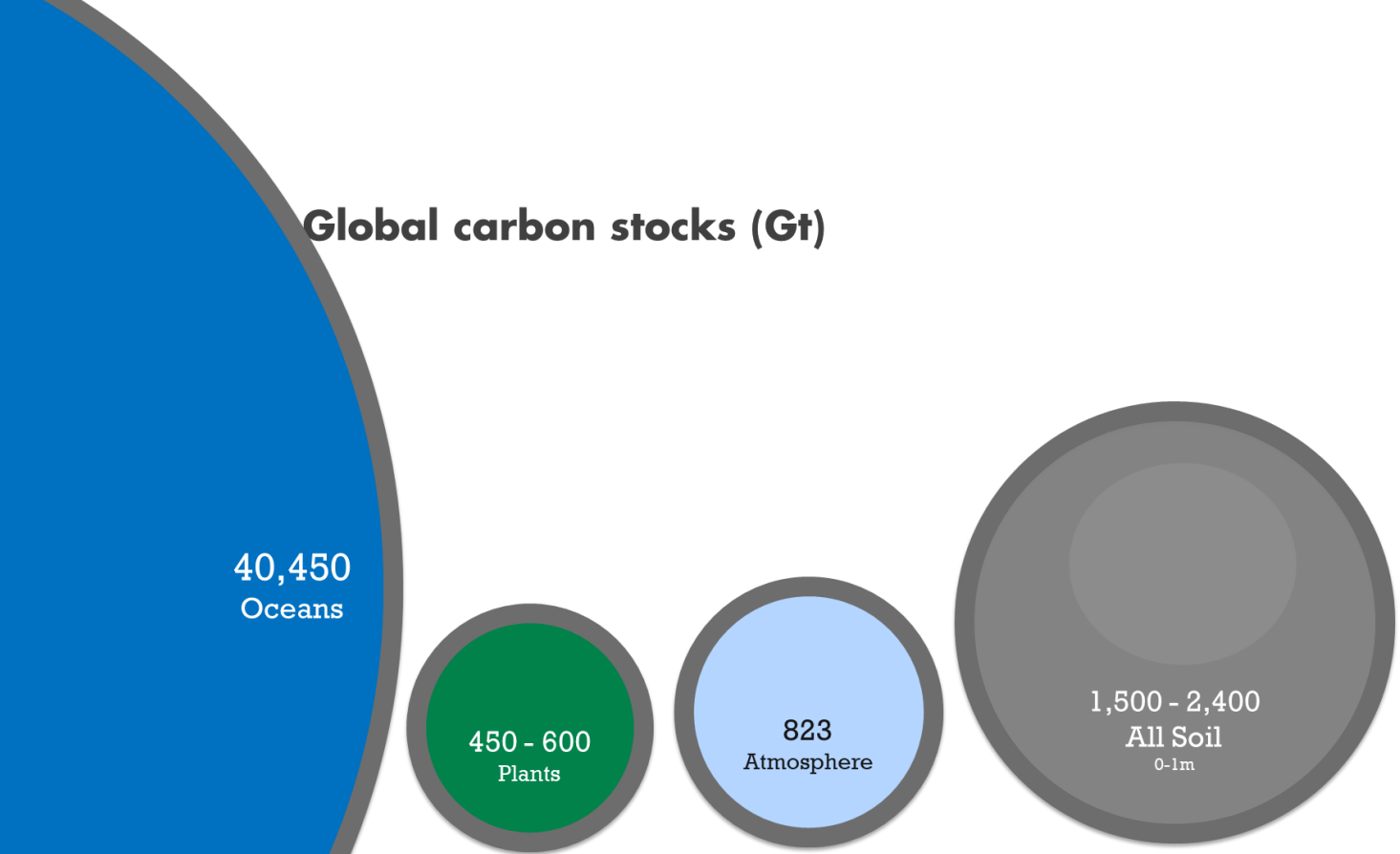
Nature Based Solutions

Christian Davies

Principal Science Expert

Shell International Exploration and Production Inc.

Global carbon stocks (Gt)



IPCC Fifth Assessment Report 2014

Different types of NBS

NBS comprise all activities related to the protection, or re-development, of natural ecosystems – such as forests, grasslands, wetlands and blue carbon – to lower concentrations of greenhouse gases in the atmosphere.

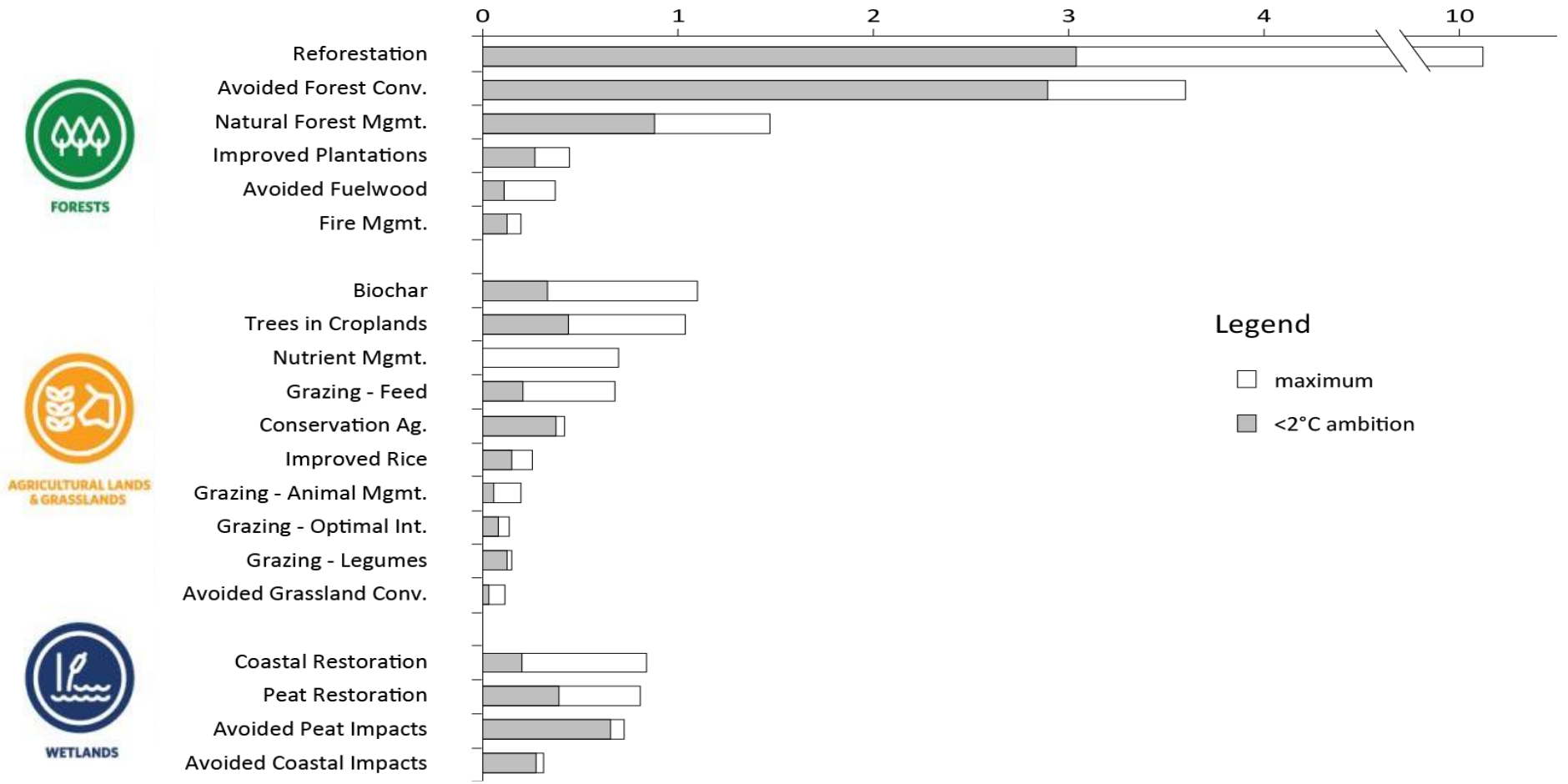
- Coastal restoration and protection
- Peat restoration and protection

