

## CHAPTER 3.

# GHG accounting and reporting principles

*This chapter provides definitions of the GHG accounting and reporting principles that are required and recommended for a GHG inventory to be in conformance with this Standard. GHG accounting refers to identifying, quantifying, recording, and classifying GHG emissions, removals, and other related metrics using standardized methods per agreed-upon protocols. GHG reporting refers to presenting data to internal management and external users such as regulators, shareholders, the general public, or specific stakeholder groups.*

## 3.1 Overview

Principles underpin and guide GHG accounting and reporting to ensure the reported inventory represents a faithful, true, and fair account of a company's GHG emissions and CO<sub>2</sub> removals. The relevance, completeness, consistency, transparency, and accuracy principles are fundamental to the GHG Protocol *Corporate Standard* and *Scope 3 Standard* and also guide the *Land Sector and Removals Standard* and *Guidance*. The conservativeness and permanence principles guide the accounting and reporting of removals in a company's GHG inventory. The comparability principle is recommended when relevant to business goals.

Principles specific to accounting for credited GHG emission reductions or removals are distinct from the inventory accounting principles and are provided in Chapter 18.

## 3.2 Requirements

### REQUIREMENT 2:

#### *Required GHG accounting and reporting principles*

Companies **shall** follow the principles of relevance, completeness, consistency, transparency, and accuracy when compiling a GHG inventory that includes land sector activities and/or removals. Companies **shall** also follow the principles of conservativeness and permanence if accounting and reporting for removals.



**Table 3.1** Definitions and applicability of principles

Principle	Definition	Applicability
<b>Relevance</b>	Ensure the GHG inventory appropriately reflects the GHG emissions, removals (if applicable), and other metrics of the company and serves the decision-making needs of users, both internal and external to the company.	Required for emissions, removals, and other metrics accounting.
<b>Completeness</b>	Account for and report on all GHG emissions, removals (if applicable), and other metrics from sources, sinks, and activities within the inventory boundary. Disclose and justify any specific exclusions.	
<b>Consistency</b>	Use consistent methodologies to allow for meaningful performance tracking of GHG emissions, removals (if applicable), and other metrics over time. Transparently document any changes to the data, inventory boundary, methods, or any other relevant factors in the time series.	
<b>Transparency</b>	Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used.	
<b>Accuracy</b>	Ensure that the quantification of GHG emissions, removals (if applicable), and other metrics is systematically neither over nor under actual emissions, removals (if applicable), and other metrics, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.	
<b>Conservativeness</b>	Use conservative assumptions, values, and procedures when uncertainty is high and accurate estimates are not practicable. Conservative values and assumptions are those that are more likely to overestimate GHG emissions and other related metrics and underestimate removals.	Required for removals accounting.
<b>Permanence<sup>a</sup></b>	Ensure mechanisms are in place to monitor the continued storage of reported removals and captured CO <sub>2</sub> , account for reversals, and report emissions from associated carbon pools.	
<b>Comparability</b>	Apply common methodologies, data sources, assumptions, and reporting formats such that the reported GHG inventories can be compared across multiple companies, as well as internally within each company.	Recommended for emissions, removals, and other metrics accounting when relevant.

*Note:* a. The permanence principle for GHG inventory accounting and reporting is distinct from the permanence principle for GHG credits. See Chapter 18 of the *Guidance* for details.

### 3.3 Recommendations

#### Comparability principle

Companies **should** follow the principle of comparability when relevant.

### 3.4 Key concepts

#### 3.4.1 Fundamentals of the land sector carbon cycle

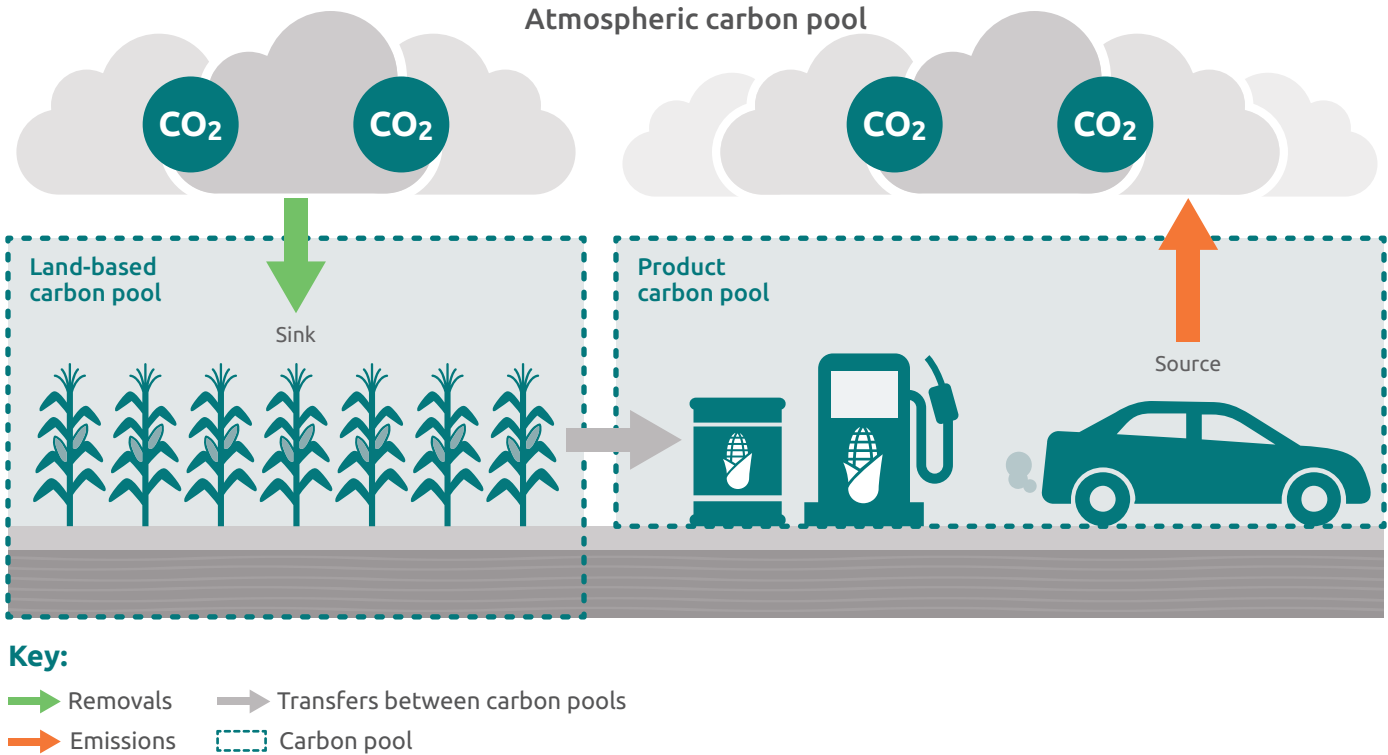
##### GHG fluxes

A GHG flux is the transfer of a GHG or carbon between two pools, expressed as an amount over a given time (e.g., tonnes of CO<sub>2</sub> per year). Fluxes can also be referred to as flows. Emissions and removals are two types of GHG fluxes:

