ENVIRONMENTAL RESEARCH LETTERS

PERSPECTIVE • OPEN ACCESS

Earth observation in national forest inventories: clear benefits yet marginal role—why?

To cite this article: Saverio Francini *et al* 2026 *Environ. Res. Lett.* **21** 131001

ENVIRONMENTAL RESEARCH
LETTERS

Check for updates

OPEN ACCESS

RECEIVED
11 March 2026

REVISED
12 June 2026

ACCEPTED FOR PUBLICATION
18 June 2026

PUBLISHED
6 July 2026

PERSPECTIVE

Earth observation in national forest inventories: clear benefits yet marginal role—why?

Saverio Francini[1,*], Emma Bambagioni[1], Yang Su[2], Chiara Bocci[3], Emilia Rocco[3], Ruben Valbuena[4], Giovanni D'Amico[5], Federico Magnani[1] and Alessandro Cescatti[6]

[1] Department of Science and Technology of Agriculture and Environment (DISTAL), University of Bologna, 40126 Bologna, Italy
[2] Département d'Informatique, École Normale Supérieure—PSL, 45 Rue d'Ulm, Paris 75005, France
[3] Department of Statistics, Computer Science, Applications 'G. Parenti', University of Florence, Firenze, Italy
[4] Department of Forest Resource Management, Swedish University of Agricultural Sciences, Umeå, Sweden
[5] Department of Agriculture, Food, Environment and Forest Science and Technology of University of Florence, Florence, Italy
[6] European Commission, Joint Research Centre (JRC), Ispra, Italy
[*] Author to whom any correspondence should be addressed.

E-mail: saverio.francini@unibo.it

Keywords: remote sensing, forest regulation, forests, forest information, forest monitoring

1. Context and aim

European forests are undergoing rapid and unprecedented changes under climate pressure, yet the official information systems used to assess them—the national forest inventories (NFIs)—remain largely designed for periodic reporting rather than continuous monitoring, and struggle to provide the timely and spatially explicit information now required for adaptive and proactive climate-smart forest management. Critically, the EU's recent attempt to establish a harmonized forest monitoring framework (Nabuurs 2026) failed as the Commission's proposal for a new forest monitoring law was rejected by 370 votes to 264 (European Parliament 2025, 21 October). This is paradoxical: Earth observation (EO) could complement ground data by providing approximate but consistent, comparable, frequent, and wall-to-wall information on forest cover, change, and structure (White *et al* 2016). Why, then, is EO still not a central component of NFIs? What truly hampers the uptake of new technologies in official forest monitoring? This paper critically revisits the prevailing why-not arguments limiting the role of EO in NFIs and argues that several of these concerns warrant reconsideration in light of current evidence, technological maturity, and emerging monitoring demands.

2. Background

Since the early 1900s, NFIs have served as the primary source of information on forest resources, health, and change over time, based on systematic field data used to generate statistics for national and international reporting. While NFIs were originally conceived as wood-production–oriented inventory systems, centered on large-scale growing stock estimation, the urgent need to foster forest adaptations to climate change makes transforming NFIs into true forest monitoring tools indispensable. Yet NFIs face key constraints, including infrequent updates, limited information on rare phenomena or ecosystems, low spatial detail in data, and limited effectiveness in monitoring disturbances and supporting forest management (Gessler *et al* 2024). Additionally, many NFIs impose accessibility restrictions on raw data, hindering scientific progress, information re-use, and exploitability. Also, European NFIs differ substantially in sampling designs, methods, and key definitions (Bontemps and Bouriaud 2025), reducing comparability across countries and highlighting the need to harmonize national statistics for international reporting (Palahí *et al* 2021). Although national and international reporting is one of the principal aims of NFIs, the lack of standardization constrains their usefulness for European forest assessments and generates inconsistencies in reporting to international frameworks such as FAO (Herold *et al* 2019). Critically, field plot measurements are inherently costly and time-consuming, which constrains the temporal frequency and spatial density of NFI sampling. As a result, surveying an entire country and completing a full national inventory cycle takes 5–10 years, too long to reliably track ongoing forest transformations and to generate the actionable information needed to intervene rather than simply observe. Similarly, the costs and logistical efforts associated with field measurements inevitably constrain sampling intensity, with ground surveys covering only a marginal proportion

Table 1. Key complementary features of NFI ground data and EO in assessing forest resources.

