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# BUSH HARVESTING, PILOT STUDIES ON RETRABIO AND BIOBALER

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# 1. Retrabio

# Mulcher-collector RETRABIO:

- Rotor with 36 hammers rotating upward on the machine front.
- Flywheel and discharge spout
- 24 $m^3$ container

# 1.A Salix coppice systematic mulching and biomass collection

# Location

As Pontes (A Coruña)

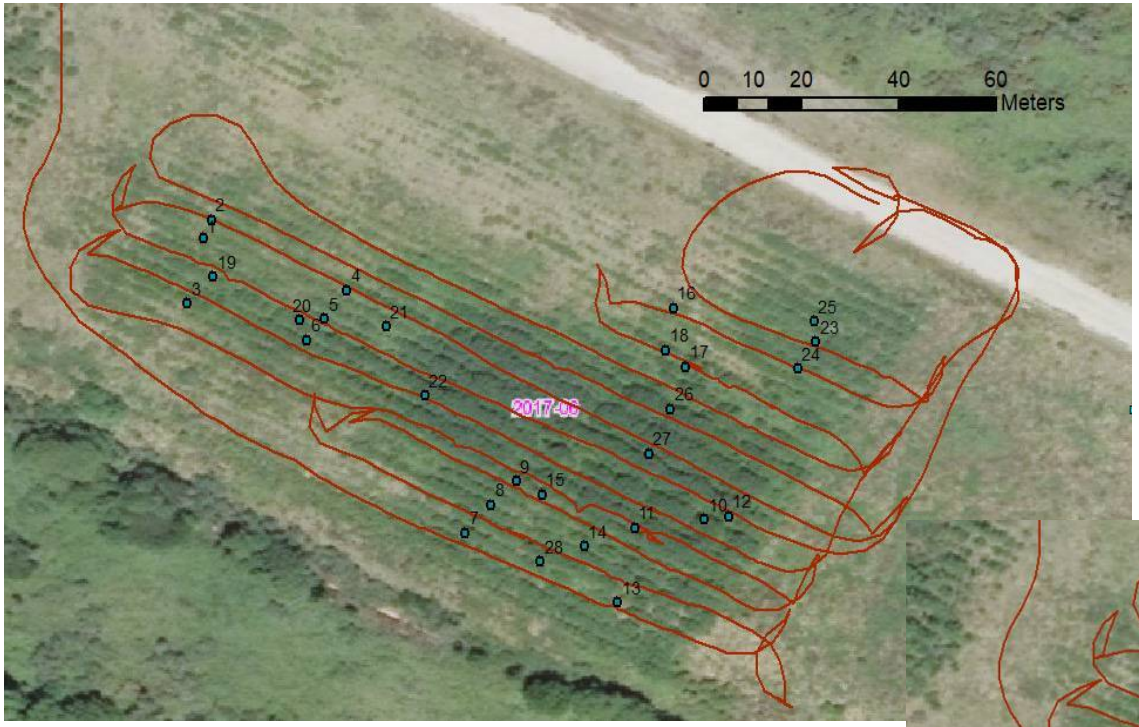
# Tasks (28 September- 2 October 2020)

- INVENTORY: 28 circular plots (2 m radius):
  - Stand conditions including scrubs
  - Weight of different *Salix* stools/moisture content samples

- Detailed – continuous - TIME STUDY

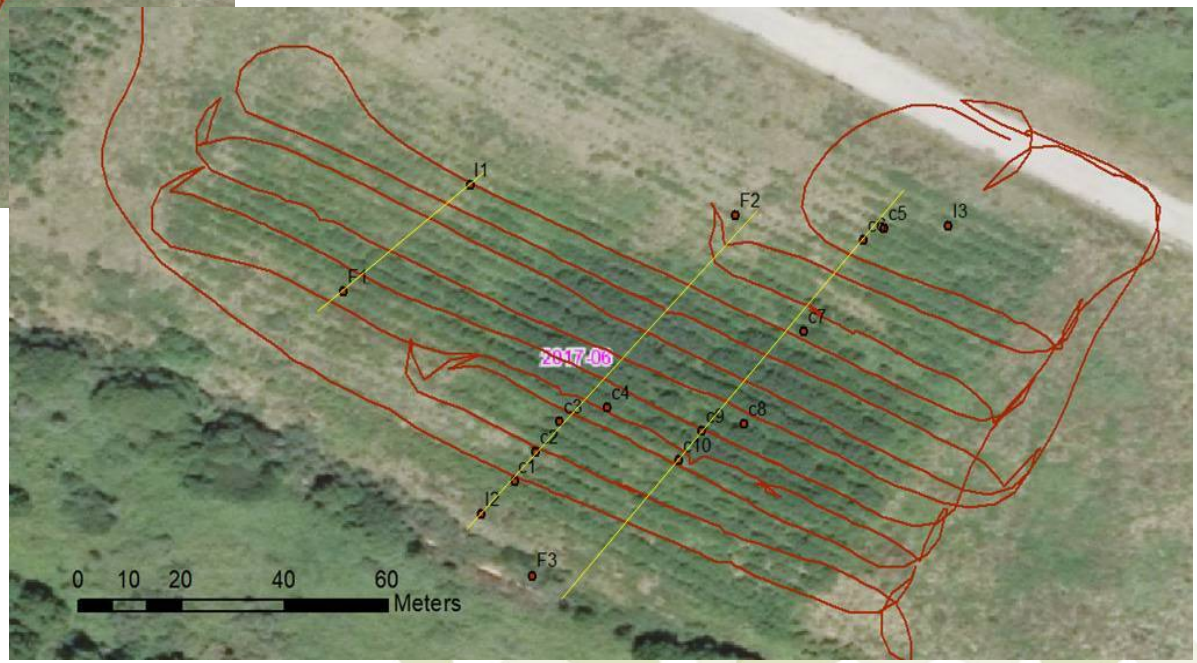
- Scaling extracted biomass /moisture content samples

- POST-TREATMENT INVENTORY ALONG TRANSECTS perpendicular to mulched strips: 26 circular plots (1 m radius):
  - Stand conditions after the treatment
  - Stand/soil damages characterization
  - Stump height and status
  - Weigth of downed woody material/moisture content samples




←Pre-harvesting inventory

Post-harvesting inventory →



←Biomass sampling-weighing

DEMAUX

SMALL wood

# Results

| N (tree/ha) | Tree h (m) | DBH (cm) | Tree canopy cover (%) | Shrub h (m) | Shurb canopy cover (%) | Fresh weight (t/ha) | ODt/ha |
|---|---|---|---|---|---|---|---|
| 36321 (10435) | 5.6 (1.1) (h max) | 2.23 (0.79) | 79.2 (16.7) | 1.9 (0.6) | 48.5 (38.0) | 57.6 (28.1) | 30.6 (15.0) |

# Results

Treated area (ha): 0.557

Odt·ha$^{-1}$ before treatment: 30.6

Machine speed while brushcutting (km·h$^{-1}$): 0.8

Total travelled distance (m): 844

Extracted dry biomass (ODt): 2.77

% Extracted/Standing biomass ≈ 45%

Productive machine hours ($PM_{15}h$): 1 h 41 min

# Time study

- Productivity reached 3.58 fresh tonnes/Productive hour = 1.86 ODt/Productive hour.
- Productivity = 1.64 ODt/PM15h
- Economic Balance (for roadside biomass price 20 €/fresh t): -205.6 €/ha$^{-1}$ (*)