- Avoiding deforestation
- Reforing degraded forest
- Improving forest management
- Afforestaion
- Reforestation

- Biochar for soil amendment
- Restor trees in croplands
- Improve nutrient management
- Improve rice cultivation
- Sustainable razing
- Avoided grassland conversion

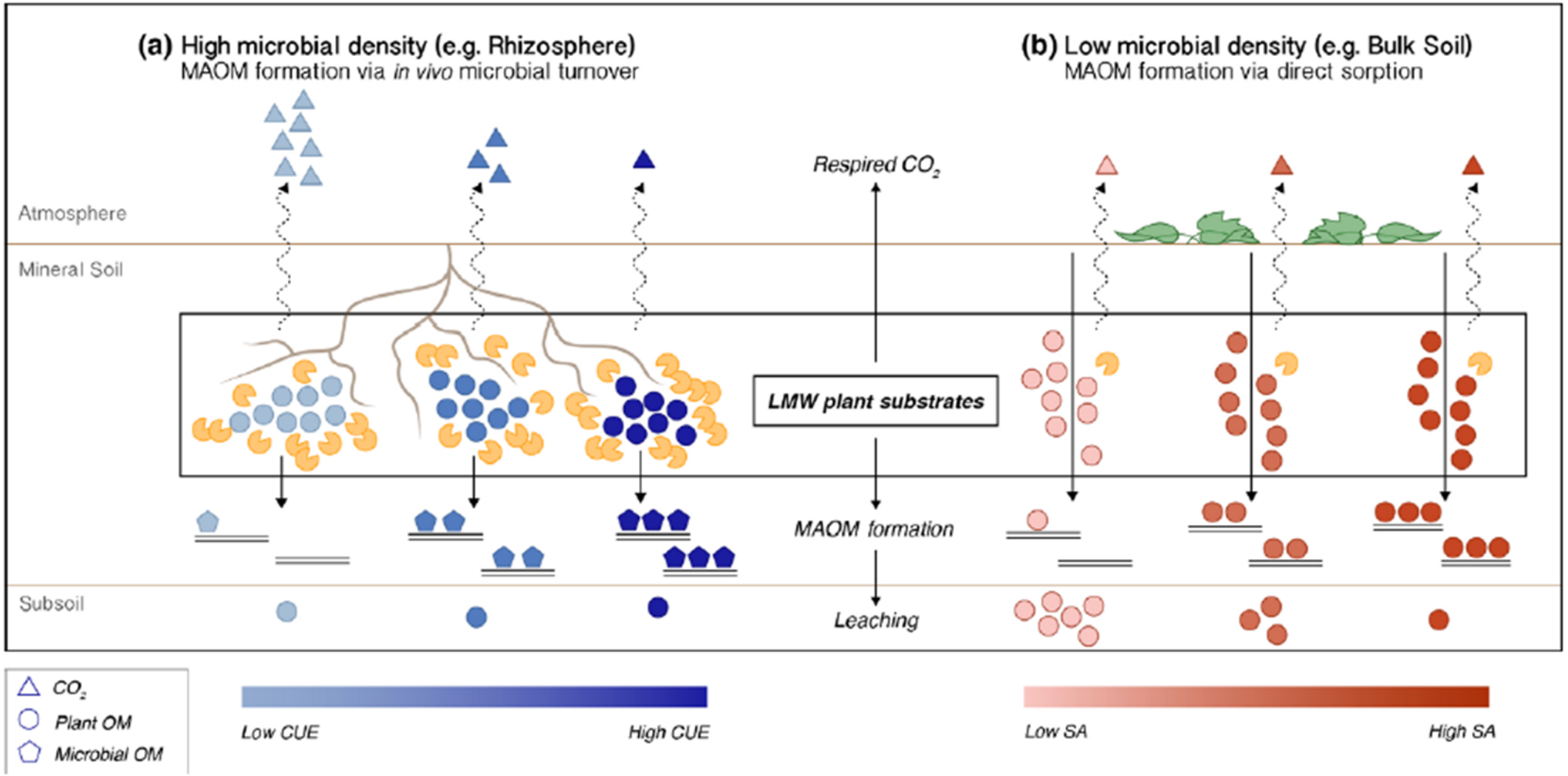
- Algae & Plankton
- Sediments of mangroves, salt marshes and seagrasses

Based on data from Proceedings of the National Academy of Sciences of the United States of America



Source: Griscom et al. (PNAS 2017)

Microbes drive C storage in soil



Source: Sokol et al. (Global Change Biology 2018)

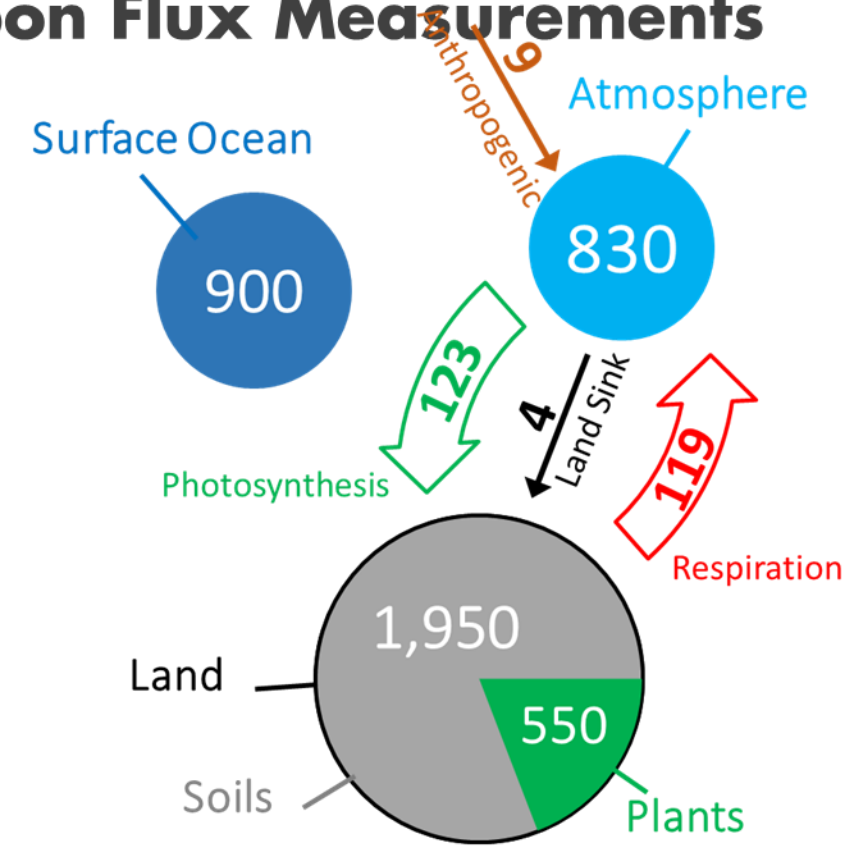
The Need for Accurate and affordable Carbon Flux Measurements

Facts of today:

1. Land sink is globally significant: ~ 48 % of anthropogenic emissions.
2. The mean flux is small: *4 PgC yr^{-1} globally ≈ 27 gC m^{-2} yr^{-1}*
3. Monitoring, Reporting and Verification (MRV) must accurately resolve small fluxes.
4. Current MRV methodologies are a large cost of every NBS activity

NBS challenge:

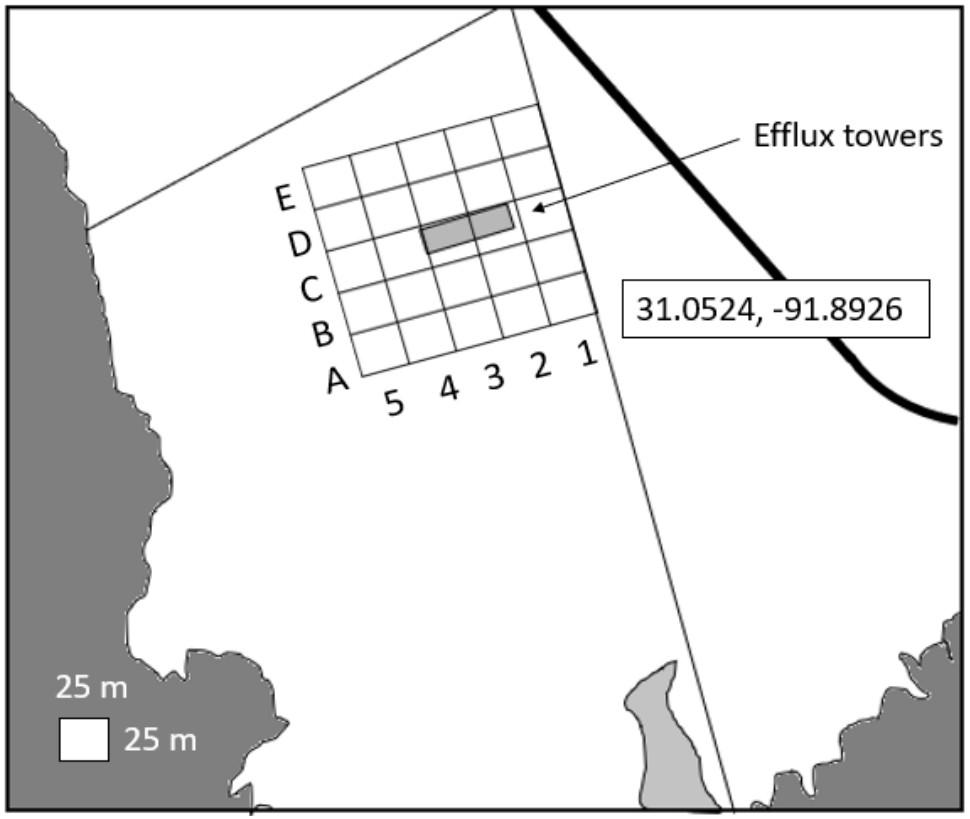
1. Create affordable and auditable quantification of net CO_2 flux to support and verify NBS activities.
2. Reducing MRV costs to expand NBS mitigation options.



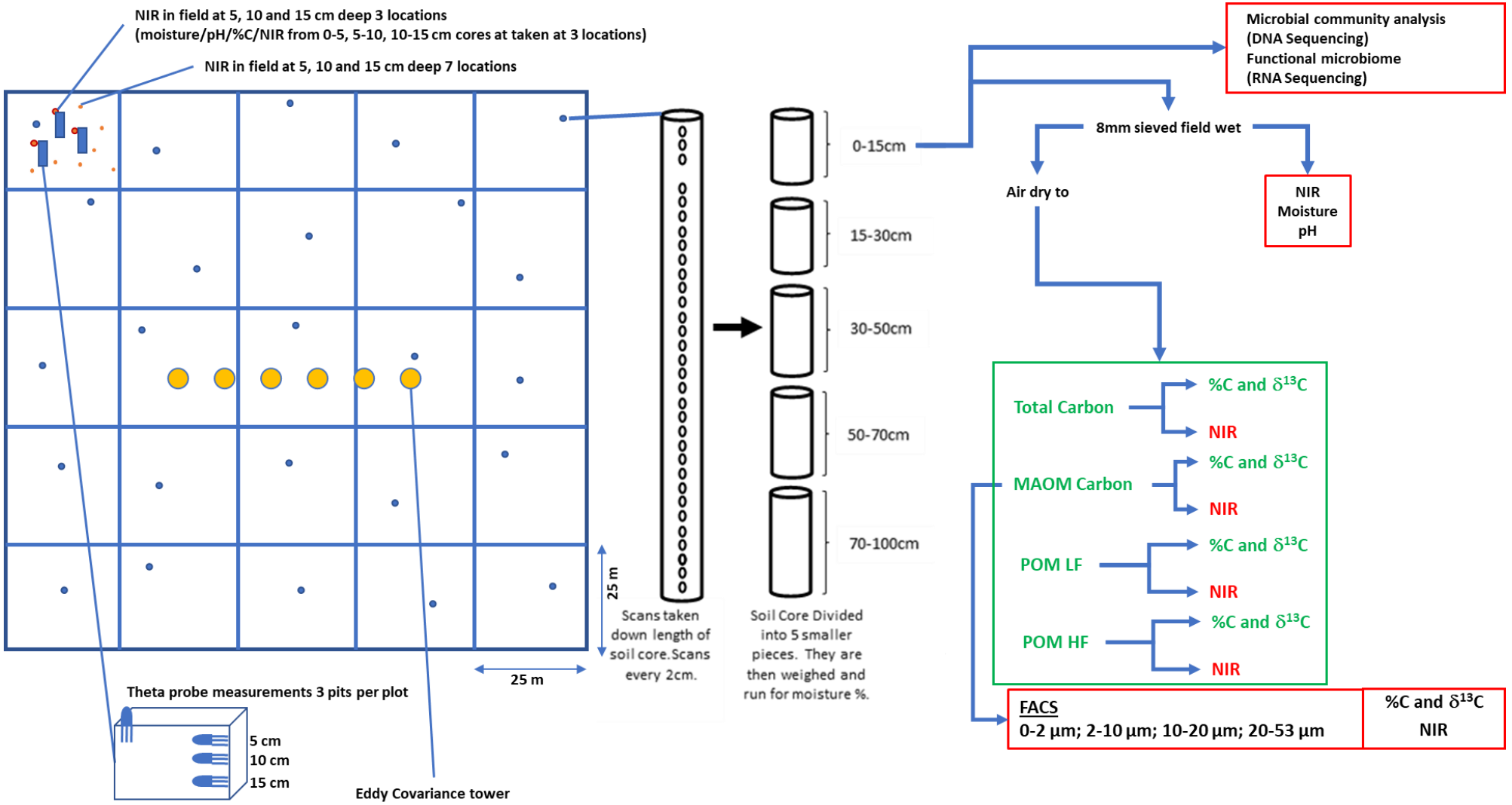
Based on IPCC AR5 Global Carbon Pools and Fluxes

UNITS: **Pools: PgC** **Fluxes: PgC yr^{-1}**

Field site



Sampling for carbon

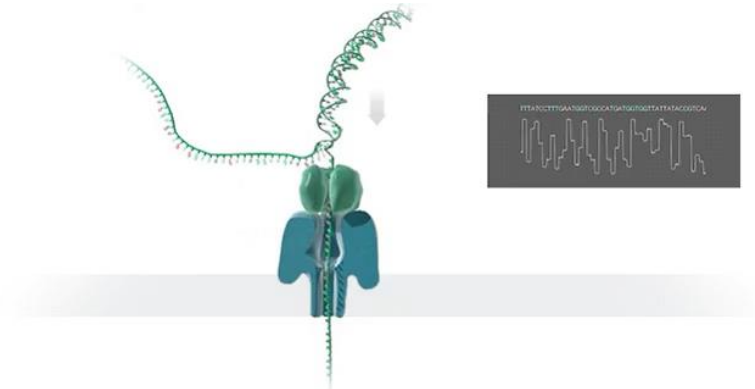


DNA Sequencing

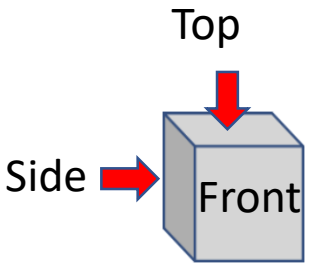
- Purified DNA was prepared from sequencing using the Oxford Nanopore Technologies (ONT) ligation preparation kit (SQK-LSK109)