Feature	NFI ground data	EO
Surveyed area	<0.01%	~100%
Revisit time	1–10 years	A few days—up to daily
Spatial resolution	Country, administrative region	Up to 10 m open access, sub-meter commercial
Delivered information	More accurate for most variables	Less accurate for most variables
Monitoring/operative potential	Low	High
Sampling design	Regular/a priori	Informed/sampling intensity can be increased in specific areas/phenomena

of total forested areas. As a result, the information produced is often insufficient from a monitoring perspective and lacks the spatial resolution required to detect emerging dynamics and support timely intervention and climate-smart forest management. While this makes it crucial to carefully target field efforts through well-designed sampling strategies, EO provides concrete opportunities to optimize sampling design and substantially expand the monitoring capacity of NFIs (Grafström *et al* 2017, Bocci *et al* 2025).

EO represents a valuable and complementary source of consistent, wall-to-wall, open-access data that enables the identification of land-use types and forest disturbances and, when integrated with field observations or LiDAR data, the proxy mapping of key forest attributes such as tree height and biomass (Schwartz *et al* 2023, Francini *et al* 2025). EO can support model-assisted estimation approaches, enable reliable estimates at finer spatial scales via small area estimators (Skakun 2025), and support the sampling design phase, for example, by identifying highly variable forest areas where it is desirable to increase the sampling intensity (Olofsson *et al* 2014). In all these cases, the use of EO would enable higher estimate precision of several forest variables without increasing the costs, or the same level of precision of the estimates while reducing ground survey efforts and costs (Francini *et al* 2022), with the magnitude of these gains depending on the ability of EO to accurately predict the specific forest variable of interest (Bocci *et al* 2025). By helping to overcome standardization challenges through the acquisition of consistent data everywhere and the application of uniform methods across regions, EO represents a critical complementary source of information that should be fused into NFIs to produce modern and effective inventory and monitoring systems (table 1).

In summary, NFIs are designed to produce statistically rigorous information, but only at a coarse spatial scale, with infrequent updates, and relying on ground data collected over less than 0.01% of the total forest area. In contrast, EO provides high-resolution information at a global scale and enables multi-temporal analyses and dynamically adaptable forest monitoring, although it may be less correlated with classical forest variables as measured on the ground and subject to biases. Overall, EO and ground-based data each have strengths and limitations and should be viewed as complementary. However, despite notable examples such as Finland, Sweden, Norway, the USA, Australia, and New Zealand (Kangas *et al* 2018, Nesha *et al* 2022), EO remains largely underutilized in forest assessments across Europe and globally.

3. Why not

Despite the numerous advantages of giving a more central role to EO in NFIs, this transition has not yet been universally embraced. This reluctance can be attributed to the following five misconceptions, or why-not arguments.

1—EO-derived forest variable maps are not accurate and reliable

Despite earlier concerns rooted in outdated EO products and issues related to model generalizability and validation practices, maps of forest attributes such as biomass or carbon density constructed by integrating EO with field or LiDAR data can reliably support forest inventory estimation (Wulder 2026), and increase the spatial detail of the information and its usefulness for forest monitoring and management (McRoberts *et al* 2014). Crucially, EO enables sampling designs that target high-variability forest areas, thereby increasing estimate precision and reducing field costs. For example, Bocci *et al* (2025) showed that sampling effort (i.e. costs) can be reduced by 5%–27% even using very simple predictors (e.g. NDVI), with larger gains expected from advanced EO and AI methods (D'Amico *et al* 2025). Importantly, forest disturbances can be detected and even classified into different categories with very high accuracy using optical EO. This would be key to complement NFIs, since disturbances affect only a small portion of the total forested area, they cannot be adequately captured—let alone monitored—by measuring less than 0.01% of the forest at ground level at minimum intervals of five years.

2—NFI samples must remain spatially balanced, and EO-guided selection disrupts this balance.

While the NFI sample design is one of the areas where EO could most readily provide support without requiring major additional efforts or structural changes, it is also where criticisms against adopting EO-based approaches are most frequently raised. Ensuring that sample locations are evenly distributed across the area of study is fundamental in NFIs

(Bontemps and Bouriaud 2025). This means no region is overrepresented or neglected, providing better coverage of the spatial variability in the data. Indeed, spatial balance is not a central objective in some EO applications, leading to spatial clustering or biased coverage, which could undermine the statistical robustness of the inventory (Herold *et al* 2019). However, established (Olofsson *et al* 2014) and emerging methodologies (Bocci *et al* 2025) demonstrate that it is entirely possible to maintain spatial representativeness while leveraging auxiliary EO data, enabling the selection of spatially balanced, information-rich samples that better match population variability and increase estimation precision (Grafström *et al* 2017), especially for forest disturbance areas (Francini *et al* 2022).

