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A call for improving forest socioeconomic data with inspiration from national forest inventories

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Abstract

National forest inventories have long and strong traditions in many countries and they can offer a wealth of information about the biophysical aspects of forests such as tree growth, carbon fluxes and biodiversity. However, these are in most cases not paralleled by data representing the socioeconomic dimensions of forests. Integration of socioeconomic and biophysical data has the potential to better unveil interactions between human and natural resources and can therefore better support policy. Climate change has multiple impacts on forest resources. Policies to support sustainable forestry, the bioeconomy, and climate change mitigation and adaptation are constantly developing. At the same time, forest owners' attitudes and forest markets are evolving. More data is needed to advance the understanding of the links between the human and biophysical factors and the relationship between these factors and the complex objectives of forests. We compared the national forest inventories, national forest owner surveys, and national forest product surveys across Argentina, Finland, Norway, Sweden and the USA. The national forest inventories in all selected countries are built on solid methodological grounds and have strong institutional support and funding. However, the consistency of methods, frequency of implementation, and institutional support for forest owner and forest product surveys are in many cases lacking. There is also a lack of integration between biophysical and socioeconomic data. The USA was the only studied country with integrated biophysical and socioeconomic data. We suggest that this approach reflects the needs of data integration and can serve as a reference for other countries.

Keywords biophysical information; data integration; forest ownership survey; forest product survey

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1 Introduction

Forests are essential to humans; also, humans are arguably one of the greatest factors impacting forests, both directly and indirectly. Due to the forests' critical role in the carbon cycle, biodiversity, material supply, and other contributions to human wellbeing, forest management and protection is high on the policy agenda. Timely and accurate information about their biophysical and socioeconomic dimensions is a prerequisite to make wise decisions.

Nation-wide information about the biophysical forest resource can be captured through National Forest Inventories (NFIs), while the socioeconomic dimensions can be addressed through National Forest Owner Surveys (NFOSs) and National Forest Products Surveys (NFPSs). The quality and analytical potential of these data depends on the frequency, institutional support, consistency, and integration of data collection efforts. With *Frequency*, we mean that the surveys are repeated regularly. With *Institutional support*, we mean that the data collection has a stable organizational home that has been given the necessary mandate, funding, and other resources to undertake the work. With *Consistency*, we mean that the key terms of the collected data are well defined to serve the established purpose and data collection methods are stable over time and space. With *Integration*, we mean if data collection is coordinated across NFIs, NFOSs, and NFPSs such that statistical analyses can be carried out to simultaneously address biophysical and socioeconomic factors.

This paper emerged out of a Nordic Forest Research network that aims to analyze spatio-temporal drivers of forests and linkages between gathered biophysical and human data (SNS 2023). Our aim is to draw attention to the stark differences regarding institutional and financial factors between biophysical inventories and socioeconomic surveys, and to call for greater efforts within the scientific communities to address these deficiencies. We present the status of NFIs, NFOSs, and NFPSs across the five countries Argentina, Finland, Norway, Sweden and the USA, represented in the network. Further, we discuss how biophysical and socioeconomic surveys differ across these countries and point to potential future directions.

2 Inventories and surveys

2.1 National Forest Inventories

All five countries have NFIs as a backbone for accounting, monitoring and reporting of forest resources. NFIs are used for reporting to international commitments like the Food and Agriculture Organization's (FAO) Forest Resource Assessments and for the United Nations Framework Convention on Climate Change (UNFCCC). Across the countries, the NFIs share core attributes, including being based on systematic, on-the-ground samples with 5–10-year inventory cycles (Table 1). The first NFI was established in Norway in 1919, with Sweden, Finland and the USA following during the 1920s. Thus, these countries have around 100 years of NFI data (Breidenbach et al. 2021). However, definitional and other changes in data collection in these countries limit in-depth time-series analyses to the past couple of decades. In all the studied countries, NFIs have strong institutional support with funding allocated from the national governments' budgets and NFI data is considered official statistics.

