VCS Tool

VT00XX

Tool for Estimating Carbon Leakage from IFM Activities

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Sectoral Scope 14: Forestry and other land use (forests, wetlands, and grasslands)

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1 SUMMARY DESCRIPTION

This tool estimates carbon leakage from IFM activities and accounts for leakage caused by the baseline agent (activity-shifting leakage) and other actors (market leakage).

This tool provides project-specific leakage factors ($LF_{,weighted,t}$), which must be applied in the applicable equation for calculating net GHG emission reductions and carbon dioxide removals under the specific methodology used for project accounting. Complete details for the proper derivation of the leakage factor, including specific parameters that project proponents must use in determining which factor is most relevant to their project, are provided in Section 5 below. The leakage factor derived using this tool must be applied as a deduction in the applicable IFM methodology.

The leakage factor is fixed at validation. Leakage factors for new instances are derived when they are added, and the weighted leakage factor must be updated to represent weighted leakage across all instances.

This tool estimates a percentage-based carbon leakage deduction based on four (4) factors:

1) The relevant geographic region, see Figure 1;
2) The relevant forest type;
3) The expected longevity of harvest volume reductions caused by the implementation of project activities; and
4) The proportion of the project-relevant geographic region that has implemented additional IFM project activities

This tool uses the Global Timber Model (GTM)[1] to generate leakage factor estimates that are relevant to all forests globally. Each leakage factor is applicable to all forests within the specified geographic region that:

a) meet the applicable forest type definition;
b) are subject to an eligible project activity; and
c) are considered economically accessible within the Global Timber Model (GTM). For the purposes of this tool, any project that demonstrates additionality in accordance with the applicable IFM methodology is considered economically accessible from the perspective of the GTM.

[1] See more in https://u.osu.edu/forest/gtm/

The GTM is an empirically parameterized, peer-reviewed dynamic optimization model of the global forest sector. Its structure makes it well suited to estimating carbon leakage — rather than harvest leakage — from IFM projects across the included regions, forest types, and other project parameters. For further details on the GTM, see Appendix 1.

2 SOURCES

This tool generates carbon leakage factors appropriate for use on any Improved Forest Management (IFM) project that reduces harvest volumes, thereby creating the opportunity for leakage. This tool is based on the following scientific article:

- *"A Globally Relevant Data-Driven Assessment of Carbon Leakage from Forestry" Environ. Res. Lett. 20 114022 DOI 10.1088/1748-9326/ae0ce2*

The following have also informed the content and structure of the tool:

- *VMD0054 "Module for Estimating Leakage from ARR Activities" (Version 1.0)*
- *VT0004 "JNR Leakage Tool" (Version 1.0)*
- *VMD0032 "Estimation of Emissions from Activity-Shifting Leakage" (Version 1.0)*
- *VMD0033 "Estimation of Emissions from Market Leakage" (Version 1.0)*
- Science for High Integrity Frameworks to Transform Carbon Markets (SHIFT-CM) leakage working group; a series of working groups convened by Yale and TNC to develop science that safeguards the integrity of carbon markets
- Forest Carbon Quantification Consortium: a group of environmental economists and academic foresters focused on development of robust leakage quantification approaches and tools

3 DEFINITIONS

Carbon leakage
Net changes in anthropogenic carbon dioxide emissions that occur outside the project or program boundary but are attributable to the project or program

Commercial timber volume
the volume of merchantable timber, in cubic meters, that could be removed from a forest to obtain income from wood products

Harvest leakage
Net changes in the volume of timber harvested that occur outside the project or program boundary but are attributable to the project or program

4 APPLICABILITY CONDITIONS

This tool is applicable under the following conditions:

1) The project result harvest volume reductions relative to the baseline scenario due to extended rotation age (ERA), low to high productivity forest (LtHP) or logged to protected (LtPF) activities, defined in Section 5.1 below.

This tool is not applicable under the following conditions:

1) The project area is subject to any pre-existing legal encumbrance (e.g., conservation easement) specifically restricting timber harvest or other active silvicultural management.

