

**National System for Forest and Carbon Monitoring (NSFCM)
Calculation of potential non-emitted emissions in tropical forest areas of PNNSC**

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One of the main challenges faced by developing countries in carrying out effective monitoring of forest cover is to generate accurate data regarding potential carbon stock, forest cover monitoring and changes thereof (i.e., deforestation and regeneration) given that cohorts of such data will be used to determine if the implementation of avoided deforestation initiatives lead or not to additional reductions in emissions.

In forests, carbon is stored in biomass—aerial and underground—necromass, withered leaves, and on the ground. In REDD+ projects, having an estimate of carbon reserves found in the aerial biomass (AB) is an imperative, but estimating the allocation of reserves in the four remaining storage areas is also desirable, if the necessary economic, technical and logistical resources are available to do so.

AB can be quantified in the field by means of direct cultivation of specimens. This method leads to calculations with low degrees of uncertainty, but it creates a high demand for logistics and requires a significant economic investment. AB can also be estimated using allometric models that utilize dendrometric variables (eg.: diameter, height) that are measured in the field. However, both methods present limitations when dealing with vast and remote geographical areas.

Due to these limitations, it is recommended that the distribution of AB be mapped both by integrating data collected in the field and by using information derived from remote sensors. The resulting maps can be used to monitor and assess changes in carbon stocks stemming from deforestation and forest degradation, as well as the effects of “plus” activities (i.e. REDD+). This method has been widely acknowledged in academia and by climate change international organizations such as UNFCCC and IPCC.

Notwithstanding this fact, the estimation method still stirs controversy due to the lack of reliable data to allow for the calibration and verification of the results obtained as well as to the discrepancies that arise when comparing data collected in the field against the forecasts produced with the models developed using satellite information. Hence the need to improve the existing methodologies before they can be used at a regional, national or continental scale on a routine basis. This is a complicated task when it is further acknowledged that AB is not homogeneous in a spatial dimension, and this holds particularly true for tropical forests. It has then been suggested that conventional methods be utilized to estimate stored carbon stock in AB using data from the National Forestry Inventories (IFN, per its acronym in Spanish).

In countries that have not implemented initiatives like this, as it is the cases with Colombia, it is necessary to integrate data from forestry inventories, vegetation profiles or floral studies covering an ample set of conditions (eg.: landscapes, types of forest, etc.). Notwithstanding the origin of the data, such methods call for the need to estimate the AB of the individual trees using allometric equations and then scale up the results at the level of the unit of analysis (i.e., the

plot), and use this information to estimate the AB of the stratum or type of forest where the sampling took place.

Therefore, it is first necessary to choose a set of allometric equations among those available in the continuum of the patropics, that allows for an accurate estimation of the AB for the study area.

Once this is determined, it is necessary to differentiate the type of forests according to a classification (i.e., a legend) that leads to reliable estimates, minimizes the degree of uncertainty and permits the scaling up of estimated carbon existence stocks for a specific set of plots based on the type of forest where the plots are located. Generally speaking, “stratification” refers to breaking down heterogeneous landscapes into different strata based on a common grouping factor.

In the case of REDD+ initiatives, it is advisable to employ stratification that uses diagnostic variables—precipitation regime, type of soil, topography—that are related to the carbon stock and its variations along regional and local scales.

However, understanding the role played by these variables at a national scale is still incipient in countries such as Colombia where there exists a large array of conditions and vegetation types. This poses a serious challenge for the implementation of REDD+ since the UNFCCC requires Parties to build the REL/RL at such a scale. The case of Colombia presents yet another challenge: since the available data used for carrying out the estimations does not come from studies that are performed under standardized sampling protocols (i.e., the size of the plots varies), it is essential to determine how to integrate them in an appropriate way, which in turn requires identifying a method of analysis that takes into account the peculiarities of the data used and lowering the degree of uncertainty associated with the estimations.

Colombia has made significant progress in this respect since the National System for Forests and Carbon Monitoring (NSFCM) was rolled out. It has generated a set of emission factors and activity data which are needed to estimate the current carbon stock and net CO₂ emissions for the 1990-2012 period, while factoring in the impact of (i) the data integration method, (ii) the allometric equations and (iii) the environmental stratification or definition of the type of forests on the estimation of AB for the country’s forests. Through this effort, the NSFCM seeks to provide information that allows for a better understanding of its functioning and information to R-PP, ENREDD+, ECDBC and Colombia’s INGEI.

The data used to estimate the reserves of carbon stock found in AB were generated by setting up 4,793 plots of forests in Colombia between 1990 and 2014. The size of plots varied from 0.02 to 1.50 ha. The total sampled area amounted to approximately 1,123 ha. Although the data used in the study were generated by using different sampling protocols, it represents the largest and most representative cohort that exists presently to estimate AB in the country’s forests.

The repository includes 545,989 records of trees with a normal diameter (D) larger or equal to 10 cm; 4,005 species, 980 genera and 178 plant families. Each record was assigned the species’ wood’s basic density (ρ) to which it belongs, based on information available in the scientific literature. Whenever this was not possible, the family’s or genus’ density was used instead. Trees

lacking botanical information were assigned the average density of all the species present in the plot. Once the AB of the trees was calculated, then the total AB of each plot was calculated (kg) by adding up the biomass of all live trees that were present in each plot. This value was then converted to tons per hectare (t ha⁻¹).

Then Holdridge's proposed classification (1967) for life zones was used for stratification purposes (it was adapted for Colombia by IDEAM in 2005). This classification system includes 16 types of natural forests.

The data were compiled in IDEAM's NSFCM repository where both the tree's and the plots' attributes were stored in separate tables. The iPlant Collaborative online application was used to standardize the taxonomic nomenclature. This tool makes it possible to verify simultaneously up to 5,000 scientific names under the classification system known as APG III (APG 2009), which uses reference data from Missouri's Botanical Garden, the Global Compositae Checklist, and the US Department of Agriculture's plant catalog.

Emission factors were calculated using conversion values of Aerial Biomass-to-Carbon recommended by IPCC (0.47). The results of the analysis revealed that current carbon stock reserves stored in the aerial biomass found in 2,564,813 ha of natural forests in PNNSCH amount to 318,362,543 Tn C (IDEAM, 2011), with an associated 14% degree of uncertainty. Using Holdridge's bioclimate classification, the average aerial biomass of tropical humid forests in this area amounts to 264.1 MG/ha, which is equivalent to 124.13 Tn C (IDEAM, 2011).

With regard to the calculation of non-emitted potential emissions, the activity data used correspond to those generated by the NSFCM for Colombia. The data were calculated through the interpretation of medium-resolution images (mainly of the Landsat TM/ETM+ kind) for the 2012 reference period and using processes of digital classification of semi-automatized images and experts' criteria. Using a conversion factor-to-CO₂eq of 3.67, recommended by IPCC, the total value of non-emitted potential emissions amounts to 1,168,390,534 Tn CO₂eq. Since the goal is to ensure the conservation of at least 95% of the remaining forest in PNNSCH, then this figure was adjusted to 1,109,971,007 Tn CO₂eq.

Due to lack of such information, neither emission factors for other types of Earth's cover (non-forest) nor the fraction of biomass that is oxidized, decomposed or burned, were taken into account in the estimations.