Evaluation of Forest Cover Loss Satellite Data in Forests Owned by CENIBRA, Brazil

Business Report

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Contents

1 Summary

The development of analytical technology using satellite data has made it possible to monitor forests over large areas and long periods of time, creating many platforms. However, these data have accuracy issues and do not accurately reflect actual local situations. In particular, in planted forests, logging as part of sustainable forest management can be mistaken for deforestation, so great care must be taken in interpreting them.

The forest assessment tool “Global Forest Change” identifies some forest areas owned by Oji Group’s CENIBRA as “Forest Cover Loss”. However, CENIBRA recognizes these areas as forests that have been logged and replanted and does not consider these areas as deforestation. Therefore, this project objectively verified the actual land use situation of these areas by analysis using both time-series satellite data and local information in combination.　A total of 48 Landsat satellite images from 1990 to 2023 covering the company-owned forests were used for the analysis, and the Normalized Difference Vegetation Index (NDVI) of each image was calculated after topographic correction. We characterized the changes in NDVI of eucalyptus plantations over time and the NDVI of eucalyptus plantations and natural forests, and determined whether the areas identified as "Forest Cover Loss" by Global Forest Change were temporary or permanent, and whether they were eucalyptus plantations or natural forests. As a result, it was found that 99.9% of the "Forest Cover Loss areas" extracted by Global Forest Change were likely not actually “deforestation”. Specifically, 94.83% was clear-cut with the assumption of reforestation through forestry operations, and 5.08% was natural forest with no change.

The Forest Cover Loss data used in Global Forest Change and other forest assessment tools are extracted from forest cover loss since 2000, and do not classify whether the forest was planted or natural as of 2000. In addition, forest loss is detected only once, so cycles of logging and reforestation are not detected for planted forests. Therefore, it is difficult to identify deforestation due to land-use change in planted forests using these data alone, and additional analysis and combination with other data is required.

2 Purpose

The forest assessment tool "Global Forest Change" identifies some forest areas owned by Oji Group's CENIBRA as "Forest Cover Loss". However, CENIBRA recognizes these areas as forests that have been logged and replanted and does not consider these areas as deforestation. Therefore, this project objectively verified the actual land use situation of these areas by analysis using both time-series satellite data and local information in combination.

3 Target Area and Target Tree Species

3.1 Target Area

The target area for this project is approximately 254,000 hectares of forest owned by CENIBRA.