2) The project does not involve IFM project activities that reduce timber harvest volumes or other forest-based commodities (e.g., reduced impact logging activities).

5 PROCEDURES

This tool provides leakage factors (i.e., LF_t) for application in IFM accounting methodologies. Leakage factors are derived from the GTM and are specific to project activity, GTM subregions, and forest type.

In general, every stratum of a project must be assigned by project activity, GTM subregion and forest type. Where the project area has more than one (1) stratum, the applicable leakage factors are weighted by commercial timber volume in each stratum under Equation 1. Apply Sections 5.1 through Section 5.4 to derive a weighted leakage factor for the project.

5.1 Determine Project Activity Type

Classify harvest volume reductions resulting from project activity as either:

1) Extended rotation age (ERA) activities and Low to High Productivity (LtHP) where harvest volumes are reduced for finite period of time and future harvest is anticipated under a forest management plan implemented during the project crediting period. Projects, or project strata, implementing ERA/LtHP must use Table 1 below to derive leakage rates.

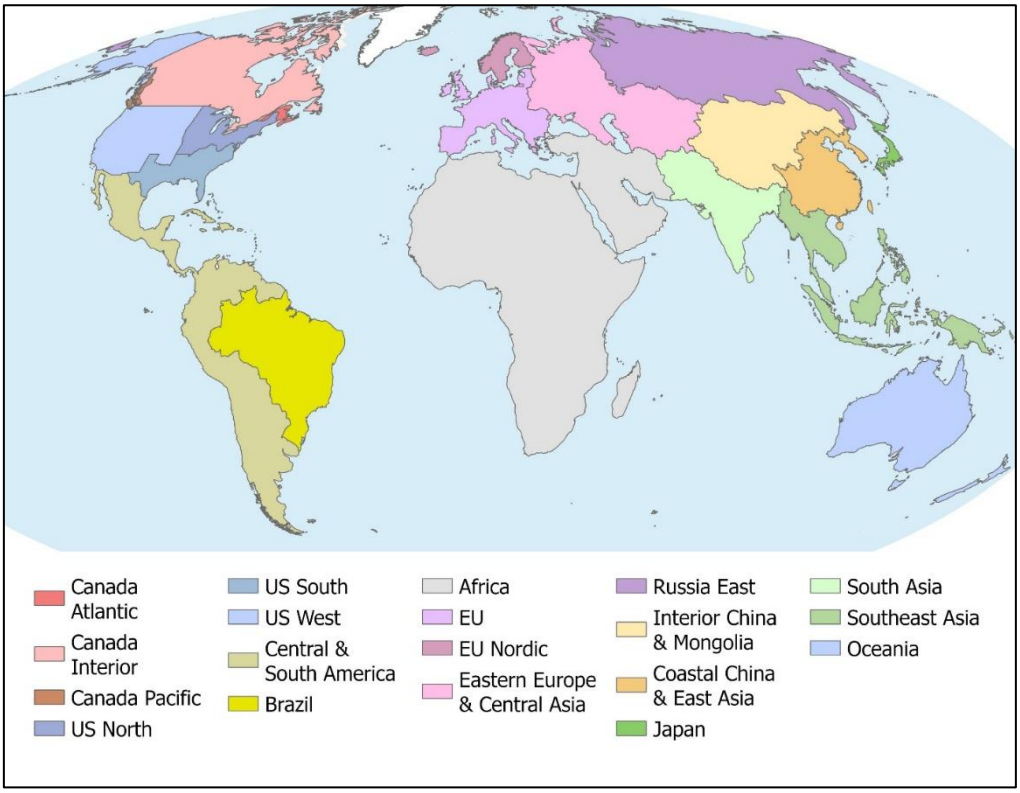
2) Logged to Protected Forests (LtPF) where project activities reserve areas from harvest during the project crediting period. Projects, or project strata, implementing LtPF must use Table 2 to derive leakage rates.

