7° CONGRESO **FORESTAL** ESPAÑOL

**Gestión del monte: servicios ambientales y bioeconomía**

26 - 30 junio 2017 | **Plasencia**
Cáceres, Extremadura

# MEDICIONES DENDROMETRICAS CON ESCANER LASER TERRESTRE (TLS) EN BOSQUES MIXTOS

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27/06/2017 Plasencia - Cáceres

Sociedad Española de Ciencias Forestales
SECF

# INDICE

FARO
FOCUS3D
LLS061101261
IP address:
172.17.15.119
Subnet mask
255.255.254.0

- 1. Introducción
- 2. Objetivo
- 3. Material y Métodos
- 4. Resultados
- 5. Discusión y Conclusión

# 1. INTRODUCCIÓN

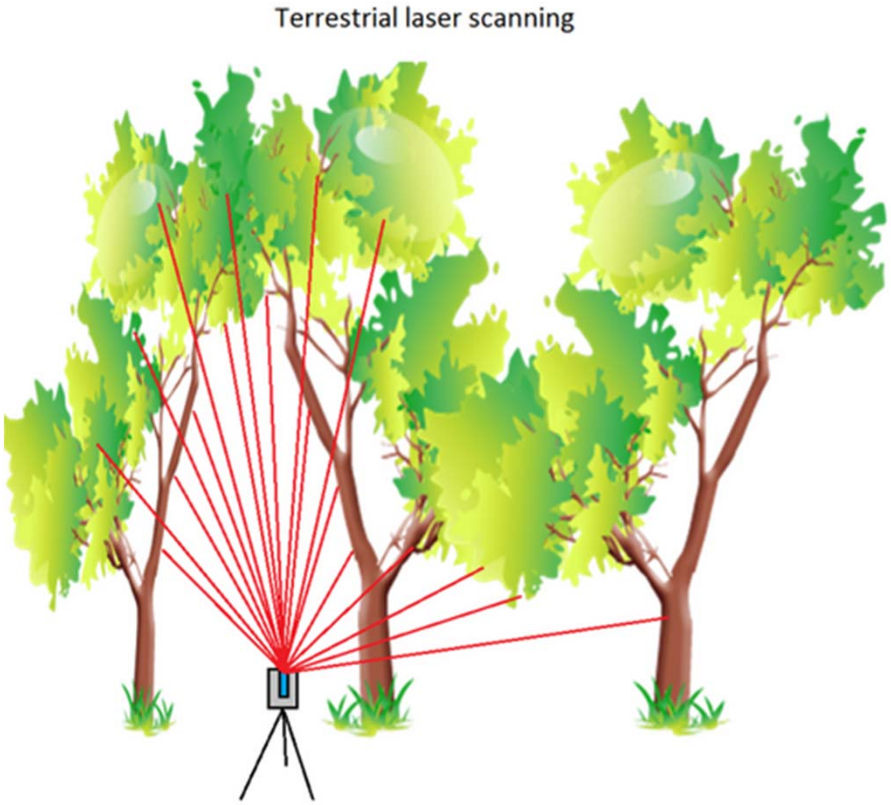
# 1. INTRODUCIÓN

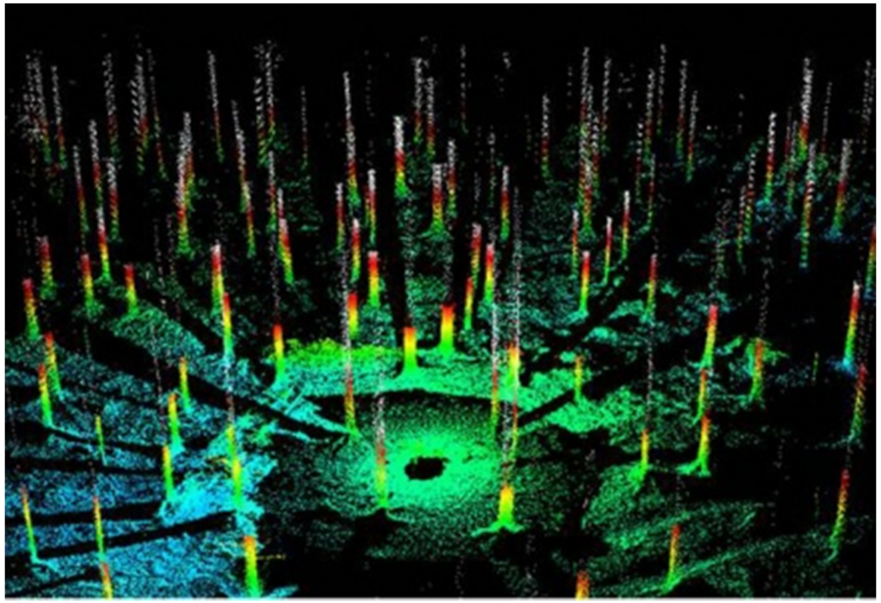
- Cuantificación de la estructura
  - – Entendimiento
  - – Predicción
  - – Mantenimiento
  - – Manejo

Dinámica masa forestal

- Carencia de conocimiento en masas mixtas
- Aprovechar la tecnología

- LiDAR: tecnología que determina distancias desde un emisor laser a un objeto
  - Aerial Laser Scanning (ALS)
  - Terrestrial Laser Scanning (TLS)


Terrestrial laser scanning



# 2. OBJETIVO

# 2. OBJETIVO

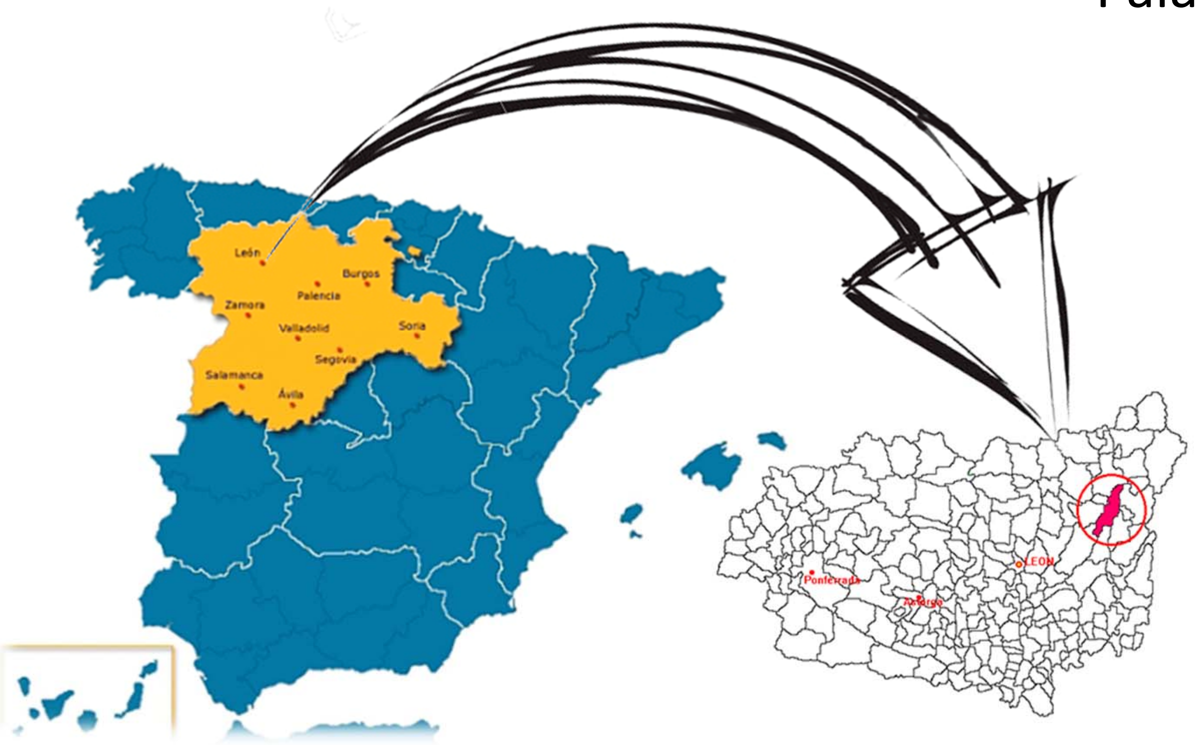
- Validación de una metodología utilizando TLS en una masa mixta
  - Selección de 30 árboles: 15 pinos y 15 robles
    - Dn, Ht, HBC, HMAC, Vol árbol.
  - Ajuste de relaciones dendrométricas
  - Efecto de la mezcla considerando las relaciones dendrométricas

# 3. MATERIAL Y MÉTODOS

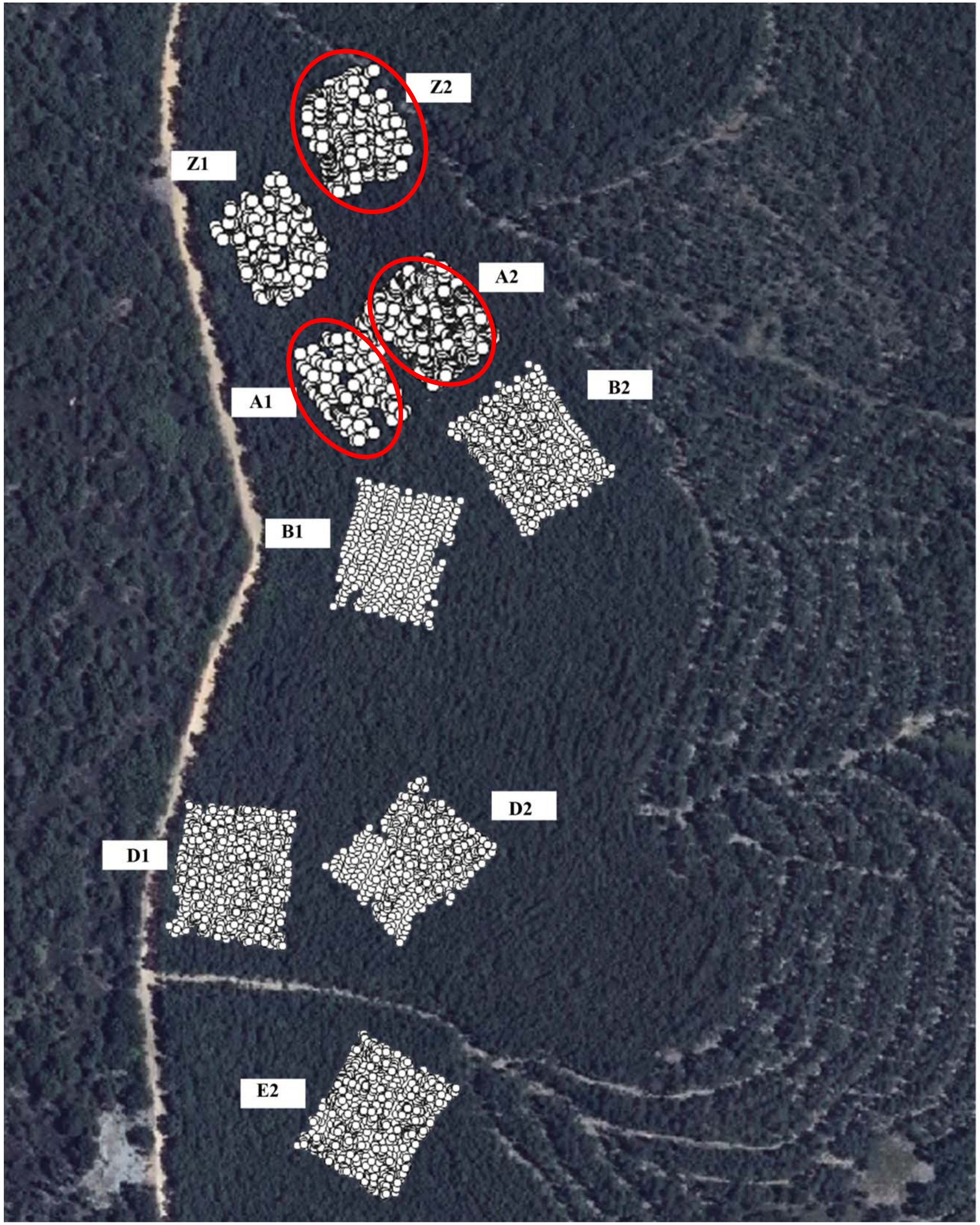
# 3. MATERIAL Y METODOS

- AREA DE ESTUDIO

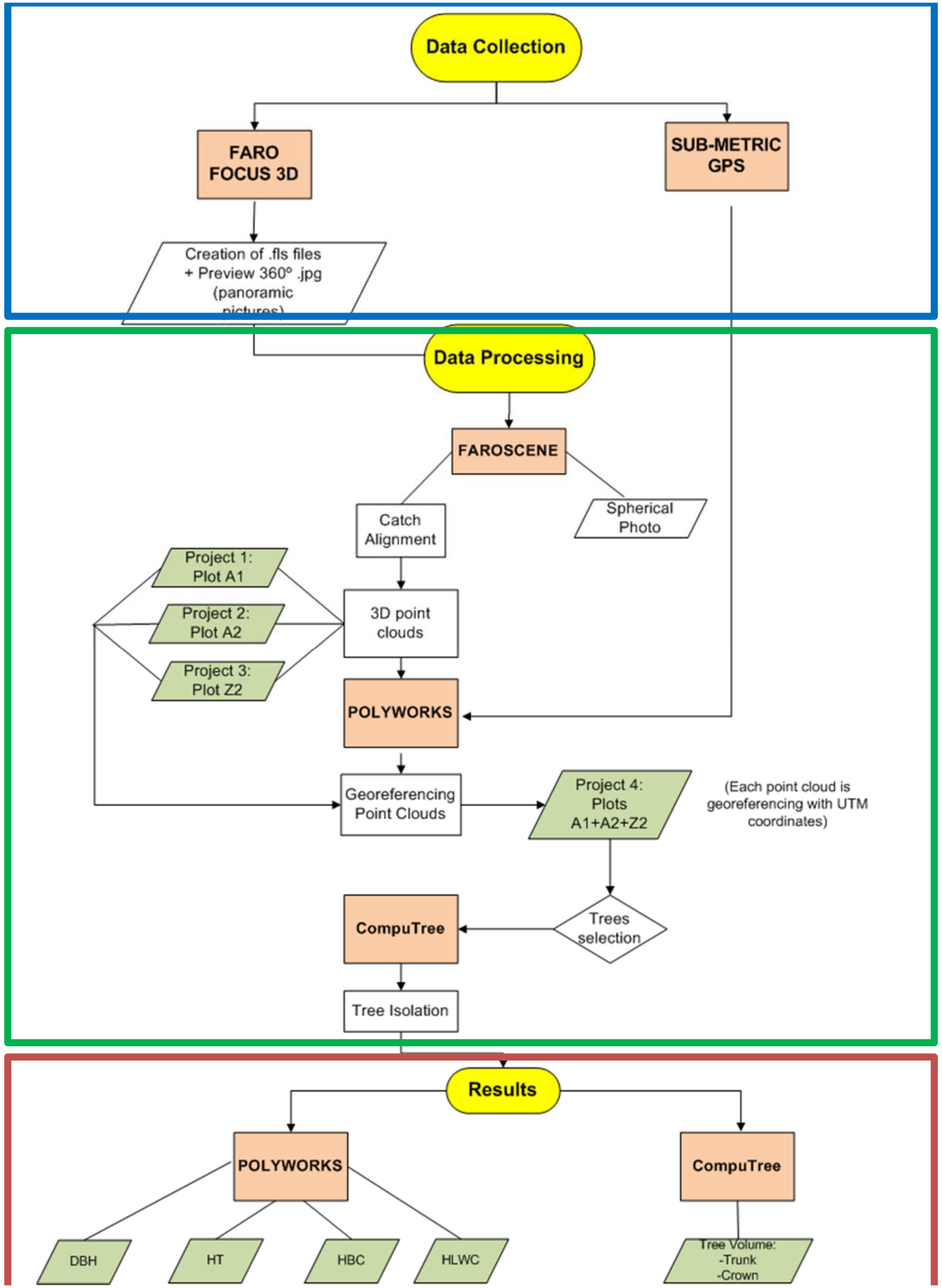
Palacio de Valdellorma (León)


