ISA

Development of a forest clear-cut reference database for Continental Portugal at Sentinel-2 resolution

MASTER'S THESIS

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S2CHANGE - PROJECT

Projeto Agenda Transform (Agenda para a transformação digital das cadeias de valor florestais numa economia portuguesa mais resiliente e hipocarbónica) no subprojecto «P1.5- Dados de deteção remota para a gestão florestal»

What ?

Production of vegetation loss maps based on Sentinel-2 temporal series.

How ?

Change detection techniques - temporal component (pixel level)

Classification techniques - spatial component (patch level)

Why ?

To improve and automate methodologies for the detection and classification of land cover changes in forest and shrub areas, every 2 months.

THESIS OBJECTIVE

What ?

Create a reference database to serve as training data for a change detection algorithm that automates the creation of vegetation loss maps, particularly clear-cut maps, using Sentinel-2 time series data.

How ?

Using a semi-automatic method

Why ?

Accurate and timely generation of vegetation loss maps, contributing to improved monitoring and analysis of land cover changes.

DATA SCIENCE THESIS

WHY?

1. Uses data to answer a question

2. Data-driven workflow
   - Collect and understand the data
   - Prepair and model data
   - Validate and interpret results

3. Use of specialized tools and techniques
   - Programming language: Python and JavaScript
   - Libraries: pandas, geopandas, processing, ...
   - Visualization tools: matplotlib

DATA DESCRIPTION

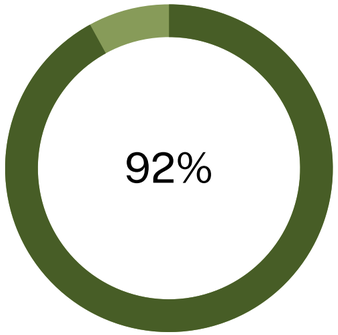
ORIGINAL DATABASE

What do we have?