Remotely sensed data have long been an important complement to the field-based NFI data. Aerial photography is being used for initial land use and land cover assessments. Satellite-based spectral sensors allow for spatially continuous coverage including direct measures of forest cover and imputed forest attributes (Wilson et al. 2012). More recently, national-level maps and inventories based on airborne laser scanning (ALS) are available in the Nordic countries that are providing

Table 1. Metadata of National Forest Inventories in Argentina, Finland, Norway, Sweden, and the United States of America (USA).

	Argentina	Finland	Norway	Sweden	USA
Administered by	Former Ministry of Environment and Sustainable Development (native forests) National Directorate of Industrial Forestry Development (planted forests)	Natural Resource Institute Finland (Luke)	Norwegian Institute of Bioeconomy Research (NIBIO)	Swedish University of Agricultural Sciences	United States Department of Agriculture (USDA) Forest Service
Measured forest	All domestic native and planted forests	All domestic forests	All domestic forests	All domestic forests	All domestic forests
Sampling design	Systematic grid	Systematic cluster	Systematic grid	Systematic cluster	Systematic, stratified random
Measured variables	Native forests: Area; Forest structure; species composition; tree volume and biomass; carbon stocks; monitored log transport. Disturbances. Planted forests: Area; Stock volume by diameter class and botanical genus; Utilization; Consumption; Transport; Soil Organic Carbon.	Area; Carbon stocks; Disturbances; Forest structure; Growth, removals, and mortality; Species composition; Tree volume and biomass	Area; Carbon stocks; Disturbances; Forest structure; Growth, removals, and mortality; Nontimber forest products (bilberry cover); Species composition; Tree volume and biomass	Area; Carbon stocks; Disturbances; Forest structure; Growth, removals, and mortality; Species composition; Tree volume and biomass	Area; Carbon stocks; Disturbances; Forest structure; Growth, removals, and mortality; Species composition; Tree volume and biomass
Fixed frequency (cycle length)	Yes (5 years)	Yes (5 years)	Yes (5 years)	Yes (5 years)	Yes (5–10 years)
Methods references	DNDFI 2021; SAyDS 2019	Korhonen et al. 2021, 2024	Breidenbach et al. 2021	Fridman et al. 2014	Bechtold et al. 2005; Westfall et al. 2022
References for recent results	DNDFI 2021; SAyDS 2019	Korhonen et al. 2021, 2024	Hysten et al. 2023	Roberge et al. 2023	Oswalt et al. 2019; USDA Forest Service 2024
Financial sources	The World Bank, United Nations Development Program, UN-REDD Program, Forest Carbon Partnership Facility	Ministry of Agriculture and Forestry	Ministry of Food and Agriculture	Ministry of Rural Affairs and Infrastructure	Federal and state governments

unprecedented levels of spatial resolution (de Lera Garrido et al. 2023; Metsakeskus n.d.; Nilsson et al. 2017). In Finland, the Finnish Forest Centre provides ALS data on multiple variables related to wood production, silviculture and the environment. The ALS inventory is repeated in six-year intervals. In Norway, the SR16 database has spatially continuous forest land coverage, with variables based on satellite data and supported by NFI data. ALS data is increasingly available across the USA and is currently available in a number of states, but access can be limited. In Argentina, a comprehensive dataset, generated from provincial information and satellite image analyses is available (Undersecretariat of Agricultural and Forestry Production 2023). NFI field measurements are critical for training and ground truthing the remotely sensed derived products.

2.2 National Forest Owner Surveys

Forest owners provide a pivotal link between forests and society (Aguilar and Kelly 2019). Within the constraints imposed by local laws, forest owners decide harvesting of timber and other management activities (Bengston et al. 2009). Forest ownership varies substantially across and within countries. The focus of many surveys has been on private individuals and families, so-called family forest owners (Table 2). This is partly due to the high number of family forest owners that collectively own substantial areas. Also, they contain considerable diversity in terms of attitudes and behaviors and are targeted by many public policies.

