GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN

Albert-Ludwigs-Universität Freiburg

UNI FREIBURG

SESSION: FOREST OPERATIONS AND ENGINEERING

Feasibility of sustainable management of secondary Atlantic Forest: Recovery and mortality rates of damaged trees two years after harvesting

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1st International Electronic Conference on Forests,

INTRODUCTION & RELEVANCE OF THE RESEARCH

Original forest cover



Forest Area

Amazon Forest = 5.5 Mi Km²
Atlantic Forest = 1.5 Mi Km²

Current forest cover



Remnant Forest Area

Amazon Forest = 83 %
Atlantic Forest = 12 %

The ***Brazilian Atlantic Forest*** is exceptionally rich in biodiversity and one of the most threatened biome in Brazil.

After centuries of intensive exploitation and conversion to other land uses, the forest area was reduced to only 12% of its original extension.

Most of the remaining Atlantic Forest is fragmented into small (less than 50 ha) and isolated forest patches, mainly covered with second growth forests and owned by private landowners.

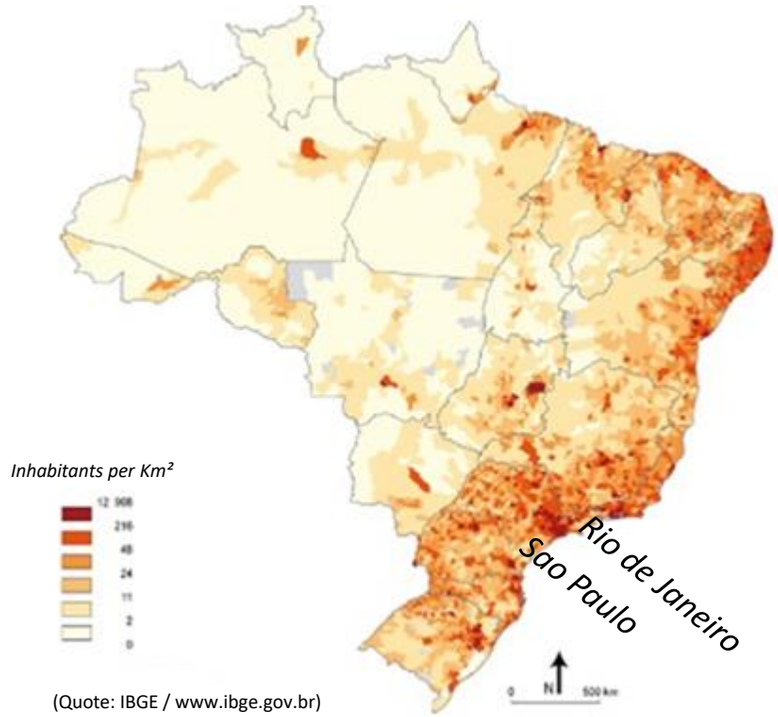
INTRODUCTION & RELEVANCE OF THE RESEARCH

Aiming to protect the remnant Atlantic Forest from deforestation and degradation, the Brazilian government established a very strict protection and restricted land uses.

However, this is a controversial issue with conflicting goals between conservation and management.

The restricted land use generated a lack of willingness to maintain the native forest as landowners were not compensated and law enforcement was insufficient.

Brazilian population density



(Quote: IBGE / www.ibge.gov.br)

Current forest cover



Located along the Brazilian coast the Atlantic Forest is housing of two-thirds of Brazil's inhabitants.



(Quote: Ricardo Zerrener/ www.g1.com.br)



Most of the bigger Brazilian cities are located in the Atlantic Forest region.

OBJECTIVES





We believe that sustainable forest management, with reduced harvesting impact, has the potential to generate income for the landowners while sustaining important ecological services of the forest.

Therefore, the goal of the present study is to enhance current knowledge on sustainable management of secondary Atlantic Forests and, in particular, assessing recovery and mortality rates of damaged trees up to two years after harvesting.



We compared the timber harvesting impact of a conventional harvesting method (CM) with an alternative and improved harvesting method (AM), In order to answer the following questions:



a) Did the harvesting method influence the recovery and mortality rates over two years?

b) Did multiple damaged trees affect recovery rates?

