FORMEC 2015 – Forest engineering: Making a positive contribution

Optimization and logistics of chip distribution using LiDAR technology and network analysis in a mountainous region of Northern Spain.

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CETEMAS
CENTRO TECNOLÓGICO FORESTAL Y DE LA MADERA

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INTRODUCTION

- **Forest logistic**

- Planning, implementing and controlling-

INTRODUCTION

- **Production system of wood chips**

Cost-effective supply of chips

- Logging
- Extraction
- Chipping
- **Transporting**

Industry

Forest harvesting operations

FOREST NETWORK

- ❖ Track density
- ❖ Slope
- ❖ Width
- ❖ Type of firm

Transportation network analysis

Digitization of existing road and track network. GIS database

OBJECTIVES

General objective

To identify optimal supply areas around several woodchip consumer centres, which met certain in criteria of accessibility depending on in terms of the distance travelled by the road network.

To calculate, the best routes to transport chips from the Supply Points to the Demand points.

Specific objective

To digitalize the tracks around a Supply Point using LiDAR technology and connect them with the road network to carry out network analyses: service area and best routes.

MATERIAL AND METHODS

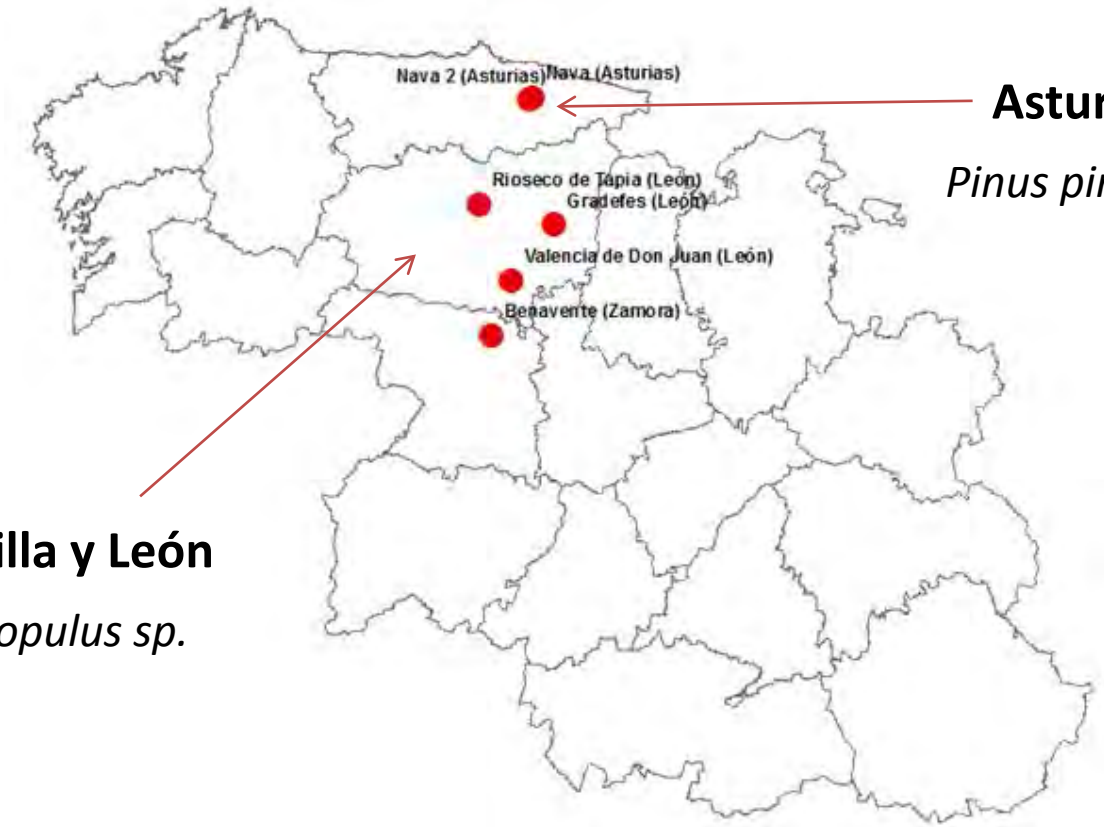
Study area

- Search for and locate the chip **Demand Points** for a single chip distributor.

MATERIAL AND METHODS

Study area

- ***Search for and locate*** the chip **Supply Points** for a single chip distributor.



Asturias

Pinus pinaster

Castilla y León

Populus sp.

MATERIAL AND METHODS

Transportation network

- **Create geodatabase**

- National Geographical Institute (IGN)
- Numeric Cartographic Base (BCN200, 2014)

FID	Etiqueta	Código	Velocidad (km/h)	Distancia (km)	Distancia (m)	Tiempo (h)	Tiempo (min)
8313	N-330	Carr_naci	64	0,369	369,100	0,006	0,346
8314	N-420	Carr_naci	64	0,172	172,100	0,003	0,161
8315	N-420	Carr_naci	64	4,660	4.659,800	0,073	4,369
8316	AP-36	Autopista	72	20,839	20.838,600	0,289	17,365
8317	AP-36	Autopista	72	1,050	1.049,700	0,015	0,875
8318	AP-36	Autopista	72	13,631	13.631,300	0,189	11,359

- **Road type.**
- **Speed (type of vehicle and road).**
- **Distance and time.**

