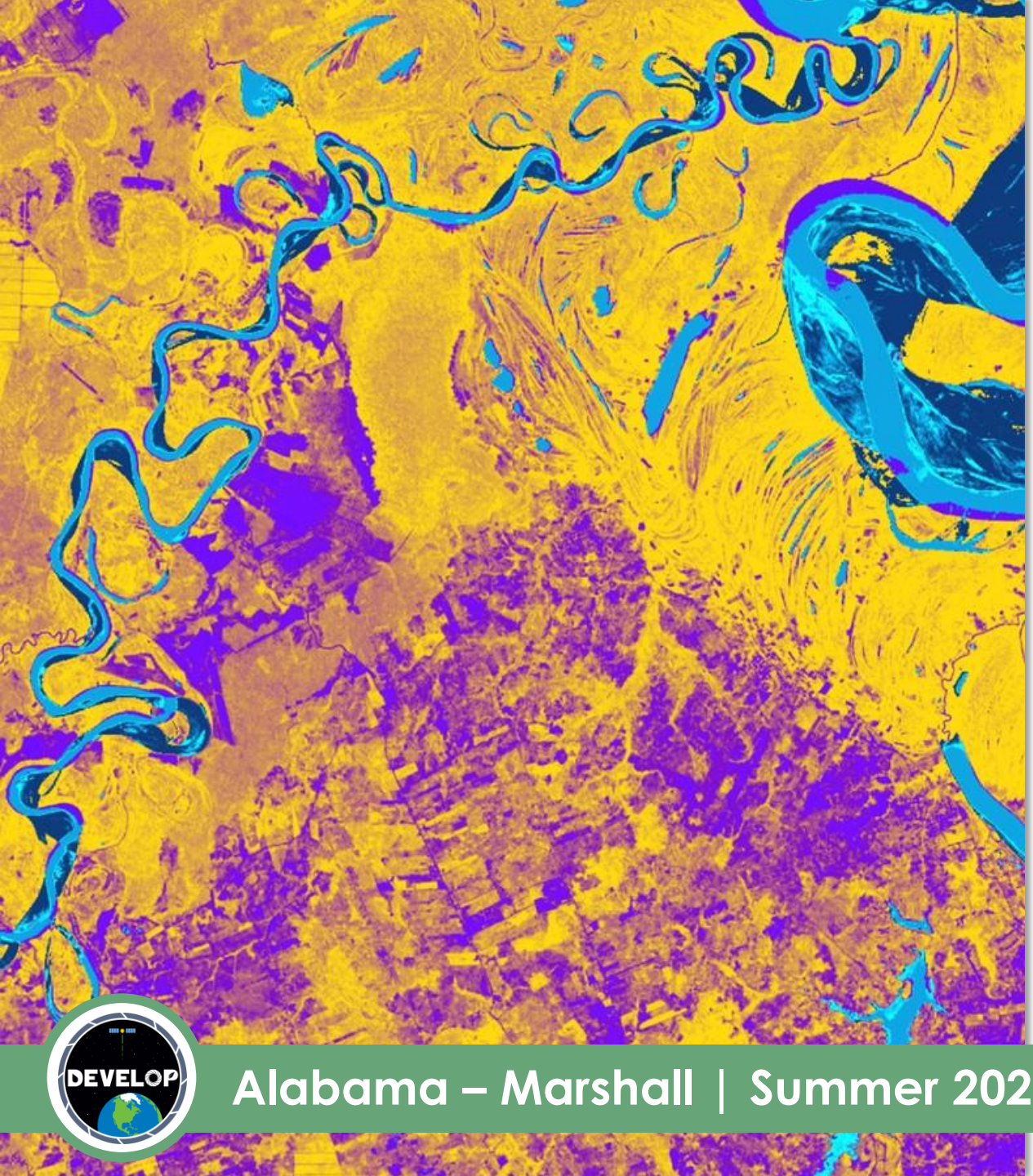


National Aeronautics and Space Administration

PERUVIAN AMAZON ECOLOGICAL CONSERVATION

Assessing Land Cover Changes in the Peruvian Amazon to Identify Exploitative Agriculture Using NASA EO and PerúSAT-1

Beck De Fazio

Ashley Laveriano

Brian Arruda

Margaret Cox

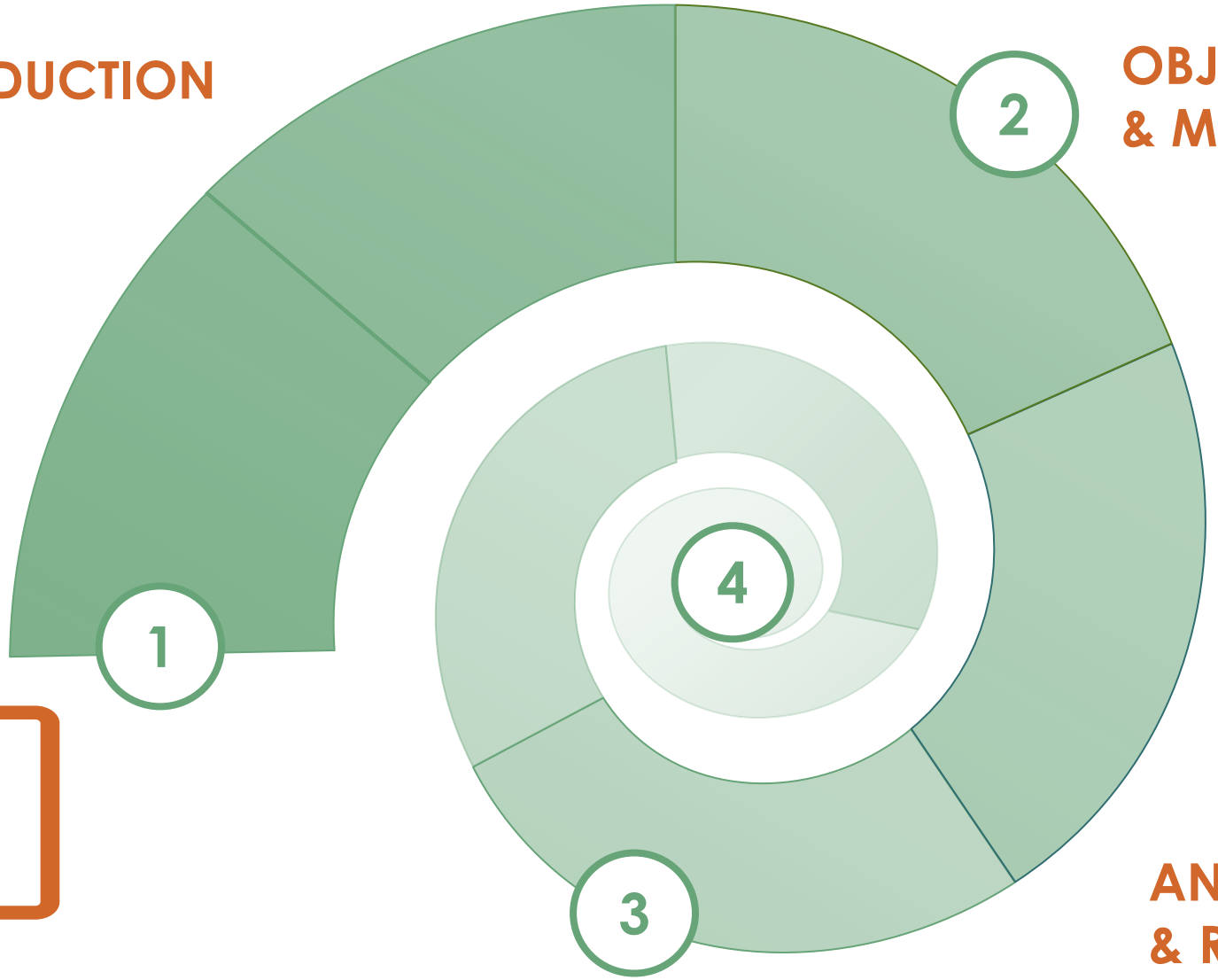
DEVELOP

Alabama – Marshall | Summer 2024

Roadmap

1 INTRODUCTION

OBJECTIVES & METHODS 2



4 DISCUSSION

3 ANALYSIS & RESULTS

Meet the Team

Brian Arruda

Beck De Fazio

Margaret Cox

Ashley Laveriano

Image Credit: Tom Fisk

The Amazon


Image Credit: Diego Perez


Image Credit: European Space Agency


Image credit: Diego Perez


Image Credit: Joelle Hernandez


Image Credit: Scott Kuo

Palm Oil in the Peruvian Amazon

93% Increase in exports since 2013

72% Expansion on forested land (2000-2010)

2000 Declared a commodity of national interest

5 Tons/ha crop productivity

Community Concerns


Image Credit: Management Sciences for Heal[illegible] Peru


Image Credit: Robert Guimaraes Vasquez


Image Credit: Rettet den Regenwald

People

- Smallholder farmers
- Industrial Corporations

Economy

- Partnerships
- Economic Disparities

Environment

- Land use differences
- Loss of ecosystem services

Project Partners

End User

Organismo de Evaluación y Fiscalización Ambiental (OEFA)