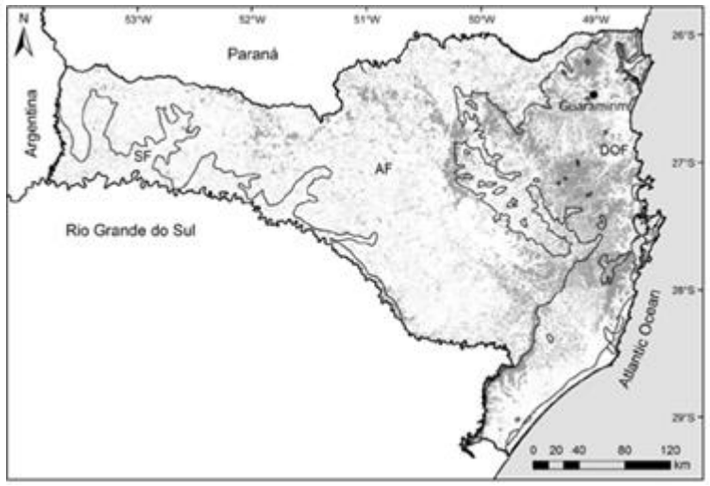
c) Did higher damage intensity reduce the recovery rate?

METHODOLOGY – RESEARCH AREA

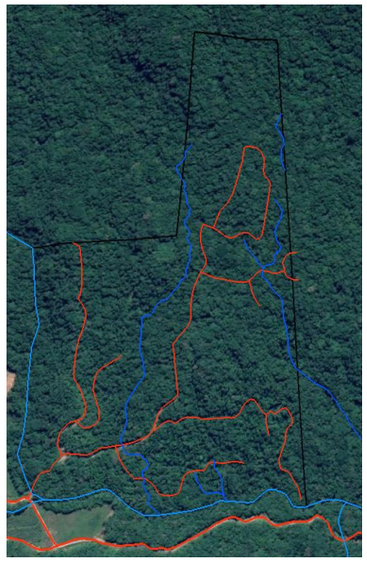
This study was performed in the municipality of Guaramirim, state of Santa Catarina, southern Brazil.

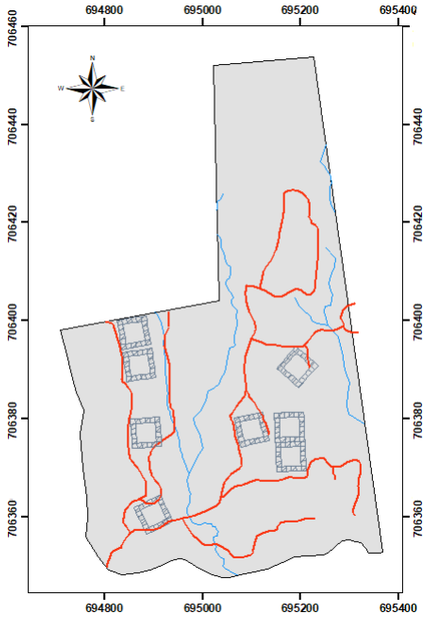


Santa Catarina state

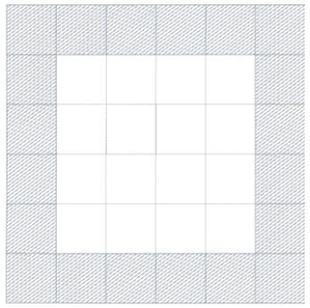


Research area





Plot area





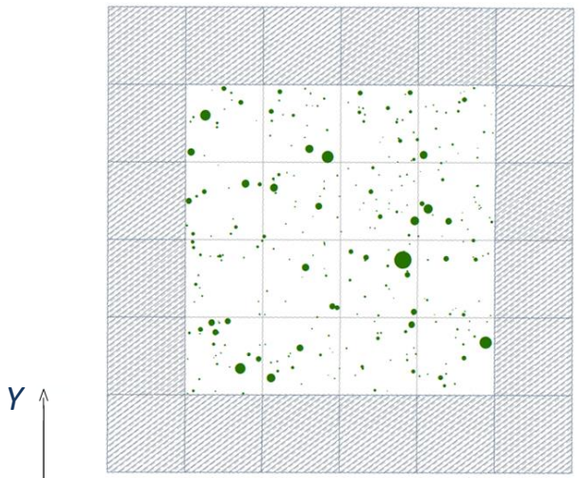


Permanent research plots (40 x 40 m) in three different stands (A, B and C) were established in a small research area (42 ha) covered with second growth forest.