5.2 Determine Geographic Subregion(s)

Based on location of the project area, assign each stratum of the project area and the share of commercial timber volume in each to a GTM subregion (see Figure 1). The project proponent must:

1) Use the IFM_Leakage_Subregions.shp file (available on the Verra website) to assign the project area to a GTM Subregion(s).
    a) Where the project area falls within a single GTM subregion, assign the entire project area to that subregion.
    b) Where the project area spans more than one (1) GTM subregion, calculate the proportion of commercial timber volume attributable to each subregion.
2) For grouped projects, recalculate the proportions and the geographically weighted leakage factor when new project instances are added.

Figure 1. GTM Geographic Subregions Map



5.3 Determine Forest Type

Forest types, and their respective leakage rates, differ by subregion. Tables 1 and 2 below identify the forest-type classifications used by the GTM for each subregion. These classifications vary to reflect regionally relevant forest characteristics. Grey cells in Table 1 indicate forest-type categories that are not applicable to the classification used for a given subregion, but do not represent gaps in geographic coverage.

When applying this tool, the project must determine the Forest Type in Table 1 and Table 2 that best aligns with project inventory data in the project area, or stratum. Assign all forest land within the project area to the forest types available in the associated project subregion(s).

Forest types are mutually comprehensive. Where stratum qualifies for more than one type, assign the more specific type that matches the project. Each stratum of a project area must be assigned to a single forest type. Forest type is assigned by either origin of the stand (i.e., planted or natural), or by its predominant species composition. Forest type is assigned to a project area, or stratum, where more than half (≥ 50%) of basal area can be classified under eligible forest origin or species within a project's subregion(s).

The tables below provide leakage factors for all combinations of the geographic subregion, IFM activity, and forest type, thus the leakage factors provided include values applicable to all IFM projects that create a periodic (e.g., ERA) or permanent reduction (e.g., LtPF) in harvest volume, regardless of the location of those projects. The main steps are as follows:

1) Identify the applicable IFM activity. For extended rotation age use Table 1. For logged to protected forest in harvest use Table 2;
2) Identify the GTM subregion in which the stratum is located; and
3) Identify the forest origin or type classifications applicable within the selected GTM subregion.

Table 1. ERA/LtHP Leakage Factors

Leakage factors applicable to IFM projects that create an ERA/LtHP in timber harvest volumes. Grey cells indicate that a given Forest Type is not applicable within the selected geographic subregion.

GTM Subregion	Natural	Plantation	Dipterocarp	Hardwood	Conifer	Doug-Fir
Africa & Middle East	20%	24%				
Brazil	24%	22%				
Canada: Atlantic	31%					
Canada: Interior	37%					
Canada: Pacific	31%					
Central & South America	21%	22%				
Coastal China & East Asia	32%	27%				
Interior China & Mongolia	33%					
Europe	33%	38%				
Europe - Nordic	30%					

East Europe & West Russia	31%					
Japan	24%	22%				
Oceania	22%	24%				
Russia East	32%					
South Asia	21%	23%				
Southeast Asia	24%	24%	25%			
USA: North				32%	30%	
USA: South				26%	24%	
USA: West				32%		25%

Table 2. LtPF reduction leakage factors

IFM projects that create a LtPF in timber harvest volumes. Grey cells indicate that a given Forest Type is not applicable within the selected geographic subregion.

GTM Subregion	Natural	Plantation	Dipterocarp	Hardwood	Conifer	Doug-Fir
Africa & Middle East	10%	10%				
Brazil	10%	10%				
Canada: Atlantic	10%					
Canada: Interior	10%					
Canada: Pacific	10%					
Central & South America	10%	10%				
Coastal China & East Asia	10%	10%				
Interior China & Mongolia	10%					
Europe	10%	10%				
Europe - Nordic	10%					
East Europe & West Russia	10%					
Japan	10%	10%				
Oceania	10%	10%				
Russia East	10%					

South Asia	10%	10%				
Southeast Asia	10%	10%	10%			
USA: North				10%	10%	
USA: South				10%	10%	
USA: West				10%		10%

NOTE — For logged-to-protected activities, the GTM predicts zero or negative leakage for most subregion and forest-type combinations. To provide a conservative allowance for uncertainty in modelled market responses, a minimum leakage factor of 10% is applied. Accordingly, where the GTM-derived leakage rate is less than 10%, the leakage factor is set to 10%.

