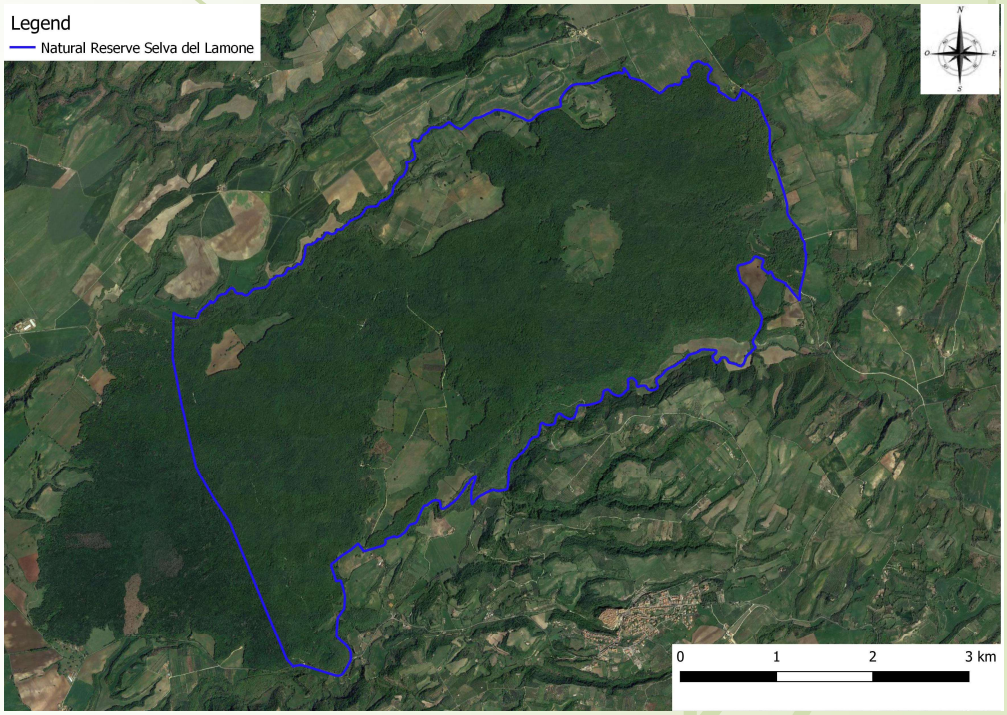
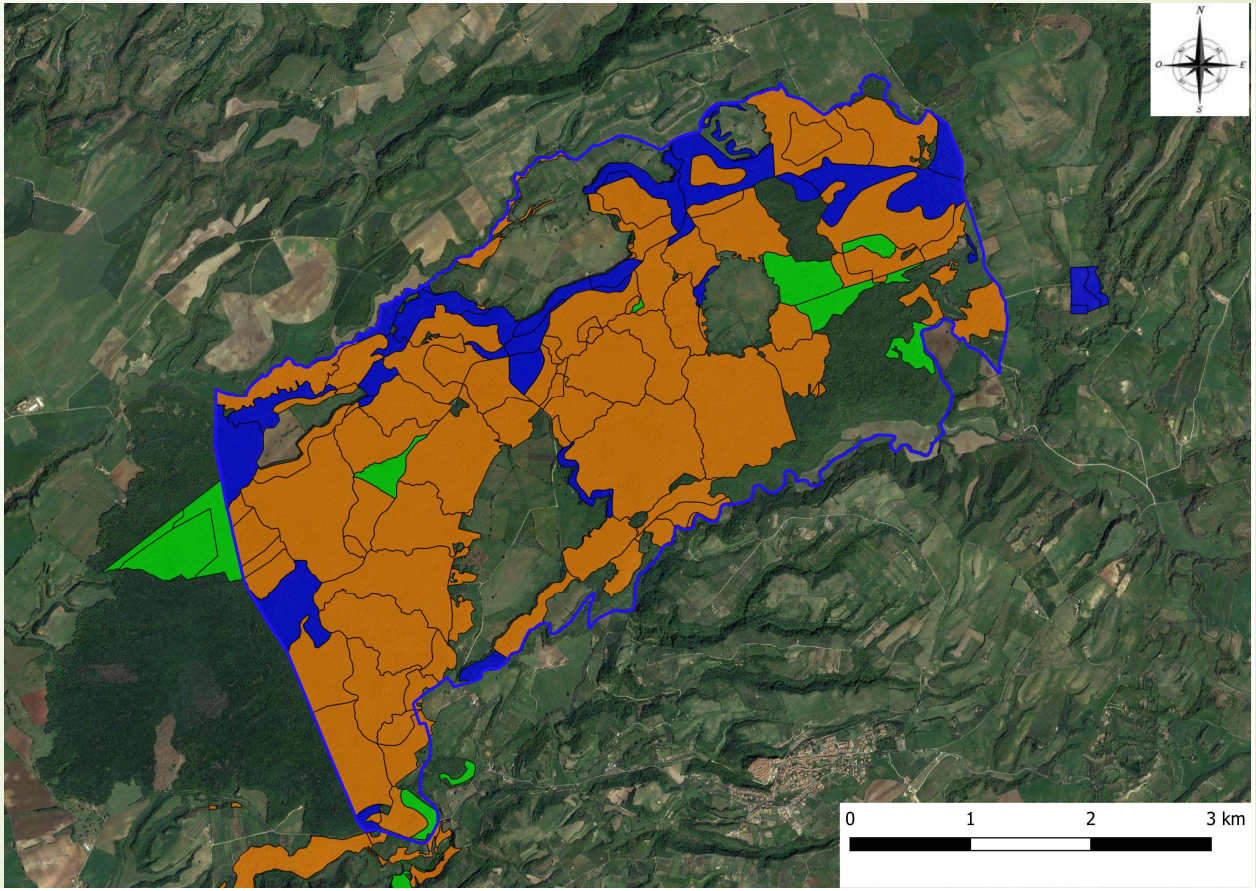
GIS-AHP Approach to Select the Most Suitable Extraction System in Mediterranean Oak Coppices Under Environmental Constraints



Damiano Tocci [1], Francesco Latterini [2], Rachele Venanzi [1], Pierluca Gaglioppa [3], Rodolfo Picchio [1]
Correspondence:venanzi@unitus.it

1 Tuscia University, DAFNE Department
2 Institute of Dendrology, Polish Academy of Sciences
3 Lazio Region

GIS-AHP Approach to Select the Most Suitable Extraction System in Mediterranean Oak Coppices Under Environmental Constraints



ABSTRACT

The selection of the most suitable alternative for harvesting operations is a challenging activities which is manageable with the precision forest harvesting approach. In details, an approach based on a combination of GIS (Geographic Information System) and AHP (Analytic Hierarchy Process), relying on geospatial data and opinion of experts in the topic of forest engineering was applied in the Natural Reserve of Lamone (Latium, Italy) to select the most suitable extraction system in the oak coppice forests of the study area. The developed approach allowed for the selection among forwarder, forestry-fitted farm tractor equipped with winch and all-terrain cable yarder. The obtained results indicated that forwarder was the most suitable extraction system for the major part of the study area, while the application of winch was limited to forest parcel with high forest road density. All-terrain cable yarder was instead identified as the best alternative only in areas with low soil bearing capacity.

