Multi-resolution quantification and driver assessment of hot spots of global forest disturbance

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NASA LCLUC Science Team Meeting

May 8, 2023

Using PlanetScope data to quantify forest loss area: Peru prototype study

remote sensing

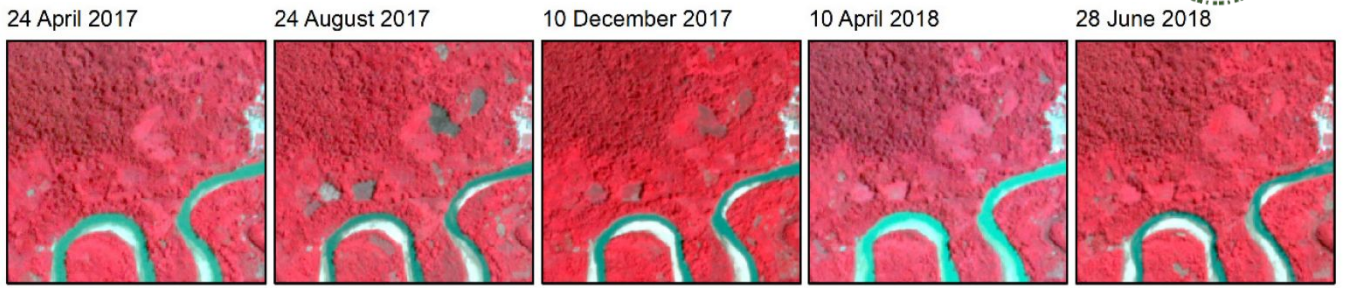
Pickering et al. (*2021*)

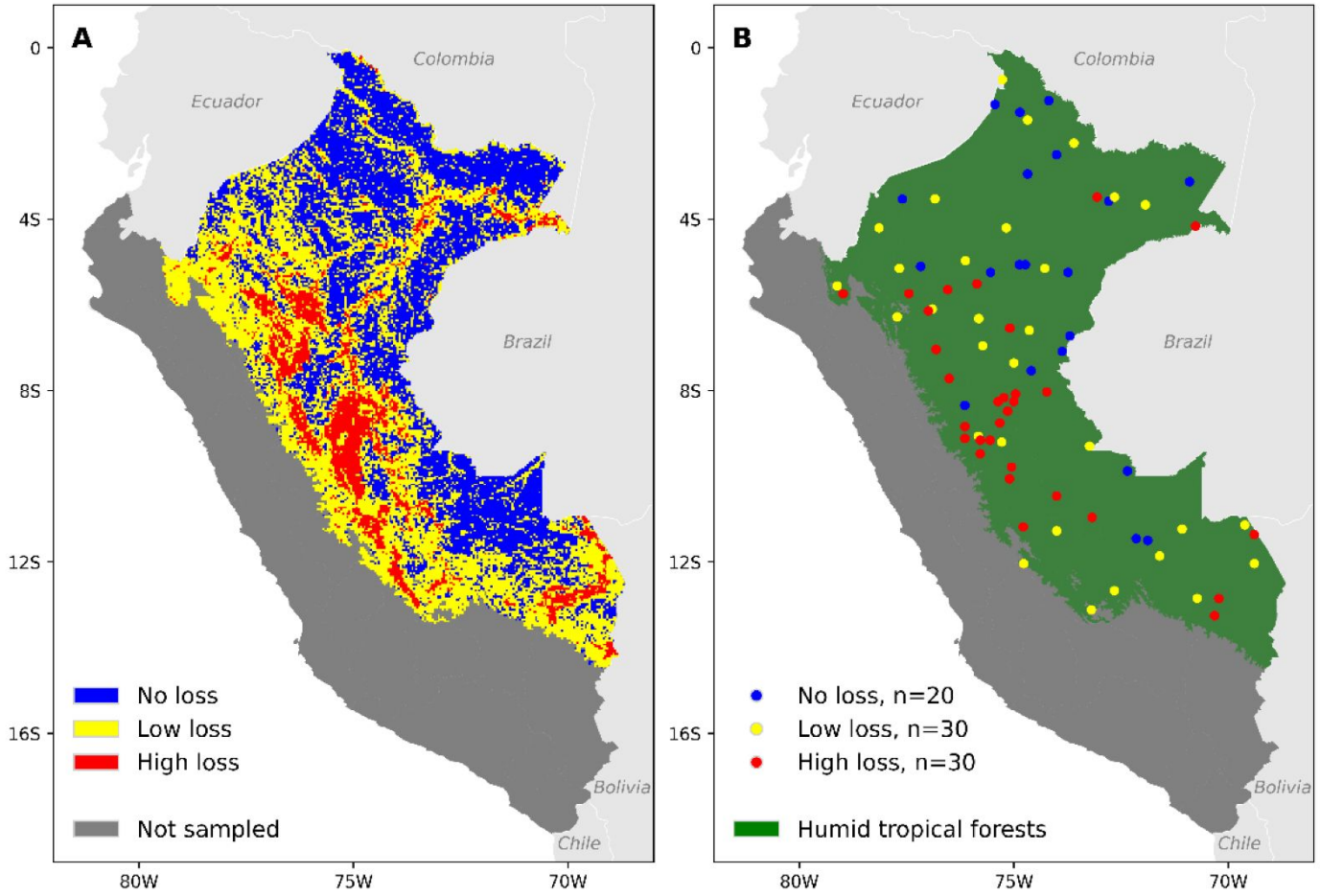
MDPI

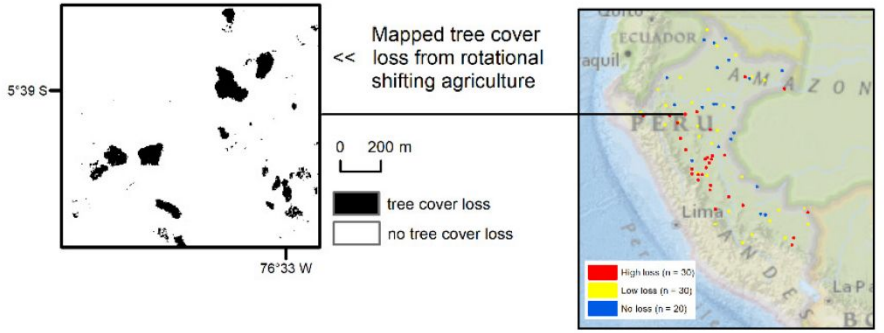
Communication

Using Multi-Resolution Satellite Data to Quantify Land Dynamics: Applications of PlanetScope Imagery for Cropland and Tree-Cover Loss Area Estimation

Jeffrey Pickering *, Alexandra Tyukavina, Ahmad Khan, Peter Potapov, Bernard Adusei, Matthew C. Hansen and André Lima







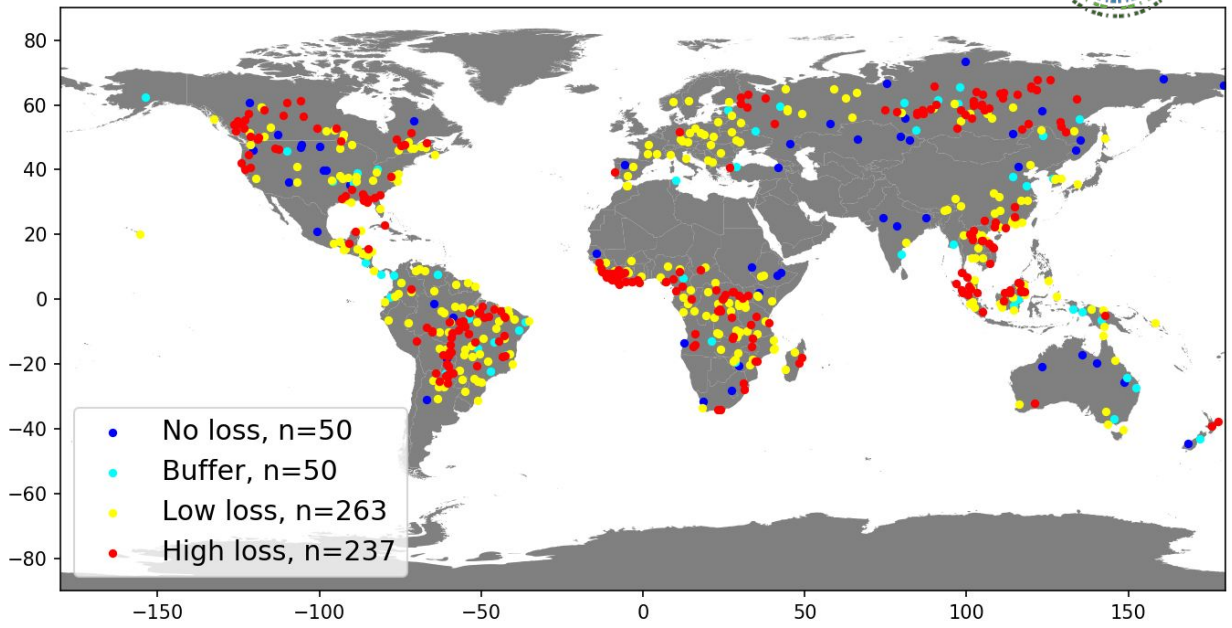
- ~3 m reference data (PlanetScope)
- 80 5x5 km reference blocks
- Reference maps loss/no loss for 2017-2018
- Natural vs. anthropogenic forest loss estimates

Results

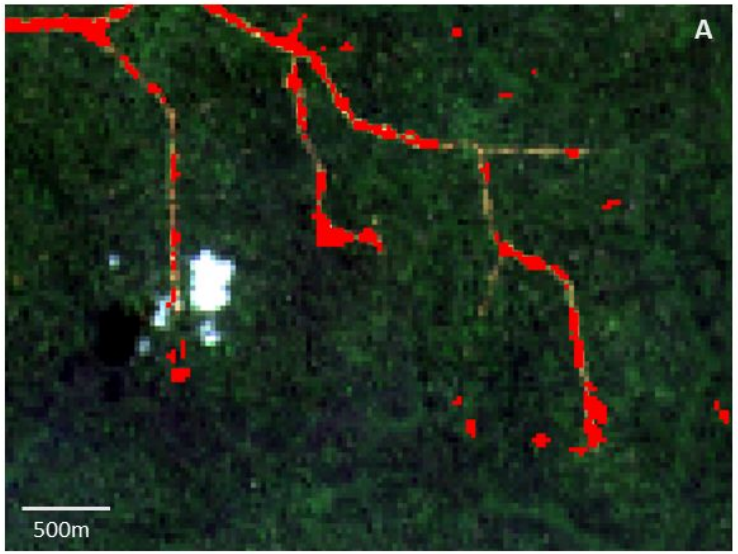
- 9% SE of total forest loss area estimate
- 8% SE - anthropogenic loss area
- Regression estimate: 5% SE of total loss area