Mainland Portugal

27.439

Hectares



Eucalyptus

Plantation

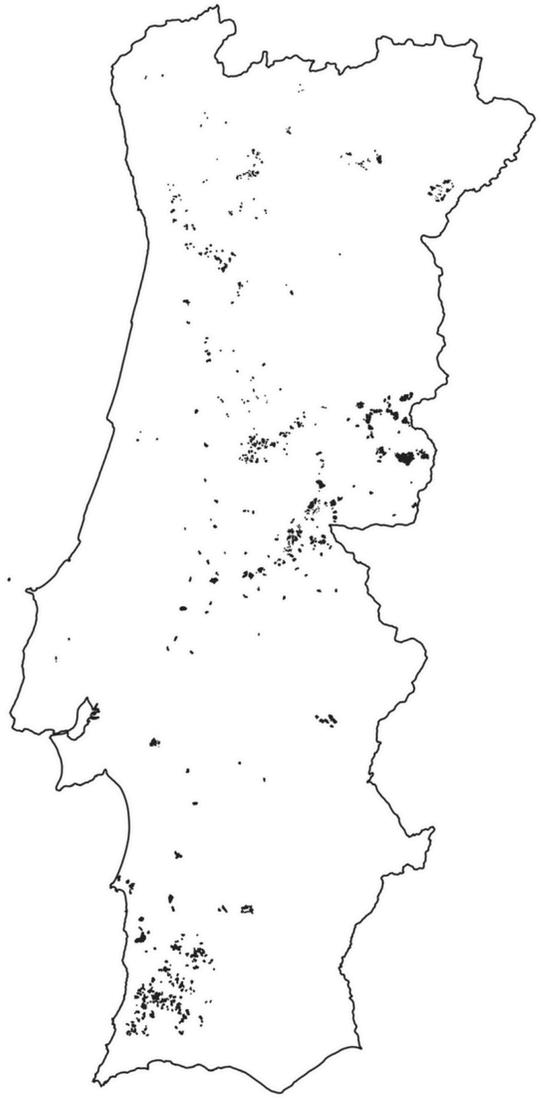
Clear-cuts

Forestry operation

DATA DESCRIPTION

ORIGINAL DATABASE

Geographic distribution



Total

1583 parcels
19702 sub-parcels

Eucalyptus

1408 parcels
18653 sub-parcels

Pinheiro-manso

35 parcels
249 sub-parcels

Pinheiro-bravo

121 parcels
641 sub-parcels

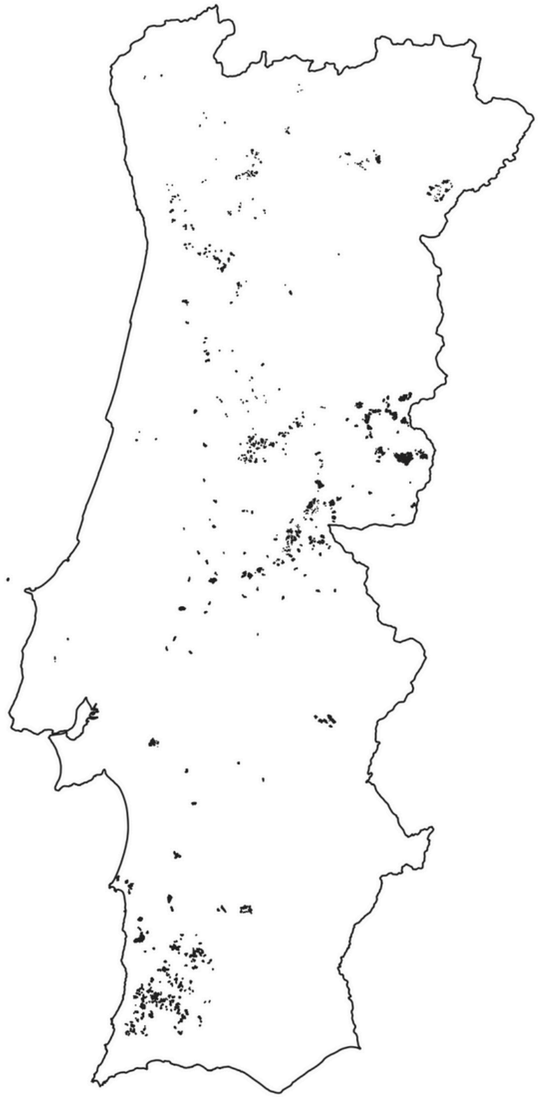
Other pine trees

19 parcels
159 sub-parcels

DATA DESCRIPTION

ORIGINAL DATABASE

Geographic distribution



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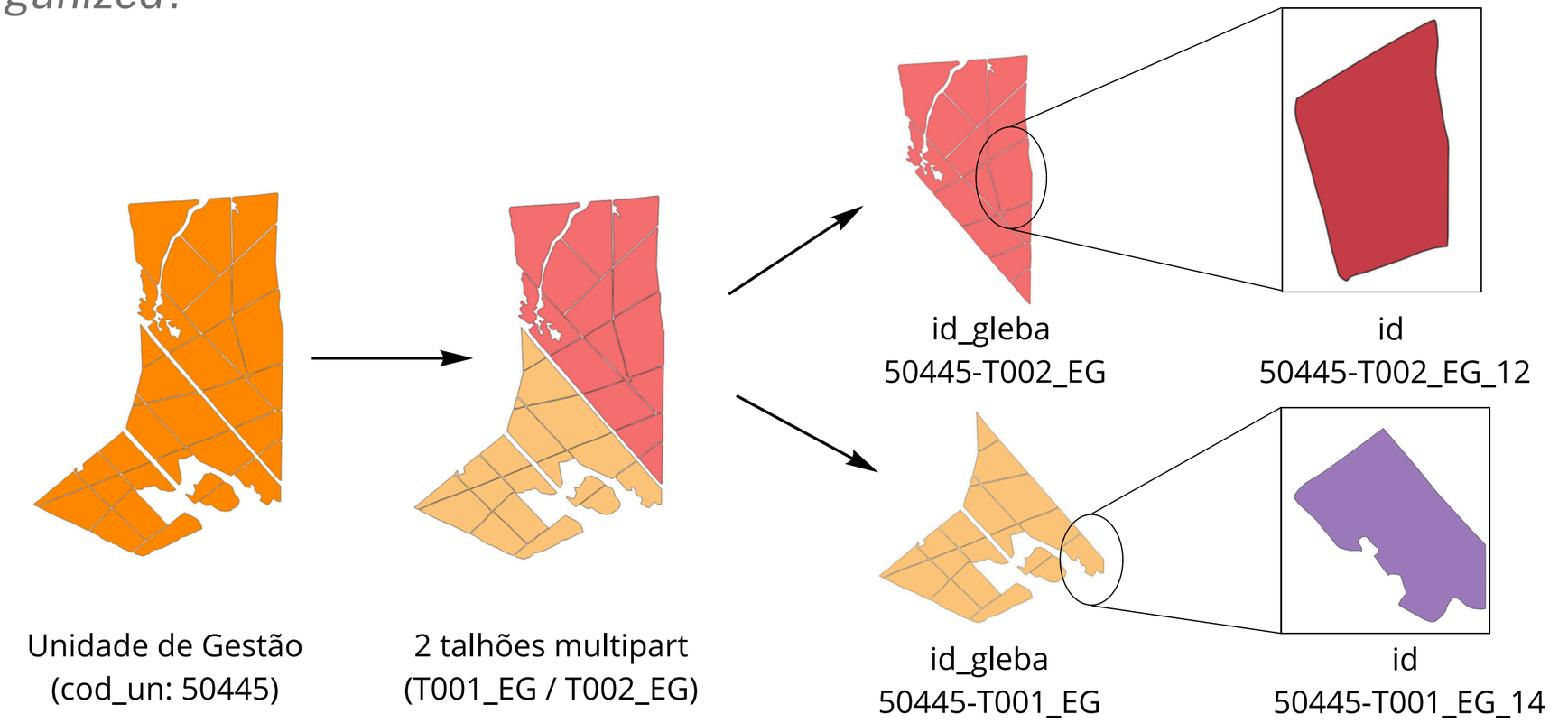
ORIGINAL DATABASE

How is is organized?



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ORIGINAL DATABASE

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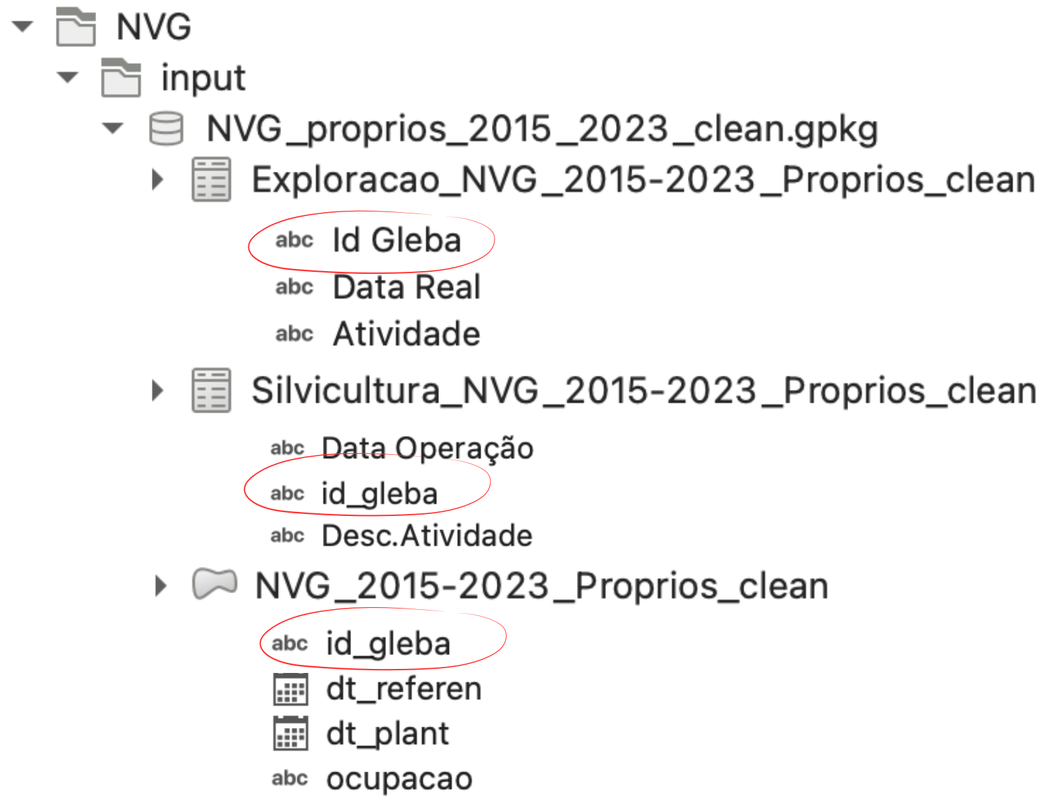


