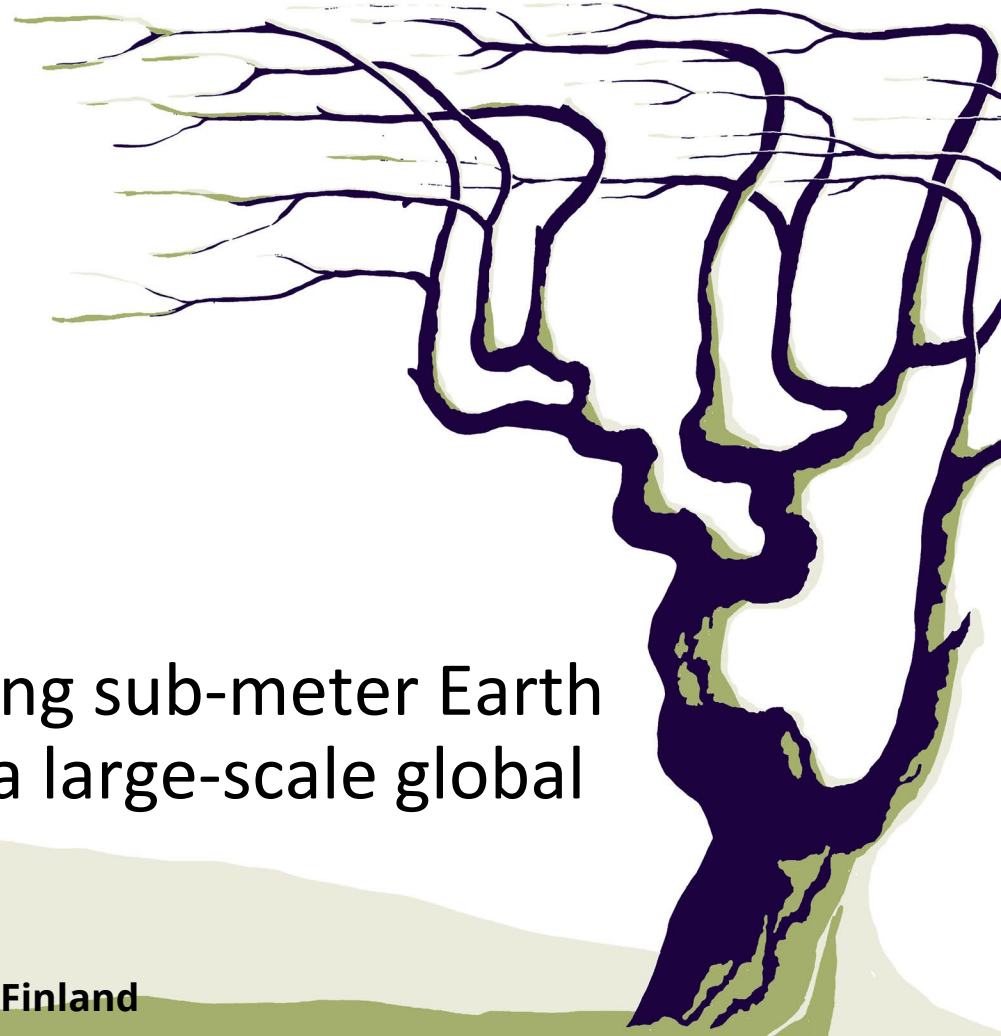
GEHO

GLOBAL ECOSYSTEM HEALTH OBSERVATORY



Mapping individual tree mortality using sub-meter Earth observation data: Advances toward a large-scale global database

Samuli Junttila, University of Eastern Finland

Anis Ur Rahman, Einari Heinaro, Antti Polvivaara, Mete Ahishali, Minna Blomqvist, Tuomas Yrttimaa, Nataliia Rehush, Markus Holopainen, Eija Honkavaara, Juha Hyyppä,Ville Laukkanen, Mikko Vastaranta, Heli Peltola, Clemens Mosig, Teja Kattenborn, Kristjan Ait, Miroslav Svoboda, Yan Cheng, Stephanie Horion

