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Nuove tecnologie per il monitoraggio dei rimboschimenti

Prof. Gherardo Chirici

geo LAB

Laboratory of Forest Geomatics

Traditional National Forest Inventories (NFIs) use a design based approach to infer statistics over **LARGE** areas from field measures acquired in a **VERY SMALL** sample (approx 0.001%) of the forest area

1st century of NFIs

REMOTE SENSING was used in NFIs since the very beginning with traditional aerial photography

From NFIs to

Enhanced Forest Inventories

Sensu White et al. (2016)

Erkki Tomppo • Thomas Gschwantner • Mark Lawrence • Ronald E. McRoberts
Editors

National Forest Inventories

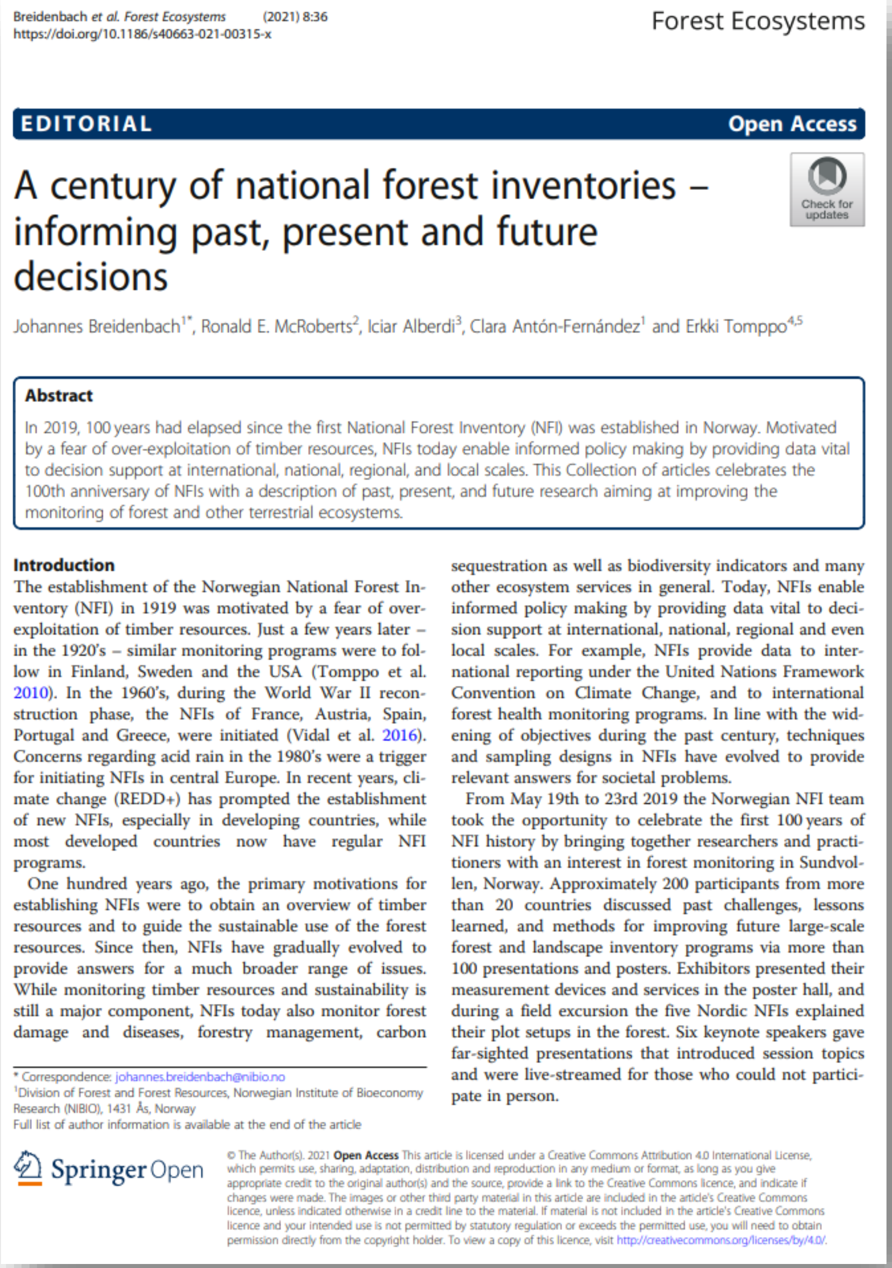
Pathways for Common Reporting

EUROPEAN SCIENCE FOUNDATION

ESF provides the COST Office through an EC contract

COST is supported by the EU RTD Framework programme

Springer



Breidenbach et al. Forest Ecosystems (2021) 8:36
https://doi.org/10.1186/s40663-021-00315-x

Forest Ecosystems

EDITORIAL Open Access

A century of national forest inventories – informing past, present and future decisions

Check for updates

Johannes Breidenbach[1*], Ronald E. McRoberts[2], Iciar Alberdi[3], Clara Antón-Fernández[1] and Erkki Tomppo[4,5]

Abstract

In 2019, 100 years had elapsed since the first National Forest Inventory (NFI) was established in Norway. Motivated by a fear of over-exploitation of timber resources, NFIs today enable informed policy making by providing data vital to decision support at international, national, regional, and local scales. This Collection of articles celebrates the 100th anniversary of NFIs with a description of past, present, and future research aiming at improving the monitoring of forest and other terrestrial ecosystems.

Introduction

The establishment of the Norwegian National Forest Inventory (NFI) in 1919 was motivated by a fear of over-exploitation of timber resources. Just a few years later – in the 1920's – similar monitoring programs were to follow in Finland, Sweden and the USA (Tomppo et al. 2010). In the 1960's, during the World War II reconstruction phase, the NFIs of France, Austria, Spain, Portugal and Greece, were initiated (Vidal et al. 2016). Concerns regarding acid rain in the 1980's were a trigger for initiating NFIs in central Europe. In recent years, climate change (REDD+) has prompted the establishment of new NFIs, especially in developing countries, while most developed countries now have regular NFI programs.

One hundred years ago, the primary motivations for establishing NFIs were to obtain an overview of timber resources and to guide the sustainable use of the forest resources. Since then, NFIs have gradually evolved to provide answers for a much broader range of issues. While monitoring timber resources and sustainability is still a major component, NFIs today also monitor forest damage and diseases, forestry management, carbon sequestration as well as biodiversity indicators and many other ecosystem services in general. Today, NFIs enable informed policy making by providing data vital to decision support at international, national, regional and even local scales. For example, NFIs provide data for international reporting under the United Nations Framework Convention on Climate Change, and to international forest health monitoring programs. In line with the widening of objectives during the past century, techniques and sampling designs in NFIs have evolved to provide relevant answers for societal problems.

From May 19th to 23rd 2019 the Norwegian NFI team took the opportunity to celebrate the first 100 years of NFI history by bringing together researchers and practitioners with an interest in forest monitoring in Sundvollen, Norway. Approximately 200 participants from more than 20 countries discussed past challenges, lessons learned, and methods for improving future large-scale forest and landscape inventory programs via more than 100 presentations and posters. Exhibitors presented their measurement devices and services in the poster hall, and during a field excursion the five Nordic NFIs explained their plot setups in the forest. Six keynote speakers gave far-sighted presentations that introduced session topics and were live-streamed for those who could not participate in person.

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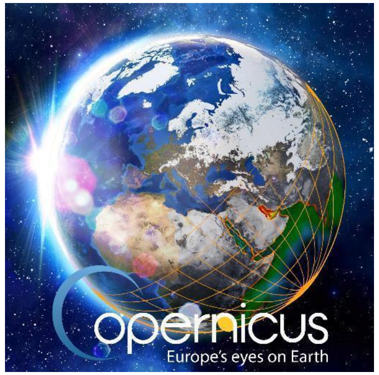
Nuove opportunità dalle piattaforme di osservazione dallo spazio

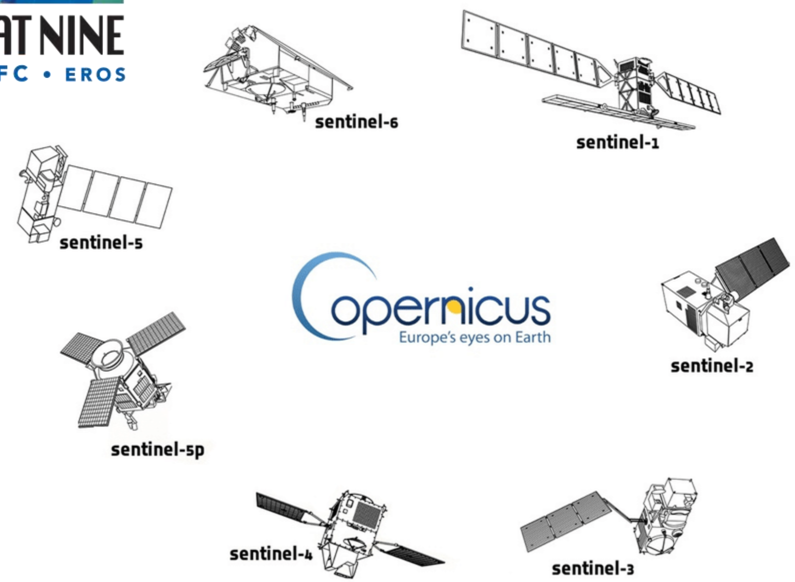


- **Increasing number** of high resolution multispectral optical and radar **platforms** (Sentinels, Landsat)
- New **LiDAR** data (ICESAT, GEDI, TLS, UAV)
- Incresing number of spatial remotely sensed based data at **COPERNICUS**
- New high resolution small satellites platforms (PLANET), **real time** monitoring
- New **hyperspectral** platforms (PRISMA)
- **UAV** and digital photogrammetry (SFM)

GEDI
ECOSYSTEM LIDAR

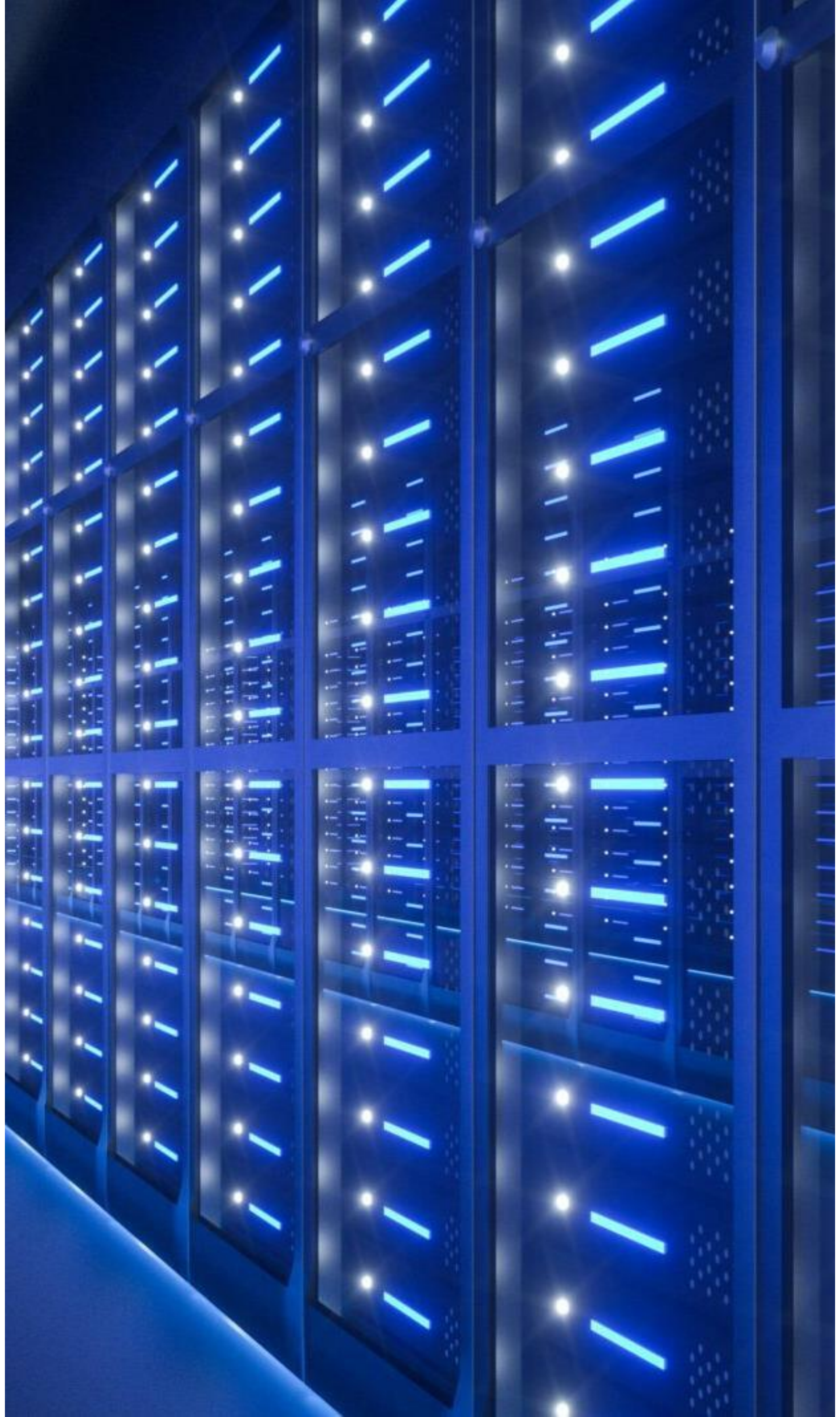
esa
European Space Agency

NASA • USGS
LANDSAT NINE
KSC • GSFC • EROS

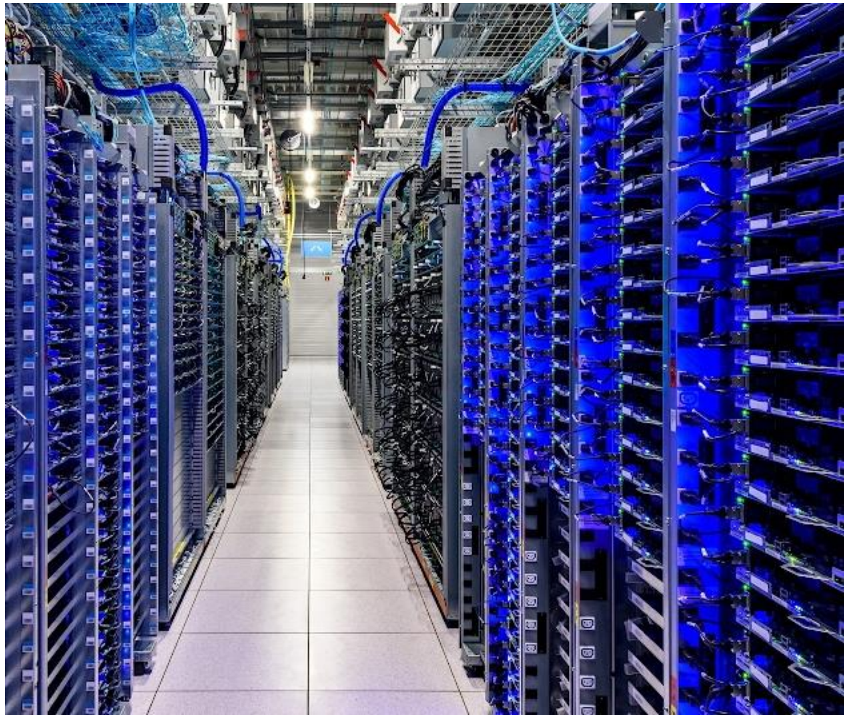


planet.
See Change.
Change the World.