(*) Hourly costs from Esteban, L. S. *et al.*, 2017

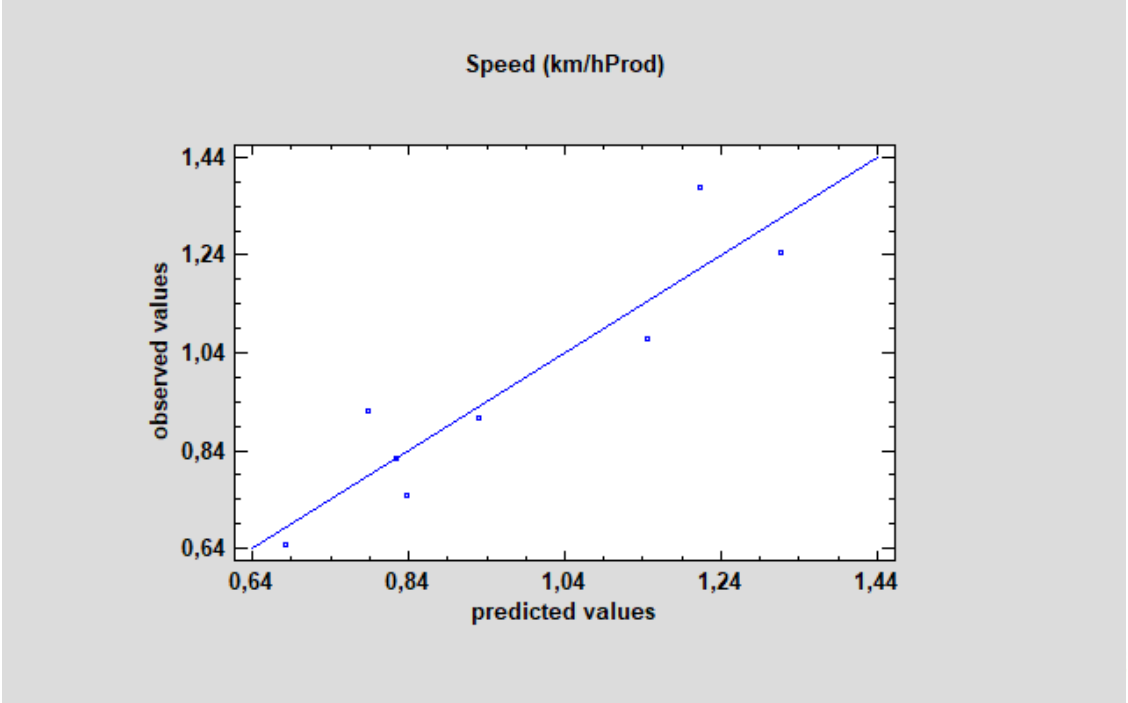
| Phase | Time | % |
|---|---|---|
| Empty movements | 0:05:24 | 5% |
| Mulching/collection | 1:01:04 | 60% |
| Manouevring/changing striproad | 0:12:23 | 12% |
| Loaded movements | 0:02:57 | 3% |
| Unloading | 0:06:42 | 7% |
| Planning | 0:03:05 | 3% |
| Other breaks | 0:09:31 | 9% |
| TOTAL | 1:41:06 | 100% |

# Productivity model

**V (km·ProdH$^{-1}$) = 4.06 – 0.0000207·Ntrees·ha$^{-1}$ – 0.385·Hmax, m – 0.0297·SBV (Shrub Cover, % · Shrub aver. Heigth, m.)**
(adj $R^2$ = 0.73, P=0.042)

Prod (ha·ProdH$^{-1}$) = 1000·V (km·ProdH$^{-1}$)·(2.75 + USW -Untreated strips' width -, m)/10000

**Prod (ha·ProdH$^{-1}$) = 0.1·(4.06 - 0,0000207·Ntrees·ha$^{-1}$ - 0,385·Hmax, m - 0,00297·SVB) ·(2.75 + USW, m)**



# 1.B Pine post-fire regeneration systematic mulching and biomass collection: wildfire preventive treatment

# Gondulfes forest, Verín (Orense)

**Surface:** 638 ha
**Ownership:** Gondulfes and Marbán villagers community

# Tasks (March-May 2021)

- INVENTORY: 85 circular plots (2 m radius):
  - Stand conditions including scrubs
  - Weight of 28 *Pinus* trees/moisture content samples

- Detailed – continuous - TIME STUDY

- Scaling extracted biomass /moisture content samples

- POST-TREATMENT INVENTORY in 32 2,75x1 m plots located along the mulched strips:
  - Stand/soil damages characterization
  - Stump height and status
  - Weigth of downed woody material/moisture content samples

- Productivity equations fitting – cost estimations

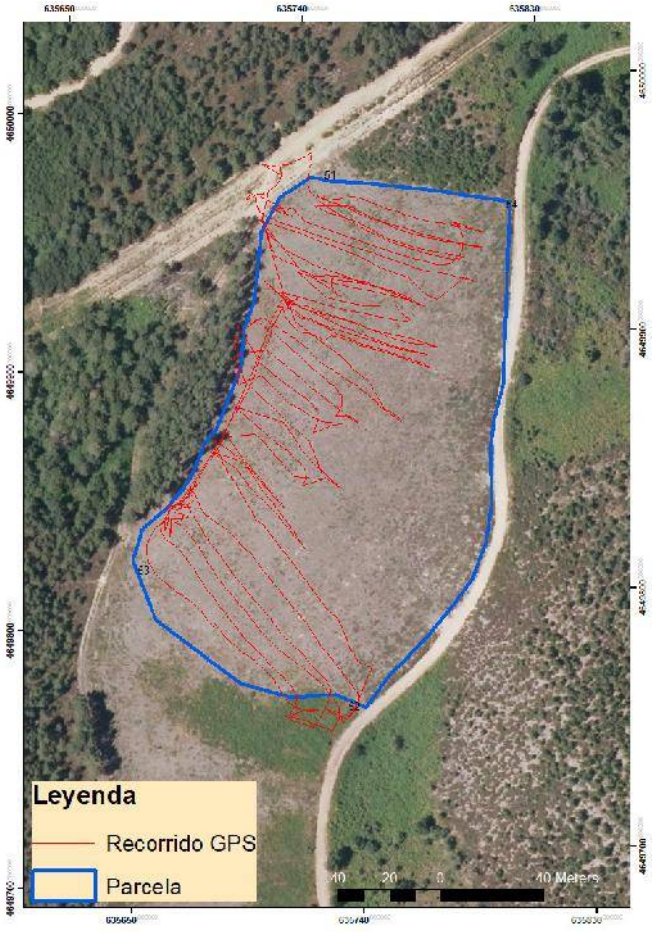
*P. pinaster, Erica cinerea*, *Genista tridentata*, *Ulex europaeus* y género *Halimium*

# INVENTORY RESULTS (SD in parentheses)

| N (trees/ha) | Tree h (m) | DBH (cm) | Tree canopy cover (%) | Shrub h (m) | Shurb canopy cover (%) | Green weight (t/ha) | ODt/ha |
|---|---|---|---|---|---|---|---|
| 4126 (3071) | 1.9 (0.67) | 2.9 (1.4) | 37.6 (23.9) | 0.5 (0.17) | 22.7 (21.1) | 21.0 (17.4) | 8.49 (7.03) |