MATERIAL AND METHODS

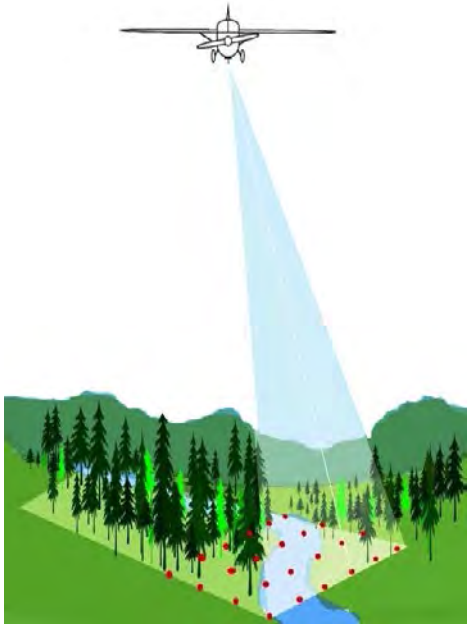
Transportation network/Network analysis

Road network (BCN200) with only a few tracks registered !!!!!!!

- **Digitalize the network** of tracks using **LiDAR** in a pilot area.
- Connect the network of roads and tracks

Why LiDAR ?

- Fast modelling of terrain in large areas with difficult access
- “Semipermeable" character which ensures that forest tracks hidden by trees or scrub are displayed.
- Driving along tracks to establish their route is not necessary, which saves both time and money.



MATERIAL AND METHODS

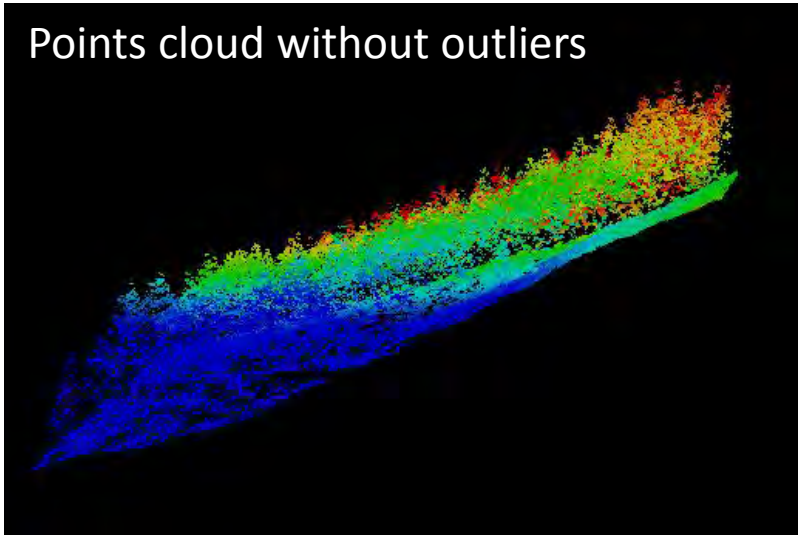
Transportation network

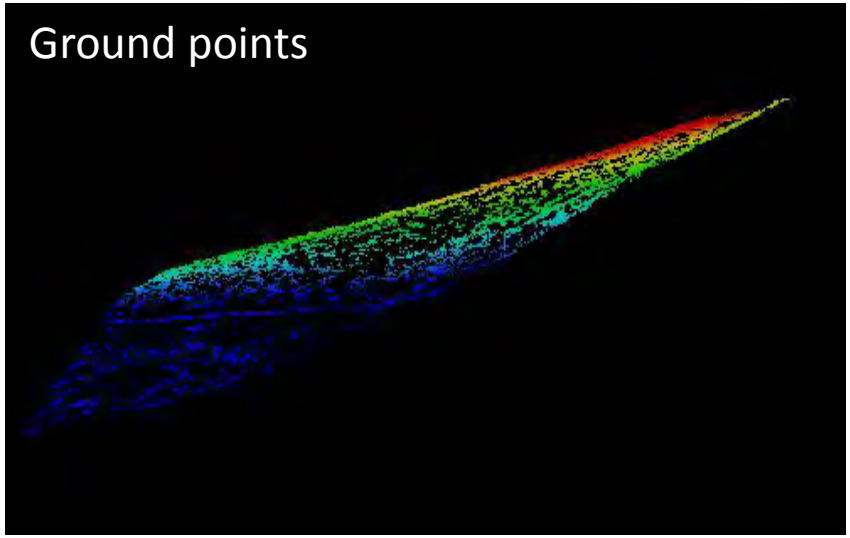
- **Digitalize the network** of tracks using **LiDAR** in a pilot area

Step 1: Analysing the LiDAR data.

- Remove outliers from the points cloud

- Points corresponding to the ground were separated from those belonging to vegetation





MATERIAL AND METHODS

Transportation network

- **Digitalize the network** of tracks using **LiDAR** in a pilot area

Step 1: Software FUSION (McGaughney, 2009)

Kraus and Pfeifer 's algorithm

$$p_i = \begin{cases} 1 & v_i \leq g \\ \dfrac{1}{1+(a(v_i-g)^b)} & g < v_i \leq g+w \\ 0 & g+w < v_i \end{cases}$$

- It is implemented as an iterative process.
- In the first step, a surface is computed with equal weights for all LIDAR points.
- The distance and direction to the surface is used to compute weights for each LiDAR point using this weight function.