Evaluation and **prevention** of environmental impacts

Supervision and compliance with regulations

Collaborator

Comisión Nacional de Investigación y Desarrollo Aeroespacial (CONIDA)

Promote R&D of space science and technology

Generate products for the socioeconomic development and security

Area of Interest

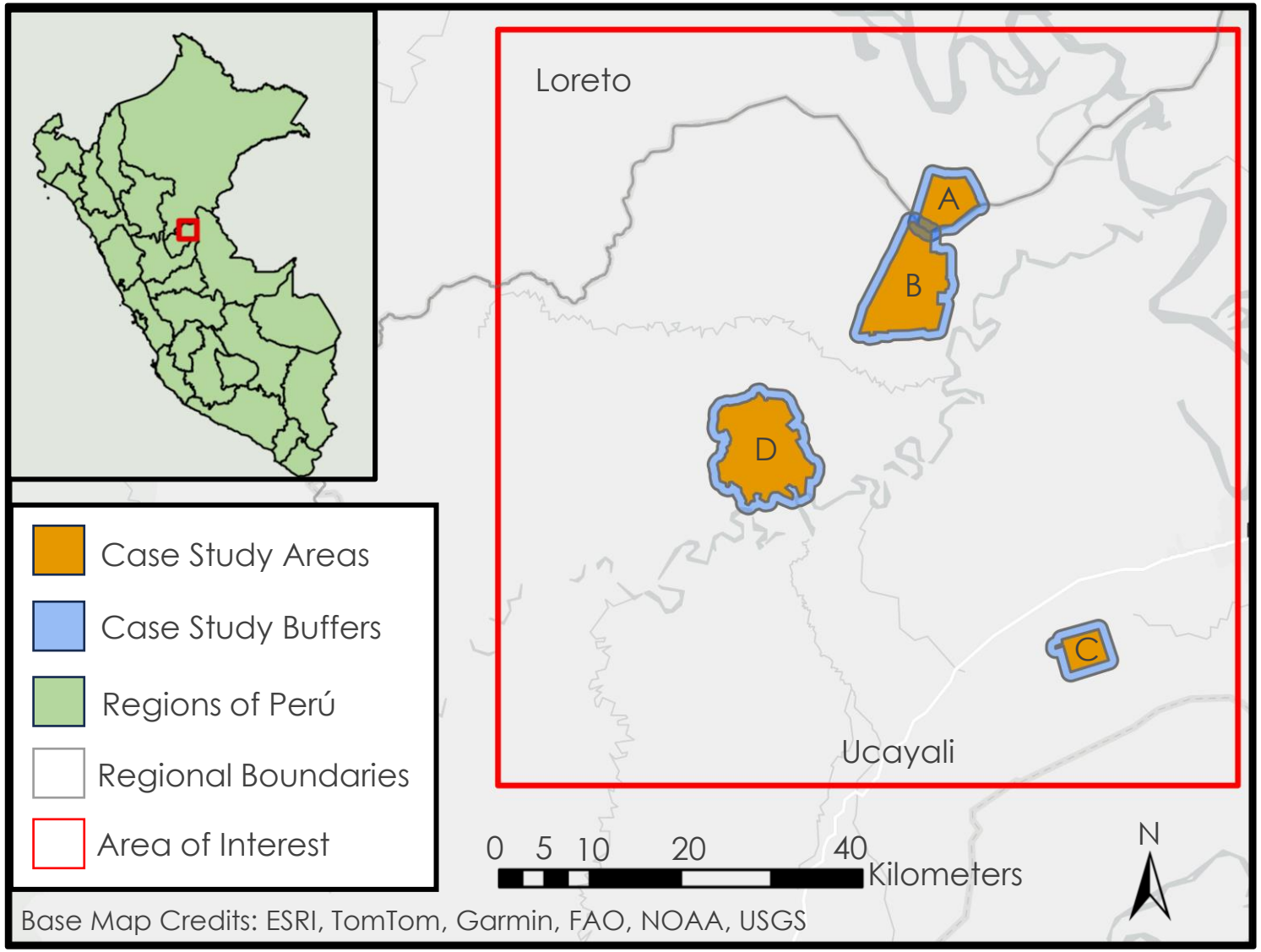
Study Area

- Peru: Ucayali & Loreto

Study Period

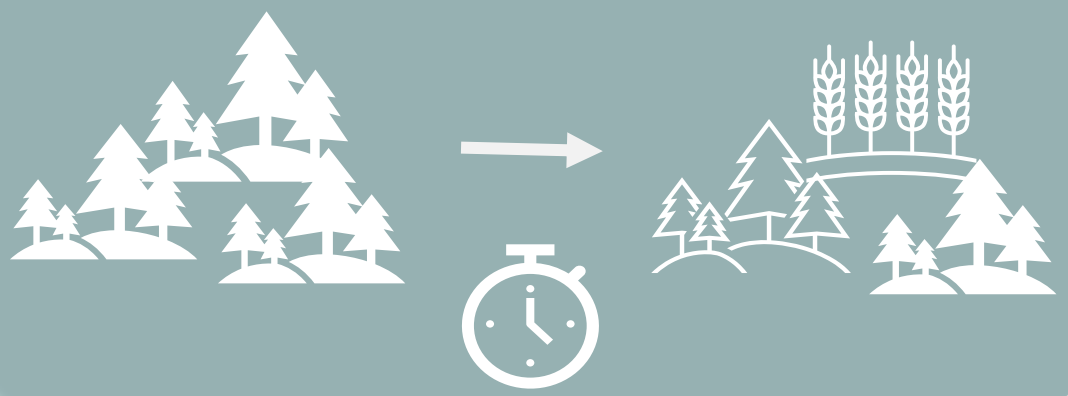
- Jan. 2017 – Dec. 2023

- Area of interest spans approximately **6,800 sq km** in the **Peruvian Amazon**
- **Four** focus case study areas that encompass designated **agroforestry** land

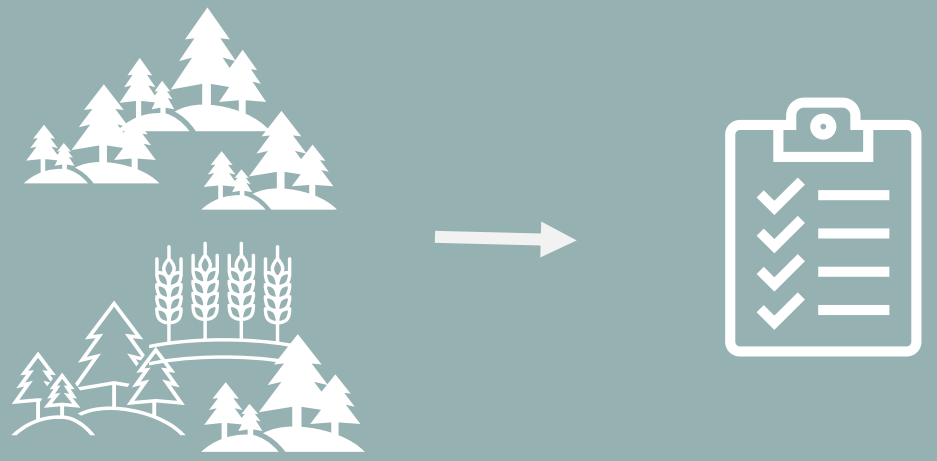


Objectives

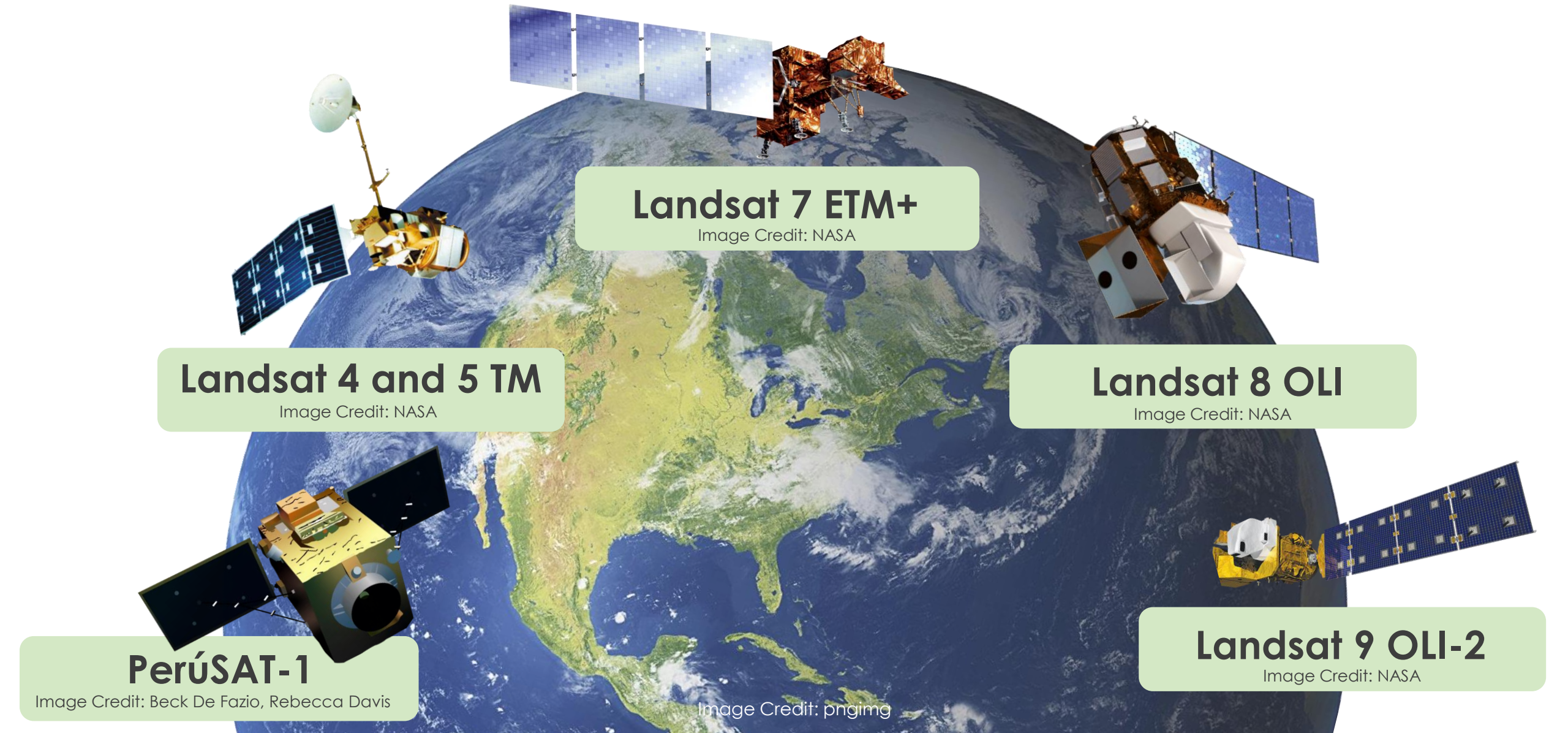
Quantify
deforestation in Perú using Landsat