León
Burgos
Palencia
Zamora
Valladolid
Soria
Segovia
Salamanca
Ávila
Ponferrada
Astorga
LEÓN

-Parcelas 40x50m
-Claras 0, 25 y 50%


Z2
Z1
A2
A1
B2
B1
D2
D1
E2

- Zona de Estudio
- Parcelas 40 x 50 m
  - A1 = 50%
  - A2 = Control
  - Z2 = 25%

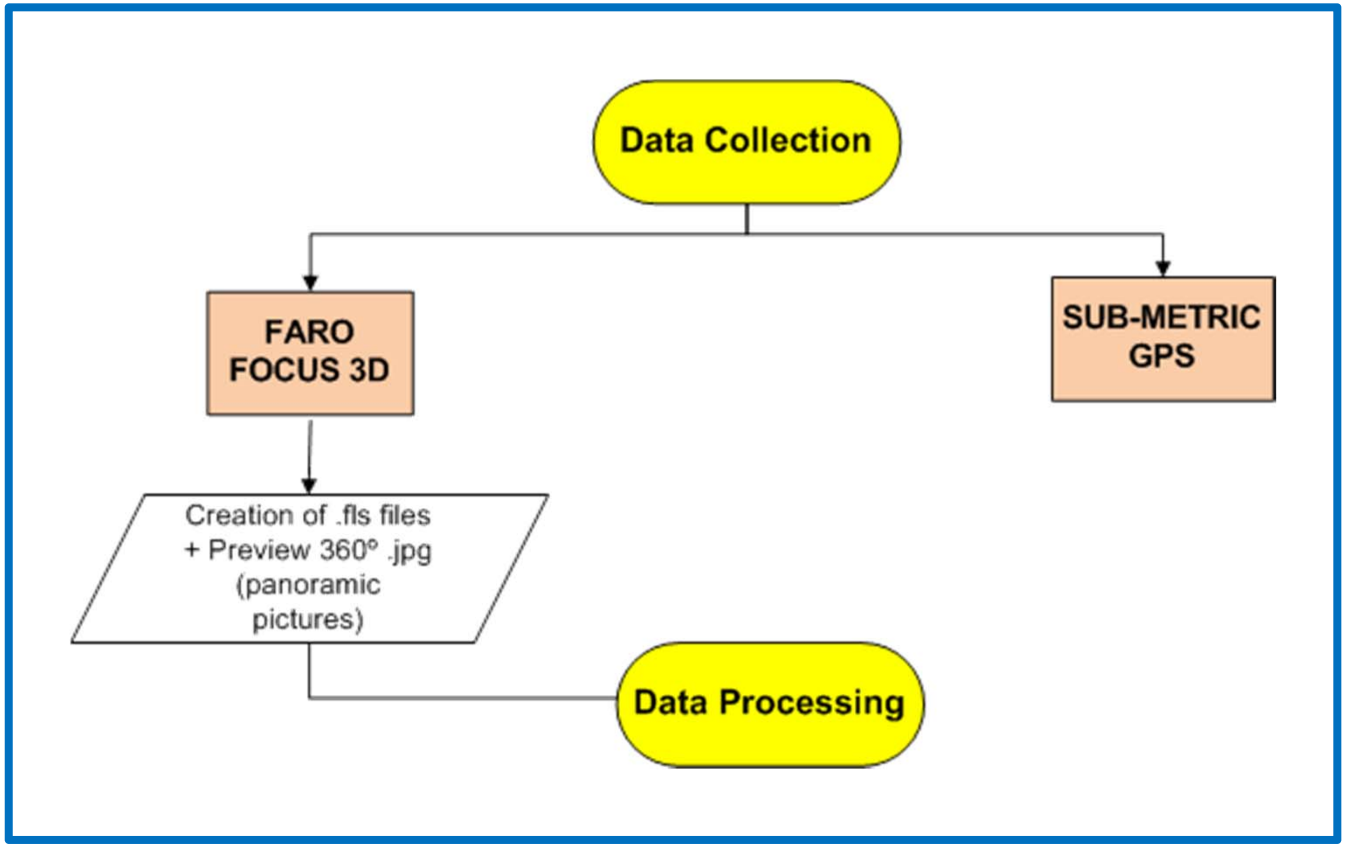

Data Collection
FARO FOCUS 3D
SUB-METRIC GPS
Creation of .fls files + Preview 360° .jpg (panoramic pictures)
Data Processing
FAROSCENE
Catch Alignment
Spherical Photo
Project 1: Plot A1
Project 2: Plot A2
Project 3: Plot Z2
3D point clouds
POLYWORKS
Georeferencing Point Clouds
Project 4: Plots A1+A2+Z2
(Each point cloud is georeferencing with UTM coordinates)
Trees selection
CompuTree
Tree Isolation
Results
POLYWORKS
CompuTree
DBH
HT
HBC
HLWC
Tree Volume: -Trunk -Crown

1.

2.

3.

# 1.



Data Collection

FARO FOCUS 3D

SUB-METRIC GPS

Creation of .fls files + Preview 360° .jpg (panoramic pictures)