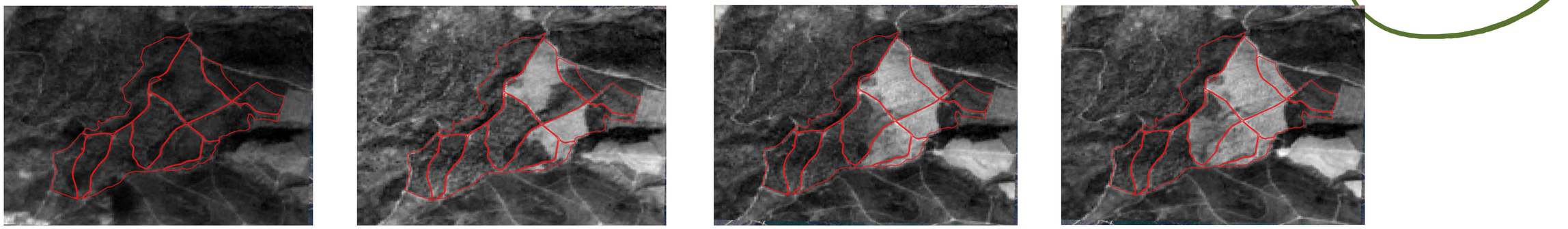
Chronologically sorted database

LIMITAÇÕES DA BASE DE DADOS

ORIGINAL DATABASE

Uncertainty of the clear-cut dates

1st clear-cut date on the Navigator's database



(Tile 29TPE)

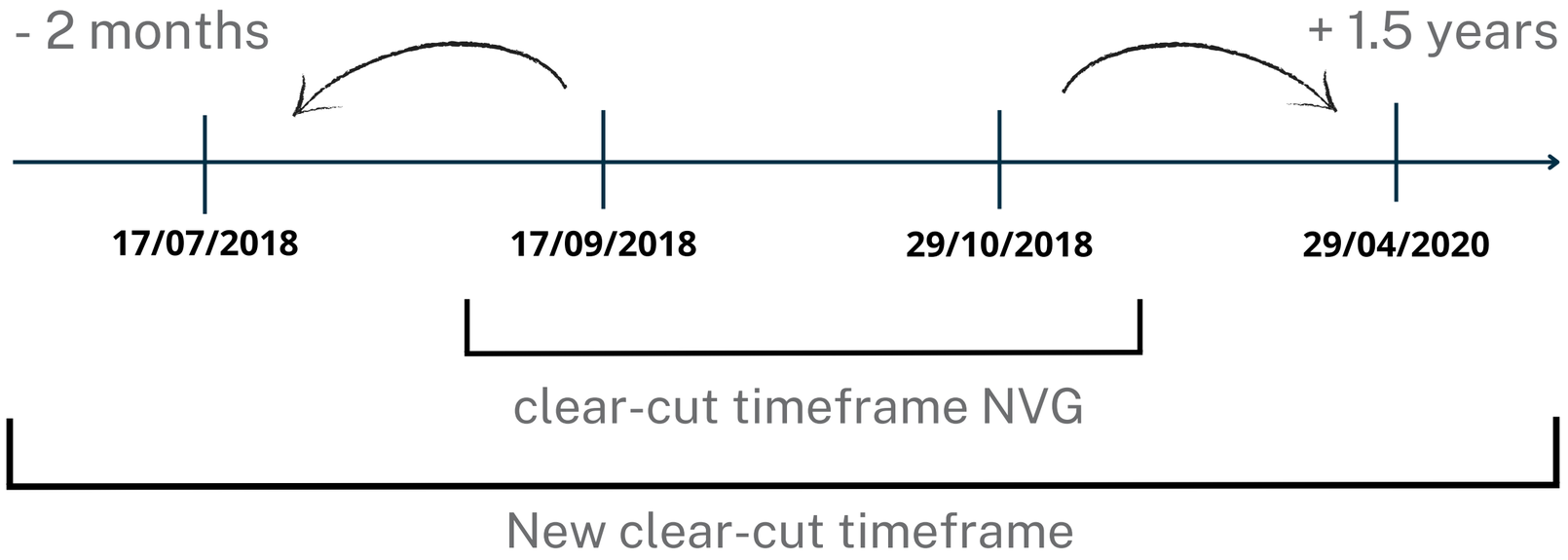
LIMITAÇÕES DA BASE DE DADOS

ORIGINAL DATABASE

Uncertainty of the clear-cut dates

New clear-cut timeframe based on NVG clear-cut dates

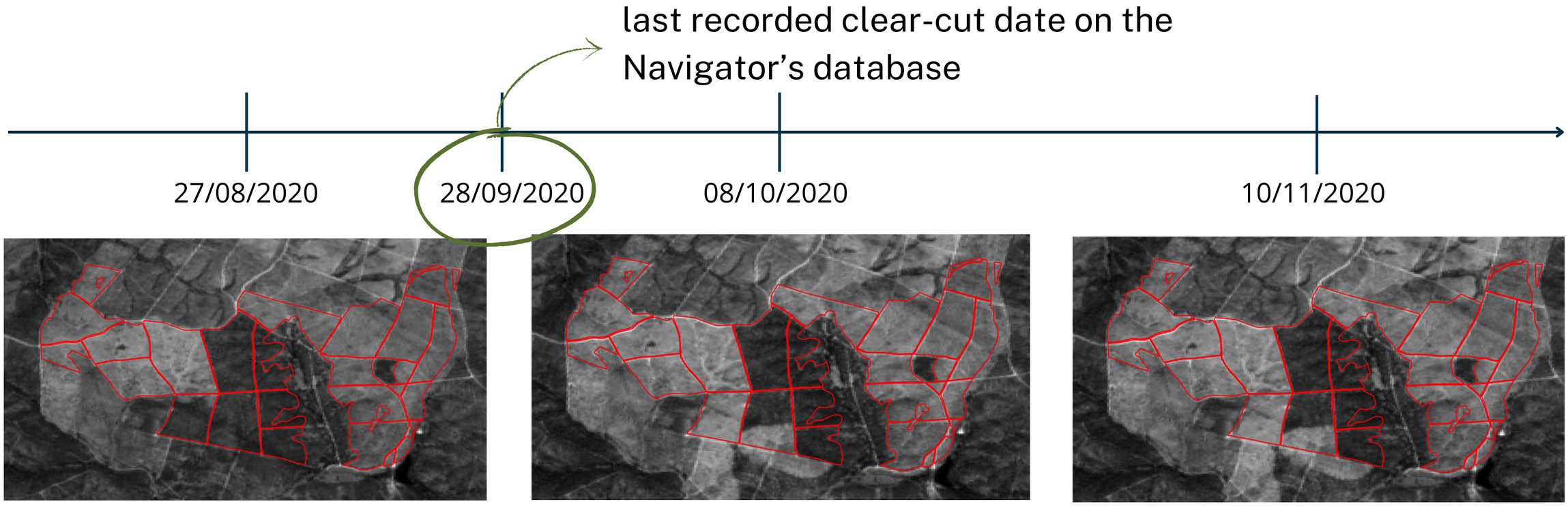
[NVG first date - 2 months; NVG last date + 1.5 years]



LIMITAÇÕES DA BASE DE DADOS

ORIGINAL DATABASE

Heterogeneity of sub-parcel's clear-cuts



(Tile 29TPE)

METHODOLOGY

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Continuous Change Detection algorithm (CCD)

- Designed to detect land cover changes continuously over time using satellite data

  ↳ *SENTINEL-2 COLLECTION WITH 'S2CLOUDLESS' FILTER*

- Detects time series breaks when the difference between consecutive observations and predicted values surpasses a set threshold.