3—Inventory coordinates cannot be made public and combined with EO

The availability of the exact location of the areas where field data are collected by NFIs is a key prerequisite to exploiting the full potential of EO and to properly combine the two information sources. However, concerns about sharing NFI plot coordinates are driven by the risk of alteration of plot forest conditions and biasing future measurements, a problem that, at most, applies specifically to permanent plots that are repeatedly remeasured over time. However, for temporary or semi-permanent plots, the disclosure of coordinates after measurement does not pose any of these risks, as these plots are not used for future remeasurements and any subsequent disturbance would not affect inventory estimates. This is the case of the French NFI, where plots are remeasured only once after five years, allowing the benefits of repeated observations, while limiting risks associated with long-term plot permanence. Similarly, a commonly cited rationale for not sharing plot coordinates refers to privacy protection operating at both the EU and national levels. While the protection of personal and property-related information is clearly regulated, it remains unclear why such restrictions are solved with non-disclosure agreements for some NFI or other EU-wide monitoring programs and not for other NFIs. Crucially, the modern fusion of EO and NFIs data does not inherently require the disclosure of plot coordinates, as non-disclosive methods, such as federated learning (Bacco *et al* 2025, Schumacher *et al* 2025), appropriate validation frameworks (Lechner *et al* 2020), and alternative data governance models (Nabuurs *et al* 2022) allow EO data to be used for model validation and calibration while preserving data confidentiality (Gessler *et al* 2024).

4—EO cannot replace ground-based measurements.

Part of the forest inventory community argues against a more intense use of EO in NFIs as it is intrinsically unable to capture all key forest information, including attributes related to biodiversity and several of the other standardized variables traditionally collected through field measurements. However, EO is not meant to replace field observations, but rather to (i) optimize their use by identifying areas where more intensive field sampling is warranted, and (ii) maximize the value of field surveys by enabling the calibration of models and the production of spatially detailed maps and products relevant for forest monitoring and management. In practice, there are good examples of the complementary use of EO data in NFIs. For instance, the Finnish multi-source NFI, demonstrated how field plots and satellite imagery can be combined to produce wall-to-wall forest variable maps and small-area estimates while preserving the statistical role of the ground sample (McRoberts and Tomppo 2007). Similar operational approaches in Norway and Sweden have used EO as auxiliary information to increase the spatial detail, precision, and practical usability of forest estimates and maps (Nilsson *et al* 2003). In the USA, NFIs use EO to detect land cover change and assess sampling efficiency, while Australia applies EO data to monitor forest loss in their NFI and for greenhouse gas reporting. Although these NFIs remain primarily field plot–based, they effectively integrate EO to enhance specific components of their workflows.

5—EO data remains uncertain and operationally challenging

Despite major technological advances, institutional uptake of EO has sometimes been slowed by concerns related to costs, data continuity, and operational consistency. In truth, EO data availability for forest monitoring is already broad and rapidly increasing (CEOS 2026). Europe's own EO missions provide a substantial and largely self-sufficient foundation of open access, high-quality, ready-to-use data, supported by established procedures to address the very small proportion of data gaps (Francini *et al* 2023) and by user-friendly cloud platforms that greatly simplify data analysis and exploitation. Considering only the European public/open access segment, at least nine satellite units have direct or complementary relevance for forest monitoring (Sentinel-1A, Sentinel-1C, Sentinel-1D, Sentinel-2A, Sentinel-2B, Sentinel-2C, Sentinel-3A, Sentinel-3B, and BIOMASS), complemented by restricted-access missions of high relevance for forest structure assessment, such as TanDEM-X. In addition, at least four European EO open access missions with clear relevance for forest monitoring are planned by 2028 (Sentinel-3C, Sentinel-2D, CHIME-A, and LSTM). At the global scale, EO capacity is now in the order of hundreds of satellites, including many tens of systems relevant to forest applications when optical, SAR, thermal, hyperspectral, and LiDAR sensors are considered; 971 active EO satellites were reported in 2021, compared with 684 in 2019 and 192 in 2013 (World Meteorological Organization, 2026, Union of Concerned Scientists 2021). Operationally, forest monitoring can already rely on long-term optical archives and operational multispectral systems, such as Landsat and Sentinel, which have enabled a wide range of environmental and forest monitoring applications (Wulder and Coops 2014), as well as on structural and 3D missions increasingly used in combination with NFI data for biomass and forest structure assessment (Bruening *et al* 2023, May *et al* 2024, Pascual *et al* 2025), and on very high spatial resolution commercial EO missions including Planet, GeoEye-1, SkySat, Pelican, WorldView, Pléiades, BlackSky, and Jilin-1, with forthcoming initiatives (2027) such as Marble Visions further targeting high-frequency 3D satellite observation and land monitoring capabilities. Finally, platforms such as Google Earth Engine have drastically democratized access to large-scale EO processing, eliminating the need for dedicated infrastructure and enabling global-scale analyses, thereby transforming the EO paradigm and overcoming many former limitations (Gorelick *et al* 2017).