KEYWORDS

cable skidder, forwarder, cable yarder, roughness, slope

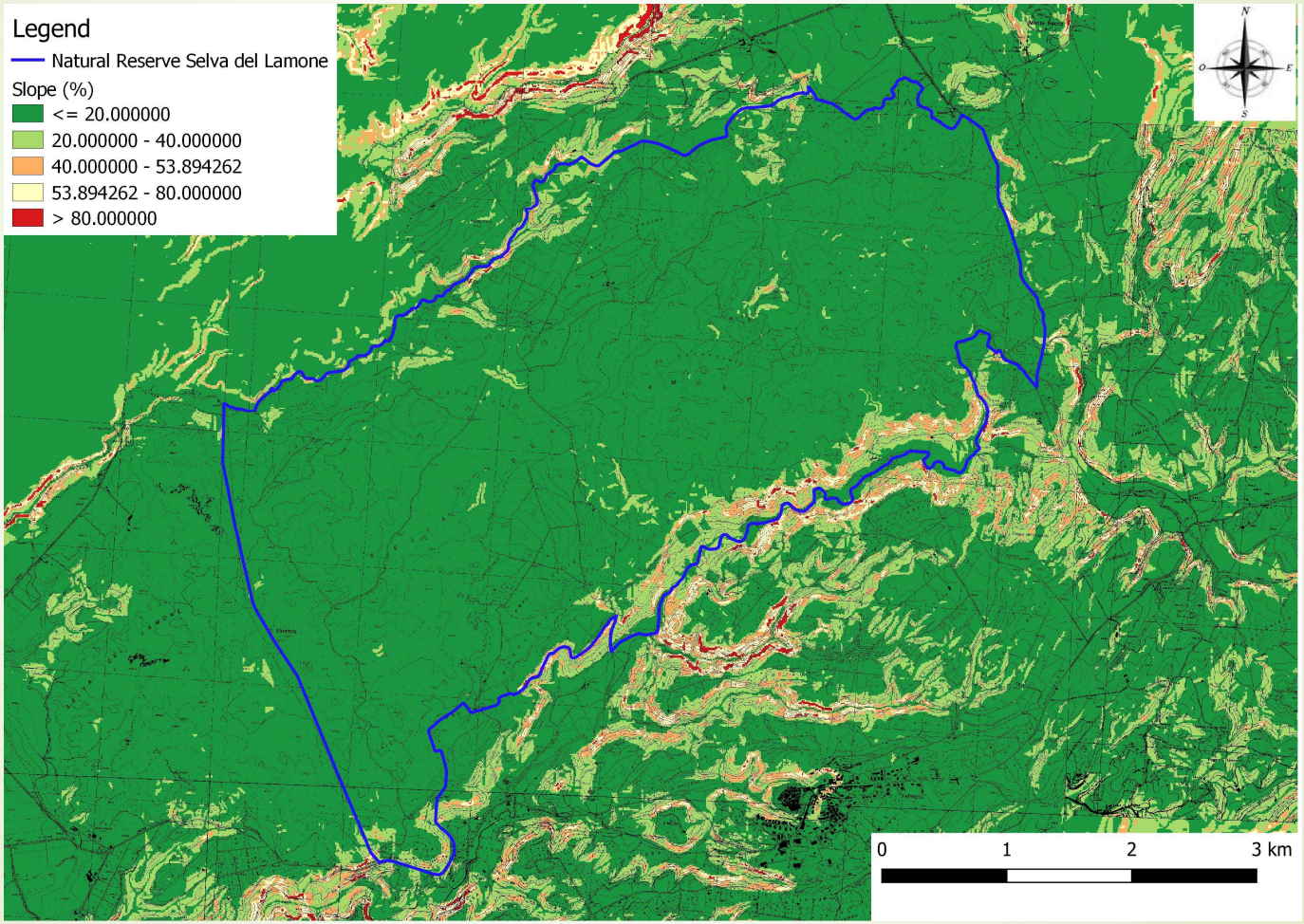
INTRODUCTION

- The selection of the best alternative for timber extraction is a fundamental issue in the framework of sustainable forest operations
- There is the need to increase the level of objectivity in the choice, which, in the context of the study area, is currently generally left for the operational phase without a proper planning
- We developed a GIS-AHP approach to identify the best alternative for timber extraction in oak coppices located in Central Italy
- We considered three extraction machines: forwarder, cable skidder and all-terrain cable yarder
- Our study area was the Natural Reserve Selva del Lamone