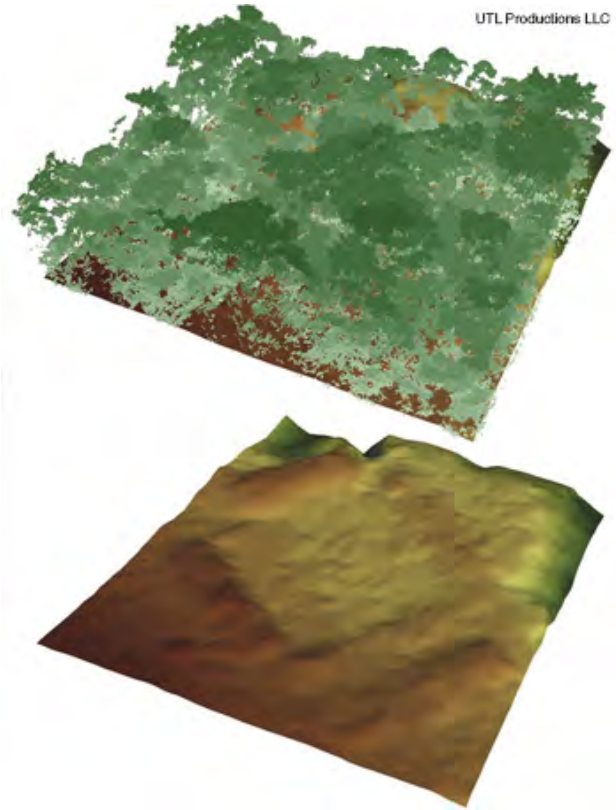
MATERIAL AND METHODS

Transportation network

- **Digitize the network** of tracks using **LiDAR** in a pilot area

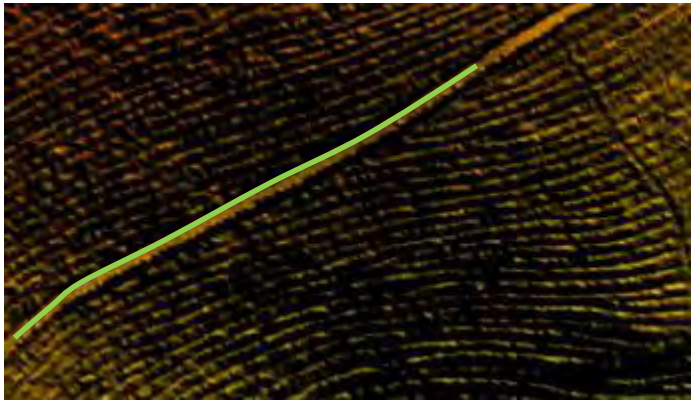
Step 2: Software FUSION (McGaughney, 2009)

DEM created interpolating ground points



Step 3:

Map Algebra and *Hillshade* tools (ArcGIS 10) were used to visualize the tracks in the DEM in a better way.



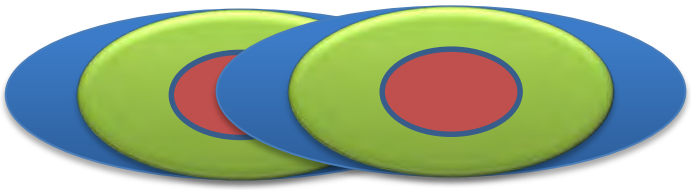
Tracks digitalization was carried out in the pilot area

MATERIAL AND METHODS

- Once the transportation network was built → **Network anlyst:** Software **ArcGis** 10.0

Step 1: **SUPPLY AREAS (Service area tool) :** different supply areas were identified around each Demand point having set a maximum road transportation distance.

Impedance: 50, 100 and 150 km.



* The option *"overlapping"* was chosen in order that each Demand Point had its own services areas and to see the overlapping areas between neighbouring points.

MATERIAL AND METHODS

Network analyst Software **ArcGis** 10.0

Step 1: **SUPPLY AREAS (Service area tool) :** different supply areas were identified around each Demand Point having set a maximum road transportation distance.

Impedance: 50, 100 or 150 km.

Step 2: **BEST ROUTES (Closest facility tool):** as a function of **time,** along roads and tracks between Demand and Supply Points

Impedance: time.

MATERIAL AND METHODS

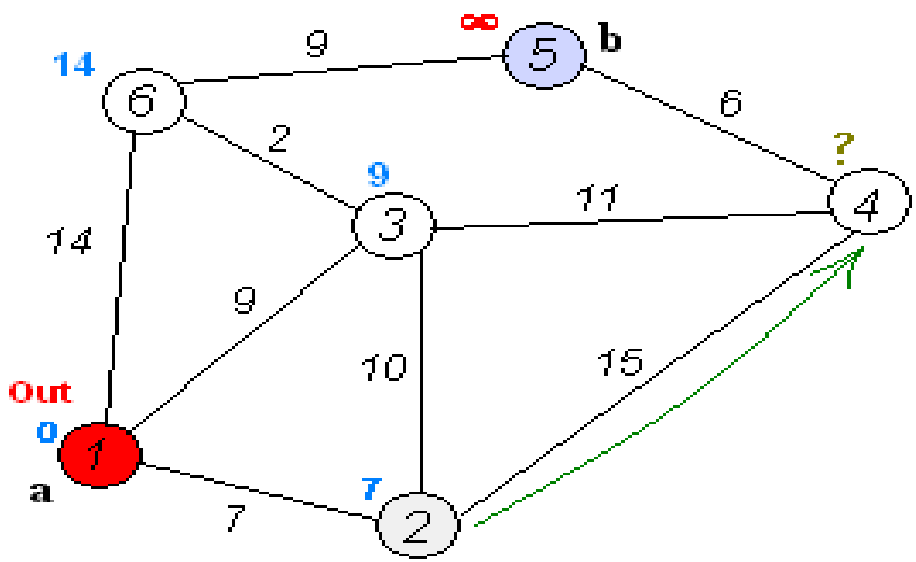
Network analysis

Network Analyst .
Software ArcGis 10.0

SUPPLY AREAS (Service area tool)