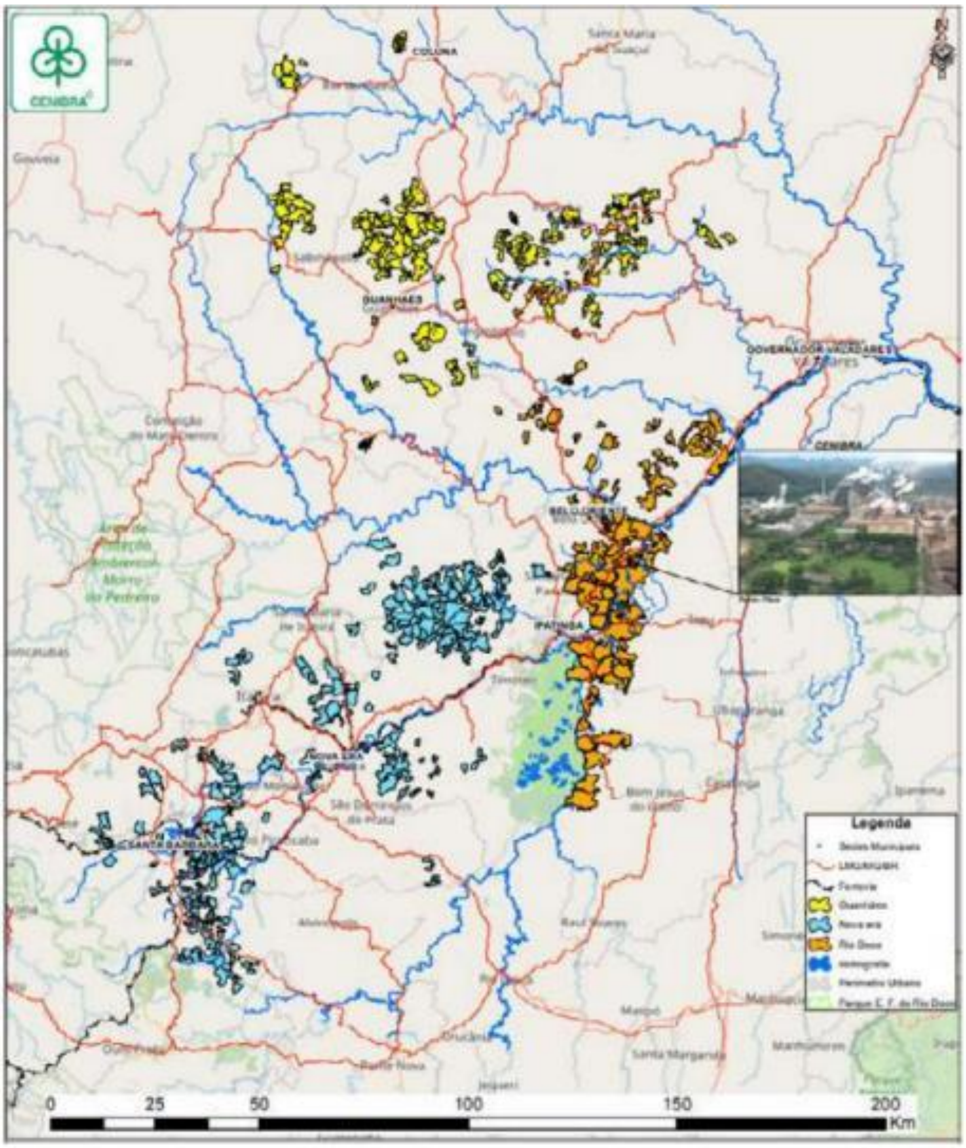


Figure 3. 1 Target area

3.2 Weather Conditions at Target Area

The climate of the target area, located near Belo Horizonte in the State of Minas Gerais, Federative Republic of Brazil, is a temperate rainy summer climate (Cwa). It is characterized by hot, humid summers (November to March) with high rainfall and dry winters (especially June to August). Therefore, the satellite images collected in Section 4, "Data Used", are mostly winter images with less cloud.

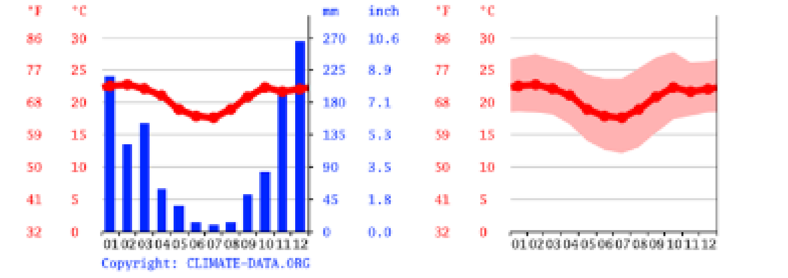


Figure 3. 2 Changes in rainfall and temperature around the target area

3.3 Target Tree Species

The tree species in the plantation in this target area is eucalyptus, an evergreen plant that does not lose its leaves at any particular time of the year. It grows very fast and has a seven year logging cycle.

4 Data Used

4.1 Satellite Images

A total of 48 Landsat satellite images from 1990 to 2023 covering the target area were used for the analysis. Table 4. 1 lists the satellite images used.