- The breaks are typically indicative of land cover changes or disturbances (such as wildfires, deforestation)

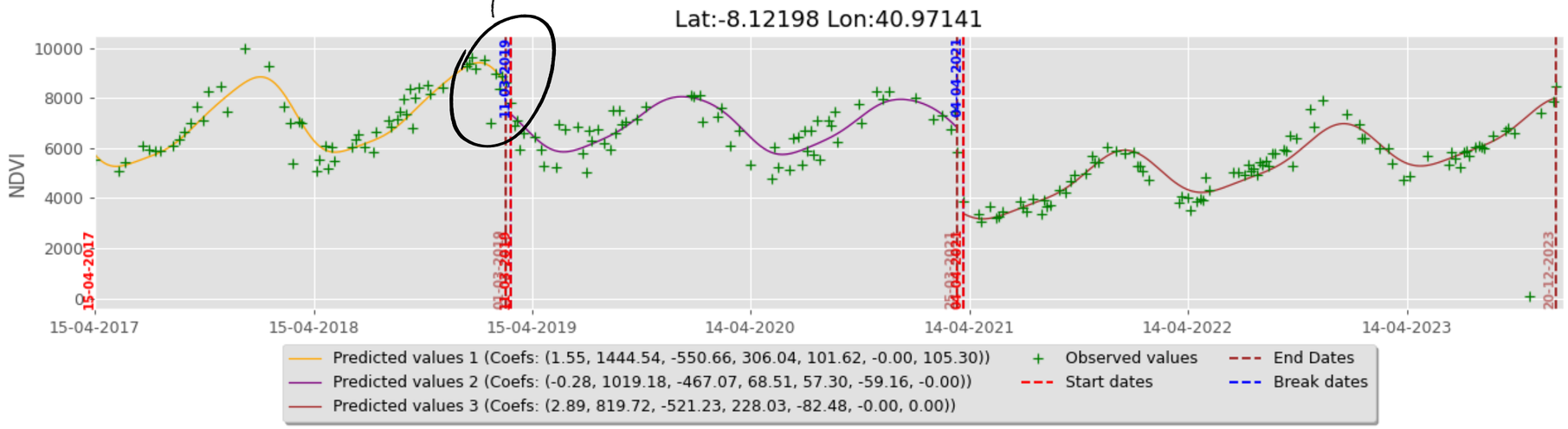
METHODOLOGY

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Continuous Change Detection algorithm (CCD)

first break date (tBreak)

CCD output for each pixel:

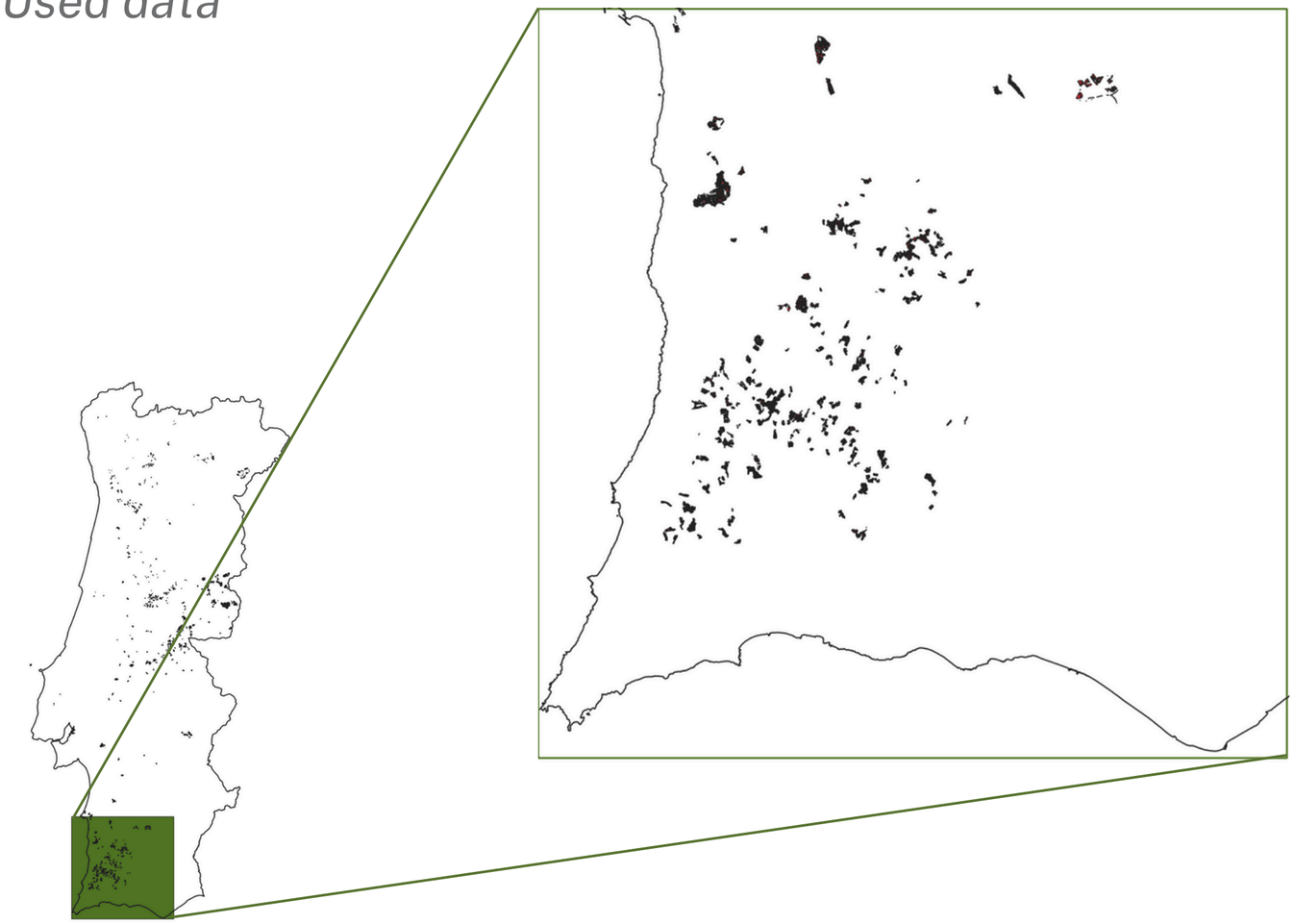


Only the first tBreak occurring within the specified timeframe was taken into account.