Argentina is the only country in our study that has not conducted a nation-wide survey of forest owners. However, some data are available from Argentina's Federal System of Protected Areas and the National Forestry Statistics Program. These institutions collect and publish data related to forest area and their usage, providing some insights into forest ownership.

Table 2. Thematic scopes, methods, and references for National Forest Owner Surveys in Argentina, Finland, Norway, Sweden, and the United States of America (USA).

	Argentina	Finland	Norway	Sweden	USA
Conducted by	NA	Natural Resources Institute Finland (Luke), University of Helsinki; Pellervo economic research PTT; Työtehoseura TTS	Norwegian University of Life Sciences; Statistics Norway	Swedish Forest Agency, Statistics Sweden	United States Department of Agriculture, Forest Service; University of Massachusetts Amherst
Population of interest	NA	Family forest owners	Family forest owners	Public and private forest owners	Private forest owners with a focus on family forest
Methods	NA	Mail and online survey complemented by information from Register of Finnish forest centre and Finnish digital and Population data services agency	Mail survey, tax record	Online survey (public and public owners), tax records (private owners)	Mail survey with online option
Topics	NA	Forest holdings characteristics; Owner characteristics; Ownership objectives; Timber sales	Forest use; Future plans; Management information and advice; Owner characteristics; Ownership objectives	Private forest owners' demographics, ownership size, number of ownerships; Silvicultural activities	Forest holdings characteristics; Forest use; Management information and advice; Forest management activities; Future plans; Owner characteristics; Ownership objectives and concerns; Recreational uses
Fixed frequency (cycle length)	NA	Yes (10 years)	No	Annual	Yes (5 years)
Methods references	NA	Karppinen et al. 2020	Sjølie et al. 2019	Swedish Forest Agency 2023a	Butler and Caputo 2021
References for recent results	NA	Karppinen et al. 2020	Sjølie et al. 2019	Swedish Forest Agency 2023b	Butler et al. 2021
Financial source(s)	NA	Project-funded: Ministry of Agriculture and Forestry; Finnish Forest Foundation. Metsämiesten Säätiö Foundation	Project-funded	Project money and Swedish Forest Agency	Federal government

Among the NFOSs in the other countries studied, there are substantial differences in terms of frequency, consistency, institutional support and covered themes (Table 2). Finland and the United States have surveys that include forest owners' attitudes funded by the national government with recurring implementation and methodological consistency. In the case of the United States, NFOSs and the NFI are both under the umbrella of the USDA Forest Service Forest Inventory and Analysis program. In Sweden and Norway, register data statistics about forest ownerships are published annually (Statistics Norway 2025; Swedish Forest Agency 2025). While these data include multiple ownership variables related to the property and some basic demographic factors, and in the case of Sweden, forest management activities, information about forest owners' attitudes is excluded. In all countries, the history of NFOSs is more recent than that of NFIs which limits longitudinal analyses with comparative assessments challenged by differences in protocols and modest response rates.

2.3 National Forest Products Surveys

Information about the forest industry comes from different sources and has different foci. All five countries have national-level reporting on the contributions of the forest industry to the national economy. Efforts to survey mills consuming wood raw material and to report on stumpage values vary across countries.