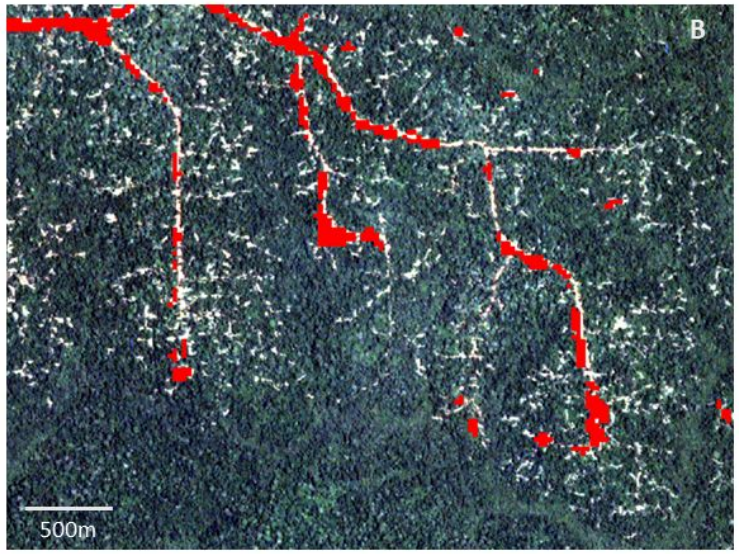
Current NASA LCLUC-funded project on hotspots of global forest loss

- Global sample: 600 5x5km blocks, stratified random sample;
- Reference satellite data: PlanetScope (~3m) and Sentinel-2 (10m);
- Time interval: 2018 loss + loss drivers based on 3 years of imagery after disturbance.



Locations of 5x5km sample blocks, colored by sampling stratum

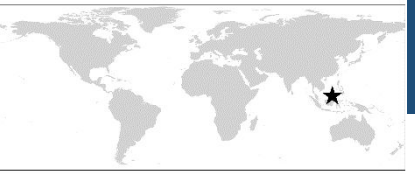




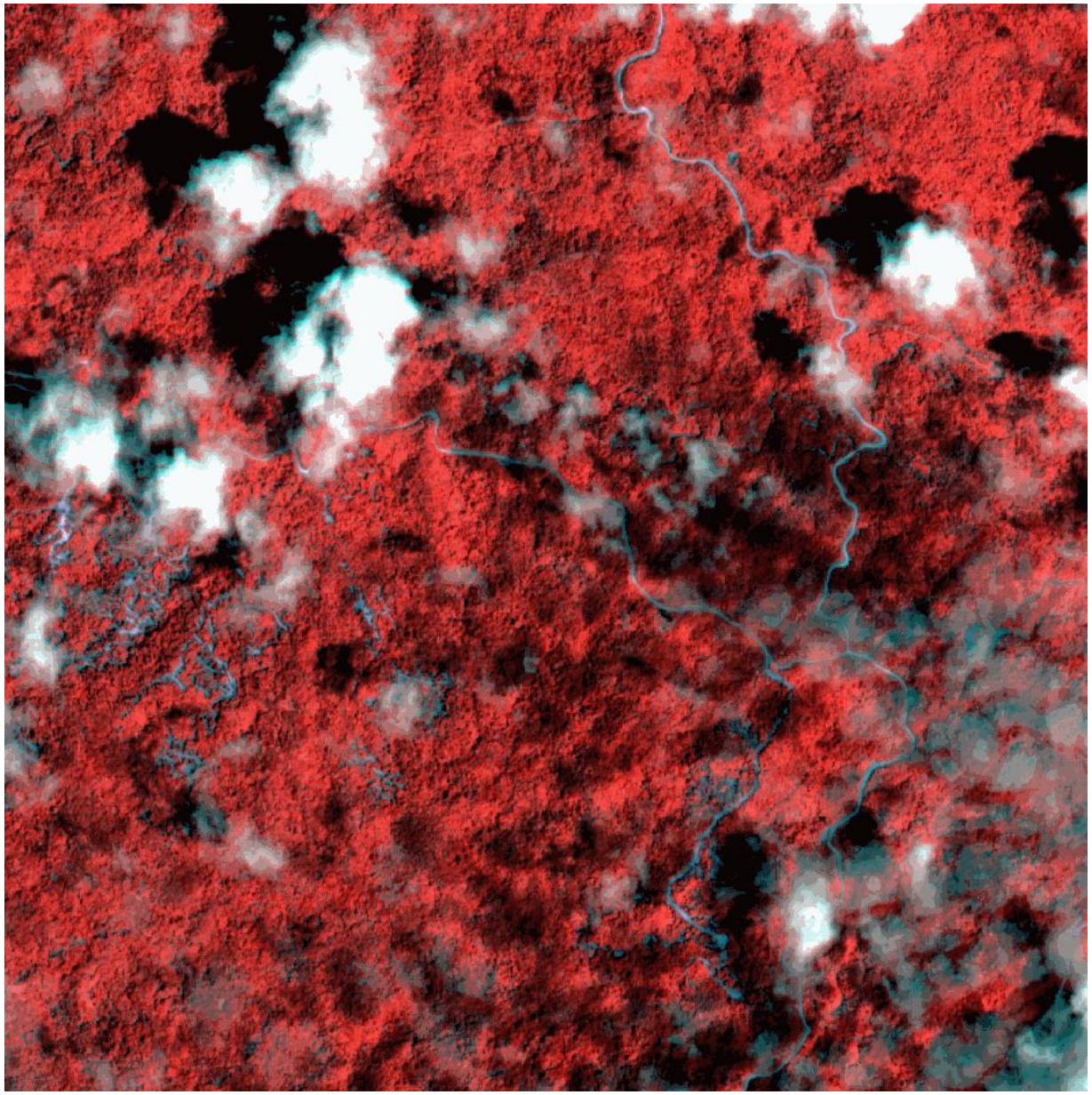
Red – global forest loss map

left (A) – over the best cloud-free post-disturbance Landsat observation

right (B) – over the PlanetScope image concurrent with disturbance



Reference block mapping method



- One-two minimally cloudy PlanetScope images per month Dec. 2017 - Jan. 2019 + all available Sentinel-2 images for each 5x5 km block;
- Stacking all images (no cloud filtering);
- Supervised classification (decision trees) of each block separately: yes/no year 2018 forest loss;
- Iterative quality assessment and map improvement process;
- Point-based validation of resulting reference block maps (upon completion of all block maps);
- Visual interpretation of PlanetScope basemaps + Landsat + GoogleEarth to assign each reference loss pixel to pre-disturbance forest type and loss driver

Image stack example, training data and classification result for a cloudy block in Malaysian Borneo: Dec. 2017 – Jan. 2019, 21 PlanetScope images + (not pictured) 30 Sentinel-2 images

Drivers of forest loss: direct (proximate) drivers vs. underlying causes

"**Proximate causes <*direct drivers*>** are human activities or immediate actions at the local level … that originate from intended land use and directly impact forest cover"

- Infrastructure extension




- Agricultural expansion



- Wood extraction



"**Underlying driving forces <causes>** are fundamental social processes … that … either operate at the local level or have an indirect impact from the national or global level"

- Demographic factors


- Economic factors


- Technological factors

- Policy & Institutional factors

- Cultural factors


- Other factors: social trigger events, natural catastrophes, predisposing environmental conditions

Adapted from: Geist & Lambin (2002) Proximate Causes and Underlying Driving Forces of Tropical Deforestation, BioScience, Volume 52, Issue 2

Drivers of global forest loss: legend

Initial forest cover

- Natural forest
- Timber plantation
- Non-timber plantation
- Palm plantation

Large rubber plantation, palm plantations intermixed with patches of natural forest Côte d'Ivoire, block 372

Initial direct driver of loss

Direct human clearing

- Mechanical (mechanized)
- Mechanical (manual)

- Flooding (dams)

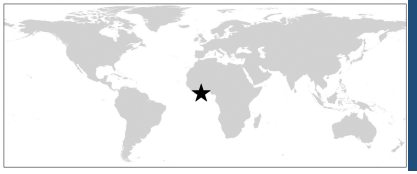
- Fire

Natural disturbances:

- Floods (natural, e.g. river meandering)
- Insects
- Hurricanes/Windfalls
- Drought
- Earthquakes/Land slides