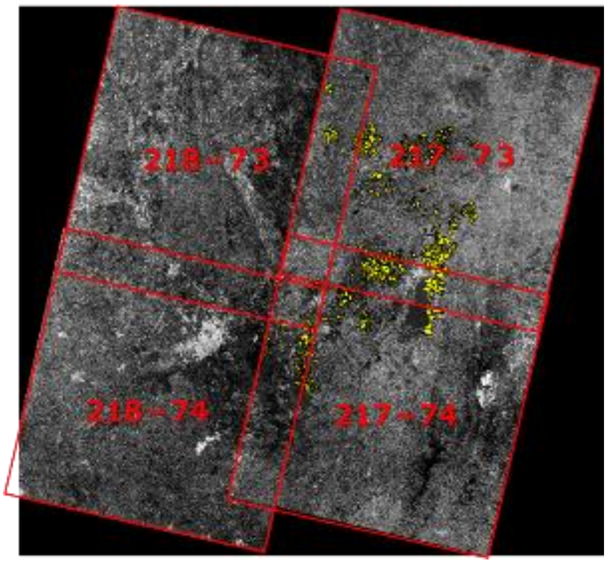


Figure 4. 1 Path-Row (area captured per image) of the acquired satellite images

Table 4. 1 List of satellite images collected

Path-R	product_id	scene_id	date	cloudcove
217-73	LT05_L1TP_217073_19900208_20200916_02_T1	LT52170731990039CUB00	1990/2/8	0
	LT05_L1TP_217073_19910211_20200915_02_T1	LT52170731991042CUB00	1991/2/11	7
	LT05_L1TP_217073_20000627_20200907_02_T1	LT52170732000179CUB01	2000/6/27	0
	LT05_L1TP_217073_20040724_20200903_02_T1	LT52170732004206COA01	2004/7/24	1
	LT05_L1TP_217073_20100506_20200824_02_T1	LT52170732010126CUB01	2010/5/6	1
	LC08_L1TP_217073_20130802_20200912_02_T1	LC82170732013214LGN01	2013/8/2	1.99
	LC08_L1TP_217073_20140805_20200911_02_T1	LC82170732014217LGN01	2014/8/5	0
	LC08_L1TP_217073_20160810_20200906_02_T1	LC82170732016223LGN01	2016/8/10	0
	LC08_L1TP_217073_20180120_20200902_02_T1	LC82170732018020LGN00	2018/1/20	0.17
	LC08_L1TP_217073_20190803_20200827_02_T1	LC82170732019215LGN00	2019/8/3	0.01
	LC08_L1TP_217073_20200602_20200825_02_T1	LC82170732020154LGN00	2020/6/2	2.3
	LC08_L1TP_217073_20210621_20210629_02_T1	LC82170732021172LGN00	2021/6/21	2.88
	LC08_L1TP_217073_20220608_20220616_02_T1	LC82170732022159LGN00	2022/6/8	0.03
	LC08_L1TP_217073_20230713_20230724_02_T1	LC82170732023194LGN00	2023/7/13	0.05
Path-Row	product_id	scene_id	date	cloudcover
217_74	LT05_L1TP_217074_19900123_20200916_02_T1	LT52170741990023CUB00	1990/1/23	0
	LT05_L1TP_217074_19910806_20200915_02_T1	LT52170741991218CUB00	1991/8/6	12
	LT05_L1TP_217074_19990828_20200908_02_T1	LT52170741999240COA00	1999/8/28	0
	LT05_L1TP_217074_20000627_20200907_02_T1	LT52170742000179CUB01	2000/6/27	0
	LT05_L1TP_217074_20051116_20200901_02_T1	LT52170742005320COA00	2005/11/16	8
	LT05_L1TP_217074_20100826_20200823_02_T1	LT52170742010238CUB00	2010/8/26	0
	LC08_L1TP_217074_20130802_20200912_02_T1	LC82170742013214LGN01	2013/8/2	0.19
	LC08_L1TP_217074_20140805_20200911_02_T1	LC82170742014217LGN01	2014/8/5	1.23
	LC08_L1TP_217074_20150925_20200908_02_T1	LC82170742015268LGN01	2015/9/25	0
	LC08_L1TP_217074_20160810_20200906_02_T1	LC82170742016223LGN01	2016/8/10	0.04
	LC08_L1TP_217074_20170829_20200903_02_T1	LC82170742017241LGN00	2017/8/29	7.71
	LC08_L1TP_217074_20180120_20200902_02_T1	LC82170742018020LGN00	2018/1/20	0.16
	LC08_L1TP_217074_20190702_20200827_02_T1	LC82170742019183LGN00	2019/7/2	0.08
	LC08_L1TP_217074_20200501_20200820_02_T1	LC82170742020122LGN00	2020/5/1	0.46
	LC08_L1TP_217074_20210128_20210305_02_T1	LC82170742021028LGN00	2021/1/28	11.52
	LC08_L1TP_217074_20230713_20230724_02_T1	LC82170742023194LGN00	2023/7/13	0.37
Path-Row	product_id	scene_id	date	cloudcover
218-73	LT05_L1TP_218073_19900709_20200916_02_T1	LT52180731990190CUB00	1990/7/9	1
	LT05_L1TP_218073_19910712_20200915_02_T1	LT52180731991193CUB00	1991/7/12	0
	LT05_L1TP_218073_19990803_20200907_02_T1	LT52180731999215COA00	1999/8/3	0
	LT05_L1TP_218073_20000517_20200907_02_T1	LT52180732000138CUB00	2000/5/17	2
	LT05_L1TP_218073_20100801_20200823_02_T1	LT52180732010213CUB00	2010/8/1	0
	LC08_L1TP_218073_20130505_20200913_02_T1	LC82180732013125LGN02	2013/5/5	0.19
	LC08_L1TP_218073_20140812_20200911_02_T1	LC82180732014224LGN01	2014/8/12	0.01
	LC08_L1TP_218073_20150103_20200910_02_T1	LC82180732015003LGN01	2015/1/3	1.21
	LC08_L1TP_218073_20170601_20200903_02_T1	LC82180732017152LGN00	2017/6/1	0.41
	LC08_L1TP_218073_20180503_20200901_02_T1	LC82180732018123LGN00	2018/5/3	0.05
	LC08_L1TP_218073_20190911_20200826_02_T1	LC82180732019254LGN00	2019/9/11	0
	LC08_L1TP_218073_20200929_20201006_02_T1	LC82180732020273LGN00	2020/9/29	0
	LC08_L1TP_218073_20210425_20210501_02_T1	LC82180732021115LGN00	2021/4/25	0.69
	LC08_L1TP_218073_20231109_20231117_02_T1	LC82180732023313LGN00	2023/11/9	0.01
Path-Row	product_id	scene_id	date	cloudcover
218-74	LT05_L1TP_218074_19900725_20200915_02_T1	LT52180741990206CUB00	1990/7/25	0
	LT05_L1TP_218074_19910712_20200915_02_T1	LT52180741991193CUB00	1991/7/12	7
	LT05_L1TP_218074_19990904_20200907_02_T1	LT52180741999247COA00	1999/9/4	0
	LT05_L1TP_218074_20000821_20200907_02_T1	LT52180742000234CUB00	2000/8/21	0
	LT05_L1TP_218074_20110719_20200822_02_T1	LT52180742011200CUB01	2011/7/19	0
	LC08_L1TP_218074_20130505_20200912_02_T1	LC82180742013125LGN02	2013/5/5	0.01
	LC08_L1TP_218074_20140812_20200911_02_T1	LC82180742014224LGN01	2014/8/12	0
	LC08_L1TP_218074_20150831_20200908_02_T1	LC82180742015243LGN02	2015/8/31	0.01
	LC08_L1TP_218074_20160918_20200906_02_T1	LC82180742016262LGN01	2016/9/18	0
	LC08_L1TP_218074_20170820_20200903_02_T1	LC82180742017232LGN00	2017/8/20	0.56
	LC08_L1TP_218074_20180706_20200831_02_T1	LC82180742018187LGN00	2018/7/6	0.44
	LC08_L1TP_218074_20190911_20200826_02_T1	LC82180742019254LGN00	2019/9/11	0
	LC08_L1TP_218074_20220903_20220913_02_T1	LC82180742022246LGN00	2022/9/3	0
	LC08_L1TP_218074_20231109_20231117_02_T1	LC82180742023313LGN00	2023/11/9	0.01

4.2 Forest Cover Loss Data

The forest cover loss data used in Global Forest Change and other forest assessment tools are annually updated global forest loss data (hereinafter referred to as Hansen Loss data) obtained from Landsat time series images by the Global Land Analysis and Discovery (GLAD) laboratory at the University of Maryland using the Google Earth Engine. The characteristics of the data are as follows.