- **Emissions** are the release of a GHG into the atmosphere. Emissions are produced from sources (e.g., combustion of biomass at a power plant or decomposition of food waste).
- **Removals** are the transfer of a GHG from the atmosphere to storage within a non-atmospheric pool. In this *Standard*, removals accounting is based on the stock-change accounting approach, outlined in Section 3.4.3, which focuses on the storage of carbon (removed from the atmosphere) in pools. Under this approach, CO<sub>2</sub> removals are synonymous with enhanced carbon storage in carbon pools (where the carbon is derived from atmospheric CO<sub>2</sub>). Removals result from sinks. A sink is a biological or technological process, activity, or mechanism that removes GHGs from the atmosphere (e.g., photosynthesis in plants or direct air capture equipment removing atmospheric CO<sub>2</sub>).

Figure 3.1 provides a simplified illustration of the relationship between carbon fluxes and carbon pools, and the sources and sinks that drive them.

**Figure 3.1** Simplified illustration of carbon fluxes between carbon pools



*Note:* This simplified illustration is not complete and does not include all carbon fluxes that may occur in agricultural systems.



GHG capture is a type of GHG flux that, in itself, is neither an emission nor a removal. GHG capture is the collection of a GHG from a source for storage within a non-atmospheric pool. In other words, GHG capture is a flux between non-atmospheric pools in which GHGs are prevented from being released to the atmosphere (i.e., preventing a GHG emission) and are instead transferred to storage in non-atmospheric pools (e.g., the capture of CO<sub>2</sub> from natural gas combustion at a power plant, where that captured CO<sub>2</sub> is then transported and stored in a geologic reservoir). This transfer is distinct from direct air capture (DAC or DACCS), where CO<sub>2</sub> is removed from the atmosphere. Chapters 14 and 15 provide further details on accounting for GHG capture and storage in geologic reservoirs or products.

## Carbon pools

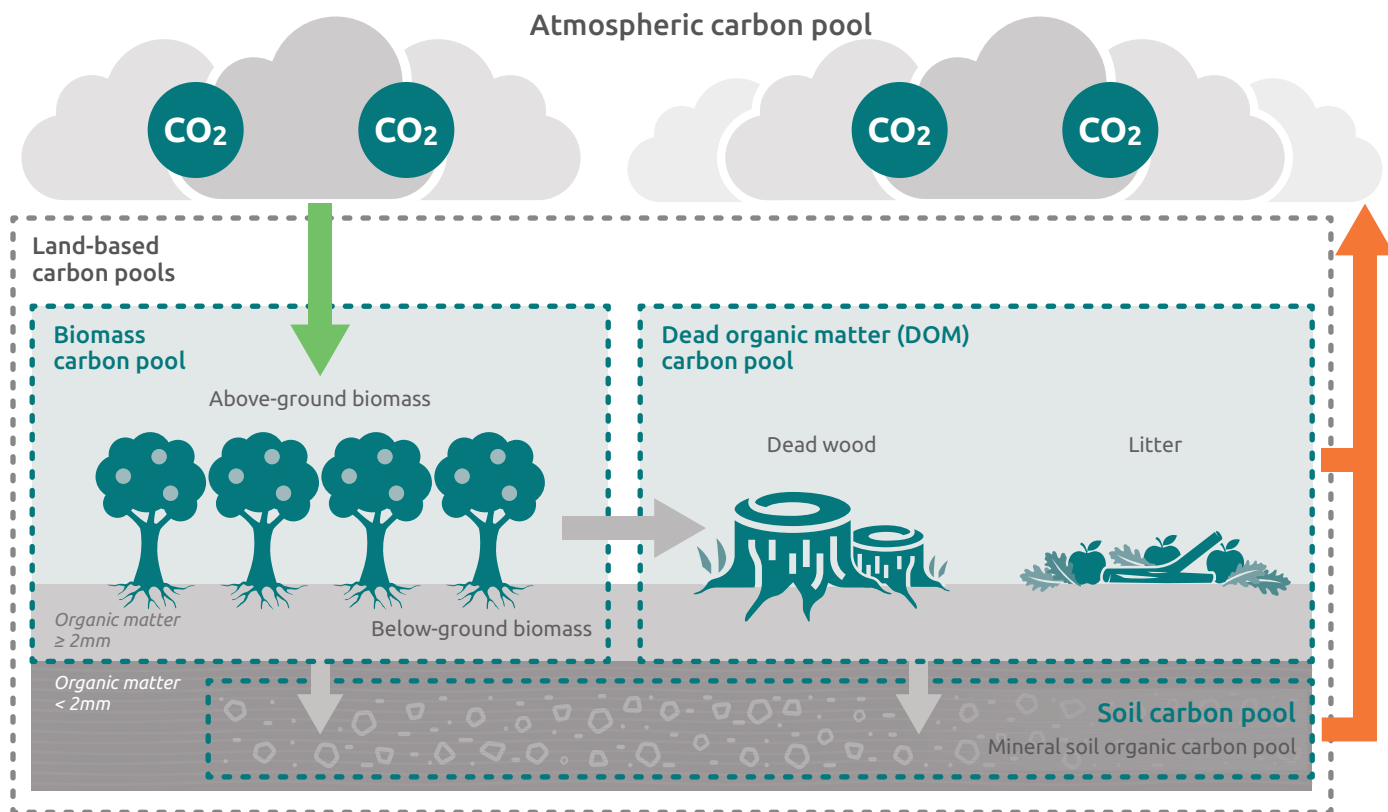
This *Standard* provides requirements and guidance on accounting for emissions and removals from land-based, geologic, and product carbon pools. While it provides requirements and guidance to account for emissions from water reservoirs (see Section 7.4.7), accounting for and reporting emissions and removals associated with ocean- or freshwater-based carbon pools are otherwise beyond the scope of this *Standard*.