In Finland, the Finnish Statistical Yearbook of Forestry (*Metsätilastollinen vuosikirja*) provided information on wood trade, consumption, and other characteristics of the forest industry until 2022 (Niinistö et al. 2023). Since then, such information is available online via the Natural Resource Institute (Luke) statistics website (Luke n.d.). In Sweden, data on forest industry production is compiled from various sources and reported in the Statistical Database of Forestry (Swedish Forest Agency 2025). Biometria publishes annual national and regional consumption of wood assortments across the Swedish forest industry (Biometria n.d.). In Norway, Statistics Norway (Statistics Norway 2026) publishes statistics related to prices and production in the wood industries, alongside all other industries, where production data are gathered through business surveys. In Argentina, annual surveys of the wood industry are published (Undersecretariat of Agricultural and Forestry Production 2023) alongside statistics of primary products, manufacturing trade, and forest fires (Argentinian Directorate of Native Forests 2024). At the federal level in the USA, the US Bureau of Economic Analysis and the US Bureau of Labor Statistics publish information on the contributions of industries, including wood products industries, to the national gross domestic product, jobs, and salaries. In addition, the USDA Forest Service conducts the Timber Products Output survey and publishes annual figures of wood processing facilities and wood production (Coulston 2022).

3 Discussion

Forests are receiving increasing attention due to the myriad ecosystem services they provide (Aguilar and Kelly 2019). Understanding the supply of ecosystem services and designing efficient policies require knowledge of the forest systems, including the forest resources, forest owners and forest economics, and their interplay. Unfortunately, the data needed for these analyses have deficits in consistency, frequency, institutional support, and integration (Table 3), and there is a lack of harmonization across countries.

The NFIs stand out in terms of solid methodological and institutional backing across all countries studied. While there is good consistency within countries, there is still a need for increased

Table 3. Summary of the frequency, consistency, and institutional support of National Forest Inventories (NFIs), National Forest Owner Surveys (NFOSs), and National Forest Product Surveys (NFPSs) and integration of all three for Argentina, Finland, Norway, Sweden, and the USA, 2024. Table key: ● denotes component is implemented frequently (every 5–10 years), is implemented consistently (allowing for trend analyses), and has strong institutional support; ○ denotes component is not implemented frequently, is not implemented consistently, or does not have strong institutional support.

	Argentina	Finland	Norway	Sweden	USA
National Forest Inventory (NFI)	●	●	●	●	●
National Forest Owner Survey (NFOS)	○	○	○	○	●
National Forest Products Survey (NFPS)	●	●	●	●	●
Integration of NFI, NFOS, and NFPS	○	○	○	○	●

harmonization in the definition of variables across countries (McRoberts et al. 2009; Vidal et al. 2016) including basic definitions. Laser scanning and other data acquisition methods are increasingly being incorporated into NFIs, but traditional field measurements are still needed practically in all applications (Maltamo 2023).

Regarding forest owner data, institutional support is often lacking, and this is negatively impacting on the consistency and frequency of the data. NFOSs are more commonly conducted on a project basis, and some rely on single individuals. While the project-based funding provides flexible and topical content, it will often impede longitudinal analyses.

Analyses of other forest ownerships, like corporations, local or state governments, non-profit and other organizations also need improvement. These groups have different goals for forest ownership and management. However, there are few analyses of their modus operandi, how they react to policies, and implications of ownership type on management and the state of the forest. Other rights, such as indigenous people's rights to use the land, should also be captured in the data (Allard 2022).

There is a gap in the types of collected economic data relevant to forest systems, including non-market values. Important data are collected from the wood products industry. However, these are often reported at scales that challenge geographic and temporal matching with forest ownership and biophysical information. Longitudinal economic data are central to the ability to assess ex post, or project ex ante, the short- and long-term impacts of climate disturbances and public policy interventions. They are equally important in any examination of co-causality and feedback effects across socio-ecological systems. Despite a substantial body of literature studying forest owners (Butler et al. 2023), most harvest behavior studies address intentions and not actual behavior (Silver et al. 2015). Further, almost all studies that analyze actual harvest behavior seem to exclude a crucial factor in the form of forest landbase attributes, because these data are usually not available to survey researchers.