[Characteristics]

(1) Data capturing forest changes since 2000.

(2) Definition of forest: Often defined as five meters or more in height and 30 to 50% in tree trunk coverage.

(3) No distinction is made between planted and natural forests. Loss data are based on forest cover loss.

(4) Forest loss is detected only once. Therefore, even if an area is logged, reforested, and then logged again, it will not be detected.

Because of these characteristics, Hansen Loss data interprets clear-cutting as part of forestry operations as "Forest Cover Loss". When we checked the proportion of Hansen Loss in the target area, about half of the target area was identified as "Forest Cover Loss".

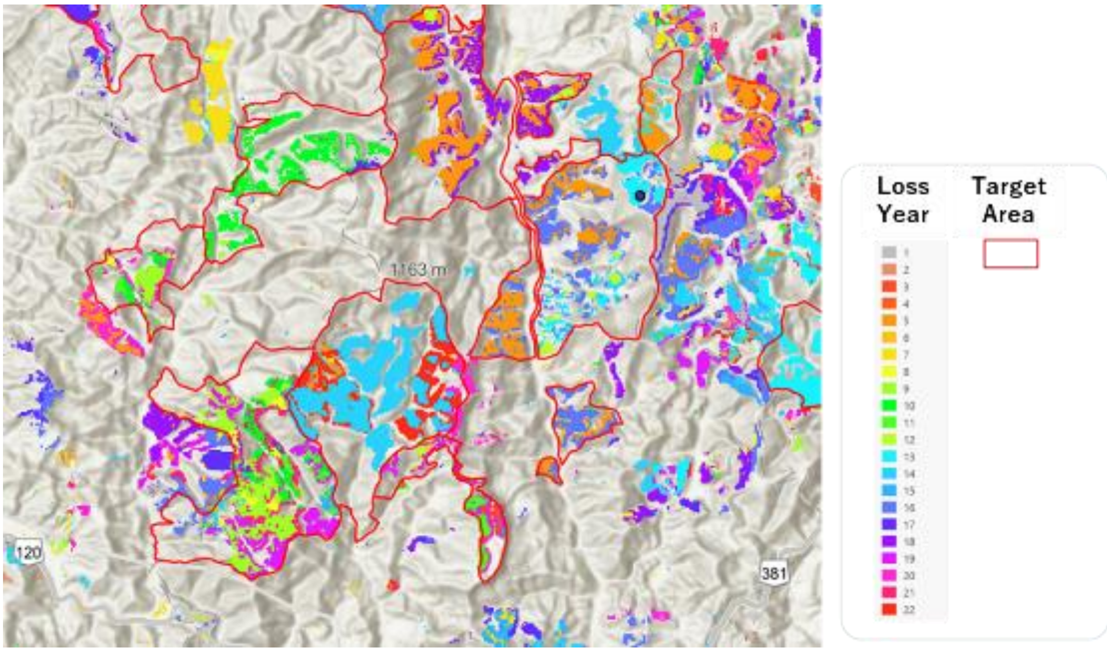


Figure 4. 2 Forest Cover Loss in the target area in Hansen Loss data

5 Analysis Details

5.1 Unit of Analysis

CENIBRA owns a total of 557 forest polygons. Visual inspection of the collected satellite images revealed that forest operations were conducted in areas smaller than each polygon. In addition, the polygons contained vegetation other than eucalyptus, and it was determined that local vegetation changes would not be reflected by aggregating data by polygon. Therefore, we first created a 100-meter mesh within the company-owned forest polygons and then performed the analysis in units of that mesh.

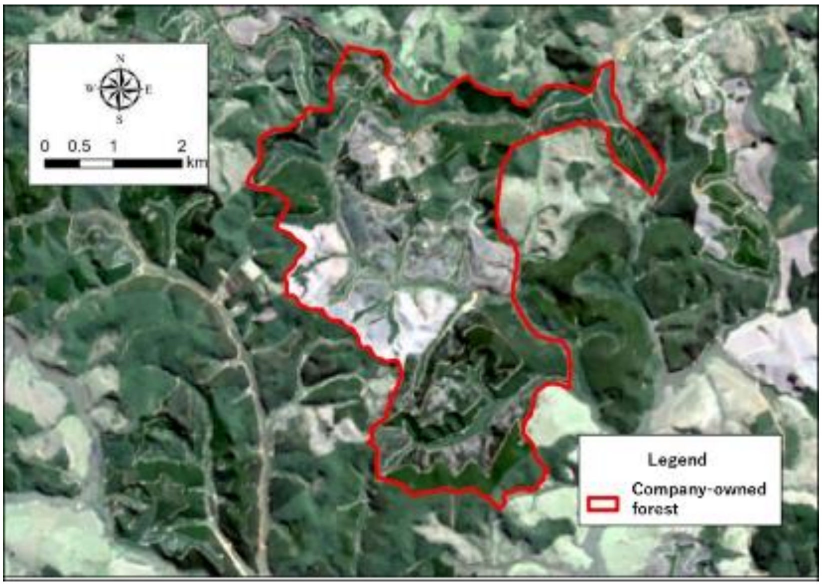


Figure 5. 1 Logging in part of a company-owned forest polygon (Background: Landsat image)

5.2 Pre-processing of Satellite Data

In general, satellite images can be affected by shadows depending on the altitude of the sun and the topography at the time of capture. Therefore, we applied a topographic correction to the satellite images using AW3D's 30-meter DEM (topographic data).

