CHALLENGES AND OPPORTUNITIES FOR NATIONAL FOREST INVENTORIES

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4.1 INTRODUCTION

The introduction (Chapter 1) highlights the relevance of national forest inventories (NFIs) for decision-making related to forest management, planning and policy. Science and public policy need to work in close collaboration, while paying attention to the role of knowledge (Siclari Bravo, 2020).

This chapter discusses the challenges and opportunities of NFIs in Latin America and the Caribbean (LAC), analysing aspects related to the influence of the institutional framework and different sampling designs, the challenges in providing estimates that can be compared internationally, and the need to improve the transparency and transfer of information (Siclari Bravo, 2020).

4.2 THE INSTITUTIONAL FRAMEWORK, PLANNING AND ORGANIZATION OF NATIONAL FOREST INVENTORIES IN LATIN AMERICA AND THE CARIBBEAN

As concluded from the results of the questionnaire on future prospects for NFIs (Chapter 3), one of the most important factors for ensuring the continuity of NFIs – and one of the most relevant aspects that LAC countries should focus on – is to advance towards their institutionalization. Institutionalization involves ownership and responsibility on the part of the national administration, including aspects such as the existence of legislation that provides NFIs with a solid legal framework, which, in turn, enables access to a guaranteed long-term government budget; it also implies a governance structure with clear roles for the participating entities, and permanently

trained staff with the technical and scientific support of research and training teams (FAO, 2017, 2021). During the work sessions held with countries of the LAC region, the financial sustainability of NFIs was a common challenge for most countries; therefore, the intention is to continue the dialogue to seek solutions that help to secure stable funding resources – primarily from national budgets, but also with the support of international cooperation – while consolidating the institutional framework in each of the countries.

Furthermore, NFIs require detailed planning in order to obtain successful, high-quality measurements. The first step should be to establish institutional arrangements for effective coordination. In Latin America and the Caribbean, most NFIs are led by the forest service, where permanent offices have been established. This condition is critical for achieving long-term sustainability. National forest inventories involve organizing with local governments and decentralized offices, mobilising staff throughout the territory and hiring local staff to facilitate access permits in each of the communities visited and to assist with species identification and data collection. The teams responsible for measurement must be trained to enter the territory and forests safely and to take high-quality measurements. Implementation strategies may vary from country to country depending on funding sources and existing capacities. Throughout the national chapters of this publication, the reader will learn about different NFI implementation strategies.

4.3 INFLUENCE OF METHODOLOGICAL DIFFERENCES ON DATA COMPARABILITY

National forest inventories are national processes, in principle independent of each other, such that in many cases the data provided internationally by different countries are difficult to compare (McRoberts, Tomppo and Næsset, 2010). Previous experiences of harmonization processes that have established common reference definitions – as in the case of the European NFI network (ENFIN) and the Inventory and Monitoring Working Group of the North American Forest Commission (NAFC) – serve as a reference for the LAC region, which seeks reliable, comparable data for planning and decision-making at national, regional and global levels.

National forest inventories in the LAC region have different designs and methodologies as they need to be adapted to multiple circumstances (see Chapter 2). However, to ensure comparability, it is not necessary to set sampling design standards such as sampling grid size (distance between sampling units) or size of sampling units; if NFIs are designed in a statistically robust way, estimates of different indicators can be compared across countries (Vidal *et al.*, 2016a). Moreover, an important point to consider is that standardizing the design would be economically expensive and would lead to a loss of information; among other factors, analysing the evolution of different indicators would not be possible given the lack of continuity with historical data (Tomppo *et al.*, 2010). Therefore, in order to improve comparability, it is essential to have clear documentation and to establish reference definitions that consider all threshold values. For example, to determine volume, the following factors should be defined: how the stem diameter of trees will be measured, the minimum tree sizes to be included in the sample, and the tree compartments to be included (Gschwantner *et al.*, 2019).

The design conditions to be considered in the harmonization process in LAC are discussed below.

4.3.1 NATIONAL FOREST INVENTORIES AND REMOTE SENSING

Forest monitoring can be based on field sampling through NFIs, remote sensing, or a combination of both; the latter provides more complete information that optimizes costs and improves estimates (Lister *et al.*, 2020; Kangas *et al.*, 2019).

