual emissions from peatland conversion, draining and burning	0.45–1.22 (medium confidence)	Reduces net carbon loss (primarily from sediment/ soils) and provides continued or enhanced natural CO2 removal.
	Restoration	0.15–0.81 (low confidence)	
COASTAL WETLANDS	Reducing the conversion of coastal wetlands (mangroves, seagrass and marshes)	0.11–2.25 (medium confidence)	Reduces release of CO_2 by carbon sequestration.
	Mangrove restoration	0.07 (rewetting) (medium confidence)	
		0.02–0.84 (biomass and soil enhancement) (medium confidence)	
RANGELAND	Management	0.09[12]	Managing fire in savanna ecosystems could reduce the amount of greenhouse gases that are emitted.
AGRICULTURAL LAND	Cropland	0.25–6.78	Soil carbon sequestration by increasing soil organic matter stocks in mineral soils.
	Grazing land	0.13–2.56	
OTHER	All mineral soils	0.4–8.64 (high confidence)	Soil carbon sequestration by increasing soil organic matter stocks in mineral soils.

v N.B. mitigation potential is a derived rather than measured figure.

SOIL CARBON

Recent research has shown that soils store a substantial amount of carbon and warrant more attention than they have received to date regarding their potential contribution to climate change mitigation. For example, a recent paper highlighted that soil carbon comprises the majority of mitigation potential for wetlands (72%), nearly half for agriculture and grasslands (47%), and modest amounts for forests (9%). Focusing on building soil carbon stocks in these often-degraded systems can and should be a major priority for natural climate solutions. Measuring above-ground biomass alone may leave significant carbon and trace gas flows missing from carbon and economic impact accounting. Measuring soil carbon is also a crucial proxy for ecosystem resilience to drought.

6. THE AMOUNT OF LAND AVAILABLE

The Earth has a surface area of about 50 billion ha, of which 15 billion ha is land. Without human interference, it is expected that around half of the land, 7.5 billion ha, would be covered with forests at this stage in the Earth's natural climate cycle. Instead, forests now cover only about 4 billion ha. Over the last 50 to 70 years, there has been a concerted attempt to conserve natural habitats, particularly forests, by establishing national parks and other protected areas. The results have, however, been limited, as the resources that have been devoted to managing these protected landscapes fall far short of what is required. Across the tropics, many protected areas are known as "paper parks", protected in name only, with little or no action on the ground to look after the habitat. Carbon markets offer an opportunity to provide an income to the owners or stewards of these lands, particularly forests where previously the route to financial benefit has been to fell and degrade forests.

While it is a prerequisite for the sustainability of any emissions reduction project to secure the buy-in of landowners and those with responsibility for managing land, improvements in scientific knowledge and capability are essential to monitor and evaluate the outcomes of these activities that ultimately enable accurate measurement of carbon stocks and sequestration.

7. TECHNOLOGY PLATFORMS FOR MEASUREMENT

Remote sensing is now sufficiently developed as a tool for quantifying the biomass in existing natural forests. It exhibits strong potential to achieve the level of accuracy required to support carbon market trading activity.

The science of top-down measurement of forest biomass has moved on substantially through airborne and satellite LiDAR (Light Detection and Ranging), satellite RADAR (Radio Detection and Ranging) and Multispectral/Hyperspectral Imaging. Combining these data sources will help to make ever-more sophisticated measurements that, in turn, increase measuring efficiency and reduce monitoring costs. Consequently, we have the capability for near real-time measurement of individual forest carbon project risk and performance, representing a potential breakthrough in our ability to establish a credible independent rating system underpinned by science.

The improving capability of technology is already helping to establish the credibility of natural climate solutions in the voluntary carbon market. This builds trust in the integrity of baselines, additionality and permanence and should help natural carbon sinks become part of formal business and industry approaches to sequestering carbon. We need better, more efficient pathways to integrate these technological advances into existing standards.