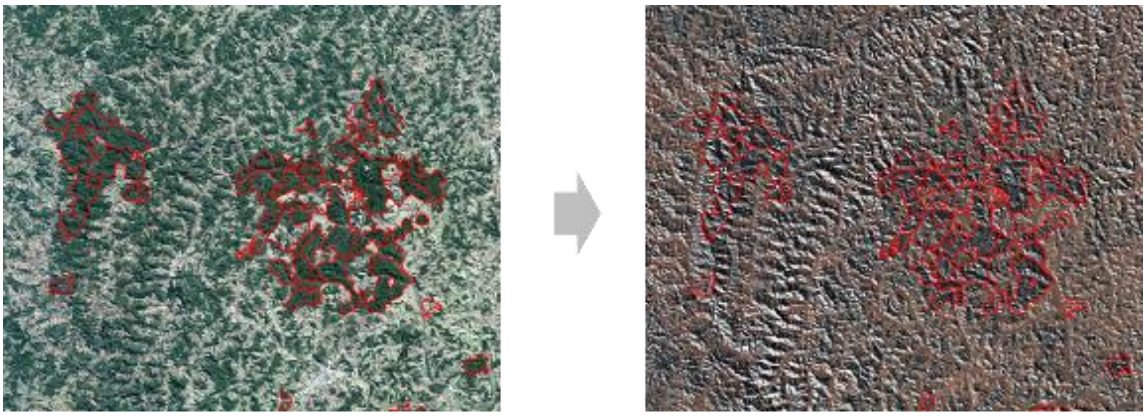


Figure 5. 2 Topographic correction of satellite images (left: before correction, right: after correction)

The corrected images were then used to calculate the Normalized Difference Vegetation Index (NDVI), an indicator of vegetation distribution and activity.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

NIR: Near-infrared reflectance, RED: Red reflectance

5.3 Trends in Eucalyptus Plantations as Indicated by NDVI

5.3.1 Changes Over Time

To determine whether NDVI could be used to detect logging and reforestation cycles, samples were collected by visual interpretation and changes in NDVI in eucalyptus plantations over time were determined. Polygons with a diameter of 100 meters were created as samples and the average NDVI was calculated. The results showed that while NDVI remained almost constant throughout the analysis period in natural forests, NDVI varied significantly in eucalyptus plantations, showing that logging and recovery by subsequent planting were captured.

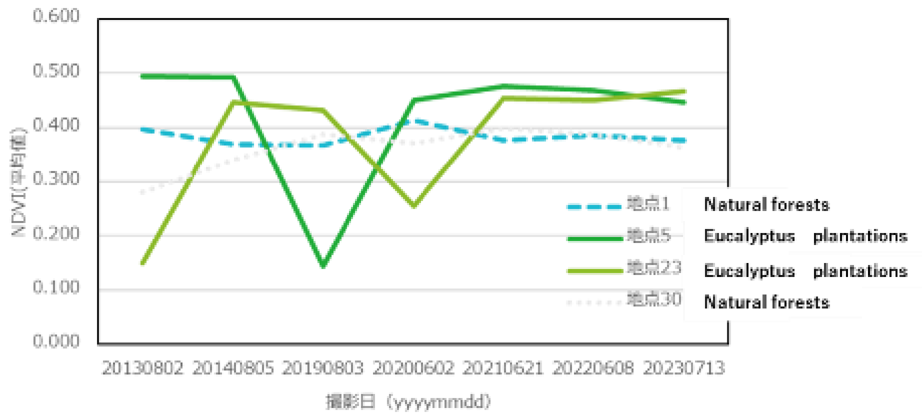


Figure 5. 3 Trends in eucalyptus as indicated by NDVI changes over time

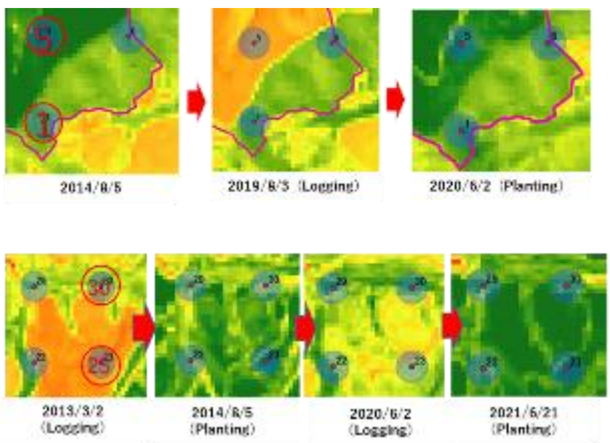


Figure 5. 4 Changes in NDVI images over time (green: high NDVI (with vegetation), orange: low NDVI (without vegetation))

5.3.2 Differences Between Eucalyptus Plantations and Natural Forests

To determine whether "eucalyptus plantations" and "natural forests" could be distinguished from the calculated NDVI, samples were first collected by visual interpretation using high-resolution images from Google Earth, and then the distribution of NDVI was confirmed. The results showed that eucalyptus and other broad-leaved trees had peaks at different values. In addition, when the same check was performed for each year, it was found that two peaks were displayed similarly for each year. On the other hand, young eucalyptus trees had low NDVI, suggesting that they could be mistaken for natural forests. In addition, the boundary between eucalyptus plantations and natural forests varies slightly from image to image, so it is necessary to set a threshold for each image rather than a common threshold for all images.