If NFI protocols and institutional workflows are not adapted now to accommodate these emerging data streams, the opportunity cost will continue to compound, potentially rendering NFIs less relevant over time and weakening their institutional and funding support.

4. Wrap-up

As forest dynamics become increasingly complex under climate change and anthropogenic pressures, integrating EO as a central component of modern official forest information systems, including broader National Forest Monitoring Systems, represents a natural evolution. EO is relevant not only for enhancing NFI sampling, estimation, and mapping, but also for connecting field-based inventories with wider national monitoring frameworks, provided that EO products are harmonized with national forest definitions and validated against high-quality reference data (Galiatsatos *et al* 2020). While ground surveys remain the cornerstone of forest monitoring, and while EO is not designed to replace fieldwork, EO and technological innovations should reshape how field data are collected and used, guiding measurement locations and enabling multitemporal mapping and modeling that extend beyond the capabilities of traditional NFIs. The practical implications of this integration can no longer be overlooked, including EO's potential to enhance NFI capabilities, support operational decision-making, broaden the user base, and influence the forestry sector more widely. Indeed, we believe that the limited uptake of a more EO-oriented forest information system in the EU appears to reflect institutional inertia and the gradual pace at which traditionally structured forest monitoring systems incorporate technological innovation, rather than shortcomings of the technology itself, which is already widely adopted in many other sectors.

Given that EO can produce approximate maps of multiple forest variables and can even outperform NFIs for specific features such as monitoring forest disturbances and supporting proactive climate-smart forestry, why is it not more systematically used both to support field plot selection and to expand NFI estimates with spatially detailed and timely products?

Given that methods for integrating EO into NFI sampling designs already exist, and given that they have proved to increase precision, reduce costs, and provide a more comprehensive representation of forest variability, why is EO still rarely used to support NFI sample selection, even when all other components of the inventory may be kept unchanged?

Given that very practical solutions exist to maintain permanent plots while exploiting EO to support sampling design and model training for map production, all without disclosing plot coordinates, why is coordinate confidentiality still cited as a major barrier to the use of EO in forest inventories?

Given the widespread availability of open access and commercial EO data acquired under consistent conditions across space and time by multiple complementary sensors and programs, given that such data are not subject to definition inconsistencies, methodological differences, or human-induced field measurement errors that can affect the comparability and reliability of NFI-based estimates, and given that there are examples and countries where remote sensing is successfully integrated with field data, why is its adoption still limited to so few cases and what are the real barriers preventing the systematic and large-scale use of remote sensing in official national forest monitoring?