ASI AGENZIA SPAZIALE ITALIANA
PRISMA
LEONARDO
OHB ITALIA




Google

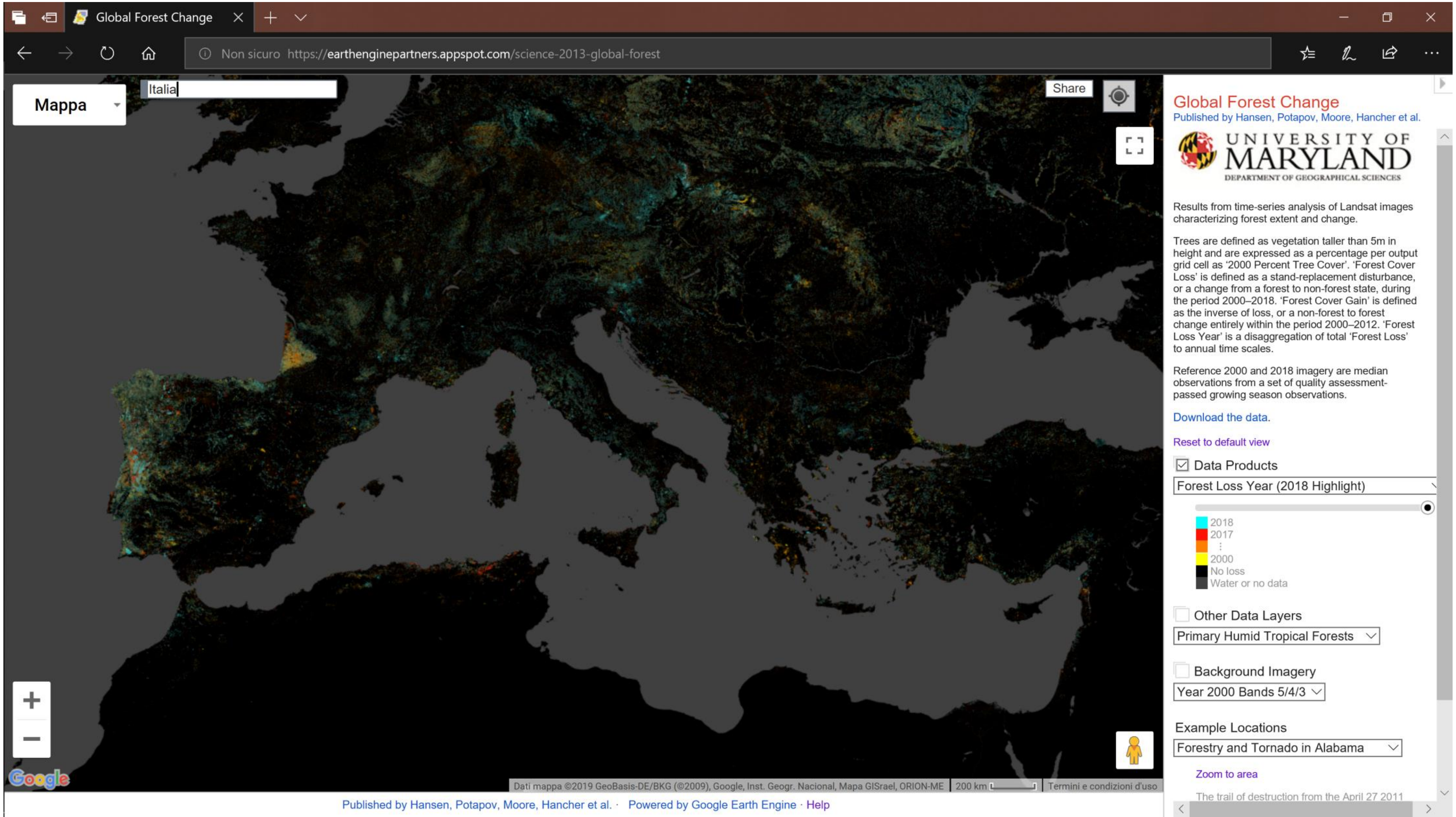


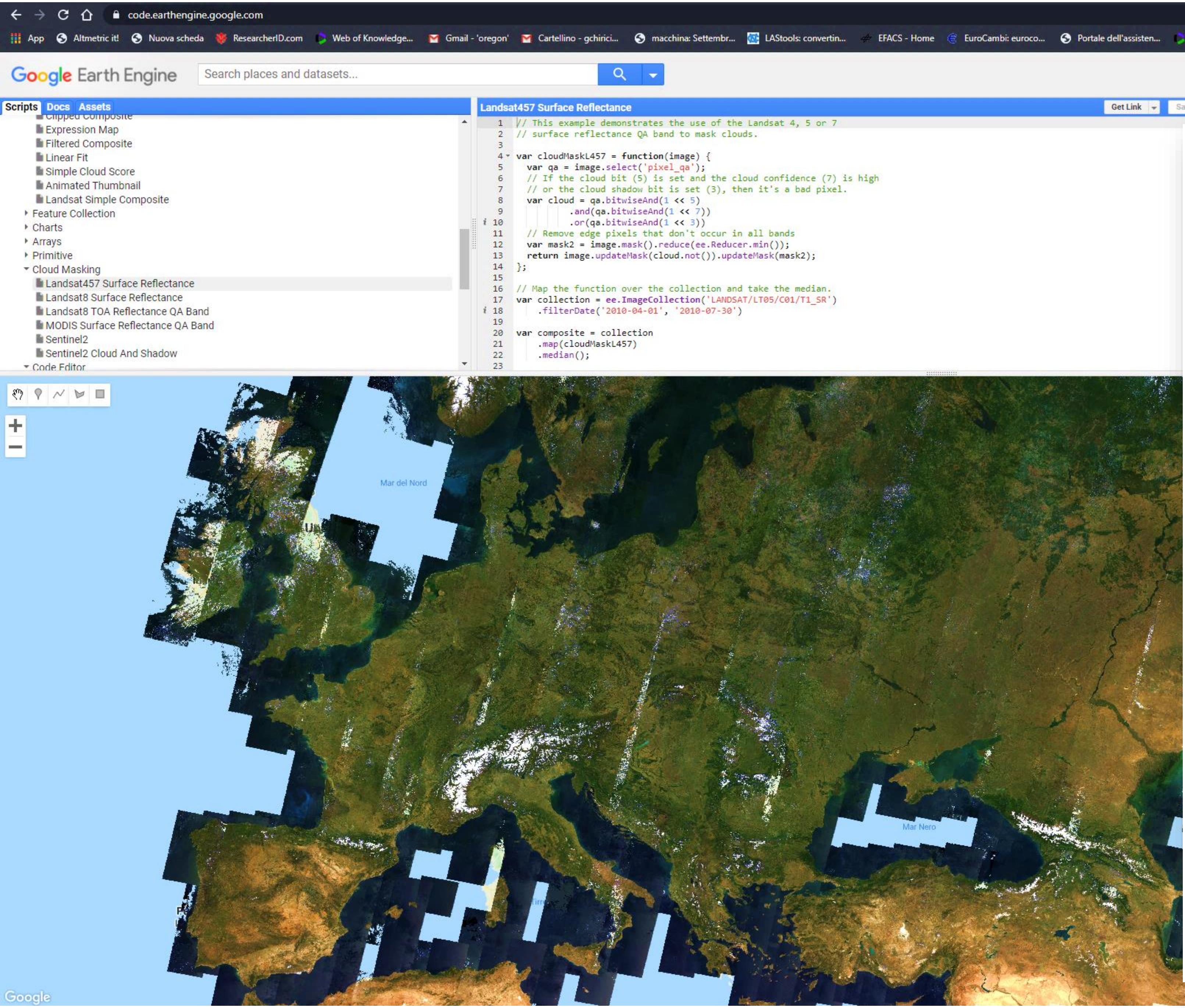
Dobbiamo basarci su Google e NASA anche in Europa?

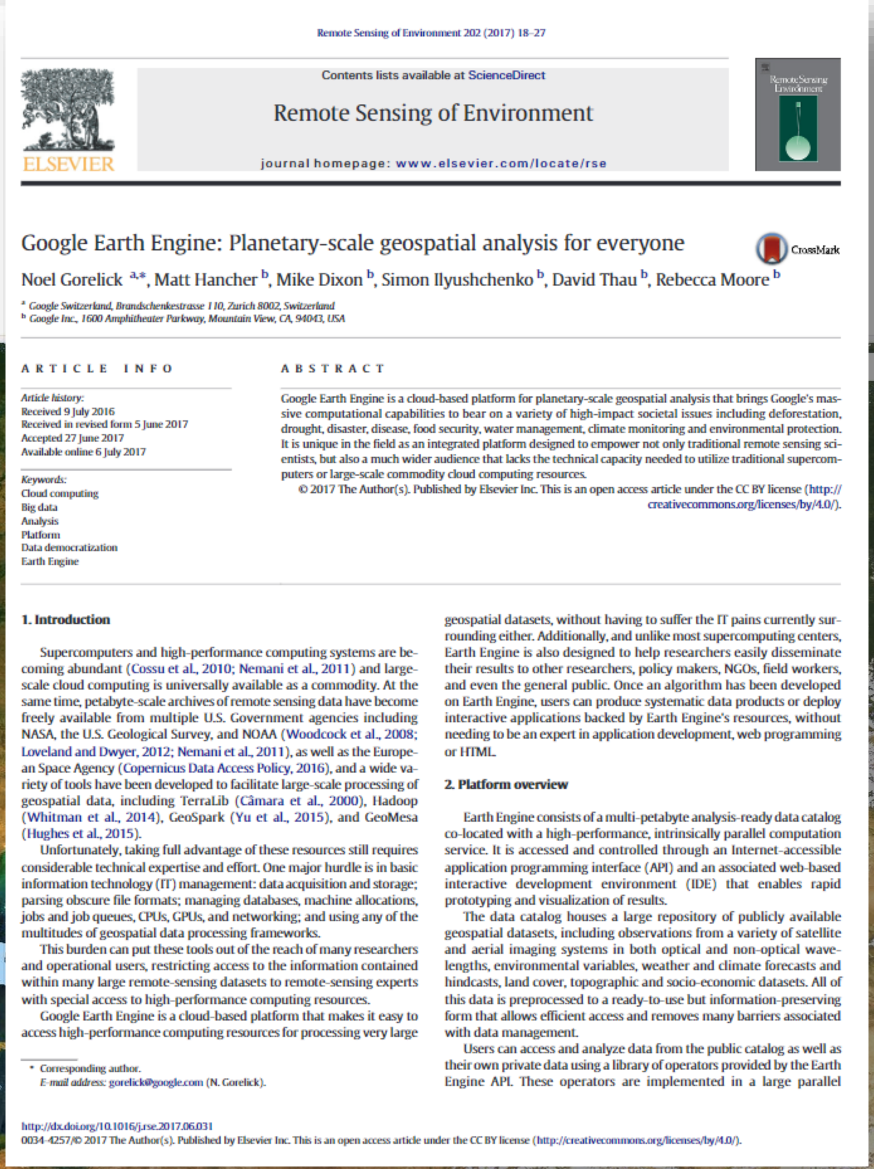
High-Resolution Global Maps of 21st-Century Forest Cover Change

M. C. Hansen[1,*], P. V. Potapov[1], R. Moore[2], M. Hancher[2], S. A. Turubanova[1], A. Tyukavina[1], D. Thau[2], S. V. Stehman[3], S. J. G...
+ See all authors and affiliations

Science 15 Nov 2013:
Vol. 342, Issue 6160, pp. 850-853
DOI: 10.1126/science.1244693







Remote Sensing of Environment 202 (2017) 18–27

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Google Earth Engine: Planetary-scale geospatial analysis for everyone

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ARTICLE INFO

Article history:
Received 9 July 2016
Received in revised form 5 June 2017
Accepted 27 June 2017
Available online 6 July 2017

Keywords:
Cloud computing
Big data
Analysis
Platform
Data democratization
Earth Engine

ABSTRACT

Google Earth Engine is a cloud-based platform for planetary-scale geospatial analysis that brings Google's massive computational capabilities to bear on a variety of high-impact societal issues including deforestation, drought, disaster, disease, food security, water management, climate monitoring and environmental protection. It is unique in the field as an integrated platform designed to empower not only traditional remote sensing scientists, but also a much wider audience that lacks the technical capacity needed to utilize traditional supercomputers or large-scale commodity cloud computing resources.

1. Introduction

Supercomputers and high-performance computing systems are becoming abundant (Cossu et al., 2010; Nemani et al., 2011) and large-scale cloud computing is universally available as a commodity. At the same time, petabyte-scale archives of remote sensing data have become freely available from multiple U.S. Government agencies including NASA, the U.S. Geological Survey, and NOAA (Woodcock et al., 2008; Loveland and Dwyer, 2012; Nemani et al., 2011), as well as the European Space Agency (Copernicus Data Access Policy, 2016), and a wide variety of tools have been developed to facilitate large-scale processing of geospatial data, including TerraLib (Câmara et al., 2000), Hadoop (Whitman et al., 2014), GeoSpark (Yu et al., 2015), and GeoMesa (Hughes et al., 2015).

Unfortunately, taking full advantage of these resources still requires considerable technical expertise and effort. One major hurdle is in basic information technology (IT) management: data acquisition and storage; parsing obscure file formats; managing databases, machine allocations, jobs and job queues, CPUs, GPUs, and networking; and using any of the multitudes of geospatial data processing frameworks.

This burden can put these tools out of the reach of many researchers and operational users, restricting access to the information contained within many large remote-sensing datasets to remote-sensing experts with special access to high-performance computing resources.

Google Earth Engine is a cloud-based platform that makes it easy to access high-performance computing resources for processing very large geospatial datasets, without having to suffer the IT pains currently surrounding either. Additionally, and unlike most supercomputing centers, Earth Engine is also designed to help researchers easily disseminate their results to other researchers, policy makers, NGOs, field workers, and even the general public. Once an algorithm has been developed on Earth Engine, users can produce systematic data products or deploy interactive applications backed by Earth Engine's resources, without needing to be an expert in application development, web programming or HTML.

2. Platform overview

Earth Engine consists of a multi-petabyte analysis-ready data catalog co-located with a high-performance, intrinsically parallel computation service. It is accessed and controlled through an Internet-accessible application programming interface (API) and an associated web-based interactive development environment (IDE) that enables rapid prototyping and visualization of results.

The data catalog houses a large repository of publicly available geospatial datasets, including observations from a variety of satellite and aerial imaging systems in both optical and non-optical wavelengths, environmental variables, weather and climate forecasts and hindcasts, land cover, topographic and socio-economic datasets. All of this data is preprocessed to a ready-to-use but information-preserving form that allows efficient access and removes many barriers associated with data management.