Fluxes of CO<sub>2</sub> or carbon occur between the carbon pools defined below (the Glossary provides definitions for disaggregated carbon pools within these general pools):

- **Land-based carbon pool:** The carbon in terrestrial biomass (including above-ground and below-ground biomass), dead organic matter (including dead wood and litter), and soil carbon pools (including mineral soil organic carbon, organic soil organic carbon, and soil inorganic carbon) (Table 3.2 and Figure 3.2).

- **Geologic carbon pool:** The carbon in geologic formations or inorganic minerals that are not used as products. Examples of geologic carbon pools include carbon in carbonate rocks, fossil carbon in sedimentary formations containing oil and natural gas, or carbon in CO<sub>2</sub> injected into deep saline aquifers or other geologic reservoirs for long-term CO<sub>2</sub> storage.
- **Product carbon pool:** The carbon in products or materials during the use stage of the product life cycle, including recycling and reuse. Product carbon pools can be further classified based on the origin of the carbon, such as biogenic or technological carbon dioxide removal (TCDR)-based product carbon pools (Table 3.3).
- **Atmospheric carbon pool:** The carbon in the atmosphere.
- **Freshwater and ocean carbon pools:** The carbon in oceans, freshwater lakes, rivers, and other water bodies. An ocean carbon pool is carbon in marine organic or inorganic carbon pools. Examples of ocean carbon pools include inorganic carbon in bicarbonate and carbonate ions in seawater, and organic carbon in seagrass beds, algae, kelp, or sediments. A freshwater carbon pool is carbon in freshwater rivers, lakes, water reservoirs, or other inland freshwater bodies in organic or inorganic carbon pools. Examples of freshwater carbon pools include dissolved inorganic carbon, or organic carbon in algae or aquatic plants in freshwater bodies.

Figure 3.2 Land-based carbon pools and fluxes



**Key:**

- ➔ Gross CO<sub>2</sub> removals
- ➔ Transfers between carbon pools
- ➔ Gross CO<sub>2</sub> emissions
- ⋯ Carbon pool

**Table 3.2 Land-based carbon pools**

Land-based carbon pool		Definition <sup>a</sup>	Examples
Biomass carbon pool	Above-ground biomass carbon pool	Carbon in terrestrial living vegetation above the soil. This includes both woody and herbaceous living vegetation, including stems, stumps, branches, bark, seeds, and foliage.	Carbon in trees, shrubs, plants, and other living vegetation above the soil.
	Below-ground biomass carbon pool	Carbon in the living biomass of terrestrial live roots. Fine roots of less than 2 mm in diameter are often excluded because these cannot always be distinguished empirically from soil organic matter or litter.	Carbon in roots.
Dead organic matter carbon pool	Dead wood carbon pool	Carbon in non-living woody biomass that is not contained in litter carbon pools, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter (or other threshold defined by the company).	Carbon in standing or lying dead wood, dead roots, stumps, and forestry residues.
	Litter carbon pool	Carbon in non-living biomass or other non-fossil organic compounds with a diameter greater than the limit for soil organic matter and less than 10 cm in diameter (or other threshold defined by the company) for dead wood, lying dead, in various states of decomposition above or within the mineral and organic soil. Live fine roots above the mineral or organic soil (or less than the minimum diameter limit chosen for below-ground biomass) are included in litter where they cannot be distinguished from it empirically.	Carbon in leaf litter, crop residues, and fine roots.
Soil carbon pool	Soil organic carbon pool in mineral soils	Carbon in soil organic matter that is smaller than 2 mm in diameter to a specified depth in soil types that are not classified as organic soils. Live and dead fine roots that are less than the minimum diameter are included with soil organic matter where they cannot be distinguished from it empirically.	Carbon in the topsoil (e.g., 0–30 cm) of croplands from particulate matter or microbial biomass.
	Soil organic carbon pool in organic soils	Carbon in soil organic matter that is smaller than 2 mm in diameter to a specified depth in organic soils that have an organic horizon greater than or equal to 10 cm in thickness and have greater than 12–20 percent organic carbon by weight, depending on soil texture and water saturation. <sup>b</sup>	Carbon in peat soils or wetland organic soils.
	Soil inorganic carbon pool	Carbon in soil carbonates and other mineral carbon forms in soil.	Carbon in calcium carbonates in desert soils.

Notes: a. Definitions are derived from IPCC (2019a) and IPCC (2006); b. See IPCC (2014) for additional details on classifying organic soils.

**Table 3.3 Product carbon pools**

Product carbon pool	Definition <sup>a</sup>	Examples
Biogenic product carbon pool	Biogenic carbon in products or materials during the use stage of the product life cycle. Biogenic carbon is carbon in, or derived from, living organisms or biological processes, but not from fossil fuels or other fossilized materials.	Carbon contained in paper, sawn wood, or bio-based plastics.
Technological carbon dioxide removal (TCDR)-based product carbon pool	TCDR-based carbon in products or materials during the use stage of the product life cycle. TCDR-based carbon is carbon derived from technological carbon dioxide removal processes.	Carbon in synthetic fuels or products derived from direct air captured CO <sub>2</sub> .

Note: a. Definitions are derived from IPCC (2019a) and IPCC (2006).