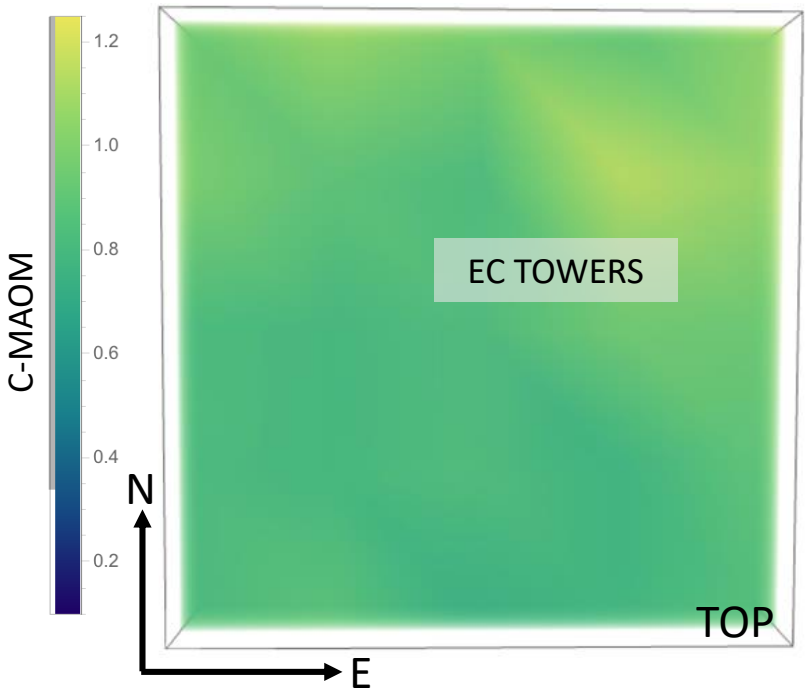
- Prepared DNA was sequenced using the ONT MinION device and flowcell (R9.4a). Resulting DNA sequence reads were basecalled using a MinIT and guppy basecaller.

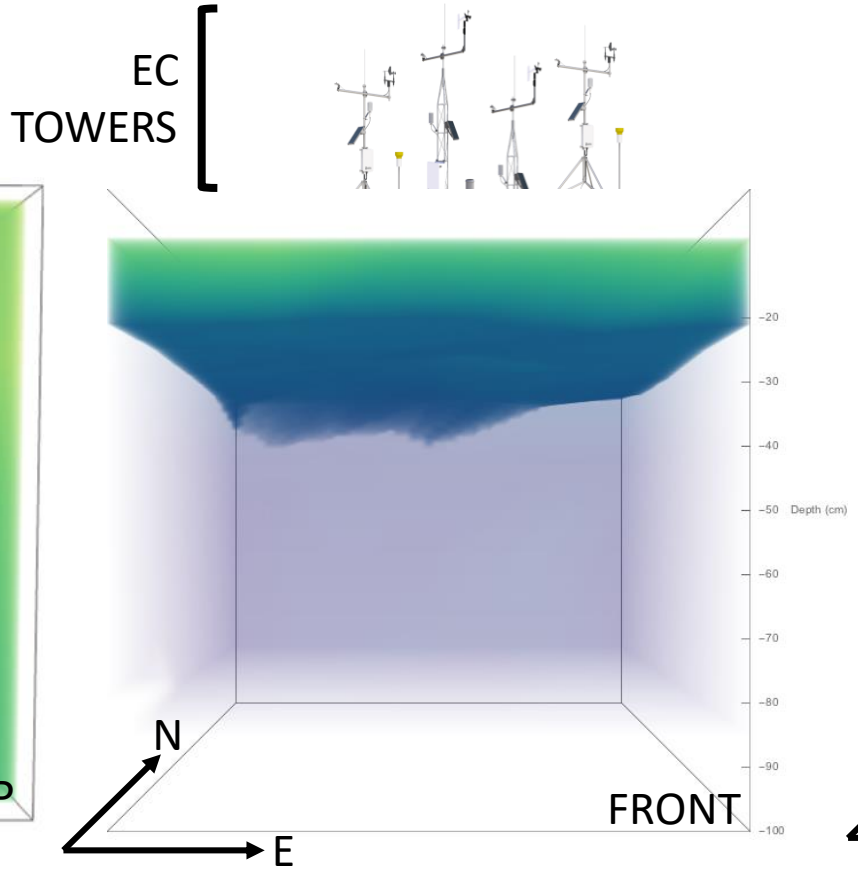
- The advantage of using the ONT MinION is the ability to sequence long DNA fragments, enabling greater accuracy in taxonomically classifying the microbiome.