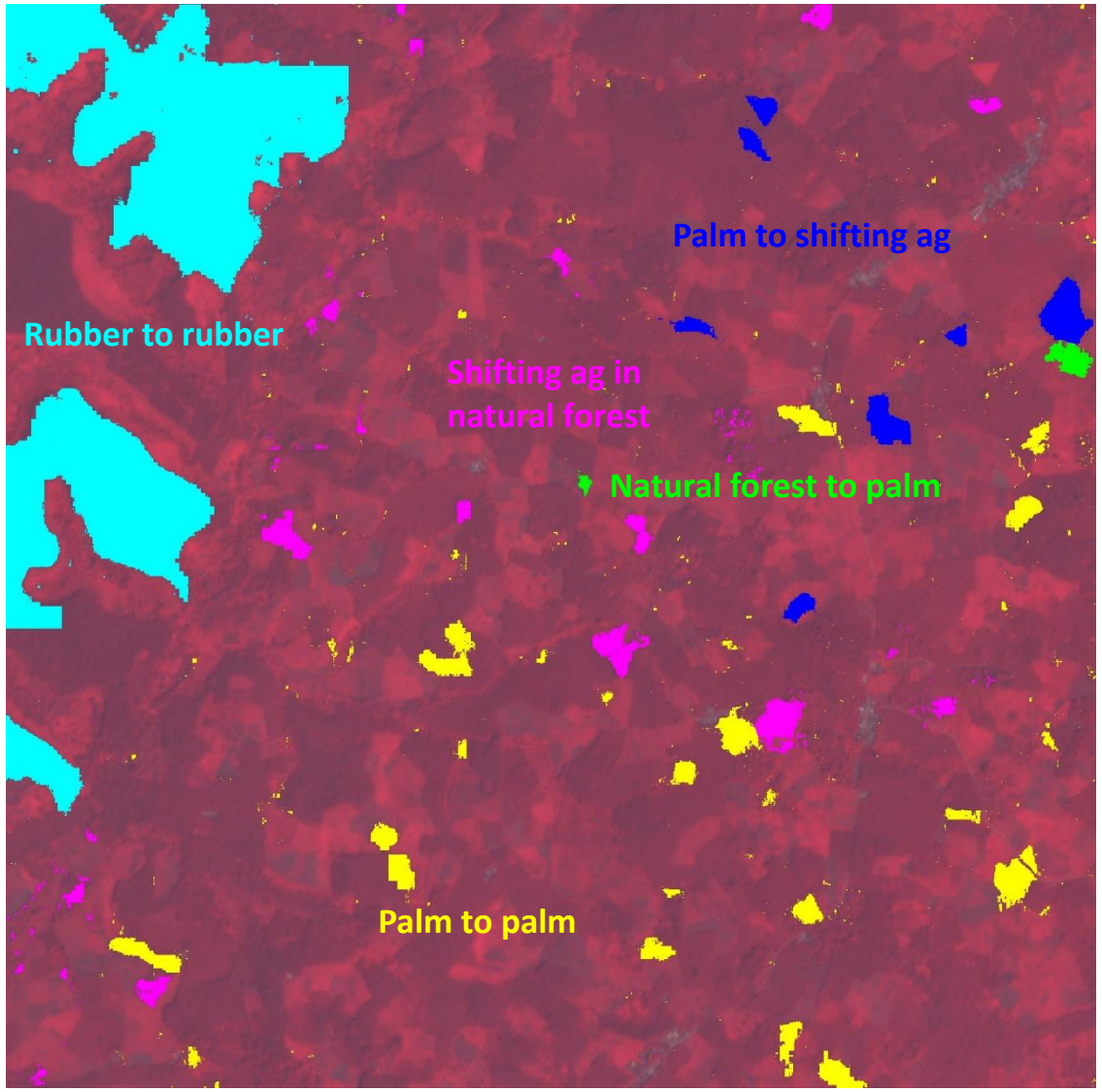
Land cover / land use 3 years after disturbance

- Shifting cultivation
- Forestry/Clearcut
- Timber tree plantation
- Non-timber tree plantation
- Palm plantation
- Selective logging
- Cropland
- Pasture
- Settlement
- Commercial construction
- Road
- Mining
- Energy infrastructure
- Flooded (dams)
- Natural disturbances
- Human clearing with uncertain purpose



Multiple loss drivers per sample block, Côte d'Ivoire

Very high resolution image (Maxar) 03/05/2021



2018 forest loss map based on PlanetScope and Sentinel 2 data

Fire in Sakha Republic, Russia

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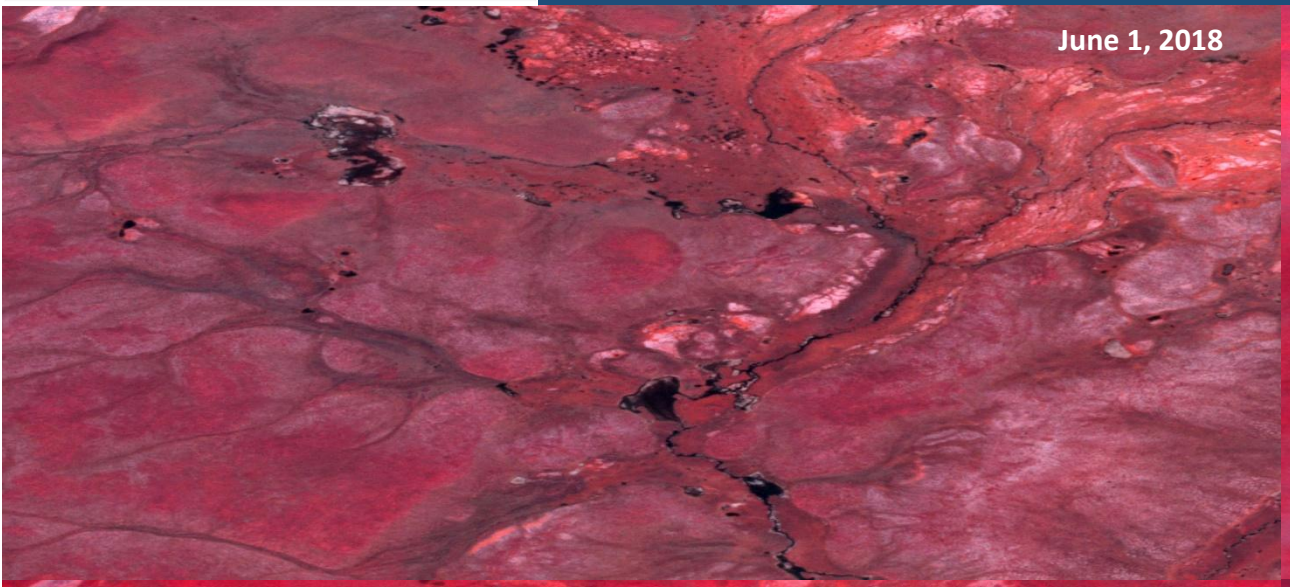
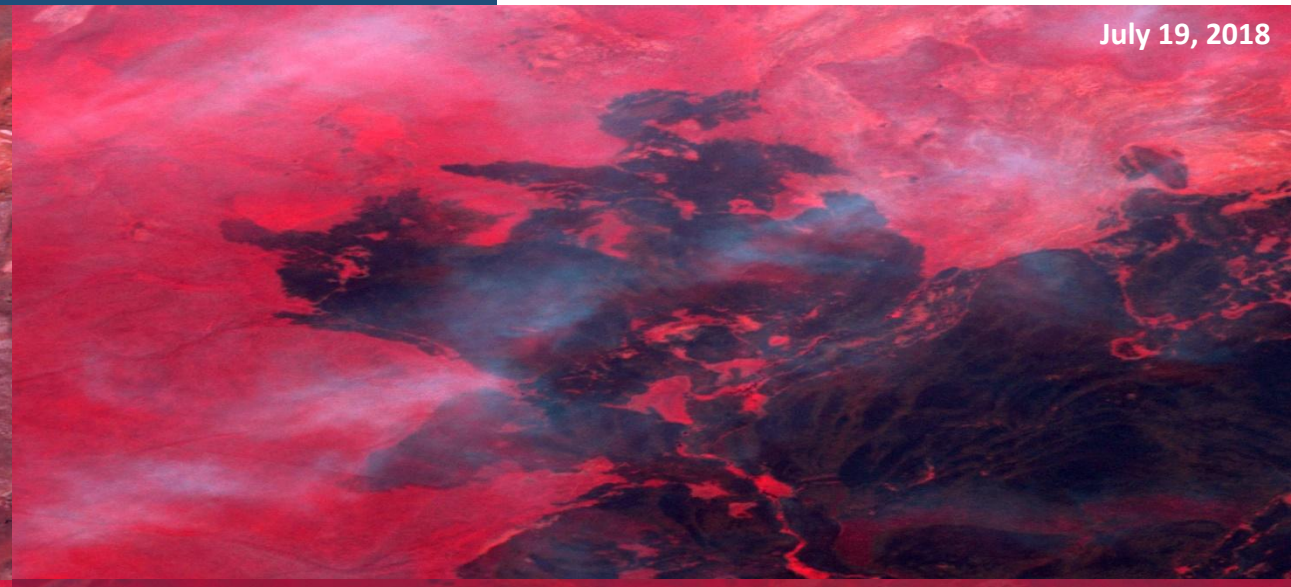
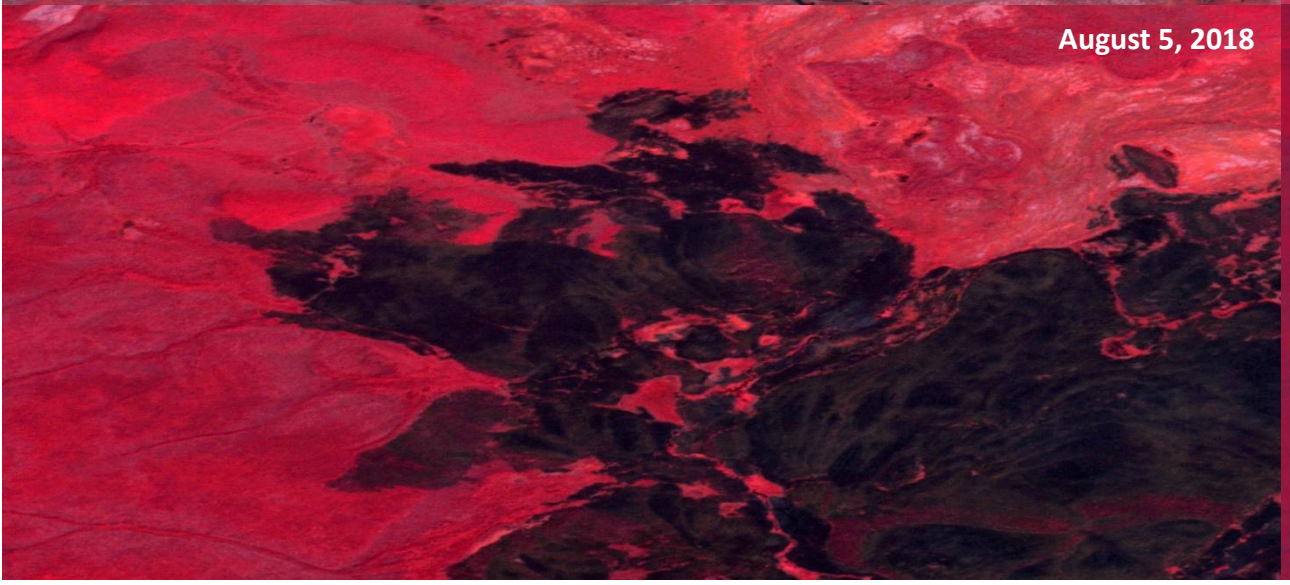
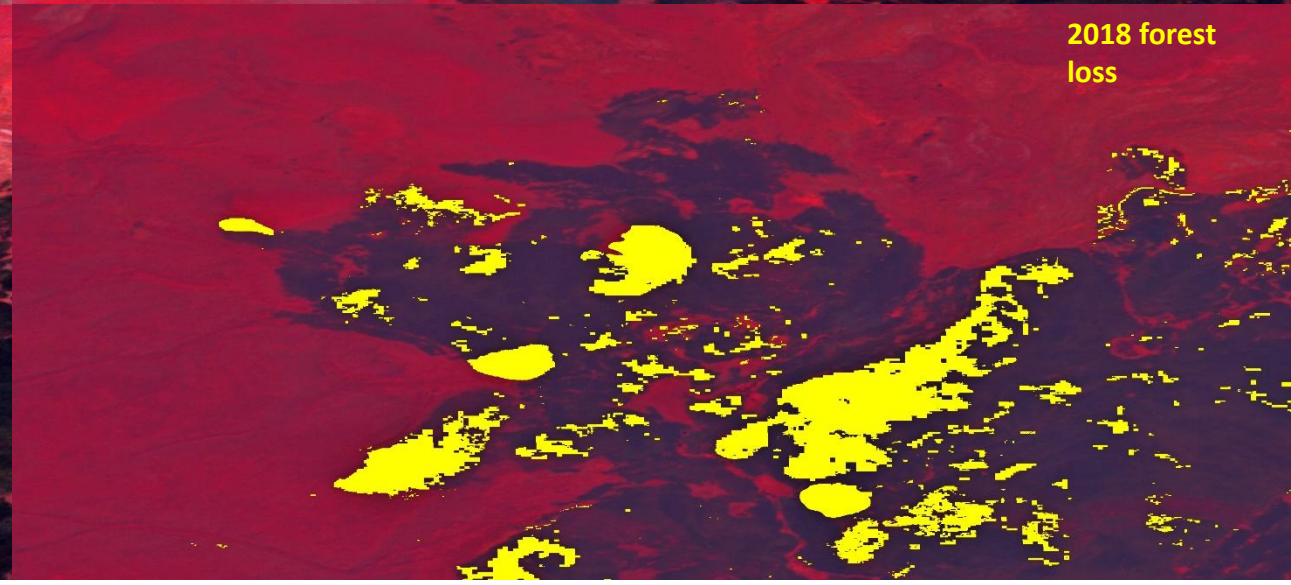
GLAD GLOBAL LAND ANALYSIS & DISCOVERY