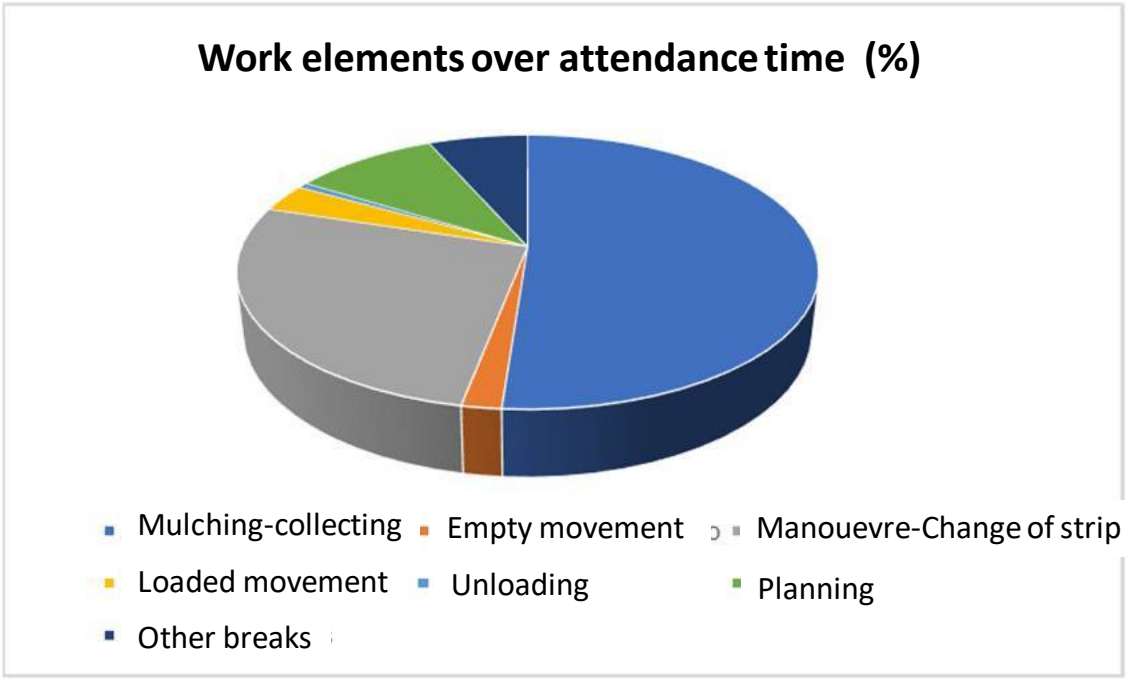
# MULCHING – BIOMASS COLLECTION TRIAL

31 mulching strips 2.75 m wide
GPS georeferenced




Trial Surface = 1.44 ha

# TIME STUDY




**Productive time: 2:08:03 (83,8 %)**

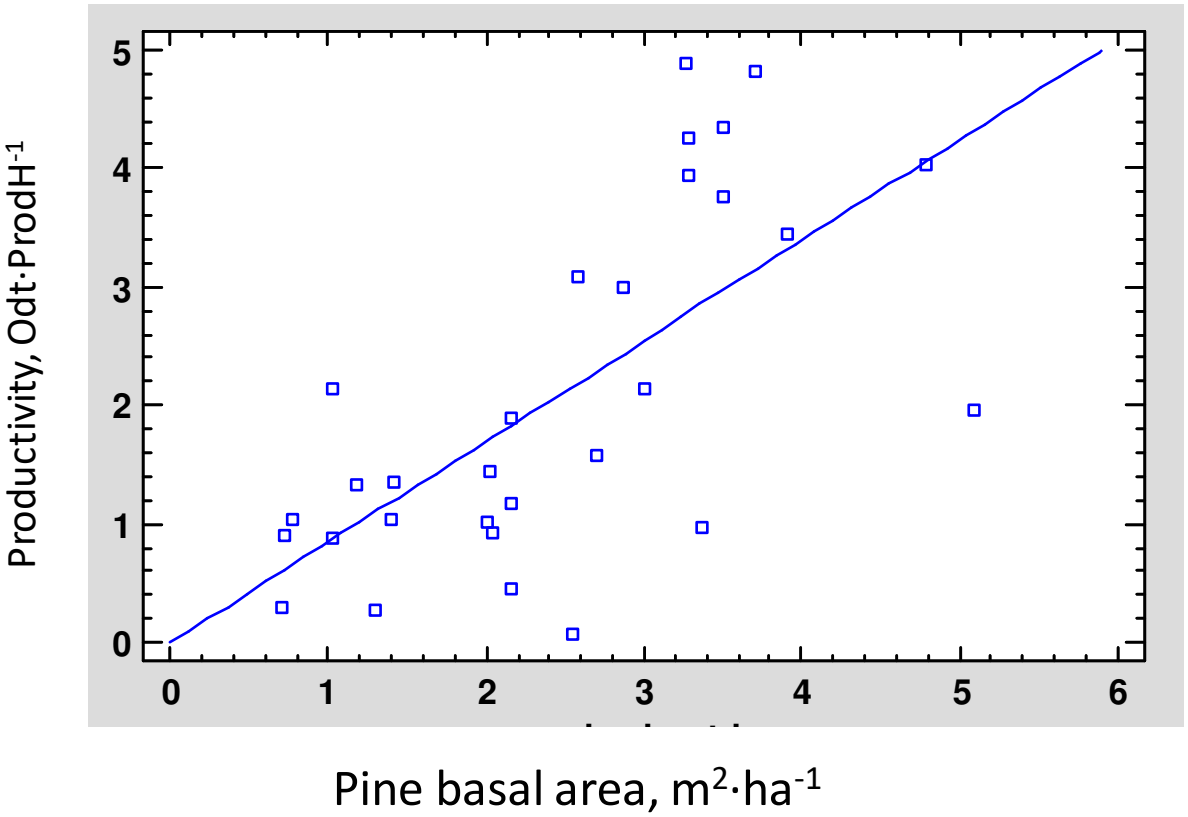
**Mulching/collecting time: 1:18:12 (51,18 %)**

**Speed and Productivity calculation**

Surface Productivity = 0,67 ha·ProdH$^{-1}$

Hourly cost= 112.0 €·ProdH$^{-1}$

# PRODUCTIVITY MODELS




| Fitted equation | Adjusted $R^2$ % | MAE | D-W |
|---|---|---|---|
| Productivity (fresh tonnes·ProdH$^{-1}$) = 2.08·BASAL AREA (m$^2$·ha$^{-1}$) | 44,5 | 2,10 | 1,13 |
| Productivity (ODt·ProdH$^{-1}$) = 0.848·BASAL AREA (m$^2$·ha$^{-1}$) | 45,2 | 0,84 | 1,14 |