METHODOLOGY – RESEARCH AREA

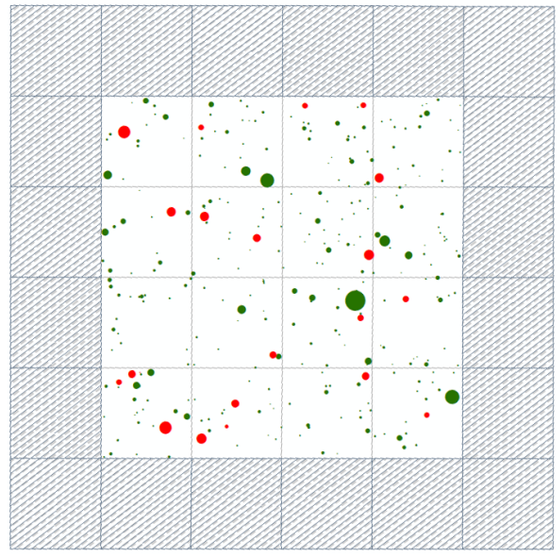
a) We performed a pre-harvesting inventory of all trees with diameter at breast height (DBH) above 5 cm, recording tree species, DBH, tree height and location (Cartesian X and Y coordinates)





Green dots represent the positioning of trees inside stand

A thinning plan was developed and implemented in all three stands targeting a harvesting of 40% basal area reduction.



Red dots represent selected trees to harvesting

Measured trees were permanently marked with an aluminum tag.



b) A first post-harvesting inventory was performed directly after harvesting and
c) a second post-harvesting inventory was performed two years after harvesting.

METHODOLOGY – TIMBER HARVESTING

In this study, two different harvesting methods were assessed and evaluated:

Conventional Method (CM)





a) the “Conventional Method” (CM), was formerly widely used by landowners in the region for timber harvesting operations in the Atlantic Forest. The operator has a long practical experience but no specific training.

Alternative Method (AM)







b) the “Alternative Method” (AM), was conducted by a contracted professional chainsaw operator, experienced in reduced impact logging techniques in the Amazon region and supplemented with a skidding cone and a snatch block.

METHODOLOGY – IMPACT ASSESSMENT

The harvesting impact on the residual stand was determined by visual inspection of all standing trees in two post harvesting inventories:

a) *directly after harvesting and*
b) *two years after harvesting*





Tree damages were recorded at three different tree zones (crown, bole and leaning) and rated in three different intensity classes (minor, moderate and severe).

Classification criteria for harvesting damage to remnant trees

Category of damage	Intensity of damage					
	Minor	*Rating value*	Moderate	*Rating value*	Severe	*Rating value*
Crown damage	X <1/3 of crown	*1*	1/3 < X < 2/3 of crown	*2*	X >2/3 of crown	*3*
Bole damage	Bark damage	*1*	Superficial wood damage (cambial tissue)	*2*	Deep wood damage (sub cambial tissue)	*3*
Tree leaning	Slight leaning	*1*	Partially uprooted	*2*	Fully uprooted	*3*
Dead Trees						*9*

METHODOLOGY

The damage intensity and rating value of each tree directly after harvesting was compared to the damage intensity of the same tree two years after harvesting and classified into:

a) Completely recovered tree = Trees that presented no damage after two years;
b) Partially recovered tree = Trees that presented a reduction of the damage rates;
c) Same damage = Trees with the same damage rates;
d) Dead trees = Trees that died off or were not found two years after harvesting).

Chi-square tests of association were performed to verify association between multiple damaged trees, damage intensity, harvesting method and recovery rates.

Correspondence analysis were performed to investigate the distribution patterns of multiple damaged trees, stands and recovery rates.