5.4 Determine Appropriate Leakage Factor

Table 1 and Table 2 provide leakage factors for all combinations of geographic subregion, IFM activity and forest type. Together, they cover every IFM project that creates a periodic or permanent reduction in harvest volume, regardless of location.

The leakage factor is fixed at validation. Leakage factors for new instances are derived when they are added, and the weighted leakage factor must be updated to represent weighted leakage across all instances.

For each stratum, the project must determine the leakage factor applied to the project as follows:

1) where the project area contains a single GTM subregion and forest type, apply that leakage factor (LF_t) directly; or,
2) where the project area contains more than one (1) GTM subregion or forest type, calculate the commercial timber volume-weighted leakage factor ($LF_{weighted,t}$) using Equation (1).
3) Ensure the proportions used for weighting sum up to 100 percent across all subregion and forest type combinations.

Where the project area contains strata in more than one GTM subregions, the leakage factor is calculated as a commercial timber volume-weighted average of the applicable leakage factors, as shown in Equation 1.

$$LF_{weighted,t} = \sum LF_{R,FT} * \%CVol_{R,FT} \quad (1)$$

Where:

$LF_{weighted,t}$ = Weighted leakage factor at time *t* (%)

$LF_{R,FT}$ = Leakage factor for GTM subregion *R* and forest type *FT* (%)

$\%CVol_{R,FT}$ = Proportion of commercial timber volume within the project area that falls within GTM subregion *R* and forest type *FT*

t = Year in which the leakage factor is determined, at validation or when a new instance is added.

6 DATA AND PARAMETERS

6.1 Data and Parameters Available at Validation

Data / Parameter	*R*
Data unit	Geographic subregion
Description	Spatially explicit geographic subregion delineated from the Global Timber Model.
Equations	(2)
Source of data	Global Timber Model
Value applied	Conditional based on project boundary
Justification of choice of data or description of measurement methods and procedures applied	GTM subregions have been designed to create areas of reasonably homogenous forest types and species distributions; harvest practices, equipment, and commercialization standards; harvest likelihood and typical harvest intensities; and market dynamics and product pricing. See links embedded within Appendix 1 for further information.
Purpose of Data	Calculation of leakage
Comments	Map of geographic subregions provided in Figure 1. Full dataset for use in project development is available as shapefile at https://verra.org/wp-content/uploads/2026/11/leakage_subregions.zip

Data / Parameter	FT_{Origin}
Data unit	Origin of regeneration leading to current stand within project area
Description	Spatially non-explicit, criteria-based forest type derived from empirical data and used to differentiate types in the Global Timber Model. FT_{Origin} differentiates between stands that arise from natural and artificial regeneration.
Equations	(1)

Source of data	All forest types are derived from land classes based on empirical data used within the Global Timber Model. Within the United States, these data include the US Forest Service's Forest Inventory and Analysis dataset. Outside the United States, forest data are sourced from a variety of national and subnational programs tracking overall forest composition and use variation within each subregion.
Value applied	Conditional based on the basal area of planted vs naturally regenerated trees within project boundary.
Justification of choice of data or description of measurement methods and procedures applied	Forest types are differentiated by origin because naturally regenerated and planted forests often differ in their productivity, management regimes, harvested products, and economic characteristics, all of which may influence leakage estimates within the Global Timber Model. See links embedded within Appendix 1 for further information on the derivation of forest types within the GTM.
Purpose of Data	Calculation of Leakage
Comments	None