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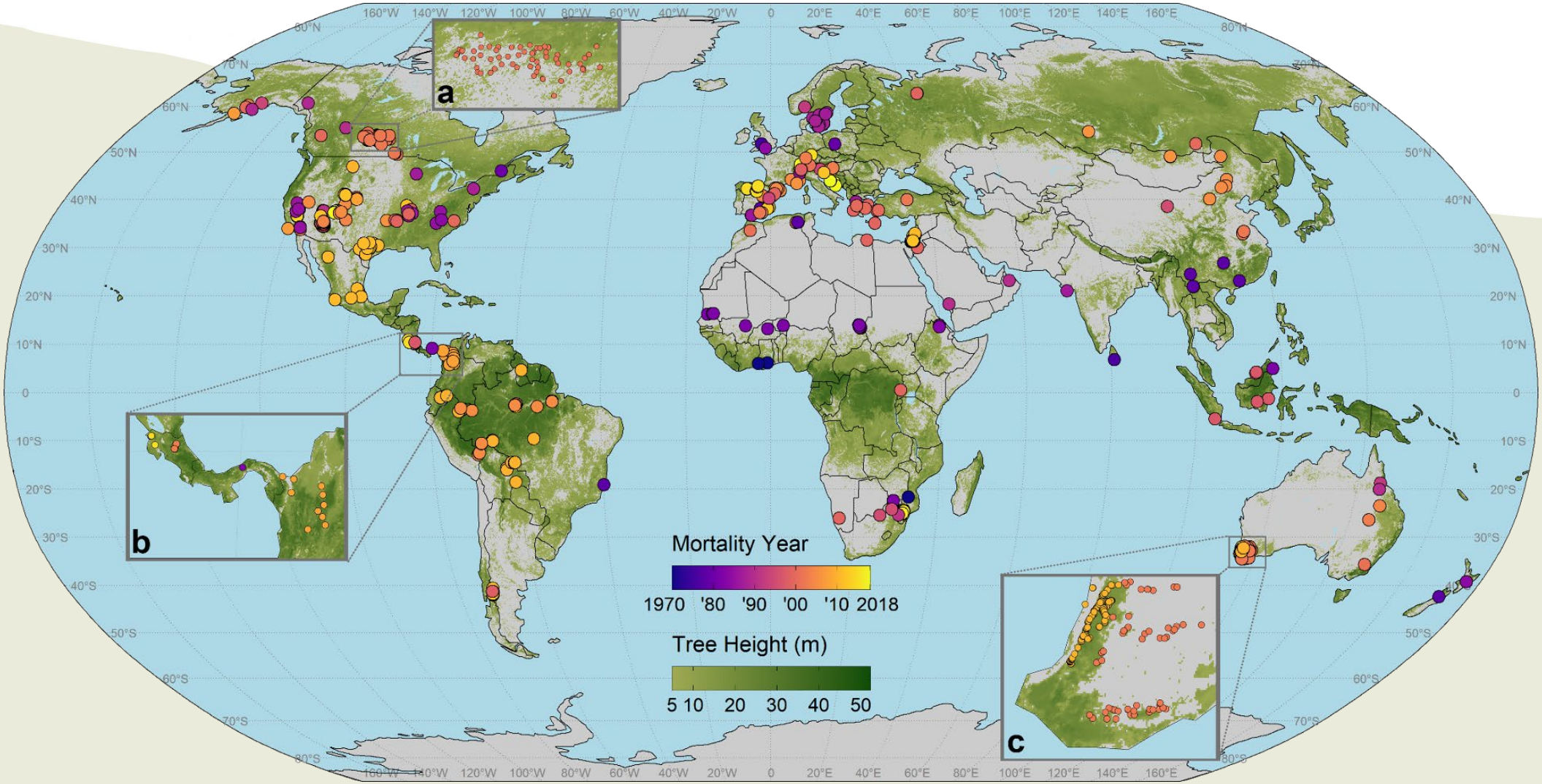

Locations with evidence of increased tree mortality related to heat or drought

Key indicator of forest biodiversity

- Deadwood is highly important for a large number of forest species
- Lack of deadwood due has led to loss of biodiversity
- We lack information on deadwood pools

We need systematic monitoring of standing dead trees

1. Assessment of tree mortality and forest disturbance rates
   - Information on the resilience of forest ecosystems
   - Where, when and what kind of trees are dying?
2. Assessment of deadwood pools
   - Information on forest biodiversity
   - Where are ecologically valuable forests located?