# COST ESTIMATION

MULCHING AND COLLECTION

Cost FM = 45.12 € · Fresh tonne$^{-1}$

Cost DM = 95.64 € · ODt $^{-1}$

Cost per hectare = 166.05 € · ha $^{-1}$

TRANSPORT TO POWER PLANT

Cost FM = 10.07 € · Fresh tonne$^{-1}$

Cost DM = 21.39 € · ODt $^{-1}$

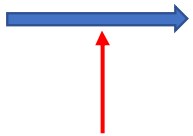
Cost per hectare = 37.14 € · ha $^{-1}$

+ 13% INDIRECT & FIXED COSTS + 6% INDUSTRIAL PROFIT

Cost FM = 65.67 € · Fresh tonne$^{-1}$

Cost DM = 139.26 € · ODt $^{-1}$

Cost per hectare = 241.79 € · ha $^{-1}$



BALANCE I-C: -94,57 €/ha

INCOME = 40 € · Fresh tonne$^{-1}$ at powerplant gate

# Conventional mulching vs RETRABIO

Cost with a chain mulcher: -185.6 €·ha$^{-1}$

Cost with RETRABIO: -94.57 €·ha$^{-1}$

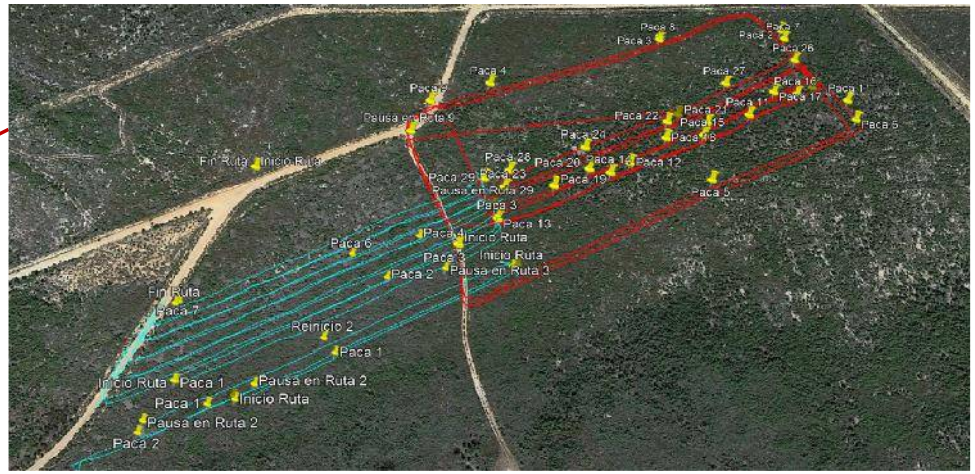
SAVINGS OF 91.03 €·ha$^{-1}$ COMPARED TO CONVENTIONAL MULCHING

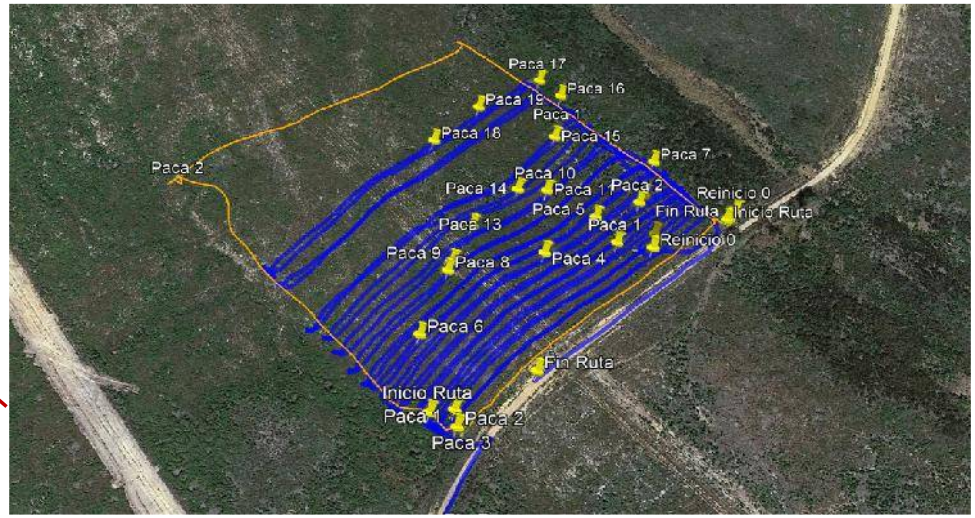
# 2. Biobaler

# Mulcher-Bundler BIOBALER WB-55:

- Biobaler WB55 is an alternative to conventional chain or hammer mulchers.
- It collects woody material from 1 to 10 cm diameter, using a continuous technology of mulching and bundling in bales 1.2 m wide and 1.2 m diameter
- Baling eases extraction, transport, stockage and further handling for energy or bioproducts production.

# Trials in Castrocontrigo and Tabuyo del Monte forests (León, Spain)



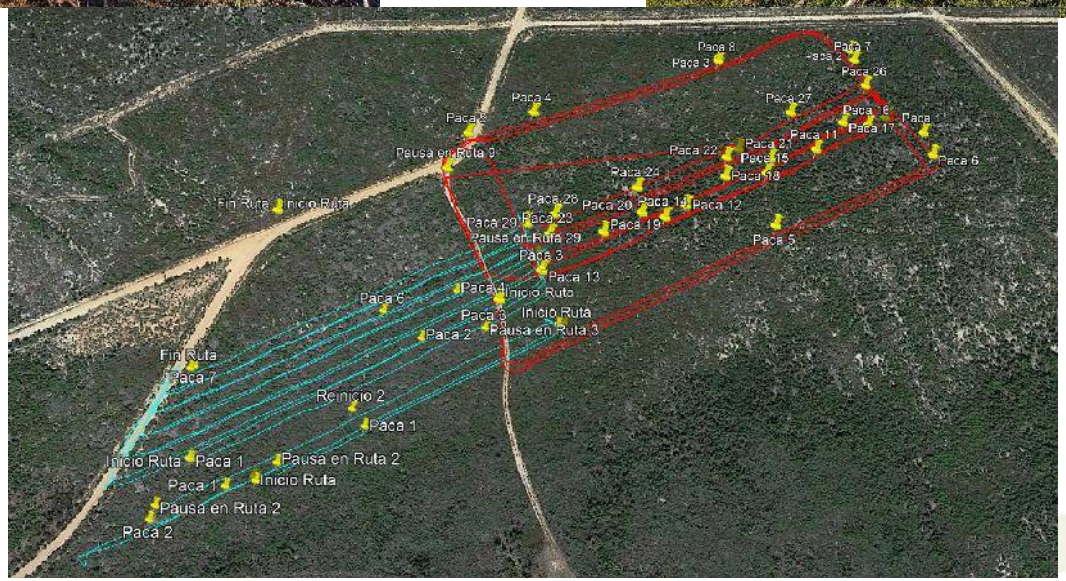




Wildfire preventive treatments by systematic mulching with mulching strips 2.65 m wide, with untreated strips with similar width (Wide) or half width (Narrow). Comparison with conventional mulcher.