Data / Parameter	$FT_{Species}$
Data unit	Species distributions for the current stand within project area
Description	Spatially non-explicit, criteria-based forest type derived from empirical data and used to differentiate types in the Global Timber Model. $FT_{Species}$ differentiates between stands where the majority of the stocking is comprised of hardwood (angiosperm) species, conifer species, Dipterocarp species (*Dipterocarpaceae spp.*), or Douglas-Fir (*Pseudotsuga menziesii*).
Equations	(1)
Source of data	All forest types are derived from land classes based on empirical data used within the Global Timber Model. Within the United States, these data include the US Forest Service's Forest Inventory and Analysis dataset. Outside the United States, forest data are sourced from a variety of national and subnational programs tracking overall forest composition and use variation within each subregion.
Value applied	Conditional based on species composition and stocking within project boundary.
Justification of choice of data or description of measurement methods and procedures applied	Forest types are defined within the context of existing systems for forest typing and are intended to account for conditions within types, including assessment of species composition, geographic and topographic distribution, and typical commercial products harvested, all of which can influence expected leakage rates. See links embedded within

	Appendix 1 for further information on the derivation of forest types within GTM.
Purpose of Data	Calculation of leakage
Comments	None

Data / Parameter	$LF_{R,FT}$
Data unit	Percent
Description	Leakage factor for forest type *FT* in subregion *R*, as derived from Table 1 and Table 2 in Section 5.3 above.
Equations	(1)
Source of data	The Global Timber Model
Value applied	Conditional on forest type and subregions within the project area
Justification of choice of data or description of measurement methods and procedures applied	The Global Timber Model is an empirically based dynamic optimization model of the global forest sector. It is capable of estimating carbon leakage from GHG mitigation projects in forest systems.
Purpose of Data	Calculation of leakage
Comments	None

Data / Parameter	$LF_{Weighted,t}$
Data unit	Percent
Description	A weighted leakage factor calculated from leakage factors from two (2) or more subregions or forest types, and the proportion of the project area's timber volume or value present in each of those component conditions.
Equations	(1)
Source of data	Global Timber Model
Value applied	Conditional based on the subregion(s) and forest type(s) found within the project boundaries.
Justification of choice of data or description of measurement methods and procedures applied	The Global Timber Model is an empirically based, global scale, dynamic optimization model of the forest sector. It is capable of credibly estimating carbon leakage from GHG mitigation projects in forest systems. More detailed information may be provided in an appendix.

Purpose of Data	Calculation of leakage
Comments	None

Data / Parameter	$\%CVol_{R,FT}$
Data unit	Percent
Description	Proportion of commercial timber volume or value within the project area that falls within GTM subregion R and forest type FT
Equations	(1)
Source of data	Forest inventory within project area
Value applied	Conditional based on forest stocking within project area
Justification of choice of data or description of measurement methods and procedures applied	Leakage is an inherently economic phenomenon caused by intentional limitation on the amount of a given commodity which is allowed to enter the marketplace from a given location. Thus, in weighting two (2) relevant leakage factors together for use within a project area that includes disparate conditions, the most reasonable weighting factor is the proportion of the commodities present in that area. The proportion of the commodities attributable to each component condition must be determined based on commercial timber volume derived from timber inventory and/or project measurements, applied to all strata.
Purpose of Data	Calculation of leakage
Comments	None

7 REFERENCES

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APPENDIX 1: DESCRIPTION OF THE GLOBAL TIMBER MODEL

The Global Timber Model (GTM) is used to generate leakage factors with global applicability. Each leakage factor applies to forests located within the specified geographic region that: (i) satisfy the applicable forest type definition; (ii) are subject to an eligible project activity; and (iii) are considered economically accessible within the GTM. All projects able to demonstrate additionality according to the requirements of the IFM methodology being used for the project accounting are inherently considered economically accessible from the perspective of the GTM.