National forest inventories are the most important source of field data for countries and, given their relevance, they require a greater commitment of resources to obtain sufficient sampling, especially in large, heterogeneous and highly diverse landscapes. However, NFIs are necessary because, among other reasons, they provide data for the generation of remotely sensed maps. These data are taken from the field, and, at present, many variables cannot be reliably obtained from remotely sensed data, such as soil carbon, species composition and tree regeneration. On the other hand, the use of remote sensing offers advantages that, in addition to cost, include the possibility of updating data more frequently and full national coverage without

issues of inaccessibility (although image quality limitations should be considered, such as areas with persistent cloud cover).

When integrating both sources of information, remote sensing is a key support for NFIs today (McRoberts and Tomppo, 2007; Kangas *et al.*, 2018; Lister *et al.*, 2020). In addition to the use of updated and classified satellite imagery based on national definitions for the production of maps and area estimates (McRoberts and Tomppo, 2007), this integration is also important for providing ancillary information to support planning, estimation and inference (Kangas *et al.*, 2018). Finally, the integration of modern technologies in data collection, such as LiDAR (light detection and ranging) and drones (Henry *et al.*, 2015), can also contribute to improving the efficiency, quantity and quality of information produced by NFIs (Breidenbach *et al.*, 2020)

At present, one of the biggest challenges in LAC is to better integrate NFIs into National Forest Monitoring Systems using remote sensing. As mentioned in Chapter 3, most countries stressed the need for integration with other monitoring initiatives. This lack of integration could imply the need for more resources to produce the country's forest statistics and could cause data discrepancies.

4.3.2 NATIONAL FOREST INVENTORY CYCLES

It is recommended that in the future all countries in the LAC region make periodic or continuous NFIs to update national and international statistics. In LAC NFIs, it is especially difficult to sustain the costs of monitoring to comply with the period of each cycle (see Chapter 2), thus a discussion at international level is timely in order to procure regular funding.

The annualisation of NFIs, understood as the planned division of the total number of sampling units foreseen in the cycle for a proportional measurement in each working year, may be an alternative to obtain annual data that can be adapted to different periods of forest information requirements. The division is made into subsets called panels, which cover the national forest area (McRoberts, 2008). However, this may not be an easy decision for many countries, as it requires stability in the availability of human and financial resources, as well as increased costs for the same sampling intensity. Some countries have already adopted annual panels, such as the United States of America (McRoberts, 2008), the Republic of Korea (Kim *et al.*, 2008), France (Vidal *et al.*, 2007), Costa Rica (Chapter 12), Honduras (Chapter 17) and Peru (Chapter 22). Moreover, it should be considered that annual inventories may partially capture sporadic events (such as storms, forest fires, etc.), although there are special considerations that should be taken into account when interpreting these data and comparing them between countries that are using different sampling systems. If estimates of forest attributes are averaged over the whole cycle based on annual measurements, each annual average estimate will contain some plots that are affected by the event and others that are unaffected (Patterson and Reams, 2005). At the end of the cycle, the data will reflect the impact of the event, but at different times; that is, the impact of the event is diminished in the year it occurs, but its impact is prolonged (Coulston *et al.*, 2020).

In order to make a simple estimate of indicators, one could consider a five-year cycle of LAC NFIs (as in most LAC countries) linked to the reporting dates of the Food and Agriculture Organization of the United Nations (FAO) Global Forest Resources Assessment (FRA) or greenhouse gas inventories (GHGI). However, there are other options when robust NFI data are available, such as data modelling to project the data to the year for which information is required (Kangas *et al.*, 2019). Indeed, as Kangas *et al.* (2019) point out, both sampling design-based data inference and data modelling are currently needed in order to meet all information needs at different temporal and spatial scales. Establishing and defining bias, as well as its implications for all data estimates used in policymaking, is also relevant and represents a topical challenge in the region.