BEST ROUTES (Closest facility tool)

Dijkstra's algorithm

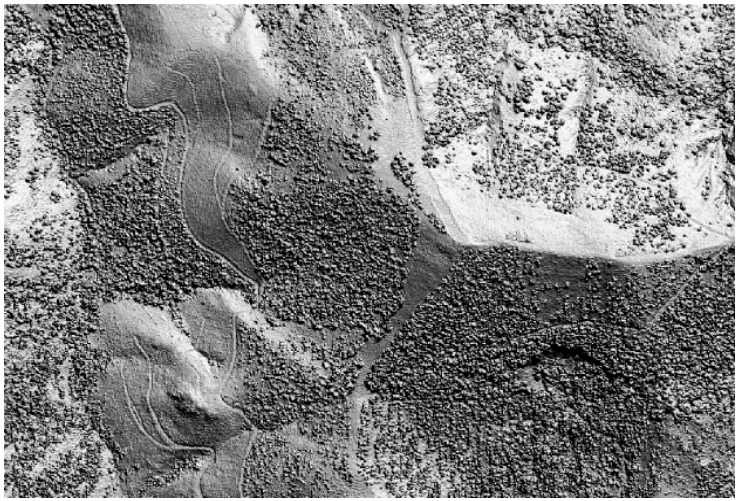


- Shortest trajectory between an origin point and one, or several, destination points.
- One-way restrictions, turn restrictions and barriers.
- **Miminimizing the cost attributes specified by the user.**

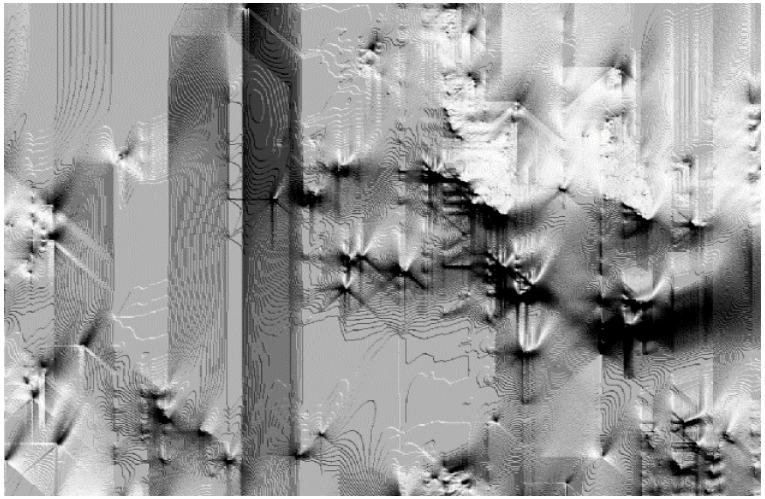
RESULTS

Transportation network

Tests carried out in the ground filtering process.



Soft filtering: 18%



Strong filtering: 81%

Large amount of vegetation wich made track identification difficult.