The Global Timber Model (GTM; Sohngen et al. 2001) is an empirically parameterized dynamic optimization model of the global forest sector. The model optimizes over land use, forest area, forest management, timber harvests, carbon stocks, and other important indicators of forest ecosystem services. The GTM has been widely used to assess policy scenarios relevant to carbon emissions mitigation and carbon sequestration related to forests, and the model has undergone extensive refinement, peer review, and calibration since its development (Sohngen and Sedjo 2000; Sohngen and Mendelsohn 2003). Its ability to credibly estimate forest carbon leakage from GHG mitigation projects is based on several key factors, namely that the GTM:

1) Enables accounting for carbon leakage, rather than harvest leakage
2) Incorporates empirical data for both supply- and demand-side aspects of IFM
3) Takes a global/regional perspective on markets and timber supply
4) Is structured as a long-run, dynamic model
5) Accounts for multiple relevant carbon pools
6) Incorporates regional heterogeneity between forest types

Importantly, the leakage factors provided by this tool represent carbon leakage, such that all estimates are based on changes in carbon stocks and the carbon content of harvested trees. This differs from another common metric, harvest leakage which represents changes in standing timber volumes and the volume of wood in harvested trees. Making carbon leakage the basis of this tool ensures that it can account for inherent differences in forests dominated by diverse species with substantial differences in wood density and growth rates, as well as across geographic regions where forest practices, wastage rates, and storage factors frequently vary. Moreover, using deductions for carbon leakage is estimating potential change in the emissions of greenhouse gases (GHGs). By comparison, harvest leakage focuses on a metric that is more relevant in the context of related-but-distinct forest product markets. Though it has higher utility in other contexts, harvest leakage often poorly accounts for the carbon emissions implications of GHG mitigation projects and serves, at best, as an error-prone proxy for estimating the impact of project activities on GHG emissions.

The GTM incorporates empirical data and is parameterized to account for global timber flows. Carbon leakage is an inherently economic phenomena, mediated by markets and trade which are themselves inherently global. These elements are quantitatively accounted for within the GTM, where empirical data reflecting dynamics in

global timber trade are explicitly incorporated into the predictive capacity of the model. These critical data used in parameterizing the GTM include supply-side elements such as forest stocking, variation in intensity and extent of timber harvest, global and regional timber trade, land rentals, input costs, harvesting costs, and global regulatory conditions. These data are critically important in ensuring that the GTM produces scenario outcomes that are constrained by the same boundaries and conditions observable in real world scenarios, e.g., biological maximum forest stocking levels. The GTM also includes empirical data for consumer demand of various forest products, i.e., those from the demand side of the same global timber trade dynamics, which allow the accounting of changes in consumption patterns also associated with changes in expendable income and wealth. The various empirical data used within the model are updated no less than every ten years to ensure consistent performance.

Furthermore, considering the broader context of the data and scenarios that a credible assessment framework for leakage needs to take into account, the GTM incorporates coverage of global markets for timber, carbon, and other forest products. As these goods are now frequently traded internationally, it is critical to include these markets at a global scale. The GTM quantifies leakage using a global market framework that captures the effects of changes in timber supply across the global forest sector. The GTM is a dynamic, long-term model that optimizes across the full modeling horizon, capturing how changes in timber supply, market conditions, and forest management decisions in one (1) period influence outcomes in future periods. These dynamics are empirically derived and correctly assume resource managers are making long-term decisions that optimize outcomes across many time steps, not just the immediately subsequent step. By comparison, myopic models only allow the outcomes from a given timestep to influence the immediate subsequent timestep.[2] GTM therefore mirrors typical decision-making of resource managers seeking to optimize long-term performance of the assets they oversee.