### Carbon cycle pathways

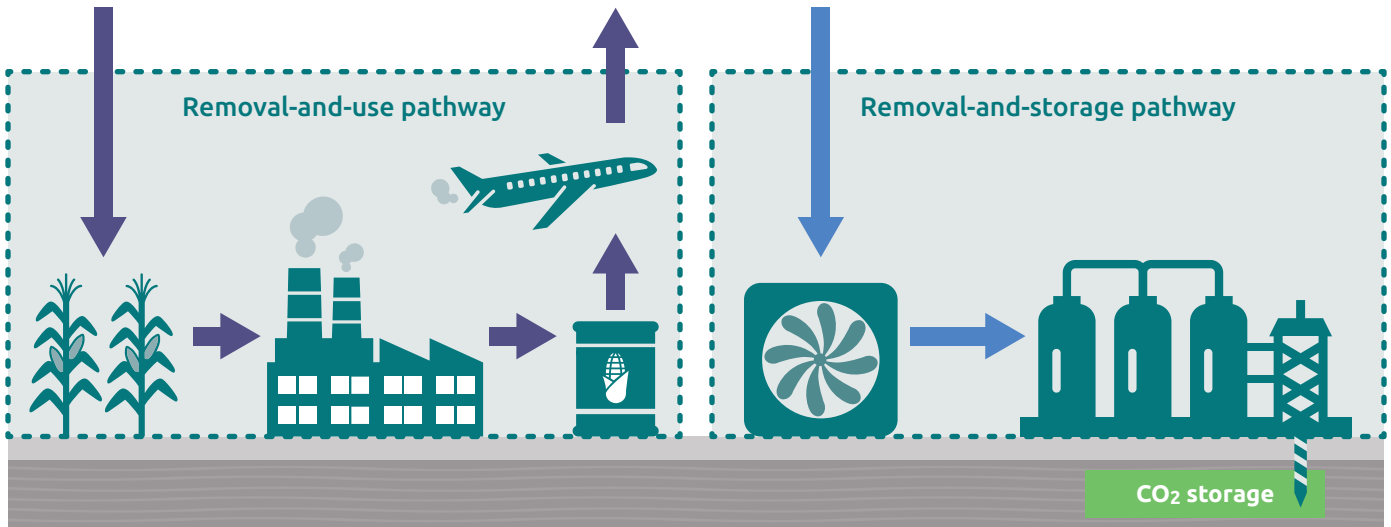
The sequential fluxes of carbon from one carbon pool to another can together be represented in carbon cycle pathways. A carbon cycle pathway that includes CO<sub>2</sub> removals can be broadly categorized as a “removal-and-use” pathway or a “removal-and-storage” pathway (Figure 3.3):

- **Removal-and-use pathway:** A carbon cycle pathway where CO<sub>2</sub> removed from the atmosphere is later returned to the atmosphere through CO<sub>2</sub> emissions.
- **Removal-and-storage pathway:** A carbon cycle pathway where CO<sub>2</sub> removed from the atmosphere contributes to increased storage in non-atmospheric carbon pools, and carbon is not emitted back to the atmosphere. For example, CO<sub>2</sub> is removed from the atmosphere via direct air capture technologies and is then injected into geologic reservoirs for carbon storage.



Carbon cycle pathways are comprised of multiple individual carbon fluxes in a biogenic or technological carbon dioxide removal (TCDR) carbon cycle. The biogenic carbon cycle includes biogenic land CO<sub>2</sub> removals, biogenic land CO<sub>2</sub> emissions, transfers of biogenic carbon between carbon pools, and biogenic CO<sub>2</sub> emissions. The TCDR carbon cycle includes technological CO<sub>2</sub> removals, transfers of TCDR-based carbon between carbon pools, and TCDR-based CO<sub>2</sub> emissions. For further background information on biogenic and TCDR-based carbon cycles, see Section 11.4.1 in Chapter 11.

**Figure 3.3** Examples of carbon fluxes in removal-and-use and removal-and-storage pathways



**Key:**  
 -> Removal and use carbon fluxes  
 -> Removal and storage carbon fluxes  
 ■ Net carbon stock increase

## Non-CO<sub>2</sub> GHG removals

This *Standard* only provides requirements and recommendations on accounting for CO<sub>2</sub> removals and carbon pools. However, there is potential for the removal of other GHGs from the atmosphere. Box 3.1 briefly highlights the current potential for removals of other non-CO<sub>2</sub> GHGs. Any non-CO<sub>2</sub> GHG removals should be separately accounted for and reported separately from scope 1 and scope 3 removals (i.e., CO<sub>2</sub> removals), as set forth in this *Standard*.

### Box 3.1 Non-CO<sub>2</sub> GHG removals

Practices that enhance natural, non-CO<sub>2</sub> GHG removal processes or new technologies that can remove non-CO<sub>2</sub> GHGs from the atmosphere are subject to ongoing research. Given much lower ambient concentrations of non-CO<sub>2</sub> GHGs (i.e., relative to CO<sub>2</sub> in the atmosphere), many emerging technologies first require increased air flow or concentration of atmospheric gases through active direct air capture technologies, similar to processes used for technological CO<sub>2</sub> removals. Direct air capture technologies include:

- **Active direct air capture:** use of mechanical devices such as fans to force air flow and recover GHGs through increased contact with removal processes.
- **Passive direct air capture:** deployment of GHG removal processes at ambient atmospheric GHG concentrations or through natural air flow processes.
- **Solar chimney:** also known as solar updraft towers, these technologies employ a large collection area to warm air using solar heating. They then direct that air into a chimney, where removal processes can be employed in addition to generating electricity.<sup>a</sup>

A snapshot of various emerging non-CO<sub>2</sub> GHG removal technologies and practices is provided in the table below. Many of these technologies are in the initial research phases and not technologically or economically viable at the time of publication. No additional guidance is provided in this *Standard* and *Guidance* to account for non-CO<sub>2</sub> GHG removals. Any non-CO<sub>2</sub> GHG removals are accounted for and reported separately from scope 1 and scope 3 CO<sub>2</sub> removals.

**Table B3.1-1 Examples of emerging non-CO<sub>2</sub> GHG removal technologies**

Removal process	Description	Relevant GHGs
Photocatalysis <sup>b</sup>	Conversion of GHG through chemical decomposition reactions using light and metal catalysts.	CH <sub>4</sub> , N <sub>2</sub> O, CFCs, HFCs
Microbial consumption	Conversion of GHG through microbial oxidation or reduction processes.	CH <sub>4</sub> , N <sub>2</sub> O
Adsorption filters <sup>c</sup>	Trapping of GHG molecules on the surface of materials with high sorption capacities, such as zeolites or porous polymer networks.	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O
Cryogenic separation	Cooling captured atmospheric GHGs to a low temperature where the gas can be liquified and separated.	CO <sub>2</sub> , CH <sub>4</sub>

Notes: a. Ming et al. 2016; b. deRichter et al. 2017; c. Jackson et al. 2021.