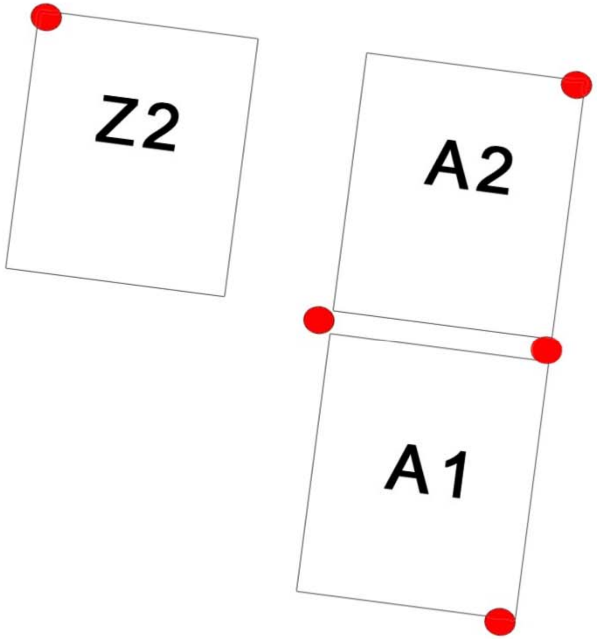
Data Processing

- # Georreferenciación

**30’ en cada punto**

-GPS submétrico Leica SR20
-Antena externa de recepción AT501

-Obtención de datos= Fichero .txt

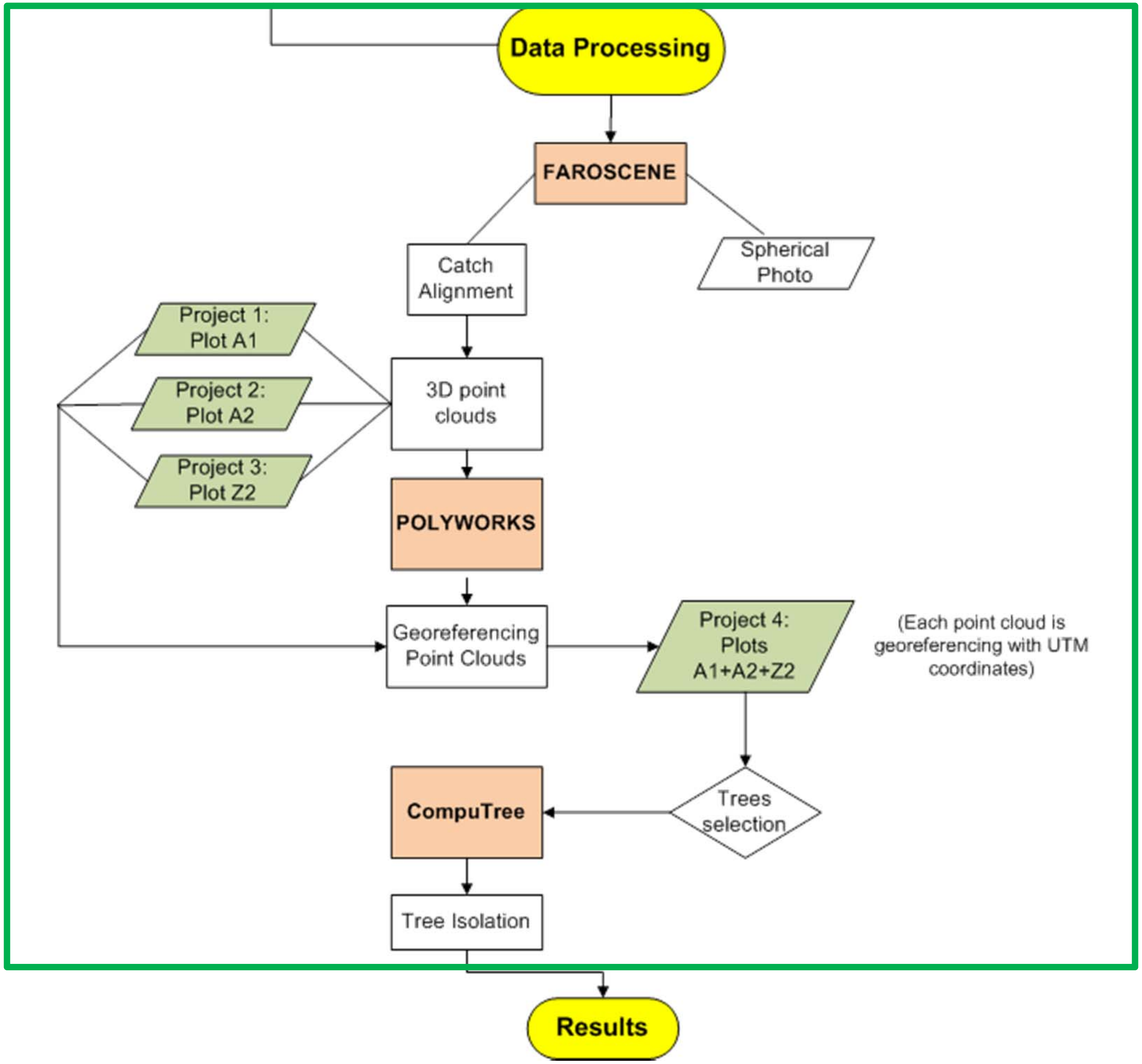


- # Proceso de Escaneo

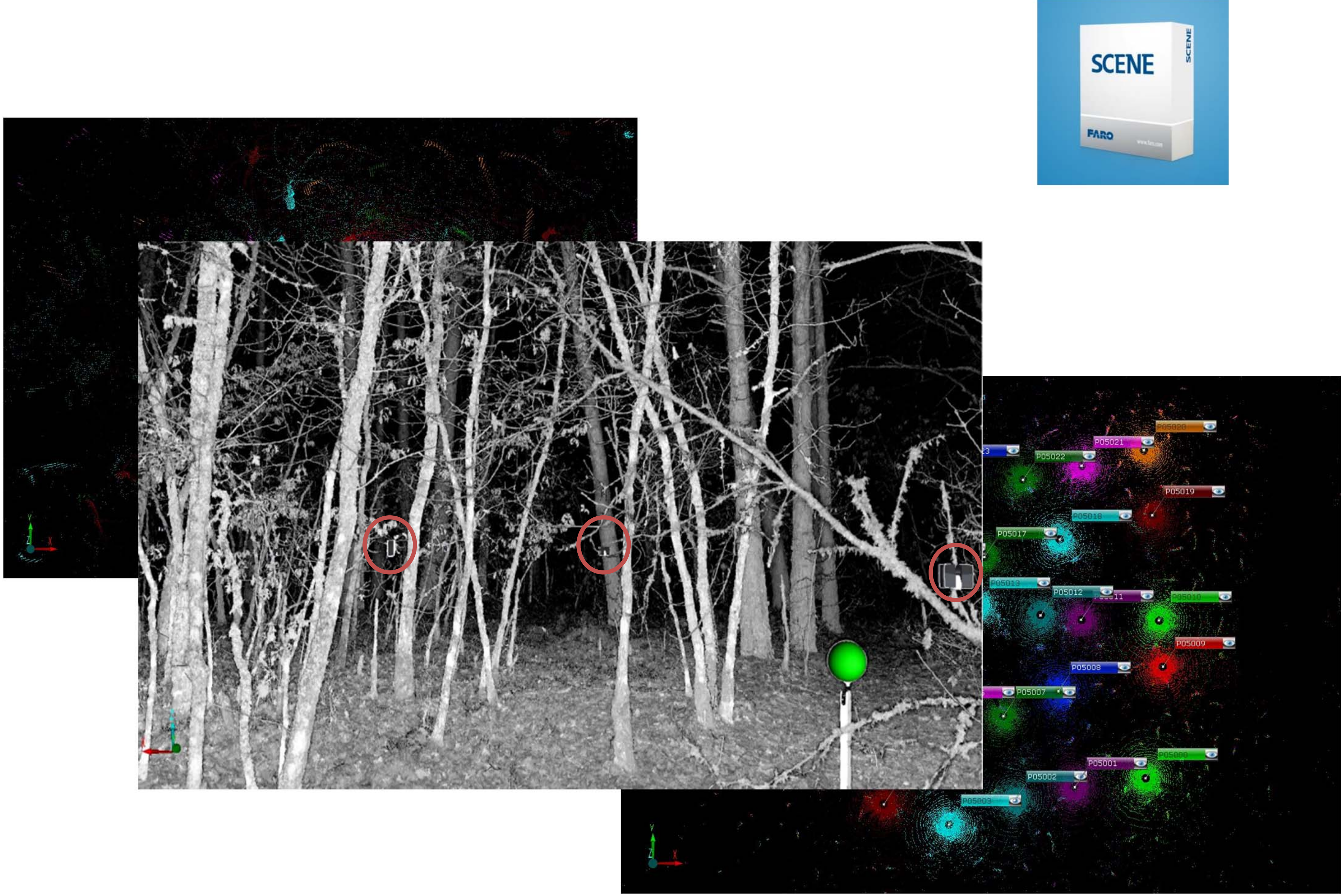
-Faro Focus 3D

  -1,3’ por escaneo
  -Según densidad = 48-24 escaneos/parcela
  -Total = 3 días

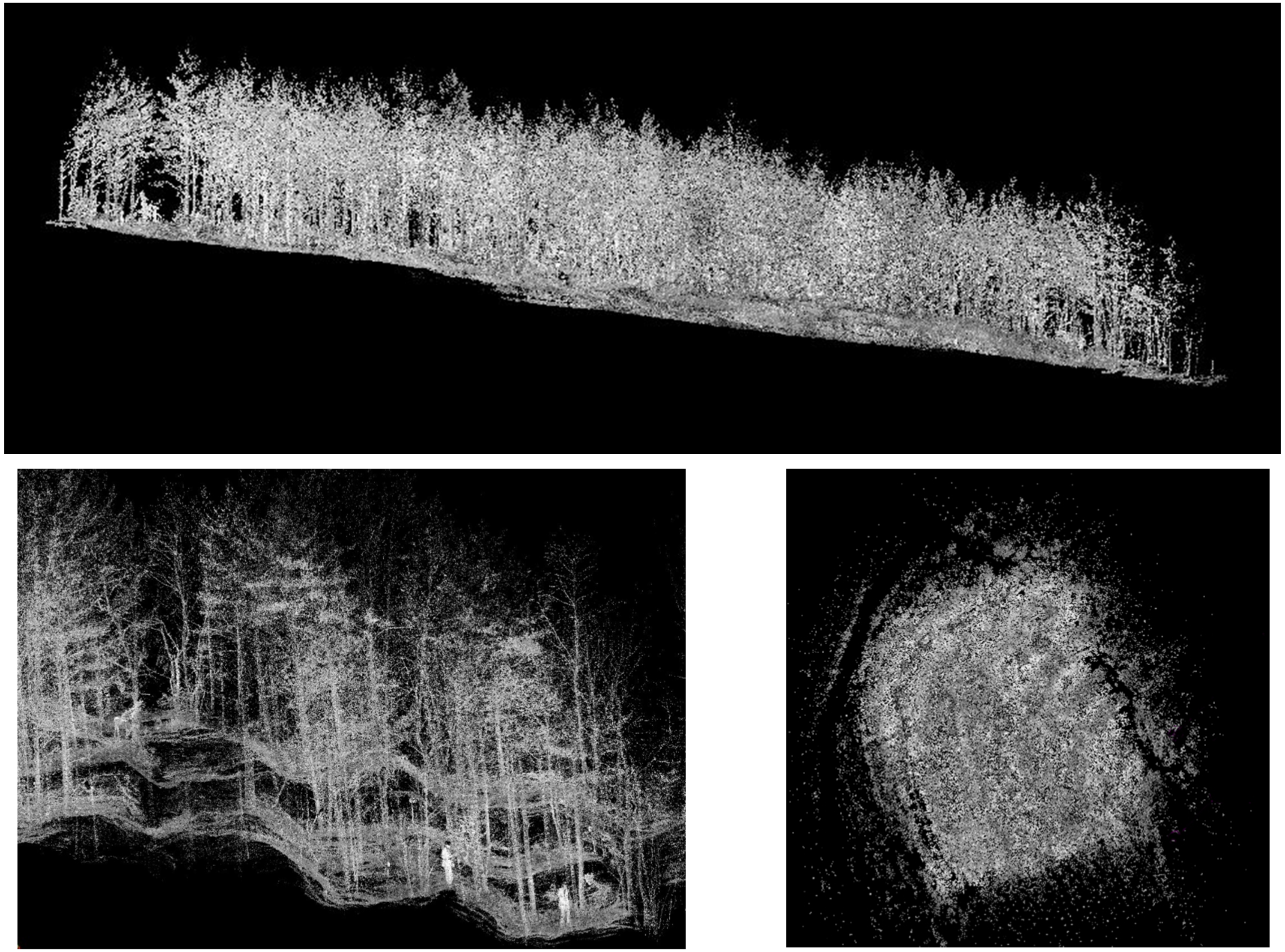
2.


Data Processing
FAROSCENE
Catch Alignment
Spherical Photo
Project 1: Plot A1
Project 2: Plot A2
Project 3: Plot Z2
3D point clouds
POLYWORKS
Georeferencing Point Clouds
Project 4: Plots A1+A2+Z2
(Each point cloud is georeferencing with UTM coordinates)
Trees selection
CompuTree
Tree Isolation
Results

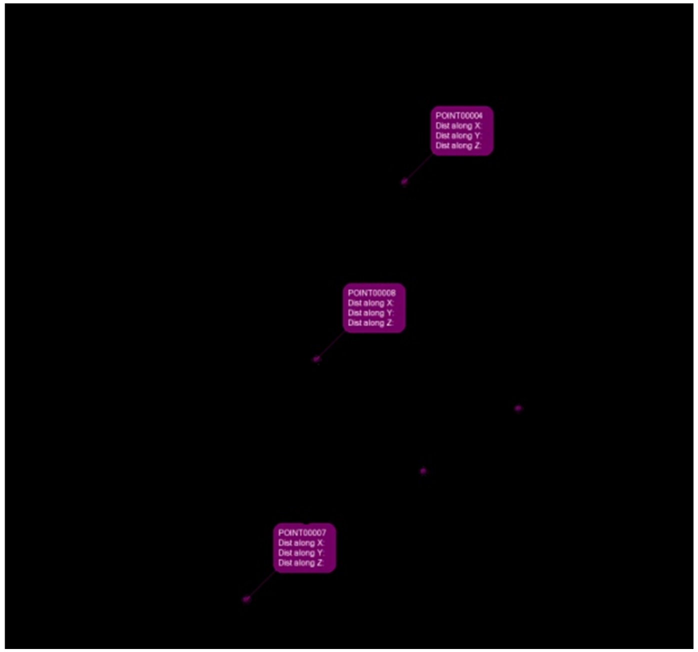
- 1. Alineación de escaneos

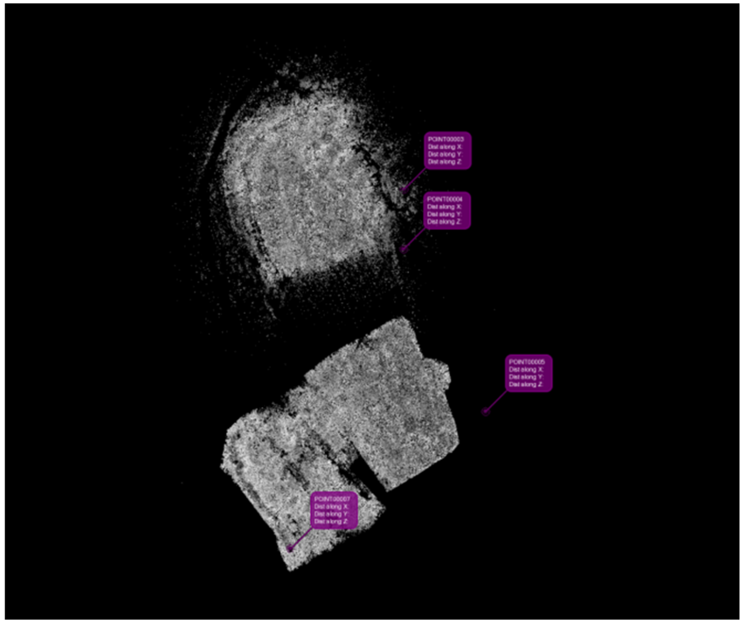

SCENE
FARO
P05020
P05021
P05022
P05019
P05018
P05017
P05013
P05012
P05010
P05009
P05008
P05007
P05001
P05000
P05002
P05003
Y
X
Z

# 2. Importación nube de puntos



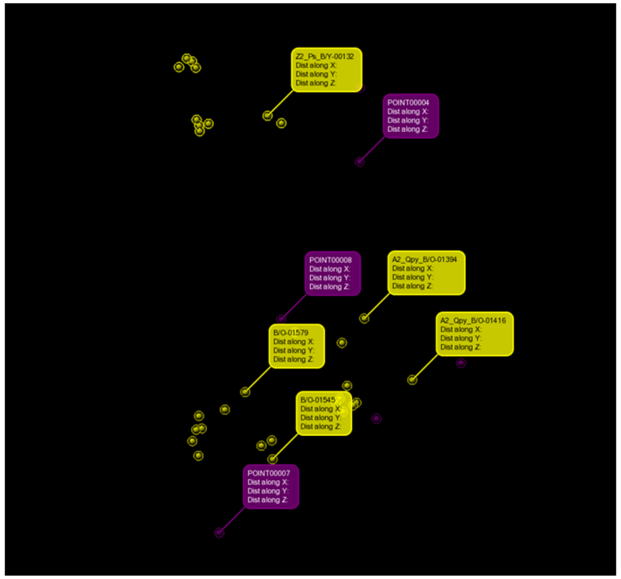
# 2. Importación puntos georreferenciados


POINT00004
Dist along X:
Dist along Y:
Dist along Z:
POINT00008
Dist along X:
Dist along Y:
Dist along Z:
POINT00007
Dist along X:
Dist along Y:
Dist along Z:

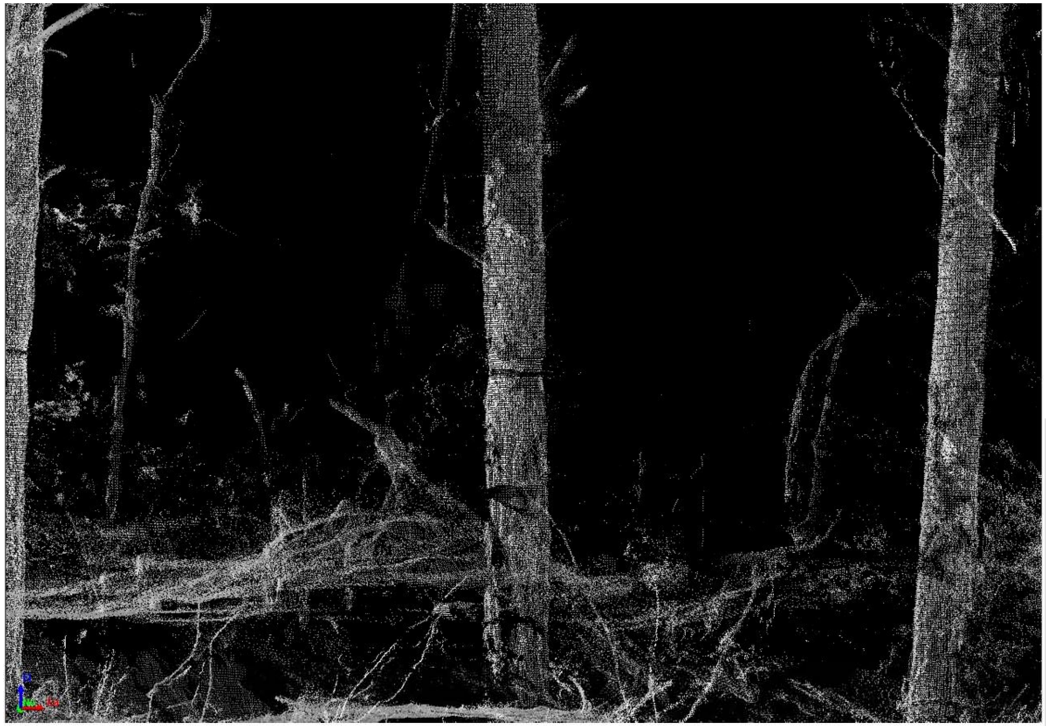

POINT00003
Dist along X:
Dist along Y:
Dist along Z:
POINT00004
Dist along X:
Dist along Y:
Dist along Z:
POINT00005
Dist along X:
Dist along Y:
Dist along Z:
POINT00007
Dist along X:
Dist along Y:
Dist along Z:

POINT00007
Dist along X:
Dist along Y:
Dist along Z:

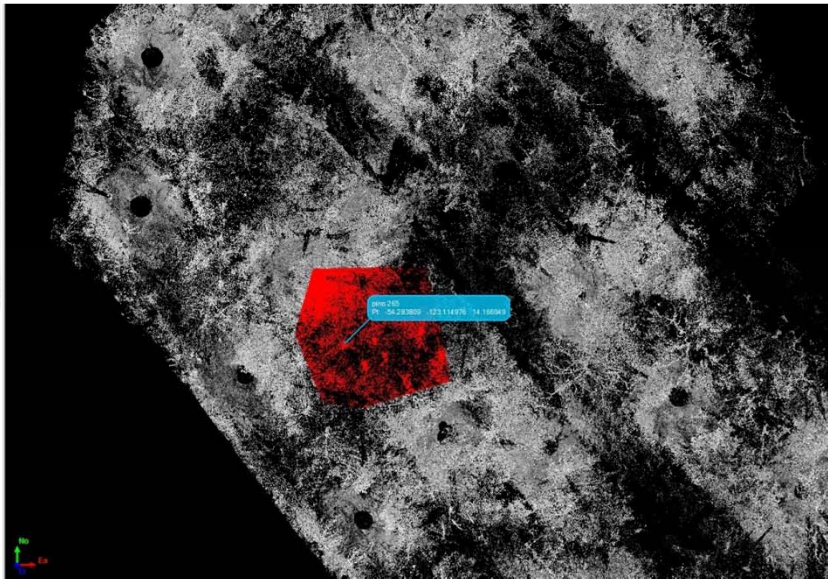
# 2.1. Identificación de árboles


Z2_Ps_B/Y-00132
Dist along X:
Dist along Y:
Dist along Z:
POINT00004
Dist along X:
Dist along Y:
Dist along Z:
POINT00008
Dist along X:
Dist along Y:
Dist along Z:
A2_Qpy_B/O-01394
Dist along X:
Dist along Y:
Dist along Z:
A2_Qpy_B/O-01416
Dist along X:
Dist along Y:
Dist along Z:
B/O-01579
Dist along X:
Dist along Y:
Dist along Z:
B/O-01545
Dist along X:
Dist along Y:
Dist along Z:
POINT00007
Dist along X:
Dist along Y:
Dist along Z:

## 1.Localización de los árboles

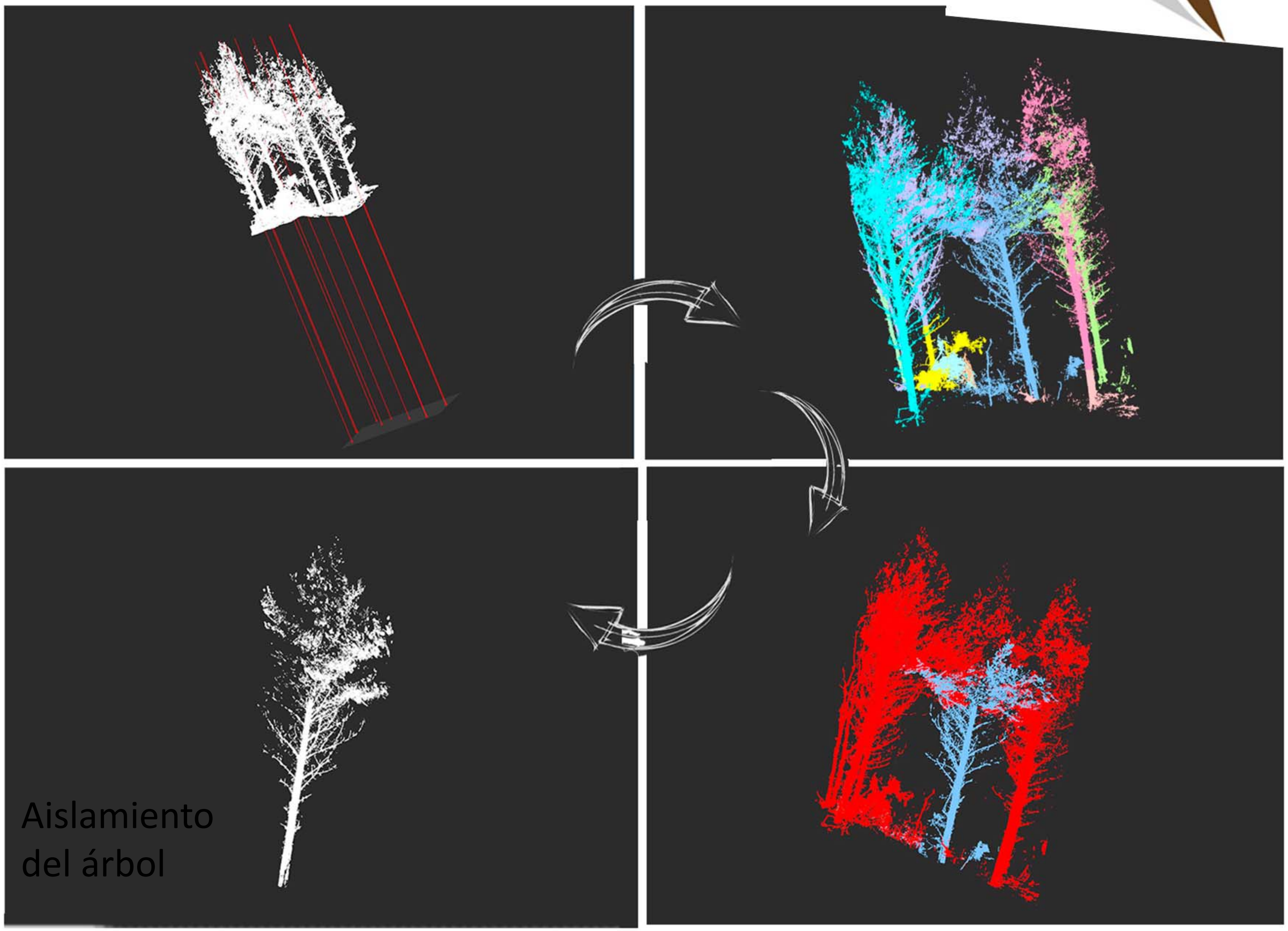


## 2.Exportación nube de puntos

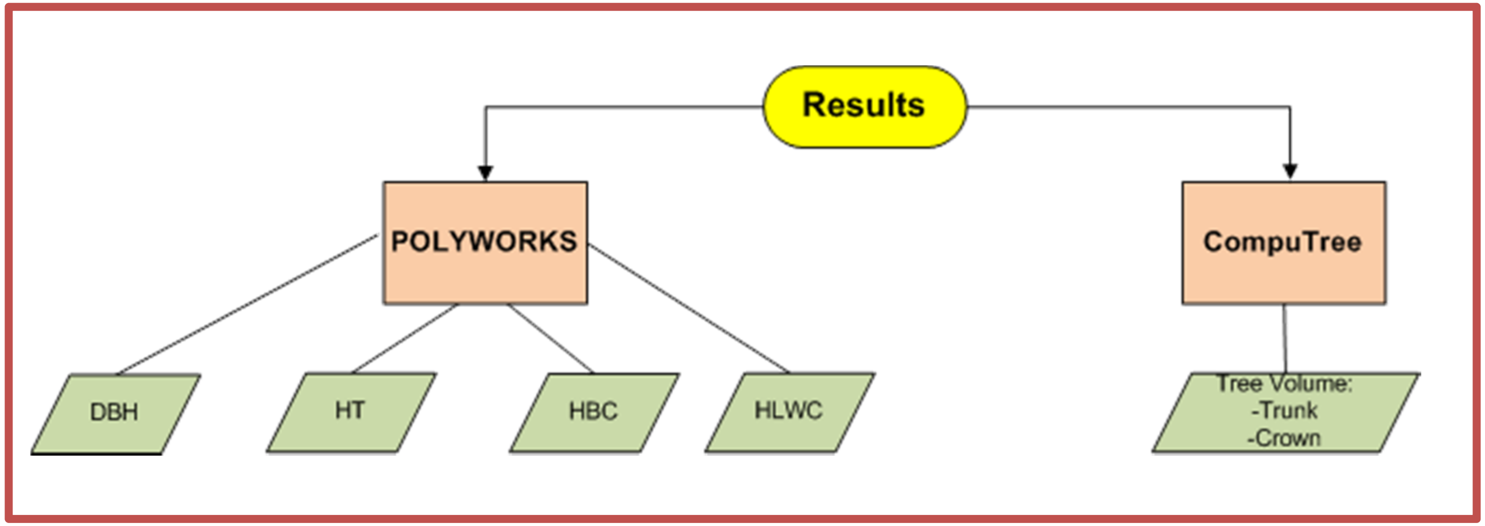

pino 265
Pt -54.283809 -123.114976 14.186949

- 3. Importación nube de puntos como archivos *.txt*

Proceso semi-automático


Aislamiento del árbol

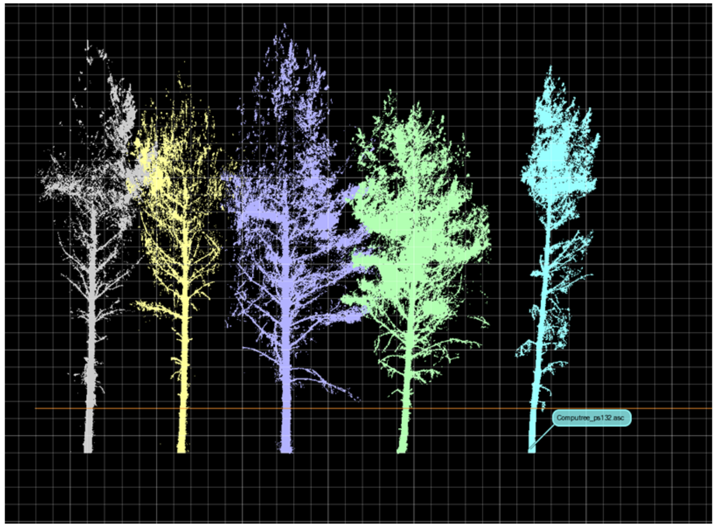
# 3.

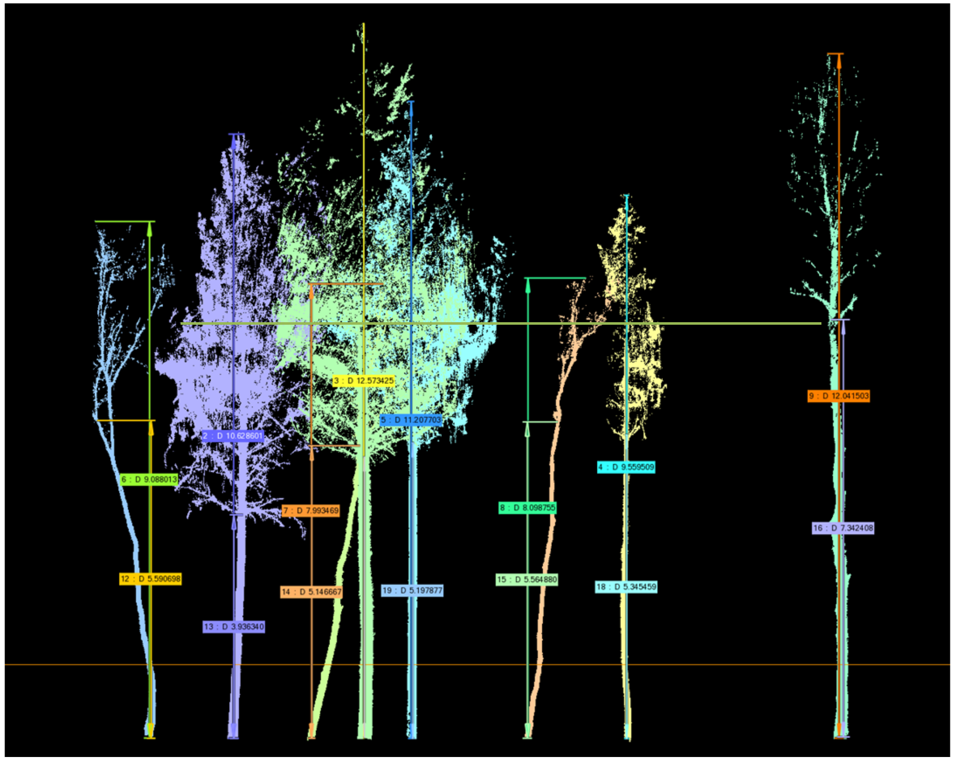

Results
POLYWORKS
CompuTree
DBH
HT
HBC
HLWC
Tree Volume:
-Trunk
-Crown

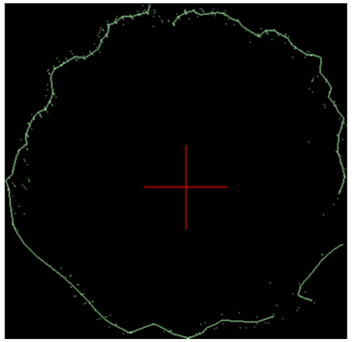
# 4. Importación arboles aislados

**Medida de Alturas**

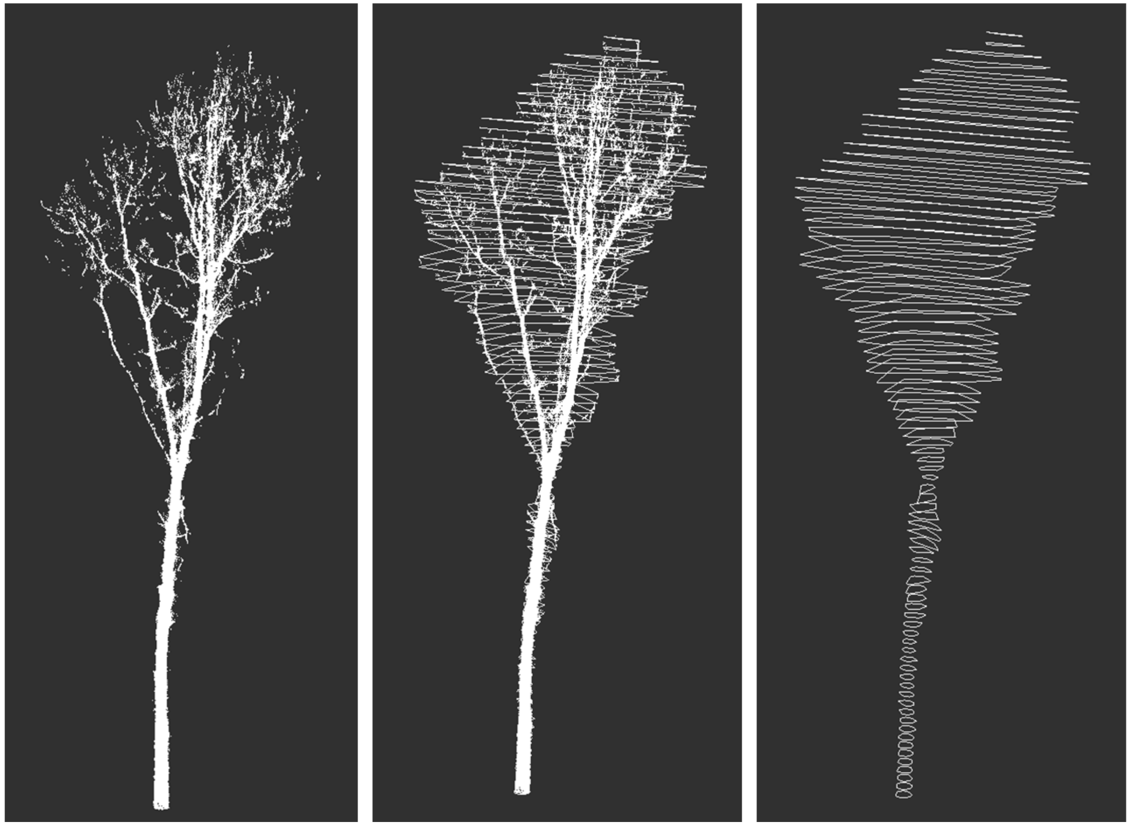
Proceso manual


Computree_ps132.asc


3 : D 12.573425
9 : D 12.041503
5 : D 11.207703
2 : D 10.628601
4 : D 9.559509
6 : D 9.088013
8 : D 8.098755
7 : D 7.993469
16 : D 7.342408
12 : D 5.590698
15 : D 5.564880
18 : D 5.345459
19 : D 5.197877
14 : D 5.146667
13 : D 3.936340