Industrial logging in Malaysia

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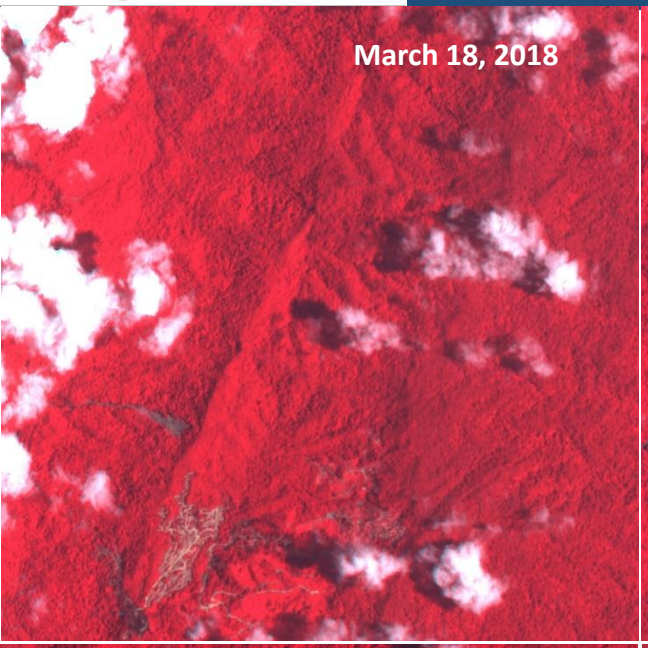

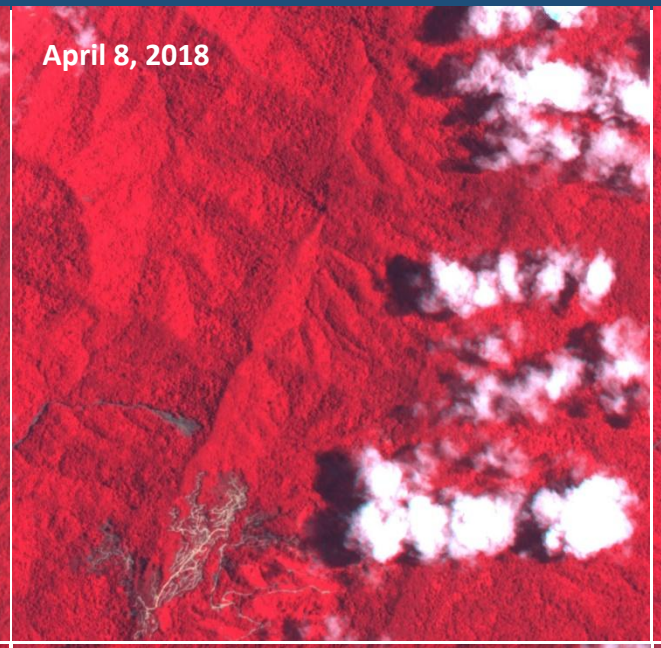

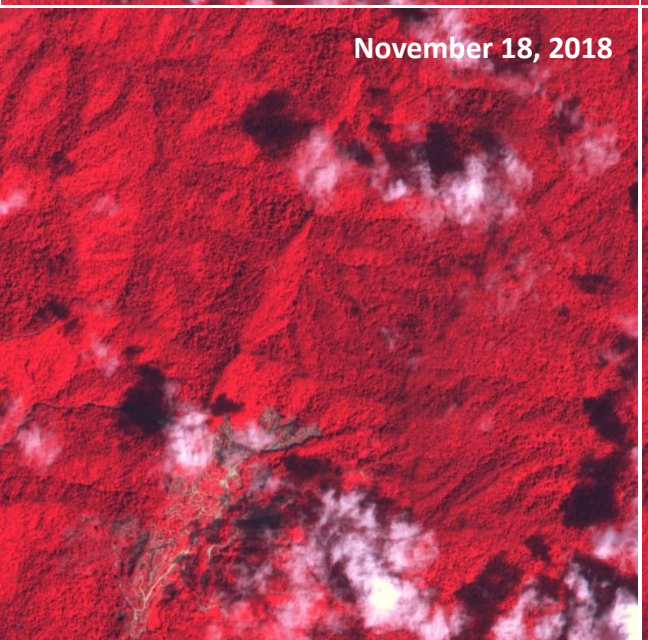

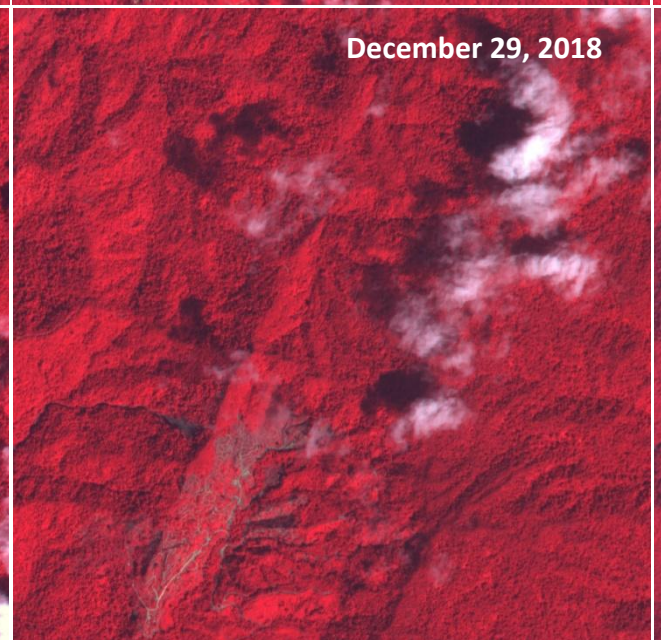

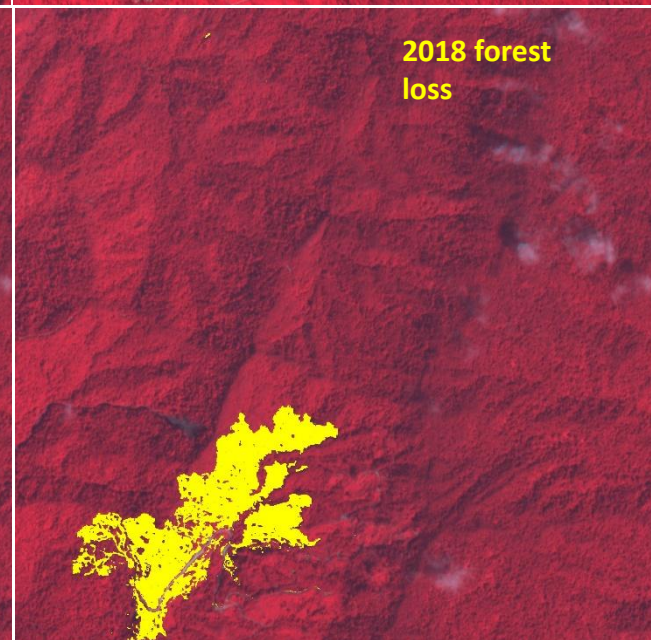

Shifting cultivation in the DRC

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January 2, 2018

May 2, 2018

September 26, 2018

November 11, 2018

December 6, 2018

December 30, 2018

January 22, 2019

2018 forest

Clearing for pasture in Argentina

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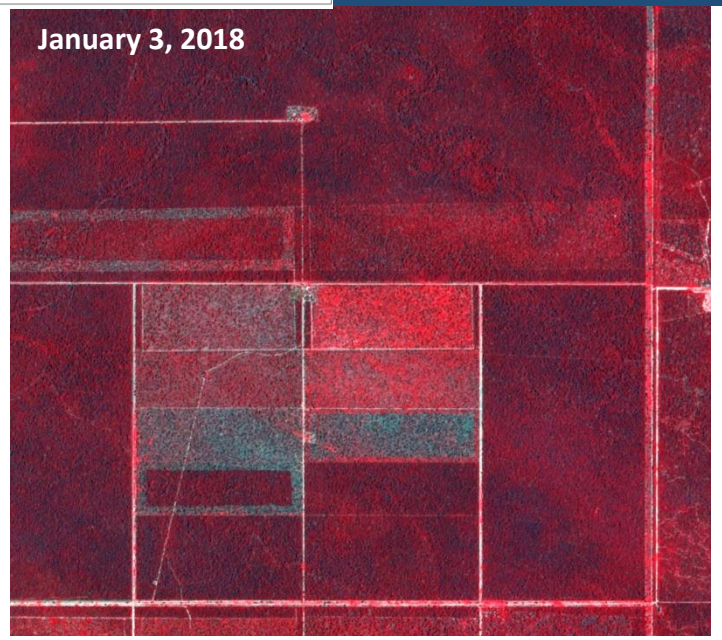