LiDAR

LiDAR uses light in the form of a pulsed laser to measure variable reflections from and consequently distances to the Earth's surface. These light pulses generate precise, three-dimensional information about forest canopies and their characteristics. A LiDAR instrument principally consists of a laser and a modified GPS receiver. Aeroplanes and helicopters are the most commonly used platforms for acquiring LiDAR data over broad areas. LiDAR is widely accepted as the most accurate way to measure forest structure to estimate forest biomass and carbon stocks held in trees, but flying a plane over the entire world, or over extensive project areas multiple times is not feasible. NASA's Global Ecosystem Dynamics Investigation (GEDI) uses space-borne LiDAR on the International Space Station (ISS) to produce an accurate and high-resolution biomass assessment of the world's tropical and temperate forests.

Researchers and project developers have worked with the GEDI Science Team lead by the University of Maryland (see Box 1) to share data to ensure the biomass products for project areas are as accurate as possible. In combination with ground measurements, LiDAR data are invaluable for the models to estimate forest biomass. Spaceborne LiDAR is the key to producing this new generation of biomass maps as it has more extensive coverage.

BOX 1: The Global Ecosystem Dynamics Investigation (GEDI)

The Global Ecosystem Dynamics Investigation (GEDI)

Accurate, transparent, and reliable estimates of forest structure and biomass are critical for managing the global response to the negative impacts of climate and land use change on atmospheric CO_2 concentrations, biological resources, and a host of other ecosystem services. The Global Ecosystem Dynamics Investigations (GEDI) is a LiDAR instrument that has been deployed on the International Space Station (ISS) since 2019. GEDI makes direct measurements of canopy height and vertical structure that are used to estimate biomass at high spatial resolution globally.

GEDI has already increased the global archive of biomass measurements by a factor of 100. GEDI is providing widespread estimates of carbon resources at the global, national, and sub-national level, and its data are being used to quantify the net impact of disturbance and subsequent regrowth, to drive ecosystem models that predict future carbon status and to identify key habitat and biodiversity hotspots.

GEDI data are expected to greatly improve and supplement existing and planned national forest inventories towards responding to emission goals in support of global climate treaty frameworks. GEDI is currently operating flawlessly but is scheduled to be removed from the ISS in January 2023.

GEDI is the only currently operating instrument specifically focused on providing these key ecosystem observations and the international community should strongly advocate for the continuation of its mission on ISS beyond this date. Space-based LiDARs are exceptionally difficult to get into space and therefore rare; we should not waste this precious resource through its premature removal.

RADAR

Satellite-based RADAR has high spatial resolution and penetrates cloud cover. This enables the creation of biomass maps for relevant areas, filling in the gaps between GEDI data. RADAR also has a very high temporal resolution (daily data available), enabling developers to estimate deforestation rates in near real-time. The European Space Agency´s Biomass Earth Explorer satellite is a five-year mission and set to fly in 2023, providing continuity to the GEDI work.

Radar can help us understand biomass through three principle approaches: it can tell us about the properties of the material reflecting a radar signal and allow us to classify land use; it can be used create digital elevation maps from which we can estimate tree heights; it can also be used to measure the properties of a forest canopy at different heights to create a model of foliage throughout the structure of a forest.

MULTISPECTRAL/HYPERSPECTRAL IMAGING

Optical satellites record the total electromagnetic energy at several wavelengths from ultraviolet to infrared radiation, including several bands in the visible light spectrum. So, whereas a standard camera has three wavelengths (or bands) of colour which are red, green and blue, optical satellites may capture data in many wavelengths. An example is Sentinel 2 which has 13 bands; some hyperspectral cameras may have hundreds. Such satellites can have global coverage and often produce many optical images of a given location; for instance, Sentinel 2 has a revisit time of five days.

Multispectral/ hyperspectral images can be used to monitor land use including the extent of forests, infer the quality and health of plants and monitor changes over time, and assess soil quality. Flood and fire extent can also be measured in imagery. An important drawback to these images is that they can suffer due to issues such as cloud cover, which obscure the land beneath.