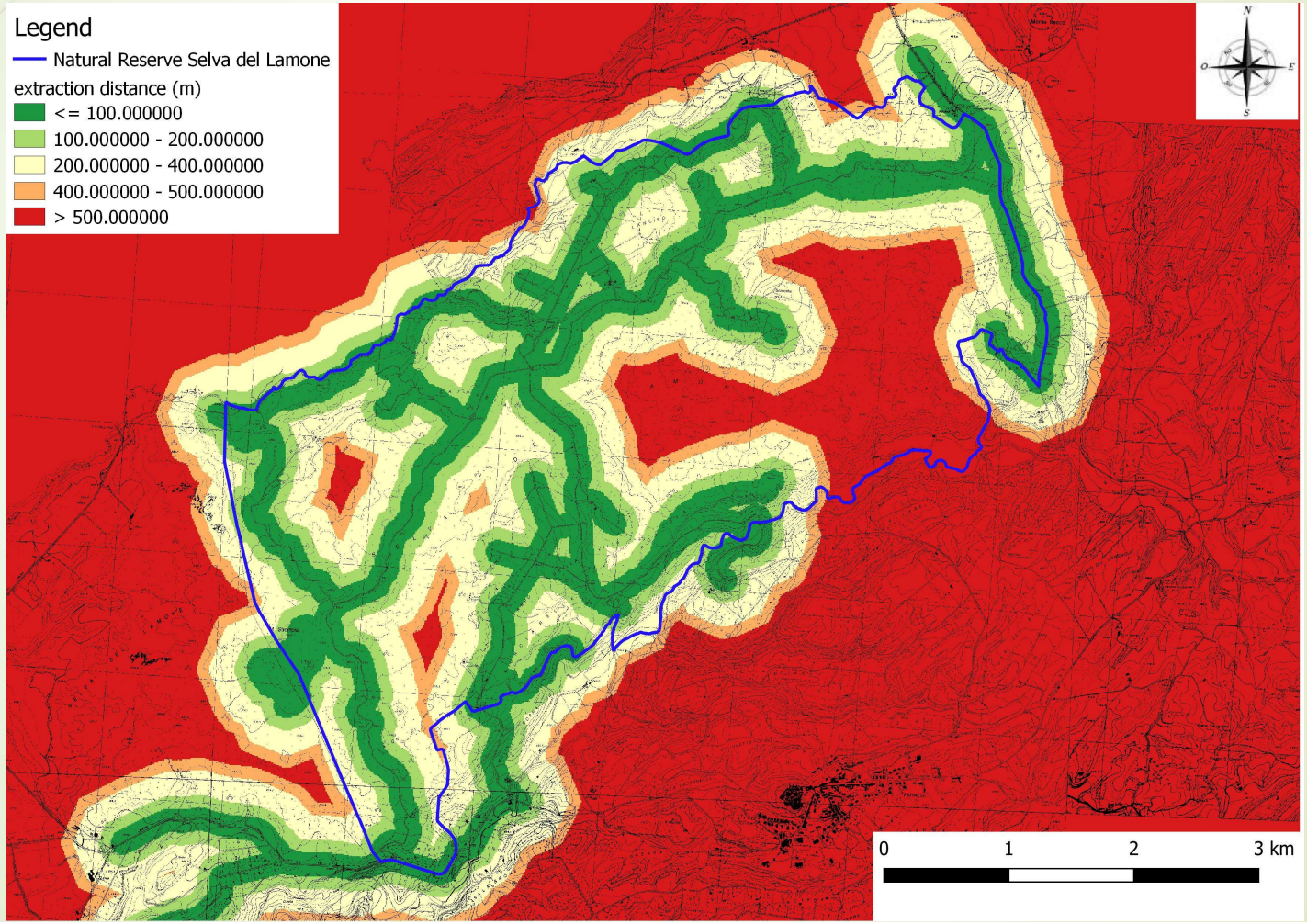
M & M

- Following the procedure developed by Latterini et al. (2022) we retrieved, from the local forest management plan and from preliminary GIS analysis, data about 6 environmental and operational variables
- Slope (%)
- Extraction distance (m)
- Roughness (%)
- Soil bearing capacity (kPa)
- Extracted timber amount (m^3/ha)
- Viability density (m/ha)

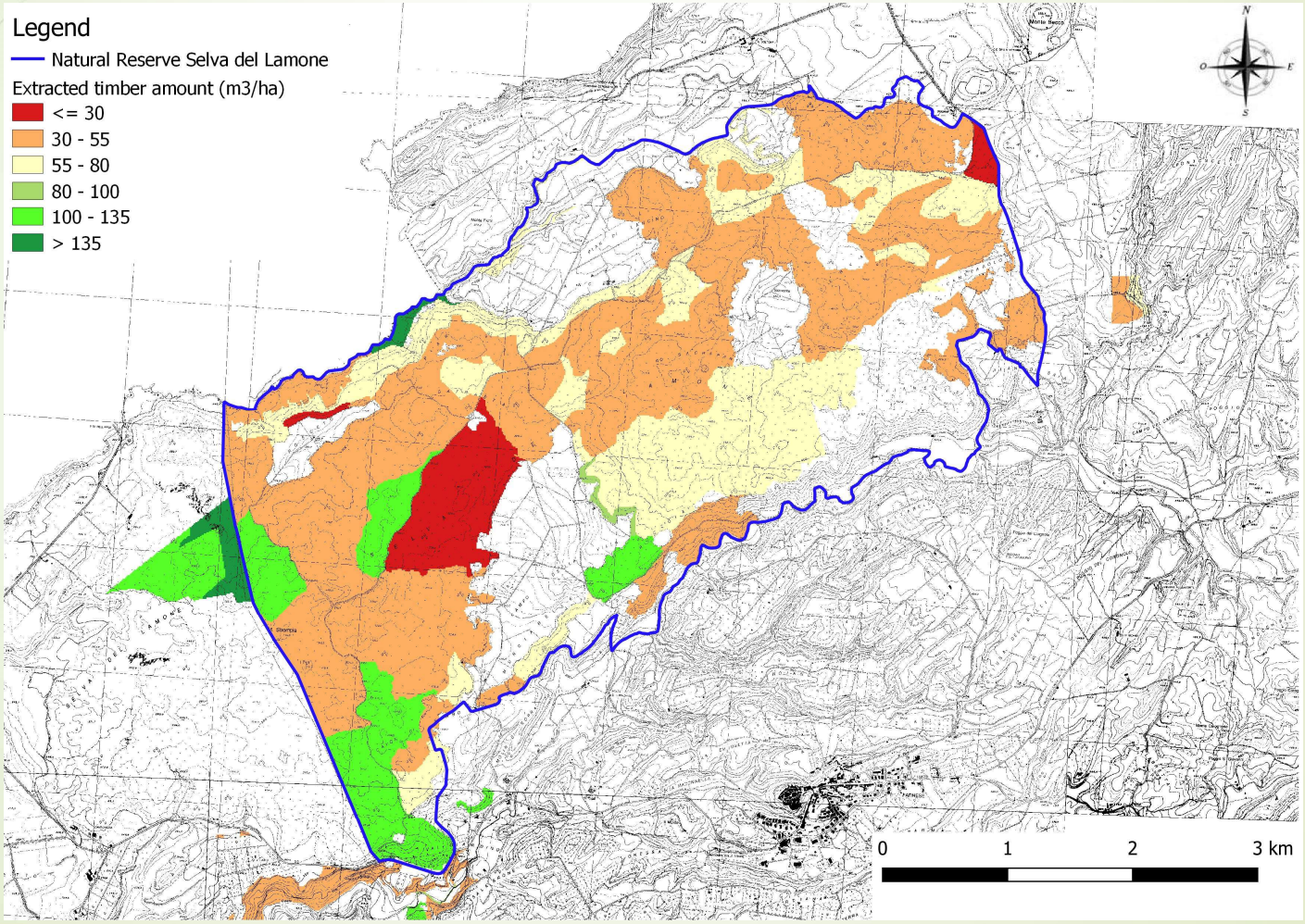
Slope


Legend
Natural Reserve Selva del Lamone
Slope (%)
<= 20.000000
20.000000 - 40.000000
40.000000 - 53.894262
53.894262 - 80.000000
> 80.000000
N
O
E
S
0
1
2
3 km