Which turn out to be too intensive

RESULTS

Transportation network

DEM created with the best combination of filtering parameters

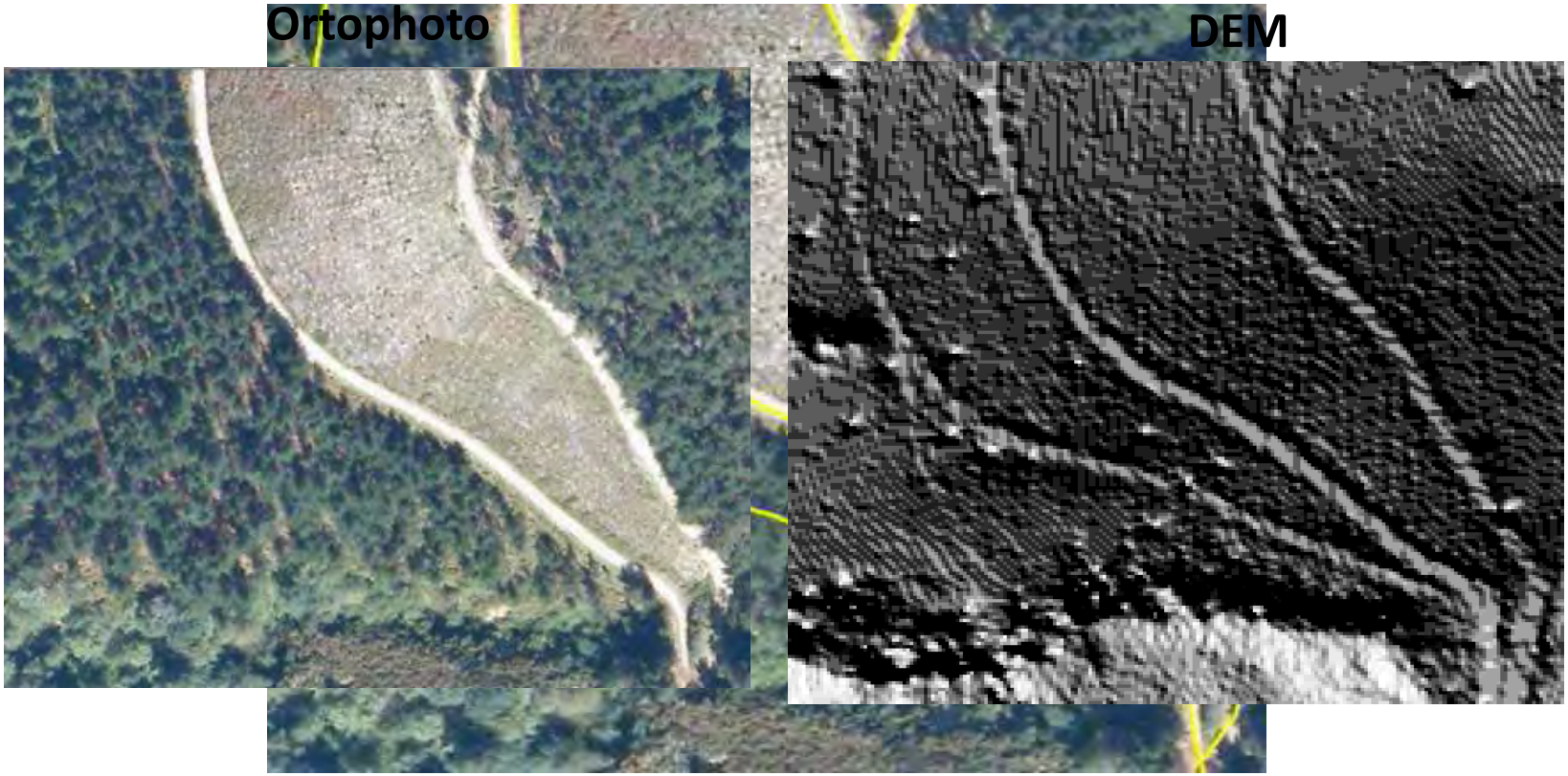
49%

RESULTS

Transportation network

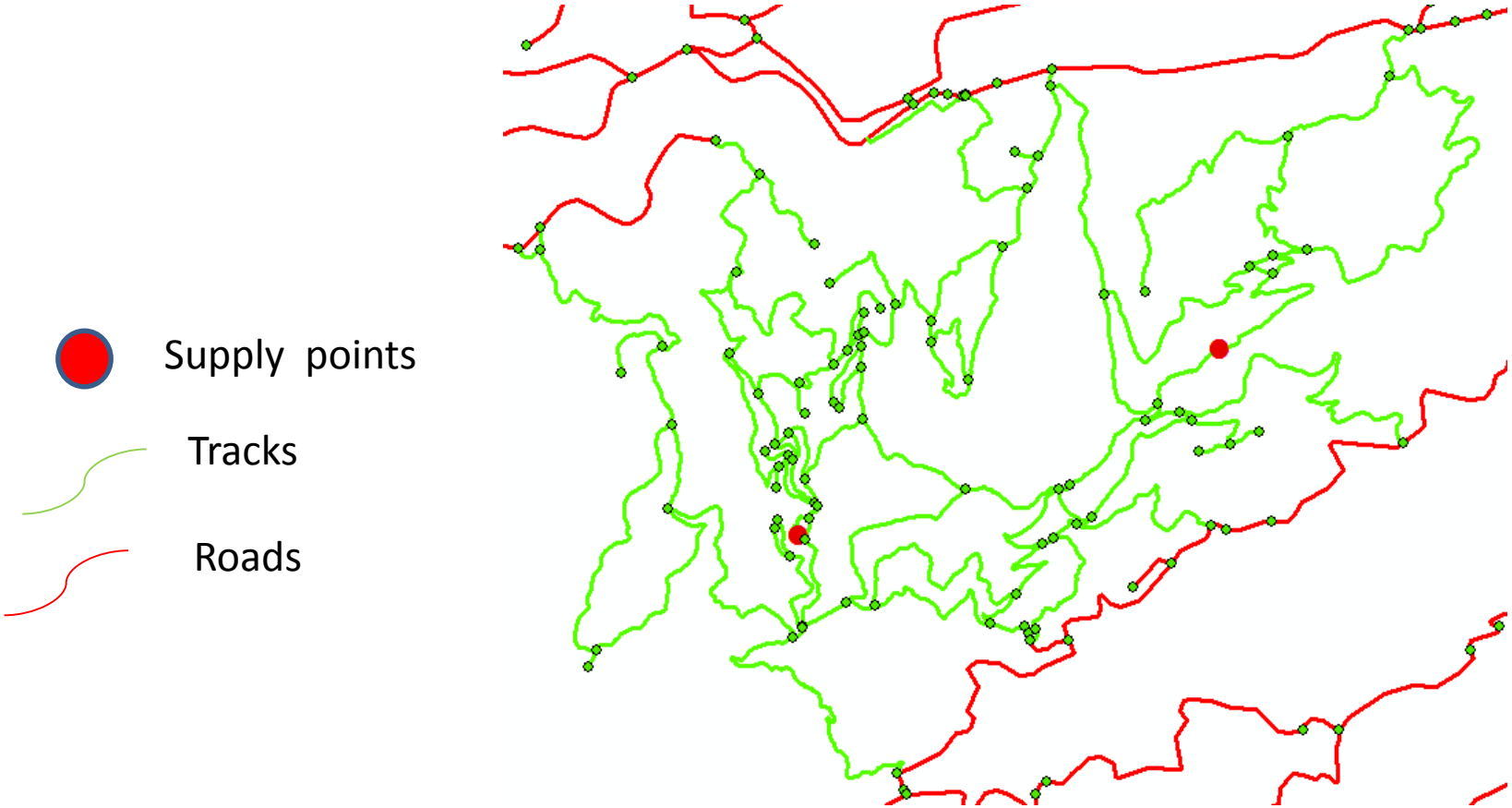
Demonstrate how the use of LIDAR displays hidden tracks, making it possible to digitalize them in a more precise way.