COMBINING TECHNOLOGIES AND TECHNIQUES TO ASSESS CHANGES IN LAND COVER OVER TIME

The increasing quality of statistical models, availability of machine learning algorithms, availability of satellite data, and lowering costs of data storage and processer time now make it possible to build accurate land-use models. These models can be used to produce up-to-date information on forest loss and gain, and therefore carbon stocks.

8. THE REMAINING SCIENTIFIC CHALLENGES

Two factors remain which create a challenge in using satellite data combined with the latest machine learning techniques. One is that the satellite sensors used to measure forests have trouble distinguishing individual trees in high density forest areas, and therefore the biomass of the trees and the associated amount of carbon sequestered. Secondly, the machine learning algorithms need lots of ecosystem datasets to learn from, and right now there is a lack of available and affordable ground truth data to "feed" the machine learning algorithms. The former challenge is being addressed but will improve as the technology develops (especially LiDAR accuracy), and we address the ground-truthing challenge in our recommendations. The continued advance of very high resolution optical remote sensing, when married with pervasive LiDAR and radar data within advancing machine learning frameworks, promises to overcome these challenges towards producing highly reliable estimates of biomass with well quantified uncertainties.

An additional consideration is that the technologies can also help monitor the permanence and reversibility of carbon stocks in natural climate projects over time. This is a further benefit to be included by the rating and standards community, since, just as with a built asset we need confidence that the asset is still there and functioning as it was expected to. These new technologies allow us to assess natural assets in a repeatable fashion and at a scale and rate of frequency that can provide comfort to investors.

9. NATURAL CLIMATE SOLUTIONS AND THE VOLUNTARY CARBON MARKET

The "rulebook" about how natural climate solutions may be included in the proposed new international climate market is unclear. This is due, in part, to there being no agreed guidelines on how to conduct international-level accounting for carbon credits. Multiple issues require resolution, such as variable quality of information requirements (in terms of carbon, environmental and social quality), as well as approaches to avoid "double-counting" and "double-claiming" of carbon credits.

Concerning double-counting, one of the main issues is that there is not yet a consensus about the need for corresponding adjustments, i.e. a mechanism through which it is possible to keep track of where credits go to avoid the same credit from being counted by both the 'host' country (where the project is located) towards achieving its Nationally Determined Contribution (NDC) and a private company to offset its emissions in another country. While it is agreed that corresponding adjustments are needed in the case of so-called internationally transferred mitigation outcomes (ITMOs) whereby countries can claim emissions reductions from activities hosted in other countries towards their own NDC targets under Article 6 of the Paris Agreement, there remains substantial debate about how to treat the international transfer of voluntary offsets.

Some argue that since any emissions reductions or removals claimed as offsets by private actors are not counted towards the NDC of their country of domicile, no corresponding adjustment is needed while others argue that double-claiming by the host country as well as the private actor will discourage host countries from putting in place the crucial reforms necessary to decarbonise their economies.

Except in a few limited circumstances, compliance regimes do not allow natural climate solutions as offsets. Of particular note related to our recommendation here, is that as natural climate solutions are incorporated into the compliance market, they too, would fall under the developing rules of Article 6. Depending on the outcomes of discussions at COP26, this could have important implications for how the voluntary carbon market develops and the speed and scale at which mitigation action can occur.

Furthermore, there is a lack of consistency in the methodologies used to quantify carbon yields from natural climate solutions across different carbon offset standards and therefore in the way in which emissions reductions are measured and verified in the Voluntary Carbon Market (VCM). Notwithstanding the fact that Verra now represents about 86% of the market by transacted volume[vi], there remains a lack of confidence in the integrity of natural climate solutions credits, the markets and the institutions that govern them, which has prevented the market for natural climate solutions from achieving scale.

Box 2: What are Standards?[13]

CARBON STANDARDS

Carbon projects used in the compliance markets, and 99% of voluntary carbon projects are designed and independently audited against third-party carbon standards.

The term 'standards' includes the registers, their methodologies (e.g. VM0032, VM0009, VM0015 for Verra soil carbon) and their approaches (e.g. third-party validation and verification).