### 3.4.2 Land use fundamentals

The *Standard* and *Guidance* contain requirements and recommendations for accounting for emissions, removals, and other metrics caused by activities on land. Land management activities within a given land use category, as well as land use change from one land use category to another, are therefore the operative categories for a corporate GHG inventory in the land sector.

Following IPCC definitions, the *Standard* and *Guidance* use six land use categories that provide a system broad enough to classify all land areas in most countries: forest land, grassland, cropland, wetlands, settlements, and other lands (Figure 3.4). These six overarching categories represent a mixture of land cover and land use classes, which are two closely related, but distinct, land classification systems (see Box 3.2). This *Standard* also defines specific subcategory land uses within these six major land use categories. Land use change is defined in this *Standard* as a transition between these six land use categories, or between subcategories within the major land use categories (see Section 7.4.1 for further guidance).

Agricultural land is the total of cropland, permanent meadows, and pastures. All cropland is by definition productive. Grasslands, wetlands, and forest lands can encompass both productive and natural (i.e., non-productive) lands (Table 3.4).

Following IPCC definitions, this *Standard* and *Guidance* define the following six major land use categories:

1. **Cropland:** A land use category with productive land used for agricultural cultivation systems, including annual (e.g., cereals, oilseeds, and vegetables and root crops) and perennial (e.g., plantations, orchards, and vineyards) production systems. All cropland is by definition productive. Cropland includes rice cultivation systems, agroforestry systems where the vegetation structure consistently falls below established forest land thresholds (see definition of “forest land” below), and land temporarily fallow as part of a cultivation system (e.g., a rotation system). Agroforestry, subsistence agriculture, and shifting cultivation also fall within the cropland category. Mixed systems, which rotate between cropland and pastureland, are also typically included as cropland, as the land’s use for forage crops or grazing is temporary.
2. **Grassland:** A land use category with perennial grasses, other non-grass vegetation, and woody vegetation structures below the forest land threshold. This land use is commonly used for grazing and includes pasture lands that are not considered cropland. Grasslands can include rangelands, savannahs, shrublands, meadows, pastureland, and other land cover that falls below forest land thresholds. Grasslands can span a wide range of climate conditions globally, are commonly used for grazing, and can withstand regular perturbation from both grazing and fire.
  - **Grassland subcategory land use:** This *Standard* defines two types of grassland subcategory land use—natural and productive grasslands:
    - **Natural grassland:** Grasslands that substantially resemble (i.e., in terms of species composition, structure, and ecological function) those that are or would be found in a given area in the absence of significant human impacts.<sup>1</sup> Natural grasslands may include native grasslands and savannahs, as long as animal stocking rates and fire regimes are not intensively managed.
    - **Productive grassland:** Grasslands used to produce an agricultural or other biogenic product or provide a service that are characterized by a loss of the main elements of ecosystem composition, structure, and function of the previous natural grassland or of a natural grassland that would be expected in that location. Productive grasslands may include pasturelands and silvopastoral systems.
3. **Wetland:** A land use category with land that is saturated by water for all or part of the year, and does not otherwise fall into the categories of forest land, cropland, grassland, or settlements. Note that land with

wet, drained, or re-wetted soils (i.e., “wetland soils,” either mineral or organic) can fall into any of the six, overarching land use categories outlined in this section (e.g., a “forested wetland” that is classified as a forest based on threshold tree cover).

- **Wetland subcategory land use:** this *Standard* defines two types of wetland subcategory land use—natural and productive wetlands:

- **Natural wetland:** Wetlands that substantially resemble (i.e., in terms of species composition, structure, and ecological function) those that are or would be found in a given area in the absence of significant human impacts.<sup>2</sup> Natural wetlands can be found inland or along the coast, and often within conservation areas.
- **Productive wetland:** Wetlands used to produce an agricultural or other biogenic product or provide a service that are characterized by a loss of the main elements of ecosystem composition, structure, and function of the previous natural wetland or of a natural wetland that would be expected in that location. Productive wetlands can support other productive uses, such as cropland and grassland management, and can include manure management ponds, industrial effluent ponds, aquaculture ponds, water reservoirs, and rewetting of previously drained wetlands.

**4. Forest Land:** A land use category with woody vegetation that meets a threshold of tree canopy cover and height. This category includes land management systems with a vegetation structure that currently falls below, but in situ could potentially reach, threshold values used to define forest lands (e.g., forest stands that have recently been replanted or are regenerating following a harvest event).<sup>3</sup> Forest land is often further specified by ecosystem type (e.g., tropical rainforest, boreal coniferous forest, etc.).

- **Forest subcategory land use:** This *Standard* defines two types of forest subcategory land use—natural and plantation forests:

- **Natural forest:** Primary forests and secondary forests following natural regrowth due to land abandonment or afforestation/reforestation.
- **Plantation forest:** Forests predominantly (i.e., > 50 percent of growing stock at maturity) composed of trees established through planting and/or deliberate seeding that is intensively managed and meets all the following criteria at planting and stand maturity: one or two species, even age class, and regular spacing.<sup>4</sup>

This plantation forest definition specifically includes, but is not limited to:

- short rotation plantations for wood, fiber, and energy

This plantation forest definition specifically excludes:

- forest established for protection or ecosystem restoration, and/or managed to restore and enhance biological and habitat diversity, structural complexity, and ecosystem functionality
- forest established through planting or seeding, which at stand maturity resembles or will resemble a naturally regenerating forest

When evaluating boundary cases, for which it may be difficult to distinguish plantation from natural forest, additional attributes that may distinguish plantation forests are:







- the planting of non-native species as a significant or primary component of trees planted
- a loss of the main elements of ecosystem composition, structure, and function of the previous natural forest or of a natural forest that would be expected in that location<sup>5</sup>

**5. Settlements:** A land use category with land developed for infrastructure or human settlements of any size. Examples of settlement land areas include, but are not limited to, developed areas including roads, buildings, and other built infrastructure. Land within this category is typically administratively associated with cities, towns, villages, or other municipalities.

Examples of land carbon stocks on settlements include the soils and herbaceous vegetation beneath and adjacent to infrastructure (e.g., garden plants and turf grass), urban trees falling below established forest land thresholds (e.g., in office parks and landscaping), green roofs, lawns, and urban agriculture. A transition from other land use classes to settlements can have significant impacts on carbon stocks, even in otherwise rural areas.