Classify & Validate
change detection using PerúSAT-1



Earth Observations



Landsat 7 ETM+
Image Credit: NASA

Landsat 4 and 5 TM
Image Credit: NASA

Landsat 8 OLI
Image Credit: NASA

PerúSAT-1
Image Credit: Beck De Fazio, Rebecca Davis

Landsat 9 OLI-2
Image Credit: NASA

Image Credit: pngimg

Remote Sensing Indices Used

CCDC-SMA: Continuous Change Detection and Classification Spectral Mixture Analysis

Combines deforestation detection time series and spectral mixture analysis through GEE

Endmembers: green vegetation (GV), soil, non-photosynthetic vegetation (NPV), shade, cloud

NDFI: Normalized Difference Fraction Index

$$\frac{GV_{shade} - (\text{NPV} + \text{Soil})}{GV_{shade} + (\text{NPV} + \text{Soil})} \quad \text{where} \quad GV_{shade} = \frac{GV}{1 - Shade}$$

Represents the fraction of each endmember in a pixel: ↑ Soil & ↓ NDFI = Disturbance (Soil – NDFI will always be > 0)

NDVI: Normalized Difference Vegetation Index

Proxy for vegetation health

$$\frac{NIR - Red}{NIR + Red}$$

EVI: Enhanced vegetation index

Corrects for atmospheric condition and canopy background noise

$$2.5 \text{ x } \frac{NIR - Red}{(NIR + (2.4\ x\ Red) + 1)}$$

Methods

Land Cover Maps

Utilizing Landsat 8 OLI & Landsat 9 OLI 2

Google Earth Engine

Normalized Difference Vegetation Index

Enhanced Vegetation Index

Vegetation Loss

Methods

Land Cover Maps

Utilizing Landsat 8 OLI & Landsat 9 OLI 2

Google Earth Engine

Normalized Difference Vegetation Index

Enhanced Vegetation Index

Vegetation Loss

Time Series Change Detection

Via Landsat Series

Continuous Change Detection and Classification Spectral Mixture Analysis

Normalized Difference Fraction Index

Square km Lost & Forest % Remaining

Methods

Land Cover Maps

Utilizing Landsat 8 OLI & Landsat 9 OLI 2

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Normalized Difference Vegetation Index