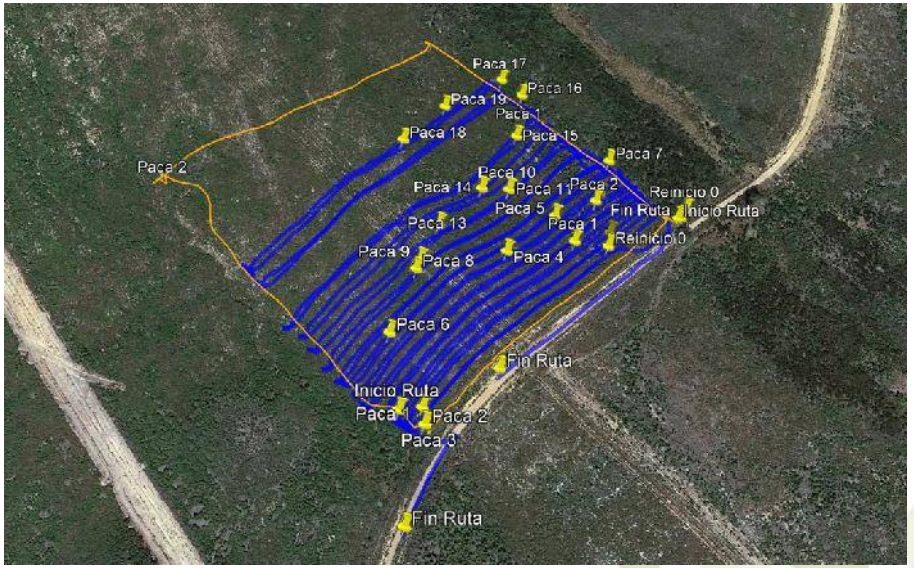
# MULCHING AND BUNDLING TRIALS

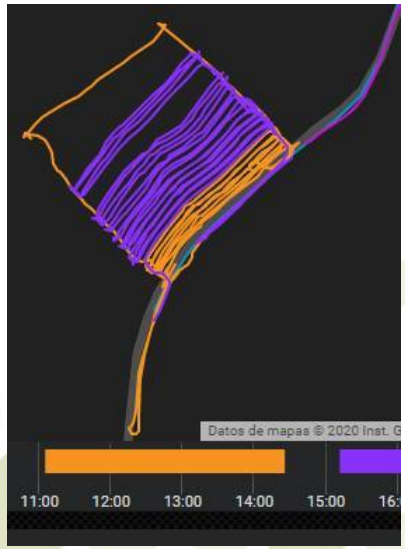
Biobaler trials Surface = 7.15 ha

# Site 1: Two plots with 1.4 vs 2.6 m wide untreated strips



# Site 2: : Other two plots with 1.6 vs 3.2 m wide untreated strips



# Tasks (October-November 2020)

- Sampling (frequency) time study

- Bundles geolocation and numbering / moisture content samples

- Post-treatment inventory along the strip roads:
  - Weigth of downed woody material / moisture content samples
  - Average height and canopy cover of trees and shrubs
  - Stand/soil damages characterization
  - Stump height

- Scaling extracted biomas / moisture content samples

# Results

Treated area with BioBaler: 7.15 total ha (4.36 ha mulched)

Dry tonnes / bale (ODt): 0.179

Machine speed while brushcutting-bundling (km/h): 2.75

Biobaler stratum characteristics (the different superscript letters indicate statistically significant differences at 95% probability). Acronyms: N, narrow; W, wide; CC, crown cover; h, height.

| Site | Stratum (% of Systematically Cleared Surface) | Pine Biovolume (CC,%·h,m) | Shrubs Biovolume (CC,%·h,m) | Total Biovolume (Pine + Shrubs) | Stumps Average Diameter, cm |
|---|---|---|---|---|---|
| 1 | N (59%) | 20.7 [a] | 49..4 [a] | 70.1 [a] | 1.0 [a] |
| | W (50%) | 91.9 [b] | 6.2 [b] | 98.1 [b] | 3.2 [b] |
| 2 | N (62%) | 10.7 [a] | 54.5 [a] | 65.2 [a.b] | 1.6 [c] |
| | W (46%) | 30.9 [a] | 53.9 [a] | 84.8 [a.b] | 1.8 [c] |

# Results

## MAIN FIGURES: COLLECTION EFFICIENCY

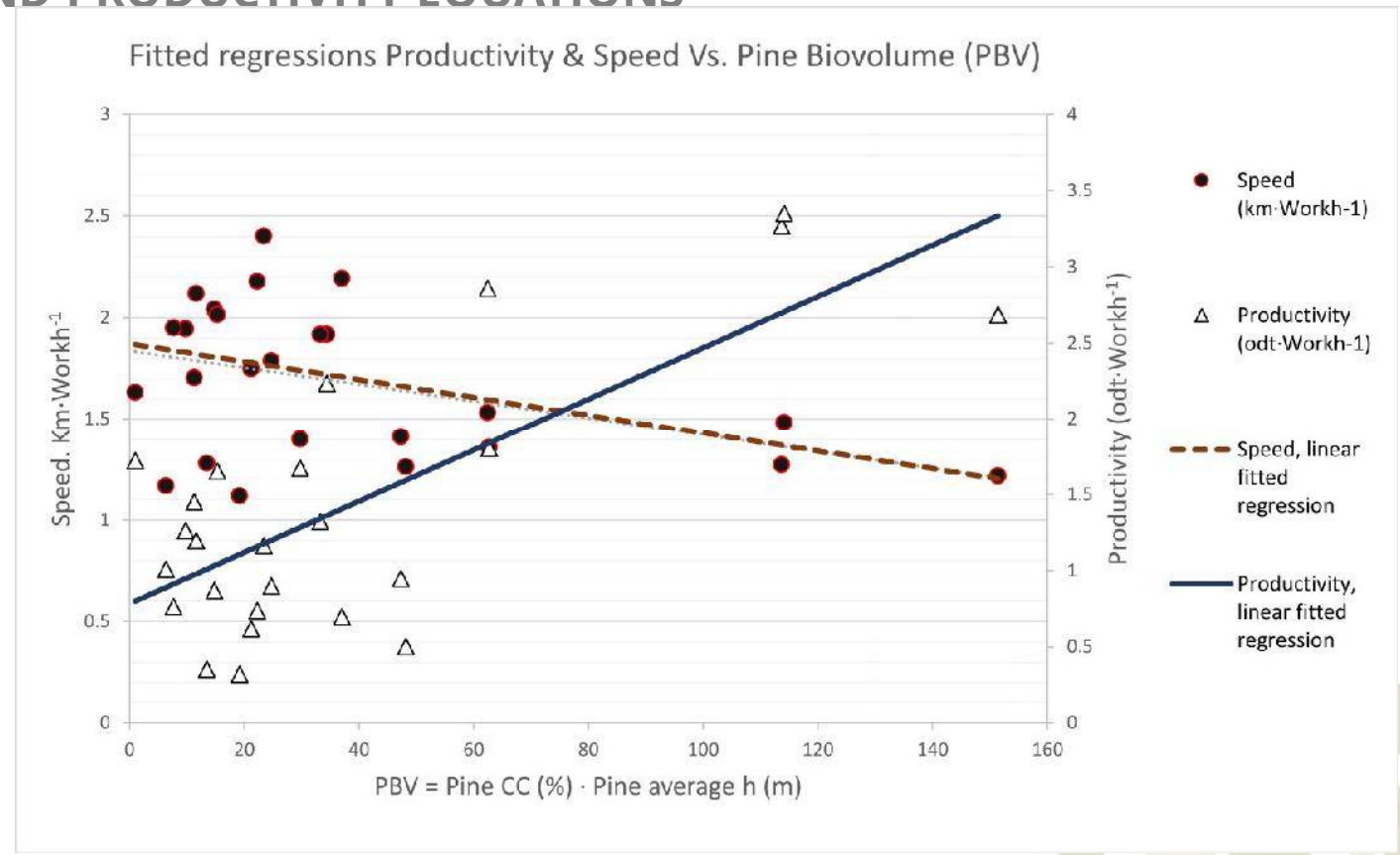
Biobaler collection efficiency (the different superscript letters indicate statistically significant differences at 95% probability). Acronyms: N, narrow; W, wide; odt, oven dry tonne; ha, hectare.