Users can access and analyze data from the public catalog as well as their own private data using a library of operators provided by the Earth Engine API. These operators are implemented in a large parallel

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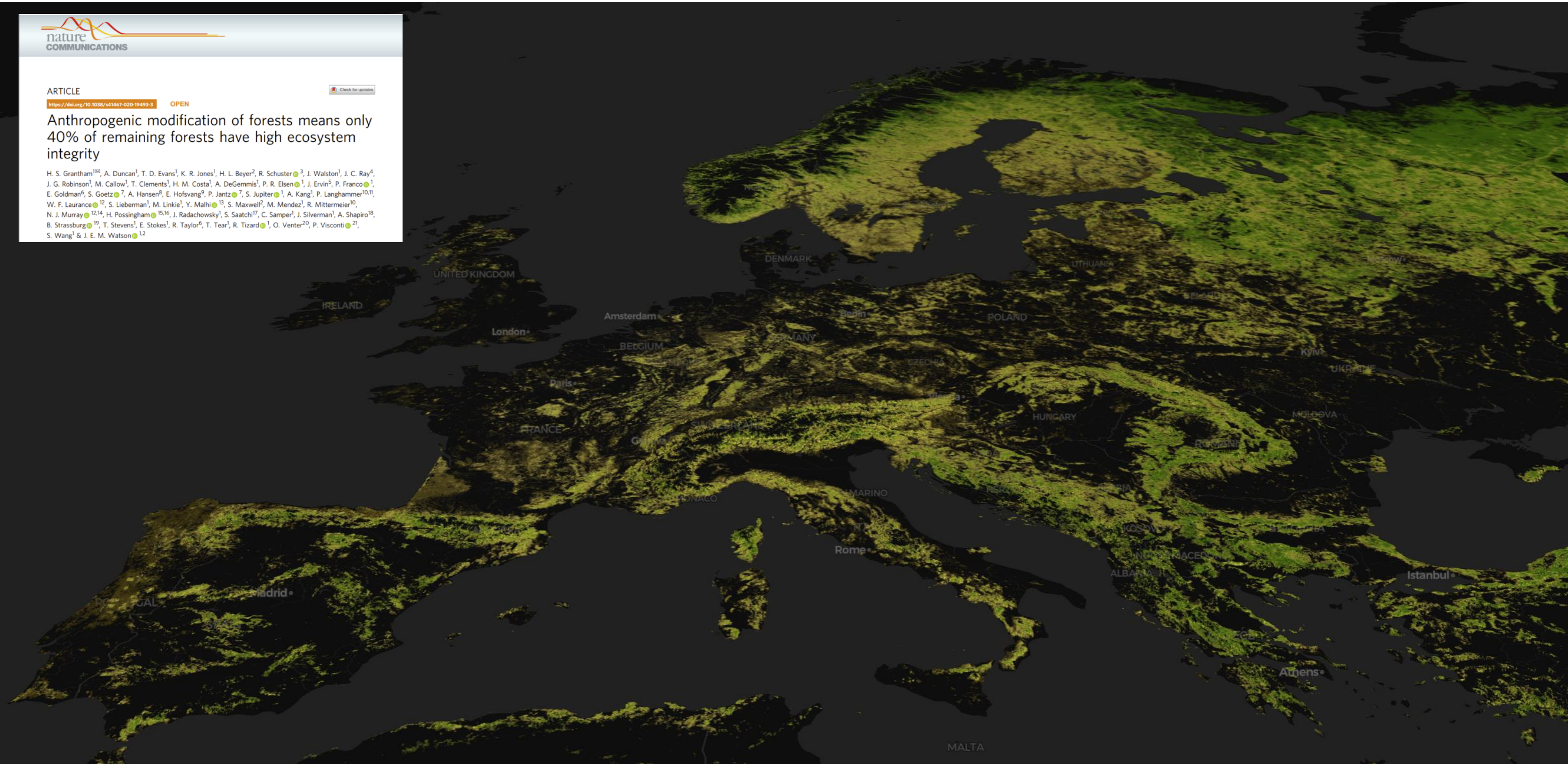
http://dx.doi.org/10.1016/j.rse.2017.06.031

Forest Landscape Integrity Index



nature COMMUNICATIONS

ARTICLE

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https://doi.org/10.1038/s41467-020-19493-3 OPEN

Anthropogenic modification of forests means only 40% of remaining forests have high ecosystem integrity

H. S. Grantham[1✉], A. Duncan[1], T. D. Evans[1], K. R. Jones[1], H. L. Beyer[2], R. Schuster[3], J. Walston[1], J. C. Ray[4], J. G. Robinson[1], M. Callow[1], T. Clements[1], H. M. Costa[1], A. DeGemmis[1], P. R. Elsen[1], J. Ervin[5], P. Franco[1], E. Goldman[6], S. Goetz[7], A. Hansen[8], E. Hofsvang[9], P. Jantz[7], S. Jupiter[1], A. Kang[1], P. Langhammer[10,11], W. F. Laurance[12], S. Lieberman[1], M. Linkie[1], Y. Malhi[13], S. Maxwell[2], M. Mendez[1], R. Mittermeier[10], N. J. Murray[12,14], H. Possingham[15,16], J. Radachowsky[1], S. Saatchi[17], C. Samper[1], J. Silverman[1], A. Shapiro[18], B. Strassburg[19], T. Stevens[1], E. Stokes[1], R. Taylor[6], T. Tear[1], R. Tizard[1], O. Venter[20], P. Visconti[21], S. Wang[1] & J. E. M. Watson[1,2]

https://www.forestintegrity.com/home

Such «GLOBAL» approaches have to be used carefully in Europe

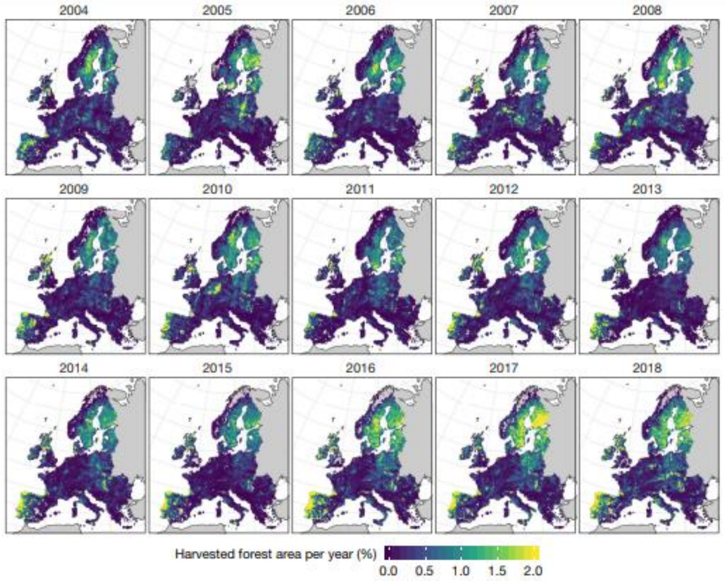
Article

Abrupt increase in harvested forest area over Europe after 2015

https://doi.org/10.1038/s41586-020-2438-y
Received: 17 May 2019
Accepted: 23 April 2020
Published online: 1 July 2020
Check for updates

Guido Ceccherini[1]✉, Gregory Duveiller[1], Giacomo Grassi[1], Guido Lemoine[2], Valerio Avitabile[1], Roberto Pilli[1] & Alessandro Cescatti[1]

Forests provide a series of ecosystem services that are crucial to our society. In the European Union (EU), forests account for approximately 38% of the total land surface[1]. These forests are important carbon sinks, and their conservation efforts are vital for



Matters arising

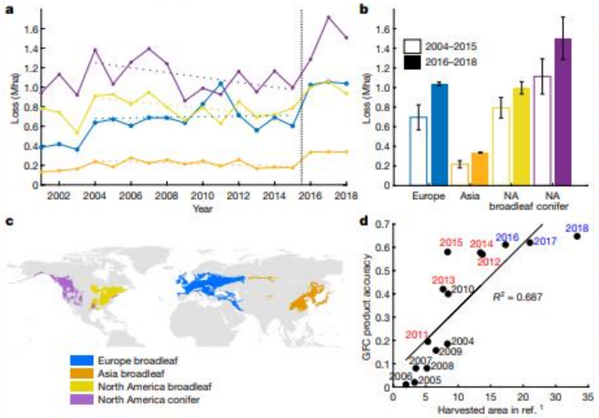


Fig. 1 | Abrupt changes in GFC after 2015 are visible in many temperate regions. This reflects the various improvements in detection that were noted in ref. [2]. **a**, Annual forest cover loss from GFC data in four forest regions: Europe broadleaf (blue); Asia broadleaf (orange); North America broadleaf (yellow) and North America conifer (purple). The vertical dashed line marks the point of the increase in loss reported by Ceccherini et al.[1]. Dashed coloured lines are linear regressions over the period 2004–2015. **b**, The mean annual loss over 2004–2015 and 2016–2018; error bars show ±1 s.d. (sample size is number of years each). **c**, The locations of the four forest regions. **d**, A comparison between the harvested area proposed by Ceccherini et al.[1] for Italy and the accuracy of the GFC forest loss as measured in ref. [5] (based on comparison against harvested areas mapped in the field). The increase in estimated harvest from the GFC largely reflects changes in detection. Different colours denote the periods compared by Ceccherini et al.[1].

detection of change between years. Instead, stratified sample estimation procedures[11] are better suited to GFC data[6]. Such analyses, which address both omission and commission errors, offer accurate and unbiased results of forest change. Moreover, sample reference data tailored to the specific purpose of a given study can be used to discriminate proportions of loss due to natural disturbances within the overall forest loss rates[12].

Ceccherini et al.[1] argue that the socio-economic context and the policy framework are the most important drivers explaining the abrupt increase in harvest area because their analyses excluded natura

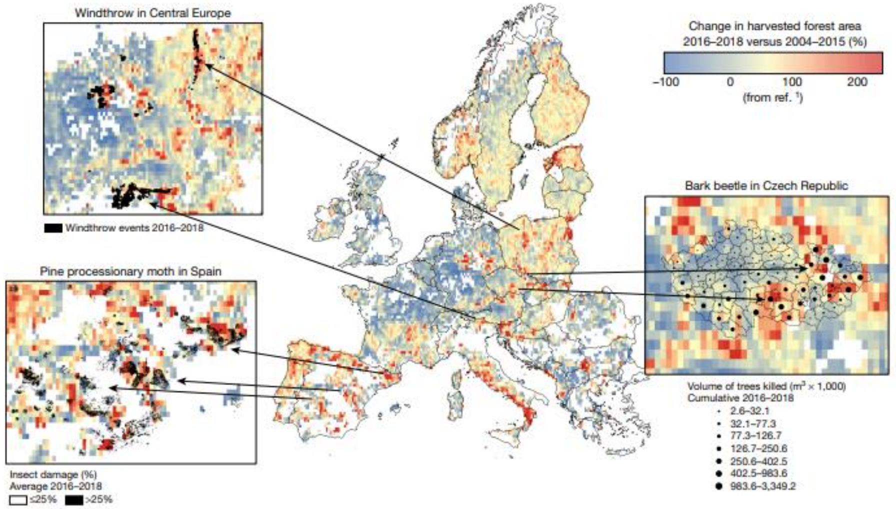


Fig. 2 | Areas identified as natural disturbances. The spatial distribution of many areas that were estimated as hotspots for increased harvesting by Ceccherini et al.[1] have been identified by us as natural disturbances, and thus these areas were not properly compensated for in the calculations in ref. [1]. The European map in the centre (reproduced from ref. [1], Springer Nature) shows the percentage variation of European harvested forest area for 2016–2018 compared with 2004–2015 (blue to red colours according to figure 2b in Ceccherini et al.[1]). Three examples of omissions are given in the insets and overlay forest disturbance information sources (all in black). Top left, 2016–2018 windthrow events from the FORWIND v2 database[13]. Bottom left, 2016–2018 averaged insect attacks in which more than 25% of trees were affected, courtesy of the Spanish Ministry of Agriculture, Fisheries and Food. Right, district-wise statistics from the Czech Republic of the cumulative cubic metres of salvaged trees that were killed by bark beetle in 2016–2018. Country boundaries © ESRI and Garmin International have been added for reference.

Matters arising

Concerns about reported harvests in European forests

https://doi.org/10.1038/s41586-021-03292-x
Received: 3 July 2020
Accepted: 26 January 2021
Published online: 28 April 2021
Check for updates

Marc Palahí[1,26]✉, Rubén Valbuena[2,26]✉, Cornelius Senf[3], Nezha Acil[4,5], Thomas A. M. Pugh[4,5,6], Jonathan Sadler[4,5], Rupert Seidl[3], Peter Potapov[7], Barry Gardiner[8], Lauri Hetemäki[1], Gherardo Chirici[9], Saverio Francini[9,10], Tomáš Hlásny[11], Bas Jan Willem Lerink[12], Håkan Olsson[13], José Ramón González Olabarria[14], Davide Ascoli[15], Antti Asikainen[16], Jürgen Bauhus[17], Göran Berndes[18], Janis Donis[19], Jonas Fridman[13], Marc Hanewinkel[17], Hervé Jactel[20], Marcus Lindner[21], Marco Marchetti[22], Róbert Marušák[11], Douglas Sheil[23], Margarida Tomé[24], Antoni Trasobares[25], Pieter Johannes Verkerk[1], Minna Korhonen[1] & Gert-Jan Nabuurs[12,23]

ARISING FROM G. Ceccherini et al. *Nature* https://doi.org/10.1038/s41586-020-2438-y (2020)

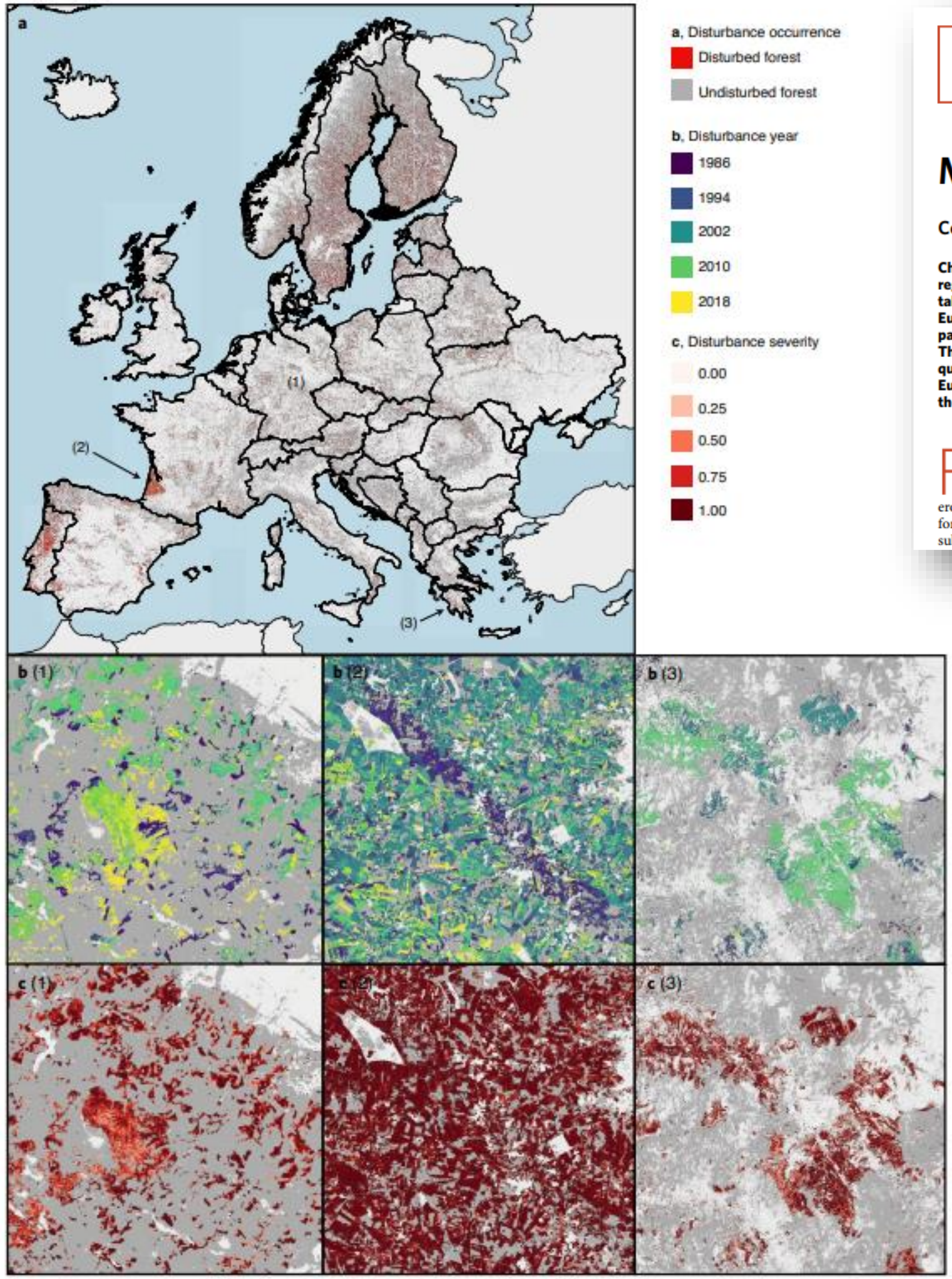


Fig. 1 | Forest disturbances in Europe, 1986-2016. a, The occurrence of disturbances across Europe. **b**, Year of disturbance. **c**, Severity of disturbance for three selected areas (scale, 0–1): (1) a bark beetle outbreak of varying severity in and around the Harz National Park (Germany); (2) salvage-logged wind disturbance in an intensively managed plantation forest in the Landes of Gascony (France), with very high disturbance severity; and (3) fire disturbances on the Peloponnese peninsula (Greece), with variable burn severity. Disturbance maps were derived from analysis of >30,000 Landsat images across continental Europe. See Extended Data Fig. 7 for a high-quality version of the main disturbance map.


nature sustainability
ANALYSIS
https://doi.org/10.1038/s41893-020-00609-y
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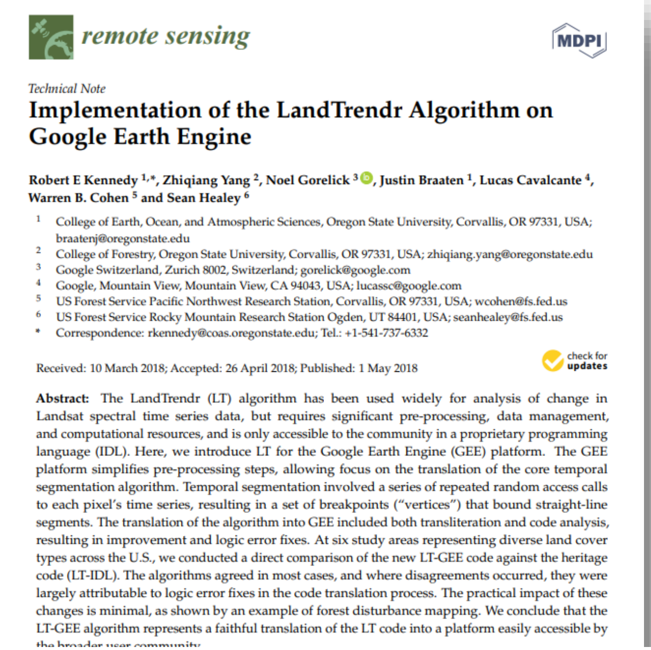
Mapping the forest disturbance regimes of Europe

Cornelius Senf[1,2] and Rupert Seidl[1,2,3]

Changes in forest disturbances can have strong impacts on forests, yet we lack consistent data on Europe's forest disturbance regimes and their changes over time. Here we used satellite data to map three decades of forest disturbances across continental Europe, and analysed the patterns and trends in disturbance size, frequency and severity. Between 1986 and 2016, 17% of Europe's forest area was disturbed by anthropogenic and/or natural causes. We identified 36 million individual disturbance patches with a mean patch size of 1.09 ha, which equals an annual average of 0.52 disturbance patches per km² of forest area. The majority of disturbances were stand replacing. While trends in disturbance size were highly variable, disturbance frequency consistently increased and disturbance severity decreased. Here we present a continental-s… Europe's forest disturbance regimes and their changes over time, providing spatial information that is c… the ongoing changes in Europe's forests.