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Vegetation Loss

Time Series Change Detection

Via Landsat Series

Continuous Change Detection and Classification Spectral Mixture Analysis

Normalized Difference Fraction Index

Square km Lost & Forest % Remaining

Land Cover Change Classification

PerúSAT-1

ArcGIS Pro 3.1.0

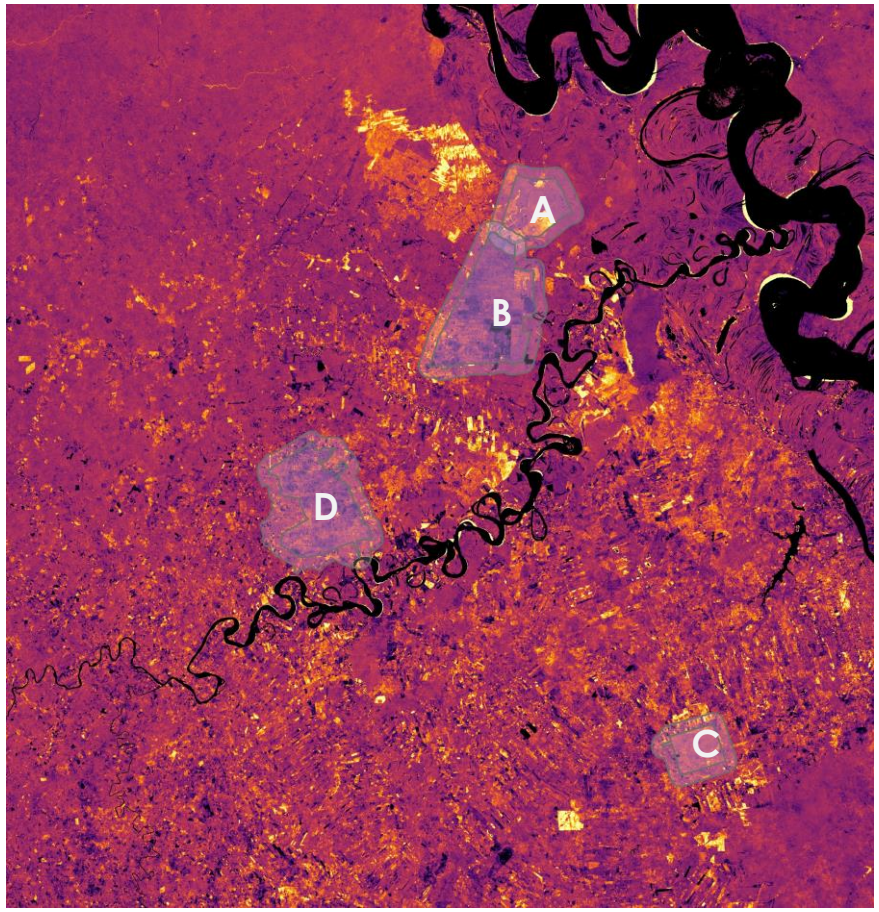
Collect Training Data

Imagery Pre-Processing

Supervised Classification

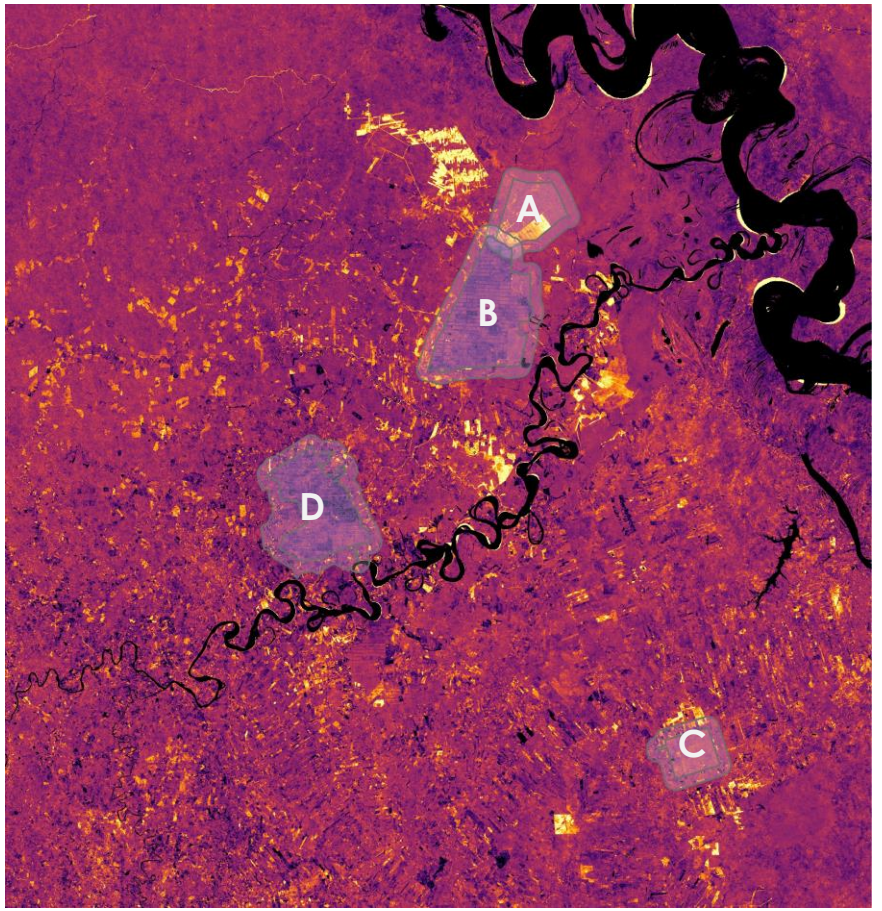
Identify Palm Expansion

NDVI & EVI

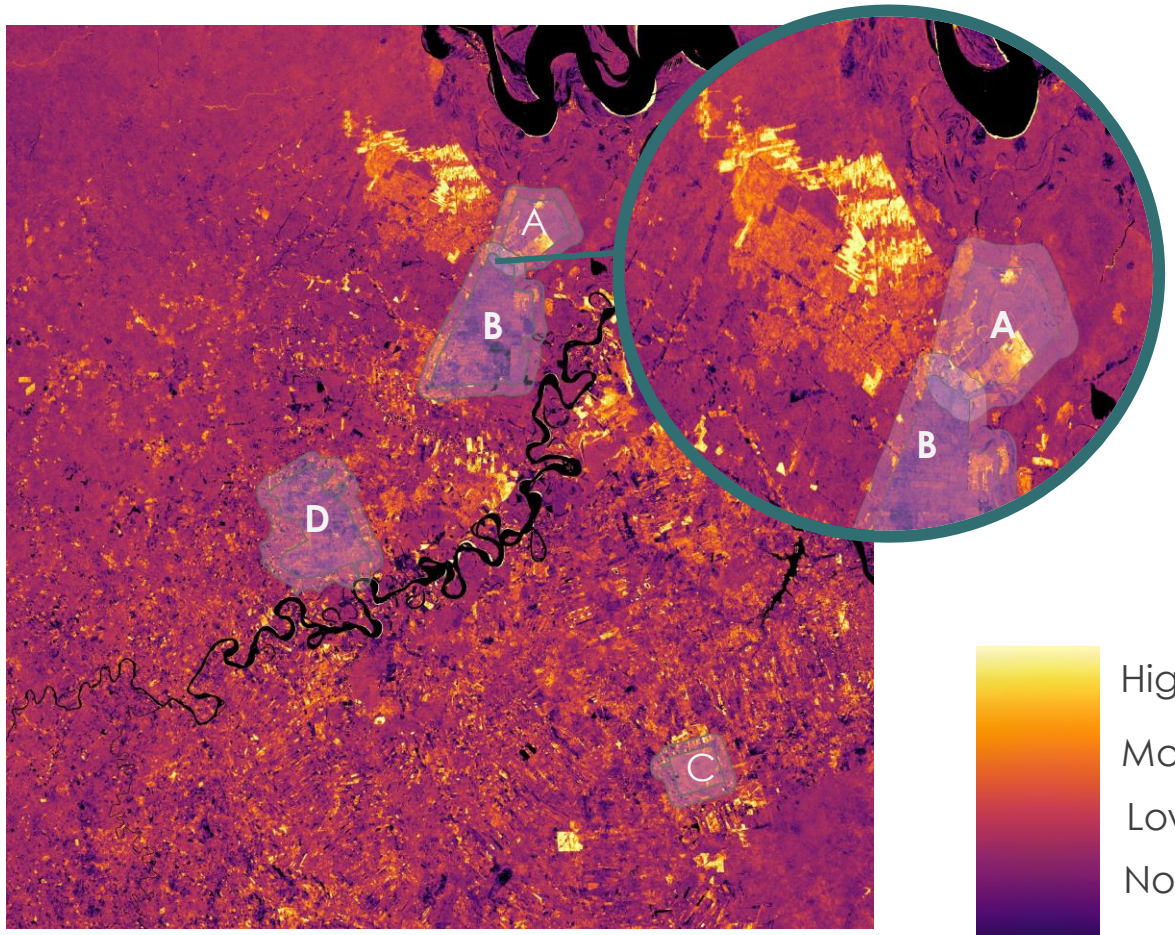


Difference in NDVI, 2017-2023

Difference in EVI, 2017-2023

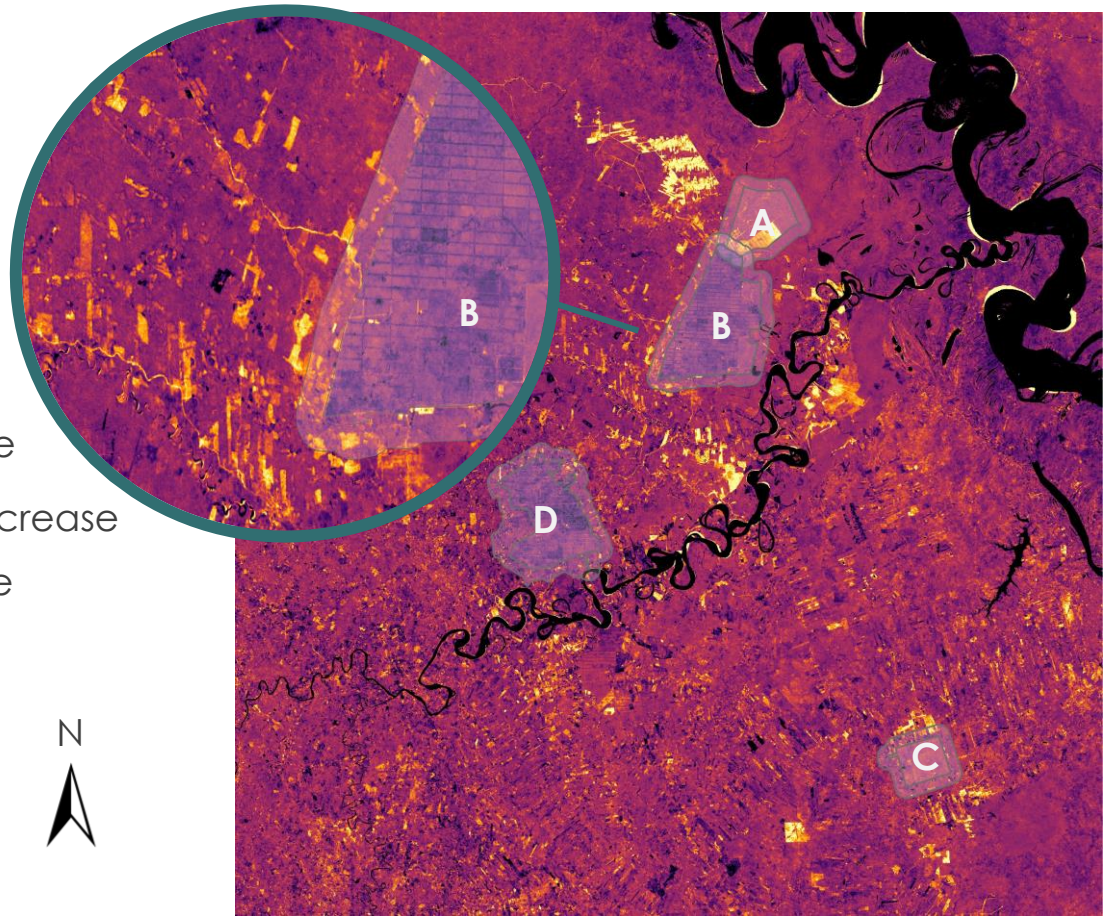


NDVI & EVI