Ortophoto with the three tracks digitalized.



RESULTS

Transportation network

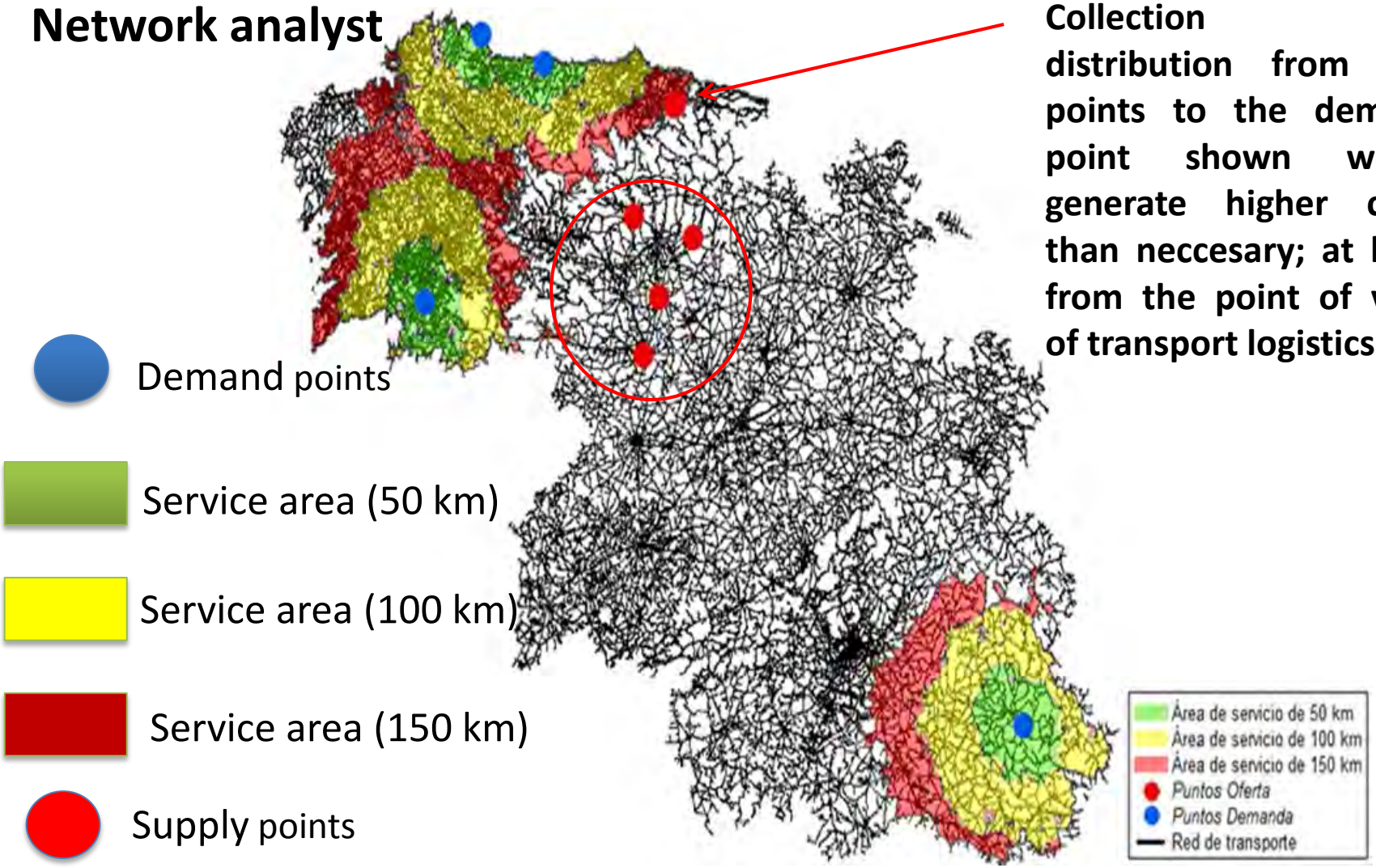


Digitalized transportation network in the pilot area.

RESULTS

Network analyst

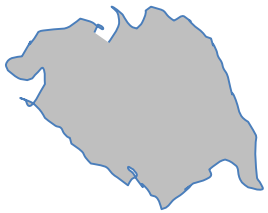
Collection and distribution from this points to the demand point shown would generate higher costs than neccesary; at least from the point of view of transport logistics.