| Site | Stratum (% of SystematiCally Cleared Surface) | Biomass Left on the Ground, odt·ha$^{-1}$ | Collected Biomass Weight, odt·ha$^{-1}$ | Total Biomass Weight, odt·ha$^{-1}$ | Collection Efficiency, % |
|---|---|---|---|---|---|
| 1 | N (59%) | 3.0 $^{a}$ | 1.35 $^{a}$ | 4.31 $^{a}$ | 29.8 $^{a.b}$ |
| | W (50%) | 4.9 $^{b}$ | 3.41 $^{b}$ | 8.35 $^{b}$ | 41.6 $^{a}$ |
| 2 | N (62%) | 3.5 $^{a.b}$ | 1.44 $^{a}$ | 5.09 $^{a}$ | 33.1 $^{a}$ |
| | W (46%) | 3.7 $^{a.b}$ | 0.88 $^{a}$ | 4.63 $^{a}$ | 20.4 $^{b}$ |

The average weight and surface productivity was 1.41 odt·Workh$^{-1}$ and 0.75 ha·Workh$^{-1}$ (0.45 cleared ha·Workh$^{-1}$)

# Results

## SPEED AND PRODUCTIVITY EQUATIONS

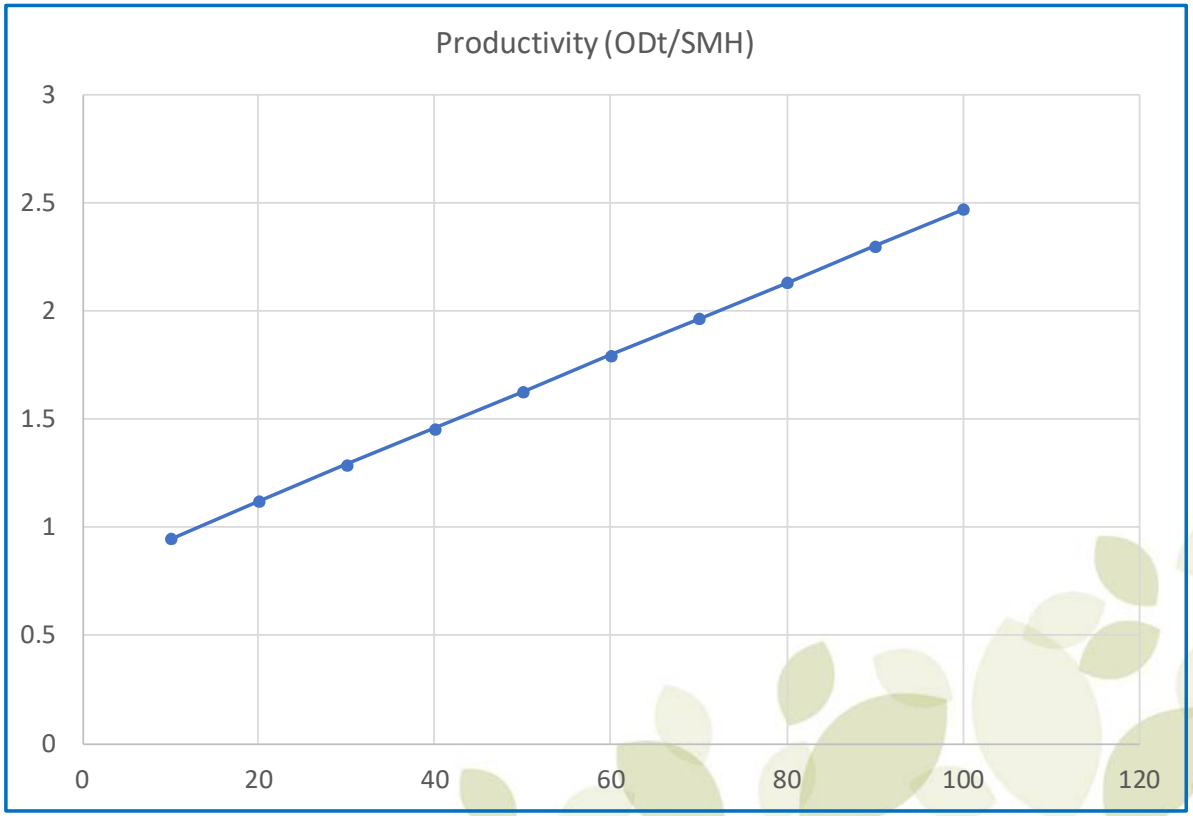


# BIOBALER
## Productivity

**P (OD t / h SMH)= (783,45 + 16,86·PB)·$10^{-3}$**

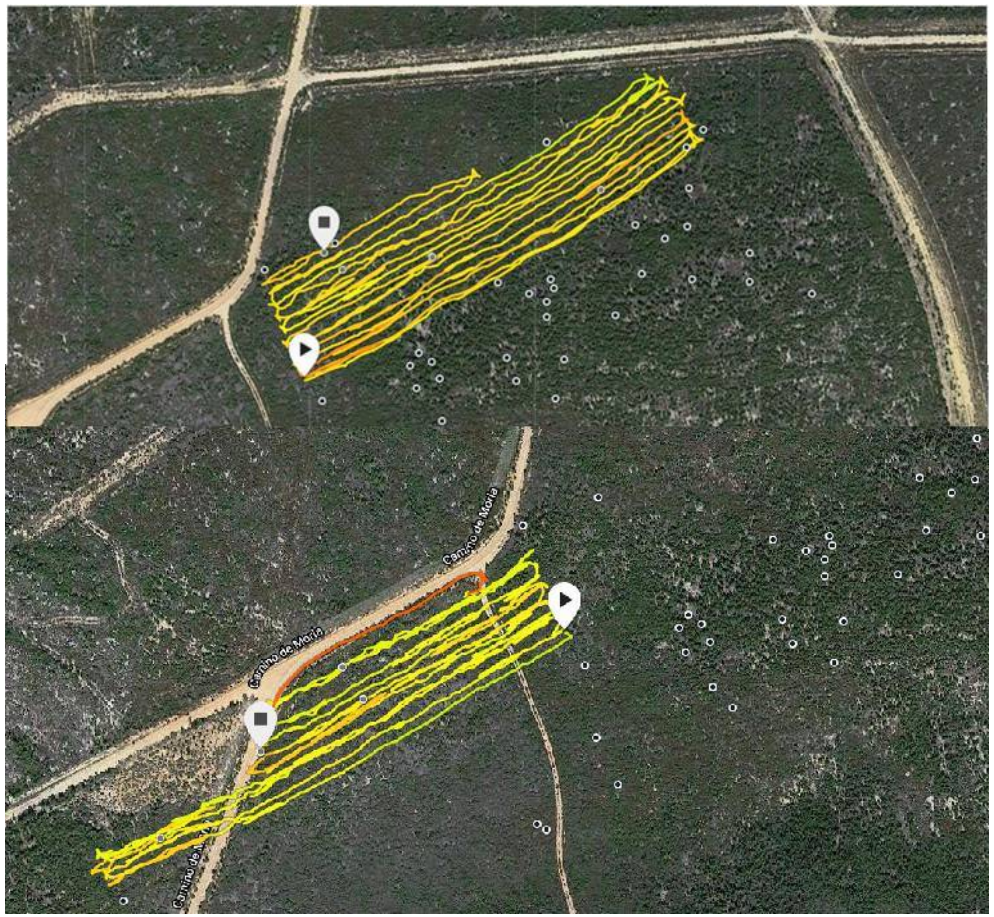
PB= Pine biovolume (canopy cover, % x height, m)