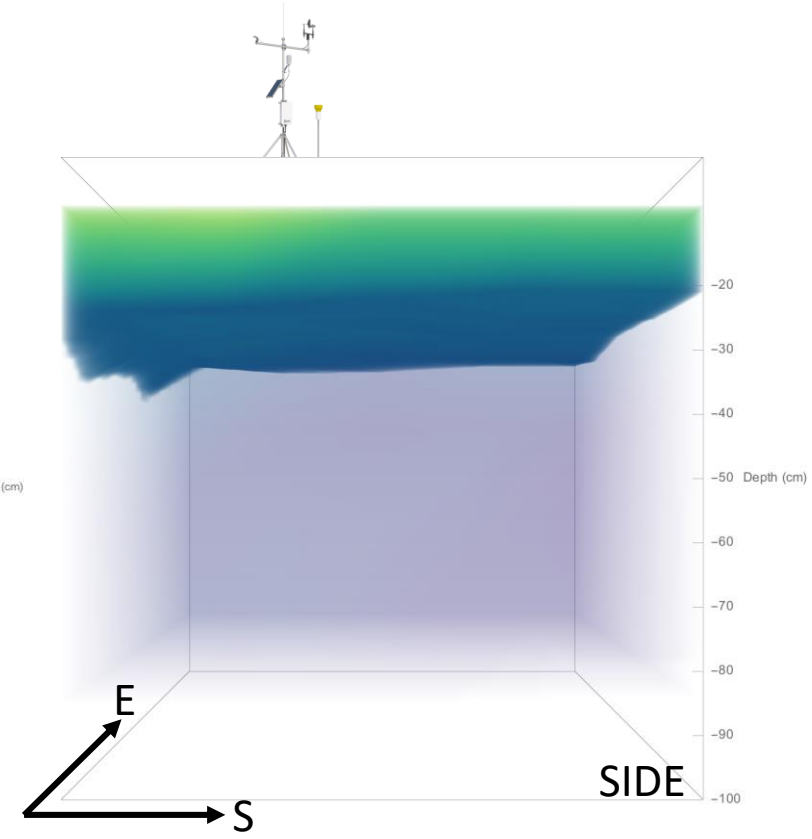


MAOM carbon

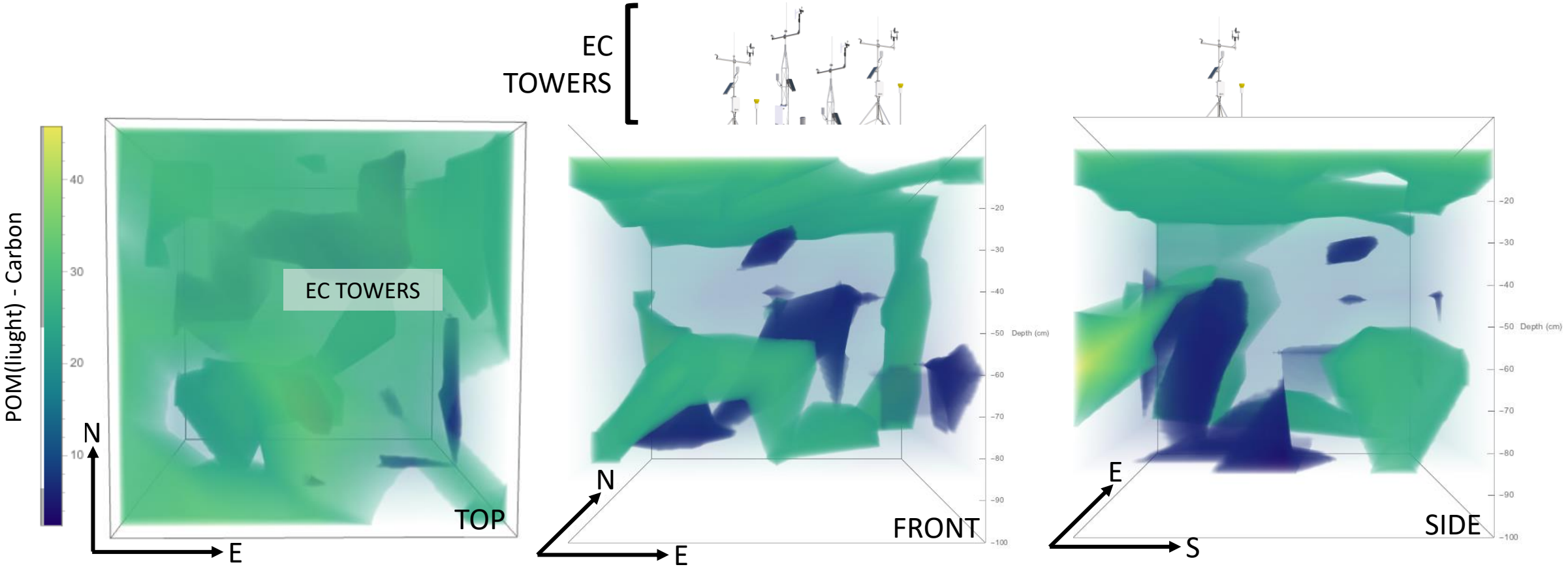

Top
Side
Front


C-MAOM
1.2
1.0
0.8
0.6
0.4
0.2
N
E
EC TOWERS
TOP

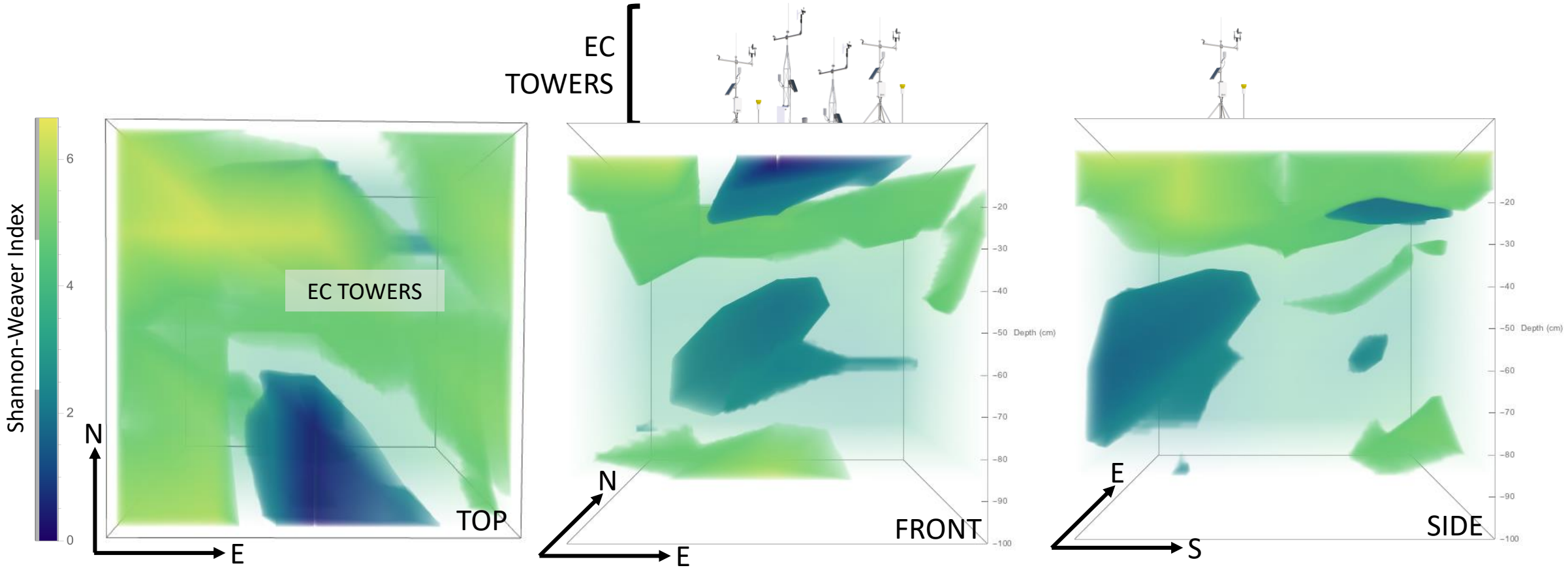

EC
TOWERS
N
E
FRONT
Depth (cm)
-20
-30
-40
-50
-60
-70
-80
-90
-100


E
S
SIDE
Depth (cm)
-20
-30
-40
-50
-60
-70
-80
-90
-100

POM carbon


EC
TOWERS
POM(liught) - Carbon
40
30
20
10
EC TOWERS
N
E
TOP
N
E
FRONT
E
S
SIDE
Depth (cm)
-20
-30
-40
-50
-60
-70
-80
-90
-100

Alpha biodiversity



Correlations between taxa and soil chemistry

Taxa - Family	r value	Acidobacteriaceae	Bryobacteraceae	Solibacteraceae	Pyrinomonadaceae	Holophagaceae	Therm
C_MAOM	1	-0.382489632	-0.032203615	-0.348404145	0.012937625	-0.036765039	
Verrucomicrobiaceae	0.335230336	-0.116302516	0.021404272	-0.159061258	0.138050689	-0.015605714	
Gallionellaceae	0.297997208	-0.110921582	-0.021202959	-0.099689213	-0.017095328	0.017447487	
Arthrodermataceae	0.291536495	-0.196057452	-0.012247067	-0.192400181	0.045102557	-0.01449195	
Ilumatobacteraceae	0.271126133	-0.122234624	-0.016004617	-0.120949027	-0.004160413	-0.008847634	
Parachlamydiaceae	0.268680786	-0.138422492	0.006314389	-0.131102044	0.07739238	0.08536704	
Aerococcaceae	0.262717652	-0.098129422	0.003513034	-0.096609164	0.013685779	-0.007069418	
Gigasporaceae	0.258667176	-0.125812777	-0.023512976	-0.124113459	0.05871221	-0.009152277	
Vicinamibacteraceae	0.255873216	-0.150684262	0.012650636	-0.146909923	0.14147104	-0.011640237	
Tolypothrichaceae	0.251860196	-0.093282587	-0.01140155	-0.090519502	-0.001233811	-0.006798161	
Cytophagaceae	0.242231084	-0.084196886	-0.023396358	-0.06795507	0.002050523	-0.010535703	
Fulvivirgaceae	0.240045094	-0.103243741	-0.002548504	-0.101983717	-0.025222639	-0.007512106	
Moraxellaceae	0.232261333	-0.083700575	0.003035765	-0.082790277	-0.020511544	-0.006108991	
Syntrophaceae	0.229421123	-0.093708483	0.003771426	-0.142868329	-0.00883157	-0.013665068	
Lindgomycetaceae	0.229229355	-0.101242575	-0.009605321	-0.101213643	0.062482611	-0.007305513	
Gordoniaceae	0.228494227	-0.121306081	-0.01318444	-0.120816455	0.062868791	-0.008696237	
Teratosphaeriaceae	0.219703548	-0.134777823	0.013014443	-0.133045141	0.062626092	-0.009762387	
Cellulomonadaceae	0.219229182	-0.090309444	-0.001467719	-0.088377487	0.019297622	-0.006444107	
Rhizopodaceae	0.219058656	-0.075289244	-0.016992834	-0.072792247	-0.01824863	-0.005435023	
Clostridiaceae	0.21641673	-0.138130126	0.014196955	-0.132794928	0.00289963	-0.011120305	
Rhodobiaceae	0.215508045	-0.096648517	0.017060229	-0.095529246	0.033864218	-0.007389628	
Didymosphaeriaceae	0.2138872	-0.08037042	0.002860078	-0.079633349	-0.019324491	-0.005755449	
Mycosphaerellaceae	0.204185112	-0.102226757	0.003630357	-0.10023566	0.033478746	-0.007305513	
Rhodocyclaceae	0.203122735	-0.134122002	0.028761862	-0.124868942	0.150017356	-0.010654753	
Kineosporiaceae	0.200490573	-0.07825264	-0.005897778	-0.078305608	0.006588724	-0.005585098	
Siphoviridae	0.199578838	-0.06959223	-0.005897778	-0.070071498	0.006588724	-0.005585098	
Nitriliruptoraceae	0.199090911	-0.06450317	-0.01466435	-0.062669305	-0.015748067	-0.004690276	
Sporomusaceae	0.198612983	-0.107816212	0.009455241	-0.106916555	0.018698758	-0.008320558	
Togniniaceae	0.19794243	-0.075540282	0.022394529	-0.074220955	0.016275805	-0.005435023	
Chlorobiaceae	0.194928827	-0.089763759	-0.010807748	-0.088502966	0.019297622	-0.006444107	
Mortierellaceae	0.194156776	-0.080647334	-0.017994659	-0.079423219	0.026375319	-0.005755449	
Pseudoalteromonadaceae	0.192705773	-0.098582934	0.012051659	-0.097871	0.013685779	-0.007069418	
Leptospiraceae	0.18860556	-0.127262423	0.010278934	-0.126025045	0.015934859	0.167501864	
Sandaracinaceae	0.18855217	-0.089306057	-0.001048851	-0.086335462	0.009665016	-0.007360194	
Thermodesulfobacteriaceae	0.182647361	-0.079096613	-0.017994659	-0.079143045	0.11777494	-0.005755449	
Brucellaceae	0.17875496	-0.123194362	0.001482217	-0.121849582	0.072478769	-0.008847634	
Spirulinaceae	0.17746932	-0.057057417	-0.012687529	-0.056838639	0.050818151	-0.004058006	-0.005747126	-0.016485416	-0.005747126
Methanobacteriaceae	0.177255841	-0.090706306	-0.020147777	-0.089318579	0.060231972	-0.006444107	-0.009126428	0.01643786	-0.009126428
Neisseriaceae	0.176737373	-0.093314339	-0.021037728	-0.091485738	0.007937887	-0.006728751	-0.009529553	0.036234985	-0.009529553
Lythraceae	0.175959491	-0.067490919	0.020508018	-0.06761324	0.035982136	-0.004977178	-0.007048899	0.144357826	-0.007048899
Alsobacteraceae	0.174972601	-0.064954501	-0.006166796	-0.064495876	-0.015748067	-0.004690276	-0.006642576	0.019718652	-0.006642576