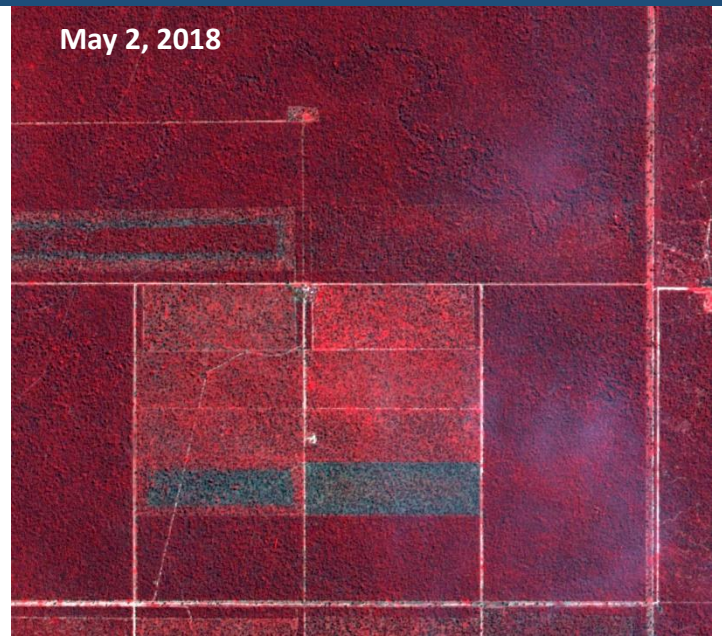

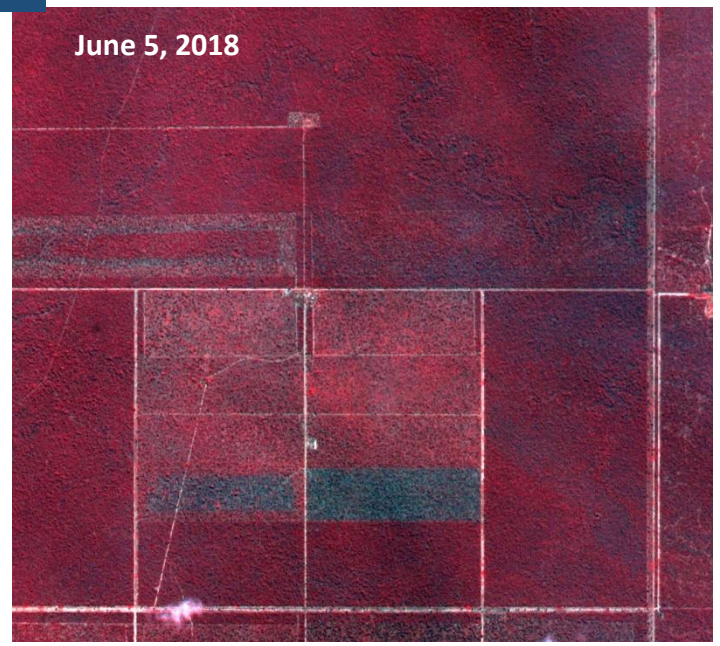

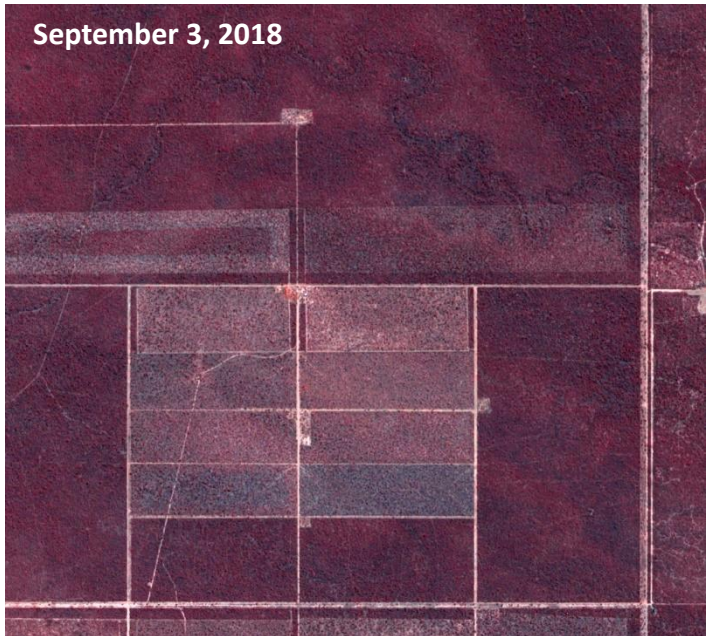

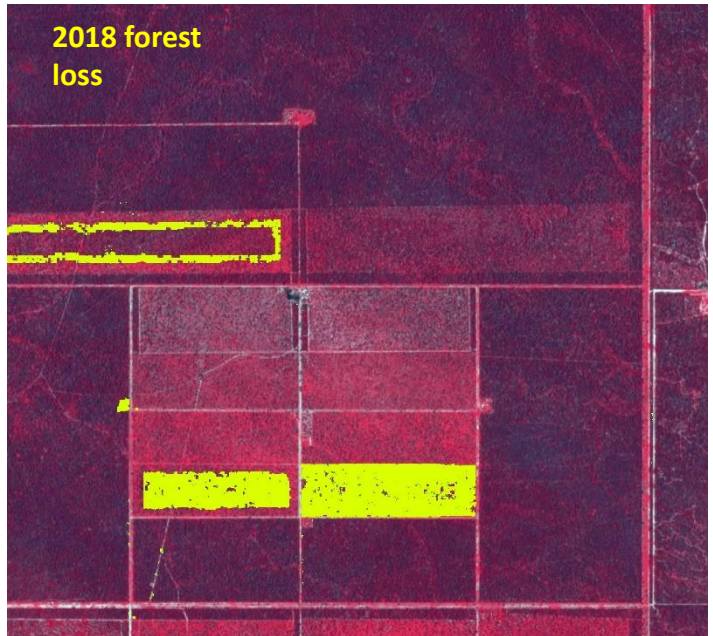

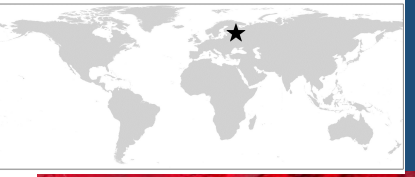

Forestry in Novgorod region, Russia

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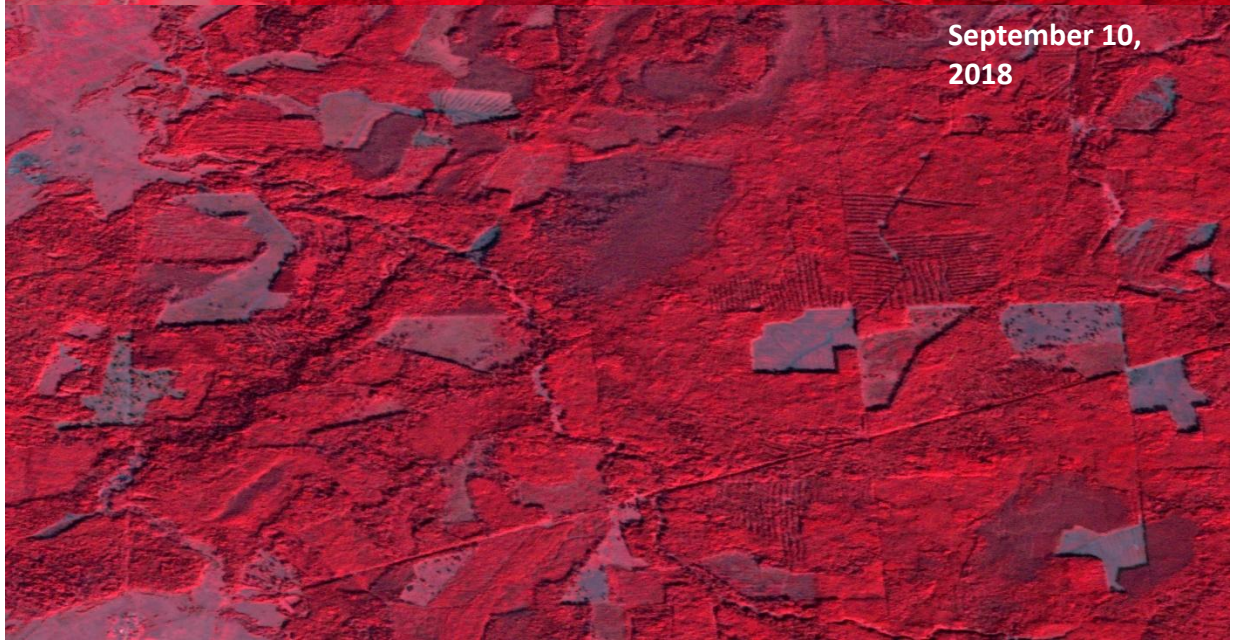