Among the many questionable assumptions, a few real barriers do exist, although they could be effectively addressed if acknowledged seriously and approached with genuine institutional commitment. For example, the limited EO technical capacity within many NFI agencies, particularly in parts of southern and eastern Europe, where personnel, infrastructure, and expertise to routinely process and interpret EO data remain insufficient. On the other hand, several research institutions in Europe and the EU research program would have the human and financial resources to offer the integration of satellite observations with NFIs at the continental level in the frame of a joint monitoring program with national authorities. More broadly, effective EO integration in official national forest monitoring still depends on factors such as model transferability, the availability and quality of training data, computational literacy and processing capacity, as well as appropriate legal frameworks and data-sharing agreements. Importantly, the availability of EO data does not automatically translate into operational readiness, as open-access data and policy reduce, but do not eliminate, costs related to infrastructure, expertise, and data governance, and cloud platforms do not fully remove existing technical and institutional bottlenecks. In addition, commercial data providers may entail high costs and licensing constraints, while research-grade sensors can present technical and operational limitations. One of the main limitations of current EO-based forest structure products (e.g. biomass, canopy height, and carbon stocks maps) is not the satellite technology itself, but the scarcity of reliable ground reference data for model calibration and validation. This is reflected in the discrepancies often observed among existing satellite-derived biomass products. Improving the availability, quality, and harmonization of field-based measurements, therefore, represents both a key challenge and a major opportunity to improve next-generation EO- and AI-based forest monitoring systems. Addressing these gaps will require targeted investments in cross-agency training, updates to NFI protocols to accommodate incoming EO missions, and the development of federated data governance frameworks. Strengthening technical expertise, standardizing methodologies, and supporting the routine integration of EO within NFI workflows will be essential to move from technological potential to operational practice. Modern forest governance and harmonized forest assessments depend on transparency and shared information infrastructures (Nabuurs *et al* 2022), and EO must play a key role in reducing inconsistencies across countries, datasets, and NFIs, as well as those associated with field-based human measurements (Lechner *et al* 2020). In this broader perspective, NFIs should be seen as a central statistical component of national forest monitoring, but not as the whole monitoring system.

Now more than ever, official forest information systems must support proactive, timely, focused, and climate-smart forest management. This cannot be achieved simply by reporting changes with very low frequency and spatial detail and without a more extensive integration of EO. In the face of accelerating climate impacts, official forest information systems must evolve from primarily reporting tools into monitoring infrastructures capable of supporting timely intervention at multiple scales.

Data availability statement

No new data were created or analysed in this study.

ORCID iDs

Saverio Francini 0000-0001-6991-0289
Chiara Bocci 0000-0001-8189-4445
Ruben Valbuena 0000-0003-0493-7581
Giovanni D'Amico 0000-0002-2341-3268
Alessandro Cescatti 0000-0002-2769-2591

References

Bacco F M, Kanellopoulos S, Di Leo M, Kotsev A and Friis-Christensen A 2025 Technology safeguards for the re-use of confidential data (JRC141298) (European Commission, Joint Research Centre) (available at: https://publications.jrc.ec.europa.eu/repository/handle/JRC141298)

Bocci C, Francini S and Rocco E 2025 A new sampling strategy for enhancing forest monitoring leveraging remote sensing data *J. Agric. Biol. Environ. Stat.* **30** 405–30

Bontemps N and Bouriaud O 2025 Harmonization of national forest inventories in Europe: progress, challenges and perspectives *Ann. For. Sci.* **82** 1–15

Bruening J, May P, Armston J and Dubayah R 2023 Precise and unbiased biomass estimation from GEDI data and the US forest inventory *Front. For. Glob. Change* **6** 1149153

CEOS—Committee on Earth Observation Satellites Earth observation satellite missions (available at: https://database.eohandbook.com/database/missiontable.aspx) (Accessed 5 June 2026)

D'Amico G, Vangi E, Schwartz M, Giannetti F, Francini S, Corona P, Mattioli W and Chirici G 2025 GEDI and Sentinel data integration for quantifying agroforestry tree height and stocks *J. Environ. Manage.* **393** 127197

European Parliament Parliament rejects proposal for a regulation on a monitoring framework for resilient European forests (European Parliament Press Release) (available at: www.europarl.europa.eu/pdfs/news/expert/2025/10/press_release/20251017IPR30993/20251017IPR30993_en.pdf) (Accessed 21 October 2025)

Francini S *et al* 2025 Bridging spatio-temporal gaps in ALS data using Landsat time series and forest disturbance–recovery metrics via multi-task neural networks *Sci. Remote Sens.* **12** 100318

Francini S, McRoberts R E, D'Amico G, Coops N C, Hermosilla T, White J C, Wulder M A, Marchetti M, Scarascia Mugnozza G and Chirici G 2022 An open science and open data approach for the statistically robust estimation of forest disturbance areas *Int. J. Appl. Earth Obs. Geoinf.* **106** 102663

Francini S, McRoberts R E, D'Amico G, Coops N C, Hermosilla T, White J C, Wulder M A, Marchetti M, Scarascia Mugnozza G and Chirici G 2023 An assessment approach for pixel-based image composites *ISPRS J. Photogramm. Remote Sens.* **203** 57–69

Galiatsatos N, Donoghue D N M, Watt P, Bholanath P, Pickering J, Hansen M C and Mahmood A R J 2020 An assessment of global forest change datasets for national forest monitoring and reporting *Remote Sens.* **12** 1790