There are many different carbon standards, including Verra's Voluntary Carbon standard, Gold Standard, Climate Action Reserve (CAR), and the American Carbon Registry (ACR).

WE NEED TO ENSURE THAT CARBON STANDARDS REFLECT THE SCIENTIFIC ADVANCES AND THAT THESE ADVANCES ARE APPLIED EFFECTIVELY ON A GLOBAL BASIS

There are well-established methodologies for the issuance of offsets and new methods are emerging. However, most of these methods do not systematically use technology to monitor projects.

Over time, the greater integration of technology can reduce the significant variance in quality among the currently active projects, including differences between claimed and real impact. This should involve adaptively managing "older" projects to incorporate "newer" technology and improve the accuracy, precision, and efficiency of carbon estimates over time. Several billion dollars' worth of credits due to come onto the market have been originated under current regimes. The veracity of methodologies must be established and ongoing monitoring of results against projections measured to ensure offsets paid for equate to offsets achieved.

Given that the market needs less fragmentation, not more, it's essential to consider these legacy projects and look at how technology can now speed the origination of new projects and allow their accurate Monitoring, Reporting and Verification (MRV). For this to happen effectively, the current methodologies for quantifying emissions reductions and removals need to be updated to reflect the latest scientific advances in carbon measurement we have covered further above.

vi Throughout the document standards refers to all the different registries, which each has different methodologies. Some require third party validation and verification, some do not (i.e. different approaches).

We suggest that there needs to be more widespread acceptance of natural climate solutions credits in compliance carbon markets as well as clarification of the rules governing voluntary carbon market transactions and national greenhouse gas accounting. Not only would this go some way to eliminating current confusion about voluntary and compliance carbon markets, but it could also inspire more innovation and finance for natural climate solutions.

We also propose that the standards for utilising and assessing technology are harmonised as much as possible to enable more uniform implementation. Moreover, there is a need for new approaches within the voluntary carbon markets to help streamline and accommodate multiple above-and below-ground carbon stocks, allowing them to be accounted for in new and existing projects. Such moves could bring added value and incentives to better understand carbon dynamics within carbon projects and in the context of long-term (over decades) changes in carbon projects introduced by climate change itself.

It will require international convening power to work through these challenges and facilitate dialogue between voluntary carbon standard registries, regional markets and global compliance leaders.

10. CO-BENEFITS

In addition to climate change mitigation benefits, investments in natural climate solutions can generate significant co-benefits for Nature, People and Planet. 'Most natural climate solution actions—if effectively implemented—also offer water filtration, flood buffering, soil health, biodiversity habitat, and enhanced climate resilience.'[6] Many climate, biodiversity and local community benefits align closely with the UN Sustainable Development Goals (SDGs). These may include, for example, heightened resilience to the effects of a changing climate through local climate regulation (shading and cooling), flood and erosion control, and protection of the ecosystem functions that sustain global food systems (e.g. via pollination or soil quality regulation) and human health and well-being, as demonstrated by the COVID-19 pandemic. Moreover, natural climate solutions can also provide employment opportunities and stimulate investment in healthcare, education and local food security.

For businesses dependent on the sustainable management of natural resources, for example water utilities, food and beverage manufacturing, clothing manufacturing, these co-benefits can address corporate operational, financial and reputational risks. They can also align with broader Environmental, Social, Governance (ESG) principles - the suite of non-financial factors that are considered as part of an investment decision. As such, the range and magnitude of co-benefits may be a significant factor for purchasers of carbon credits.

Beyond providing evidence that a project is not harming a community, understanding the broader ESG impact (both positive and negative) is not typically part of standard project development. Projects that deliver co-benefits can often charge a premium for the carbon credits. However, it has proven difficult to quantify and monetise these benefits as there is limited formalised reporting or means of verification. Indeed, at the moment, it's hard to understand why some credits are more expensive than others.

