ENVIRONMENTAL CRIMES WORKSHOP 2024
11-12 June 2024 | ESA-ESRIN, Frascati, Italy

Geospatial intelligence to identify illegal forest logging: user requirements perspective

Filipponi F.[1], Agrillo E.[2], Pezzarossa A.[2], Calcagni L.[2], Bonora N.[2]

1 Italian National Research Council (CNR)

2 Italian Institute for Environmental Protection and Research (ISPRA)

Geospatial Intelligence

"GEOINT encompasses all aspects of imagery and geospatial information and services. It includes, but is not limited to the analysis of literal imagery; geospatial data; and information technically derived from the processing, exploitation, literal, and non-literal analysis of spectral, spatial, and temporal fused products. These types of data can be collected on stationary and moving targets by electro-optical, synthetic aperture radar, related sensor programs, and non-technical means (to include geospatial information acquired by personnel in the field)."

Retired Air Force Lt. Gen. James R. Clapper, October 2005

GEOINT4ENV – Copernicus FPCUP project

Geospatial Intelligence for Environment Protection against illegal activities (GEOINT4ENV) is a top-down activity supported by DG ENV as part of the FPCUP WP 2021

GEOINT4ENV is a FPCUP action supporting the investigation of both public authorities and private entities information needs related to:

- illegal activities affecting the environment
- performance of remote sensing and geospatial intelligence (GEOINT) methods to answer those information needs (where, when, what, why, who)

Activities are performed taking into account the EU context and actions to improve environmental compliance and governance and aim at designing appropriate workflows allowing to collect and process EO space and in-situ data, as needed to produce actionable intelligence to be used in Environmental Compliance Assurance (ECA)

GEOINT4ENV – Copernicus FPCUP project

- **Need analysis**
  - types of non-compliant events
  - current knowledge on patterns and features
  - types of actionable intelligence required
- **Identify methodology**
  - needed to raise warning, measure, quantify, assess, ascertain, produce evidence
- **Prepare and run demonstrations**
  - identify relevant cases
  - collect data
  - apply methodologies to identified cases
  - validate findings
- **Disseminate and report**
  - design and implement the Knowledge–Sharing Platform based on selected cases addressed in demonstration activities gathering information on requirements, methods and data

GEOINT4ENV – Copernicus FPCUP project

Topics

- Illegal building / construction
- Manure spreading
- Air pollution
- Oil Spills
- Detection of floating marine litter
- Waste
- Illegal logging

Illegal logging: overview

Illegal logging is the harvesting of timber in contravention of the laws and regulations of the country of harvest. It is a global problem with significant negative economic, environmental and social impact.

- results in lost revenues and other benefits
- is associated with deforestation, climate change and a loss of biodiversity
- is linked to conflicts over land and resources

Illegal activities also undermine the efforts of responsible operators by making cheaper, but illegal timber and timber products available.

Illegal logging: regulation at EU level

New EU Forest Strategy for 2030

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0572

Stepping up implementation and enforcement of existing EU acquis

Illegal logging is particularly worrying when it concerns **primary** and **old growth forests** or **forest habitats** with very small areas left due to the irreversibility of the damage. A poor implementation of the relevant acquis may also cause **forest degradation** or a **lack** of improvement in **forest conservation status**.

FLEGT Action Plan

Forest Law Enforcement Governance and Trade Action Plan (EU Action to Protect and Restore the World's Forests)

Regulation on deforestation-free products (Regulation (EU) No 2023/1115), which repeals the EU Timber Regulation (Regulation (EU) No 995/2010)

Regulatory references in Italy

National Forestry Strategy (NFS)

https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2018-04-03;34

Provides a long-term (20 year) framework for national and regional forestry policies in line with international and European commitments on **climate change**, **biodiversity protection** and **socio-economic development**. The strategy was approved recently in accordance with the mandate defined by the Legislative Decree No 34 of 3 April 2018 (Testo Unico in materia di Foreste e Filiere forestali).