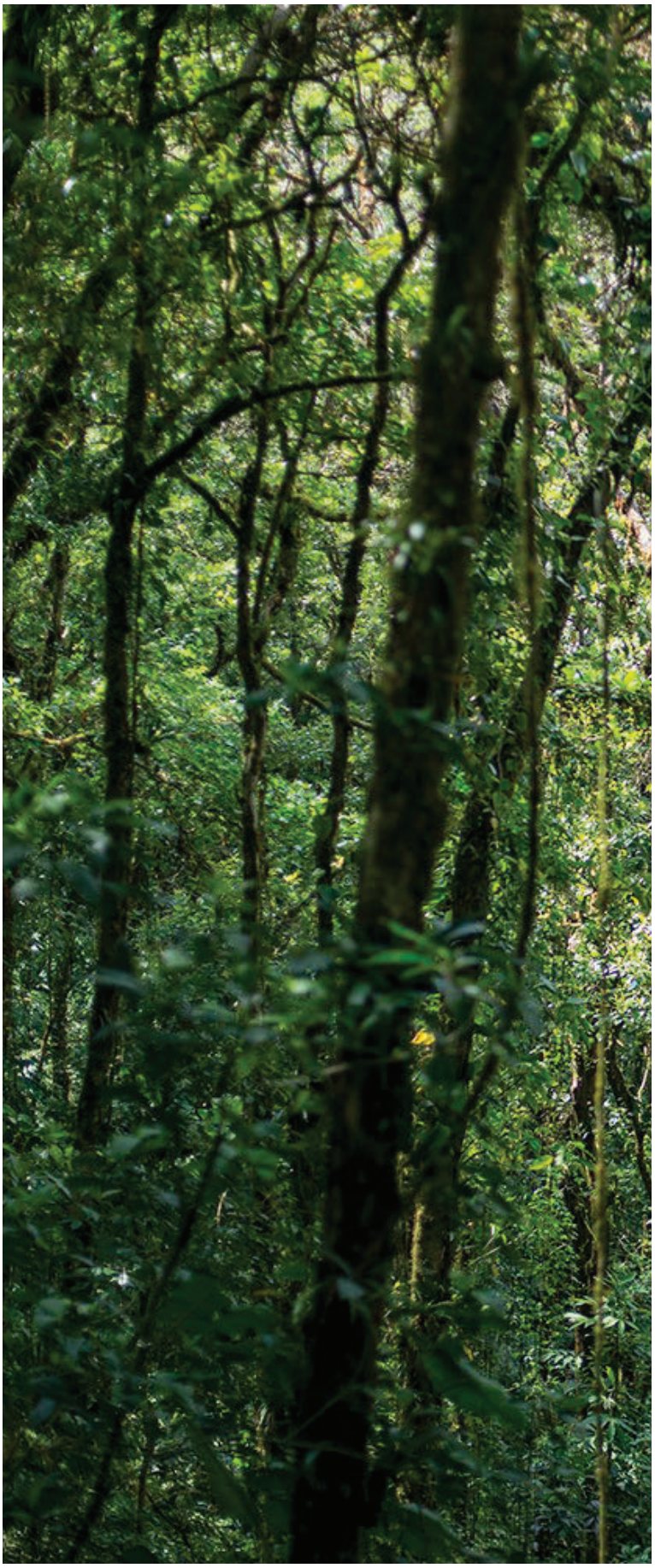
4.3.3 SAMPLING DESIGN

The size of the field sampling unit is diverse in LAC NFIs, considering that it is defined according to forest characteristics, information needs and implementation costs. In general, larger sampling units are used in heterogeneous areas and in open (low density) forests (McRoberts, Tomppo and Czaplewski, 1992). In addition, differences between countries in sample size and design can also be found within the same country. This is the case in Peru, which has two types of sampling units: i) clusters of 10 circular plots are used for highland tropical rainforest, coastal highland and hydromorphic zone subpopulations, and ii) 7 rectangular plots are used for the lowland tropical rainforest subpopulation (see Chapter 22).

There has been a clear trend in recent years towards the use of clusters in LAC (see Chapter 2), with the aim to form a sampling unit that better captures variability at the sampling site (compared to a single plot of equal or larger area). Such sampling should be undertaken when the time and resource savings in the measurement process – within a sampling unit with multiple plots of a given size at a specific distance – exceed those of a large plot (McRoberts, Tomppo and Czaplewski, 2015).

Regardless of the plot design chosen by a country for implementation in its NFI, a change in design from one NFI to the next should be seriously considered and planned. The benefits of an innovative design, such as improved efficiencies, increased accuracy and precision of the estimate, harmonization with international standards, etc., must be weighed against the potential loss of the continuity of data to analyse historical trends; this can occur either because of an inherent incompatibility between the old and new designs, or due to greater uncertainty in distinguishing a true change in the resource from a variation introduced by the change in methodology.