Some standards (e.g. Gold Standard) and secondary standards (e.g. Verra's Climate, Community and Biodiversity (CCB) and SD VISta) address this by requiring some level of broader social and environmental impact review and reporting. For example, Gold Standard allows certification against up to 6 SDGs, but the approaches for measuring the contribution (if it is measured at

all) varies. Often projects are simply counting the number of SDGs to which the project is meant to contribute without any evidence of the quantity/value of this contribution, making it hard to compare project, investment alternatives, or actual impacts.

The Terra Carta calls for adoption of a common set of ESG metrics, and a common methodology, and disclosure process, such as the World Economic Forum's International Business Council's Stakeholder Capitalism Common Metrics. Leveraging universal metrics and reporting of co-benefits may provide a way to evaluate co-benefits as consistently, transparently and rigorously as the carbon.

While the primary focus of this note is on how technology can improve the credibility of carbon measurement, it is worthwhile considering how these technologies may also enable the proliferation of projects that maximise both carbon and wider environmental and social net benefits by providing the desired transparency (i.e. watershed health, biodiversity, local economic impact). That said, the limitations of these technologies also need to be recognised (e.g. to what extent can they be used to monitor community health, livelihoods and human rights) and make sure the technology requirement isn't, in fact detrimental (i.e. only funding projects that have advanced remote sensing capability and, perhaps thereby, preventing recognition of much needed projects in developing nations).

11. KEY RECOMMENDATIONS

The following three recommendations have been set out in a way that can build on the technology platforms, which is the main topic of this paper with approaches and initiatives that will enhance future application of remotely sensed assessments.

11.1. RECOMMENDATION 1

- Mobilise an international taskforce for "ground truthing"

Mobilise an international taskforce for "ground truthing" global forests modelled along the lines of the VSO and PeaceCorps possibly using DFD grant funds (Box 3). Science is now years ahead of the Kyoto and Paris protocols as one can now measure the amount of carbon stored with more accuracy. The challenge is that the global resource to do the bottom-up measurement to increase the carbon measurement to closer to 100% accuracy does not exist, even though the exercise is cheap to finance and training of the necessary local staff is straight forward.

A plan would be to marry estimates of global rainforest biomass (such as those produced by NASA's GEDI mission) with a coordinated international effort led by the U.K. to train up tens of thousands of forest-local communities to complete what is possible with current science with a meaningful impact on global carbon assessment. The GEDI mission was specifically designed to provide data that may be used with local inventories to produce in-country estimates of biomass within an uncertainty framework that promotes carbon standards.

This would in turn would provide greater confidence in the performance of individual natural climate solutions, strengthen the integrity and size of the voluntary carbon market, and ultimately, support the inclusion of natural climate solutions in the global carbon compliance market. We will be closely monitoring the outcome of article 6 negotiations at COP26.

Box 3: Ground Truth Task Force

GROUND TRUTH TASK FORCE

To meet our Net Zero targets, it is essential to prevent the deforestation and degradation of our global forests.

The scale of the problem relies on being able to accurately Monitor, Report and Validate vast areas of inaccessible forestry in multiple jurisdictions.

The Ground Truth Task Force is part of a $100 million global campaign which will bring together the very best commercial intelligence sensors, techniques and technology to combine with local communities and expert partners. It will be an integrated standing task force to provide timely, accurate and reliable Monitoring, Reporting and Verification across global forests.

A critical element of the concept is the deployment of capacity building, training and capital to provide a standardized, locally recruited network of Ground Survey Teams. These teams will provide the local and community MRV and scientific capability to access the techniques, technology and analysis from the global programme. Local teams will be funded to use international teams of youth volunteers to build awareness, education and support community interests.

Currently 83% of REDD Voluntary Carbon projects are unviable because of a lack of accurate information. Increased accuracy in quantification and measurement will:

- Unlock hundreds of millions of tonnes of voluntary REDD projects.
- Improve speed, accuracy, and reliability for 'payments by results' scheme.
- Improve confidence for supply side investors to develop new projects.
- Enhance certainty for net zero corporate buyers, increasing demand for carbon offset.
- Enable increased deployment of capital for protection and restoration of projects.
- Increase provision of economic support for communities.
- Enhance data and understanding for biodiversity and socio-economic projects.