# Creación de envolventes para determinar volumen árbol

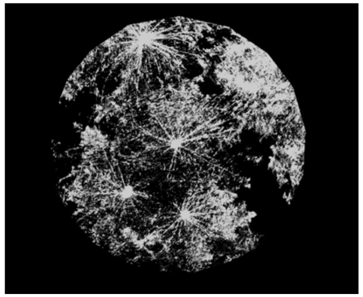


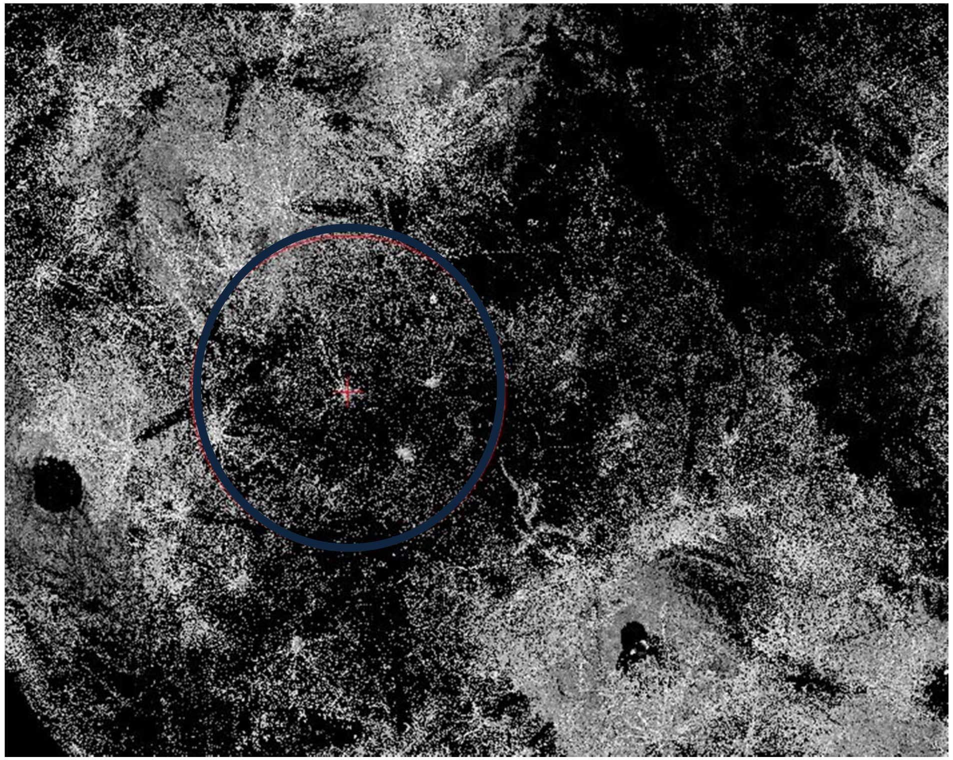
Datos exportados a una hoja de cálculo

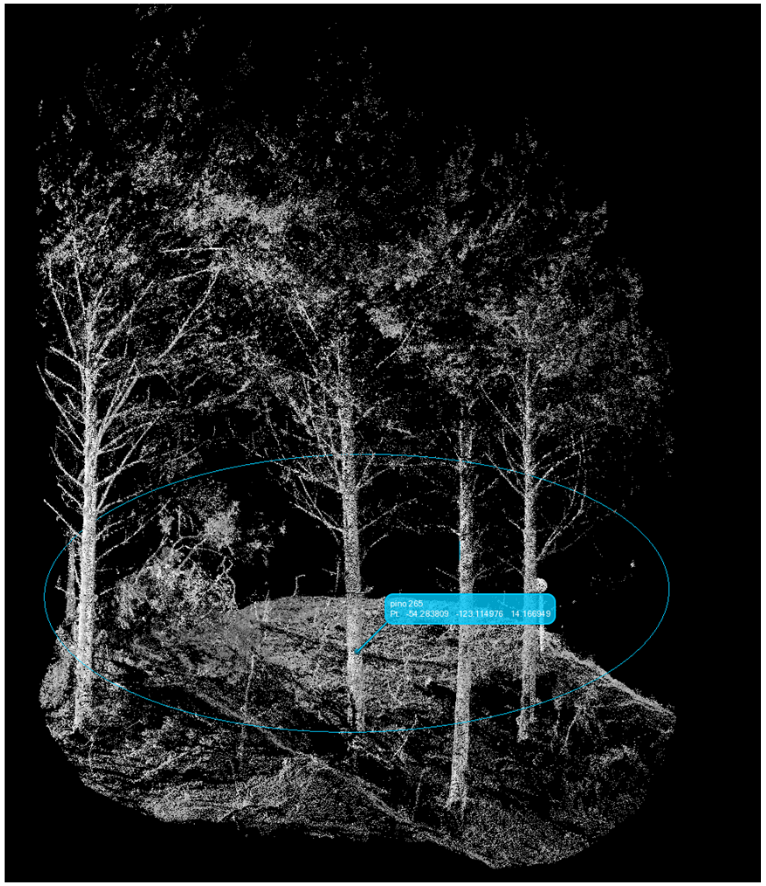
# Cálculo del área basimétrica

PolyWorks®
By InnovMetric Software Inc.

- Subparcelas 5m radio alrededor del árbol objetivo



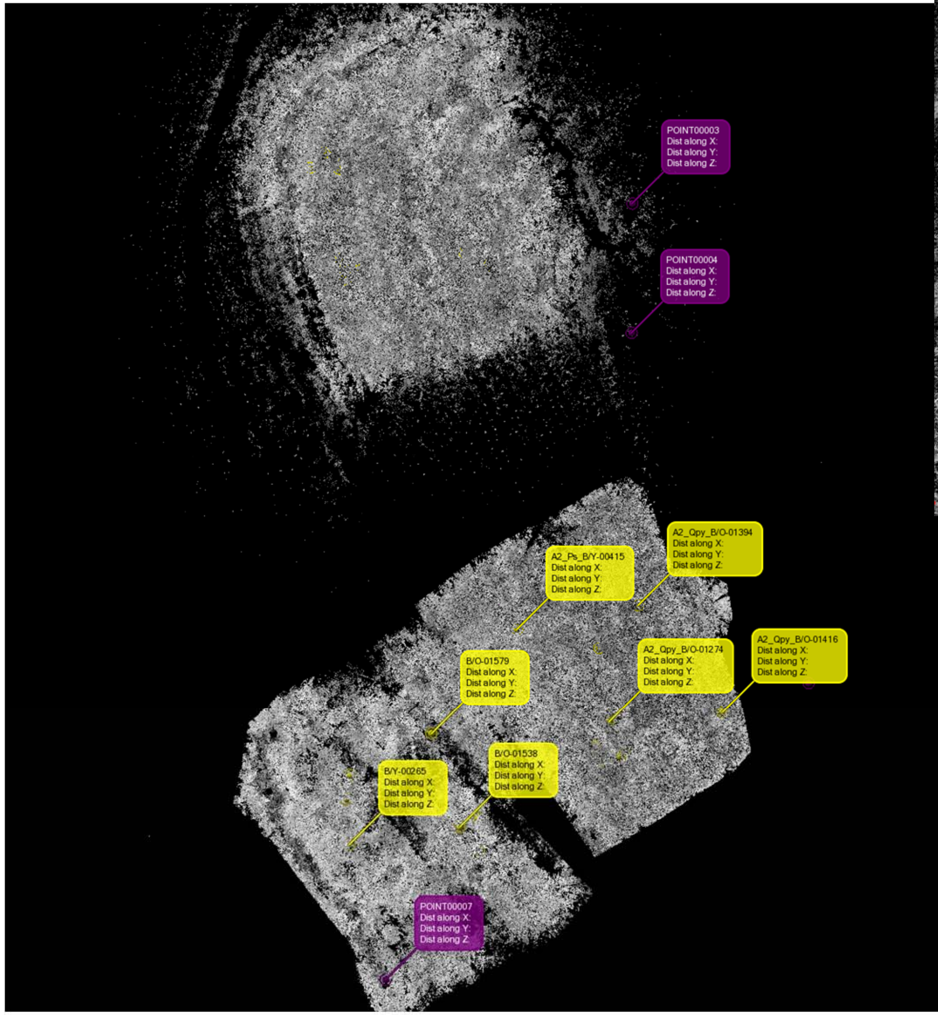


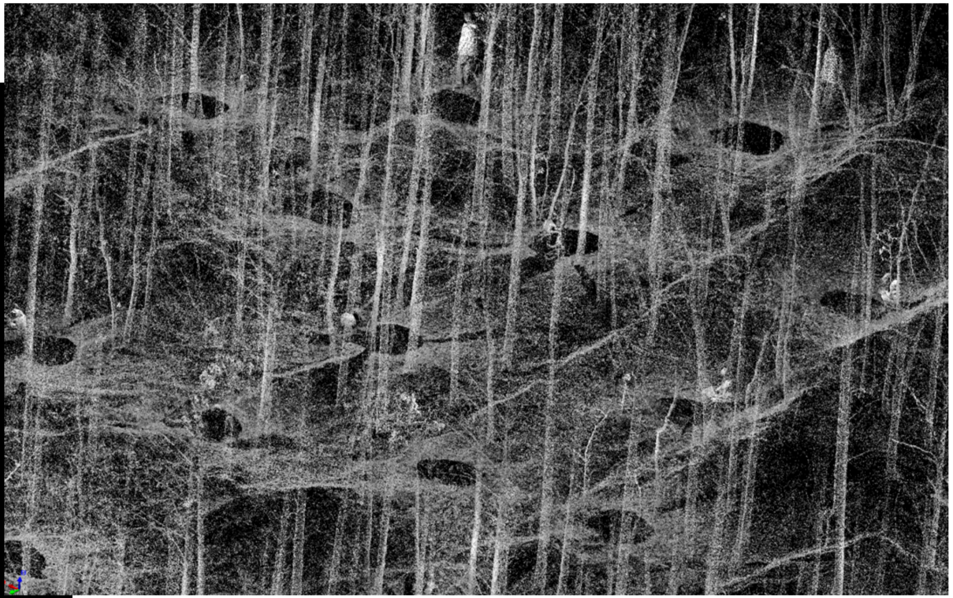

pino 265
Pt: -54.283809 -123.114976 14.166949

# 4. RESULTADOS

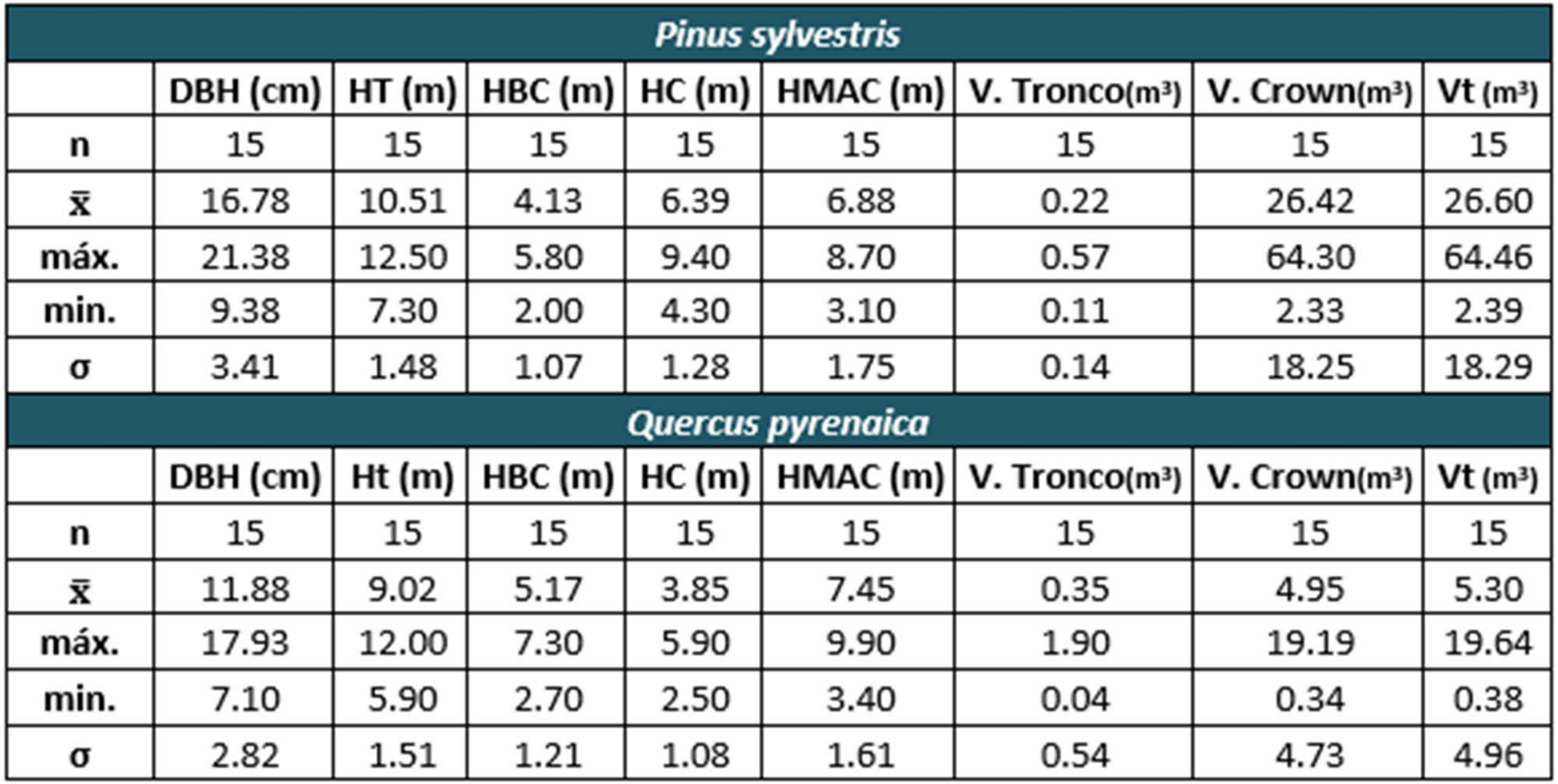
# 4. RESULTADOS

-Posición de los árboles
-Digitalización del terreno


POINT00003
Dist along X:
Dist along Y:
Dist along Z:
POINT00004
Dist along X:
Dist along Y:
Dist along Z:
A2_Ps_B/Y-00415
Dist along X:
Dist along Y:
Dist along Z:
A2_Qpy_B/O-01394
Dist along X:
Dist along Y:
Dist along Z:
B/O-01579
Dist along X:
Dist along Y:
Dist along Z:
A2_Qpy_B/O-01274
Dist along X:
Dist along Y:
Dist along Z:
A2_Qpy_B/O-01416
Dist along X:
Dist along Y:
Dist along Z:
B/Y-00265
Dist along X:
Dist along Y:
Dist along Z:
B/O-01538
Dist along X:
Dist along Y:
Dist along Z:
POINT00007
Dist along X:
Dist along Y:
Dist along Z:



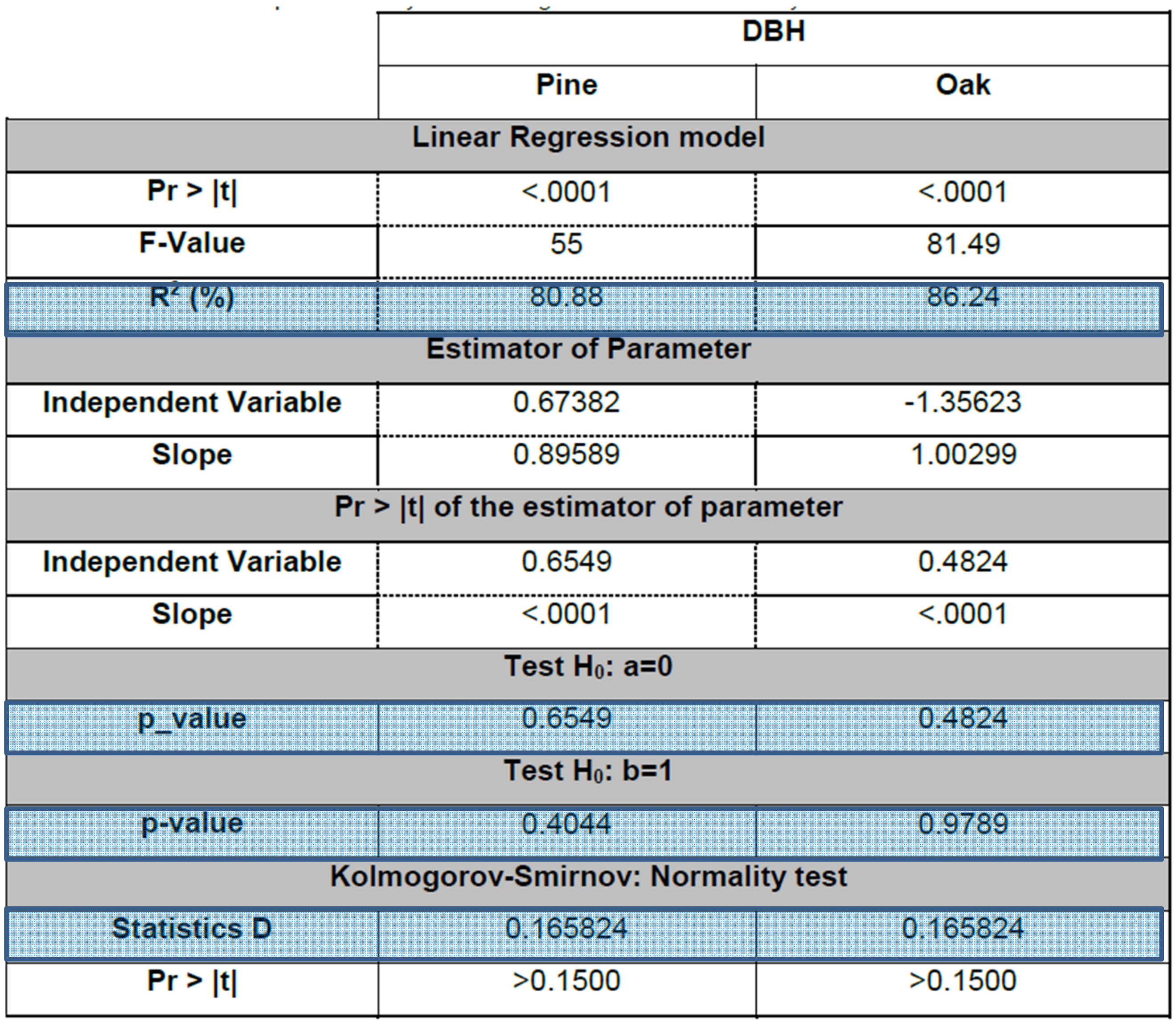
- Estadística descriptiva: nivel árbol



| *Pinus sylvestris* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | DBH (cm) | HT (m) | HBC (m) | HC (m) | HMAC (m) | V. Tronco($m^3$) | V. Crown($m^3$) | Vt ($m^3$) |
| n | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| $\bar{x}$ | 16.78 | 10.51 | 4.13 | 6.39 | 6.88 | 0.22 | 26.42 | 26.60 |
| máx. | 21.38 | 12.50 | 5.80 | 9.40 | 8.70 | 0.57 | 64.30 | 64.46 |
| min. | 9.38 | 7.30 | 2.00 | 4.30 | 3.10 | 0.11 | 2.33 | 2.39 |
| σ | 3.41 | 1.48 | 1.07 | 1.28 | 1.75 | 0.14 | 18.25 | 18.29 |

| *Quercus pyrenaica* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | DBH (cm) | Ht (m) | HBC (m) | HC (m) | HMAC (m) | V. Tronco($m^3$) | V. Crown($m^3$) | Vt ($m^3$) |
| n | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| $\bar{x}$ | 11.88 | 9.02 | 5.17 | 3.85 | 7.45 | 0.35 | 4.95 | 5.30 |
| máx. | 17.93 | 12.00 | 7.30 | 5.90 | 9.90 | 1.90 | 19.19 | 19.64 |
| min. | 7.10 | 5.90 | 2.70 | 2.50 | 3.40 | 0.04 | 0.34 | 0.38 |
| σ | 2.82 | 1.51 | 1.21 | 1.08 | 1.61 | 0.54 | 4.73 | 4.96 |

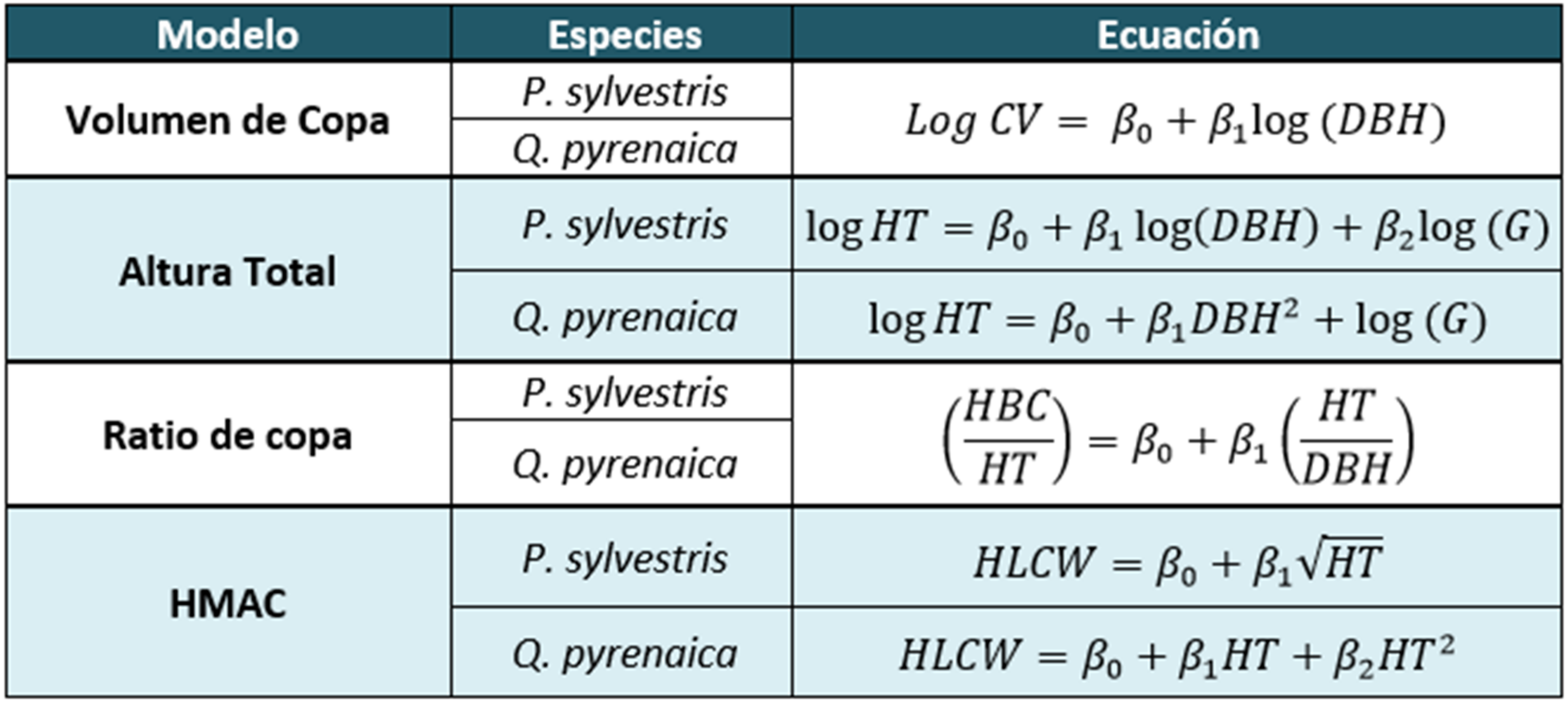
- Regresión lineal simple



|  | DBH |  |
|---|---|---|
|  | Pine | Oak |
| **Linear Regression model** |  |  |
| **Pr > \|t\|** | <.0001 | <.0001 |
| **F-Value** | 55 | 81.49 |
| **$R^2$ (%)** | 80.88 | 86.24 |
| **Estimator of Parameter** |  |  |
| **Independent Variable** | 0.67382 | -1.35623 |
| **Slope** | 0.89589 | 1.00299 |
| **Pr > \|t\| of the estimator of parameter** |  |  |
| **Independent Variable** | 0.6549 | 0.4824 |
| **Slope** | <.0001 | <.0001 |
| **Test $H_0$: a=0** |  |  |
| **p_value** | 0.6549 | 0.4824 |
| **Test $H_0$: b=1** |  |  |
| **p-value** | 0.4044 | 0.9789 |
| **Kolmogorov-Smirnov: Normality test** |  |  |
| **Statistics D** | 0.165824 | 0.165824 |
| **Pr > \|t\|** | >0.1500 | >0.1500 |

No hay diferencias significativas en obtener Dn TLS Vs. Forcípula

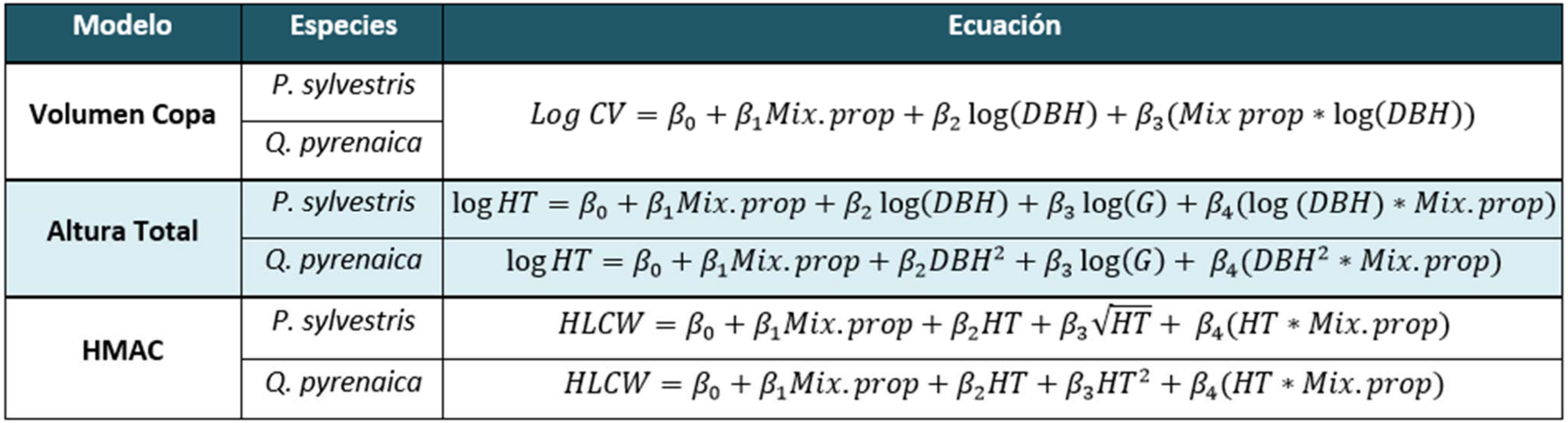
- Modelos básicos aplicados



| Modelo | Especies | Ecuación |
|---|---|---|
| **Volumen de Copa** | *P. sylvestris* | $Log\ CV = \beta_0 + \beta_1 \log{(DBH)}$ |
| | *Q. pyrenaica* | |
| **Altura Total** | *P. sylvestris* | $\log HT = \beta_0 + \beta_1 \log(DBH) + \beta_2 \log{(G)}$ |
| | *Q. pyrenaica* | $\log HT = \beta_0 + \beta_1 DBH^2 + \log{(G)}$ |
| **Ratio de copa** | *P. sylvestris* | $\left(\frac{HBC}{HT}\right) = \beta_0 + \beta_1 \left(\frac{HT}{DBH}\right)$ |
| | *Q. pyrenaica* | |
| **HMAC** | *P. sylvestris* | $HLCW = \beta_0 + \beta_1 \sqrt{HT}$ |
| | *Q. pyrenaica* | $HLCW = \beta_0 + \beta_1 HT + \beta_2 HT^2$ |

| Modelo | Especies | Variables | Coeficientes | | | | |
|---|---|---|---|---|---|---|---|
| | | | Estimate Std. | Error | t value | pr (<\|t\|) | Sig. |
| **Volumen Copa** | *P. sylvestris* | Intercept | -5.4506 | 1.8344 | -2.971 | 0.010819 | * |
| | | Log (DBH) | 3.0247 | 0.6568 | 4.606 | 0.000493 | *** |
| | *Q. pyrenaica* | Intercept | -5.7219 | 2.2994 | -2.488 | 0.02717 | * |
| | | Log (DBH) | 2.8165 | 0.9348 | 3.013 | 0.00999 | ** |
| **Altura de Copa** | *P. sylvestris* | Intercept | -3.74353 | 0.99936 | -3.746 | 0.003233 | ** |
| | | log (DBH) | 0.30383 | 0.06627 | 4.585 | 0.000784 | *** |
| | | log (G) | 1.51668 | 0.28677 | 5.289 | 0.000257 | *** |
| | *Q. pyrenaica* | Intercept | -4.9846789 | 1.9247282 | -2.59 | 0.02367 | * |
| | | $(DBH^2)$ | 0.0009317 | 0.0004211 | 2.212 | 0.04707 | * |
| | | log (G) | 2.031847 | 0.56448 | 3.634 | 0.00342 | ** |
| **Ratio de copa** | *P. sylvestris* | Intercept | 0,86579 | 0,08529 | 10,151 | 1,51E-07 | *** |
| | | (Htotal/DBH) | -0,39104 | 0,12834 | -3,047 | 0,00936 | ** |
| | *Q. pyrenaica* | Intercept | 0,5205 | 0,1152 | 4,52 | 0,000576 | *** |
| | | (Htotal/DBH) | -0,1179 | 0,1427 | 0,1427 | 0,423609 | |
| **HMAC** | *P. sylvestris* | Intercept | -13.528 | 3.651 | -3.705 | 0.00264 | ** |
| | | $\sqrt{HT}$ | 6.278 | 1.132 | 5.545 | 9.46E-05 | *** |
| | *Q. pyrenaica* | Intercept | -9.74624 | 3.83995 | -2.538 | 0.02603 | * |
| | | HT | 2.86556 | 0.85729 | 3.343 | 0.00586 | ** |
| | | $\sqrt{HT}$ | -0.10365 | 0.04723 | -2.195 | 0.0486 | * |