METHODOLOGY

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Used data



TILE 29SNB
251 parcels
3793 sub-parcels

METHODOLOGY

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Visual Analysis of Parcels

When the CCD results do not match the trend showed on the S2 images → ADD **NEW ATTRIBUTES** TO ATTRIBUTES TABLES

NC (“not cut”) - when the sub-parcel is not cut within the defined timeframe.
(values between 0 and 1 representing an estimation proportion of the sub-parcel that was not cut)

(“Error CCD”) - when the S2 images show a clear-cut but the algorithm identifies a different tBreak date or fails to detect one at all.

- **ECCD1 -** S2 image date immediately before the first observed clear-cut *(date-type)*
- **ECCD2** - S2 image date after the last cut in the sub-parcel was identified *(date-type)*

METHODOLOGY

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tolerância de +- 5 dias

METHODOLOGY

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Visual Analysis of Parcels

CCD-correct sub-parcels

A sub-parcel is considered correct when:

1. Drop_date is not NULL, and ECCD1, ECCD2, and NC variables are NULL
2. Drop_date is NULL and NC = 1

Isolates NULL's: pixels with a NULL drop_date even though the CCD returns an accurate description of the temporal dynamics of the cuts

CCD-incorrect sub-parcels

A sub-parcel is considered incorrect when it does not meet the conditions above

METHODOLOGY

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Visual Analysis of Parcels

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READ AT PIXEL LEVEL

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A sub-parcel is considered incorrect when it does not meet the conditions above

READ AT SUB-PARCEL LEVEL

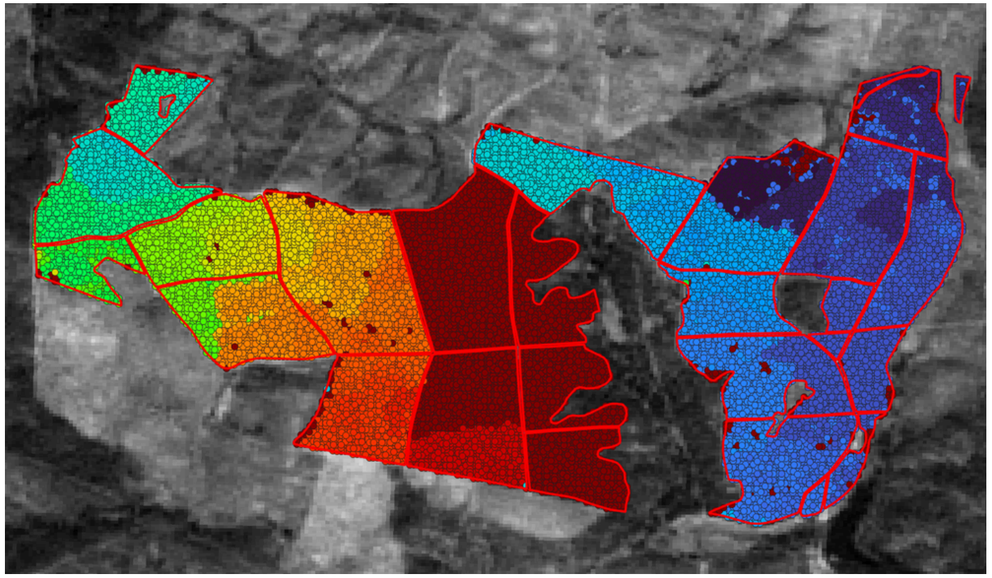
RESULTS

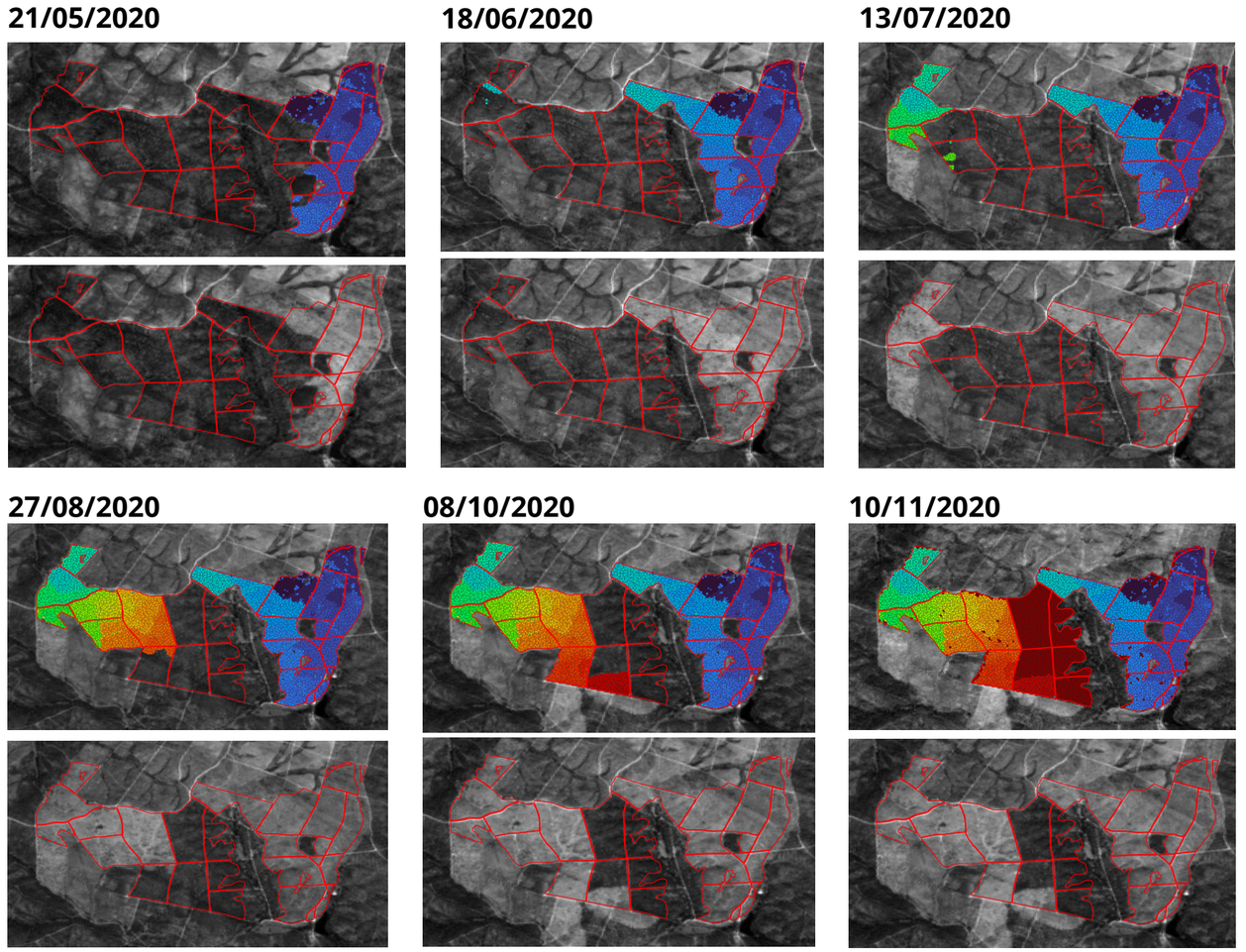
ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Visual Analysis of Parcels