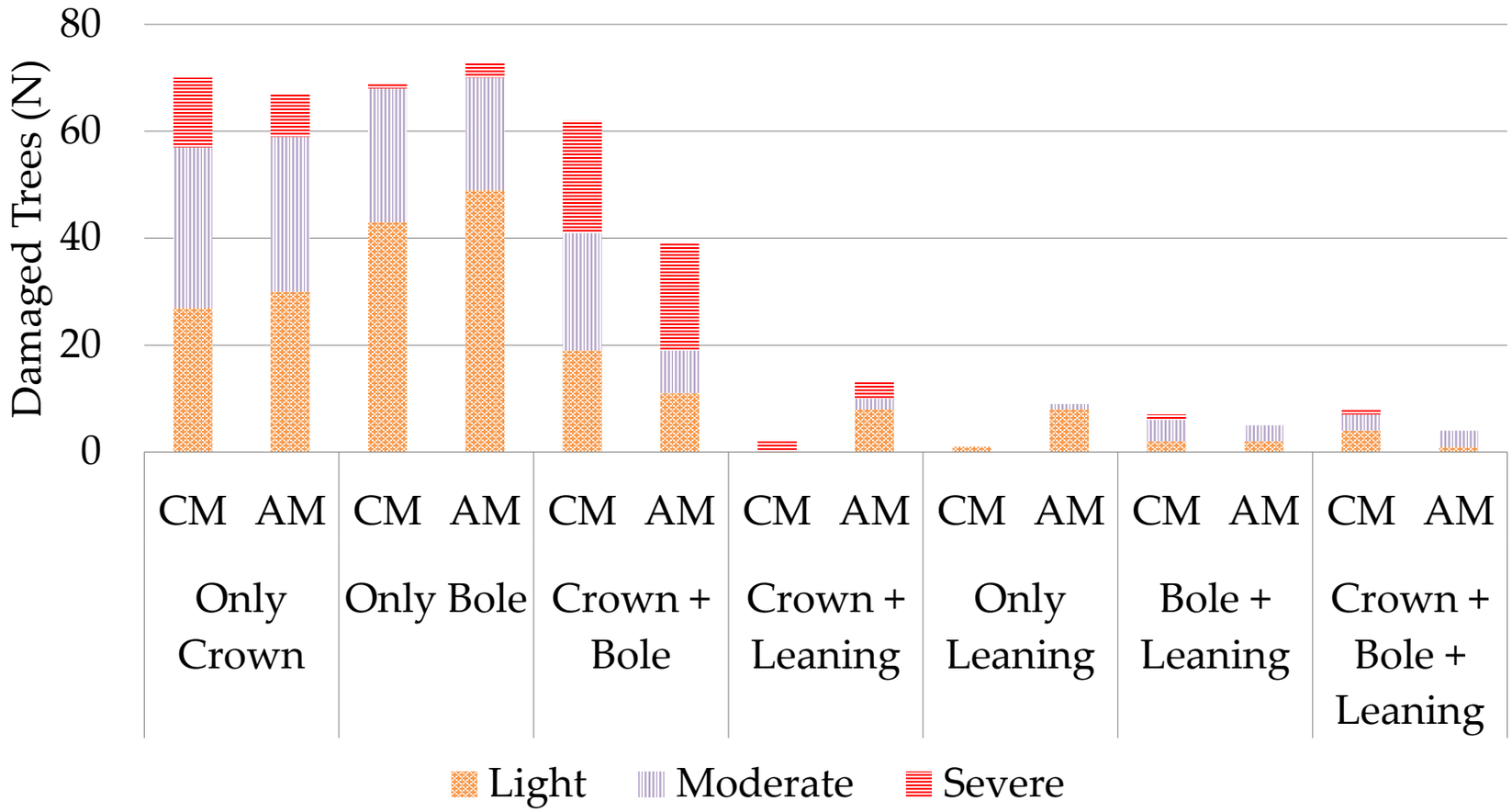


RESULTS

In total 429 trees were damaged during the harvesting within our research plots (0.96 ha).

Multiples damages on the same tree were responsible for circa of 33 % of all damaged trees.

Crown and bole damages were the predominant damage categories.



CM presented a slightly higher number of total damaged trees (51%) compared with AM (49 %).