Lack of understanding of future trajectories of tree mortality

WHERE, WHEN, WHAT

Lack of information on tree mortality at tree-level

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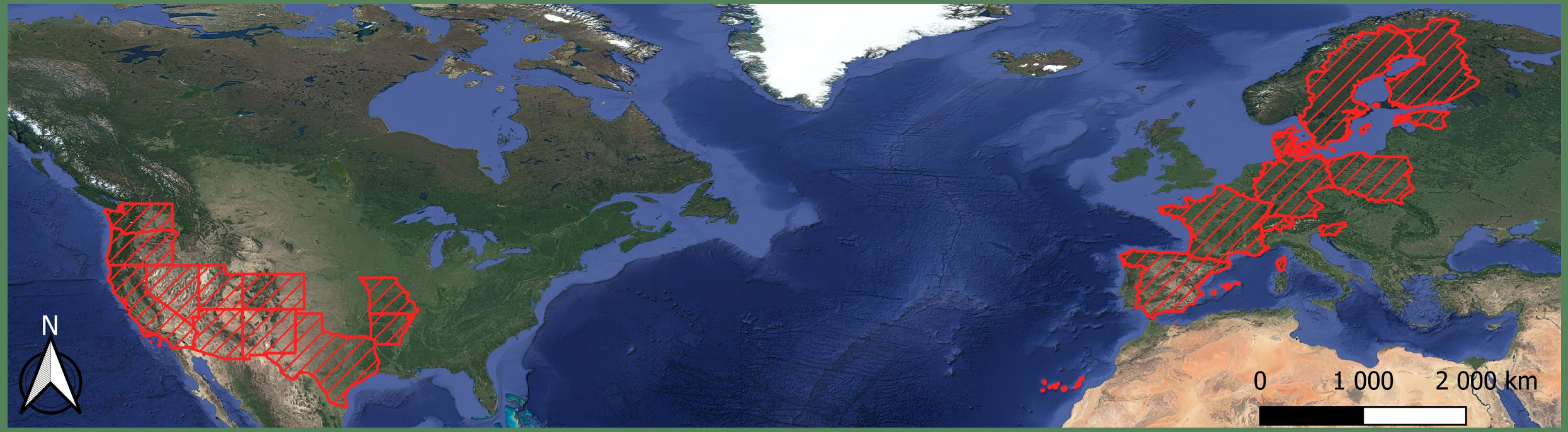
WHY

Lack of knowledge of **tree mortality drivers and environmental thresholds**

Towards Individual Tree Mortality Database

- Spatial and temporal patterns of tree mortality
- New database of 100s of millions of individual geolocated tree mortality events across different climate gradients over time



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Significant increase in forest canopy mortality in boreal forests in Southeast Finland

S. Junttila [a], M. Blomqvist [a b], V. Laukkanen [c], E. Heinaro [a], A. Polvivaara [a], H. O'Sullivan [b], T. Yrttimaa [a], M. Vastaranta [a], H. Peltola [a]