Purpose:

a) ensure the **conservation of forests** in their extension, distribution, geographical distribution and **ecological diversity**

b) promote the active and **rational management of assets national forestry** in order to guarantee the environmental functions, economic and socio-cultural;

c) to **promote** and protect the **forest economy**, the mountain economy and the respective production chains as well as the development of agro-forestry-pastoral activities;

d) **protect the forest by promoting prevention actions** from natural and anthropic risks, hydrogeological defence, defence against fires and biotic and abiotic adversities, adaptation to climate change, recovery of degraded areas or damaged, carbon sequestration and other disbursement ecosystem services generated by sustainable forest management;

e) promote programming and planning of **forest management interventions** in compliance with the role of the regions and local autonomies.

Illegal logging: interaction with users

Survey to address:

- state of the art on current National/Regional regulations and policies;
- technical and administrative elements that hinder the identification/assessment of the investigated topic;
- the identification of criteria to detect the areas where to monitor illegal activities;
- the minimum requirement in term of spatial and temporal monitoring needs;
- the best delivery timeliness of the mapping products;
- any other relevant information needed to monitor the events.

Illegal logging: interaction with users

Main obstacles (i.e. technical and administrative elements) that hinder the identification / assessment of illegal logging are:

- having a digital platform for planning and monitoring a forestry management
- general lack of surveillance of the territory
- high fragmentation of competence on permission and control, by different territorial authorities, on forestry authorizations issued
- timing on identification to ascertain the offence

Territorial Authorities	Competence level	Capabilities and Functions
National Park	National	Nature Conservation and Protection
Administrative Region	Regional	Government of the regional territory (i.e. forest management, environmental policies etc.)
Environmental Protection Agency	Regional	Environmental monitoring and verification of the application of environmental legislation

Illegal logging: user needs

- Over 30% of Italian user indicate illegal logging occurring outside concession boundaries of a forest management plan
- Ancillary information are required to identify illegal logging using satellite Earth Observation, to exclude authorized logging sites or areas of forest loss related to natural factors (i.e. wildfires, insect outbreaks, wind disturbance)
- Required minimum mapping unit: 1 to 5 hectares
- Optimal update frequency: from weekly to monthly
- Earth Observation products support planning of local authorities in-situ checks for the cases where there is really a high risk of infringement

Method to identify illegall logging

Identification of changes related to forest disturbances

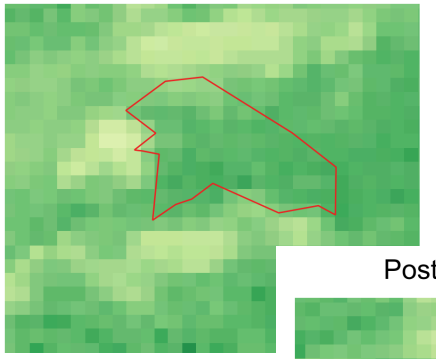
Characterization of changes
(based on spectral and spatio-temporal variability)

Forest logging identification

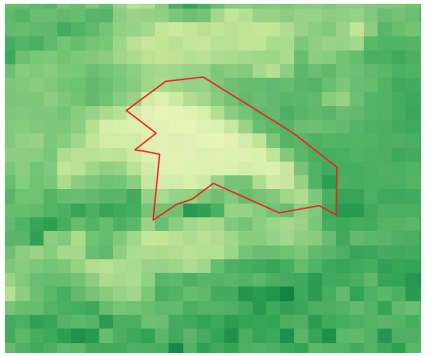
Comparison with authorized logging sites

Illegal logging detection

Pre-logging (2016)



Post-logging (2017)

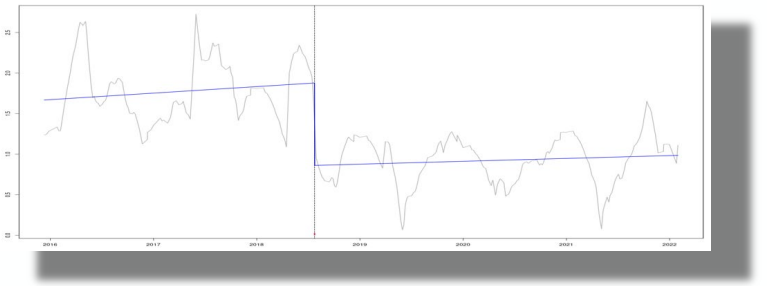


Satellite Earth Observation to identify and characterize illegal logging

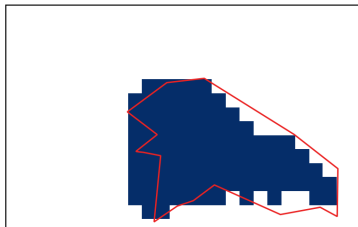
- *Data:* Copernicus Sentinel-2 MSI time series
  Copernicus Sentinel-1 time series