CCD-correct sub-parcels

Id gleba 53001-T006_EG





(Tile 29TPE)

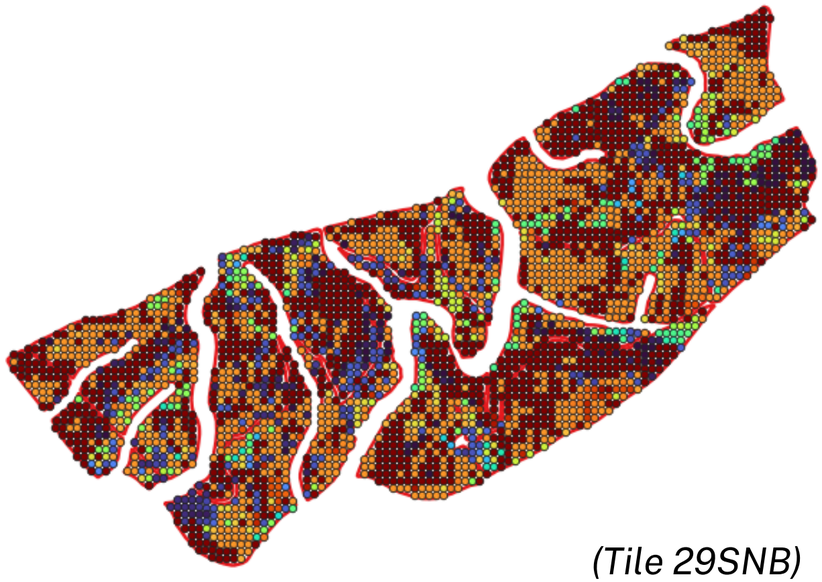
RESULTS

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Visual Analysis of Parcels

CCD-incorrect sub-parcels

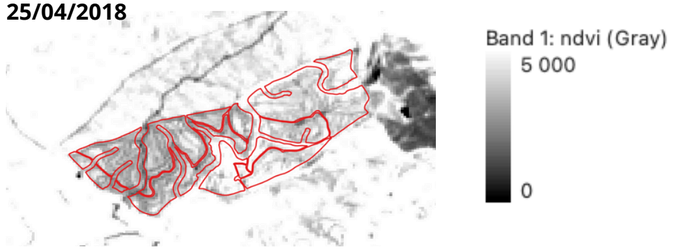
Id gleba 51316-T003_EG



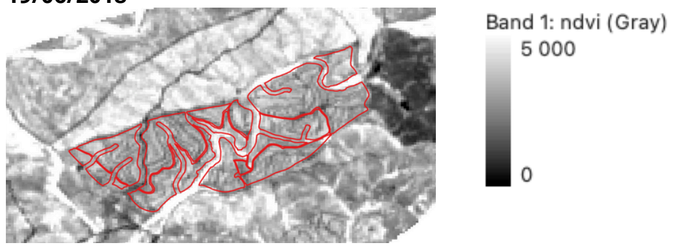
(Tile 29SNB)

26/03/2018

25/04/2018



19/06/2018



id	ECCD1	ECCD2
51316-T003_EG_07	26/03/2018	25/04/2018
51316-T003_EG_06	26/03/2018	25/04/2018
51316-T003_EG_09	26/03/2018	25/04/2018
51316-T003_EG_08	26/03/2018	25/04/2018
51316-T003_EG_11	26/03/2018	19/06/2018
51316-T003_EG_10	26/03/2018	19/06/2018
51316-T003_EG_13	26/03/2018	19/06/2018
51316-T003_EG_12	26/03/2018	19/06/2018
51316-T003_EG_15	26/03/2018	25/04/2018
51316-T003_EG_14	26/03/2018	19/06/2018
51316-T003_EG_17	25/03/2018	19/06/2018
51316-T003_EG_01	26/03/2018	25/04/2018
51316-T003_EG_16	26/03/2018	19/06/2018
51316-T003_EG_03	26/03/2018	25/04/2018
51316-T003_EG_02	26/03/2018	25/04/2018
51316-T003_EG_05	26/03/2018	25/04/2018
51316-T003_EG_04	26/03/2018	25/04/2018

RESULTS

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Revised Reference Database

Id_gleba ← NVG original database

Id

Start_date

End_date

based on NVG original database

Drop_date ← from CCD results

ECCD1

ECCD2

NC

visual analysis results

Data0

Data1

based on the CCD and visual analysis results

RESULTS

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Revised Reference Database

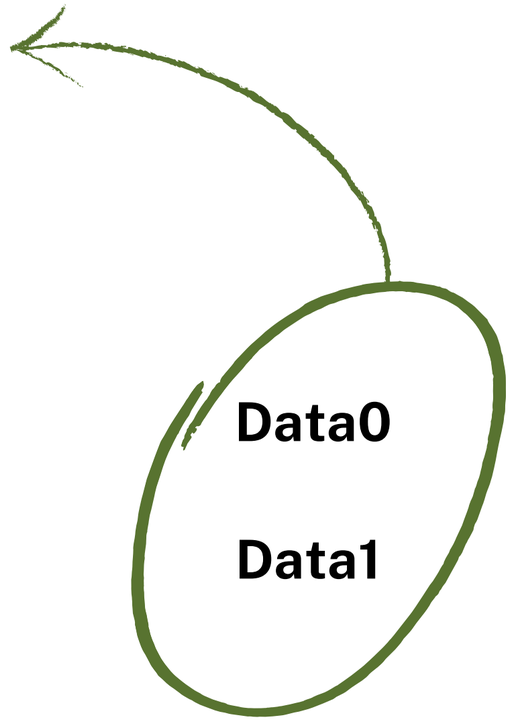
DEPEND ON THE CORRECTNESS OF THE CCD RESULTS

Correct CCD results

↳ based on the drop_date value

Incorrect CCD results

↳ based on the ECCD1, ECCD2 and NC



The ideal difference between data0 and data1 is **10 days**

RESULTS

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Revised Reference Database - Conditions

Data0

When drop_date is not NULL:

If ECCD1 = 01-01-1000 then data0 = start_date

If ECCD1 = date then data0 = ECCD1

If ECCD1 = NULL AND NC = NULL then data0 = (drop_date – 5 days)

If ECCD1 = NULL AND NC != NULL then data0 = NULL

When drop_date is NULL:

If ECCD1 = NULL AND NC = NULL then data0 = NULL

If ECCD1 is not NULL AND ECCD1 != ’01-01-1000’ then data0 = ECCD1

If ECCD1 = 01-01-1000 then data0 = start_date

Data1

When drop_date is not NULL:

If ECCD2 = 01-01-1000 then data1 = end_date

If ECCD2 = date then data1 = ECCD2

If ECCD2 = NULL AND NC = NULL then data1 = (drop_date – 5 days)

If ECCD2 = NULL AND NC != NULL then data1 = NULL

When drop_date is NULL:

If ECCD2 = NULL AND NC = NULL then data1 = NULL

If ECCD2 is not NULL AND ECCD2 != ’01-01-1000’ then data1 = ECCD2

If ECCD2 = 01-01-1000 then data1 = end_date

RESULTS

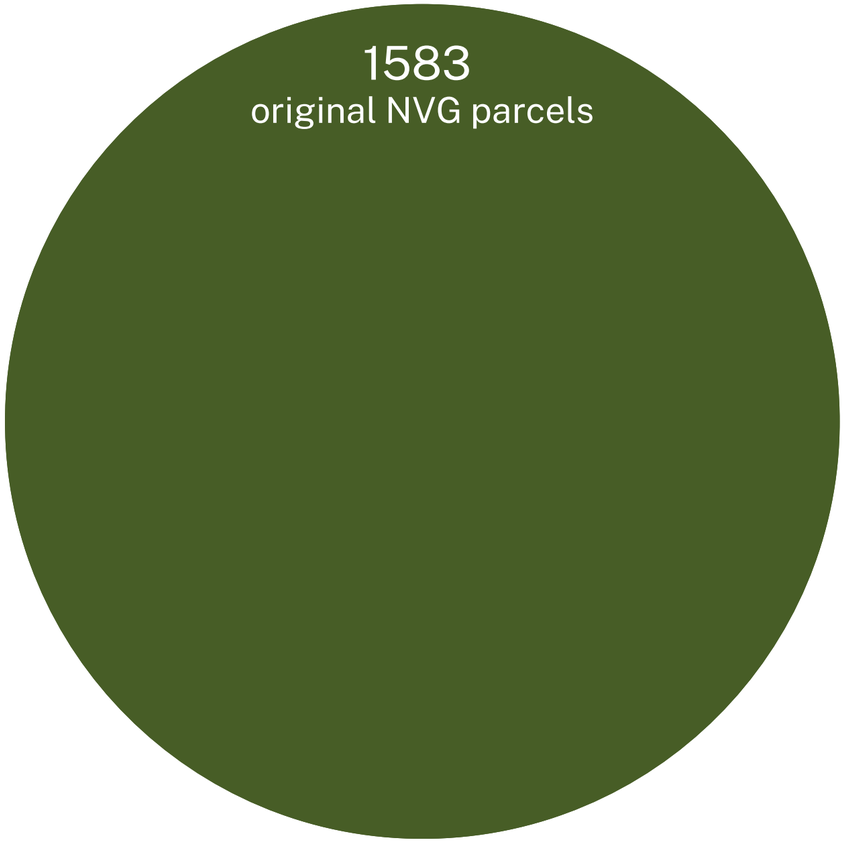
ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Revised Reference Database - Tile 29SNB

RESULTS

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

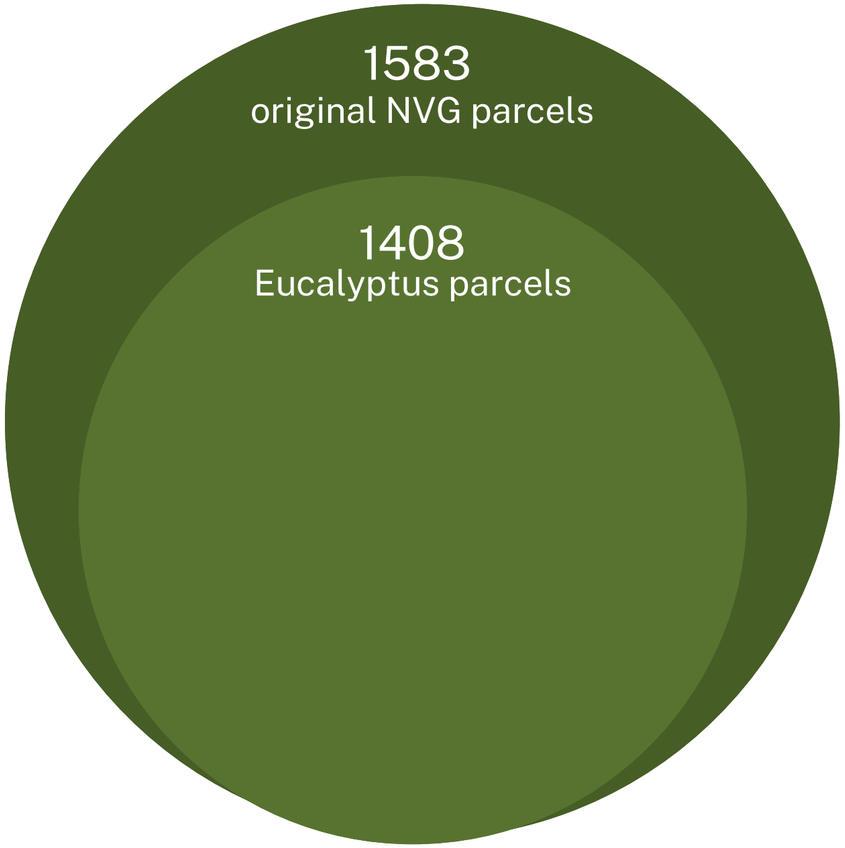
Revised Reference Database - Tile 29SNB



RESULTS

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Revised Reference Database - Tile 29SNB