Difference in NDVI, 2017-2023

Difference in EVI, 2017-2023



High Decrease

Moderate Decrease

Low Decrease

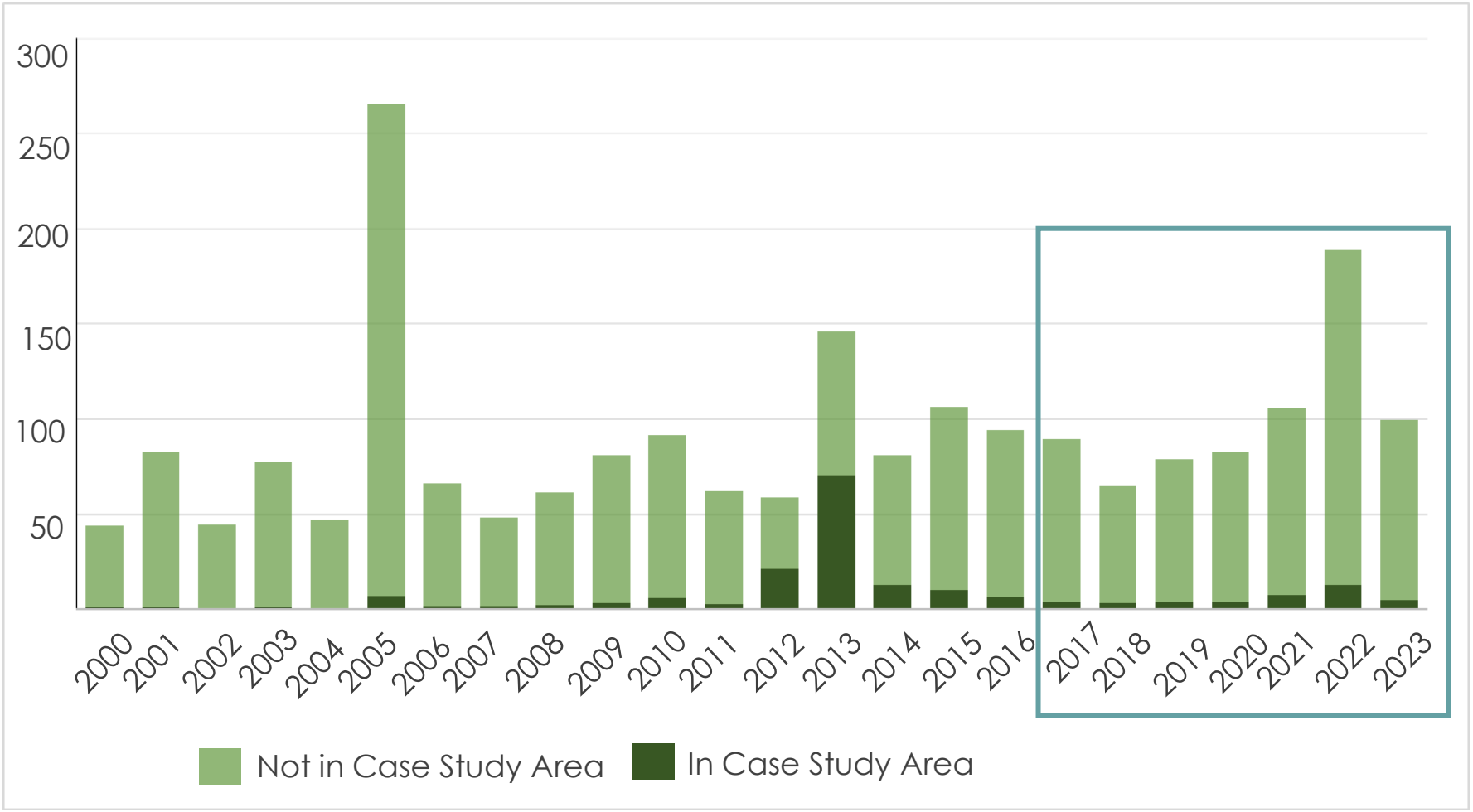
No Decrease

Water Mask

N

5 10 20 40

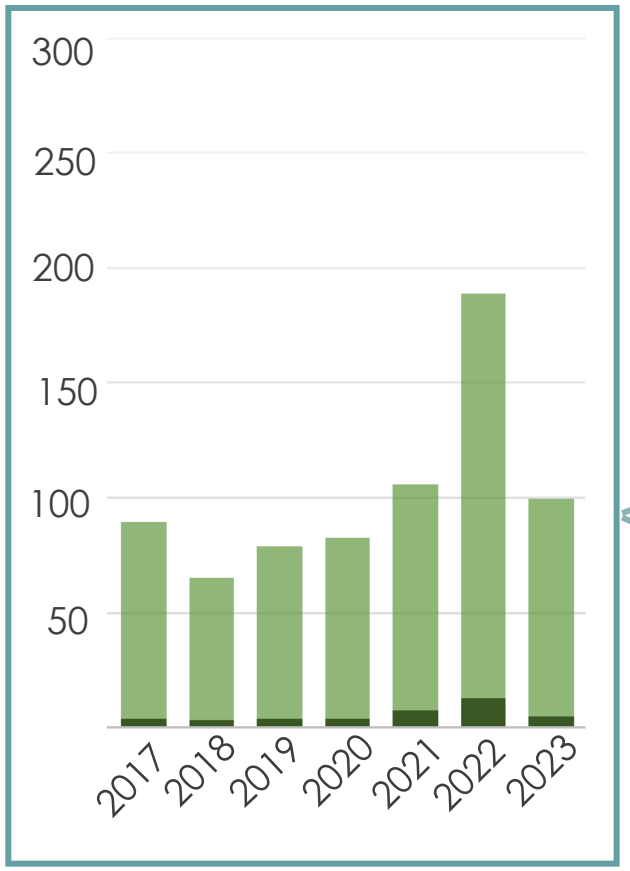
CCDC-SMA: Deforestation by Year



2165.2 km^2

Total Area Deforested, 2000-2023

CCDC-SMA: Recent Deforestation



Deforestation from 2017-2023:

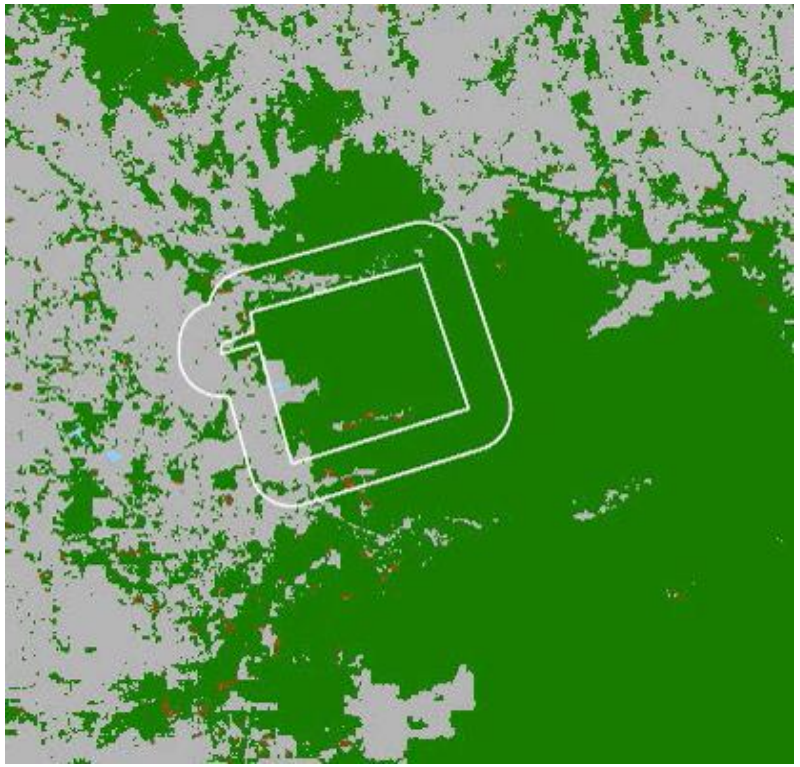
708.8 km²

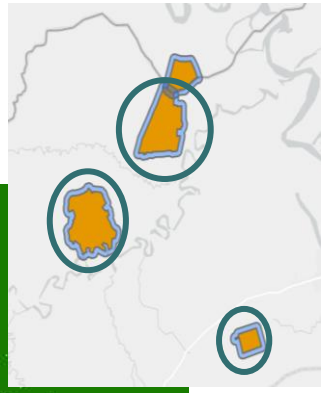
Year	Deforested Area (km²)	% Total Loss
2022	189	26.6 %
2021	105	14.9 %
2023	99	14.0 %

Total Area Deforested: **2165.2 km²**

Percent Intact Forest: B, C, and D

Was the case study area > 30% forest as of 2023?