Forests cover 33% of Europe's total land area and provide important ecosystem services to society, ranging from carbon sequestration to the filtration of water, and protection of soil from erosion and human infrastructure from natural hazards[1]. Europe's forests have expanded in recent decades[2] and have accumulated substantial amounts of biomass due to intensive post-World War II

In regard to Europe there is current… mation available on disturbance regime… time, especially when considering both r… bances. While previous studies have cha… regimes of some of Europe's forest ecos… ies have either focused on purely natural…


remote sensing
MDPI

Technical Note

Implementation of the LandTrendr Algorithm on Google Earth Engine

Robert E Kennedy [1,*], Zhiqiang Yang [2], Noel Gorelick [3], Justin Braaten [1], Lucas Cavalcante [4], Warren B. Cohen [5] and Sean Healey [6]

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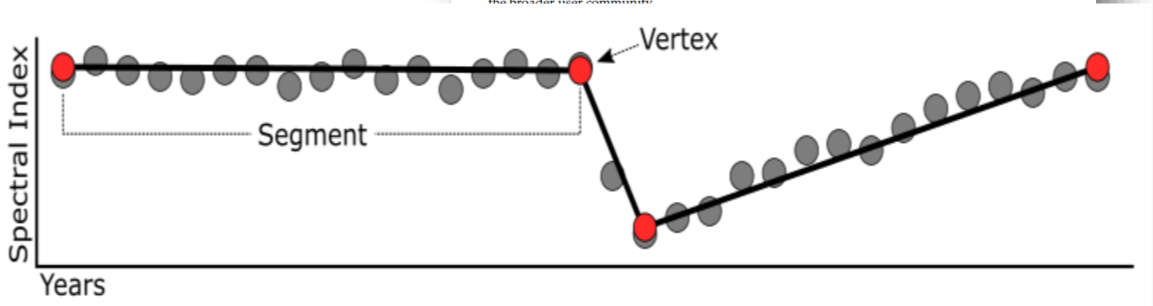
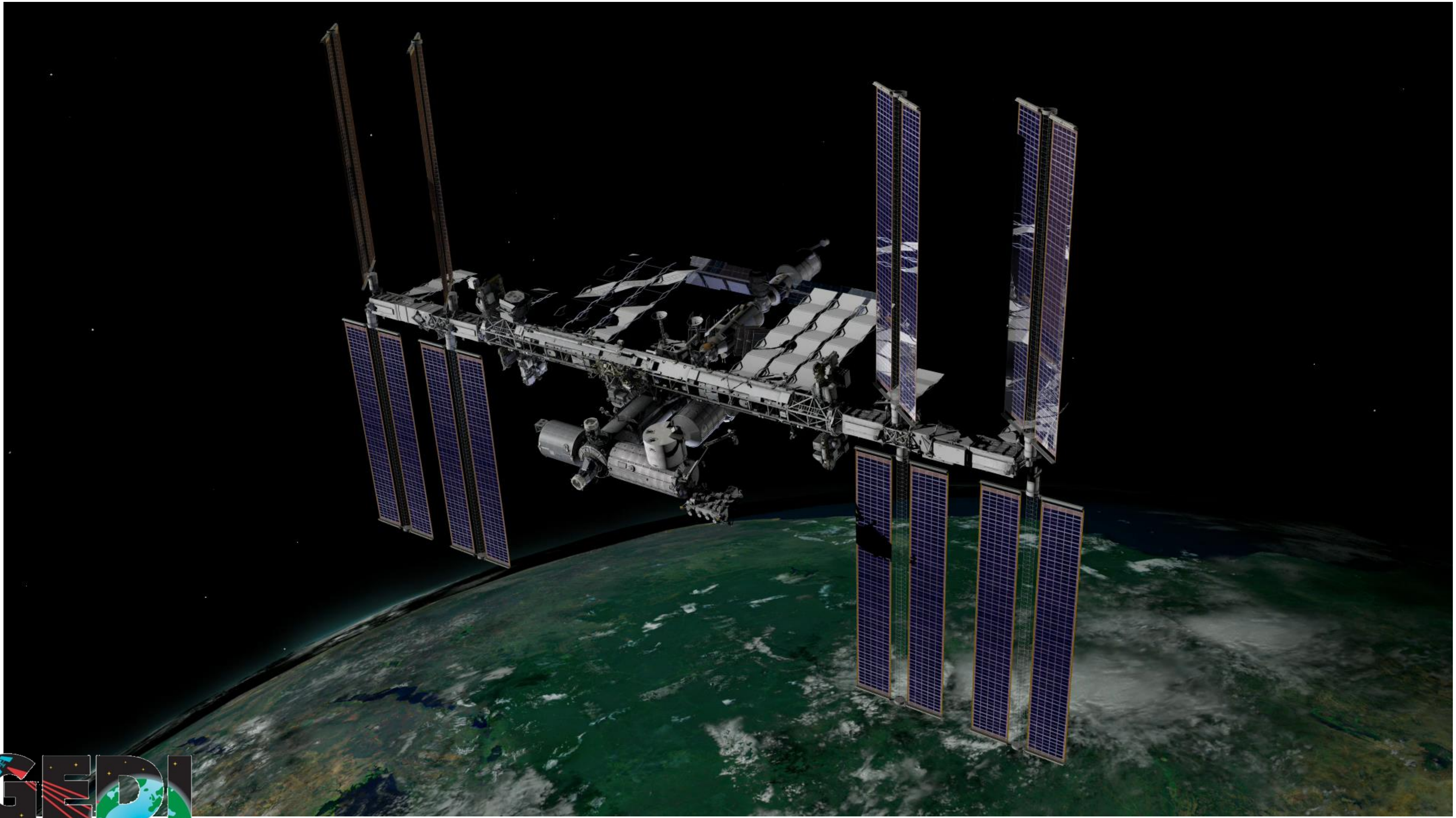
check for updates

Received: 10 March 2018; Accepted: 26 April 2018; Published: 1 May 2018

Abstract: The LandTrendr (LT) algorithm has been used widely for analysis of change in Landsat spectral time series data, but requires significant pre-processing, data management, and computational resources, and is only accessible to the community in a proprietary programming language (IDL). Here, we introduce LT for the Google Earth Engine (GEE) platform. The GEE platform simplifies pre-processing steps, allowing focus on the translation of the core temporal segmentation algorithm. Temporal segmentation involved a series of repeated random access calls to each pixel's time series, resulting in a set of breakpoints ("vertices") that bound straight-line segments. The translation of the algorithm into GEE included both transliteration and code analysis, resulting in improvement and logic error fixes. At six study areas representing diverse land cover types across the U.S., we conducted a direct comparison of the new LT-GEE code against the heritage code (LT-IDL). The algorithms agreed in most cases, and where disagreements occurred, they were largely attributable to logic error fixes in the code translation process. The practical impact of these changes is minimal, as shown by an example of forest disturbance mapping. We conclude that the LT-GEE algorithm represents a faithful translation of the LT code into a platform easily accessible by the broader user community.

«GLOBAL» approach (LANDTRENDR in GEE) but optimized for EU

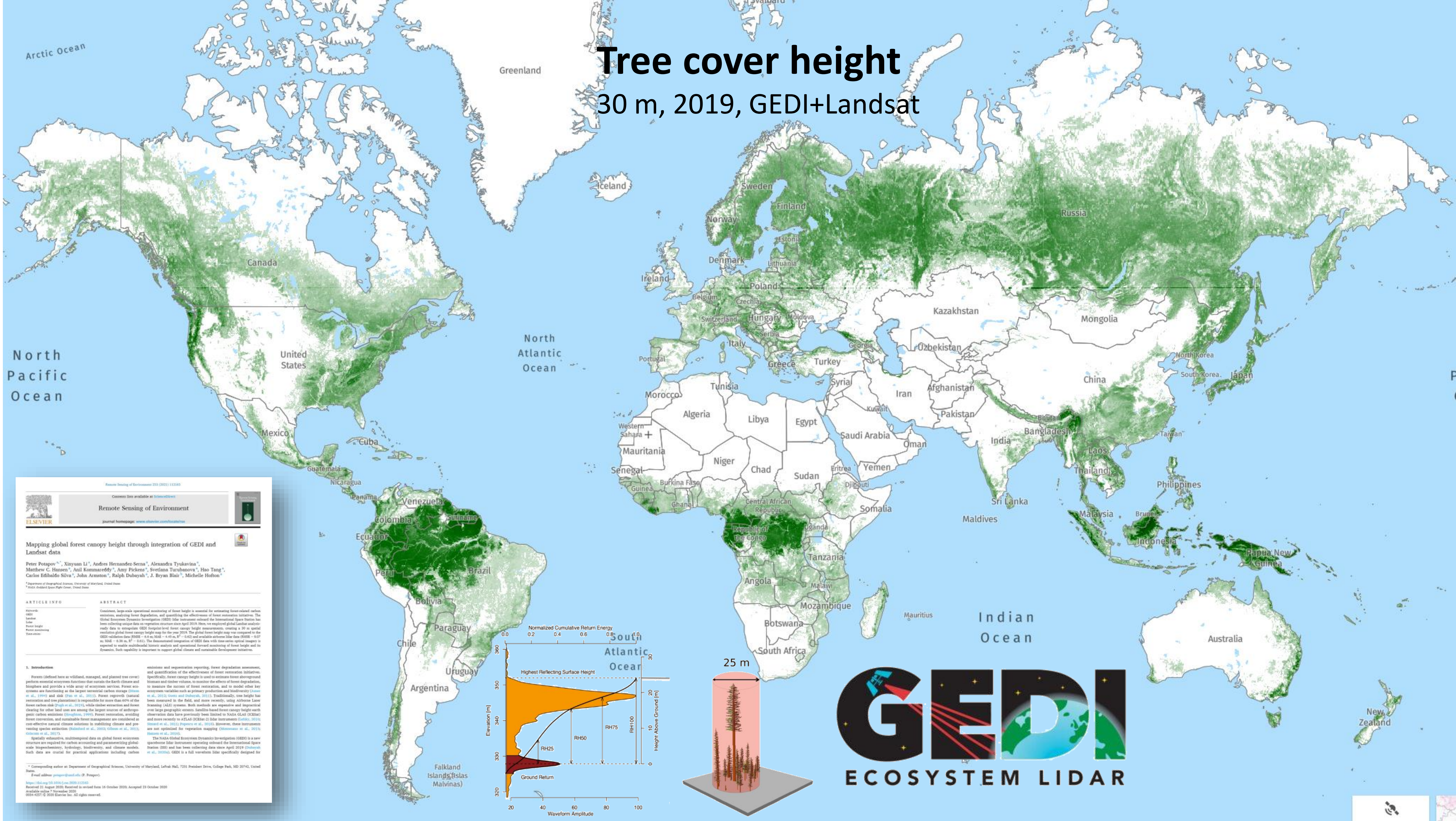




GEDI
ECOSYSTEM LIDAR

Tree cover height

30 m, 2019, GEDI+Landsat



Remote Sensing of Environment 253 (2021) 112165

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

ELSEVIER

Mapping global forest canopy height through integration of GEDI and Landsat data

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ARTICLE INFO

Keywords:
GEDI
Landsat
Lidar
Forest height
Forest monitoring
Time-series

ABSTRACT

Consistent, large-scale operational monitoring of forest height is essential for estimating forest-related carbon emissions, analyzing forest degradation, and quantifying the effectiveness of forest restoration initiatives. The Global Ecosystem Dynamics Investigation (GEDI) lidar instrument onboard the International Space Station has been collecting unique data on vegetation structure since April 2019. Here, we employed global Landsat analysis-ready data to extrapolate GEDI footprint-level forest canopy height measurements, creating a 30 m spatial resolution global forest canopy height map for the year 2019. The global forest height map was compared to the GEDI validation data (RMSE = 6.6 m; MAE = 4.45 m, R^2 = 0.62) and available airborne lidar data (RMSE = 9.07 m; MAE = 6.36 m, R^2 = 0.61). The demonstrated integration of GEDI data with time-series optical imagery is expected to enable multidecadal historic analysis and operational forward monitoring of forest height and its dynamics. Such capability is important to support global climate and sustainable development initiatives.

1. Introduction

Forests (defined here as wildland, managed, and planted tree cover) perform essential ecosystem functions that sustain the Earth climate and biosphere and provide a wide array of ecosystem services. Forest ecosystems are functioning as the largest terrestrial carbon storage (Dixon et al., 1994) and sink (Pan et al., 2011). Forest regrowth (natural restoration and tree plantations) is responsible for more than 60% of the forest carbon sink (Pugh et al., 2019), while timber extraction and forest clearing for other land uses are among the largest sources of anthropogenic carbon emissions (Houghton, 1999). Forest restoration, avoiding forest conversion, and sustainable forest management are considered as cost-effective natural climate solutions in stabilizing climate and preventing species extinction (Balmford et al., 2002; Gibson et al., 2011; Griscom et al., 2017).

Spatially exhaustive, multitemporal data on global forest ecosystem structure are required for carbon accounting and parameterizing global-scale biogeochemistry, hydrology, biodiversity, and climate models. Such data are crucial for practical applications including carbon emissions and sequestration reporting, forest degradation assessment, and quantification of the effectiveness of forest restoration initiatives. Specifically, forest canopy height is used to estimate forest aboveground biomass and timber volume, to monitor the effects of forest degradation, to measure the success of forest restoration, and to model other key ecosystem variables such as primary production and biodiversity (Asner et al., 2012; Goetz and Dubayah, 2011). Traditionally, tree height has been measured in the field, and more recently, using Airborne Laser Scanning (ALS) systems. Both methods are expensive and impractical over large geographic extents. Satellite-based forest canopy height earth observation data have previously been limited to NASA GLAS (ICESat) and more recently to ATLAS (ICESat-2) lidar instruments (Lefsky, 2010; Simard et al., 2011; Popescu et al., 2018). However, these instruments are not optimized for vegetation mapping (Montesano et al., 2015; Hansen et al., 2016).