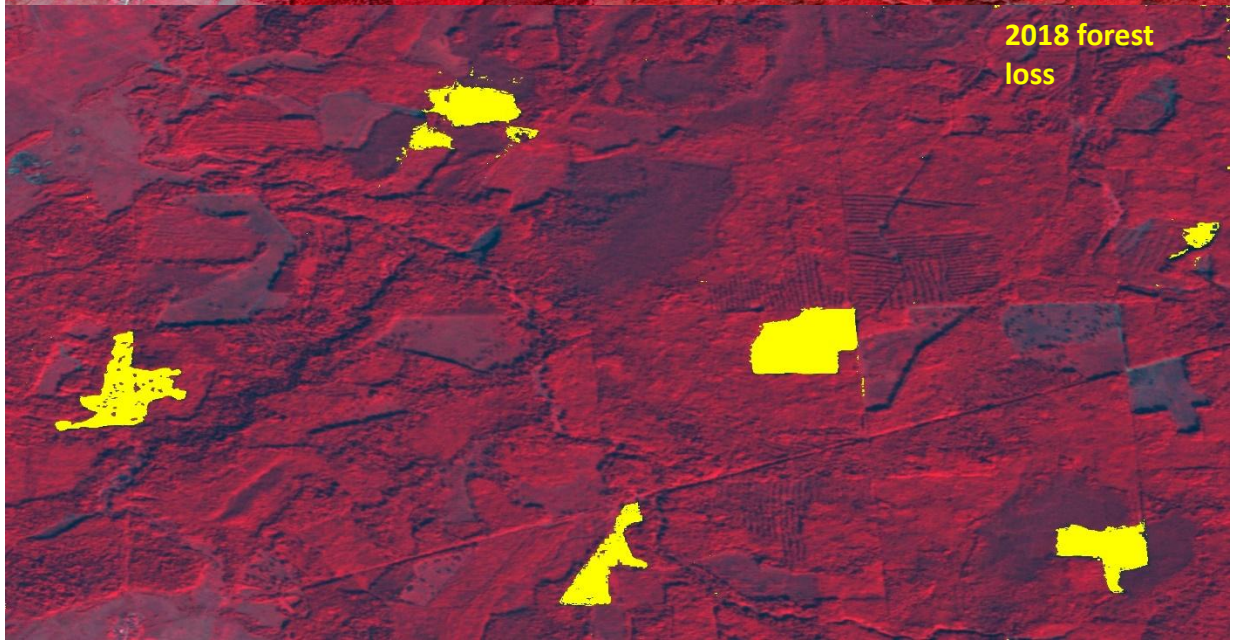

Timber plantation management (thinning) in Brazil

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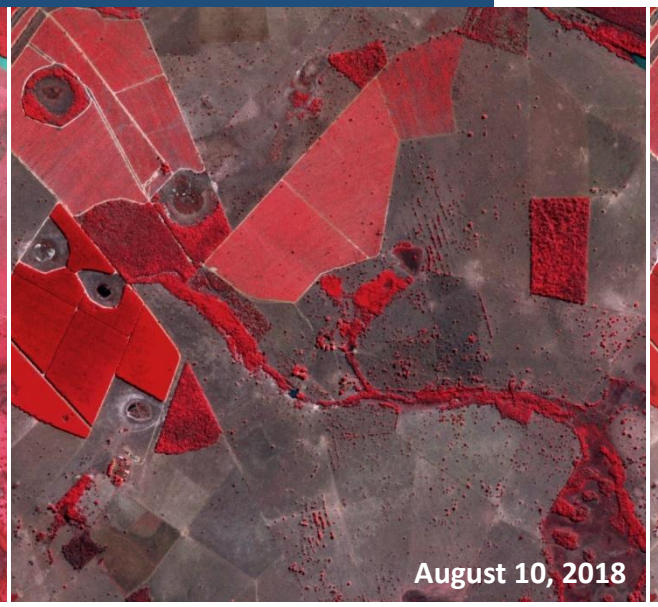
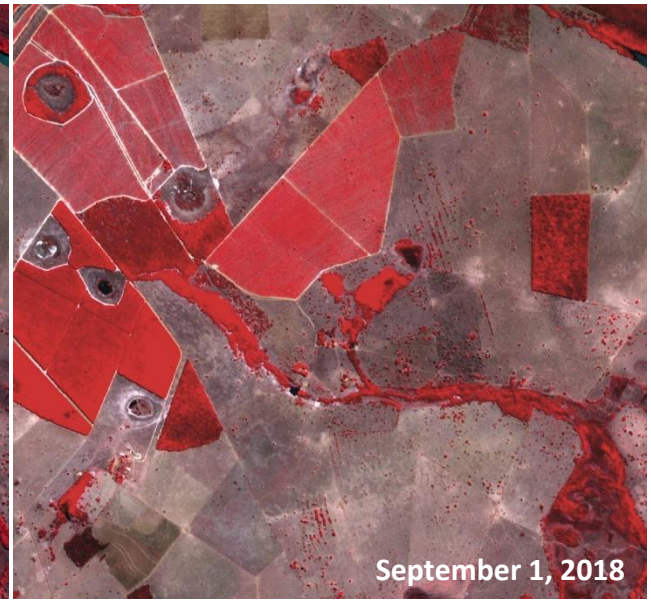
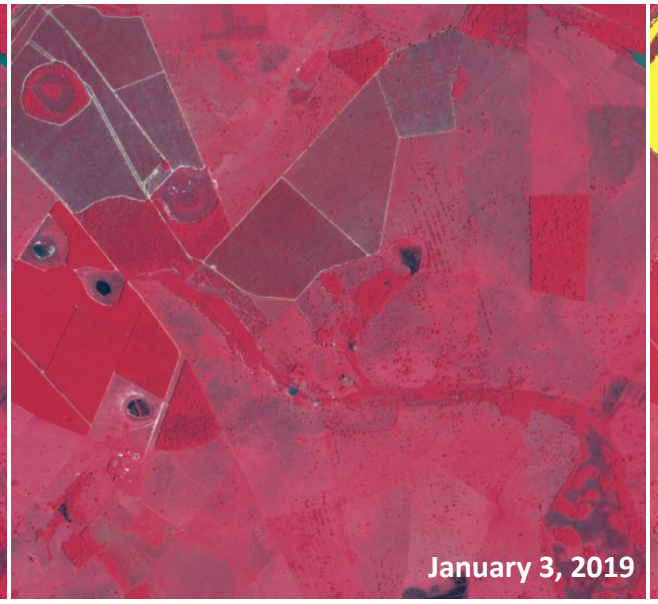




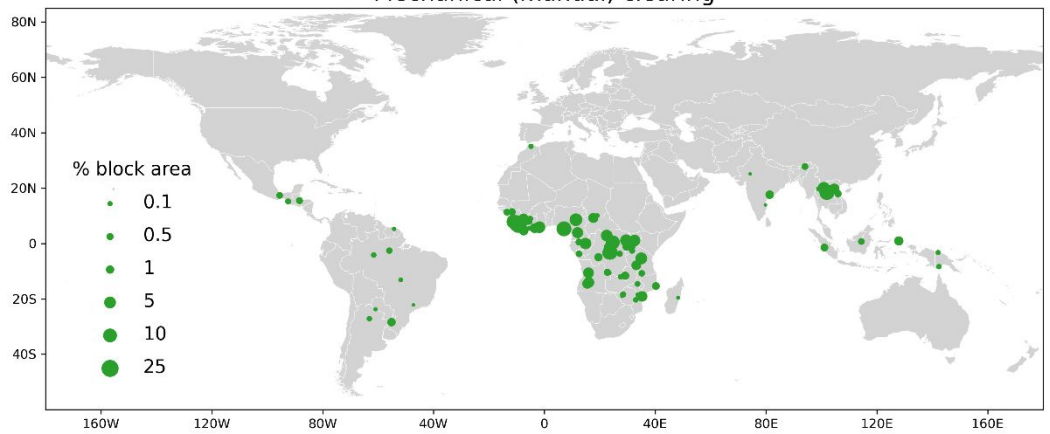


Initial forest disturbance type

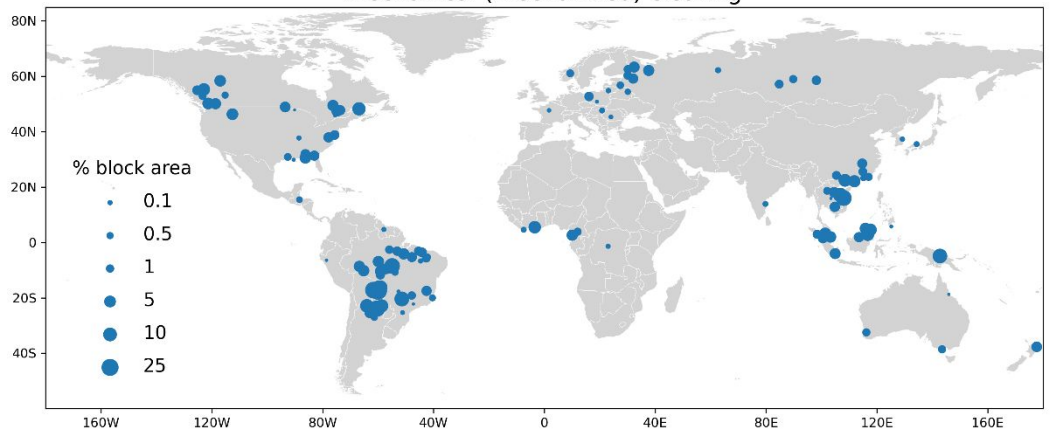
Mechanical clearing: *manual vs. mechanized*

Criteria: clearing size, presence of access roads for machinery + auxiliary information on land use practices