- Modelos expandidos aplicados



| Modelo | Especies | Ecuación |
|---|---|---|
| **Volumen Copa** | *P. sylvestris* | $Log\ CV = \beta_0 + \beta_1 Mix.prop + \beta_2 \log(DBH) + \beta_3 (Mix\ prop * \log(DBH))$ |
| | *Q. pyrenaica* | |
| **Altura Total** | *P. sylvestris* | $\log HT = \beta_0 + \beta_1 Mix.prop + \beta_2 \log(DBH) + \beta_3 \log(G) + \beta_4 (\log(DBH) * Mix.prop)$ |
| | *Q. pyrenaica* | $\log HT = \beta_0 + \beta_1 Mix.prop + \beta_2 DBH^2 + \beta_3 \log(G) + \beta_4 (DBH^2 * Mix.prop)$ |
| **HMAC** | *P. sylvestris* | $HLCW = \beta_0 + \beta_1 Mix.prop + \beta_2 HT + \beta_3 \sqrt{HT} + \beta_4 (HT * Mix.prop)$ |
| | *Q. pyrenaica* | $HLCW = \beta_0 + \beta_1 Mix.prop + \beta_2 HT + \beta_3 HT^2 + \beta_4 (HT * Mix.prop)$ |

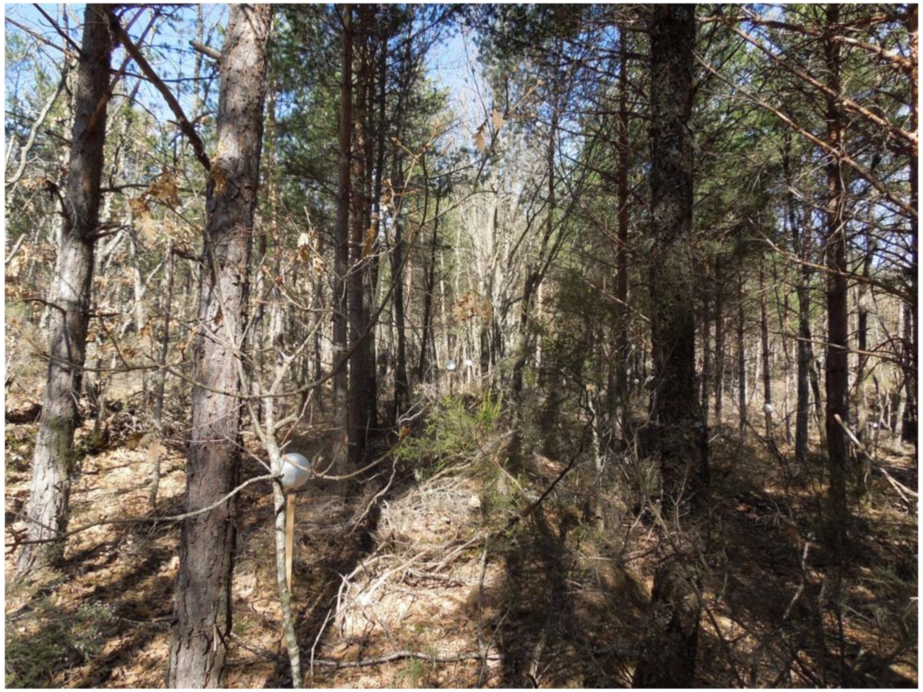
- Efecto de la mezcla sobre las variables

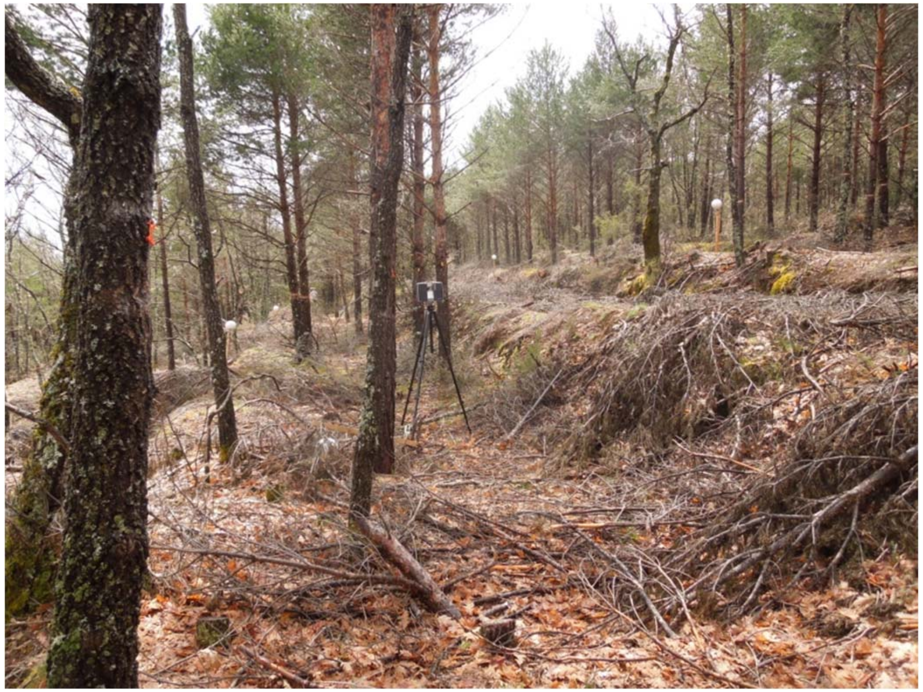
| Modelo | Especies | Variables | Coeficientes | | | | |
|---|---|---|---|---|---|---|---|
| | | | Estimate Std. | Error | t value | pr (<\|t\|) | Sig. |
| **Volumen Copa** | *P. sylvestris* | Intercept | -24.44 | 28.76 | -0.85 | 0.413 | |
| | | Mix prop. | 29.16 | 44.36 | 0.657 | 0.524 | |
| | | Log (DBH) | 10.08 | 10.4 | 0.969 | 0.353 | |
| | | Mix prop: Log(DBH) | -10.81 | 15.99 | -0.676 | 0.513 | |
| | *Q. pyrenaica* | Intercept | -34.115 | 22.873 | -1.492 | 0.164 | |
| | | Mix prop. | 77.488 | 61.958 | 1.251 | 0.237 | |
| | | Log (DBH) | 14.878 | 9.333 | 1.594 | 0.139 | |
| | | Mix prop: Log(DBH) | -33.093 | 25.333 | -1.306 | 0.218 | |
| **Altura Total** | *P. sylvestris* | Intercept | -0.2377 | 2.7994 | -0.085 | 0.9342 | |
| | | log (DBH) | -0.5376 | 0.912 | -0.59 | 0.56999 | |
| | | Mix prop. | -4.3632 | 3.8976 | -1.119 | 0.29192 | |
| | | log (G) | 1.2947 | 0.291 | 4.447 | 0.00161 | ** |
| | | Mix prop: log(DBH): | 1.3539 | 1.4052 | 0.963 | 0.36047 | |
| | *Q. pyrenaica* | Intercept | -5.321768 | 2.078197 | -2.561 | 0.02834 | * |
| | | $DBH^2$ | -2.404562 | 1.922596 | -1.251 | 0.23925 | |
| | | Mix prop. | -0.004012 | 0.004287 | -0.936 | 0.37146 | |
| | | log (G) | 2.379233 | 0.659332 | 3.609 | 0.00478 | ** |
| | | Mix prop: $DBH^2$ | 0.013494 | 0.011657 | 1.158 | 0.27391 | |
| **HMAC** | *P. sylvestris* | Intercept | 55.581 | 92.326 | 0.602 | 0.561 | |
| | | HT | -3.195 | 4.415 | -0.724 | 0.486 | |
| | | Mix prop | -78.698 | 72.007 | -1.093 | 0.300 | |
| | | sqrt(HT) | -2.835 | 33.668 | -0.084 | 0.935 | |
| | | Mix Prop: HT | 6.641 | 6.759 | 0.983 | 0.349 | |
| | *Q. pyrenaica* | Intercept | -12.93863 | 6.52195 | -1.984 | 0.07539 | . |
| | | Mix prop. | 15.4941 | 31.60973 | 0.49 | 0.63459 | |
| | | HT | 2.80988 | 0.78373 | 3.585 | 0.00497 | ** |
| | | sqrt(HT) | -0.08357 | 0.07615 | -1.097 | 0.29817 | |
| | | Mix Prop: HT | -1.04057 | 3.58729 | -0.29 | 0.77769 | |

# 5. DISCUSIÓN Y CONCLUSIÓN

# 5. CONCLUSIÓN Y DISCUSIÓN

- Ajuste de modelos
- TLS
  - - Tiempo de escaneo
  - - Tiempo de procesado ⏰



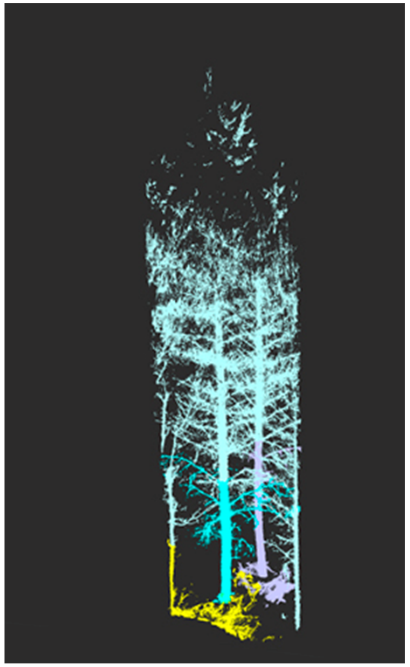


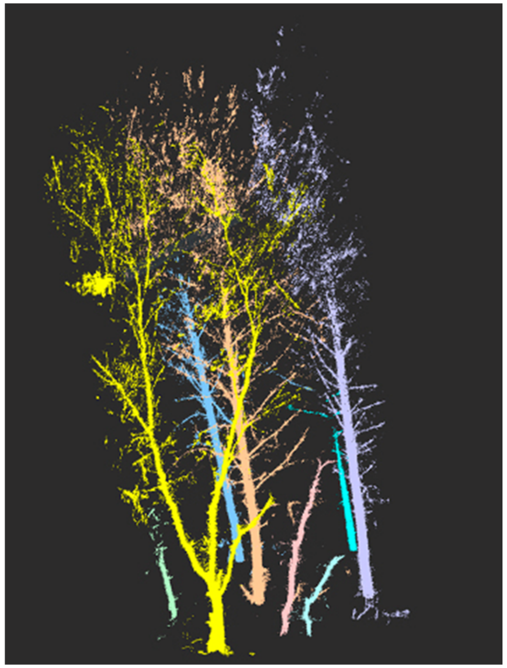
Masa poco aclarada Vs. Masa muy aclarada

# • CompuTree

✗

- De 1 en 1
- Datos < 2Gb
- Demasiada densidad = problemas



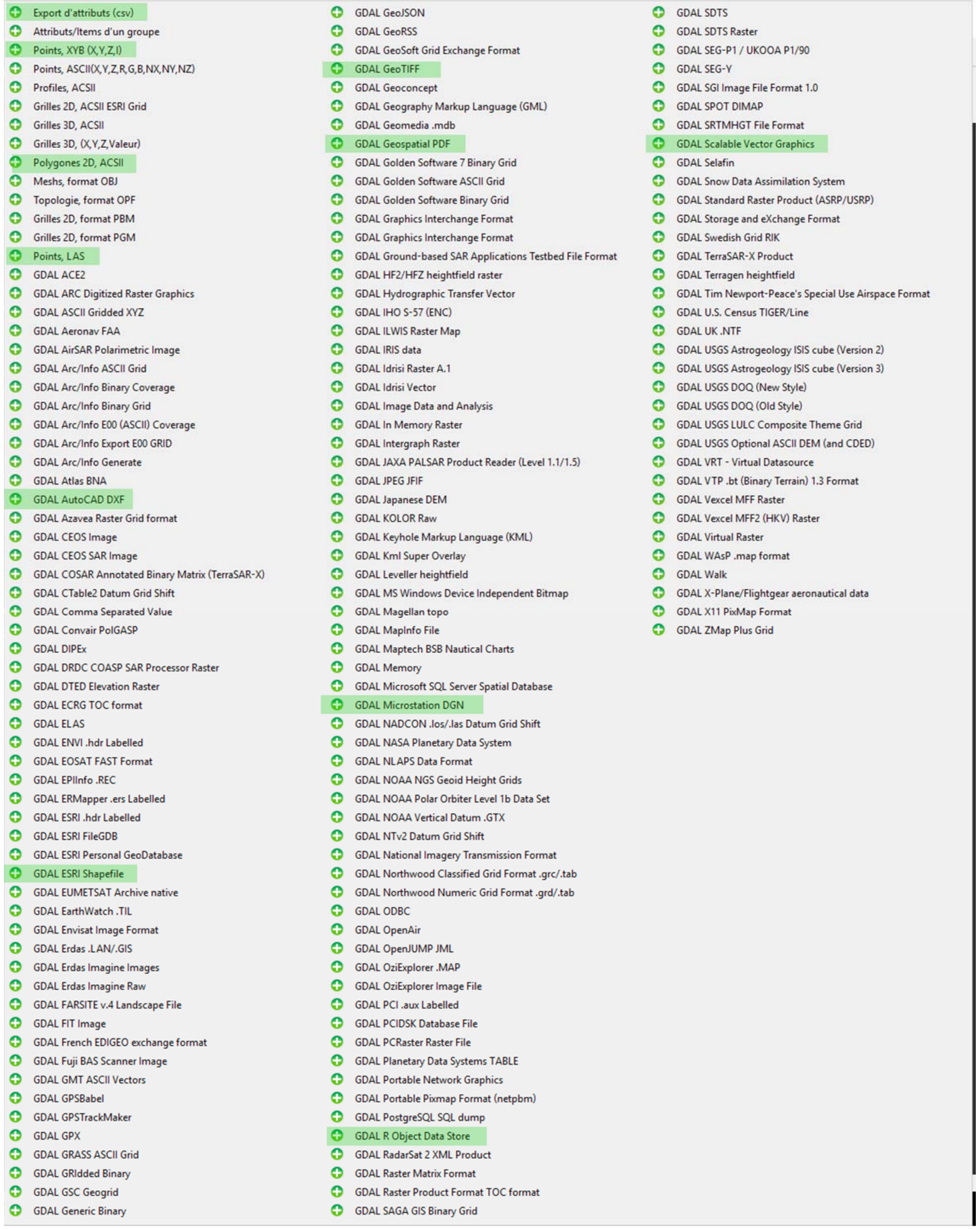


✓

- Extracción Exacta
- Sin sesgos
- Exportación rápida de datos
- Extracción del suelo rápido
- Extracción de altura automática