The NASA Global Ecosystem Dynamics Investigation (GEDI) is a new spaceborne lidar instrument operating onboard the International Space Station (ISS) and has been collecting data since April 2019 (Dubayah et al., 2020a). GEDI is a full waveform lidar specifically designed for

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https://doi.org/10.1016/j.rse.2020.112165
Received 21 August 2020; Received in revised form 16 October 2020; Accepted 23 October 2020
Available online 7 November 2020
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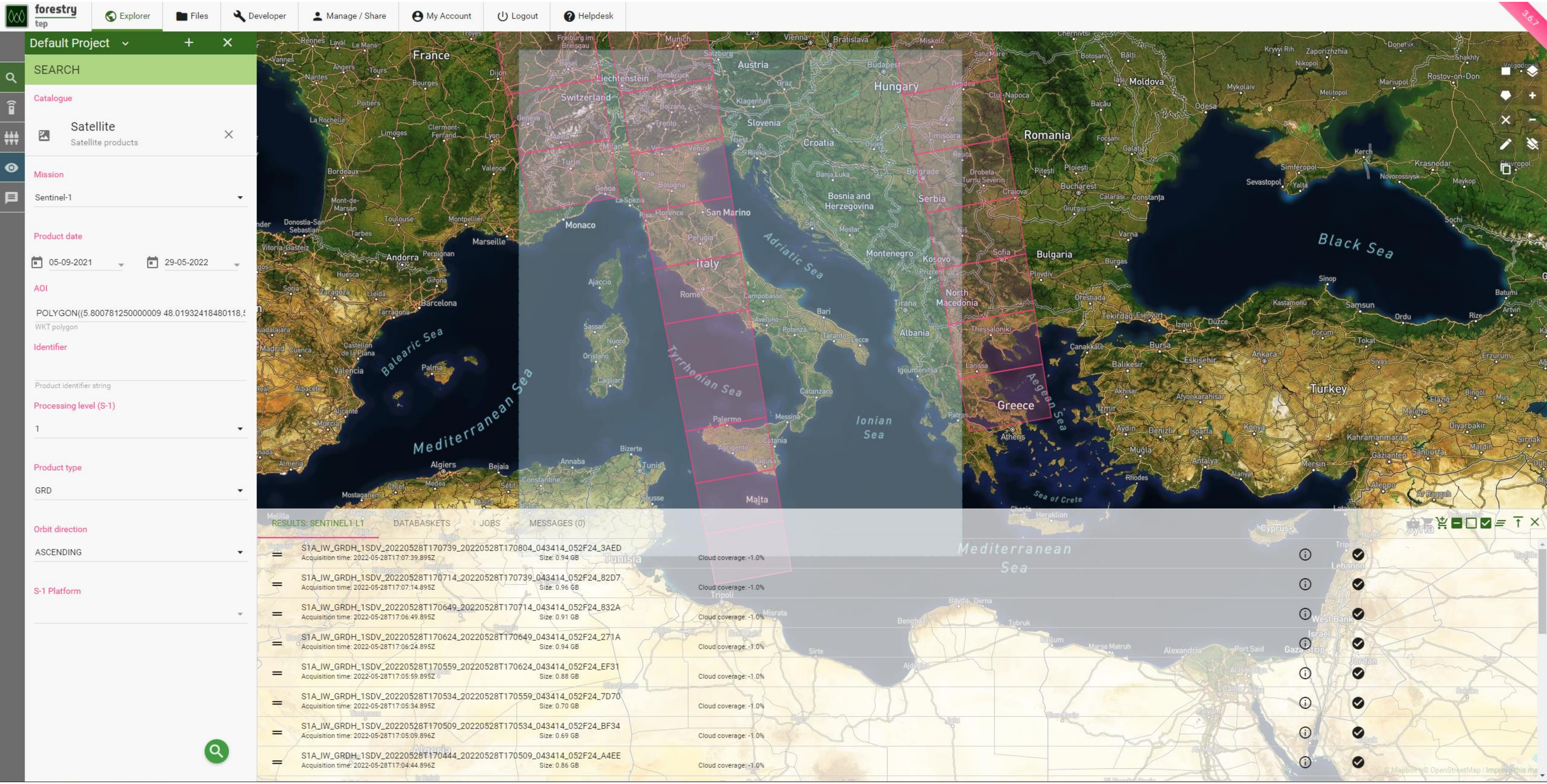
ECOSYSTEM LIDAR

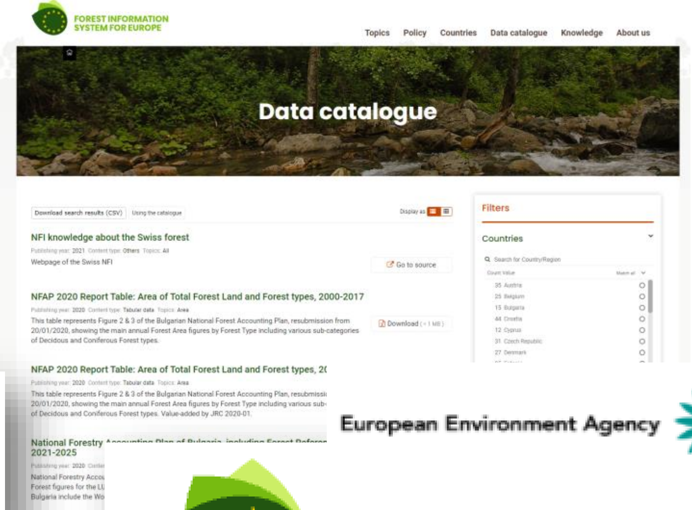
F-tep: la risposta Europea a Google Earth Engine?



Food and Agriculture Organization of the United Nations
for a world without hunger

FAO: FRA, EarthM

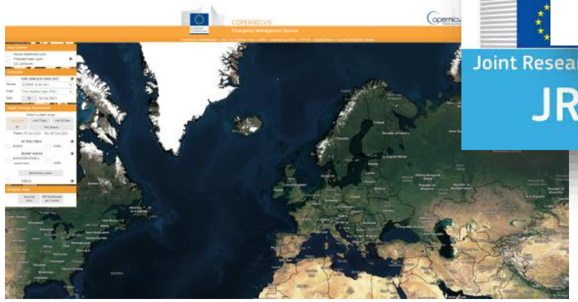
https://earthmap.



European Environment Agency

FOREST INFORMATION SYSTEM FOR EUROPE

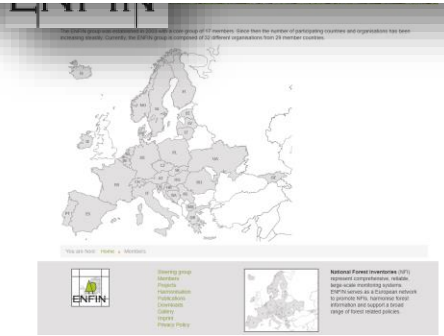
https://forest.eea.europa.eu/



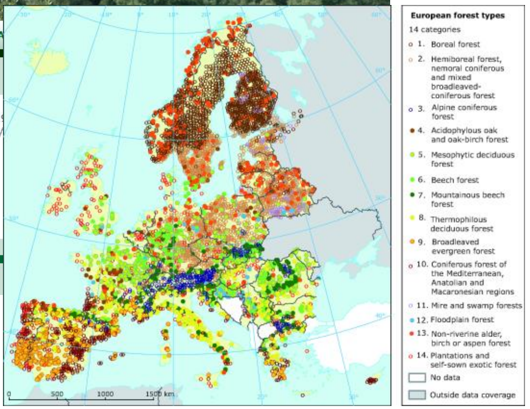
Joint Research Centre
JRC

EFFIS, Trees Atlas, EFDAC, …

https://forest.jrc.ec.europa.eu/en/



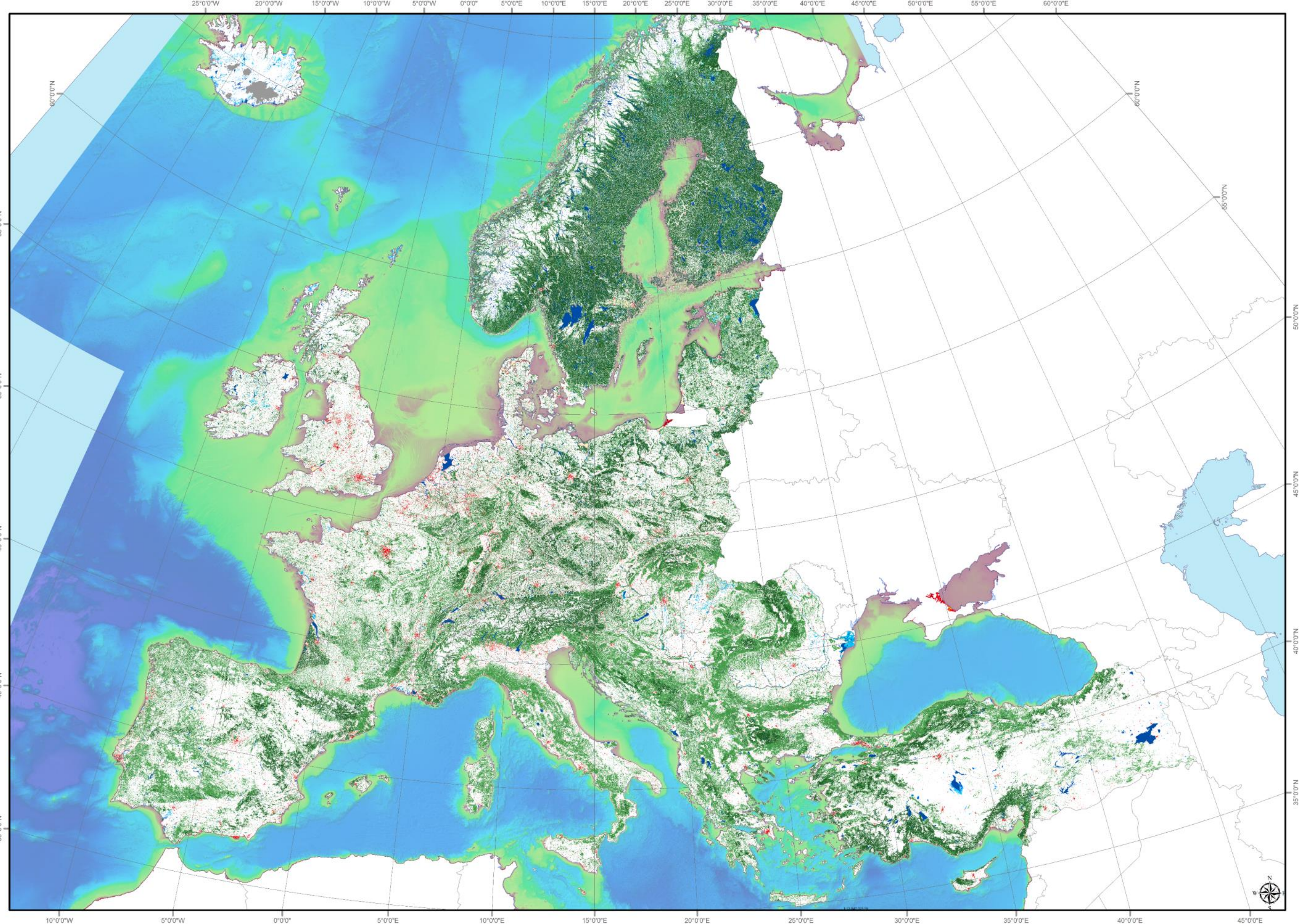
http://enfin.info/



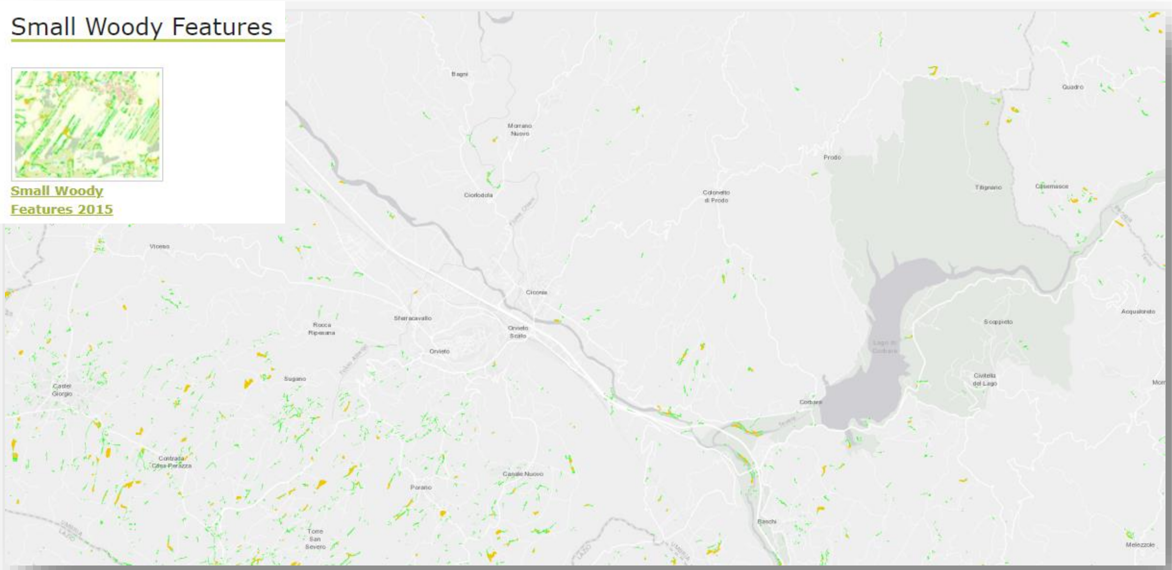
http://icp-forests.net/

Copernicus High Resolution Layers

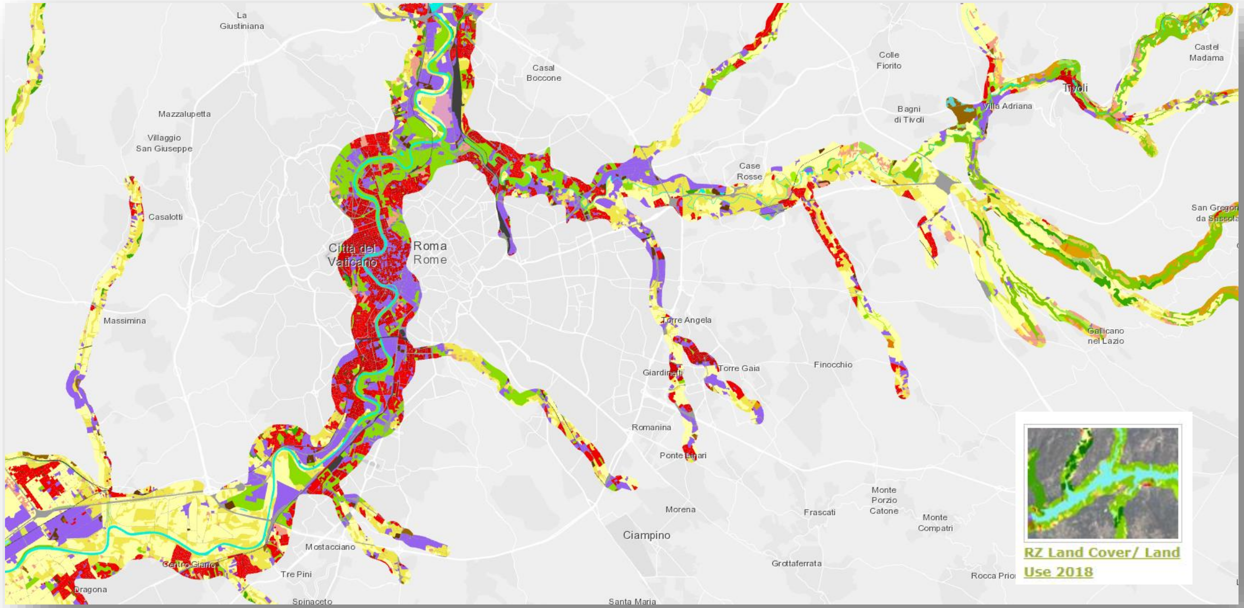
«Forest Type Map»
10 m resolution
2018
Coniferous/Broadleaves