Spatial resolution: 10- 20 m

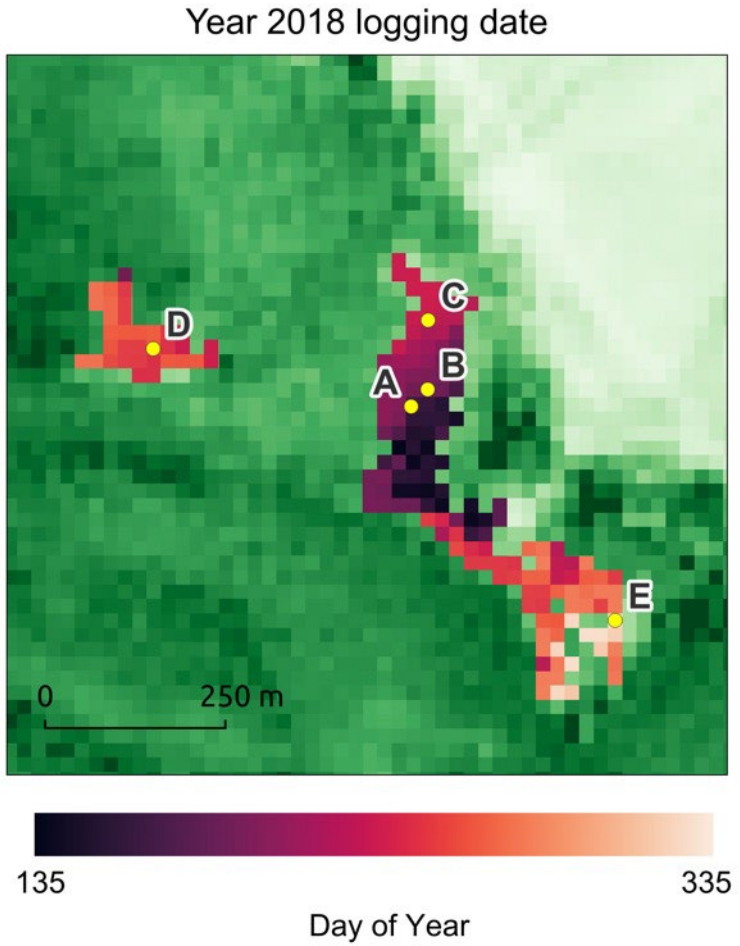
Methodology: time series abrupt changes identification (Bfast), spatio-temporal analysis of changes