In any case, the existence of different sampling unit sizes and designs is not an obstacle to the harmonization of estimates; nevertheless, the influence of this design variability on each of the different variables must be analysed.



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4.4 CHALLENGES TO PROVIDING HARMONIZED DATA IN THE LATIN AMERICAN AND CARIBBEAN REGION

There are challenges to harmonization within and between countries in the Latin American and Caribbean region. Despite significant advances in recent years, there is a need to improve communication, cooperation and technical discussion on a regular basis. International collaborative research aimed at data harmonization is required as part of the process.

In many cases, estimates of forest area in LAC are based solely on remotely sensed data, while in other cases these estimates combine both sources. It is particularly noteworthy that the minimum tree cover used to define a forest varies between NFIs. In the FAO definition of forest, the tree canopy cover should be 10 percent (FAO, 2020), but several countries consider higher values, generally in the range of 25 percent to 30 percent (Chapter 2). This raises the need to work specifically on improving the comparability of this highly relevant data in the region and on combining remote sensing and forest inventory techniques.

Dasometric variables such as height and diameter are measured in all NFIs (Chapter 2), although there are differences in their definition and in the subsequent estimation of related indicators (such as volume or biomass). Definitions differ due to the thresholds considered as the minimum diameter or height to measure a tree; in volume or biomass estimations, the equations used may take into account different tree compartments (branches, bark, stump, among others) (Gschwandtner *et al.*, 2019). Therefore, this book discusses for the first time the definitions and thresholds used for three key variables: forest land area, volume and above-ground biomass.

Three aspects highlighted by LAC NFI national experts that would be of great interest to improve the comparability of data are as follows:

- Develop a classification of forest types for LAC, based on FRA terms and definitions and building on the experiences of harmonizing land use and land cover classifications in countries such as Guatemala (Saput *et al.*, forthcoming) and Costa Rica (CENIGA, 2020).
- Use the same data model and nomenclature for plant species in LAC, for instance, Plinian Core (https://github.com/tdwg/PlinianCore).
- Generate a database with recommended allometric equations per species or taxonomic group, which could be based on existing platforms such as FAO's GlobAllomeTree (www.globallometree.org/).

4.5 INCREASING INFORMATION REQUIREMENTS AND THE POTENTIAL OF NATIONAL FOREST INVENTORIES

New demands from society and the international forest agenda contribute to the incorporation of new variables and more rigorous assessments on issues such as biodiversity (including the collection of data on genetic material), non-wood forest products, soils and the local value of forests for people. This information is being collected by some countries, although the inclusion of new field variables needs to be carefully evaluated from the point of view of the amount of time invested (and the associated cost), as well as the training of technicians to avoid assessment errors (Ringvall *et al.*, 2005).

The considerable number of variables measured, coupled with the credibility and suitability of the information produced (such as a statistically based sampling system, defined field protocols, trained field teams and quality control), enhance the application of NFIs as a source of information for various national and international reports (Vidal *et al.*, 2016b). For example, in the international context, NFIs are very important for estimating greenhouse gas emissions from the forest sector to be reported in reference levels for the Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism and for reporting progress or results in National Communications (NCs), Biennial Update Reports or Biennial Transparency Reports (FAO, 2018, 2020).

The use of NFIs can also be extended to other potential requirements, for instance, those related to biodiversity monitoring (Chirici *et al.*, 2012) or forest restoration (Ramírez and Morales, forthcoming).

4.6 NEED TO IMPROVE THE TRANSFER OF INFORMATION

Proper data management of NFIs is essential to establish a clear pathway between planners and decision-makers of countries in the region. Data entry, analysis and reporting systems, such as Open Foris and Arena, are examples that can be followed by LAC countries and their further development could help emerging NFIs. A complete harmonization of LAC NFI indicators to allow for comparability would support regional decision-making.

Although data policies in different NFIs vary, a key aspect to encourage and maximise the use of data collected by NFIs is to promote the transparency of forest data (see Chapter 5).

It is also crucial to communicate comprehensive forest information to society through accessible databases, comprehensive reports and publications aimed at different target groups (managers, policymakers, etc.) (Alberdi *et al.*, 2017; FAO, 2017).

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