SCIENTIFIC REPORTS

nature research

Check for updates

OPEN

Novel cultivated endophytic *Verrucomicrobia* reveal deep-rooting traits of bacteria to associate with plants

Wiebke Bünger[1], Xun Jiang[1], Jana Müller[1,2], Thomas Hurek[1] & Barbara Reinhold-Hurek[1] ✉

Thriving through the energy transition, there is no single solution

To help you reduce your carbon footprint Shell offers solutions to avoid, reduce and compensate your emissions.

RETAIL	LUBRICANTS	AVIATION	BITUMEN	SULPHUR	CHEMICALS	COMMERCIAL FUELS	LNG	PIPELINE GAS

AVOID EMISSIONS

ELECTRIC CHARGING POINTS*

HYDROGEN*

ELECTRIC-PUMP JET REFUELLER*

RENEWABLES

REDUCE EMISSIONS

BIOFUELS & BIOCOMPONENTS

LOWER EMISSION FUELS

FUEL EFFICIENCY

LOW TEMPERATURE PRODUCTS

0W LUBRICANTS

LNG CARGO

CIRCULAR ECONOMY

COMPENSATE EMISSIONS

CARBON NEUTRAL PRODUCTS[1]

*When sourced from renewables

[1] The terms "Carbon Neutral", "Carbon Offset" or "Carbon off-set compensation" are applied in a non-technical way to indicate that Shell has engaged in a transaction to ensure that an amount of carbon dioxide equivalent to that associated with the production, delivery and usage of the fuel has been removed from the atmosphere through a nature-based process or emissions saved through avoided deforestation

How do nature-based solutions work?

Stabilise global warming to below 2°C

- Nature-based solutions are projects which protect or redevelop natural ecosystems, such as forests, grasslands and wetlands.
- Such nature projects can lead to the creation, marketing, trading and sale of carbon credits.
- A carbon credit represents the avoidance or removal of 1 tonne of carbon dioxide.

How much CO_2 is stored in wood?

A tree converts an average of 1 tonne of CO_2 into 1.1 cubic meters of wood. This means one cubic metre of wood contains 0.9 tonnes of CO_2.

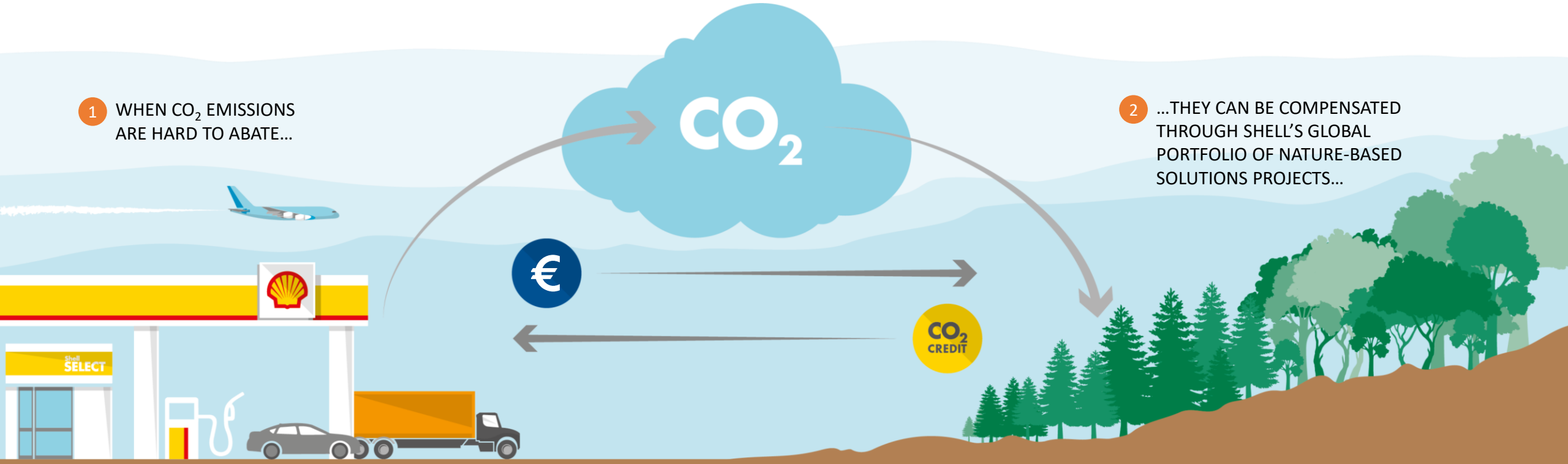
How fast do trees mature?

Trees in a forest have slow early growth, followed by a spike in growth and later growth decreases slowly. Peak growth is around 15 years for poplars and 90-100 years for oaks.