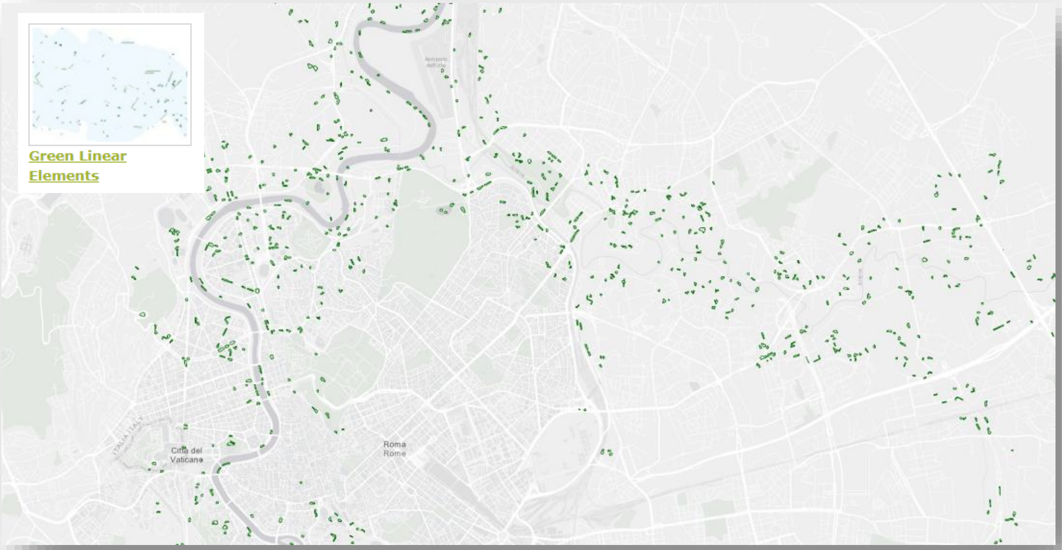


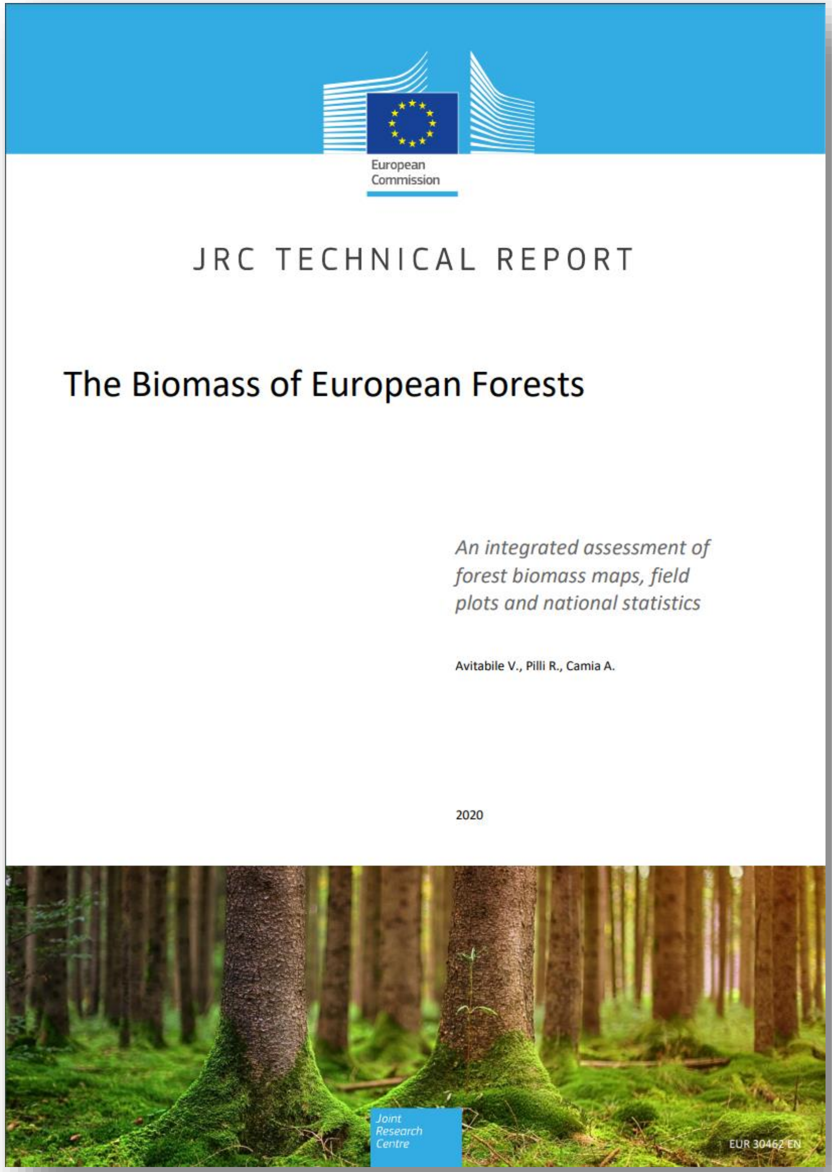
Copernicus
Europe's eyes on Earth



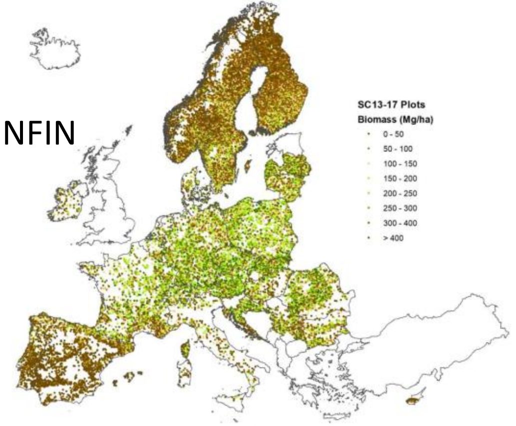
Riparian Zones (RZ)

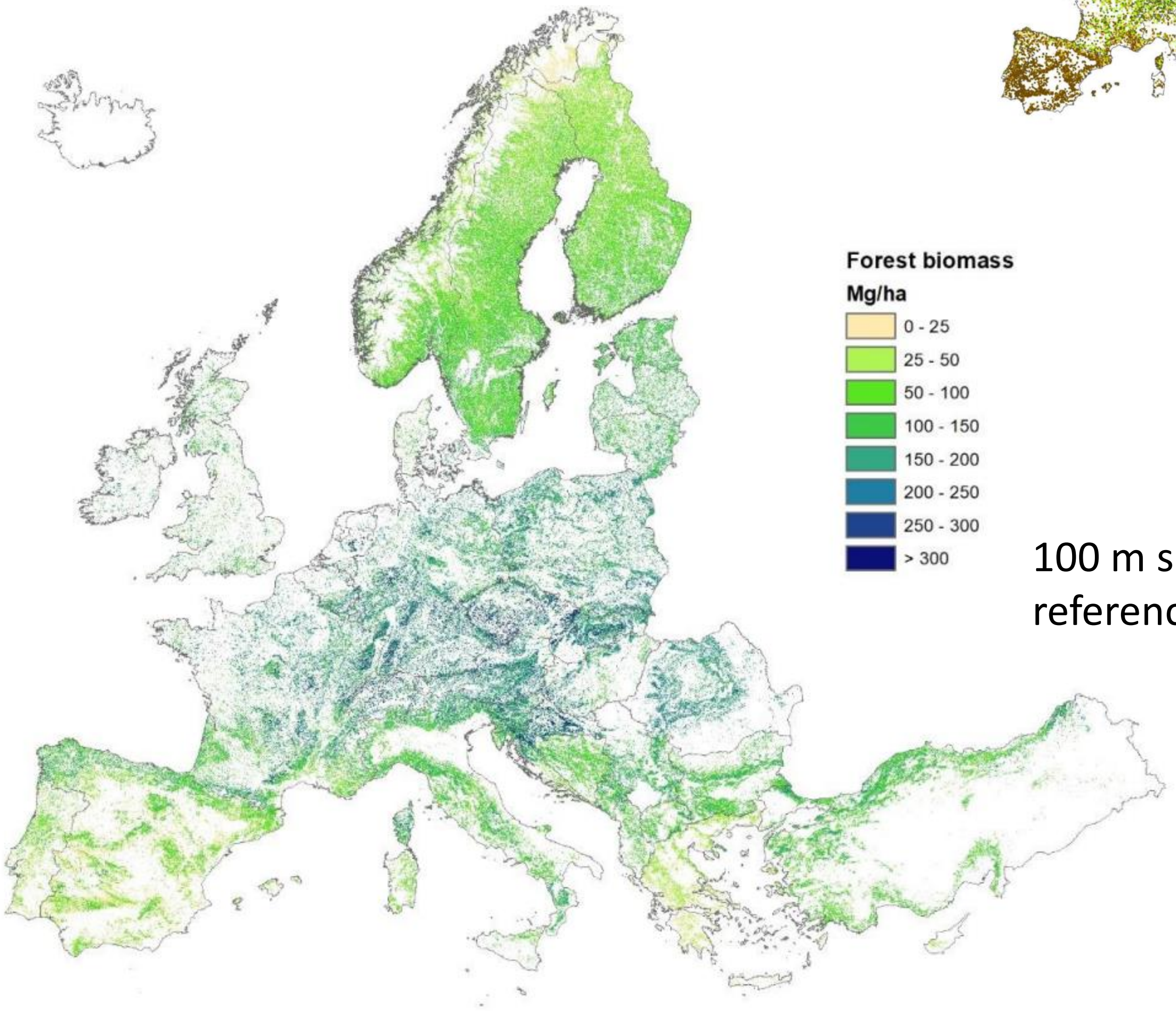






22166 NFI plots
SC13-17
from framework contract JRC-ENFIN





100 m spatial resolution
reference year 2010

Avitabile, V., Pilli, R. and Camia, A., The Biomass of European Forests, EUR 30462 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-26101-8, doi:10.2760/311876, JRC122635.

Ma in Europa manca ancora ma cartografia forestale

Natural Resources Canada | Ressources naturelles Canada

Forest composition across Canada

Canada's forests contain many tree species. Grouping species according to genus makes it easier to see where trees of different types are dominant.

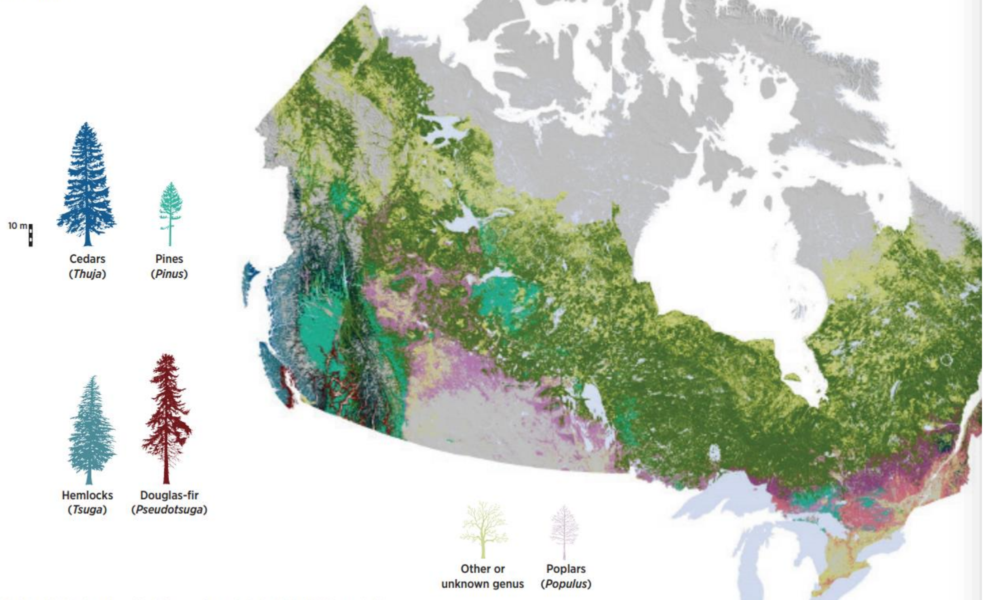
For example, moving northward from Canada's most densely populated areas in Ontario and Quebec, one passes first through maple-dominated forests, then through birch, and on into the spruces (including black spruce, white spruce and others) that dominate the boreal zone, a broad sweep of land from Yukon to Newfoundland and Labrador.

The forests around Canada's prairies are dominated by poplars (including trembling aspen and balsam poplar), but these species can also be found almost anywhere in Canada. Pines, too, are common throughout Canada, but are especially dominant in areas where forest fires have occurred frequently.

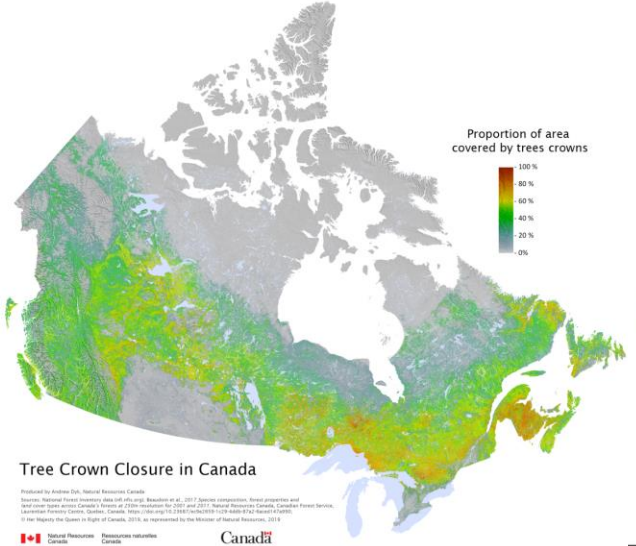
The West Coast is dominated by forests of

East Coast are heavily mixed and species ri

Faded colours on the map represent less d of each genus, to represent that genus and different parts of Canada.



Sources: Beaudoin, A., Bernier, P., et al. 2014. Mapping attributes of Canada's forests at moderate resolution through kNN and MODIS imagery. Canadian Journal of Forest Research. DOI: 10.1139/cjfr-2013-0401; Canada's National Forest Inventory; Silhouettes reproduced from Trees in Canada by J.L. Farrar, 1995.



Remote Sensing of Environment 209 (2018) 90–106

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

ELSEVIER

Large-area mapping of Canadian boreal forest cover, height, biomass and other structural attributes using Landsat composites and lidar plots

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A R T I C L E I N F O

Keywords:
Lidar
Landsat
Forest structure
Monitoring
Imputation
Random Forest

A B S T R A C T

Passive optical remotely sensed images such as those from the Landsat satellites enable the development of spatially comprehensive, well-calibrated reflectance measures that support large-area mapping. In recent years, as an alternative to field plot data, the use of Light Detection and Ranging (lidar) acquisitions for calibration and validation purposes in combination with such satellite reflectance data to model a range of forest structural response variables has become well established. In this research, we use a predictive modeling approach to map forest structural attributes over the ~552 million ha boreal forest of Canada. For model calibration and independent validation we utilize airborne lidar-derived measurements of forest vertical structure (known as lidar plots) obtained in 2010 via a > 25,000 km transect-based national survey. Models were developed linking the lidar plot structural variables to wall-to-wall 30-m spatial resolution surface reflectance composites derived from Landsat Thematic Mapper and Enhanced Thematic Mapper Plus imagery. Spectral indices extracted from the composites, disturbance information (years since disturbance and type), as well as geographic position and topographic variables (i.e., elevation, slope, radiation, etc.) were considered as predictor variables. A nearest neighbor imputation approach based on the Random Forest framework was used to predict a total of 10 forest structural attributes. The model was developed and validated on > 80,000 lidar plots, with R^2 values ranging from 0.49 to 0.61 for key response variables such as canopy cover, stand height, basal area, stem volume, and aboveground biomass. Additionally, a predictor variable importance analysis confirmed that spectral indices, elevation, and geographic coordinates were key sources of information, ultimately offering an improved understanding of the driving variables for large-area forest structure modeling. This study demonstrates the integration of airborne lidar and Landsat-derived reflectance products to generate detailed and spatially extensive maps of forest structure. The methods are portable to map other attributes of interest (based upon calibration data) through access to Landsat or other appropriate optical remotely-sensed data sources, thereby offering unique opportunities for science, monitoring, and reporting programs.