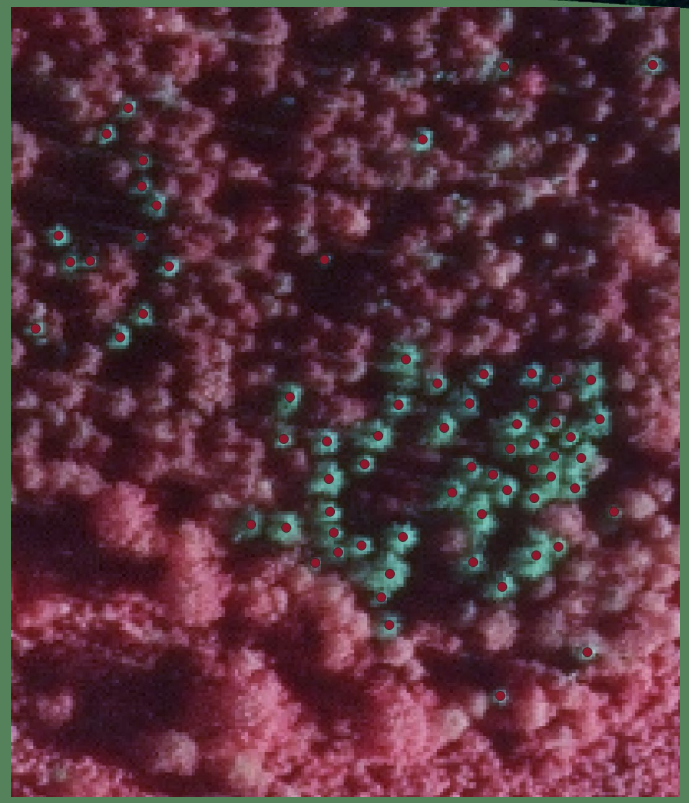
Scattered tree death contributes to substantial forest loss in California

Yan Cheng, Stefan Oehmcke, Martin Brandt, Lisa Rosenthal, Adrian Das, Anton Vrieling, Sassan Saatchi, Fabien Wagner, Maurice Mugabowindekwe, Wim Verbruggen, Claus Beier & Stéphanie Horion

Nature Communications **15**, Article number: 641 (2024) | Cite this article

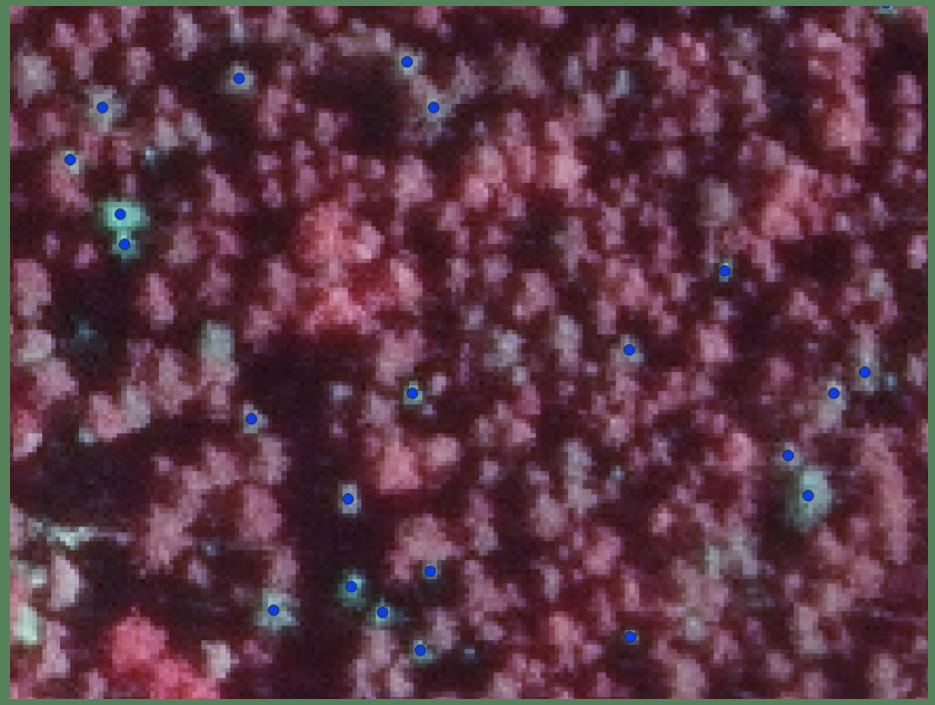
Towards Individual Tree Mortality Database

- Individual dead trees can be captured using very high-resolution imagery (< 1 m) and deep learning methods (U-Nets) with high accuracy
  - Aerial and satellite imagery
  - F1-score: 0.86-0.93 (Junttila et al. 2024)
  - Mean absolute error: 2.3 dead trees per ha (Cheng et al. 2024)
- Openly available aerial imagery



Why we need very high-resolution imagery?