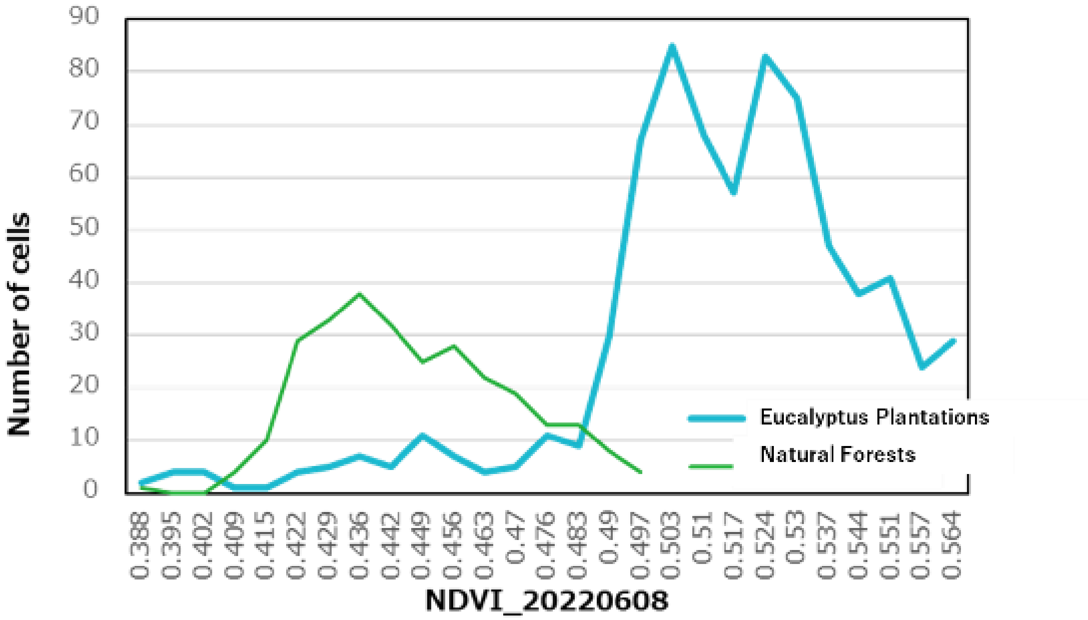


Figure 5. 5 Differences between eucalyptus plantations and natural forests as indicated by NDVI

5.4 Confirmation of Deforestation

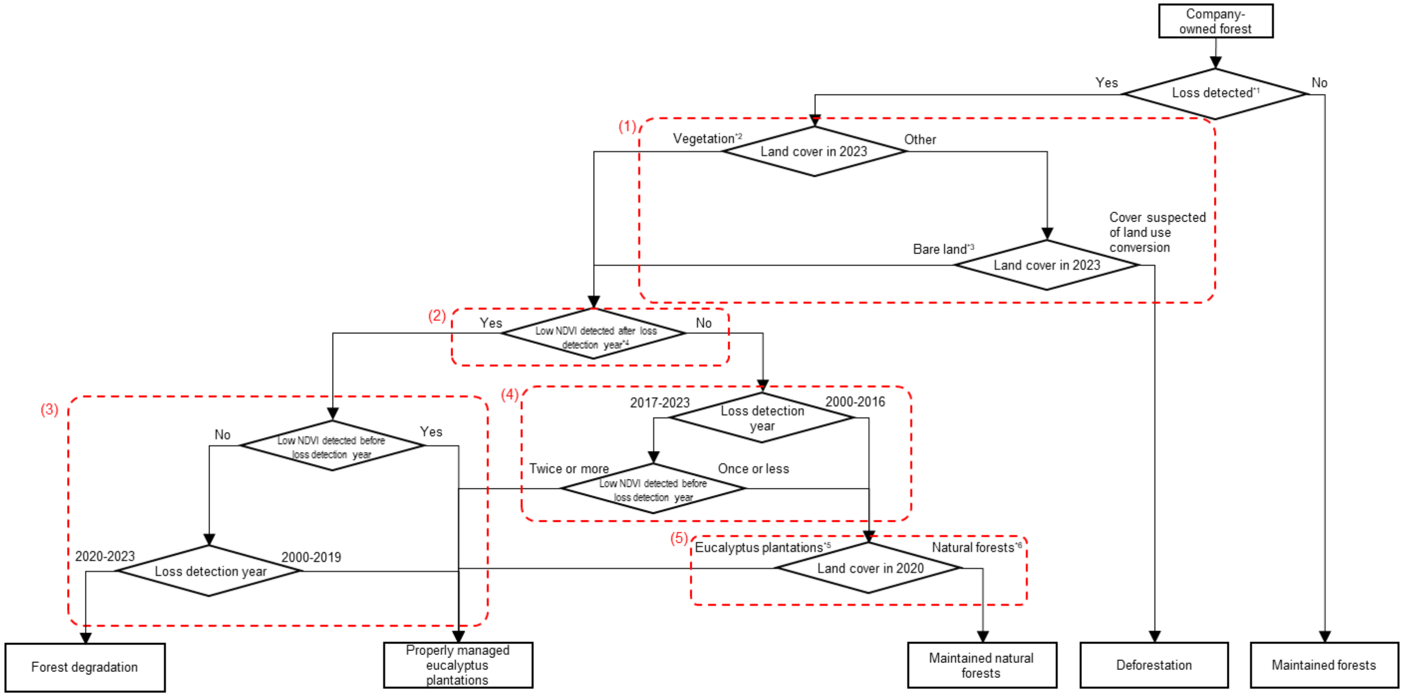
The characteristics of eucalyptus as indicated by NDVI in Section 5.3 are as follows.