1. Introduction

In Canada, forest ecosystems are a mosaic of trees, wetlands, and lakes, occupying an area of ~650 million ha (Wulder et al., 2008b), with a treed area of 347 million ha (Natural Resources Canada, 2016). The boreal forest, an important source of both renewable and non-renewable resources, occupies an area of 552 million ha (with 270 million ha of trees) and forms an east-west band across the country, representing a range of climatic, physiographic, and vegetation conditions (Brandt, 2009). To effectively implement sustainable management and development practices aiming at accommodating both conservation (e.g., preservation of wildlife habitats) and human use needs (e.g., building materials, fuels), boreal forests require comprehensive, timely, and accurate inventory and monitoring efforts. To this end, data collection campaigns are necessary to characterize and map forest structure, determining attributes such as canopy cover, height, biomass, stem volume as well as age, species, land-cover, and disturbance history (White et al., 2014).

The availability of accurate national forest structural information, often collected following sample-based inventories (Tomppo et al., 2010), is the foundation for satisfying a variety of science and policy information needs as well as for meeting national and international

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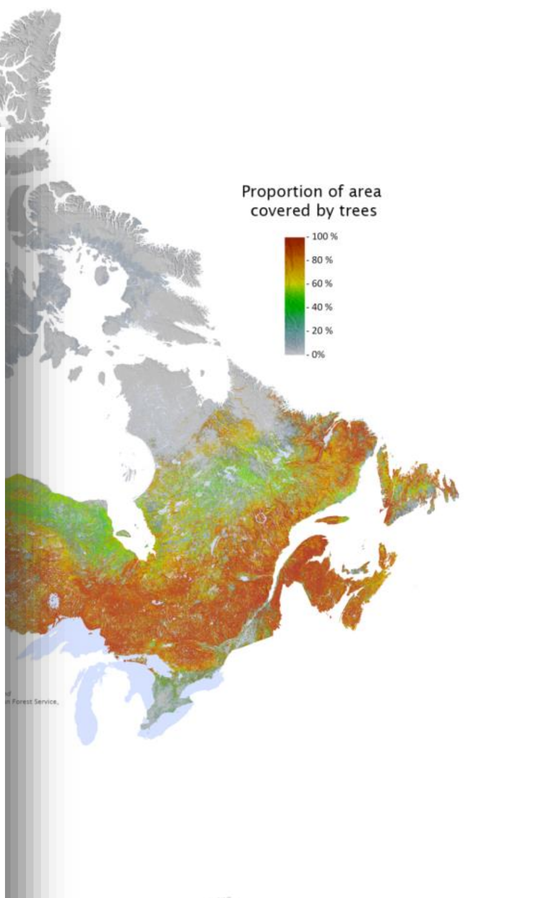
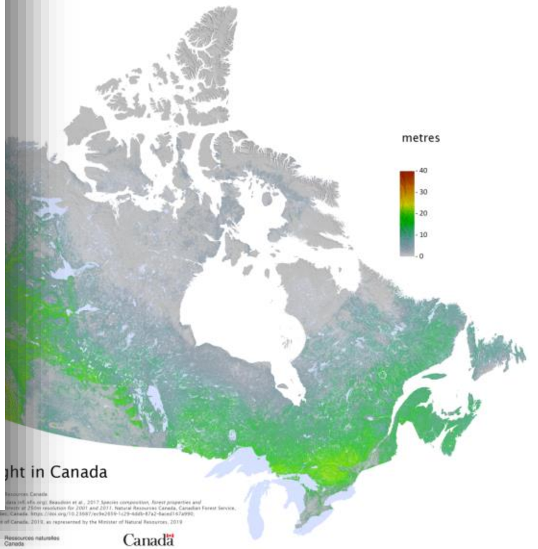
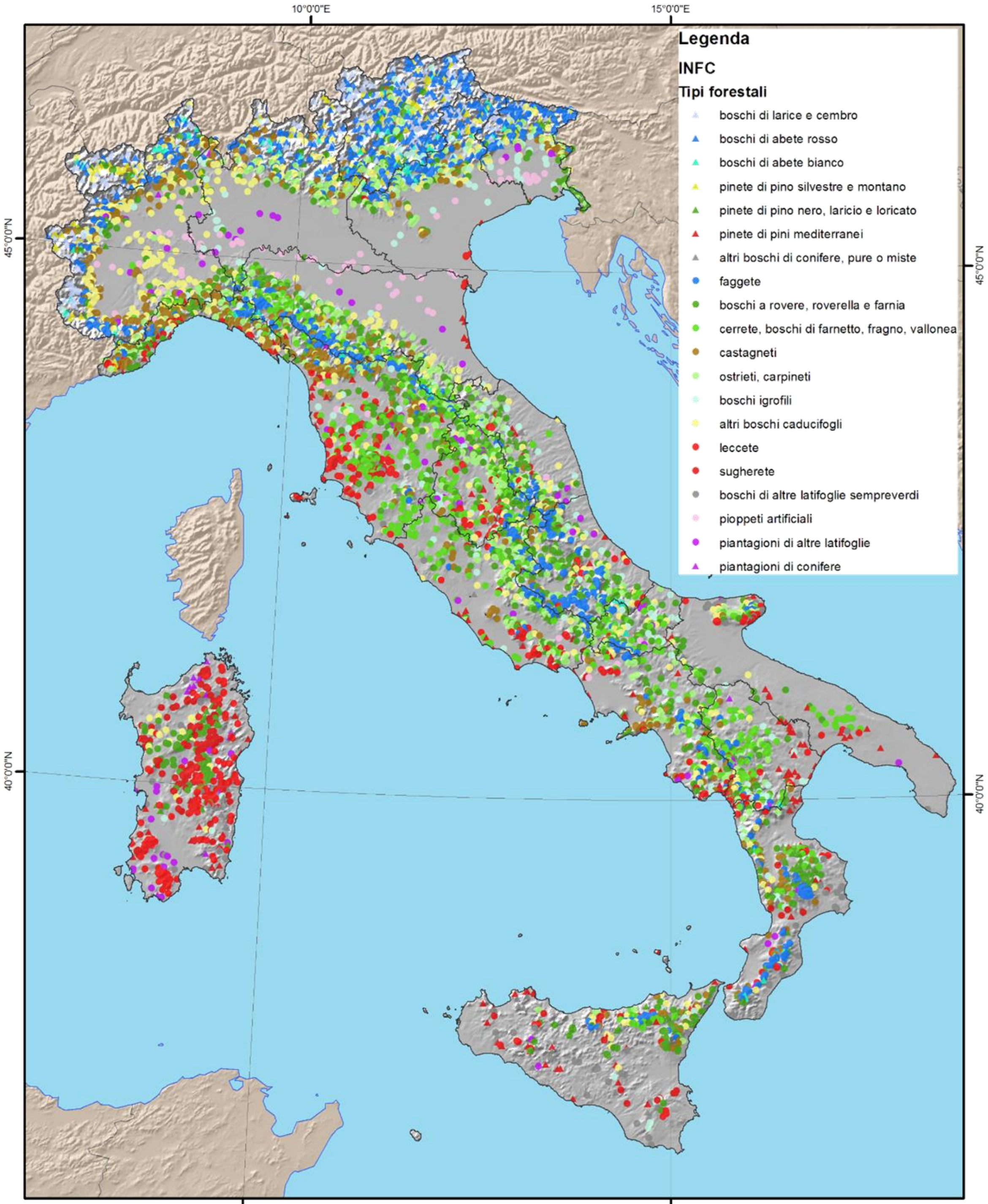
https://doi.org/10.1016/j.rse.2017.12.020
Received 15 June 2017; Received in revised form 5 December 2017; Accepted 15 December 2017
Available online 19 March 2018



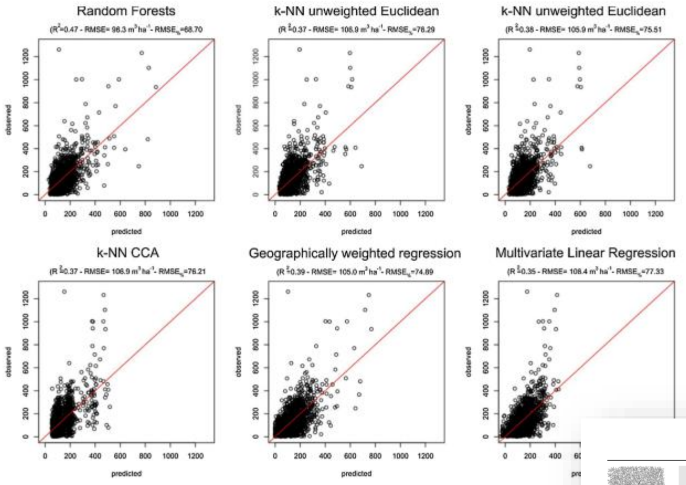


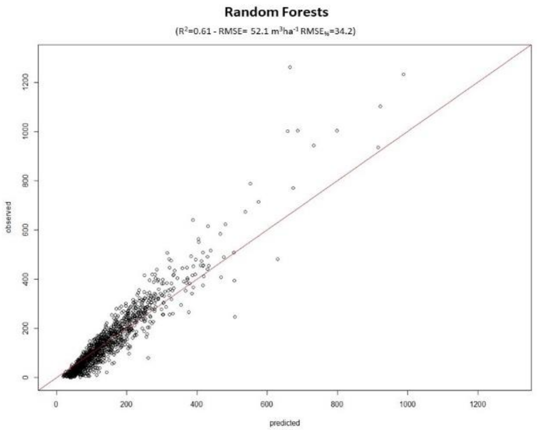
...e in Italia?

Da INFC2005 a INFC2015



National application





Int J Appl Earth Obs Geoinformation 84 (2020) 101959

Contents lists available at ScienceDirect

Int J Appl Earth Obs Geoinformation

journal homepage: www.elsevier.com/locate/jag

ELSEVIER

Wall-to-wall spatial prediction of growing stock volume based on Italian National Forest Inventory plots and remotely sensed data

Gherardo Chirici[a], Francesca Giannetti[a], Ronald E. McRoberts[b,c], Davide Travaglini[a], Matteo Pecchi[a], Fabio Maselli[d], Marta Chiesi[d], Piermaria Corona[e]

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ARTICLE INFO

Keywords:
National Forest Inventory
Spatial estimation
Growing stock
Landsat
Italy
Growing stock volume

ABSTRACT

Spatial predictions of forest variables are required for supporting modern national and sub-national forest planning strategies, especially in the framework of a climate change scenario. Nowadays methods for constructing wall-to-wall maps and calculating small-area estimates of forest parameters are becoming essential components of most advanced National Forest Inventory (NFI) programs. Such methods are based on the assumption of a relationship between the forest variables and predictor variables that are available for the entire forest area. Many commonly used predictors are based on data obtained from active or passive remote sensing technologies. Italy has almost 40% of its land area covered by forests. Because of the great diversity of Italian forests with respect to composition, structure and management and underlying climatic, morphological and soil conditions, a relevant question is whether methods successfully used in less complex temperate and boreal forests may be applied successfully at country level in Italy.

For a study area of more than 48,657 km^2 in central Italy of which 43% is covered by forest, the study presents the results of a test regarding wall-to-wall, spatially explicit estimation of forest growing stock volume (GSV) based on field measurement of 1350 plots during the last Italian NFI. For the same area, we used potential predictor variables that are available across the whole of Italy: cloud-free mosaics of multispectral optical satellite imagery (Landsat 5 TM), microwave sensor data (JAXA PALSAR), a canopy height model (CHM) from satellite LiDAR, and auxiliary variables from climate, temperature and precipitation maps, soil maps, and a digital terrain model.

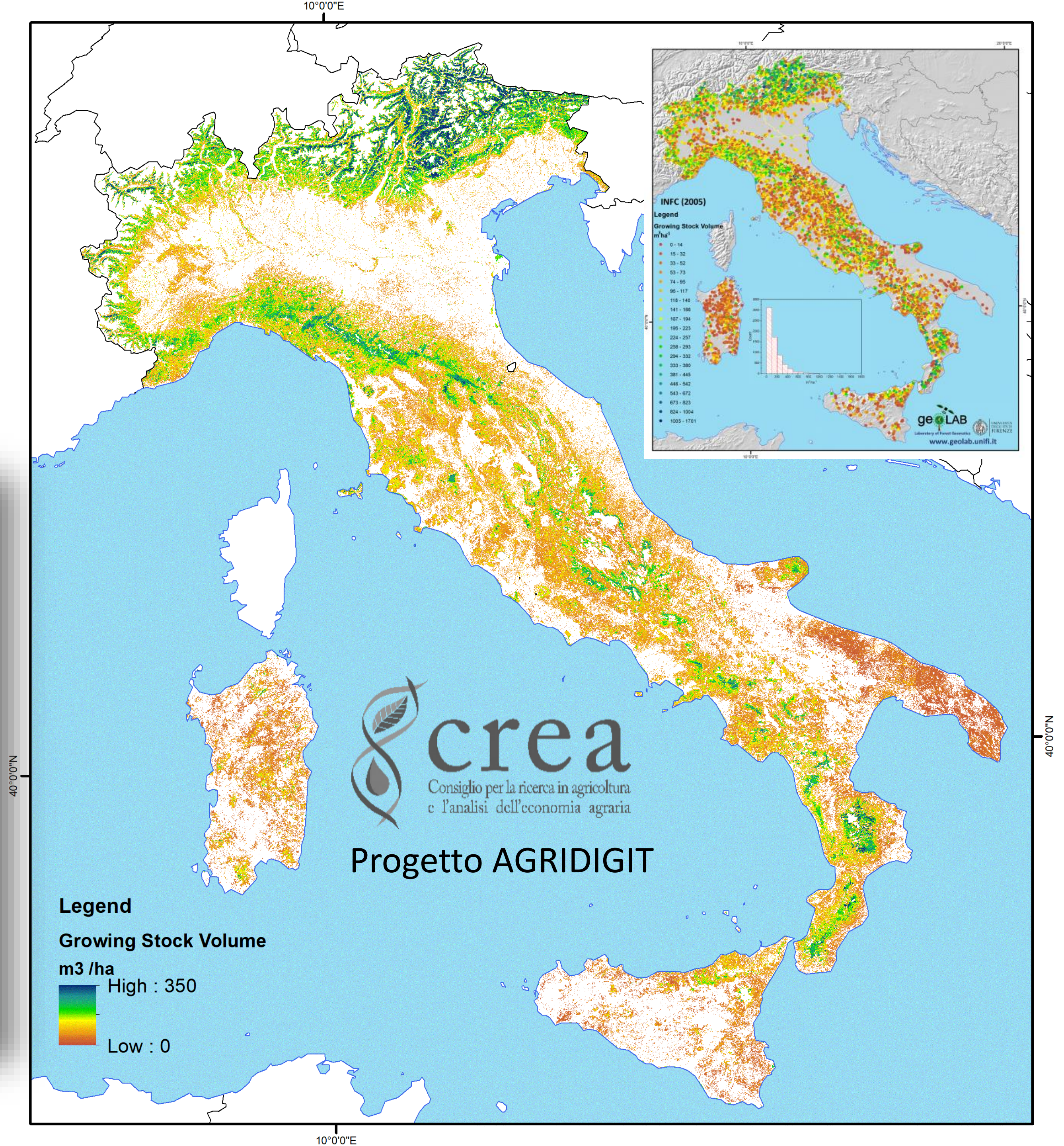
Two non-parametric (random forests and k-NN) and two parametric (multiple linear regression and geographically weighted regression) prediction methods were tested to produce wall-to-wall map of growing stock volume at 23-m resolution. Pixel level predictions were used to produce small-area, province-level model-assisted estimates. The performances of all the methods were compared in terms of percent root mean-square error using a leave-one-out procedure and an independent dataset was used for validation. Results were comparable to those available for other ecological regions using similar predictors, but random forests produced the most accurate results with a pixel level R^2 = 0.69 and $RMSE_{\%}$ = 37.2% against the independent validation dataset. Model-assisted estimates were more precise than the original design-based estimates provided by the NFI.

1. Introduction

Forest data are essential for multiple purposes including international and national forest monitoring programs, reporting and assessing forest resource distribution (e.g. Kyoto protocol) (Corona et al., 2011; FAO, 2010), monitoring biodiversity (Chirici et al., 2012; FOREST EUROPE, 2015), improving restoration programs (FAO and UNCCD, 2015; Smith et al., 2016) and managing at local scales to improve decision-making processes, silvicultural measures, harvesting and conservation activities.