**6. Other lands:** A land use category with land that does not otherwise fall into the other main land use categories (i.e., forest land, grassland, cropland, wetland, and settlements), including bare soil, rock, and ice. This land generally cannot support agricultural and forestry activities.

**Table 3.4 Land use categories and subcategories**

Land use	Land use subcategory	Examples
 <b>Cropland</b>	All cropland is productive by definition	<ul style="list-style-type: none"> <li>• Annual croplands</li> <li>• Perennial croplands</li> <li>• Rice paddies</li> <li>• Land in agroforestry systems that fall below forest land thresholds</li> <li>• Land temporarily fallowed in a cultivation system</li> </ul>
 <b>Grasslands</b>	Productive grassland	<ul style="list-style-type: none"> <li>• Pasturelands</li> <li>• Permanent meadows</li> <li>• Land in silvopastoral systems</li> </ul>
	Natural grassland	<ul style="list-style-type: none"> <li>• Native grasslands and savannahs, as long as intensive animal stocking rates and fire management practices are not applied</li> </ul>
 <b>Wetlands</b>	Productive wetland	<ul style="list-style-type: none"> <li>• Aquaculture ponds</li> <li>• Manure management and effluent ponds</li> <li>• Water reservoirs</li> <li>• Paludiculture</li> </ul>
	Natural wetland	<ul style="list-style-type: none"> <li>• Wetlands that substantially resemble (i.e., in terms of species composition, structure, and ecological function) those that are or would be found in a given area in the absence of significant human impacts</li> </ul>
 <b>Forest lands</b>	Natural forest	<ul style="list-style-type: none"> <li>• Primary forests and secondary forests following natural regrowth due to land abandonment or afforestation/reforestation</li> </ul>
	Plantation forest	<ul style="list-style-type: none"> <li>• Short rotation plantations for wood, fiber, and/or energy</li> </ul>
 <b>Settlements</b>		<ul style="list-style-type: none"> <li>• Cities and communities</li> <li>• Roads</li> <li>• Built infrastructure</li> <li>• Landscaping between buildings that falls below forest land thresholds</li> </ul>
 <b>Other lands</b>		<ul style="list-style-type: none"> <li>• Deserts</li> <li>• Barren land</li> <li>• Ice-covered surfaces</li> </ul>

### Box 3.2 Land cover versus land use

The IPCC distinguishes between land cover and land use as follows:<sup>a</sup>

- **Land cover:** the observed physical and biological cover of the Earth’s land
- **Land use:** the arrangements, activities, and inputs that people undertake in a certain land parcel

Land cover classification systems broadly focus on identifiable land characteristics, such as open water, bare ground, and deciduous forest. Land cover characteristics are largely derived from field surveys and analysis of remote sensing imagery. In contrast, land use classifications (e.g., grazing, conservation, timber extraction, etc.) often relate to socio-economic activity, can be context-specific, and occur across land cover types.

For example, consider a forest that was recently harvested, with temporarily decreased tree canopy cover, but that is being replanted under a forest management plan. Under a land cover definition, this might not meet the threshold to be classified as a forest; however, due to the arrangements on the land, it would still be considered forest land according to a land use definition. Land cover and land use classifications can vary across data sources, making it important to understand the relevant definitions, especially when considering changes in land designation over time.

*Note:* a. IPCC 2000.

### 3.4.3 Corporate GHG inventory accounting

GHG inventories enable companies to account for and track annual changes in GHG emissions, removals, and other metrics. Compiling a GHG inventory supports a range of business goals, including informing strategies to reduce GHG emissions and enhance removals, tracking progress toward climate targets, and disclosing GHG emissions and removals to stakeholders through mandatory or voluntary reporting programs.

Corporate GHG inventories are based on inventory accounting methods. Inventory accounting provides a complete assessment of the annual emissions from sources (and removals by sinks, if applicable) within the reporting company’s inventory boundary. The inventory boundary is defined using three scopes: direct emissions/removals (i.e., scope 1) and indirect emissions/removals (i.e., scopes 2 and 3). In inventory accounting, emissions (and removals, if applicable) are reported annually, and progress is tracked relative to a historic base year or period.



Intervention accounting, in contrast, is used to estimate the systemwide GHG impacts of actions intended to reduce GHGs relative to counterfactual baseline scenarios or other performance standards. This includes accounting approaches such as project accounting and project-level GHG crediting. An inventory accounting approach is applied in Chapters 5–15 of this *Standard*. An intervention accounting approach is applied in Chapters 16 and 18. Companies should use both inventory and intervention accounting approaches to inform decision-making, as described in Chapter 16.

### 3.4.4 Fundamentals of land sector and removals accounting approaches

Accounting for GHG emissions and removals in a carbon cycle pathway (see Section 3.4.1) can be based on accounting for individual gross fluxes or the net flux. When the accounting is complete, the sum of all gross fluxes should equal the net flux. However, quantifying gross versus net fluxes can be done with different data and methodological considerations.

- **Gross CO<sub>2</sub> flux:** A one-directional transfer of CO<sub>2</sub> or its constituent carbon from one carbon pool to another.
- **Net CO<sub>2</sub> flux:** The difference between CO<sub>2</sub> emissions and removals associated with a given carbon pool or set of carbon pools over a defined period of time.

There are two general approaches to account for emissions and removals fluxes in a carbon cycle pathway: a stock-change accounting approach, which accounts for the net flux, and a flow accounting approach, which accounts for one or more individual gross fluxes (Table 3.5). This *Standard* requires a stock-change accounting approach. Conceptually, applying a stock-change or a flow accounting approach will result in the same net CO<sub>2</sub> flux, but these approaches differ as follows:

- **Stock-change accounting:** An accounting approach that estimates the net flux of carbon to or from the atmosphere during a time period, based on the net change in carbon stocks in the system at the beginning and end of that period. A carbon stock is the mass of carbon contained in a carbon pool at a given time, and a carbon stock change is the difference in carbon stocks between two points in time. Carbon stock changes are assumed to represent a net flux of CO<sub>2</sub> to and from the carbon stock. Carbon stock changes can be quantified using the Stock-Difference Method (i.e., as the difference between carbon stocks at two points in time) or the Gain-Loss Method (i.e., as the difference between individual carbon stock gains and losses in that time period). See Section 9.5.3.1 for further discussion of the Stock-Difference versus Gain-Loss Methods.