- Over 60% of standing dead trees appear isolated
  - Observations from California and Finland
- Individual dead trees cannot be detected from Sentinel-2 data with 10 m spatial resolution



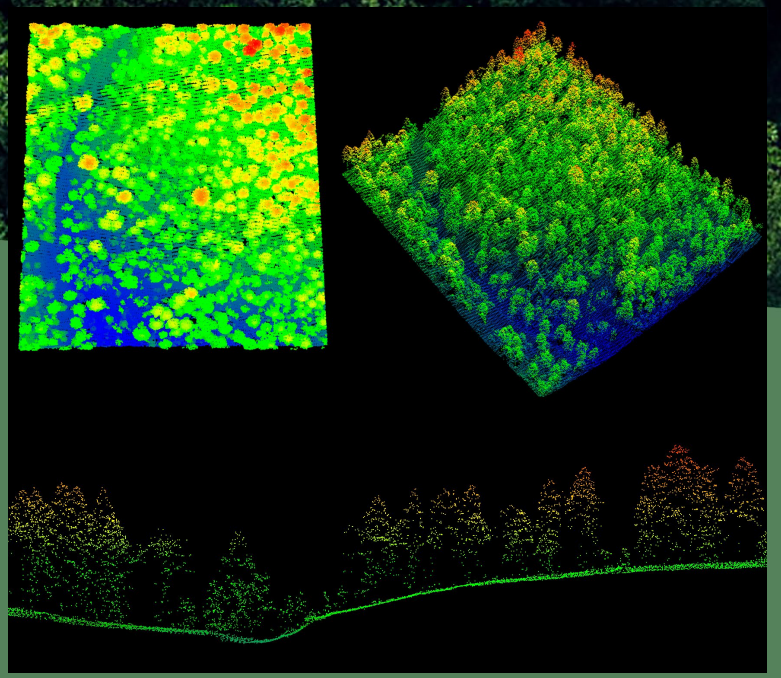
Database structure

- Basic information
  - Point type
  - Coordinates, date of image, image source, image resolution
- PostGIS database for efficient data management and querying
- Will be part of the deadtrees.earth initiative

deadtrees.earth

Additional attributes

- Crown projection area and tree height from airborne lidar
- Tree species from existing maps
- Diameters using allometric models



ID	lat	lon	height_m	canopyarea_m2	species	dbh_cm	dead_year	dead_month
105648	24.92164	60.24807	23.1	21.4	Picea abies	35.8	2021	8
105649	24.91134	60.24923	18.7	29.8	Picea abies	29.5	2021	8
105650	24.91265	60.25001	25.6	24.3	Picea abies	31.1	2021	8
105651	24.90442	60.25102	28.9	26.7	Picea abies	34.5	2021	8
105652	24.89023	60.24888	25.6	24.9	Picea abies	32.8	2021	8
105653	24.89921	60.24735	19.8	23.1	Picea abies	27.9	2021	8
105654	24.85013	60.24689	20.4	19.5	Picea abies	28.4	2021	8

Individual Tree Mortality Database – current status

- California: 91 400 000 dead trees
- Finland: 30 000 000 dead trees
- Estonia: 3 900 000 dead trees

Scattered tree death contributes to substantial forest loss in California

Yan Cheng, Stefan Oehmcke, Martin Brandt, Lisa Rosenthal, Adrian Das, Anton Vrieling, Sassan Saatchi, Fabien Wagner, Maurice Mugabowindekwe, Wim Verbruggen, Claus Beier & Stéphanie Horion