A related aspect of the GTM's long-run nature is that its output can be used to estimate carbon leakage across different time horizons. Recent work has shown that the time horizon used for assessment can substantially impact the leakage estimates (Daigneault et al. 2025). While it is obvious that the time horizon across which GHG mitigation projects implement project activities can vary widely, the development and use of leakage factors for projects with differing timelines is burdensome for both project proponents and tool developers. Thus, this tool calculates leakage deductions based on the single most relevant time horizon of the 80 years that follow the initiation of project activities. This timeline for emissions and leakage accounting was selected based primarily on two (2) pieces of information regarding leakage accounting. First, we recognize that leakage takes time to occur (i.e., it is not instantaneous), but that the amount of leakage produced will usually peak early in a project's lifetime as the impact of reduced harvest volume first impacts related markets, and that it will decline over time. This implies that leakage factors can remain robust even if they exclude some portion of a project's impact on other agents, provided the estimates extend far enough into the future to capture a reasonable majority of those impacts. Secondly, using a discounting approach (set at 5% discount rate, consistent with Daigneault et al. 2025) to sum up leakage impacts across time, it is possible to calculate the proportion of leakage that is captured by a time horizon of a given length. A sensitivity analysis of this

[2] Wear, D.N., and B.C. Murray. 2004. Federal Timber Restrictions, Interregional Spillovers, and the Impact on U.S. Softwood Markets. Journal of Environmental Economics and Management 47(2): 307–330. doi:10.1016/S0095-0696(03)00081-0

phenomenon showed that selecting a time horizon of 80 years after project initiation captures 98% of the potential leakage impacts a project creates.

Another important aspect of the GTM that allows it to function effectively in a variety of forested settings is that it accounts for multiple carbon pools in its calculations, all of which are informed by empirical data and published scientific literature. The GTM explicitly accounts for carbon fluxes from aboveground biomass, belowground biomass, and soil carbon, and uses scientifically informed conversion factors between different pools where necessary. This helps to ensure that the model does not reach spurious conclusions based on poorly understood or insufficiently parameterized tradeoffs between, e.g., aboveground vs soil organic carbon pools.

Finally, it is vitally important to the accuracy of the model that the GTM incorporate regional variation in forest types, thereby accounting for underlying aspects of forest ecology, productivity, and local practices. The GTM includes more than 300 forest types globally, each of which has empirical growth and yield equations based on Chapman-Richards' growth estimators for individuals and logistic growth curves for stands. Each distinct forest type also includes relevant economic information, including the proportion of merchantable stocking in explicit diameter classes, estimates of timber quality, and market-informed prices that can themselves fluctuate between forest types and stand ages. This information is incorporated into model outcomes through its influence on management decisions that are driven by price premiums based on the amount, availability, product yields, and quality of the growing stock in a given forest type.

These several criteria ensure that the GTM is able to produce robust estimates of forest carbon leakage for IFM projects across the included regions, forest types, and other project parameters. For additional information regarding GTM and its development, see:

- Global Timber Model Information, Updates and Insights
- Global Timber Model Code Repository
- Environmental Protection Agency Science Inventory: Global Timber Model

APPENDIX 2: ANALYSIS OF THE EXTENT OF EXISTING IMPROVED MANAGEMENT PROJECTS WITHIN GTM SUBREGIONS

The peer-reviewed research which informed the development of this tool identified four (4) major drivers, which influence the estimation of leakage from an IFM project: the practice being implemented, the time horizon across which accounting occurs, the geographic region and forest type in which a project is located, and the proportion of the landscape surrounding a project that is already implementing improved practices. To account for the impact of the latter variable, we analyzed the extent of documented improved forest management projects within each of 19 subregions used within this tool. The proportion of each landscape comprising IFM projects was then used to tailor GTM estimates to the current improved management context using the most up to date data for 2025.

A brief but replicable summary of methods used in that analysis are provided below.

Objective: Summarize the total area of managed forests and the total area of forest carbon emissions mitigation projects within each of 19 leakage analysis subregions.