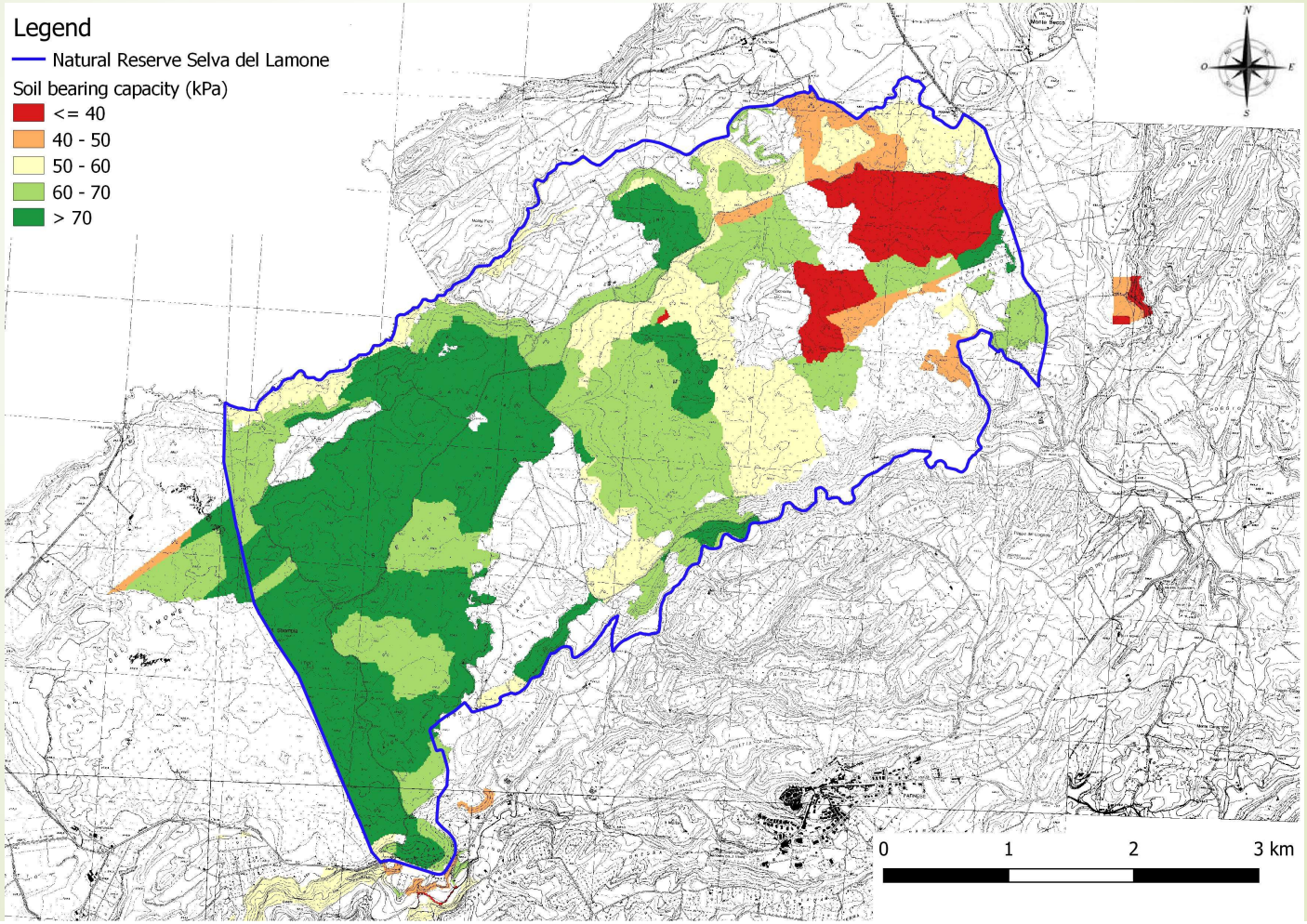
Extraction distance



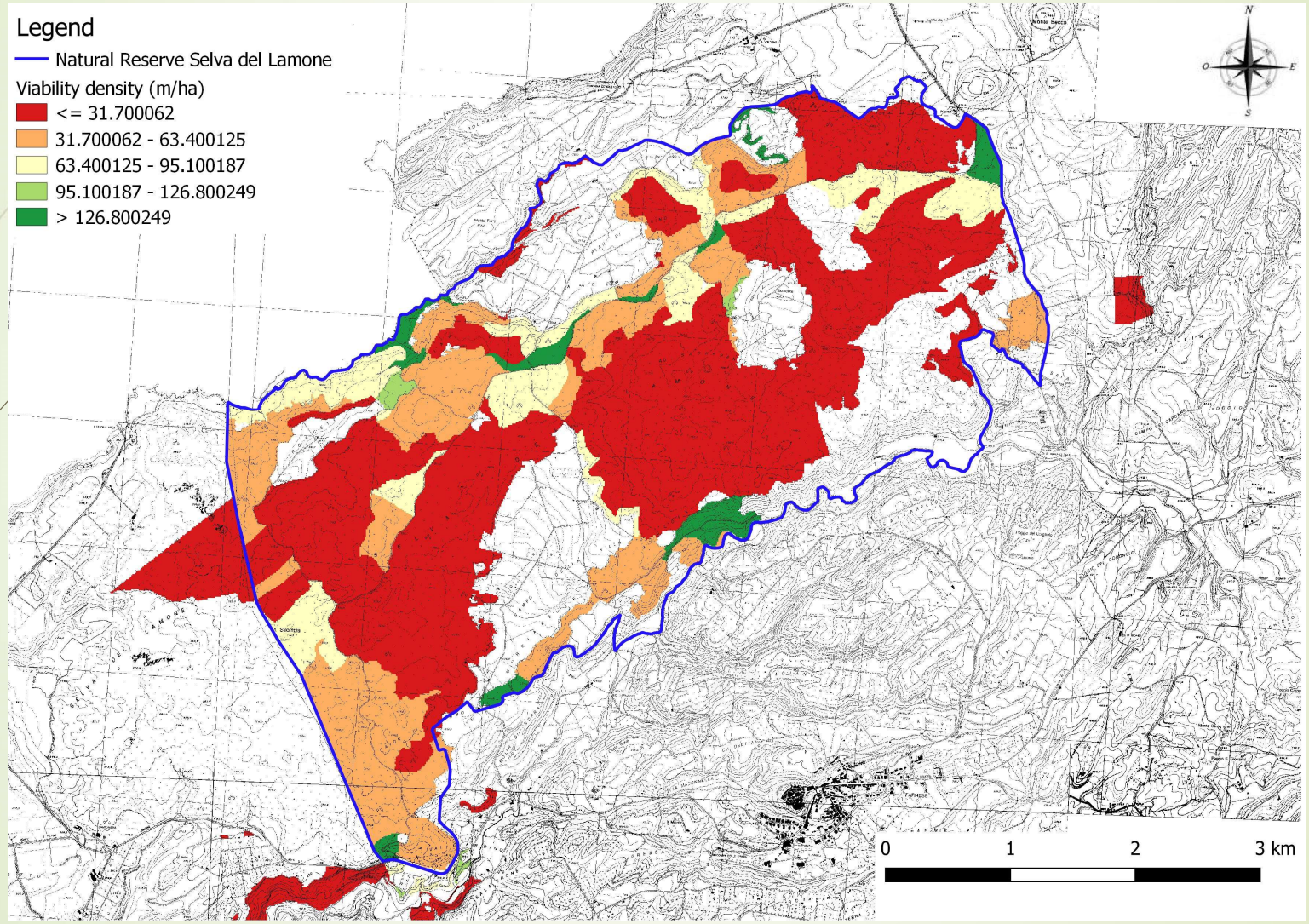
Extracted timber amount



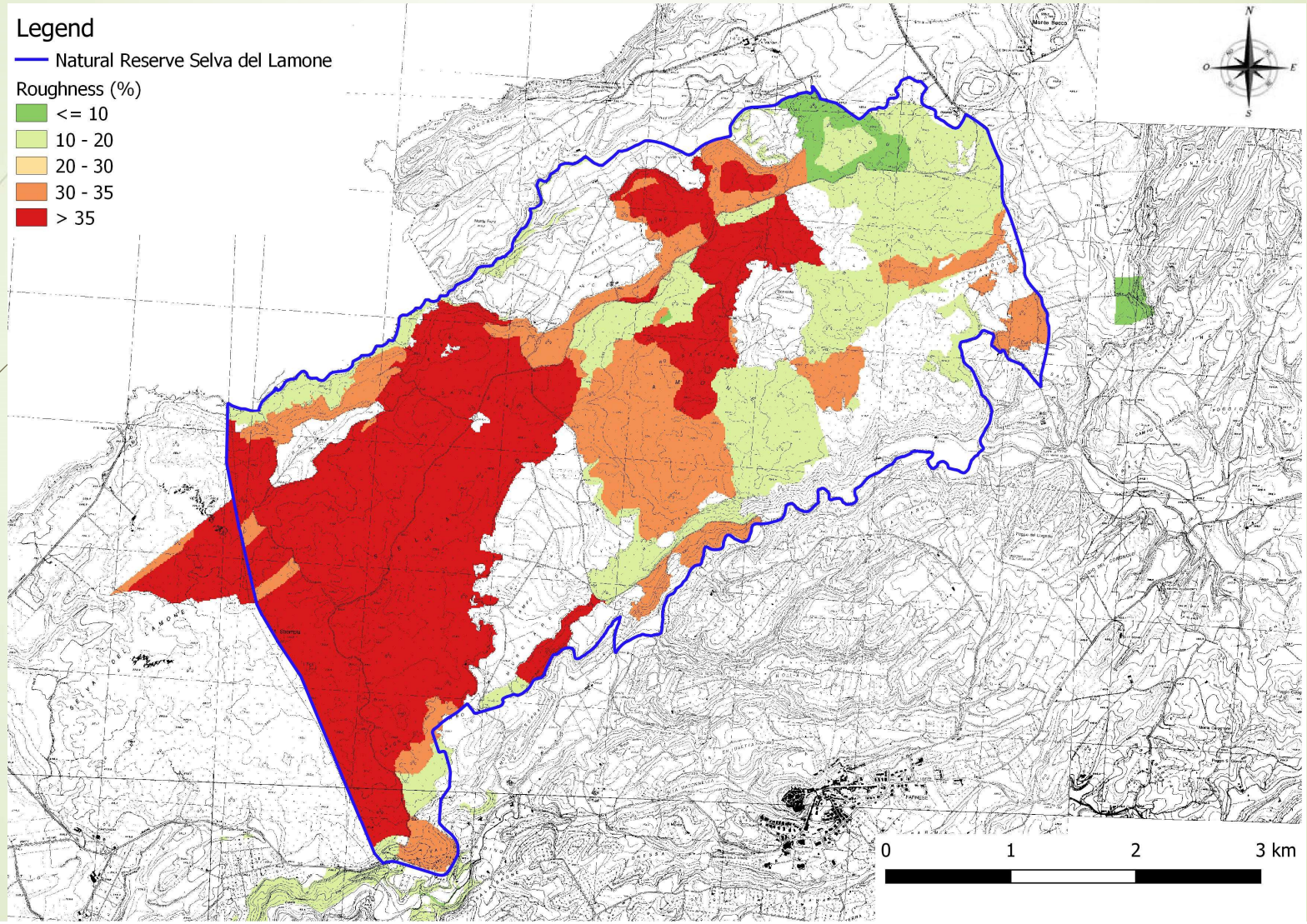
Soil bearing capacity



Viability density



Roughness


Legend
Natural Reserve Selva del Lamone
Roughness (%)
<= 10
10 - 20
20 - 30
30 - 35
> 35
N
O
E
S
0
1
2
3 km

Extraction System	Criteria											
	Slope		Extraction Distance		Soil Bearing Capacity		Extracted Timber Amount		Road Density		Roughness	
	Range (%)	Score	Range (m)	Score	Range (kPa)	Score	Range (m^3 ha^{-1})	Score	Range (m ha^{-1})	Score	Range (%)	Score
Forwarder	0–20	5	0-100	5	>80	5	>200	5	>207	5	0–15	5
	20–40	4	100–200	5	60–80	4	100–200	4	138–207	4	15–30	4
	40–60	1	200–400	4	40–60	2	80–100	3	69–138	3	30–45	1
	>60	0	>400	1	<40	0	<80	1	<69	1	>45	0
Cable Skidder	0–20	5	0-100	5	>80	5	>200	5	>207	5	0–15	5
	20–40	5	100–200	1	60–80	5	100–200	5	138–207	5	15–30	5
	40–60	4	200–400	0	40–60	3	80–100	4	69–138	4	30–45	4
	>60	2	>400	0	<40	1	<80	3	<69	2	>45	3
Medium gravity Cable Yarder	0–20	0	0–100	1	>80	5	>200	5	>207	5	0–15	5
	20–40	4	100–200	3	60–80	5	100–200	5	138–207	5	15–30	5
	40–60	5	200–400	5	40–60	5	80–100	4	69–138	4	30–45	5
	>60	5	>400	5	<40	3	<80	1	<69	3	>45	4