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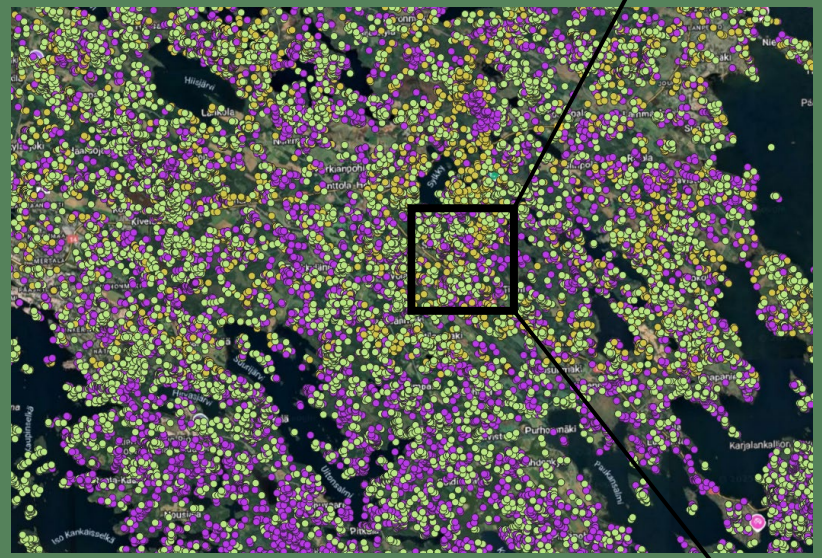