Methods:

1) Acquire Renoster Global Dataset of Nature-Based Carbon Offset Boundaries (Karnik et al. 2025) from https://www.renoster.co/resource/global-database-of-nature-based-carbon-offset-boundaries and prepare the data for analysis.
2) Merge continental scale data with single global datasets representing projects with available boundaries (polygon format) and projects without available boundaries (point format).
    a) Subset the projects to only include ARR (afforestation and reforestation) and IFM (improved forest management) projects and exclude AD (avoided deforestation projects). This decision reflects how various projects influence the availability of timber resources, which is the critical variable within the Global Timber Model (GTM).
    b) Reproject to global equal area projection (Mollweide).
3) Acquire leakage analysis subregions boundaries and prepare for analysis.
4) Subregions are defined from an aggregation of forest types in GTM, which are not spatially explicit, but are derived from regional data. The current 19 subregions were selected based on the available data, strength of economic relationships, and confidence estimates of model output
    a) Reproject to global equal area projection (Mollweide)
5) Acquire datasets for representing managed forests (i.e., forests where forestry is likely to occur) and prepare the data for analysis.
    a) Acquire ESA CCI 2015-2019 land cover classification from https://www.esa-landcover-cci.org/, reclassify the data to retain any pixel with evergreen or broadleaf evergreen or deciduous forest, and reproject to global equal area projection (Mollweide) with 500 m resolution.

6) Acquire Walker at al. 2022 potential biomass data from https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/DSDDQK, reproject to global equal area projection (Mollweide) with 500 m resolution, and overlay on the dataset in 3a to exclude any pixel with < 30 MgC/ha (i.e., forests with low potential productivity).

   a) Acquire World Database of Protected Areas data from https://www.protectedplanet.net/en/thematic-areas/wdpa, select polygons with GAP status of 1 or 2 (i.e., strict nature reserves), convert to raster dataset in global equal area projection (Mollweide) and with 500 m resolution, and overlay on the dataset in 3b to exclude any pixel within a protected area (i.e., areas where forestry is unlikely due to protected area regulations).

   b) Acquire global roads raster used in Theobald et al. 2020 human modification analysis https://essd.copernicus.org/articles/12/1953/2020/, reproject to global equal area projection (Mollweide) with 500 m resolution, calculate the Euclidean distance to each road pixel, and overlay on the dataset in 3c to exclude any pixel > 20 km from a road (i.e., areas where forestry is unlikely due to accessibility).

7) Summarize the area of 3 within leakage subregions.

8) Summarize the area of carbon projects within subregions.

   a) For point data, use the mean area of projects by project type and registry in the project boundary dataset (i.e., polygon data) to infer project area.

APPENDIX 3: LEAKAGE MITIGATION (UNDER CONSIDERATION)

Verra is considering adding leakage mitigation to the final version of this tool. Leakage mitigation offers a direct means of reducing leakage, because increasing timber supply outside the project area offsets part of the reduced harvest that would otherwise shift to other forests.

Leakage mitigation is the observed increase in timber supply above a historical baseline, whether through increased production or more efficient harvest and processing, that results from clearly identifiable leakage mitigation activities outside the project area. The current draft of this tool does not provide for leakage mitigation.

The following working assumptions for leakage mitigation accounting will be assessed as part of public consultation:

- Implementing leakage mitigation as an option for projects.
- The initial leakage mitigation component of this tool will focus on enabling a limited number of common and quantifiable leakage mitigation practices. These practices may include but are not limited to:
    - enhanced productivity,
    - improved harvest/processing efficiency, and
    - reforestation of marginal sites.
- Accounting for leakage mitigation will focus on the amount of excess volume produced by the leakage mitigation activities. The developers are exploring several options for application of that volume to project accounting, including options that:
    - Apply the excess volume within the project envelope, through an adjustment to the net reduction in live tree biomass removals (i.e. harvested volume).
    - Apply the excess volume outside the project envelope, through an adjustment to the leakage factor (LF_t) derived from this tool.
- The ability to mitigate leakage and reduce a project's leakage deduction will likely be capped at a conservative minimum leakage deduction.

The research enabling leakage mitigation will be conducted based on public consultation and expert feedback and may be included in the final version 1.0 of this tool.

DOCUMENT HISTORY

Version	Date	Comment
v1.0	19 November 2026	Initial version for public consultation