Identified logging area

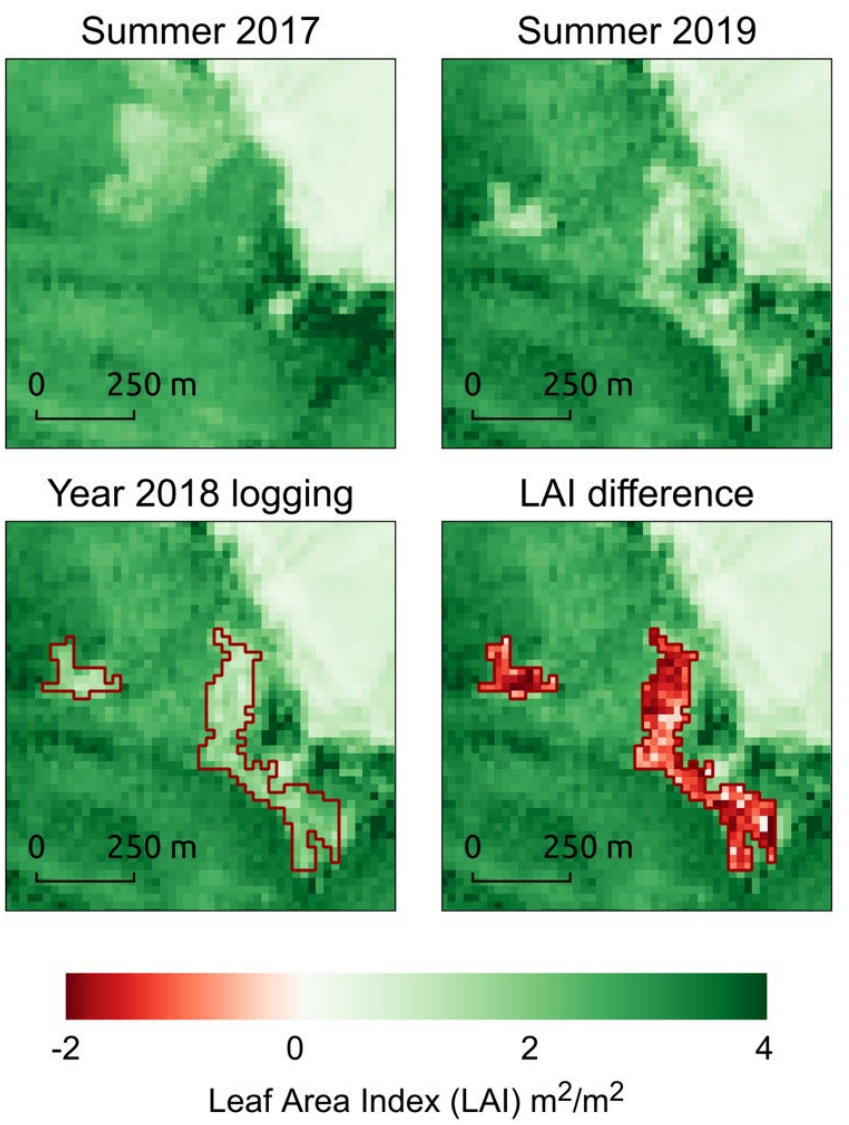


Logging identification - Italy



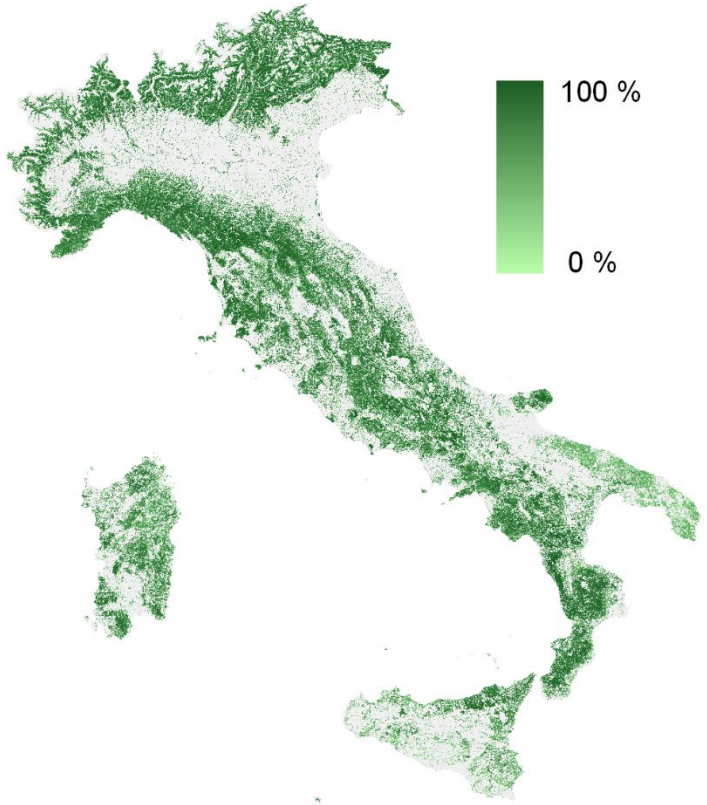
Quantify forest disturbance

Time series analysis allows
to quantify loss
in terms of biophysical
parameters:
Leaf Area Index (LAI)