RTS

Forwarder

Criteria	S	ED	SBC	ETA	RD	RG	weights	CR
S	1	1	0.5	1	1	1	0.143	0.0001
ED	-	1	0.5	1	1	1	0.143	
SBC	-	-	1	2	2	2	0.286	
ETA	-	-	-	1	1	1	0.143	
RD	-	-	-	-	1	1	0.143	
RG	-	-	-	-	-	1	0.143	

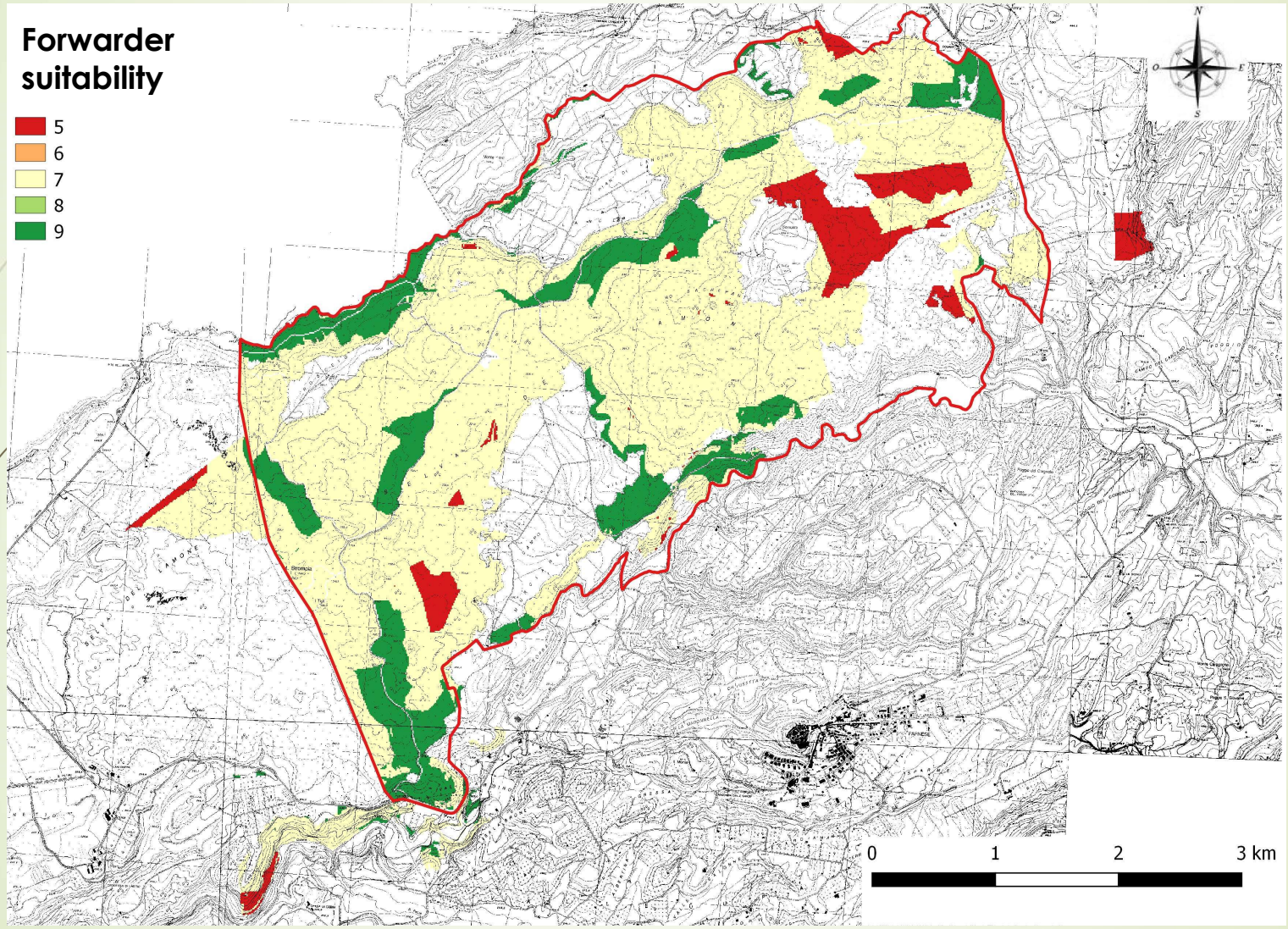
Cable Skidder

Criteria	S	ED	SBC	ETA	RD	RG	weights	CR
S	1	0.5	1	2	0.5	1	0.136	0.002
ED	-	1	2	3	1	2	0.259	
SBC	-	-	1	2	0.5	1	0.136	
ETA	-	-	-	1	0.3333	0.5	0.075	
RD	-	-	-	-	1	2	0.259	
RG	-	-	-	-	-	1	0.136	