[Characteristics]

- Large variations in NDVI over time due to repeated logging and reforestation.
- Although eucalyptus plantations and natural forests have different NDVI peaks, young eucalyptus trees can be mistaken for natural forests.

5.4.1 Analysis Method

Using the above characteristics, we predicted whether the areas where Hansen Loss has occurred (forest cover loss has been detected since 2000) are eucalyptus plantations or natural forests, and whether the decline is temporary or permanent. Figure 5. 6 shows the flowchart.



*1 "Loss" in this flow refers to Hansen Loss, and areas where loss has been detected are at risk of deforestation between 2000 and 2023.
*2 "Vegetation" in this flow refers to land with an NDVI at or above the threshold (Table 5.1).
*3 "Bare land" in this flow refers to land with an NDVI below the threshold (Table 5.1) and is predicted to have low potential for non-forestry use.
*4 "Low NDVI" in this flow is defined by the NDVI threshold shown in Table 5.1.
*5 "Eucalyptus plantations" in this flow is defined by the NDVI threshold shown in Table 5.2.
*6 "Natural forests" in this flow is defined by the NDVI threshold shown in Table 5.2.

Figure 5. 6 Analysis flow

(1) In the meshes where Hansen Loss was detected, land with NDVI as of 2023 at or above the threshold shown in Table 5. 1 was identified as "Vegetation", and land below the threshold was identified as "Other". Since meshes classified as "Other" may contain eucalyptus plantations immediately after clear-cutting, Google Earth images and past satellite images were visually checked to extract meshes where forests may have been lost due to land use conversion. In addition, the conversion of forests to forest roads or timber yards as part of forestry operations is not included in "deforestation" in accordance with the Good Practice Guidance for Land Use, Land-Use Change and Forestry (LULUCF-GPG), a standard manual published by the Intergovernmental Panel on Climate Change (IPCC) on how to calculate and report greenhouse gas emissions and absorptions.

(2) Eucalyptus plantations are often clear-cut, replanted, and then clear-cut again after about seven years of logging cycle. Therefore, if the NDVI falls below the threshold shown in Table 5.1 after the year of loss, it was considered highly likely to be a "eucalyptus plantation".

Table 5. 1 NDVI threshold for extraction of logging areas

Image Name	Threshold	Image Name	Threshold	Image Name	Threshold	Image Name	Threshold
N19900208	0.46	N19900123	0.39	N19900709	0.3	N19900725	0.43
N19910211	0.46	N19990828	0.31	N19910712	0.3	N19910712	0.32
N20000627	0.37	N20000627	0.37	N19990803	0.32	N19990904	0.34
N20040724	0.45	N20100826	0.33	N20000517	0.37	N20000821	0.37
N20100506	0.3	N20130802	0.24	N20100801	0.3	N20110719	0.4
N20130802	0.3	N20140805	0.28	N20130505	0.3	N20130505	0.25
N20140805	0.28	N20150925	0.28	N20140812	0.2	N20140812	0.26
N20160216	0.3	N20160810	0.25	N20150103	0.32	N20150103	0.32
N20180120	0.3	N20180120	0.3	N20160716	0.2	N20160918	0.28
N20190803	0.27	N20190702	0.23	N20170601	0.1	N20170820	0.25
N20200602	0.27	N20200501	0.29	N20180503	0.28	N20180706	0.22
N20210621	0.26	N20220819	0.24	N20190911	0.24	N20190911	0.26
N20220608	0.28	N20230713	0.25	N20200929	0.3	N20200929	0.28
N20230713	0.27	N20231110	0.3	N20210425	0.32	N20210628	0.2
				N20220911	0.28	N20220903	0.25
				N20231109	0.34	N20231109	0.27

(3) If a low NDVI is detected before the year of loss in a mesh that is likely to have been a eucalyptus plantation, it is highly likely that it has been a eucalyptus plantation as of 2000. On the other hand, if low NDVI is not detected before the year of loss, it is possible that the area has been converted from natural forest to eucalyptus plantation. Therefore, we checked the meshes in the area where Hansen Loss was detected after 2020. The year 2020 is chosen here because the EUDR uses a cut-off date of December 31, 2020. Areas where Hansen Loss was confirmed after 2020 were identified as "having the potential for conversion from natural vegetation to eucalyptus land (forest degradation)".

(4) Among the meshes where low NDVI was not detected after the year of loss detection in (2), for the meshes where loss was detected between 2000 and 2016, considering that eucalyptus has a logging cycle of seven years and therefore such meshes should have been logged, there is a possibility that Hansen misidentified the meshes or overlooked low NDVI after the loss. On the other hand, the reason why low NDVI was not detected in meshes where loss was detected after 2016 was highly likely because the trees had not yet reached the logging cycle. Therefore, we checked for low NDVI before the year of loss detection, and if low NDVI was found more than once, it was considered highly likely to be a "eucalyptus plantation". For meshes where one or less low NDVI was detected before the year of loss detection, it was considered that there is a possibility that Hansen misidentified the meshes or overlooked low NDVI after the loss.

(5) For the meshes identified in (4) as "there is a possibility that Hansen misidentified the meshes or overlooked low NDVI after the loss", the vegetation as of 2020 was classified as "eucalyptus plantation" and "natural forest". The year 2020 is chosen here because the EUDR uses a cut-off date of December 31, 2020. The thresholds used for classification are shown in Table 5. 2 .