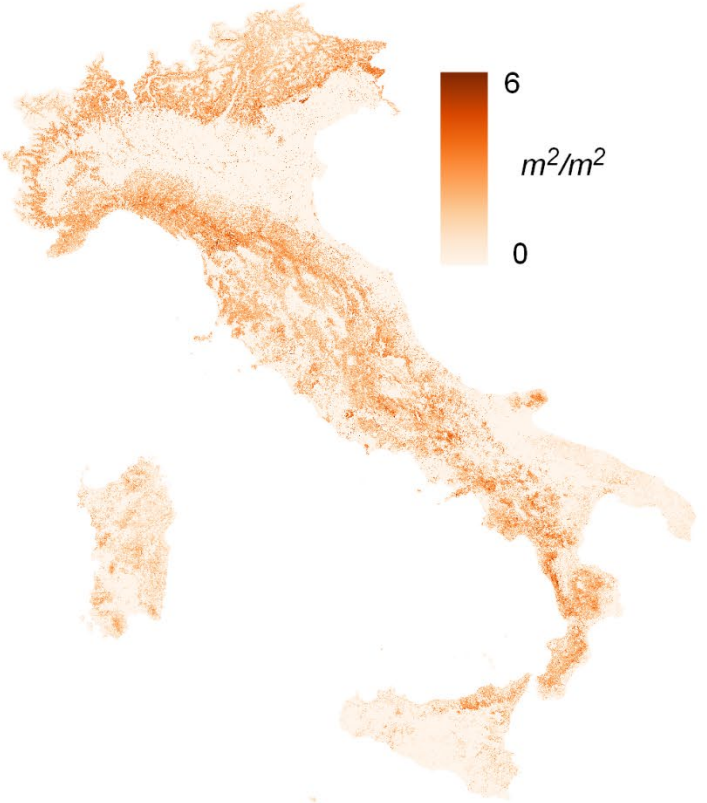


Biomass downscaling

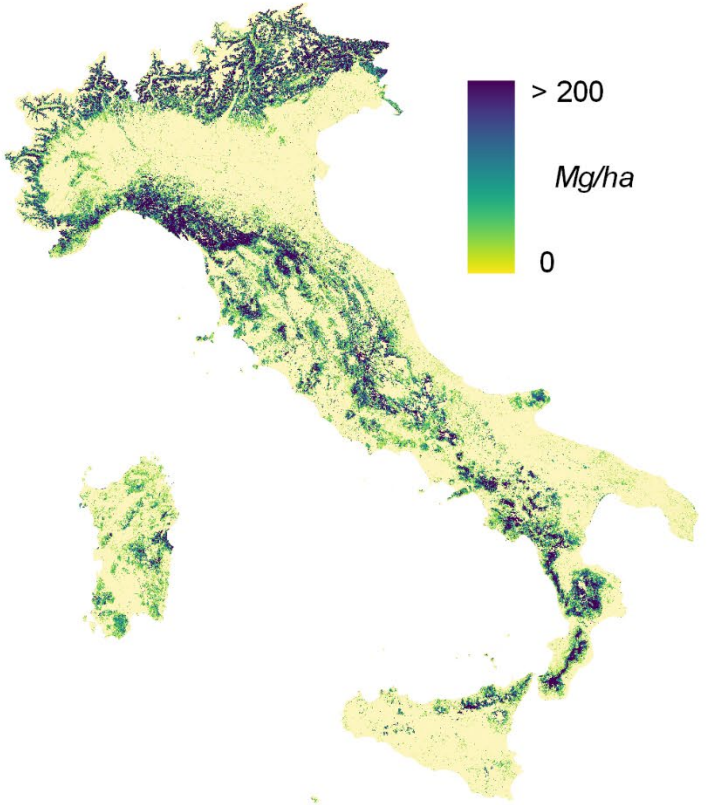
Tree Cover Density (TCD) - 2018



Leaf Area Index tree (LAIt) - 2018



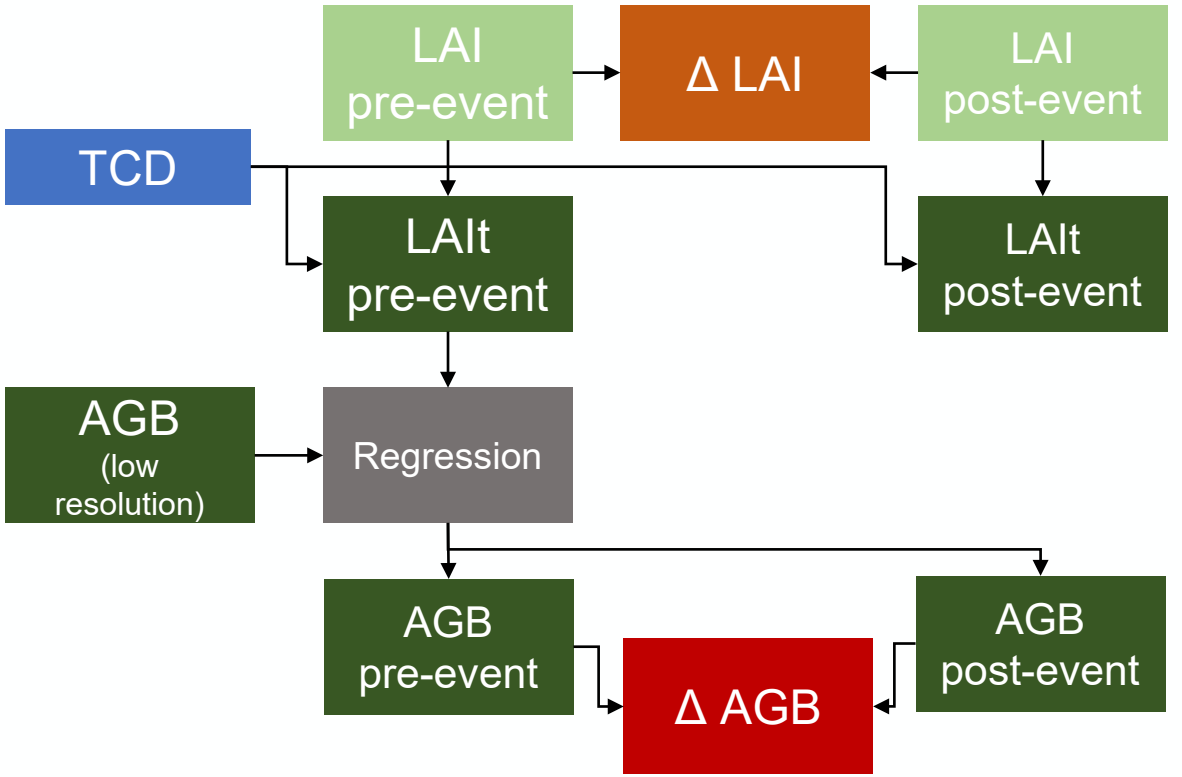
Above Ground Biomass (AGB) - 2018



Biomass downscaling

DATA SOURCES

- Tree Cover Density (TCD): Copernicus Land HRL
- LAI: Estimated from Sentinel-2 MSI acquisitions
- Above Ground Biomass: ESA CCI Biomass
  (Santoro et al., 2023)