Integrated biophysical and socioeconomic data may provide enhanced analytical power. Causal relationships between a forest owner's attitudes and behavior and the forest's biophysical attributes could be unveiled through the integration of NFI and NFOS data. Another example would be the analysis of the effectiveness of policies targeting groups of forests and forest owners. A successful example of biophysical and socioeconomic data integration is the USA (Butler and Sass 2023) which could act as a reference to other countries. Surveys could be focused on the owners of the NFI plots or remotely sensed data could be combined with forest owner surveys. While limited access to detailed NFI plot data in some countries will hamper such data gathering, remotely sensed data collections could offer a solution to integrating socioeconomic and biophysical data. Also, coupling of wood industry data with biophysical data as has been done in the Southern

United States, mutual relationships can be identified (Aguilar et al. 2020). The various sources and methods for data acquisition limit the feasibility of direct comparisons of wood industry data between countries.

In this discussion paper, we focused on forest inventories, forest owner surveys, and mill surveys due to their clear mutual interdependence. However, these data do not capture the full breadth of benefits provided by forests. For example, recreation is an important forest benefit that is the focus of multiple data collection efforts. The right to public access (“everyone’s rights”) in the Nordic countries, that grants the right to roam freely and collect certain non-wood forest products reinforces the importance of this social value of forest (Nichiforel et al. 2018). In Argentina and Norway, recreational data cannot be disaggregated to the ecosystem level. In Finland, the National Outdoor Recreation Demand inventory has systematically monitored outdoor recreation since 1990 via a nationwide population survey, published for the third time in 2022 (Neuvonen et al. 2022). In Sweden, the Swedish Environmental Protection Agency (SEPA) occasionally conducts national surveys of the public’s outdoor recreational habits, with the most recent result published in 2019 (Fredman et al. 2019). In the USA, data on forest recreation are collected through the U.S. Forest Service (English et al. 2020), which provides detailed information primarily related to public lands. While not specifically focused on forestlands, the U.S. Fish and Wildlife Service (2022) periodically conducts surveys related to fishing, hunting, and wildlife-associated recreation. Non-wood forest products, such as collection of berries and mushrooms, and how these interact with forest management, are other topics that warrant additional attention across all countries. However, in Finland, annual trade statistics of wild berries and mushrooms have been published since 1977 (MARS 2025).

4 Conclusions

We see a clear need to improve consistency, frequency, and support for measuring the human dimensions of forests, which range from owner data, forest management practices, and non-wood products to the public’s usage and valuation of forests, and forest industry value-creation. Better data pertaining to these aspects can help in the design of policies and services. The value of integrated information is emphasized as more forest policies are being deployed, discussion about forest use is increasing, and climate change is altering forest composition and management options. Improved data would help reveal the directions of impacts between the state of the forest and human factors like management, harvesting of wood and non-wood products, recreation, industry investment, and societal valuation of forests. NFIs were established 100 years ago because of the necessity to monitor the forest resource base. We believe there is a parallel need to better understand the human dimensions of forests.

The lack of harmonization of methods used across countries is a major barrier for cross-country comparisons. Using the success of NFIs as an inspiration, we see a clear need within the scientific community to better support the collection of harmonized socioeconomic data to ensure nation-wide population representation, consistent time-series, and ultimately cross-country comparisons. While country-specific aspects necessitate the need for some level of tailored surveys, core data elements could be identified, something especially relevant for the deployment of the EU-wide forest policies (European Commission 2021). At a time when forests are under increasing pressure, harmonization can facilitate international learning and cooperation.

Author's contributions

Conceptualization (H.K.S., B.J.B., F.X.A., I.H.S., V.T., A.K., M.M., S.M.K., D.K., L.N.L., A.C.T., L.O.), Funding acquisition (H.K.S., F.X.A.), project administration (H.K.S.), writing – original draft preparation (H.K.S., B.J.B., F.X.A., I.H.S., V.T., A.K., M.M., S.M.K., D.K., L.N.L., A.C.T., L.O.), writing – review and editing (H.K.S., B.J.B., F.X.A., I.H.S., V.T., A.K., M.M., S.M.K., D.K., L.N.L., A.C.T., L.O.). All authors have read and agreed to the published version of the manuscript.

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