Net decreases in carbon stocks in the system are used to estimate net CO<sub>2</sub> emissions to the atmosphere (typically reported as positive CO<sub>2</sub> fluxes). Net increases in carbon stocks in the system are used to estimate net CO<sub>2</sub> removals from the atmosphere (typically reported as negative CO<sub>2</sub> fluxes). Note that there can also be carbon transfers between pools within the system, based on the measurement of annual net carbon stock changes within all non-atmospheric carbon pools in that system.

- **Flow accounting:** An accounting approach that estimates the gross fluxes of carbon to and from the atmosphere based on the flows of carbon from the atmosphere to the system (i.e., gross removals) and flows of carbon out of the system to the atmosphere (i.e., gross emissions). Gross CO<sub>2</sub> emissions are gross fluxes from non-atmospheric carbon pools to the atmosphere and are typically reported with positive values. Gross CO<sub>2</sub> removals are gross fluxes from the atmosphere to storage in non-atmospheric carbon pools and are typically reported with negative values. These gross emissions and removals fluxes can be added to obtain a net emission or removal flux of CO<sub>2</sub> between the system and the atmosphere.

### Net and gross CO<sub>2</sub> flux accounting in this Standard, compared to other GHG Protocol standards

This *Standard* requires reporting the net CO<sub>2</sub> flux based on the stock-change accounting approach. For transparency, this *Standard* also requires reporting certain gross CO<sub>2</sub> fluxes in additional categories (see Figures 4.1 and 4.2), based on a flow accounting approach.

Because this *Standard* is primarily based on a stock change accounting approach, “CO<sub>2</sub> removals” means *net* CO<sub>2</sub> removals throughout the text. As suggested in the subcategory name, accounting for land management net biogenic CO<sub>2</sub> emissions is based on a stock-change accounting approach. When used more generally in this *Standard* and *Guidance* (i.e., when not referring to a specific accounting category), the terms “biogenic emissions” and “biogenic removals” mean *gross* biogenic CO<sub>2</sub> emissions or removals. Accounting for biogenic product emissions, gross biogenic land CO<sub>2</sub> emissions, and gross biogenic land CO<sub>2</sub> removals is based on a flow accounting approach.

Note that the GHG Protocol’s *Corporate Standard*, *Scope 2 Guidance*, and *Scope 3 Standard* are structured around flow accounting for fossil fuel and industrial GHG emissions to the atmosphere (e.g., from combustion of fossil fuels). Table 3.5 highlights key differences between stock-change and flow accounting approaches.



**Table 3.5** Comparison of stock-change and flow carbon accounting approaches

	Stock-change accounting approach	Flow accounting approach
<b>Description</b>	Accounts for <i>carbon stock changes</i> by estimating the net flux of carbon to or from the atmosphere during a time period, based on the net change in carbon stocks in the system at the beginning and end of that period.	Accounts for <i>emissions and removals flows</i> by estimating the gross fluxes of carbon to and from the atmosphere based on the flows of carbon from the atmosphere to the system (i.e., gross removals) and flows of carbon from the system to the atmosphere (i.e., gross emissions).
<b>Measures</b>	Carbon storage in pools.	GHG flows by sink or source processes.
<b>Accounts for</b>	Net emissions or net removals from carbon pools.	Gross emissions and gross removals from carbon pools.

In general, stock-change and flow accounting approaches provide different types of information about shorter-term and longer-term carbon cycles (see Box 3.3). Stock-change accounting records the annual net CO<sub>2</sub> flux. Therefore, unless applied to a sub-annual time period, stock-change accounting does not typically contain information on carbon cycles shorter than one year. This means that, in general, the stock-change accounting approach cannot reliably identify when and where gross emissions fluxes and gross removals fluxes occur in the system in a single year. In contrast, flow accounting provides information regarding all gross CO<sub>2</sub> emissions and CO<sub>2</sub> removal fluxes that occur within a year, and can be used to identify key drivers influencing the net CO<sub>2</sub> flux within shorter-term cycles. For example, if maize is grown, harvested, and used as animal feed in a single year, flow accounting would account for gross biogenic CO<sub>2</sub> removals from plant growth and gross biogenic CO<sub>2</sub> emissions from plant harvest, while stock change accounting would not report any net CO<sub>2</sub> fluxes, as the annual net carbon stock change on the land that produced the maize is zero (assuming there were no soil carbon stock changes).

Due to this inherent difference, stock-change accounting can, in general, provide better representation of relatively longer-term carbon cycles, typically associated with CO<sub>2</sub> “removal-and-storage” pathways (e.g., carbon storage in soils or in geologic reservoirs). In contrast, flow accounting can, in general, provide better representation of relatively shorter-term carbon cycles, typically associated with CO<sub>2</sub> “removal-and-use” pathways (e.g., biomass growth, harvesting, and use, or short-lived direct air capture CO<sub>2</sub>-based products). See Section 3.4.1 for further discussion of carbon cycle pathways.

**Box 3.3 Examples of the difference between stock-change and flow accounting for CO<sub>2</sub> emissions and removals**

The examples below illustrate the conceptual differences when accounting for CO<sub>2</sub> emissions and removals in the net accounting categories using the stock-change accounting approach, compared with the gross accounting categories using the flow accounting approach.<sup>a</sup>

**Table B3.3-1 Examples of the difference between stock-change and flow accounting for CO<sub>2</sub> emissions and removals**

Scenario	Carbon cycle pathway	Net accounting categories	Gross accounting categories
<b>A direct air capture facility producing CO<sub>2</sub>-based fuels, where those fuels are combusted in the same year</b>	Removal-and-use	<ul style="list-style-type: none"> <li>The net TCDR-based product carbon stock does not change, resulting in zero TCDR-based product carbon storage</li> </ul>	<ul style="list-style-type: none"> <li>Gross technological CO<sub>2</sub> removals, accounted for based on the CO<sub>2</sub> removed from the atmosphere through direct air capture</li> <li>TCDR-based product CO<sub>2</sub> emissions, accounted for based on the CO<sub>2</sub> emitted from combustion of the CO<sub>2</sub>-based fuels</li> </ul>
<b>A direct air capture facility producing CO<sub>2</sub>-cured cement, which leads to increased carbon storage in cement</b>	Removal-and-storage	<ul style="list-style-type: none"> <li>The net TCDR-based product carbon stock increases, resulting in TCDR-based product carbon storage</li> </ul>	<ul style="list-style-type: none"> <li>Gross technological CO<sub>2</sub> removals, accounted for based on the CO<sub>2</sub> removed from the atmosphere through direct air capture</li> <li>TCDR-based product CO<sub>2</sub> emissions, accounted for based on the CO<sub>2</sub> emitted from fugitive losses during processing or other CO<sub>2</sub> emissions during the cement’s use stage or end-of-life treatment</li> </ul>

Note: a. These examples consider carbon flows and carbon stock changes representing fluxes only between TCDR-based carbon pools and the atmosphere. Fossil fuel and industrial GHG emissions may also occur in these pathways, but these emissions are accounted for separately in the inventory.