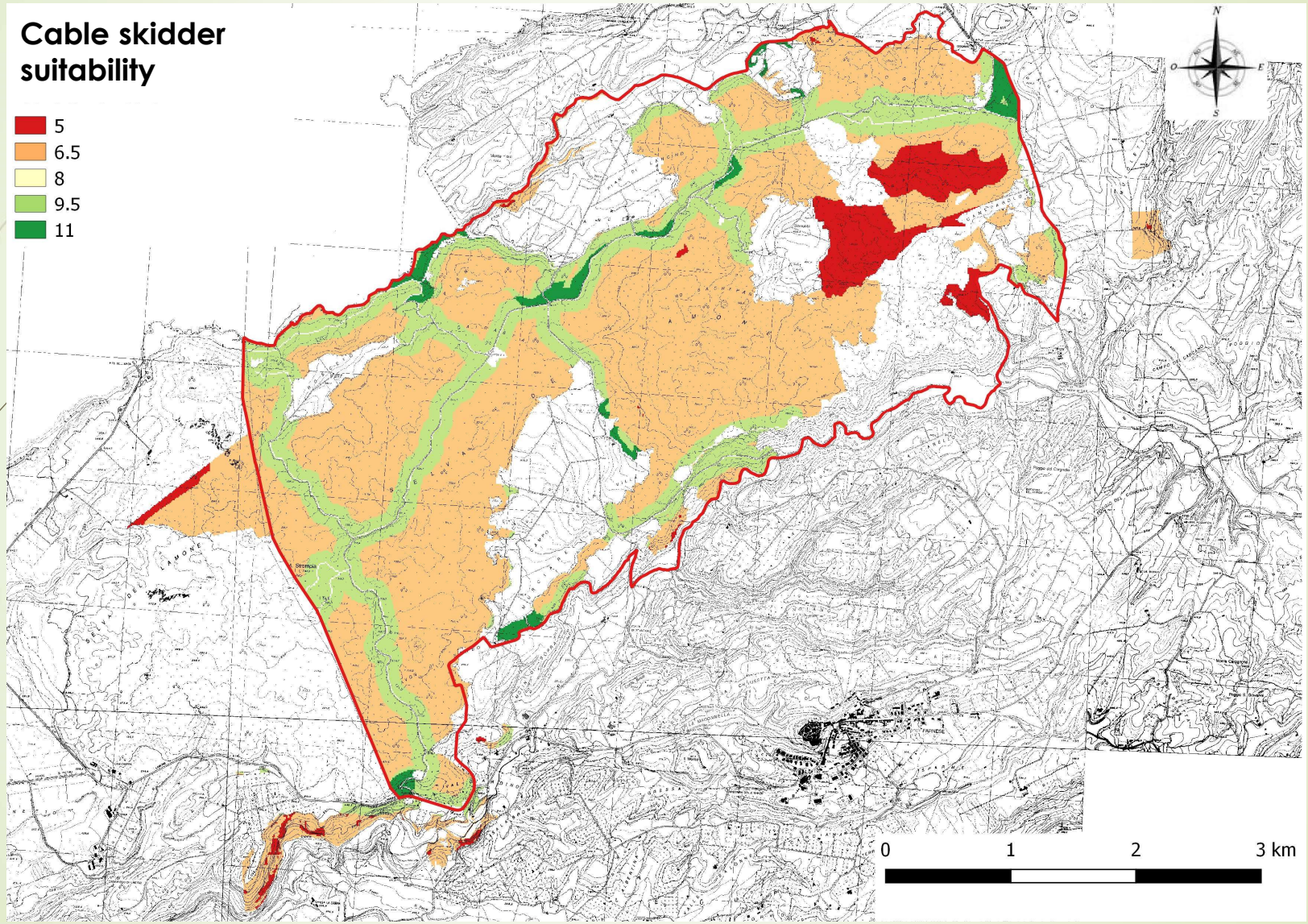
Medium Gravity Cable Yarder

Criteria	S	ED	SBC	ETA	RD	RG	weights	CR
S	1	1	3	0.3333	1	3	0.161	0.01
ED	-	1	3	0.3333	1	3	0.161	
SBC	-	-	1	0.2	0.3333	1	0.06	
ETA	-	-	-	1	3	5	0.399	
RD	-	-	-	-	1	3	0.161	
RG	-	-	-	-	-	1	0.06	