Compensate your CO_2 emissions

1 WHEN CO_2 EMISSIONS ARE HARD TO ABATE…

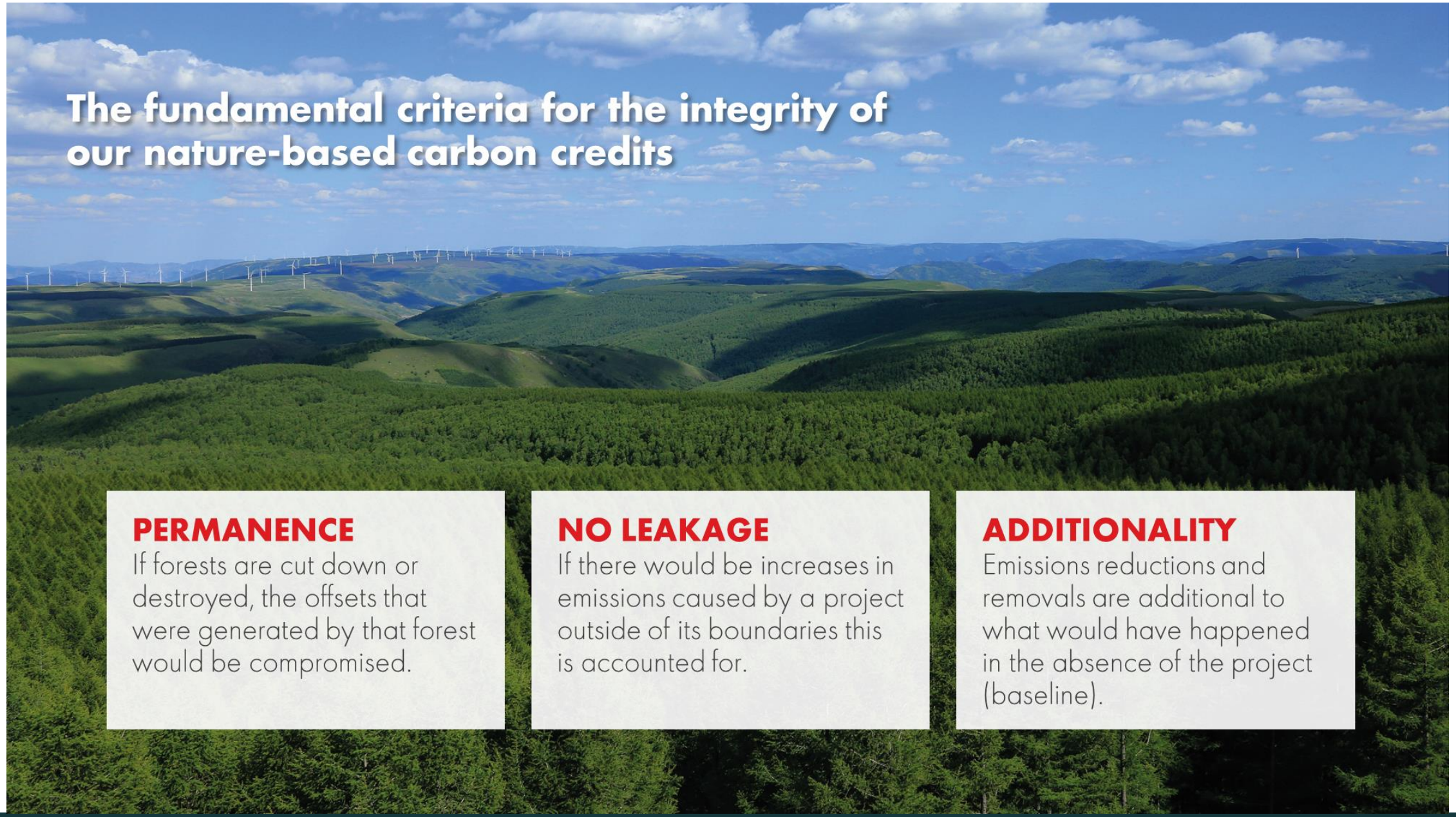
2 …THEY CAN BE COMPENSATED THROUGH SHELL'S GLOBAL PORTFOLIO OF NATURE-BASED SOLUTIONS PROJECTS…

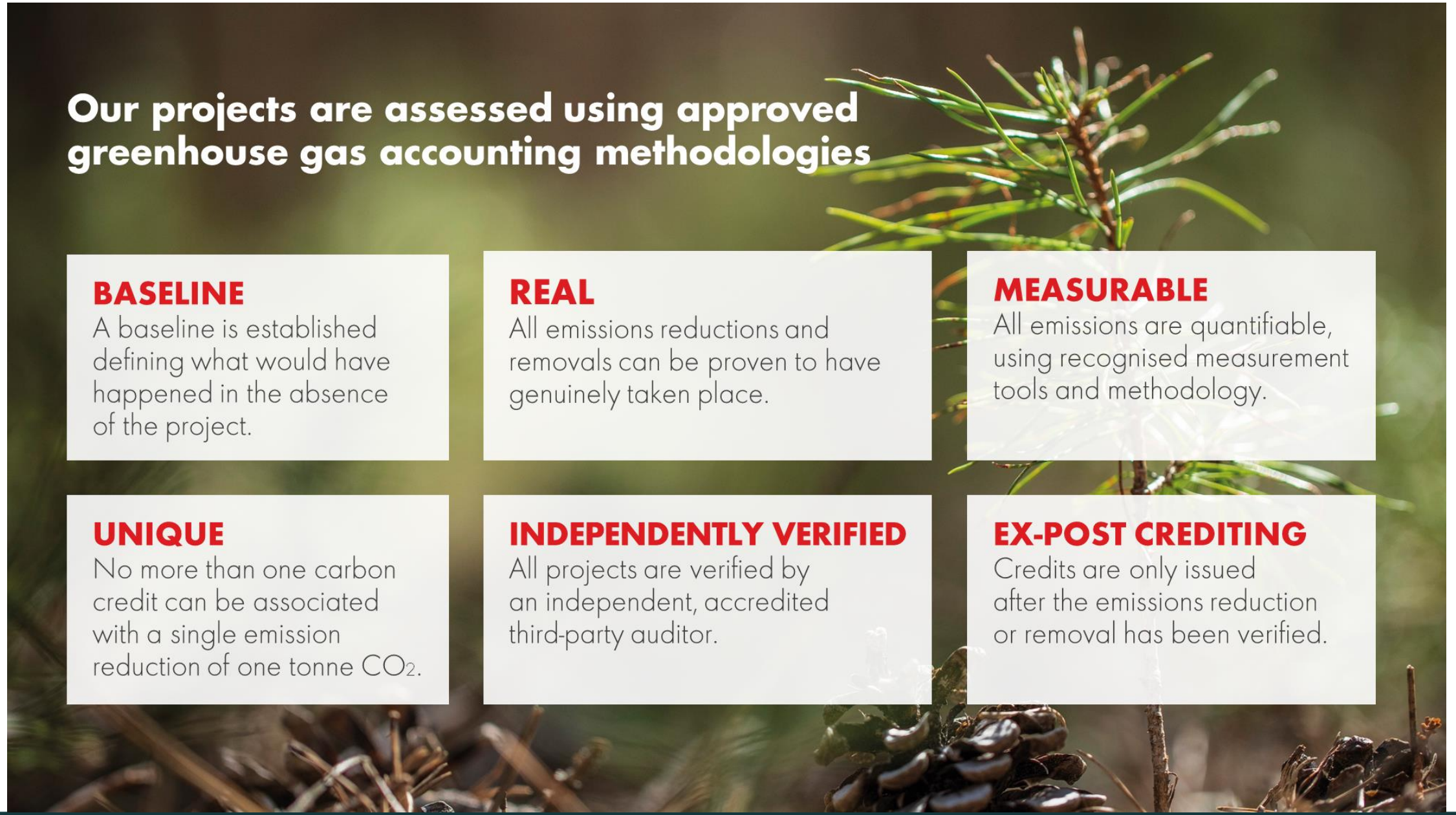


3 …THEY ARE INDEPENDENTLY VERIFIED TO CAPTURE OR REDUCE CO_2 EMISSIONS AND CREATE CARBON CREDITS…

4 …WHICH CAN BE RETIRED TO DEMONSTRATE AN AMOUNT OF CO_2 EMISSIONS HAVE BEEN COMPENSATED FOR.

1 CARBON CREDIT REPRESENTS THE AVOIDANCE OR REMOVAL OF 1 TONNE OF CO_2


The fundamental criteria for the integrity of our nature-based carbon credits
PERMANENCE
If forests are cut down or destroyed, the offsets that were generated by that forest would be compromised.
NO LEAKAGE
If there would be increases in emissions caused by a project outside of its boundaries this is accounted for.
ADDITIONALITY
Emissions reductions and removals are additional to what would have happened in the absence of the project (baseline).



Our projects are assessed using approved greenhouse gas accounting methodologies

BASELINE
A baseline is established defining what would have happened in the absence of the project.