Usually, in the context of international and national programs, this type of data is collected using sample-based National Forest Inventories (NFIs) that are designed to provide aggregated estimates of forest parameters such as forest area, growing stock volume, biomass, increments at national and regional levels (Brosofske et al., 2014; Kangas et al., 2018). These aggregated statistics are essential to support decision-making processes and to develop strategies over large areas only, because they just provide limited explicit geographic spatial detail, such as large sub-national regions. In these traditional NFIs, remote sensing is used for purposes such as initial stratification of sampling units

https://doi.org/10.1016/j.jag.2019.101959
Received 17 May 2019; Received in revised form 8 August 2019; Accepted 2 September 2019
Available online 03 October 2019



Earth Engine

Data in Brief 42 (2022) 108297

Contents lists available at ScienceDirect

Data in Brief

journal homepage: www.elsevier.com/locate/dib

Data Article

A Sentinel-2 derived dataset of forest disturbances occurred in Italy between 2017 and 2020

Saverio Francini [a,b,*], Gherardo Chirici [a,b]

[a] Department of Agriculture, Food, Environment and Forestry, Università degli Studi di Firenze, Via San Bonaventura, 13, 50145 Firenze, Italy
[b] Fondazione per il Futuro delle Città, Firenze, Italy

A R T I C L E I N F O

Article history:
Received 21 March 2022
Revised 9 May 2022
Accepted 16 May 2022
Available online 21 May 2022

Dataset link: A Sentinel-2 derived dataset of forest disturbance occurred in Italy between 2017 and 2020 (Original data)

Keywords:
Google Earth Engine
Remote Sensing
Open-access
Big data
Cloud computing
forest fires
wind damages
forest harvestings

A B S T R A C T

Forests absorb 30% of human emissions associated with fossil fuel burning. For this reason, forest disturbances monitoring is needed for assessing greenhouse gas balance. However, in several countries, the information regarding the spatio-temporal distribution of forest disturbances is missing. Remote sensing data and the new Sentinel-2 satellite missions, in particular, represent a game-changer in this topic.
Here we provide a spatially explicit dataset (10-meters resolution) of Italian forest disturbances and magnitude from 2017 to 2020 constructed using Sentinel-2 level-1C imagery and exploiting the Google Earth Engine GEE implementation of the 3I3D algorithm. For each year between 2017 and 2020, we provide three datasets: (i) a magnitude of the change map (between 0 and 255), (ii) a categorical map of forest disturbances, and (iii) a categorical map obtained by stratification of the previous maps that can be used to estimate the areas of several different forest disturbances. The data we provide represent the state-of-the-art for Mediterranean ecosystems in terms of omission and commission errors, they support greenhouse gas balance, forest sustainability assessment, and decision-makers forest managing, they help forest companies to monitor forest harvestings activity over space

DOI of original article: 10.1016/j.jag.2021.102663
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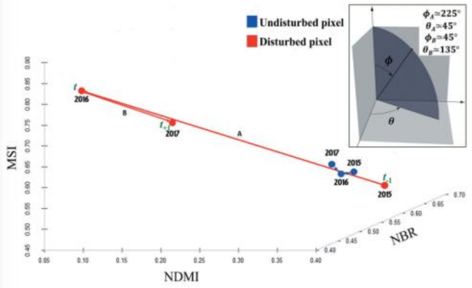
https://doi.org/10.1016/j.dib.2022.108297

Fig. 1. Forest disturbances predicted in Italy between 2017 and 2020 using the 3I3D algorithm. The percentage of the forests that were disturbed over Italy considering the whole period is shown in the largest panel using a pixel size of 1-km. The four smaller panels (a-d) show zooms of the disturbance boolean maps.



INTERNATIONAL JOURNAL OF REMOTE SENSING
2021, VOL. 42, NO. 12, 4693–4711
https://doi.org/10.1080/01431161.2021.1899334

Taylor & Francis
Taylor & Francis Group

The Three Indices Three Dimensions (3I3D) algorithm: a new method for forest disturbance mapping and area estimation based on optical remotely sensed imagery

Saverio Francini [a,b,c], Ronald E. McRoberts [d], Francesca Giannetti [a], Marco Marchetti [b], Giuseppe Scarascia Mugnozza [c] and Gherardo Chirici [a]

[a] Department of Agriculture, Food, Environment and Forestry, Università Degli Studi Di Firenze, Firenze, Italy; [b] Dipartimento Di Bioscienze E Territorio, Università Degli Studi Del Molise, Isernia, Italy; [c] Dipartimento per l'Innovazione Dei Sistemi Biologici, Agroalimentari E Forestali, Università Degli Studi Della Tuscia, Viterbo, Italy; [d] Department of Forest Resources, University of Minnesota, Saint Paul, Minnesota, USA

ABSTRACT
Although estimating forest disturbance area is essential in the context of carbon cycle assessments and for strategic forest planning projects, official statistics are currently not available in several countries. Remotely sensed data are an efficient source of auxiliary information for meeting these needs, and multiple algorithms are commonly used worldwide for this purpose. However, both more accurate maps and precise area estimates are strongly required, especially in Mediterranean ecosystems, and scientific research in this topic area is anything but concluded.
In this study, we present the new Three Indices Three Dimensions (3I3D) algorithm for the automated prediction of forest disturbances using statistical analyses of Sentinel-2 data. We tested 3I3D in Tuscany, Italy, for the year 2016, and we compared the results to those obtained using the Global Forest Change Map (GFC), LandTrendr (LT), and the Two Thresholds Method (TTM). The 3I3D map was the most accurate (*omissions* = 27%, *commissions* = 30%) followed by TTM (*omissions* = 35%, *commissions* = 39%), LT (*omissions* = 41%, *commissions* = 43%) and lastly GFC with slightly fewer *omissions* than LT (39%) but with many more *commissions* (69%). We also presented a probability sampling framework to estimate the forest harvested area using a model-assisted estimator that can be used at an operational level to produce large-scale statistics. 3I3D and TTM produced the smallest standard errors of the area estimates (8%) followed by LT (13%) and GFC (17%).

ARTICLE HISTORY
Received 10 November 2020
Accepted 13 February 2021

1. Introduction

Environmental problems arising from forest degradation, deforestation and human land use are greater than ever and are increasing rapidly (Ramankutty et al. 2007). In this context, and in view of climate change, sustainable management of forest ecosystems is essential (FAO, 2015) because forest growth offsets a substantial proportion of carbon

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Supplemental data for this article can be accessed here.

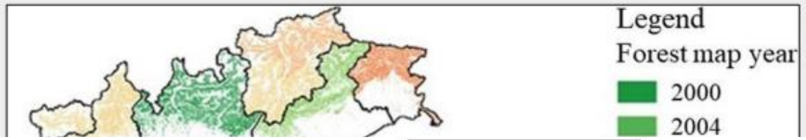
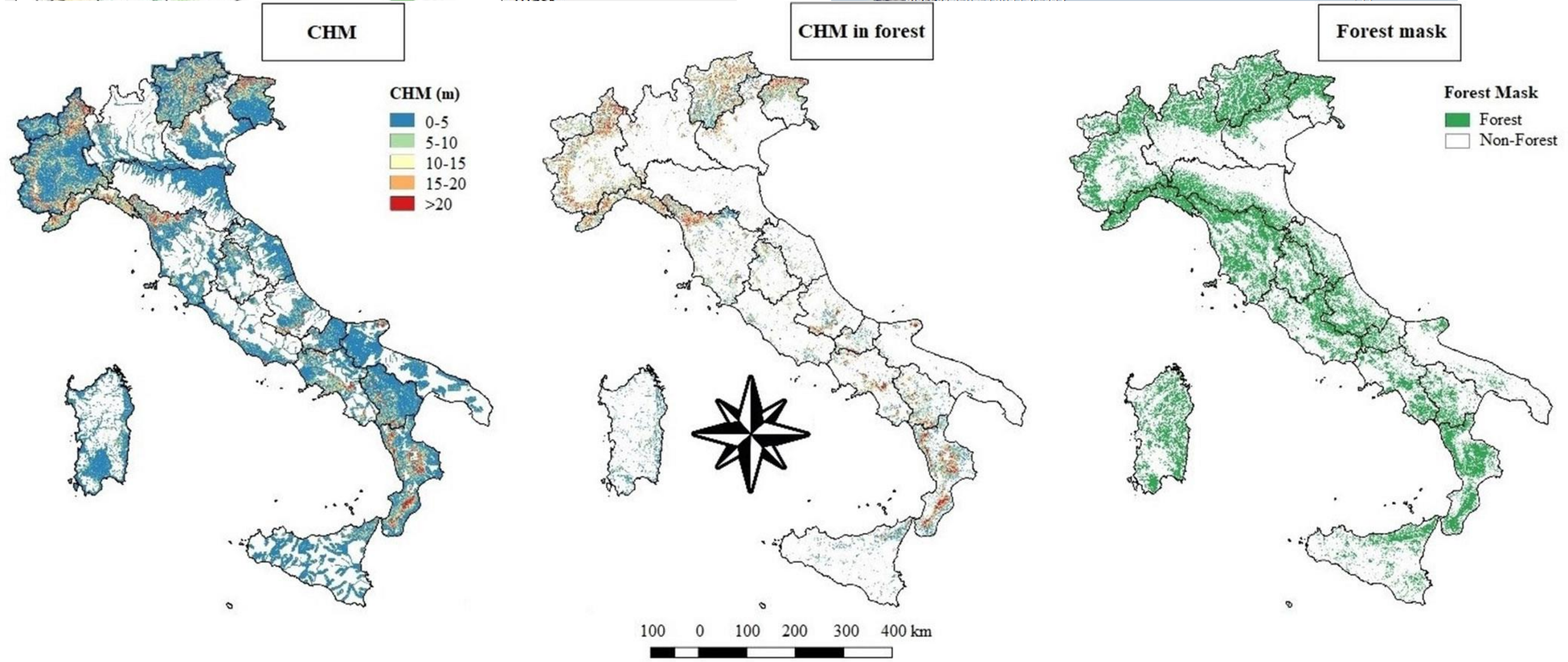
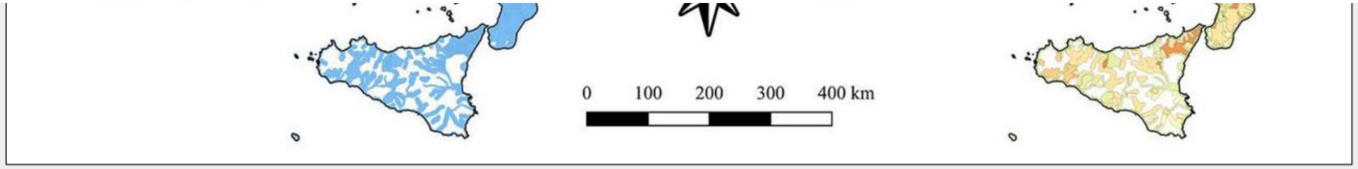


Fig. 1 - Acquisition year of local maps used to create the high resolution forest mask

iForest
Biogeosciences and Forestry
Research Article
doi: 10.3832/ifor3648-014
vol. 14, pp. 144-154

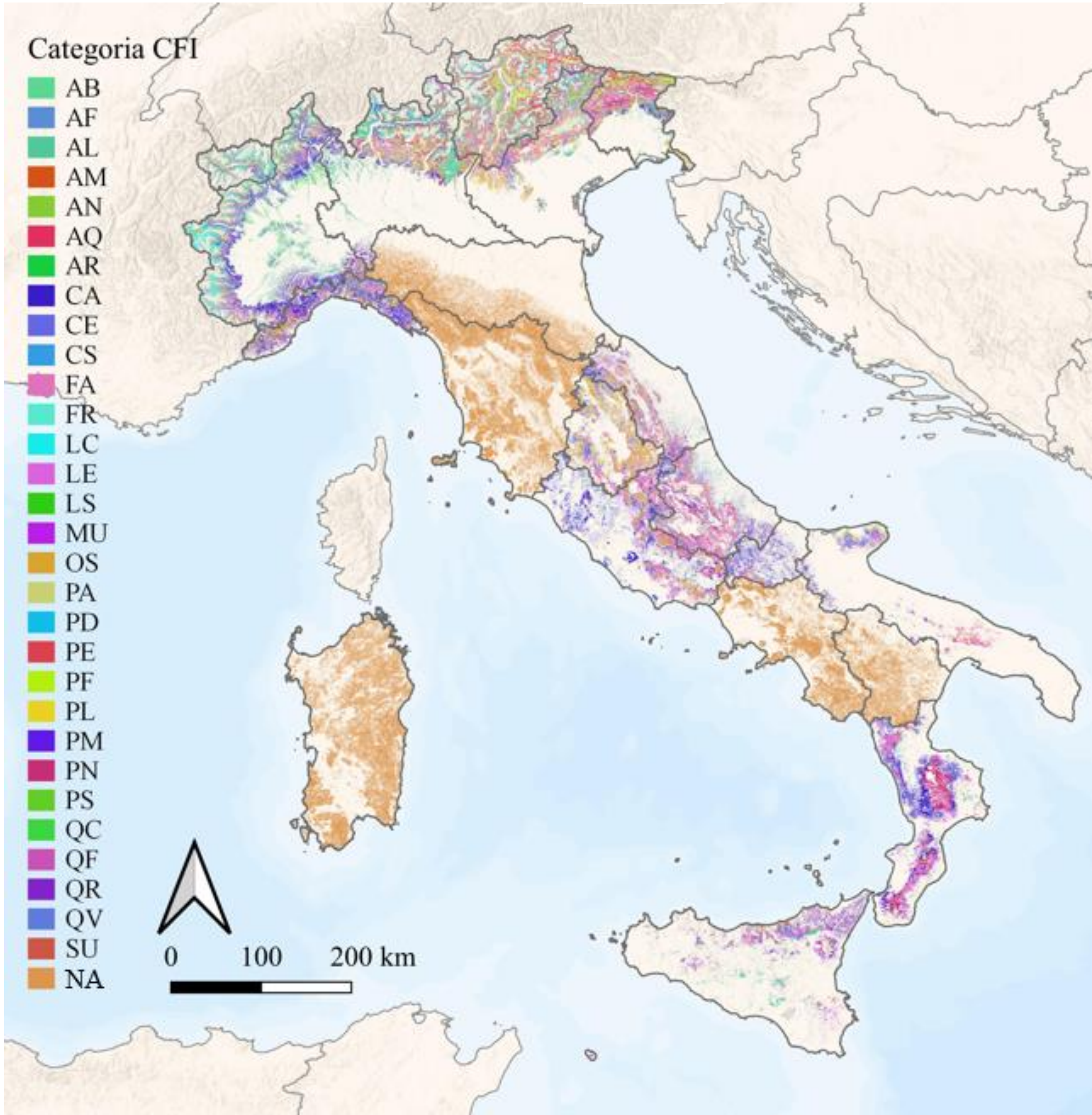




Prototipo della Carta Forestale Italiana

Scala 1:10.000
Multidefinizione

Regione	Carta Forestale con nomenclatura	Carta forestale senza nomenclatura	Nomenclatura locale
Abruzzo	X		X
Basilicata		X	X
P.A. Bolzano	X		X
Calabria	X		X
Campania			Definita
Emilia-Romagna		X	X
FVG	X		X
Lazio	X		X
Liguria	X		X
Lombardia	X		X
Marche	X		X
Molise	X		X
Piemonte	X		X
Puglia	X		X
Sardegna		X	Definita
Sicilia	X		X
Toscana		X	X
P.A. Trento	X		X
Umbria	X		X
Valle d'Aosta	X		X
Veneto	X		X



RESONATE
Resilient Forests for Society

European Forest Information Network - EFINET

EFINET

ForestPaths
CO-DESIGNING HOLISTIC FOREST-BASED POLICY PATHWAYS FOR CLIMATE CHANGE MITIGATION
Duration: September 2022 – February 2027

W E

Forest Navigator

Navigating european forests and forest bioeconomy sustainably to EU climate neutrality

SUPERB
Upscaling Forest Restoration

I-MAESTRO

Innovative forest management strategies for a resilient bioeconomy under climate change and disturbances