RESULTS

Chi-square test showed an association between harvesting method and damage categories

[X^2 (6) = 21.370; p = 0.002]

Chi-square test of association between harvesting method and damage category.

Damage Category	Conventional Method (CM)			Alternative Method (AM)		
	Observed N	Expected N	Adjusted residuals	Observed N	Expected N	Adjusted residual
Only Crown	70	69.9	0.0	67	67.1	0.0
Only Bole	69	72.5	-0.7	73	69.5	0.7
Only Leaning *	1	5.1	-2.6	9	4.9	2.6
Crown + Bole *	62	51.6	2.4	39	49.4	-2.4
Crown + Leaning *	2	7.7	-3.0	13	7.3	3.0
Bole + Leaning	7	6.1	0.5	5	5.9	-0.5
Crown + Bole + Leaning	8	6.1	1.1	4	5.9	-1.1

Noticeable is the association between harvesting method and the category of combined crown and bole damages.

While CM presented a positive association with a higher number of damaged trees than expected by the model, AM presented a negative association with a lower number of damaged trees than the expected.

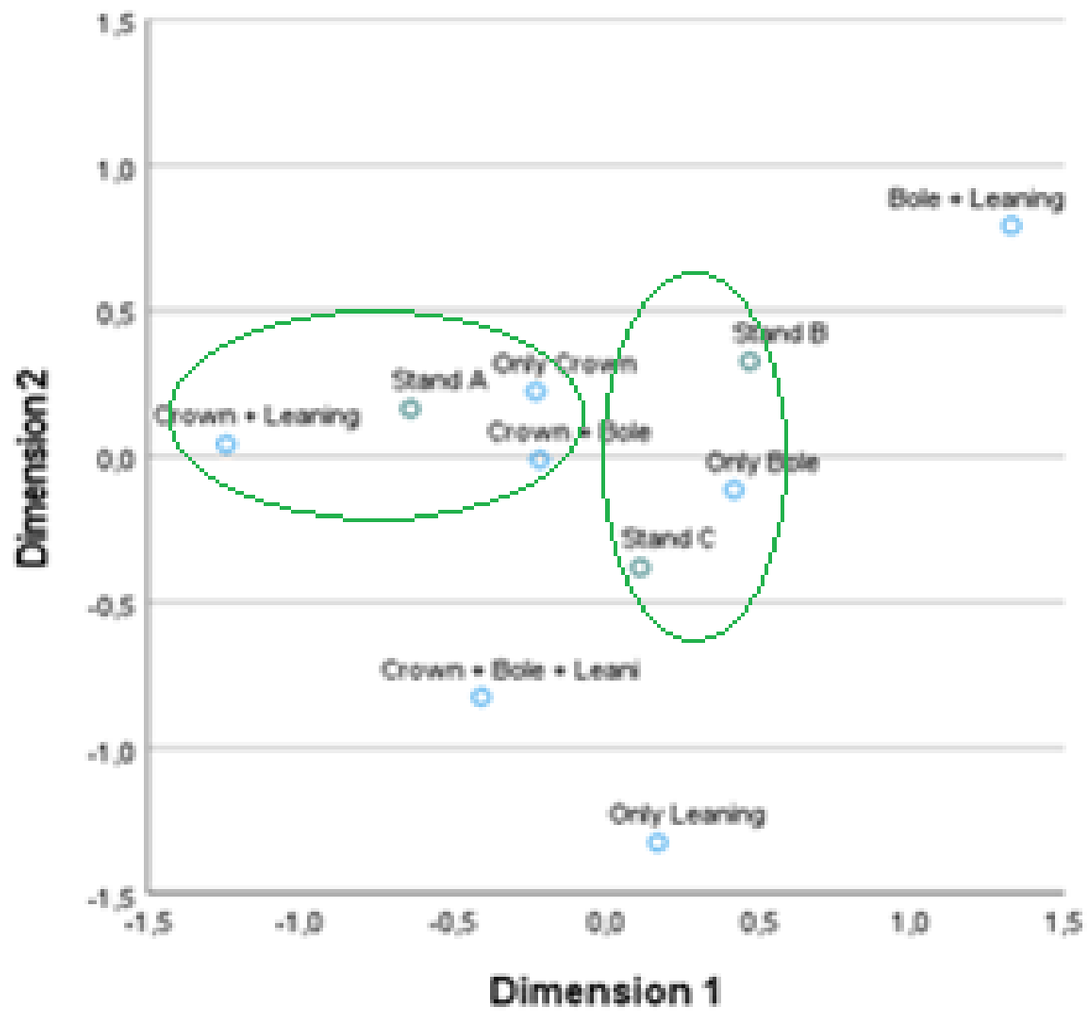
RESULTS

Correspondence analysis between damage category and stands, showed that we can roughly divided into three parts:

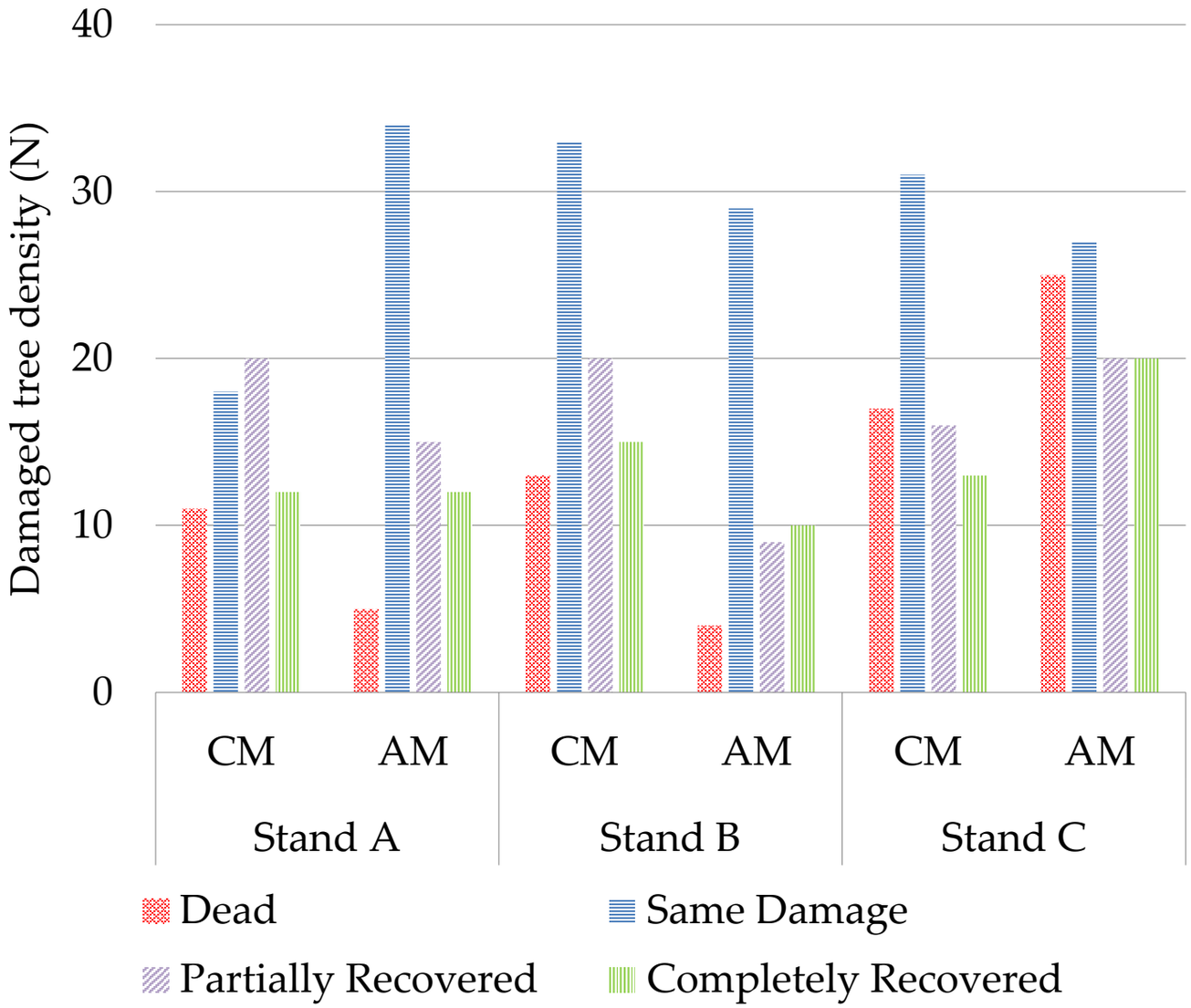
1- Sample points clustered with Stand A were predominant crown damage categories.