N

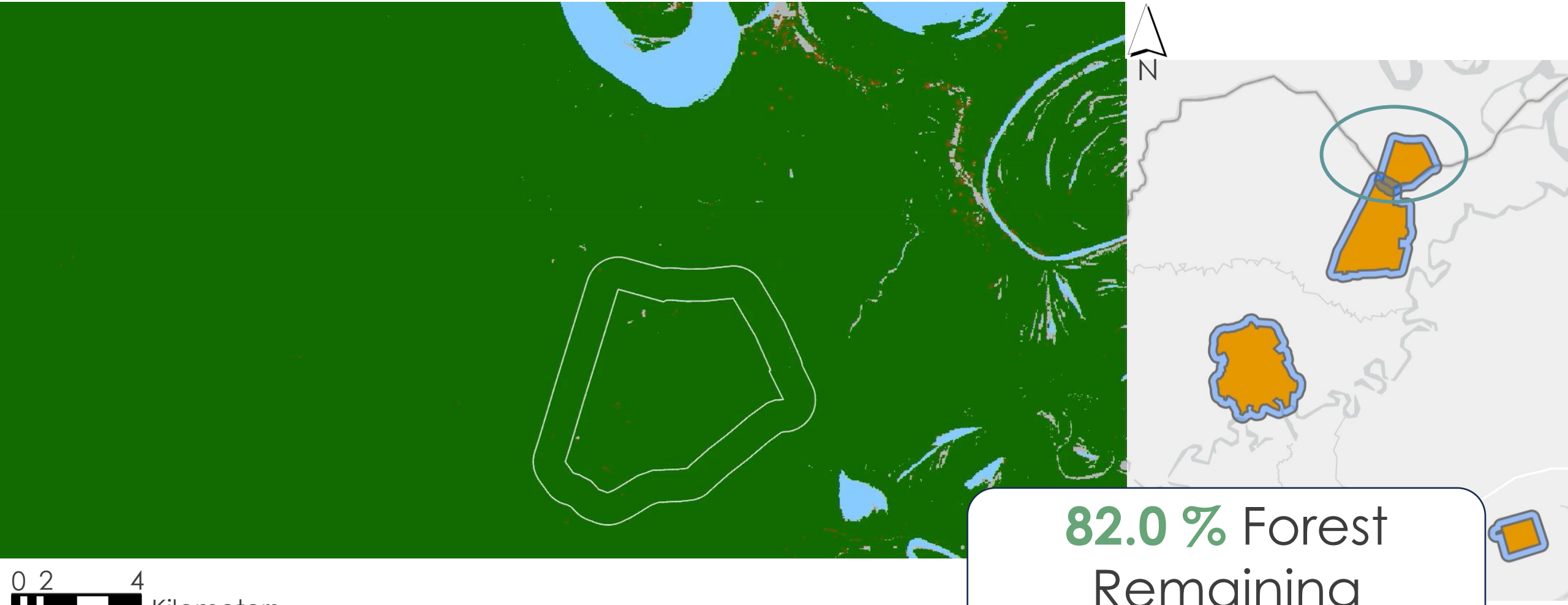
0 2 4
Kilometers

C: 68.2%

B: 12.8%

D: 25.7%

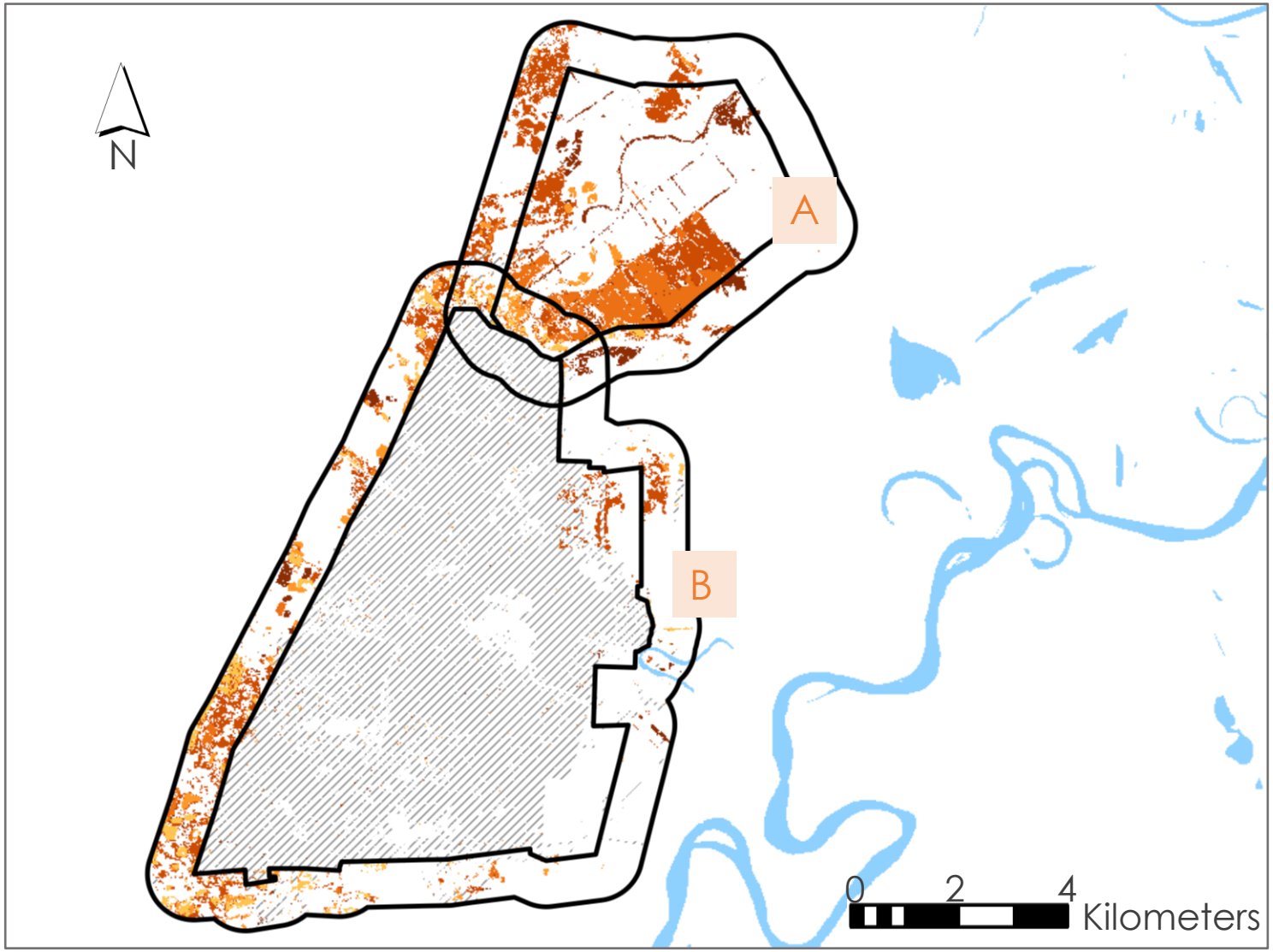
Percent Intact Forest: A



82.0 % Forest Remaining

As of 2023

Deforestation in Case Study A & B



Recent Forest Disturbance

- 2019
- 2020
- 2021
- 2022
- 2023

Previous Disturbances in Mid 2010s

- 2012- 2015

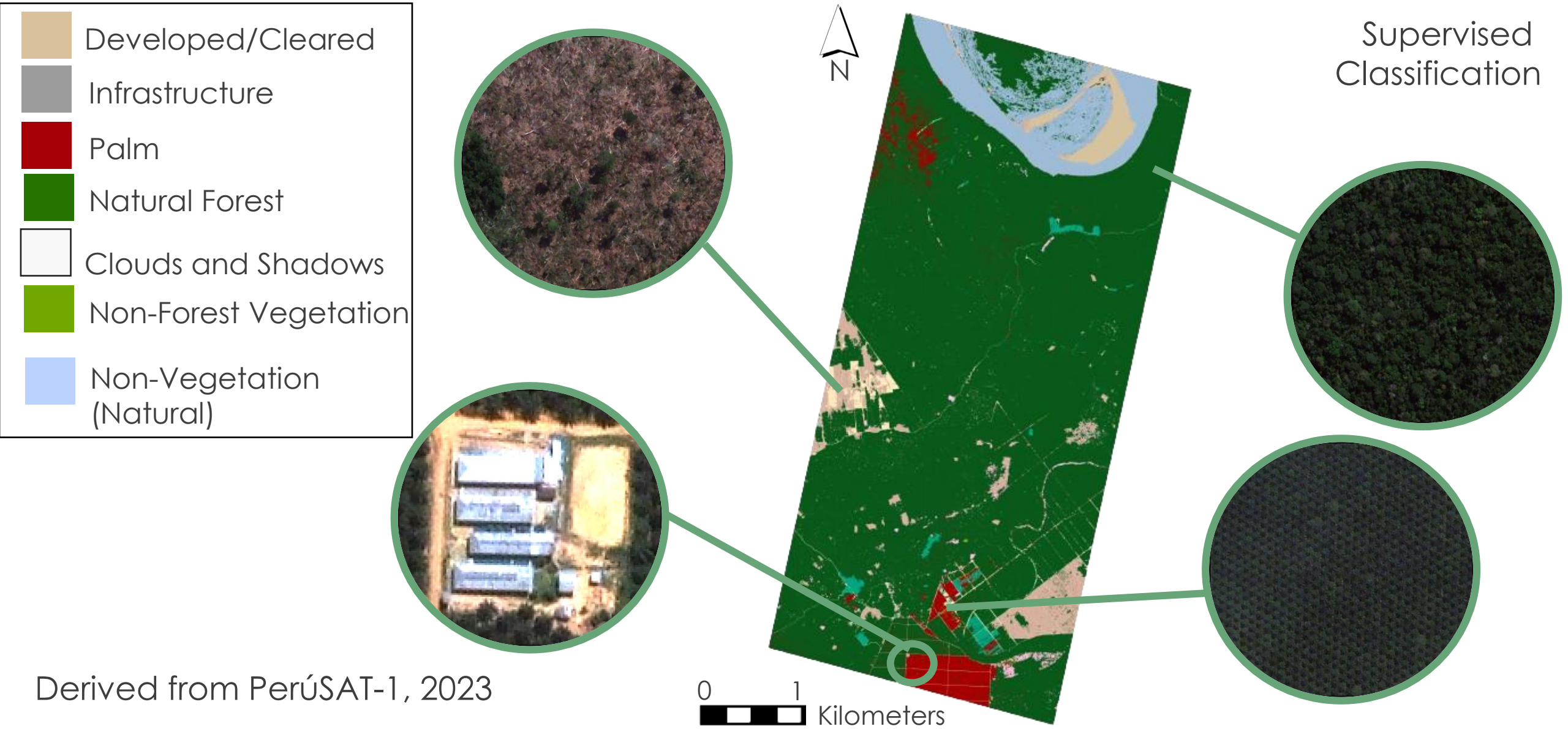
- 1 km Around Case Study
- Bodies of Water