Service areas for the four Demand Points

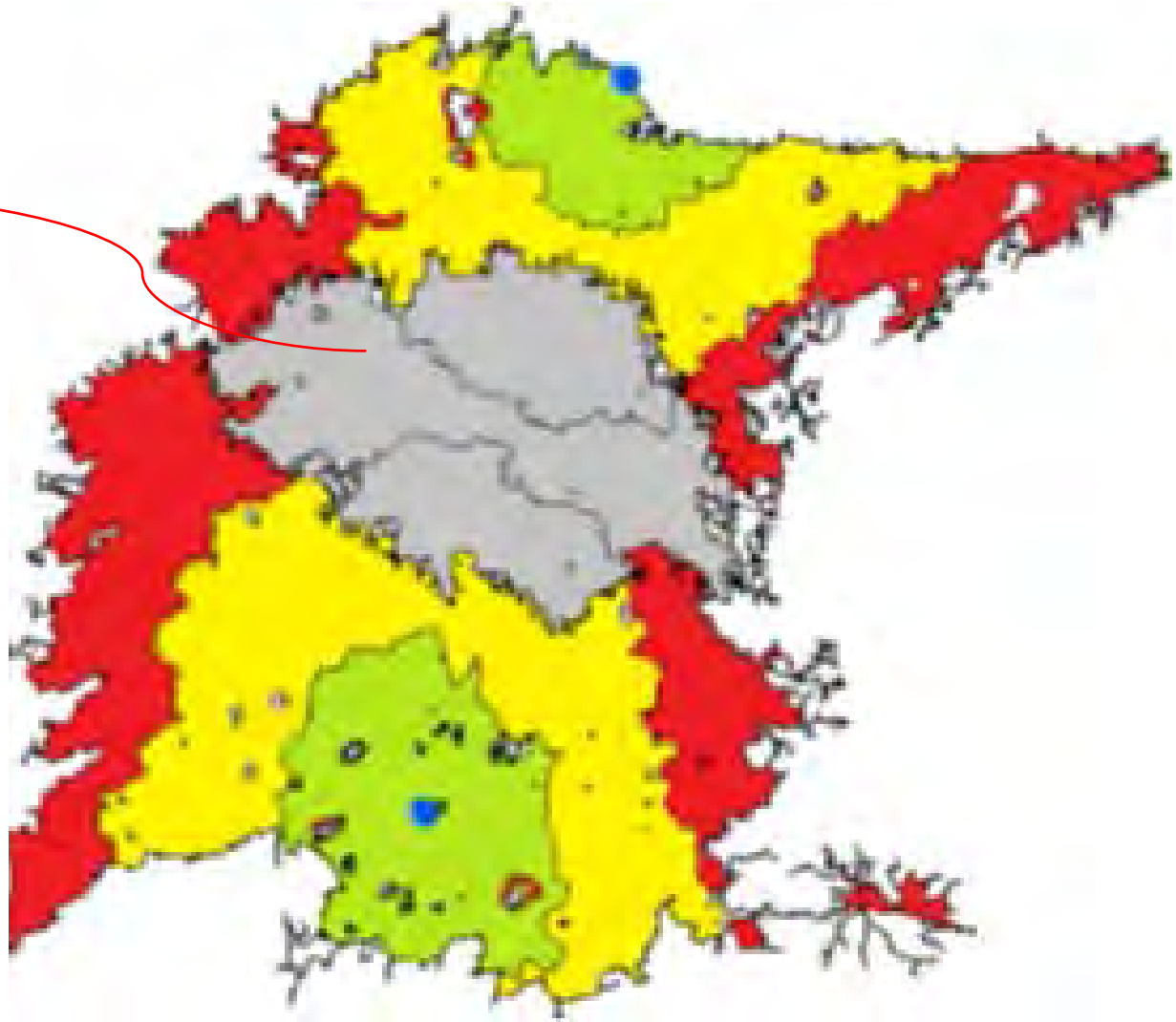
RESULTS

Network analyst



Overlapping zone

The precise location of the overlap zone between service areas enables **competition** to be identified.