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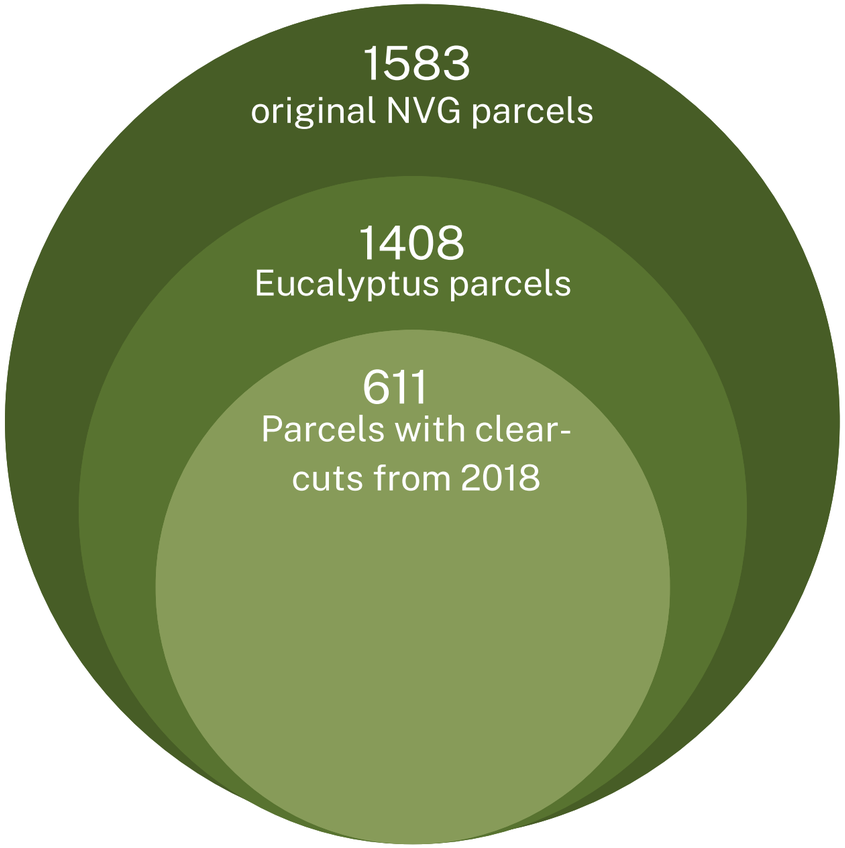

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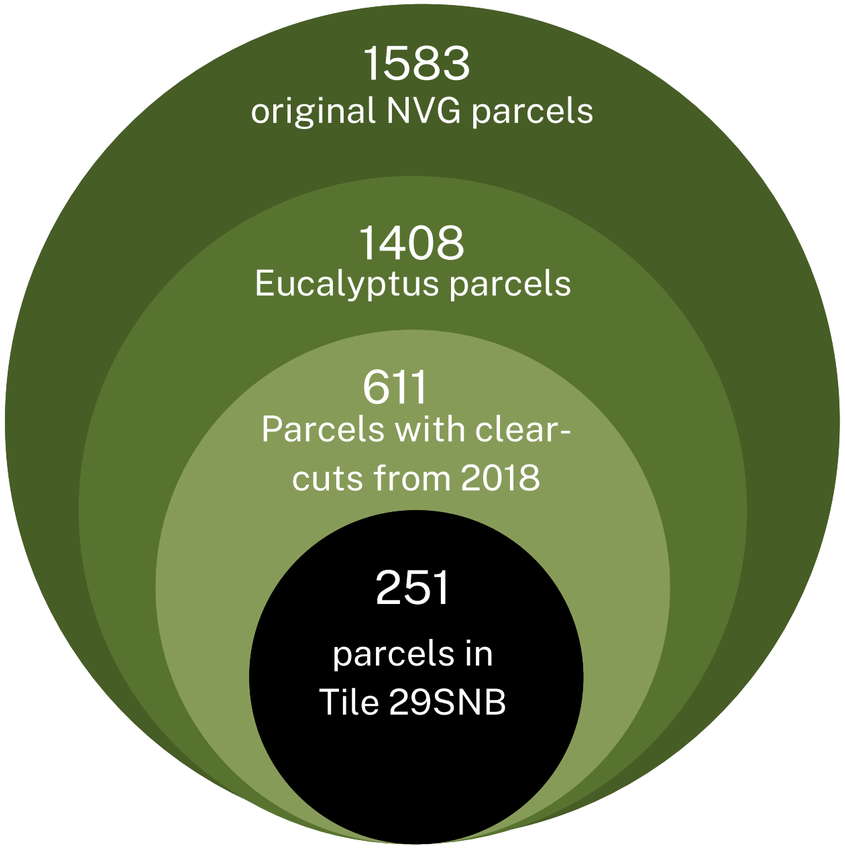

RESULTS

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Revised Reference Database - Tile 29SNB

74.3% CCD-correct sub-parcels

25.7% CCD-incorrect sub-parcels

21.7% sub-parcels updated with new date range interval

*** 20 sub-parcels with no pixels

DISCUSSION

The primary focus was to assign an **estimated clear-cut date to each sub-parcel**

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Visual analysis of parcels from tile 29SNB

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Visual analysis of parcels from tile 29SNB

Revised Reference Database

DISCUSSION

CHALLENGES AT USER'S PERSPECTIVE

↳ Sub-parcels with a high count of isolated NULL

↳ CCD-incorrect sub-parcels with a large temporal uncertainty.

DISCUSSION

CHALLENGES AT USER'S PERSPECTIVE

↳ Sub-parcels with a high count of isolated NULL

- introduces noise into the database
- data0 and data1 will be NULL

↳ CCD-incorrect sub-parcels with a large temporal uncertainty.

estimate a clear-cut date using the most frequent pixel value within the sub-parcel

DISCUSSION

CHALLENGES AT USER'S PERSPECTIVE

↳ Sub-parcels with a high count of isolated NULL

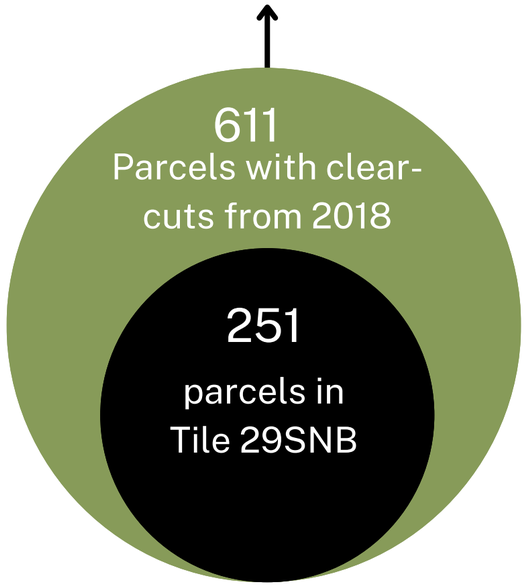
↳ CCD-incorrect sub-parcels with a large temporal uncertainty.

- large time intervals between data0 and data1
- less precise data0 and data1 values

EXTENSIONS OF THE RESULTS TO ALL CONTINENTAL PORTUGAL

ESTIMATE CLEAR-CUT DATES AT PIXEL LEVEL

Revised Reference Database - All tiles



8018 sub-parcels → *** → 7980 sub-parcels

- 72.7% CCD-correct sub-parcels
- 27.3% CCD-incorrect sub-parcels
- 24.3% sub-parcels updated with new date range interval

*** 38 sub-parcels with no pixels

CONCLUSION

- First comprehensive reference database
  - ↳ polygon format
  - ↳ covers Continental Portugal
  - ↳ clear-cuts
- Semi-automatic method
  - ↳ can be extended to other reference database (e.g. areas ardidas do ICNF)
  - ↳ feasible with limited resources
- Development of machine learning change detection algorithms
  - ↳ train
  - ↳ validation

Thank you!

Inês Silveira