## Conversion of carbon stock changes to net CO<sub>2</sub> flux

A conversion from carbon to CO<sub>2</sub> is necessary when applying the stock-change accounting approach. Carbon stock changes are measured in units of carbon, while emissions and removals are measured and reported in the GHG inventory in units of CO<sub>2</sub>. To convert carbon stock changes to units of CO<sub>2</sub>, units of carbon (C) are multiplied by the ratio of the molecular weight of CO<sub>2</sub> to C (44:12), as shown in Equation 3.1.

An increase in carbon stocks is typically reported as a positive value, while a decrease in carbon stocks is typically reported as a negative value. To align with conventions for reporting CO<sub>2</sub> fluxes as emissions or removals, carbon stock changes are multiplied by -1 to convert net carbon stock changes into net CO<sub>2</sub> emissions or removals. For example, converting a carbon stock decrease (negative value) into a net CO<sub>2</sub> emission (positive value) requires multiplying by -1, as shown in Equation 3.1.

**Equation 3.1 Conversion of carbon stock changes to net CO<sub>2</sub> flux**

$$CO_2 = \Delta C \times \frac{44}{12} \times -1$$

Description	Unit	Source
CO <sub>2</sub> Net CO <sub>2</sub> flux	tonnes CO <sub>2</sub> (year) <sup>-1</sup>	Calculated
ΔC Net carbon stock change	tonnes C (year) <sup>-1</sup>	Calculated
44/12 Conversion factor: C to CO <sub>2</sub>	tonne CO <sub>2</sub> (tonne C) <sup>-1</sup>	Constant

### 3.4.5 Relationship between corporate and national GHG inventory accounting

This *Standard* and *Guidance* rely on certain national inventory methodologies set forth in the Intergovernmental Panel on Climate Change (IPCC) *Guidelines for National Greenhouse Gas Inventories*,<sup>6</sup> as a basis for estimating corporate GHG emissions and CO<sub>2</sub> removals. Shared principles and methods help to promote alignment between corporate-level GHG inventories and national GHG inventories.

Both corporate and national GHG inventories use inventory accounting methods but apply different inventory boundaries, thus providing two parallel inventory accounting frameworks. However, there are some areas where corporate GHG inventories differ from national GHG inventories, particularly regarding the inventory boundary:

- National GHG inventory boundaries are based on lands included in a country’s territorial boundary, which are largely fixed.
- Corporate GHG inventory boundaries are defined based on ownership or control of lands and other operations or lands relevant to activities in a company’s value chain (see Chapters 4 and 5), which may change over time.

In general, this *Standard* and *Guidance* seek to align with national GHG inventory frameworks. Because a company’s operational or value chain boundaries are more likely to change over time (compared to geopolitical boundaries), corporate GHG inventories require some different approaches. For instance, companies must monitor the

permanence of previously reported removals, even if the inventory boundary changes and the carbon pool where the removed carbon is stored is no longer within the reporting company's inventory boundary. This reversals accounting and reporting requirement is not applicable to national inventories, since the national inventory boundary is unlikely to change over time.

Corporate-level inventories take a different approach to other accounting and reporting topics, including:

- The scopes framework, including direct (scope 1) and indirect (scope 3) emissions and removals (see the *Corporate Standard* and Chapter 4)
- Life cycle accounting for indirect (scope 3) emissions (see the *Scope 3 Standard* and Chapter 4)
- Accounting categories and subcategories (see the *Corporate Standard* and Chapter 4)
- Requirements for reporting CO<sub>2</sub> removals, including reversals accounting (see Chapter 12)
- Land use change (LUC) emissions accounting across a retrospective LUC assessment period, where a company accounts for emissions due to land use change occurring in that assessment period, rather than only accounting for LUC emissions in the reporting year (see Chapter 7)

For some companies, it may be particularly important to align their corporate GHG inventories with national GHG inventories in countries or jurisdictions where they have operations or value chain activities. In this case, companies should seek to be consistent with the data and methods used in that country's national GHG inventory. Where national GHG inventory approaches do not provide a necessary level of resolution, companies should seek to apply methods that enable more accurate estimates where they have increased data resolution (e.g., through the application of specific emission factors for sourcing regions or land management units, compared to national- or global-average emission factors).

Double counting of emissions or removals between corporate and national GHG inventories is inherent, as a given source or sink will be within both a company's inventory boundary and a national inventory boundary, if the company operates in that country. Where data and methods are aligned, mitigation outcomes may be reflected as reduced emissions or increased removals under both national and corporate GHG accounting frameworks.

---

## Endnotes

- 1 See the Accountability Framework Initiative's (AFi) *Applying the Definitions Related to Deforestation and Conversion* (AFi 2023) for further guidance on natural ecosystems, including natural grasslands.
- 2 See the Accountability Framework Initiative (AFi 2023) for further guidance on natural ecosystems, including natural wetlands.
- 3 For example, a forest land threshold could include land spanning at least 0.5 hectares with trees higher than five meters and canopy cover of over 10 percent of the area (threshold definition adapted from FAO 2018).
- 4 Definition adapted from FAO (2018).
- 5 See the Accountability Framework Initiative's (AFi) *Applying the Definitions Related to Deforestation and Conversion* (AFi 2023) for further guidance on distinguishing boundary cases between natural forests, plantation forests, and other lands.
- 6 The *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2019a) can be accessed, alongside earlier guidance and more recent supplementary material, at <https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/>

## Photo Credits

Pg. 16, Luba; Pg. 19, Nick Fewings; Pg. 22, Getty Images; Pg. 27, Ricardo Gomez Angel; Pg. 29, Getty Images