PerúSAT-1 Imagery

Image, PerúSAT-1, 2018

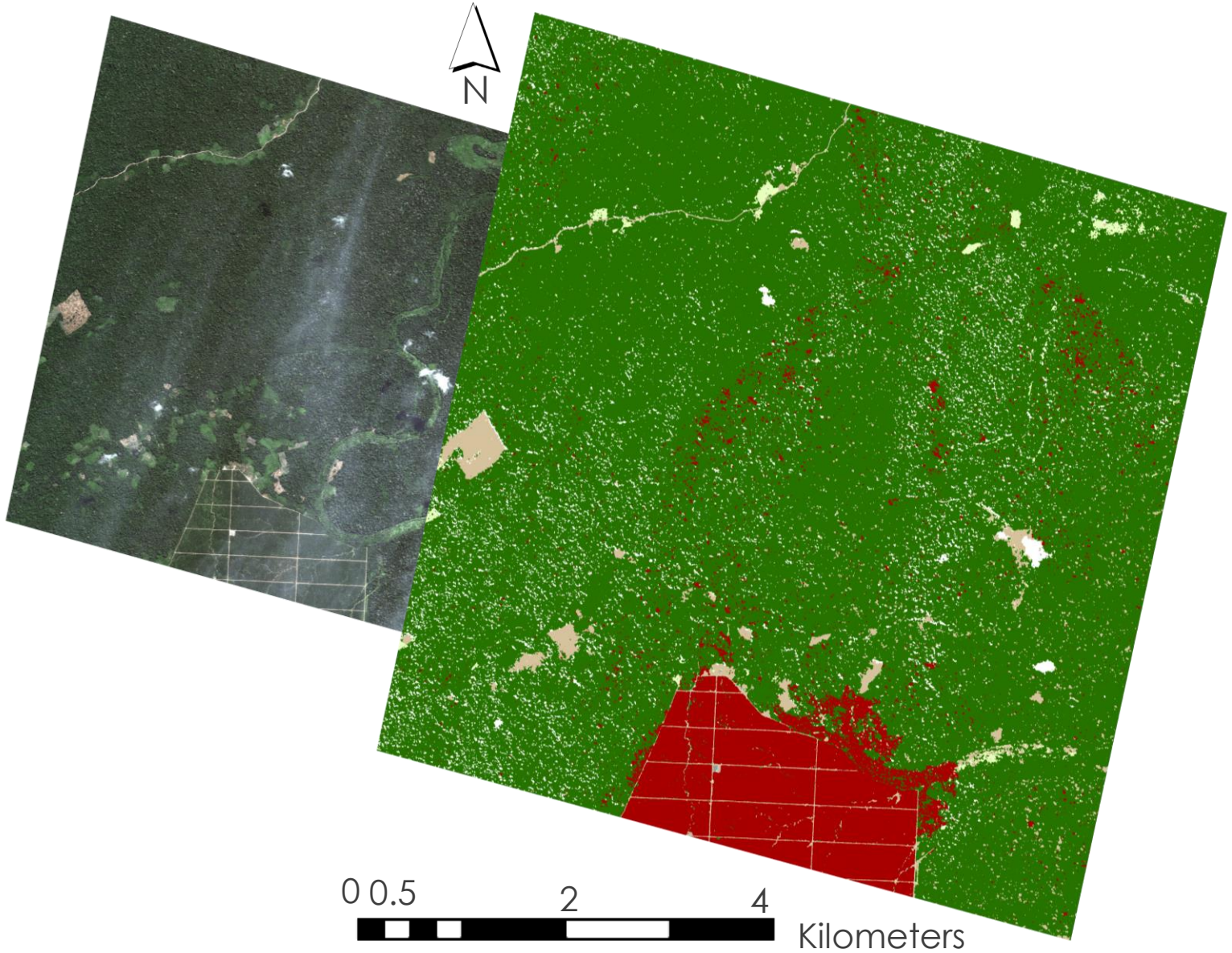
Image, PerúSAT-1, 2023

PerúSAT-1: Classification (2023)



Derived from PerúSAT-1, 2023

PerúSAT-1: 2018 Classification



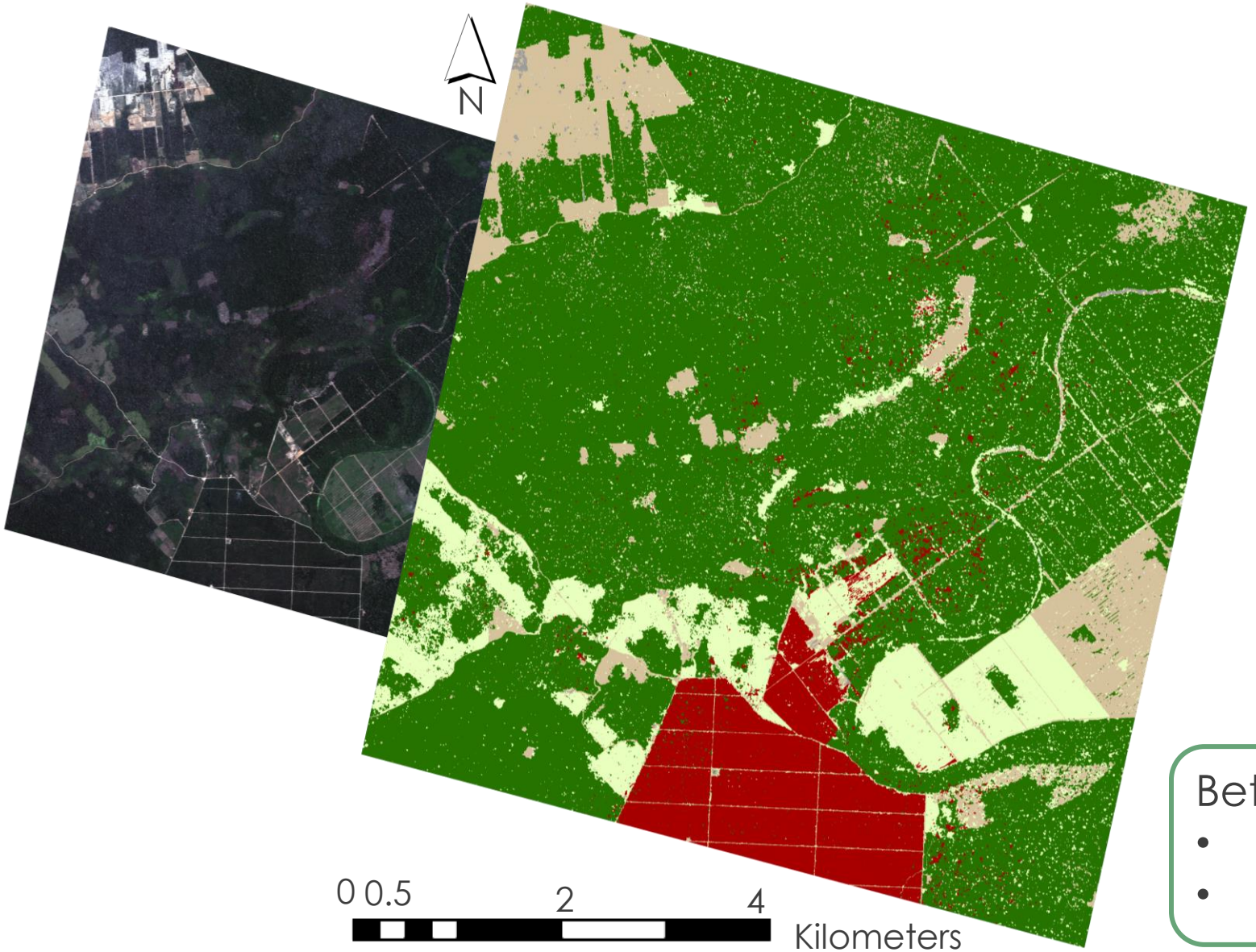
Class [2018]	% of Area
Natural Forest	83.37%
Palm (Agriculture)	8.98%
Developed/Cleared	3.01%
Non-Forest Vegetation	0.86%
Clouds and Shadows	3.72%

0.06% of Area is 'Other'

Land Classes

- Natural Forest
- Palm
- Non-Forest Vegetation
- Developed and Cleared
- Clouds and Shadows

PerúSAT-1: 2023 Classification



Class [2023]	% of Area
Natural Forest	68.07%
Palm (Agriculture)	8.61%
Developed/Cleared	10.21%
Non-Forest Vegetation	12.70%

0.41% of Area is 'Other'

Land Classes

- Natural Forest
- Palm
- Non-Forest Vegetation
- Developed and Cleared

Between 2018 and 2023:

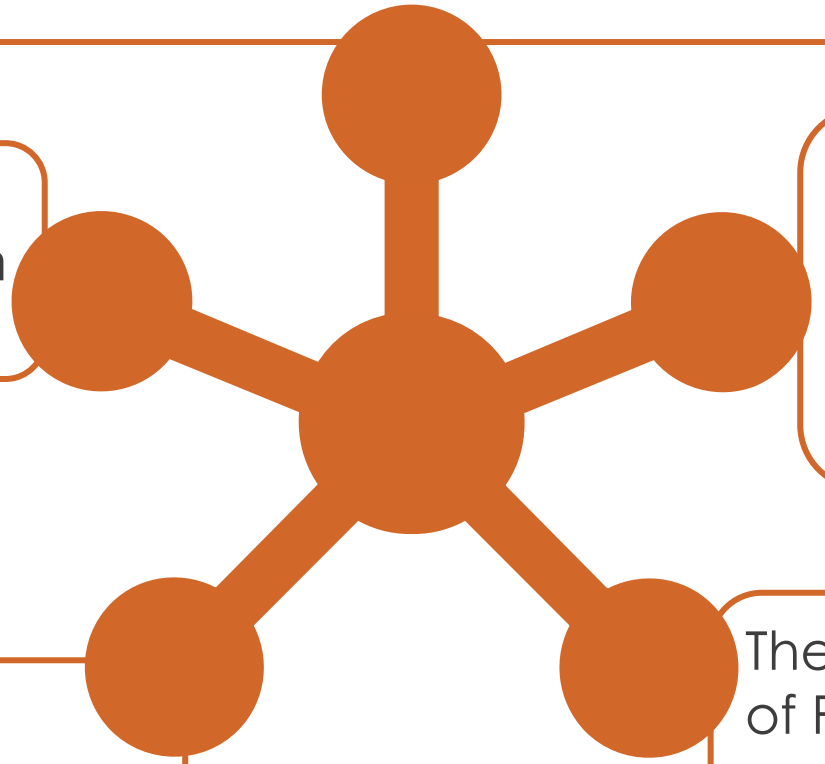
- 15.30% decrease in Natural Forest
- 7.19% increase in developed land

Conclusions

Total area deforested in the region from 2000-2023 was **2165.2 km²**

NDVI and EVI indicate an overall **decrease in vegetation** health over 2017-2023

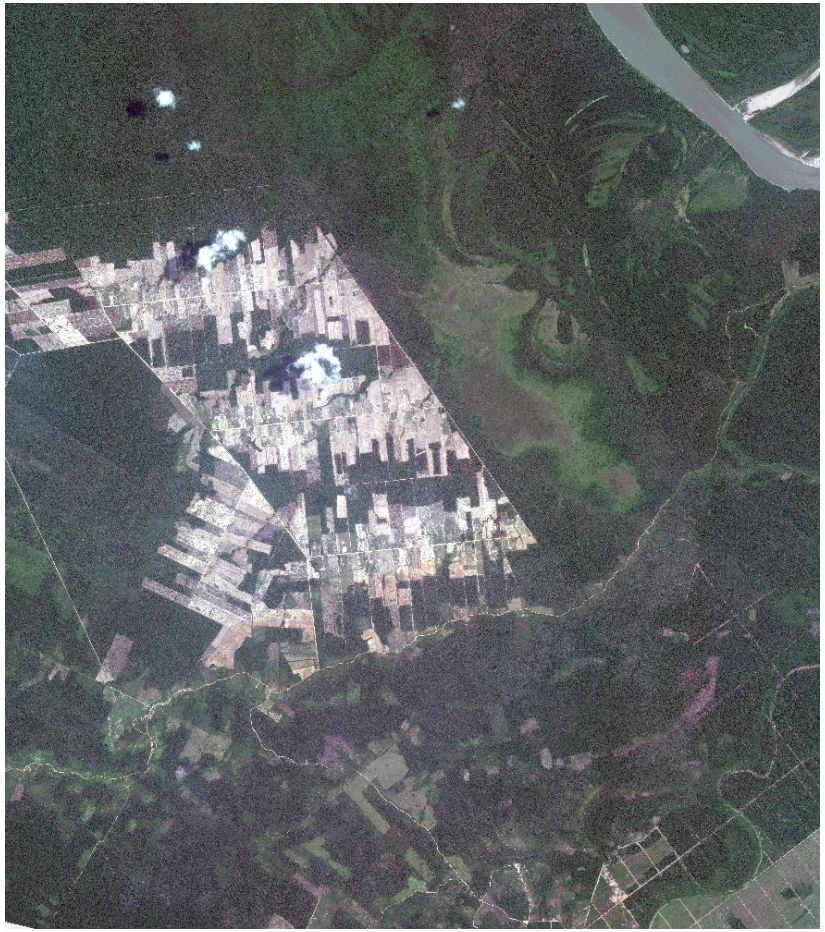
Supervised Classification using PerúSAT-1 showed a **15.30% decline in forest cover** from 2018 to 2023 in the observed images



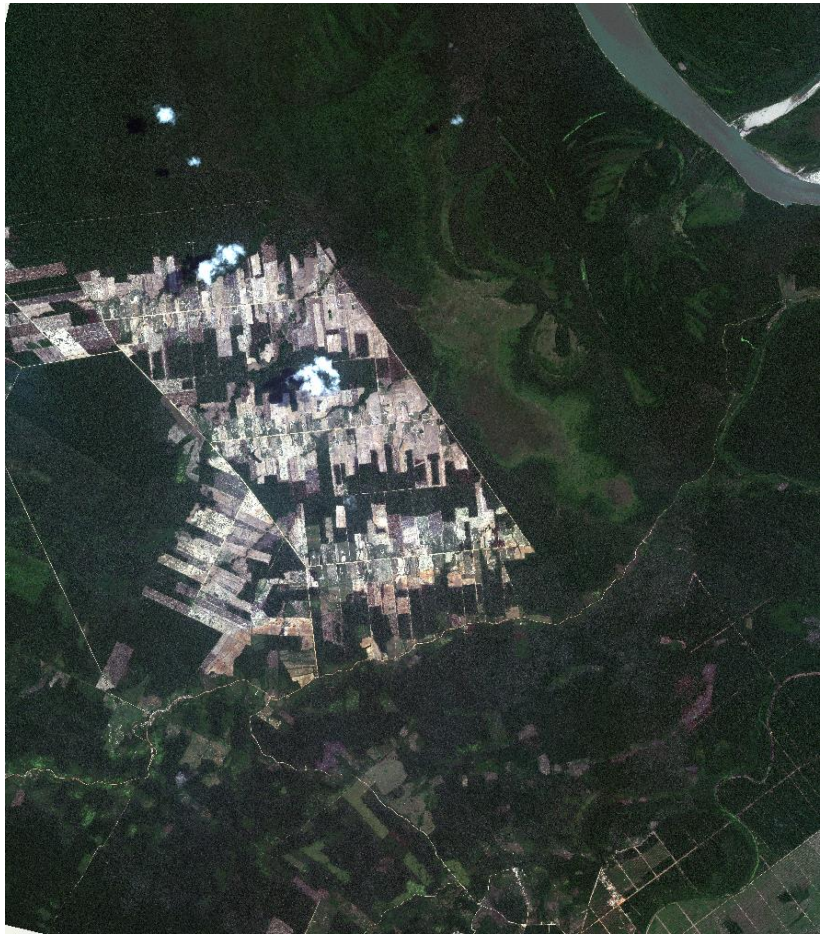
Case Studies A & B are **less than 30% forest** as of 2023

The low **temporal resolution** of PerúSAT-1 limited the coverage Potential for Supervised Classification

PerúSAT-1 Imagery Modifications



VS



Radiance Image, PerúSAT-1

Reflectance Image, PerúSAT-1

PerúSAT-1 Imagery Modifications

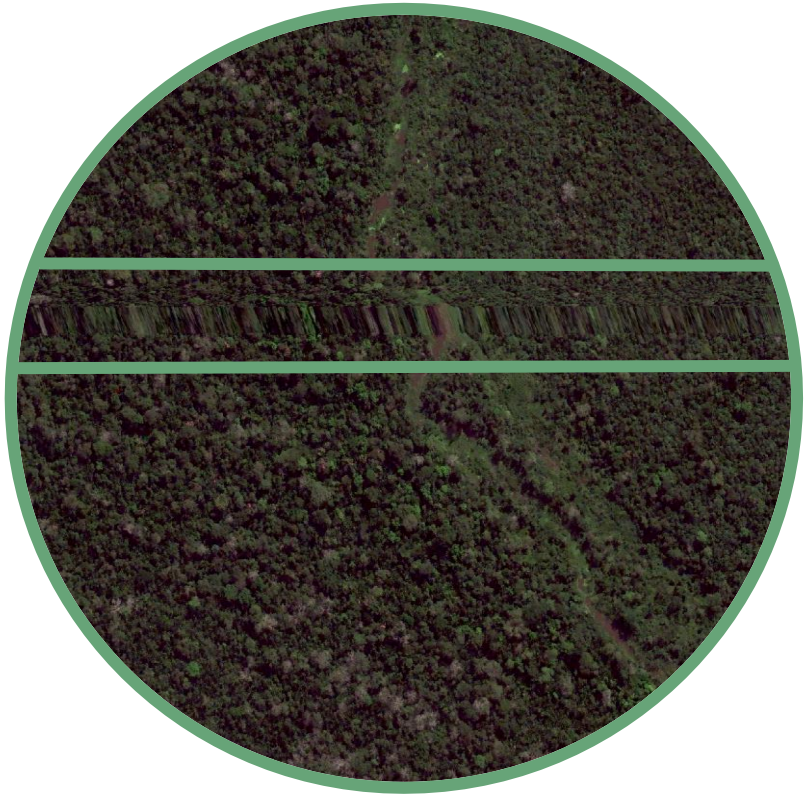
Classification with Radiance

VS

Classification with Reflectance

Errors & Uncertainties

- Inconsistency between Landsat Series
  - Cloud cover availabilities
  - Sensor functionalities: ETM+ and OLI
- Data collection process of satellite imagery (See Image)
- Geolocation inconsistencies
  - PerúSAT-1 to ArcGIS Pro
- Training data by visual selection



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