Gessler A, Schaub M, Bose A, Trotsiuk V, Valbuena R, Chirici G and Buchmann N 2024 Finding the balance between open access to forest data while safeguarding the integrity of national forest inventory-derived information *New Phytol.* **242** 344–6

Gorelick N, Hancher M, Dixon M, Ilyushchenko S, Thau D and Moore R 2017 Google Earth engine: planetary-scale geospatial analysis for everyone *Remote Sens. Environ.* **202** 18–27

Grafström A, Zhao X, Nylander M and Petersson H 2017 A new sampling strategy for forest inventories applied to the temporary clusters of the Swedish national forest inventory *Can. J. For. Res.* **47** 1161–7

Herold M *et al* 2019 The role and need for space-based forest biomass-related measurements in environmental management and policy *Surv. Geophys.* **40** 757–78

Kangas A *et al* 2018 Remote sensing and forest inventories in Nordic countries—roadmap for the future *Scand. J. For. Res.* **33** 397–412

Lechner A M, Foody G M and Boyd D S 2020 Applications in remote sensing to forest ecology and management *One Earth* **2** 405–12

May P B, Dubayah R O, Bruening J M and Gaines G C 2024 Connecting spaceborne LiDAR with NFI networks: a method for improved estimation of forest structure and biomass *Int. J. Appl. Earth Obs. Geoinf.* **129** 103797

McRoberts R E, Liknes G C and Domke G M 2014 Using a remote sensing-based percent tree cover map to enhance forest inventory estimation *For. Ecol. Manage.* **331** 12–18

McRoberts R E and Tomppo E O 2007 Remote sensing support for national forest inventories *Remote Sens. Environ.* **110** 412–9

Nabuurs G J 2026 Counting trees together in the EU *Science* **391** 851

Nabuurs G-J, Harris N, Sheil D, Palahí M, Chirici G, Boissière M, Fay C, Reiche J and Valbuena R 2022 Glasgow forest declaration needs new modes of data ownership *Nat. Clim. Change* **12** 415–7

Nesha K *et al* 2022 Exploring characteristics of national forest inventories for integration with global space-based forest biomass data *Sci. Total Environ.* **850** 157788

Nilsson M *et al* 2003 Combining remote sensing and field data for deriving unbiased estimates of forest parameters over large regions *Advances in Forest Inventory for Sustainable Forest Management and Biodiversity Monitoring. Forestry Sciences* vol 76, ed P Corona, M Köhl and M Marchetti (Springer)

Olofsson P, Foody G M, Herold M, Stehman S V, Woodcock C E and Wulder M A 2014 Good practices for estimating area and assessing accuracy of land change *Remote Sens. Environ.* **148** 42–57

Palahí M *et al* 2021 Concerns about reported harvests in European forests *Nature* **592** E15–E17

Pascual A, May P B, Cárdenas-Martínez A, Guerra-Hernández J, Hunka N, Bruening J M, Healey S P, Armston J D and Dubayah R O 2025 Calibration of GEDI footprint aboveground biomass models in Mediterranean forests with NFI plots: a comparison of approaches *J. Environ. Manage.* **375** 124313

Schumacher J *et al* 2025 Federated learning in forest resource modelling and monitoring: bridging data confidentiality and collaborative research Zenodo (https://doi.org/10.5281/zenodo.17415920)

Schwartz M *et al* 2023 FORMS: forest multiple source height, wood volume, and biomass maps in France at 10–30 m resolution based on Sentinel-1,Sentinel-2, and global ecosystem dynamics investigation (GEDI) data with a deep learning approach *Earth Syst. Sci. Data* **15** 4927–45

Skakun S 2025 The impact of map accuracy on area estimation with remotely sensed data within the stratified random sampling design *Remote Sens. Environ.* **326** 114805

Union of Concerned Scientists 2021 UCS satellite database (Union of Concerned Scientists)

White J C, Coops N C, Wulder M A, Vastaranta M, Hilker T and Tompalski P 2016 Remote sensing technologies for enhancing forest inventories: a review *Can. J. Remote Sens.* **42** 619–41

World Meteorological Organization OSCAR/space: list of all satellites (available at: https://space.oscar.wmo.int/satellites) (Accessed 5 June 2026)

Wulder M A 2026 Challenges in comparing national forest statistics: Canada as a case study *For. Chron.* **102** 28–35

Wulder M A and Coops N C 2014 Satellites: make Earth observations open access *Nature* **513** 30–1