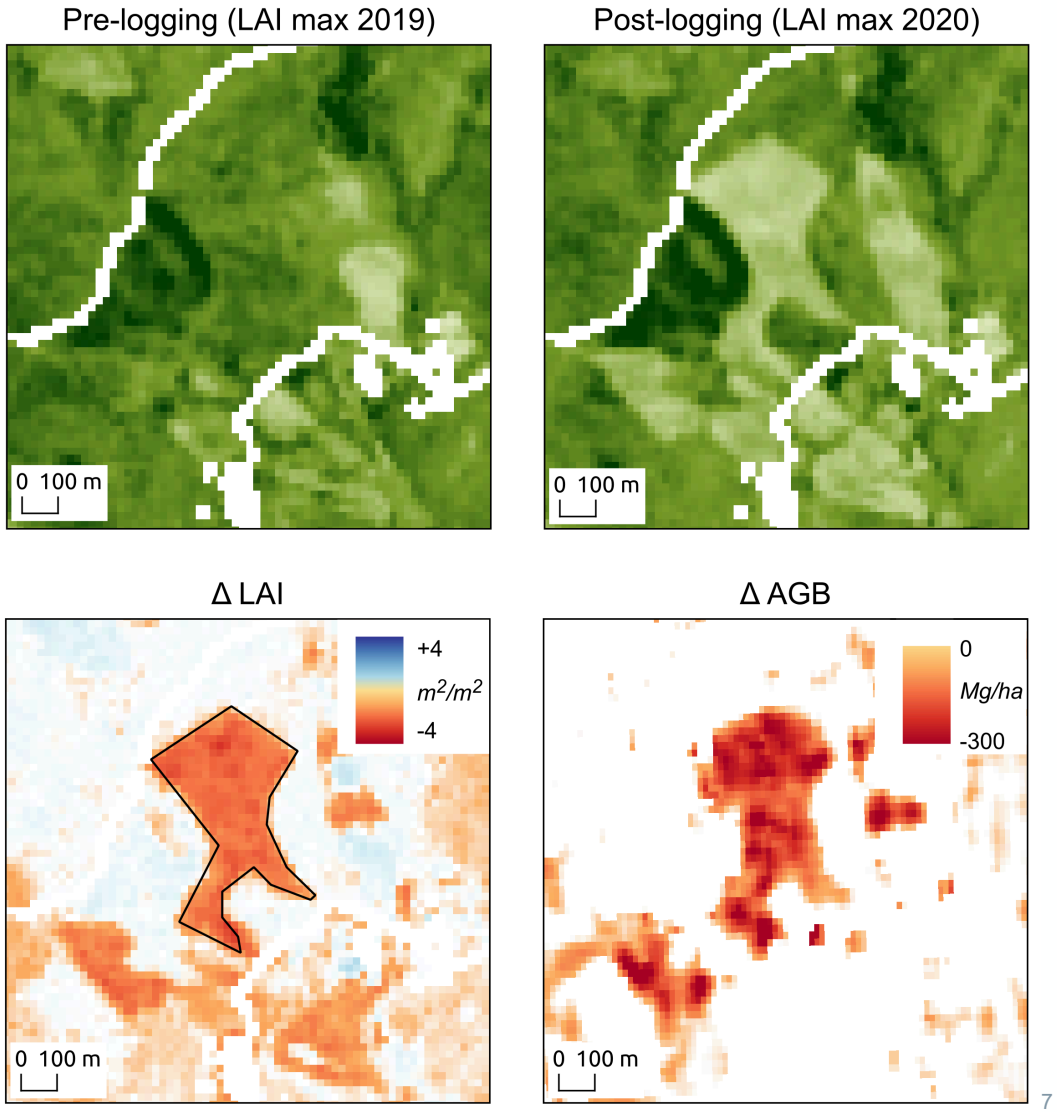


DOWNSCALING APPROACH

- Spatial downscaling from ESA CCI AGB estimates
- Use of LAI to identify spatial variability

Quantify forest disturbance

Time series analysis allows
to quantify loss
in terms of biophysical
parameters:
Above Ground Biomass (AGB)



Technical strengths and limitations of products

Strengths

- single time series required (e.g vegetation index)
- works with both optical and Synthetic Aperture Radar (SAR) time series
- Very High Hesolution (VHR) data can be used
- can deal with missing data in time series (due to e.g. cloud cover, snow cover, topographic shadow)
- enable to differentiate from other forest disturbances
- can be used for near-real time monitoring (e.g. to provide monthly mapping products)
- integrates quantitative estimation of biophysical parameters

Technical strengths and limitations of products

Limitations

- authorized logging sites map required to identify illegal ones
- spatial resolution is related to input dataset characteristics
- Very High Resolution data should be collected with a high revisit time
- pre-event acquisitions are required
- need for a high number of cases to compute accuracy metrics
- uncertainty estimates not yet developed

Acknowledgments

Figures contain modified Copericus Sentinel and Services data (2024)

ENVIRONMENTAL CRIMES WORKSHOP 2024

11-12 June 2024 | ESA-ESRIN, Frascati, Italy

Geospatial intelligence to identify illegal forest logging: user requirements perspective

Thanks for your attention

federico.filipponi@cnr.it

Filipponi F.[1], Agrillo E.[2], Pezzarossa A.[2], Calcagni L.[2], Bonora N.[2]

1 Italian National Research Council (CNR)

2 Italian Institute for Environmental Protection and Research (ISPRA)