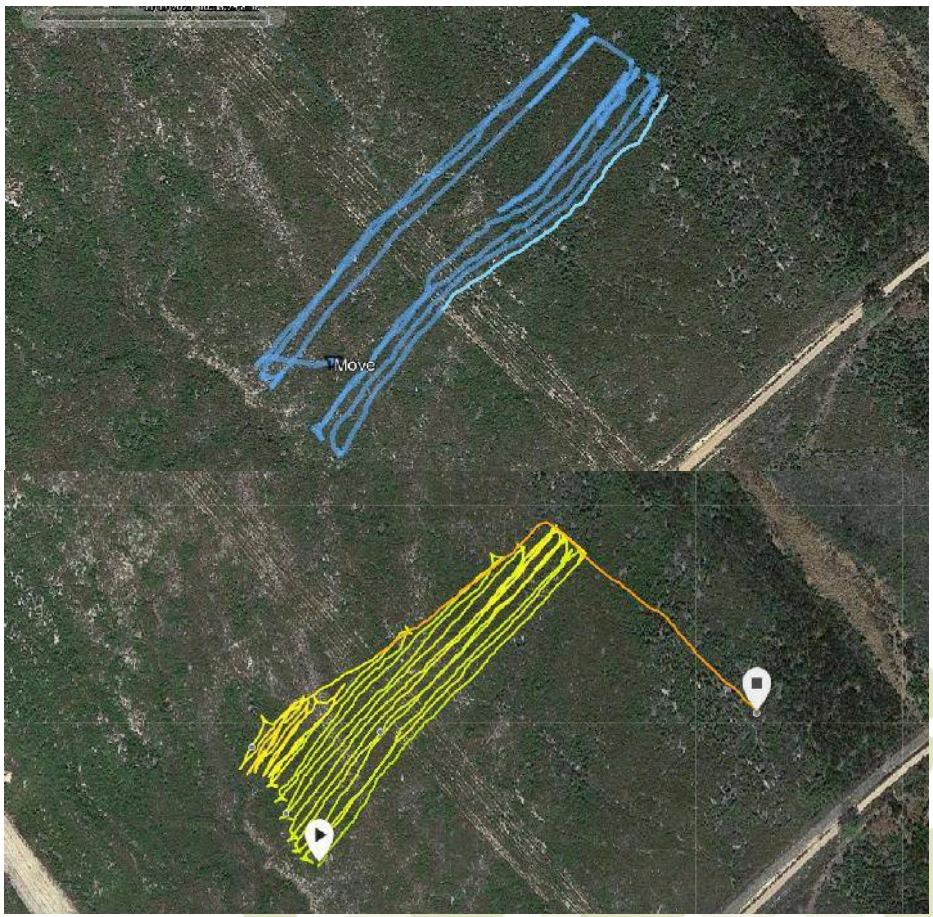
$R^2$= 53,5



# CHAIN MULCHER STUDY PLOTS

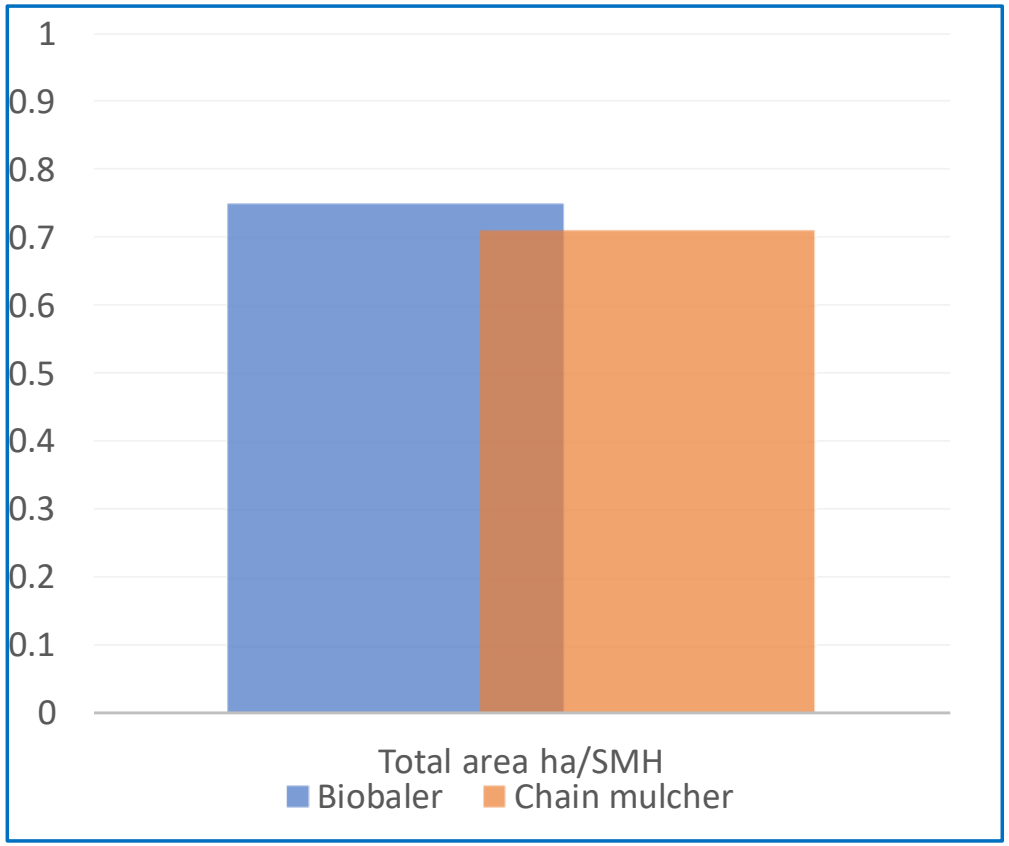
2 Sites, 2 Wide and narrow strips strata per site (surface mulched: 2.32 out of 4.70 total ha)