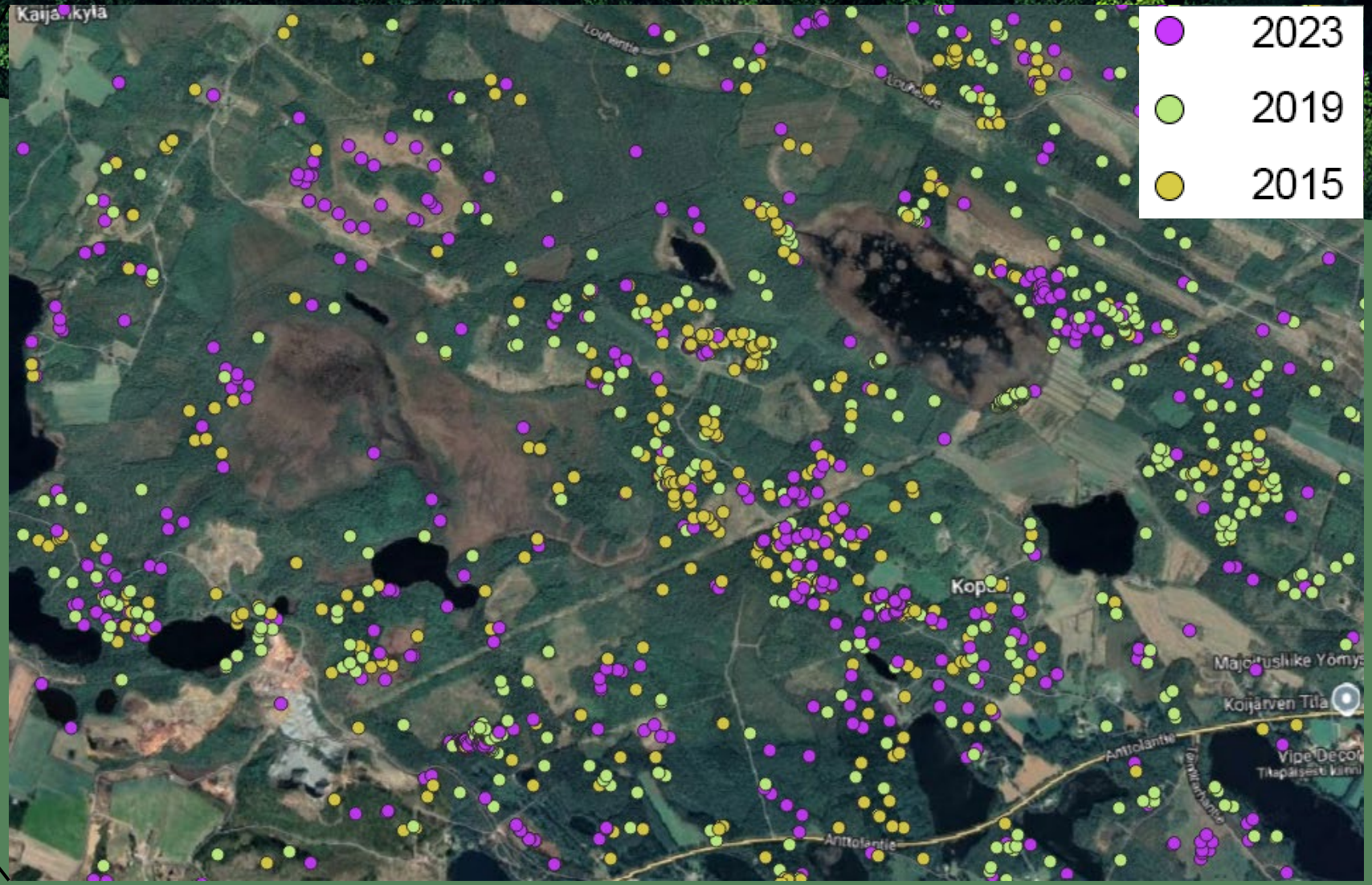
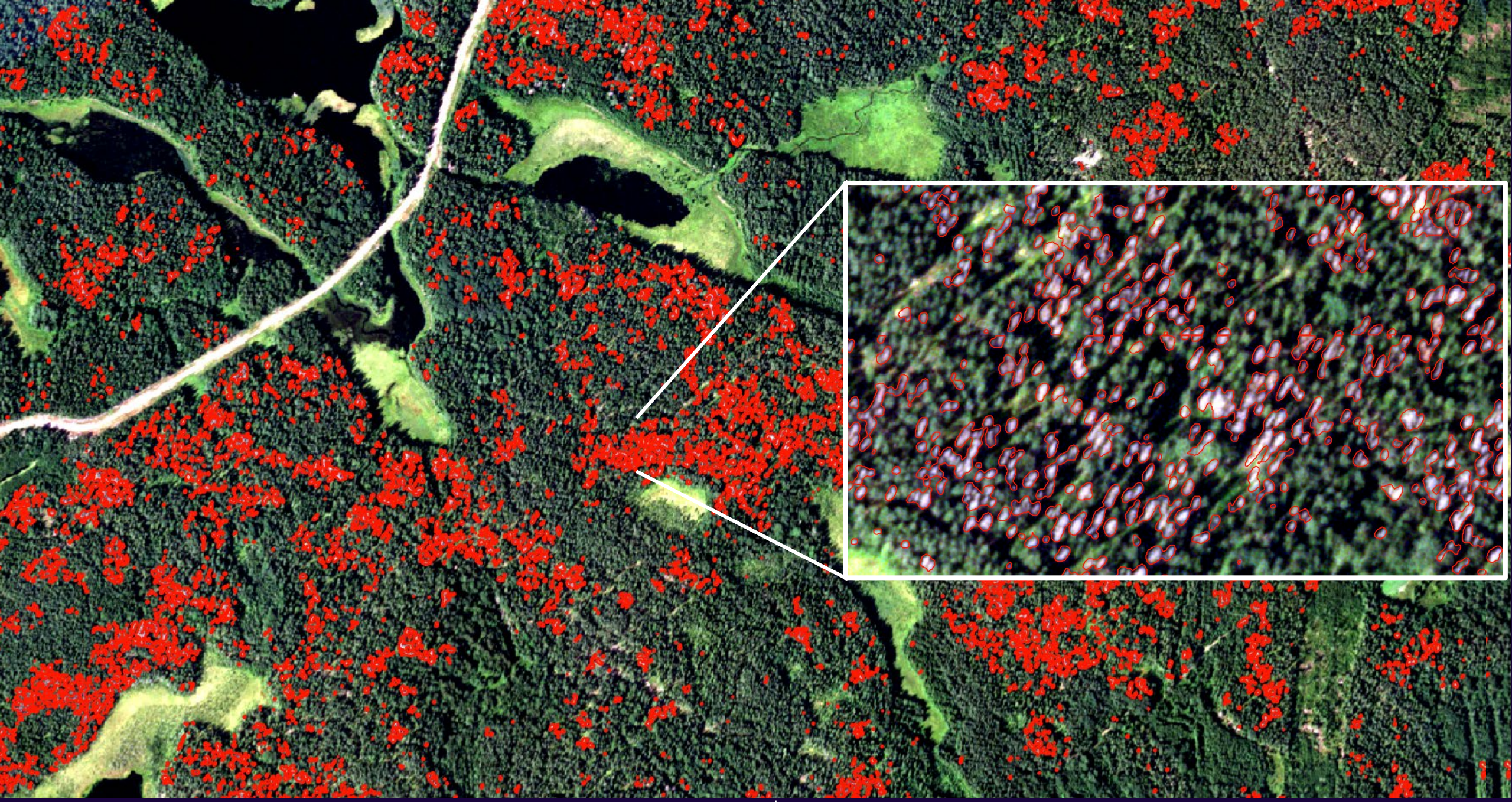