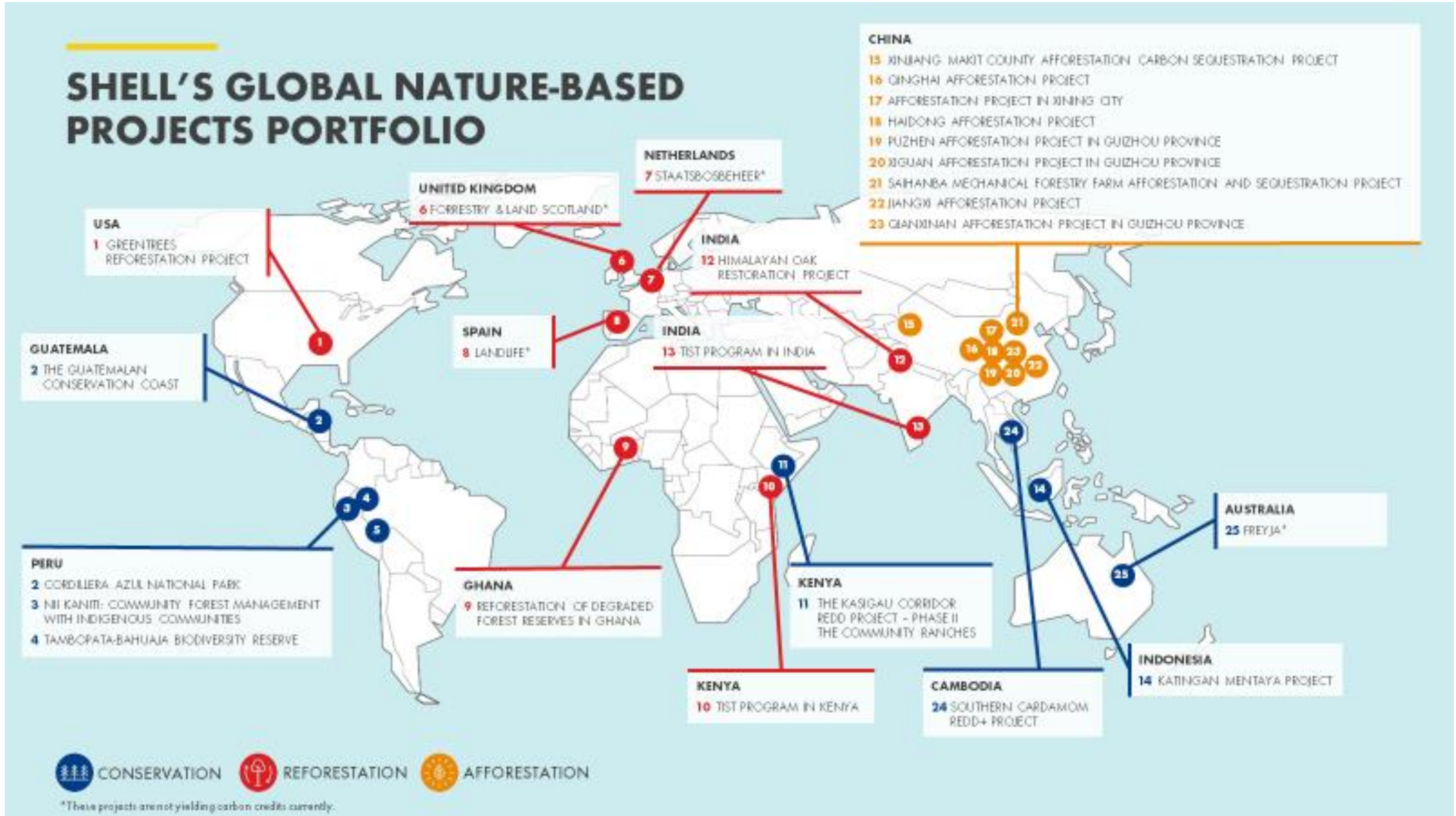
REAL
All emissions reductions and removals can be proven to have genuinely taken place.

MEASURABLE
All emissions are quantifiable, using recognised measurement tools and methodology.

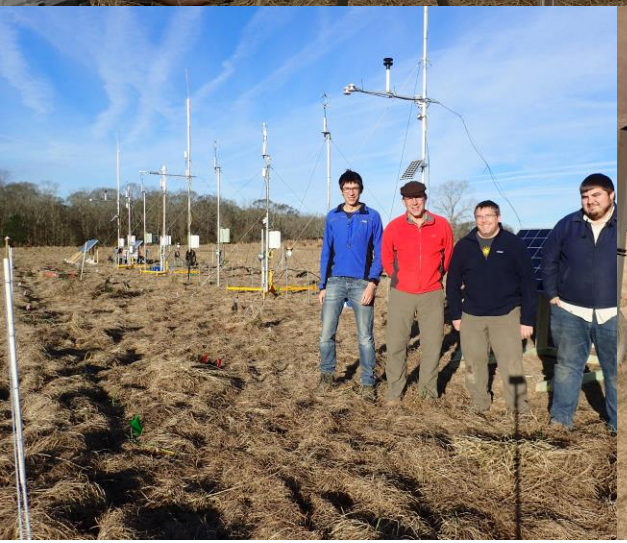
UNIQUE
No more than one carbon credit can be associated with a single emission reduction of one tonne CO_2.

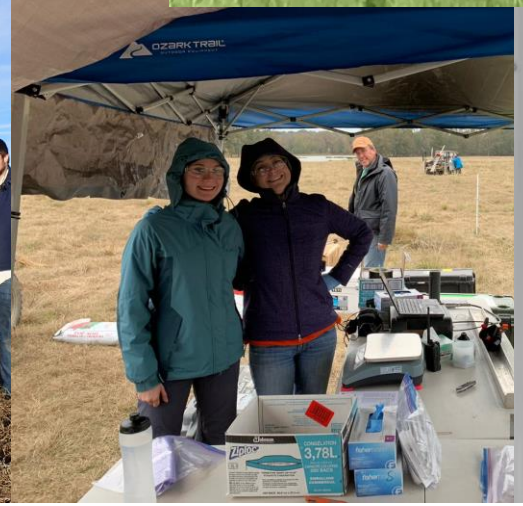
INDEPENDENTLY VERIFIED
All projects are verified by an independent, accredited third-party auditor.

EX-POST CREDITING
Credits are only issued after the emissions reduction or removal has been verified.


SHELL'S GLOBAL NATURE-BASED PROJECTS PORTFOLIO
CHINA
15 XINJIANG MAKIT COUNTY AFFORESTATION CARBON SEQUESTRATION PROJECT
16 QINGHAI AFFORESTATION PROJECT
17 AFFORESTATION PROJECT IN XINING CITY
18 HAIDONG AFFORESTATION PROJECT
19 PUZHEN AFFORESTATION PROJECT IN GUIZHOU PROVINCE
20 XIGUAN AFFORESTATION PROJECT IN GUIZHOU PROVINCE
21 SAIHANBA MECHANICAL FORESTRY FARM AFFORESTATION AND SEQUESTRATION PROJECT
22 JIANGXI AFFORESTATION PROJECT
23 QIANXINAN AFFORESTATION PROJECT IN GUIZHOU PROVINCE
NETHERLANDS
7 STAATSBOSBEHEER*
UNITED KINGDOM
6 FORRESTRY & LAND SCOTLAND*
USA
1 GREENTREES REFORESTATION PROJECT
INDIA
12 HIMALAYAN OAK RESTORATION PROJECT
SPAIN
8 LANDLIFE*
INDIA
13 TIST PROGRAM IN INDIA
GUATEMALA
2 THE GUATEMALAN CONSERVATION COAST
AUSTRALIA
25 FREYJA*
PERU
2 CORDILLERA AZUL NATIONAL PARK
3 NII KANITI: COMMUNITY FOREST MANAGEMENT WITH INDIGENOUS COMMUNITIES
4 TAMBOPATA-BAHUAJA BIODIVERSITY RESERVE
GHANA
9 REFORESTATION OF DEGRADED FOREST RESERVES IN GHANA
KENYA
11 THE KASIGAU CORRIDOR REDD PROJECT – PHASE II THE COMMUNITY RANCHES
INDONESIA
14 KATINGAN MENTAYA PROJECT
KENYA
10 TIST PROGRAM IN KENYA
CAMBODIA
24 SOUTHERN CARDAMOM REDD+ PROJECT
CONSERVATION
REFORESTATION
AFFORESTATION
*These projects are not yielding carbon credits currently.


First Cup Caf




OZARK TRAIL
3,78L