The Ground Truth Task Force will be created as a new organisation and network to provide the most accurate picture of global forest carbon. It will:

- Audit and understand the gaps in our knowledge and data across global forests and soils to more monitor above and below ground carbon stocks.
- Direct and deliver the collection of data from an integrated system of remote sensors and local ground survey teams in coordination with local jurisdictions and communities.
- Integrate other Forest Carbon data, imagery, research and open source information.
- Through the use of a centralised Hub to conduct modelling, analysis and assessment for continuous Monitoring, Reporting and Verification in a single accessible picture.
- Disseminate the most up to date situation and data for investment and REDD+ project decisions, for academic research and R&D, for local jurisdictions and policy makers.

11.2. **RECOMMENDATION 2**

- Improve the rapid integration of technology advances into carbon standards

Carbon methodologies will need to clarify the quality and reliability of data derived from remote digital devices/instruments. They will have to prescribe how devices prove what they are accurately measuring scientifically, according to scientifically agreed process, as defined by existing and emerging carbon and biodiversity codes. Evidence of device calibration and strong authentication, of data validation and verification and governance will be required.

Our recommendations with respect to integrating the technology developments into the carbon standards, can be summarised by updating methodologies to be based around high resolution carbon maps, rather than average values for forest types and strata. We suggest the following approach:

- Encourage and facilitate common protocols for defining the parameters, projections and monitoring that improves the automation of project data and digital information.

- Encourage the use of independent data providers which use the project parameters, identified in bullet point one, to evaluate all projects' performance and baselines in more consistent and transparent ways to improve the comparability across projects as well as monitor progress within projects.

- Use remote monitoring to lower costs, facilitate increased frequency and accuracy of tracking, and ultimately increase the efficiency and effectiveness of monitoring and evaluation activities. Furthermore, remote monitoring can be used beyond the contracting period to ensure permanence as guaranteed by the standards.

- Use project verification as an opportunity to align the legacy projects with newer methodologies.

- Ensure that the carbon monitoring ecosystem contains third party auditors with the technical capability to evaluate and ideally replicate projects as well as MRV providers with the ability to use large scale earth observation pipelines and machine learning to track projects.

- Convene a global summit that brings together leaders in the Voluntary Carbon market, global carbon compliance policies, academic researchers, and carbon developers to craft a more unified, strategic, and efficient approach to improving carbon accounting via integration of technological advances and improved adaptive management systems to enhance carbon sequestration and emission reduction activities across the globe.

- This recommendation could be an adjunct to Mark Carney's Taskforce on Scaling the Voluntary Carbon Market.[14]

11.3. RECOMMENDATION 3

- Convening an international summit of policy leaders and implementers, including the relevant standards bodies, to resolve outstanding barriers and advance innovation

Related to recommendation 2, the accounting rules that define the relationship between voluntary carbon market transactions and efforts by countries to reduce national emissions in line with their Nationally Determined Contributions need to be urgently agreed to avoid confusion and in a way that stimulates climate action rather than stifles it. To this end, we recommend convening an international summit of policy leaders, key registries (Verra, Gold Standard, Climate Action Reserve (CAR), and the American Carbon Registry (ACR) etc.) with other selected stakeholders (e.g., scientists, climate policy experts, and investors) to generate a plan to integrate rapidly changing technology into the methodologies within each registry.

Right now, the integration of technology is the responsibility of each methodology author. This is challenging as:

- It is not possible for most methodology authors to integrate the technology as the burden is on them;
- Auditors that review these projects are unaware of these developments; and
- The new technologies are not proven and so are not available for use in the methodologies.

Therefore, convening power is needed to see how best to advance the use of new technology in this field given the current constraints. Significant funds will be needed (~half a million dollars) in order to hire a lead for this, organize a meeting of these stakeholders, complete a comprehensive report, and use that as an action path forward. It would be a 1-2-year project and would need a high-powered well-connected consultant to lead it. We are in discussions with several leading corporate groups who are interested in supporting the MRV campaign financially.

12. ENDNOTES

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