2- Stand B and stand C were clustered with bole damages.

3- A high dispersion of leaning damage points, indicated that these damage categories are not related to a specific stands.



RESULTS



The majority of damaged trees directly after harvesting presented the same damage two years after harvesting.

Circa of 19 % (CM) and 16 % (AM) of all damaged trees died off two years after harvesting.

Moreover, 18 % (CM) and 20 % (AM) of all damaged trees completely recovered two years after harvesting.

A higher rates of dead trees in stand C was observed for both harvesting methods.

RESULTS

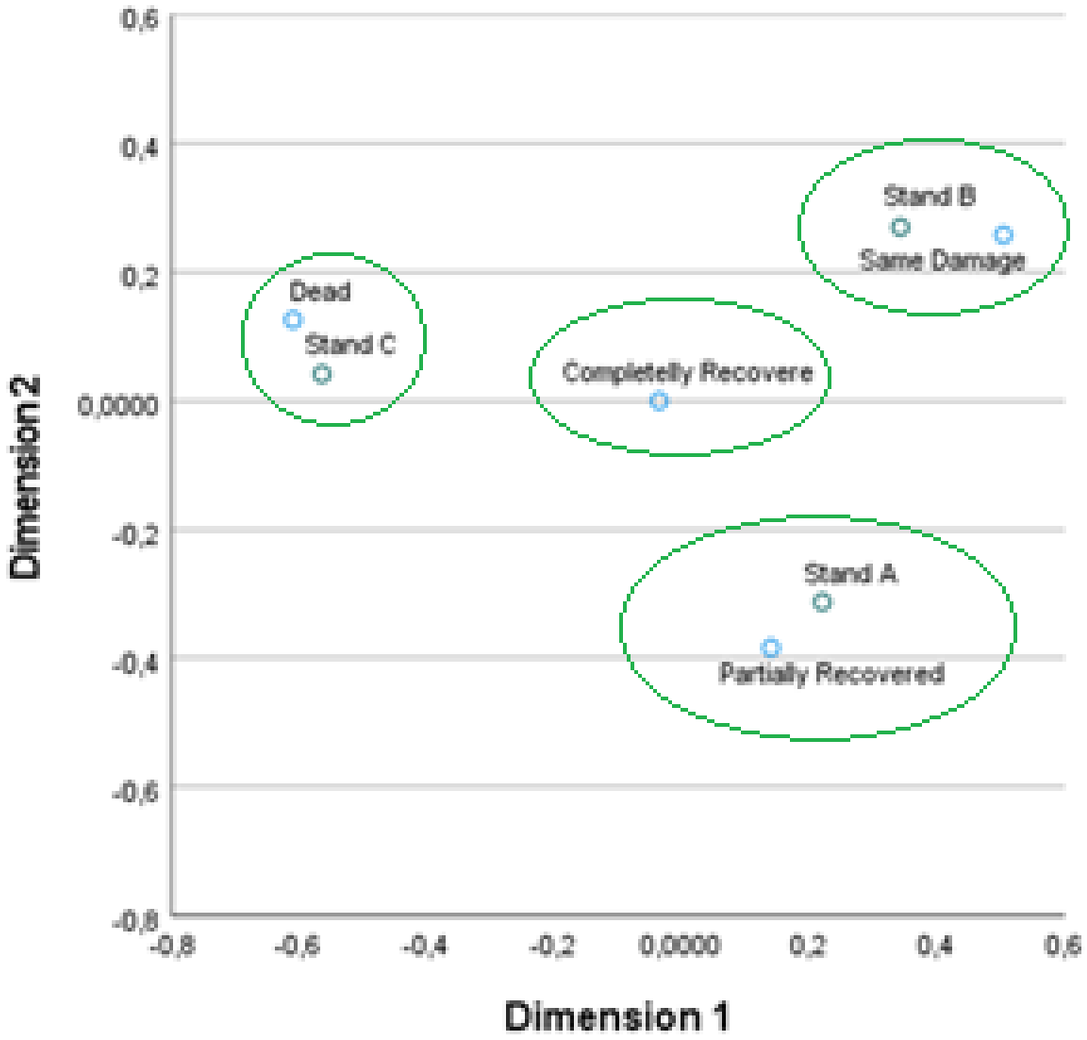
Correspondence analysis showed a clear clustering between stands and recovery rates two years after harvesting.