# CompuTree

- Permite numerosos tipos de exportación ✓



Export d'attributs (csv)
Attributs/Items d'un groupe
Points, XYB (X,Y,Z,I)
Points, ASCII(X,Y,Z,R,G,B,NX,NY,NZ)
Profiles, ACSII
Grilles 2D, ACSII ESRI Grid
Grilles 3D, ACSII
Grilles 3D, (X,Y,Z,Valeur)
Polygones 2D, ACSII
Meshs, format OBJ
Topologie, format OPF
Grilles 2D, format PBM
Grilles 2D, format PGM
Points, LAS
GDAL ACE2
GDAL ARC Digitized Raster Graphics
GDAL ASCII Gridded XYZ
GDAL Aeronav FAA
GDAL AirSAR Polarimetric Image
GDAL Arc/Info ASCII Grid
GDAL Arc/Info Binary Coverage
GDAL Arc/Info Binary Grid
GDAL Arc/Info E00 (ASCII) Coverage
GDAL Arc/Info Export E00 GRID
GDAL Arc/Info Generate
GDAL Atlas BNA
GDAL AutoCAD DXF
GDAL Azavea Raster Grid format
GDAL CEOS Image
GDAL CEOS SAR Image
GDAL COSAR Annotated Binary Matrix (TerraSAR-X)
GDAL CTable2 Datum Grid Shift
GDAL Comma Separated Value
GDAL Convair PolGASP
GDAL DIPEx
GDAL DRDC COASP SAR Processor Raster
GDAL DTED Elevation Raster
GDAL ECRG TOC format
GDAL ELAS
GDAL ENVI .hdr Labelled
GDAL EOSAT FAST Format
GDAL EPIInfo .REC
GDAL ERMapper .ers Labelled
GDAL ESRI .hdr Labelled
GDAL ESRI FileGDB
GDAL ESRI Personal GeoDatabase
GDAL ESRI Shapefile
GDAL EUMETSAT Archive native
GDAL EarthWatch .TIL
GDAL Envisat Image Format
GDAL Erdas .LAN/.GIS
GDAL Erdas Imagine Images
GDAL Erdas Imagine Raw
GDAL FARSITE v.4 Landscape File
GDAL FIT Image
GDAL French EDIGEO exchange format
GDAL Fuji BAS Scanner Image
GDAL GMT ASCII Vectors
GDAL GPSBabel
GDAL GPSTrackMaker
GDAL GPX
GDAL GRASS ASCII Grid
GDAL GRIdded Binary
GDAL GSC Geogrid
GDAL Generic Binary
GDAL GeoJSON
GDAL GeoRSS
GDAL GeoSoft Grid Exchange Format
GDAL GeoTIFF
GDAL Geoconcept
GDAL Geography Markup Language (GML)
GDAL Geomedia .mdb
GDAL Geospatial PDF
GDAL Golden Software 7 Binary Grid
GDAL Golden Software ASCII Grid
GDAL Golden Software Binary Grid
GDAL Graphics Interchange Format
GDAL Graphics Interchange Format
GDAL Ground-based SAR Applications Testbed File Format
GDAL HF2/HFZ heightfield raster
GDAL Hydrographic Transfer Vector
GDAL IHO S-57 (ENC)
GDAL ILWIS Raster Map
GDAL IRIS data
GDAL Idrisi Raster A.1
GDAL Idrisi Vector
GDAL Image Data and Analysis
GDAL In Memory Raster
GDAL Intergraph Raster
GDAL JAXA PALSAR Product Reader (Level 1.1/1.5)
GDAL JPEG JFIF
GDAL Japanese DEM
GDAL KOLOR Raw
GDAL Keyhole Markup Language (KML)
GDAL Kml Super Overlay
GDAL Leveller heightfield
GDAL MS Windows Device Independent Bitmap
GDAL Magellan topo
GDAL MapInfo File
GDAL Maptech BSB Nautical Charts
GDAL Memory
GDAL Microsoft SQL Server Spatial Database
GDAL Microstation DGN
GDAL NADCON .los/.las Datum Grid Shift
GDAL NASA Planetary Data System
GDAL NLAPS Data Format
GDAL NOAA NGS Geoid Height Grids
GDAL NOAA Polar Orbiter Level 1b Data Set
GDAL NOAA Vertical Datum .GTX
GDAL NTv2 Datum Grid Shift
GDAL National Imagery Transmission Format
GDAL Northwood Classified Grid Format .grc/.tab
GDAL Northwood Numeric Grid Format .grd/.tab
GDAL ODBC
GDAL OpenAir
GDAL OpenJUMP JML
GDAL OziExplorer .MAP
GDAL OziExplorer Image File
GDAL PCI .aux Labelled
GDAL PCIDSK Database File
GDAL PCRaster Raster File
GDAL Planetary Data Systems TABLE
GDAL Portable Network Graphics
GDAL Portable Pixmap Format (netpbm)
GDAL PostgreSQL SQL dump
GDAL R Object Data Store
GDAL RadarSat 2 XML Product
GDAL Raster Matrix Format
GDAL Raster Product Format TOC format
GDAL SAGA GIS Binary Grid
GDAL SDTS
GDAL SDTS Raster
GDAL SEG-P1 / UKOOA P1/90
GDAL SEG-Y
GDAL SGI Image File Format 1.0
GDAL SPOT DIMAP
GDAL SRTMHGT File Format
GDAL Scalable Vector Graphics
GDAL Selafin
GDAL Snow Data Assimilation System
GDAL Standard Raster Product (ASRP/USRP)
GDAL Storage and eXchange Format
GDAL Swedish Grid RIK
GDAL TerraSAR-X Product
GDAL Terragen heightfield
GDAL Tim Newport-Peace's Special Use Airspace Format
GDAL U.S. Census TIGER/Line
GDAL UK .NTF
GDAL USGS Astrogeology ISIS cube (Version 2)
GDAL USGS Astrogeology ISIS cube (Version 3)
GDAL USGS DOQ (New Style)
GDAL USGS DOQ (Old Style)
GDAL USGS LULC Composite Theme Grid
GDAL USGS Optional ASCII DEM (and CDED)
GDAL VRT - Virtual Datasource
GDAL VTP .bt (Binary Terrain) 1.3 Format
GDAL Vexcel MFF Raster
GDAL Vexcel MFF2 (HKV) Raster
GDAL Virtual Raster
GDAL WAsP .map format
GDAL Walk
GDAL X-Plane/Flightgear aeronautical data
GDAL X11 PixMap Format
GDAL ZMap Plus Grid

# Desventajas de la metodología

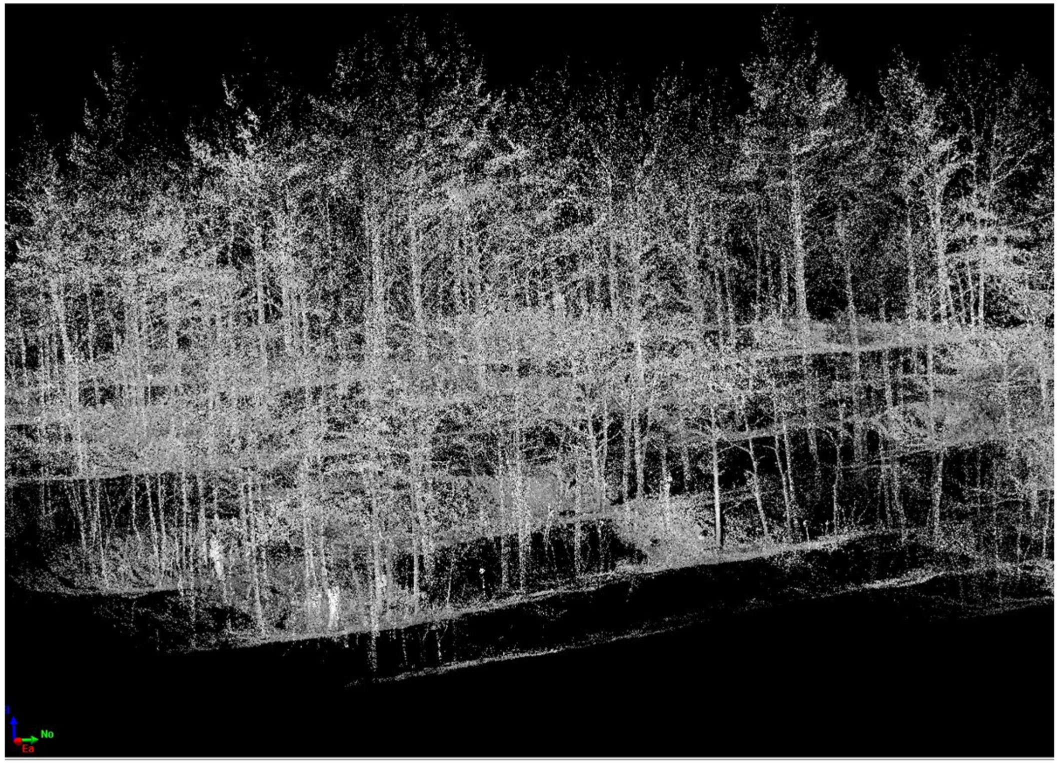
- Lenta extracción de datos

- Familiarizarse con cada programa

- Conseguir licencias y equipo necesario

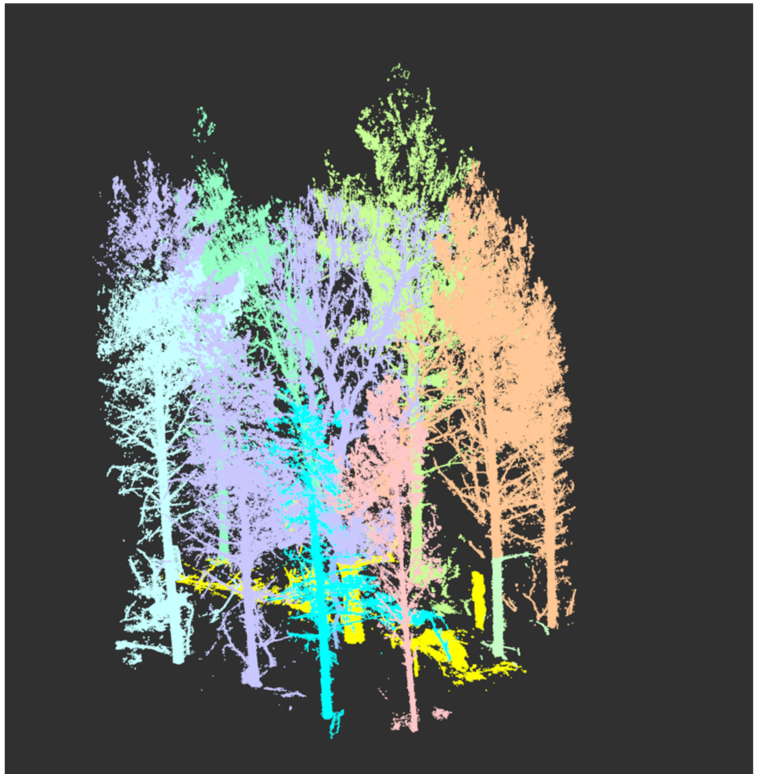
# Ventajas de la metodología

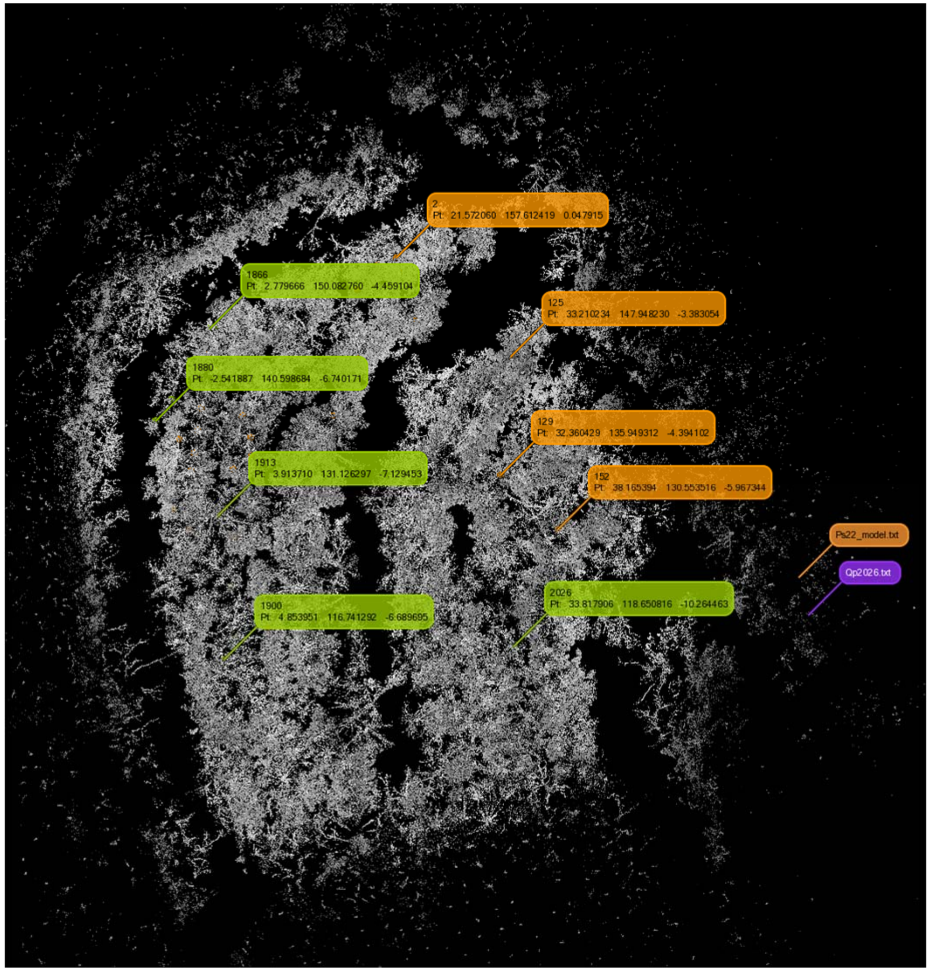
- Versatilidad del aparato
- Registro de datos
- Gran nivel de detalle
- Georreferenciación exacta



# *Siguientes pasos*

- Aumento del número de datos
- Estudio del efecto de la mezcla

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2026
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1900
Pt: 4.853951 116.741292 -6.689695

## AGRADECIMIENTOS

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INRA - Nancy (Francia)

*Cost Action* - EUMIXFOR

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