Table 5. 2 NDVI thresholds

PathRow	Natural Forests	Eucalyptus Plantations
217073	$0.27 \leqq NDVI < 0.4$	$0.4 \leqq NDVI$
217074	$0.29 \leqq NDVI < 0.44$	$0.44 \leqq NDVI$
218073	$0.3 \leqq NDVI < 0.4$	$0.4 \leqq NDVI$
218074	$0.28 \leqq NDVI < 0.4$	$0.4 \leqq NDVI$

5.4.2 Verification Results of Thresholds by Comparison with Field Photographs

Borrowed field photographs and planting histories were used to validate the accuracy of the classification thresholds shown in Table 5. 1 and Table 5. 2 . Specifically, the accuracy was verified by comparing the results of classification using the thresholds shown in Table 5. 1 or Table 5. 2 for the meshes of the locations where the field photographs were taken with the field photographs and afforestation history.

The results are shown in Table 5. 3 . The accuracy rate of logging area extraction was 88%, while the accuracy rate of eucalyptus plantation and natural forest classification was 91%, showing relatively high accuracy rates. On the other hand, the possibility of bias in the above accuracy cannot be excluded, as the samples for validation in this analysis were not sufficient.

Table 5. 3 Threshold verification results

Table 5.1 Logging area extraction		Table 5.2 Eucalyptus plantation classification	
TRUE	7	TRUE	10
FALSE	1	FALSE	1
Accuracy Rate	88%	Accuracy Rate	91%

5.4.3 Analysis Results

Table 5. 4 shows the analysis results. Of the Hansen Loss, 94.83% was clear-cut assuming reforestation through forestry operations, and 5.08% was likely to be mis-extracted Hansen Loss, that is, natural forest with no changes; in other words, there was a high probability that 99.9% were areas that did not actually fall under "deforestation".

Table 5. 4 Analysis results

	%
Eucalyptus plantation managed appropriately	94.8%
Maintained natural forest	5.1%
Other	0.1%

6 Discussion and Conclusion

The Hansen Loss data is extracted from forest cover loss since 2000, and does not classify whether the forest was planted or natural in 2000. In addition, forest loss is detected only once, so no cycles of logging and reforestation are detected. Therefore, it is difficult to identify deforestation due to land-use change in planted forests using these data alone, and additional analysis and combination with other data is required.

As is true in this analysis and in the Hansen Loss data, deforestation is difficult to detect using satellite images, and may be difficult to detect accurately due to resolution, tree shading, vegetation changes, seasonal changes, and other factors. Of the meshes identified in this analysis as having incorrectly extracted Hansen Loss, 1,173 meshes, or 15%, were sampled and visually checked for logging, and 93% of them showed no logging. In many of these cases, logging was incorrectly extracted in natural forests between forest compartments, as shown in Figure 6. 1 .

Figure 6. 1 Example of incorrect extraction of Hansen Loss

(example of incorrect extraction of logging in natural forests remaining between clear-cuts)

（Background: Landsat image）

7 Lastly...

As described above, automatic detection of deforestation using satellite images is very difficult, and even in this analysis, including publicly available platforms, it may be difficult to accurately detect deforestation due to resolution issues and other factors. In addition, forest environments are very complex and diverse, and factors such as tree shading, vegetation changes, and seasonal changes can affect image interpretation, often leading to errors in identifying deforestation.

8 Appendix

Table 8.1 Glossary

Term	Definition
Global Forest Change	The open dataset showing the results of time-series analysis of Landsat imagery characterizing the extent and change of the world's forests.
Landsat satellite image:	Image data acquired from the U.S. Landsat satellite. It has a resolution of 30 meters and has been in operation since 1972, allowing data to be collected over a long period of time.
Normalized Difference Vegetation Index (NDVI):	An index of vegetation activity. It is calculated using near-infrared and red reflectance. The higher the NDVI, the healthier the vegetation.
AW3D:	A high-resolution 3D map generated from satellite images.
Mesh:	A parcel of land used as a unit of analysis. It is a 100-meter square area in this analysis.
Forest Cover Loss	A stand-replacement disturbance, or a change from a forest to non-forest state.
Deforestation:	In accordance with the FAO's definition of "deforestation", it refers to the permanent conversion of forest to non-forest, whether it is artificial or not.
Clear-cutting:	A method of logging used as part of forest management in which all trees in a given area are cut down at once.
Reforestation:	This refers to the replanting of forests that have been lost due to logging or natural disasters. This is an activity aimed at the restoration and sustainable management of forests.
Natural forests:	Natural forests are forests that have been formed by natural processes and are largely untouched by human intervention. Natural forests include those formed by natural regeneration.
Planted forests:	Forests created by humans through planting or seeding. Planted forests include those created by reforestation (replanting trees after logging) and afforestation (planting trees on land that was not previously forested).
Eucalyptus plantations:	Artificial forests operated by CENIBRA in the area covered by this analysis.
EUDR:	Regulations established by the European Union (EU) to prevent deforestation. The regulations aim to ensure that products supplied to the EU market are not linked to deforestation.

Table 8.2 Data Source

Data Name	Cited
Hansen Loss Data	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. “High-Resolution Global Maps of 21st-Century Forest Cover Change.” Science 342 (15 November): 850–53. Data available on-line from:http://earthenginepartners.appspot.com/science-2013-global-forest. Accessed through Global Forest Watch on 07/10/2024. www.globalforestwatch.org
Landsat satellite image	Landsat OLI, USGS Earth Observation and Science Center, and Google Earth Engine