1st - Stand A is clustered with the category of “partially recovered” trees.

2nd - Stand B is clustered with the category of "same damage“ trees.

3rd - Stand C is clustered with the category of “dead trees”.

4th - Completely recovery trees did not cluster with any stand.



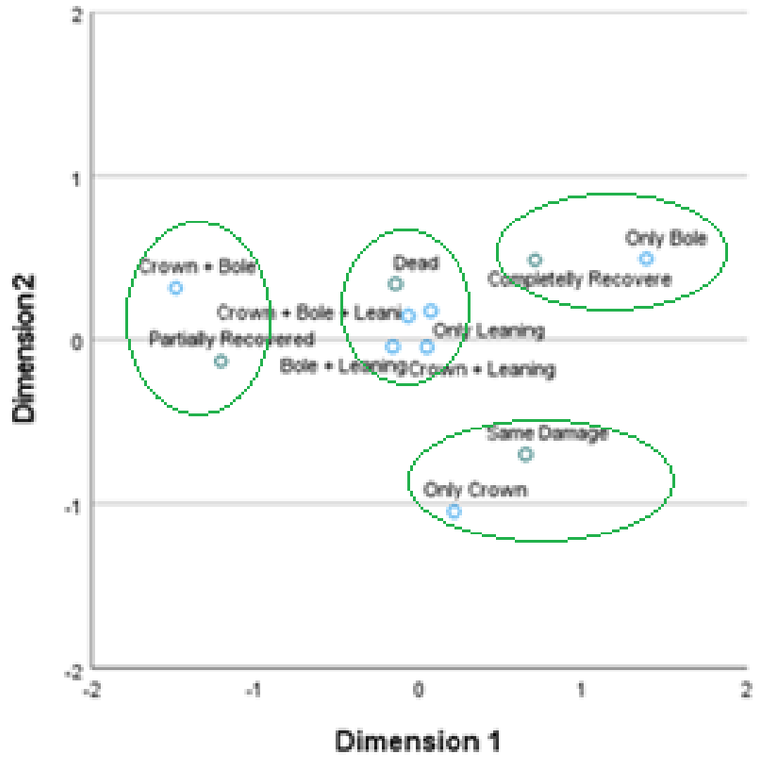
RESULTS

Correspondence analysis showed a relationship between recovery rates and multiple damage categories.

Chi-square test showed an evident association between recovery rates and damage intensity for crown damages and bole damages for both harvesting methods.

	Damage Category	Pearson Chi-square	df	P-value
CM	Crown	67.30	9	0.00
	Bole	19.60	9	0.02
	Leaning	12.14	9	0.21
AM	Crown	89.01	9	0.00
	Bole	49.84	9	0.00
	Leaning	16.83	6	0.01

It was noticeable that “moderate and severe” crown damages presented a positive association with “partially recovered trees”.



It was also noticeable a positive association between “minor bole damages” and “completely recovered” trees.

Dead Trees two years after harvesting presented a strong relationship with “leaning damages”.

CONCLUSIONS

Small improvements of AM method could reduce the harvesting impact on remnant trees, in particular, when the damage occurred on trees with combined crown and bole damages.

There was a strong relationship between crown damages and steep terrain (stand A).

High mortality rates were related to a high density of trees in the lower DBH classes (stand C).

Tree leaning damages were also related to a high mortality rates two years after harvesting.

Partially recovered trees were related to severe and moderated crown or bole damages.

Minor bole damages are strong related with completely recovered trees.



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THANK YOU...



