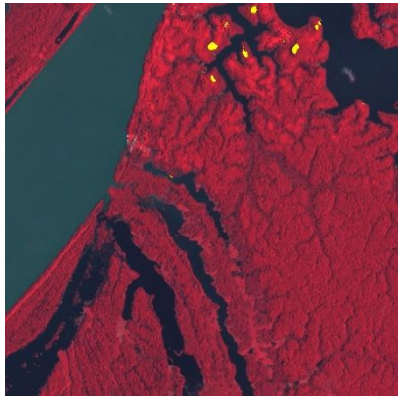
Mechanical (manual) clearing



Mechanical (mechanized) clearing



Example of **manual** clearing

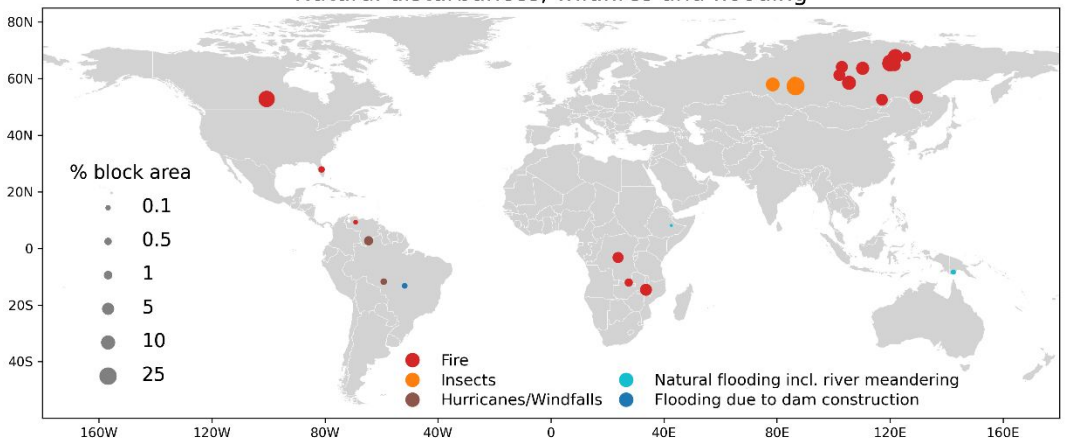


Shifting cultivation, State of Amazonas, Brazil

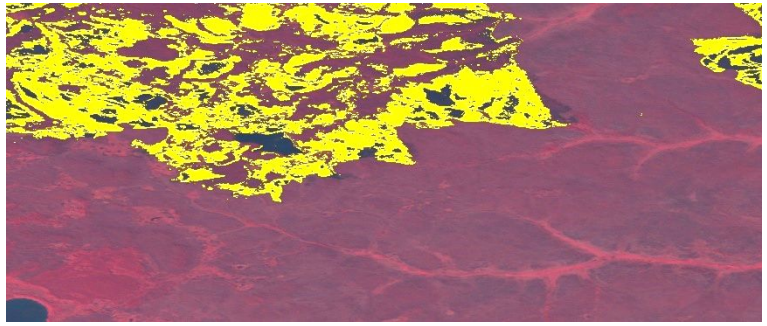
Example of **mechanized** clearing

Clearing for pasture, Paraguay

Natural disturbances, wildfires and flooding

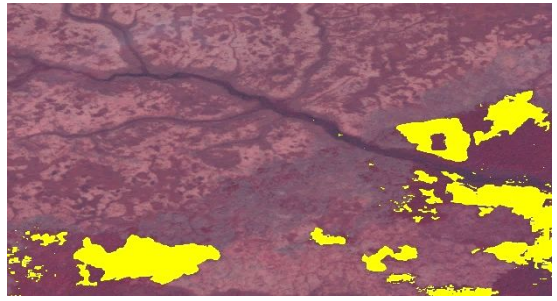


Example of **fire**



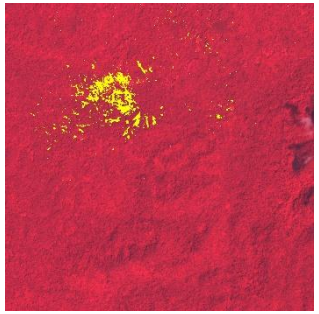
Sakha Republic, Russia

Example of **insect damage**



Tomsk region, Russia

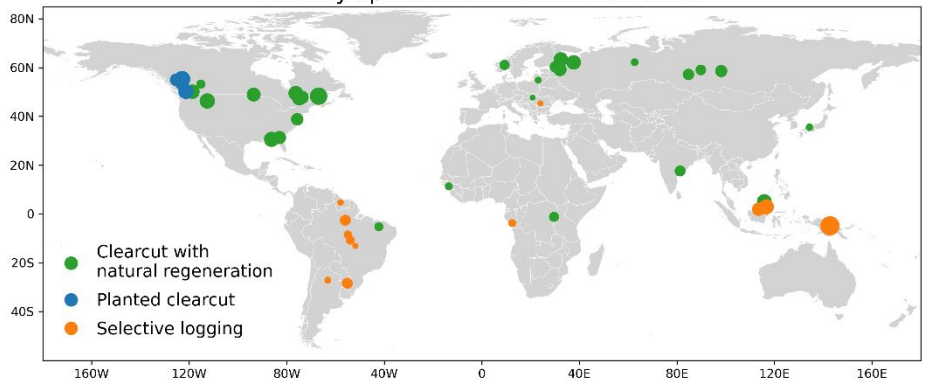
Example of **windfalls/hurricanes**



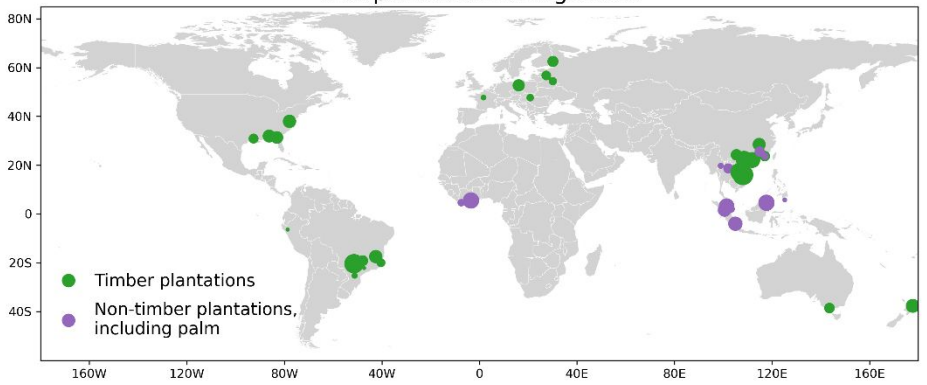
Amazonas state, Venezuela

Proximate cause (direct driver) of forest loss

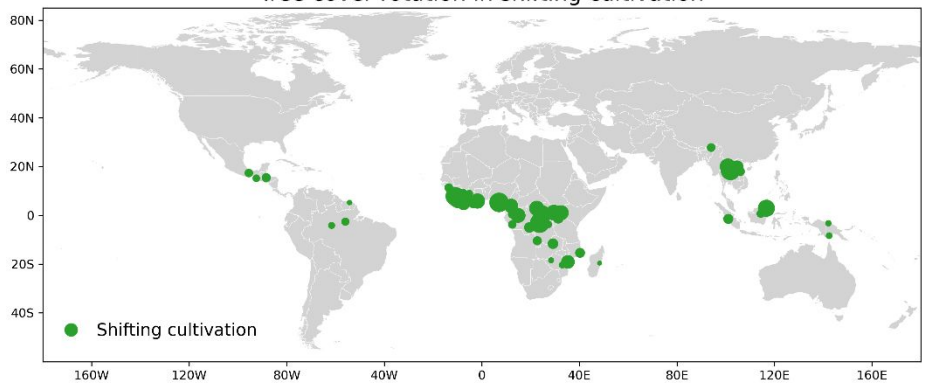
Forestry operations in natural tree cover



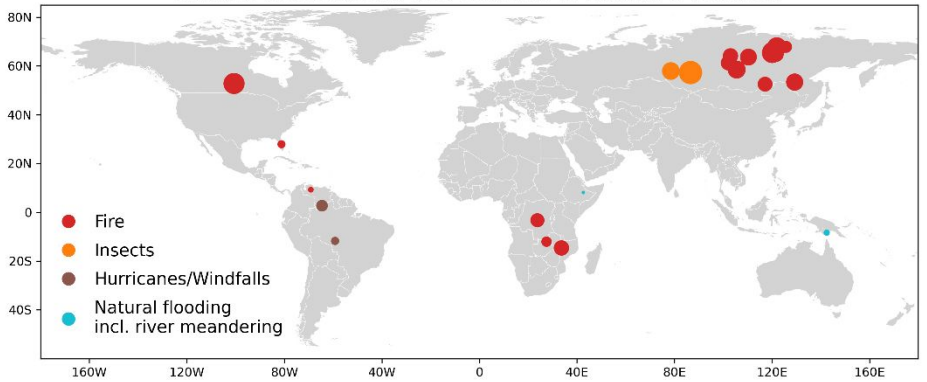
Tree plantation management



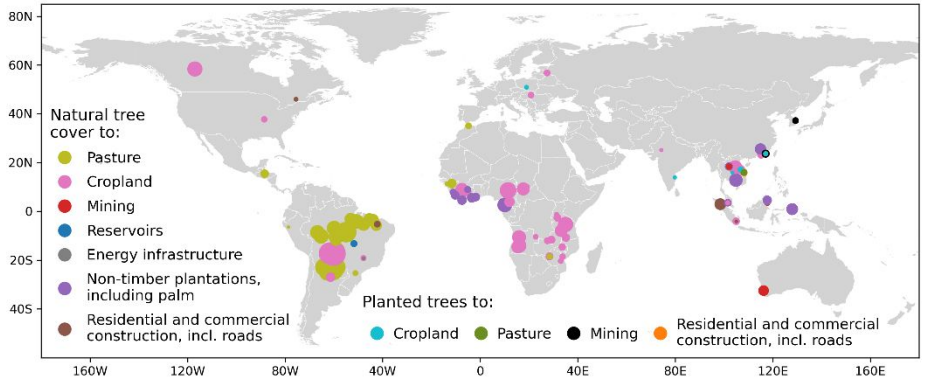
Tree cover rotation in shifting cultivation