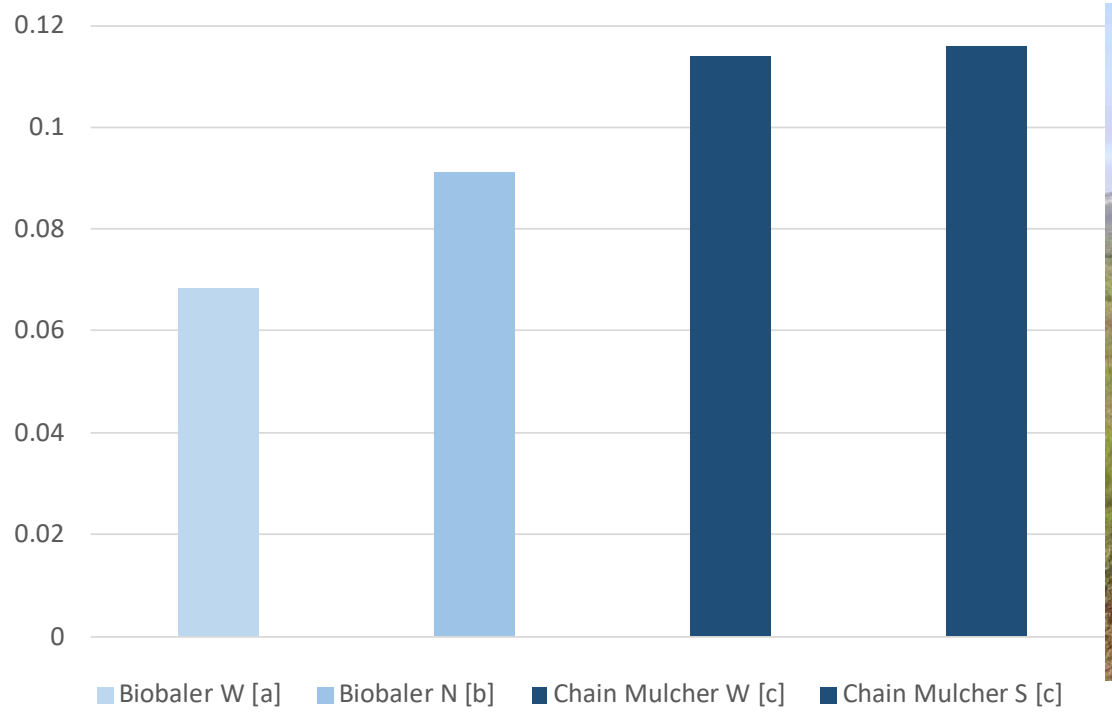
# BIOBALER VS CHAIN MULCHER PRODUCTIVITY

Surface per SMH



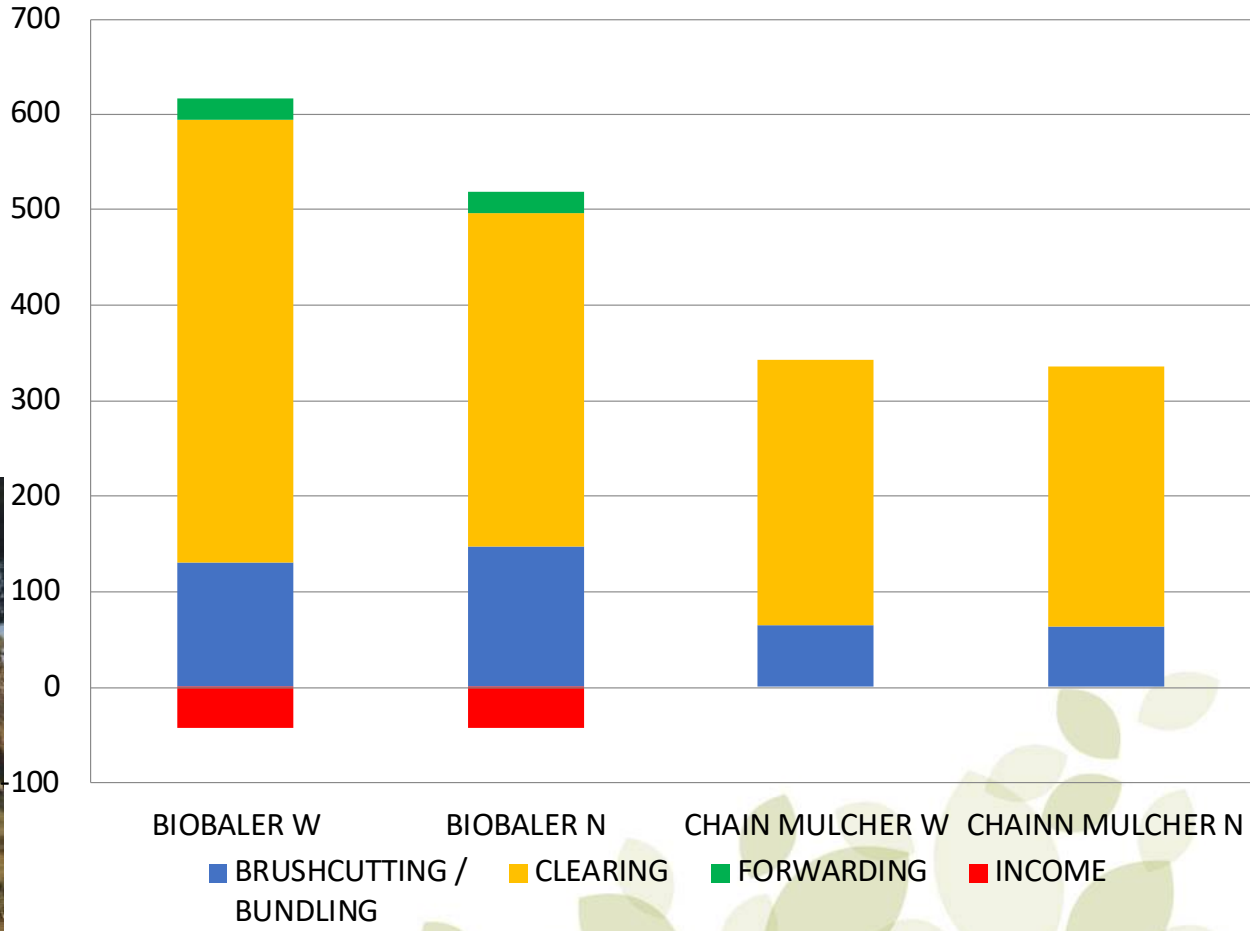
# Statistical analisys motormanual clearing

**Productivity: Total Surface (ha)  per WH and worker (team of 4 workers equiped with clearing saws)**



# COST

€·ha$^{-1}$ for the 4 tried alternatives



# CONCLUSSIONS

✓ **RETRABIO** PERMITS THE TREATMENT OF **VERY DENSE SALIX COPPICES** AT A COST OF SLIGHTLY MORE THAN 200 €·HA$^{-1}$. THE **PRODUCTIVITY DEPENDS NEGATIVELY OF DENSITY, TREE SIZE AND SHRUB BIOVOLUME** (COVERAGE% *SHRUB HEIGTH).

✓ **RETRABIO** TECHNOLOGY DOES NOT PERMMIT SELF-FINANCING **WILDFIRE PREVENTIVE TREATMENTS ON POST-FIRE REGENERATED VERY YOUNG PINE STANDS**, BUT, IN THE STUDIED CONDITIONS, **ALLOWS SAVING 49% IF COMPARED WITH THE MOST COMMON ALTERNATIVE TREATMENT** (HAMMER MULCHER), BESIDES COLLECTING BIOMASS. THE **PRODUCTIVITY DEPENDS POSITIVELY OF BASAL AREA**.

✓ UNDER THE STUDIED CONDITIONS, **BIOBALER IS NOT COST-COMPETITIVE WITH THE ALTERNATIVE TECHNOLOGY FOR SYSTEMATIC-SELECTIVE CLEARINGS OF POST-FIRE REGENERATED VERY YOUNG PINE STANDS**, BECAUSE ITS **LOW COLLECTION EFFICIENCY** AND BECAUSE THE STUMPS LEFT ON THE MULCHED SURFACE **DIFFICULTS THE SELECTIVE TREATMENT WITH PORTABLE CLEARING SAWS**.