2023
2019
2015
Loutiantie
Antolantie
Koijärven Tila



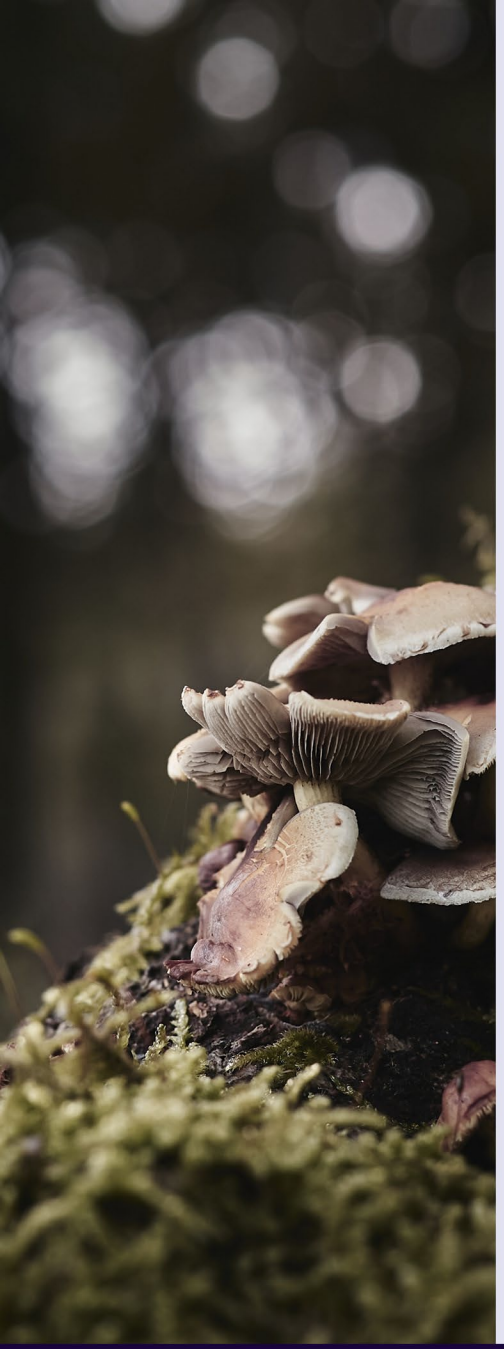
60 sites for mapping tree mortality using very high-resolution satellite imagery

Limitations of optical remote sensing

- Dead trees under the upper canopy cannot be detected
- Tendency to detect large trees
- Comparison against field plots reveal that a large proportion of standing dead trees are not visible from above
    - In-situ field data is also needed

Looking for contributions and collaborations

- Very-high resolution imagery from regions outside of Europe and US
- Tree mortality observations
- Collaborations that would benefit from tree mortality mapping using very high-resolution satellite imagery
  - Tree mortality hotspots
  - Sites with field observations



Future work

deadtrees.earth

- Applying the developed methods to scale up the Individual Tree Mortality Database
  - First version online by the end of the year
  - Sign up for the newsletter for updates at deadtrees.earth
- Using the data to understand environmental thresholds for tree mortality and indentifying ecologically valuable forests

Recommendations

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- Systematic monitoring of tree mortality and standing deadwood is required for understanding forest resilience
- Very-high resolution is required for scattered tree-level events like tree mortality
- Joint efforts to collect in-situ data in a consistent manner

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