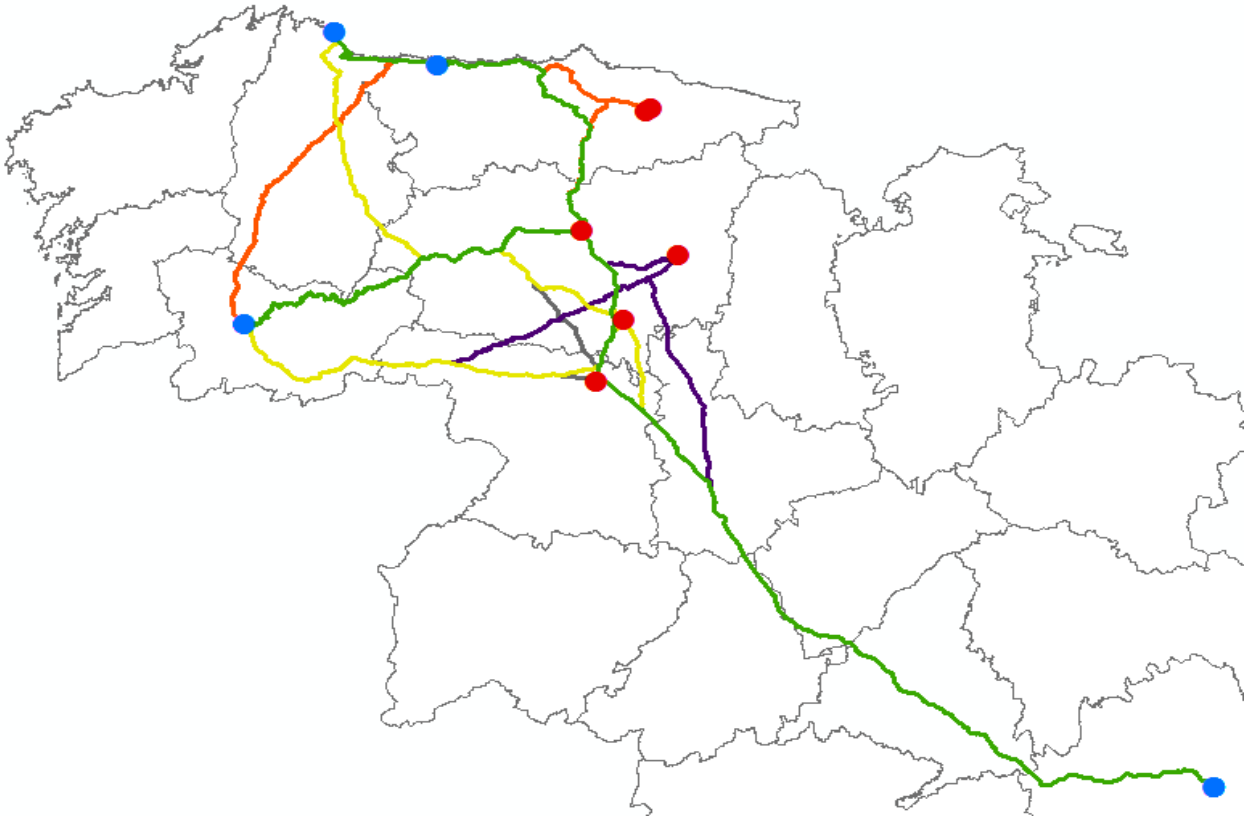


Overlapping zones of two service areas (in grey).

RESULTS

Network analyst

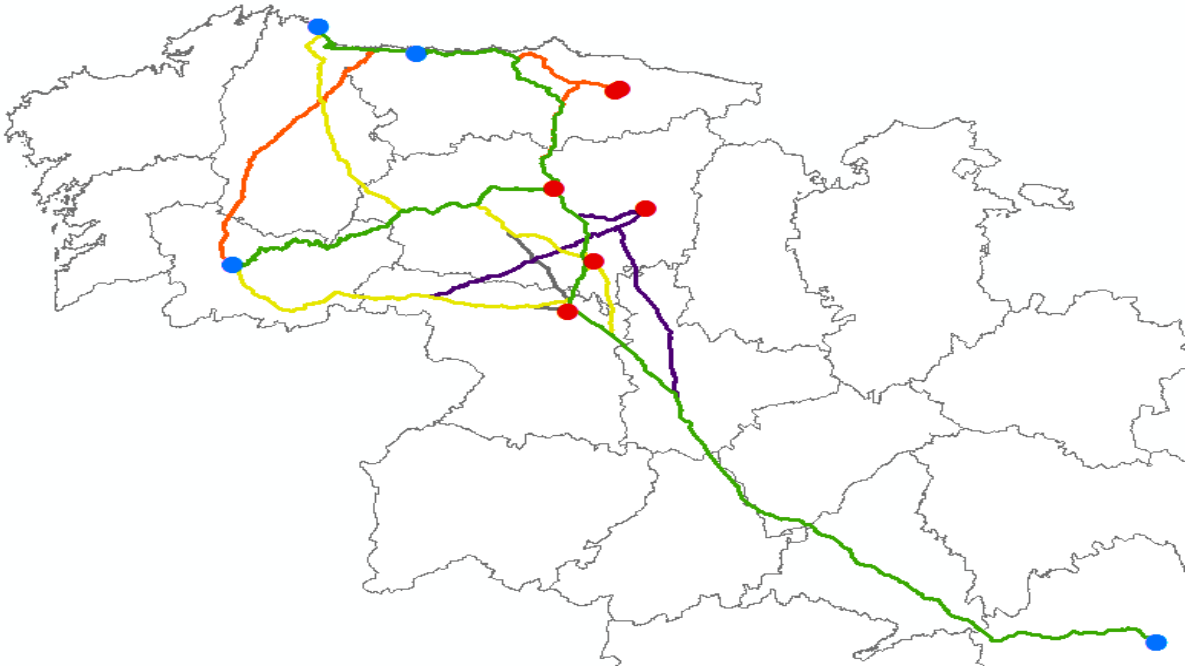
- In total, 24 routes were calculated.



RESULTS

Network analyst

- Each one is the fastest route between Supply and Demand points, that is, the one which takes least time taking into account type of road and vehicle, speed limits, etc.



RESULTS

Network analyst

- Both variables have been calculated for the different vehicles (**truck, forwarder**) which might travel by **road or track** between **Demand and Supply points**.

Supply Point (Origin)	Demand Point (destination)	Truck distance (km)	Forwarding distance (km)	Truck time (h)	Forwarding time (h)
Nava Asturias	BIOMASA NAVIA - ENCE	128,920	2,910	1,875	0,208
	ECESA	200,737	2,910	2,946	0,208
	BIOALLARLUZ – NORVENTO BIOMASA	352,673	2,910	5,302	0,208
	PINASA BIOMASA – COMETA (GRUPO LOSAN)	642,909	2,910	9,070	0,208

- The average route distance was **321 km.**

CONCLUSIONS

- ✓ As I hope our results have demonstrated there are many practical applications for this methodology:
  - With respect to biomass, creation of such areas could help forest biomass distributors, for example, to look for other possible Supply Points within service areas created with specific criteria, or generate these service areas around existing Supply points and locate potential consumption points within those areas.
  - But in addition, it has interesting implications for all sectors which rely on road and forest networks.

CONCLUSIONS

- ✓ In the future we must work to make available more data and better technologies in order to be able to carry out more precise analyses of routes.
- ✓ To do this, it is essential to have a complete and updated forest track network, and it requires further work and progress in digitalization of tracks using LiDAR, as well as automating this procedure.

THANK YOU

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