Natural disturbances and wildfires in natural tree cover



Conversion of tree cover into other land uses



% forest loss from block area

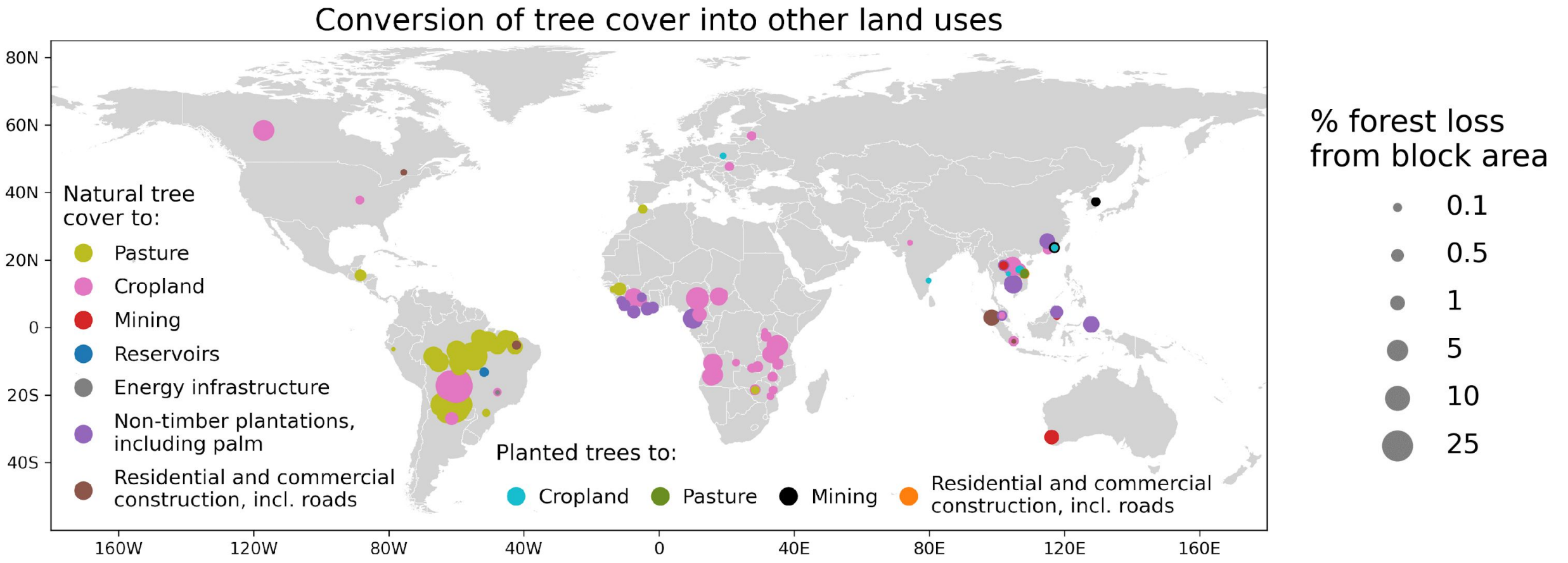
- 0.1
- 0.5
- 1
- 5
- 10
- 25

Based on land use 3 years post-disturbance (end of 2021)

June 2021, PlanetScope monthly mosaic

Example of conversion to cropland in Bolivia, identified from presence of active cropland in 2021 PlanetScope imagery

Proximate cause (direct driver) of forest loss



Project timeline

Project task	2021				2022				2023				2024
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
1. Finalize stratification and sample selection for baseline loss year (2018)													
2. Select, download and pre-process 2018 PlanetScope and Sentinel-2 data for all sampled blocks													
3. Classify forest loss from high resolution reference data for each sampled block													
4. Attribute direct drivers of forest loss and pre-disturbance forest type to mapped loss pixels													
5. Perform accuracy assessment of reference forest loss maps													
6. Perform statistical analysis, finalize findings, share data													
7. Write manuscript and submit it for publication in a peer-reviewed journal													
Project reports, presentations at LCLUC Science Team meetings													
Travel to visit research collaborators													
Presentation of preliminary findings at the ESA Living Planet Symposium													
Presentation of final results at the AGU Fall Meeting													

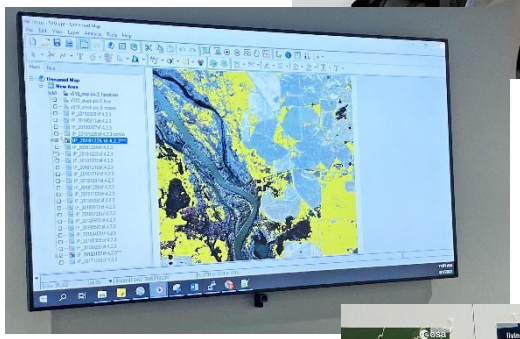
Project task status:

orange – completed

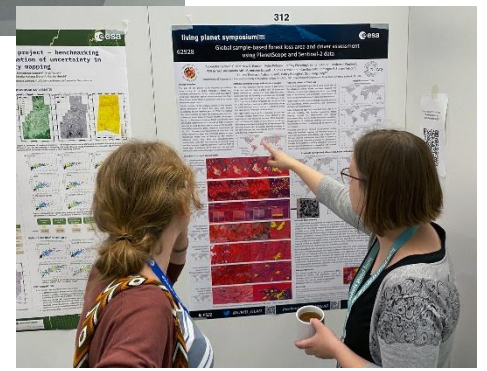
green – in process

blue – not yet started

We are here

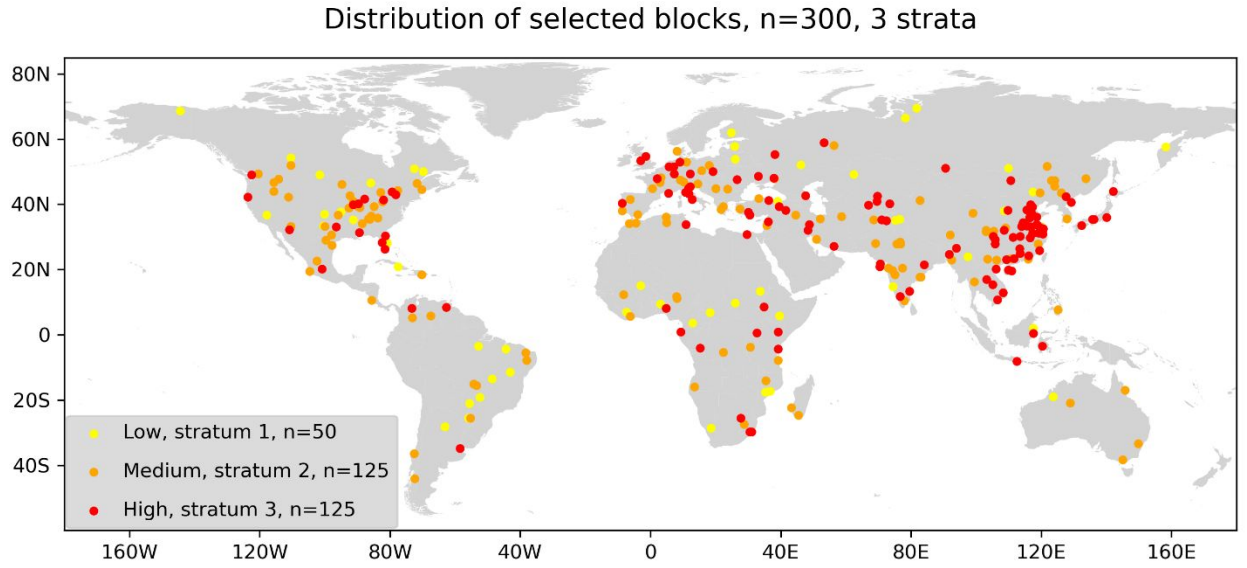


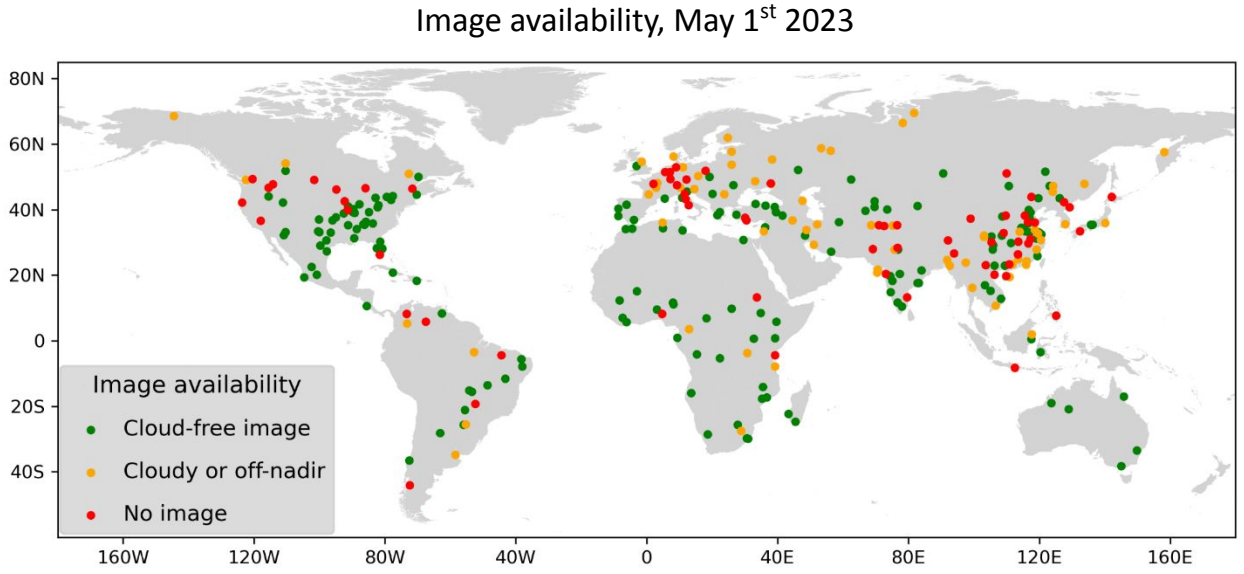
QA session – checking block mapping results



ESA Living Planet Symposium 2022

Current LCLUC project augmentation: CSDA BlackSky evaluation





Purpose:

Employ BlackSky imagery to validate time-series of global change in **built-up area**, which is one of the drivers of global forest disturbance, and estimate the global built-up area in 2022-23.

Study Objectives:

- Estimate built-up land area from the sample of BlackSky and drivers of built-up area change;
- Estimate the accuracy of Landsat- and Planet-based maps.

Study Design:

Stratified random sample of 300 2.5 km blocks; stratification is based on existing Landsat-based built-up maps.

Note from a first-time PI:

It is exciting to task a satellite!

Thank you for your attention!

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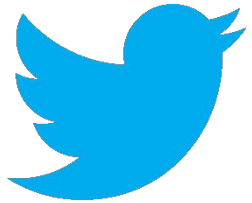

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