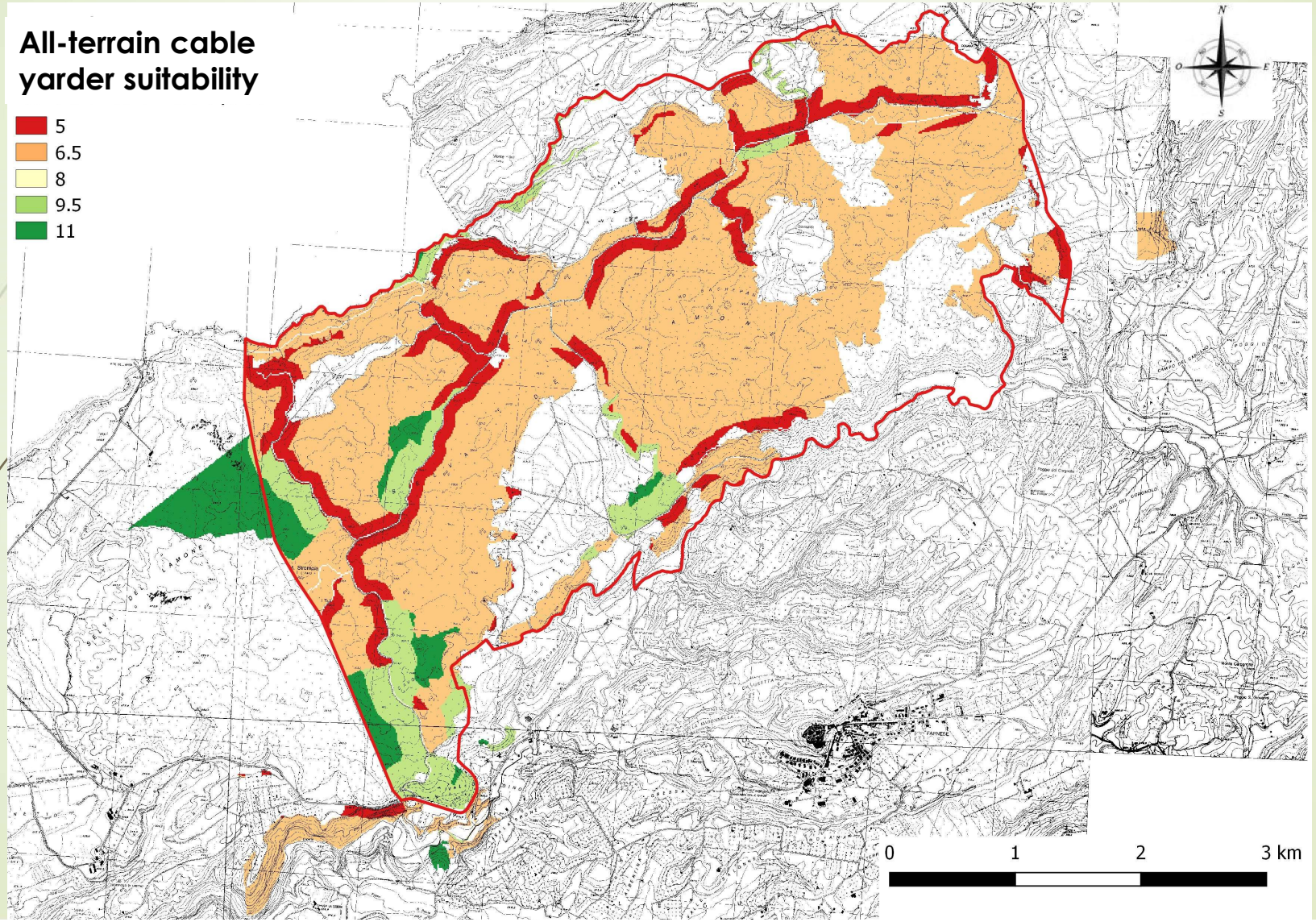
Results: forwarder suitability



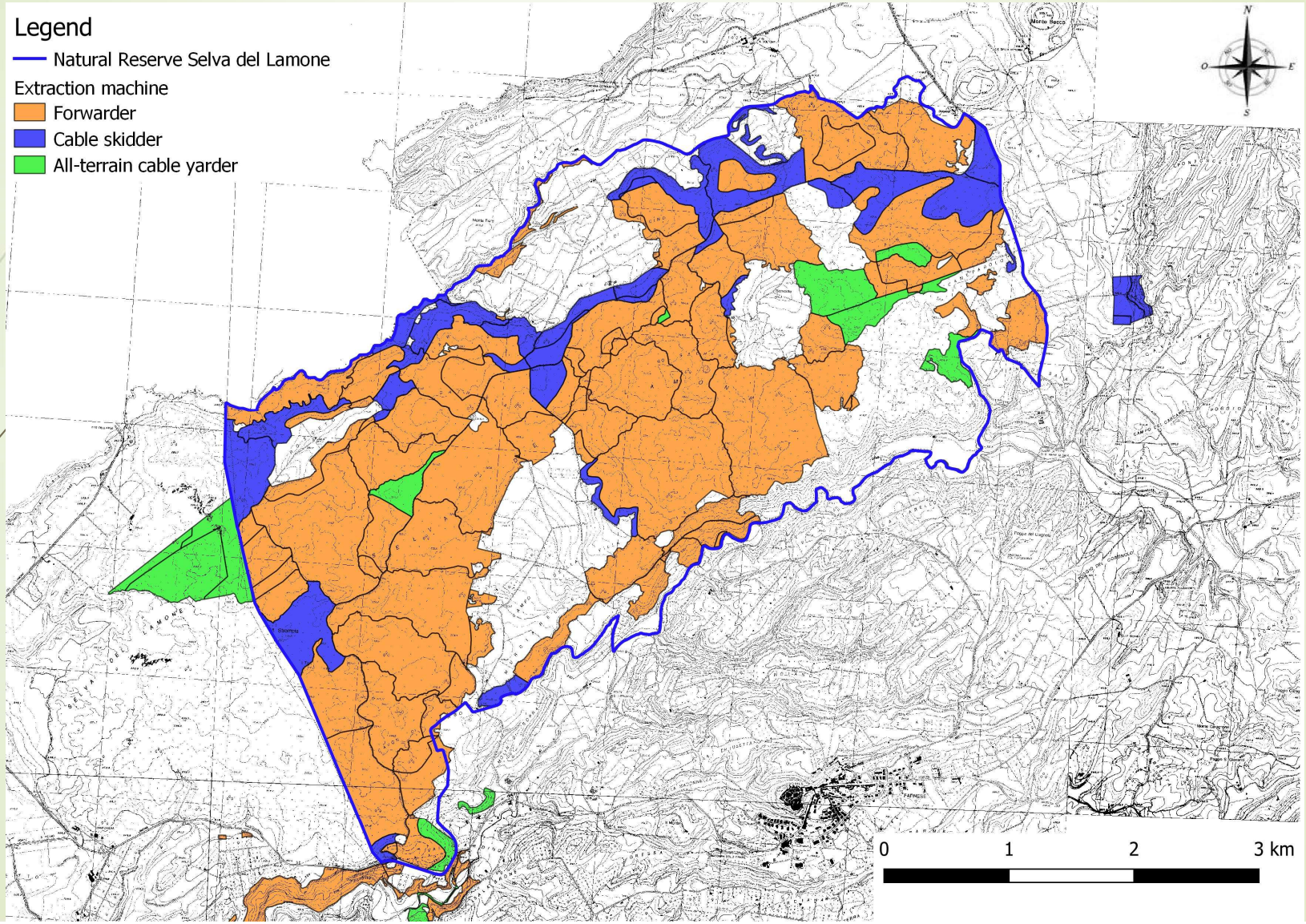
Results: winch suitability



Results: all-terrain cable yarder suitability

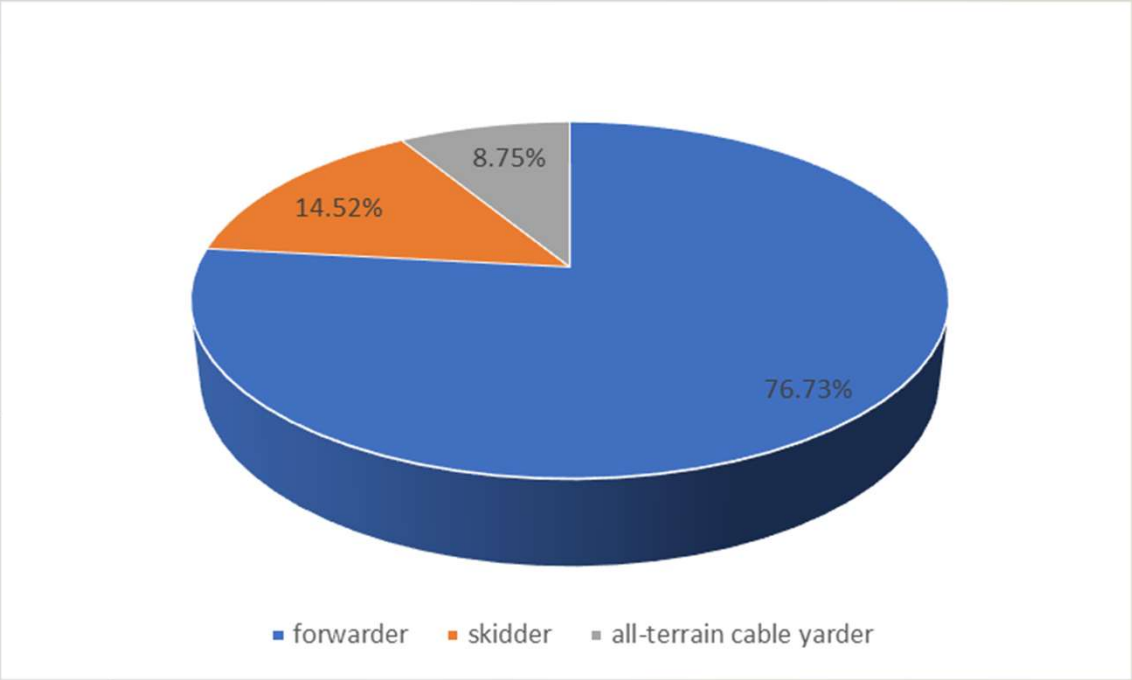


Results: forest harvesting plan

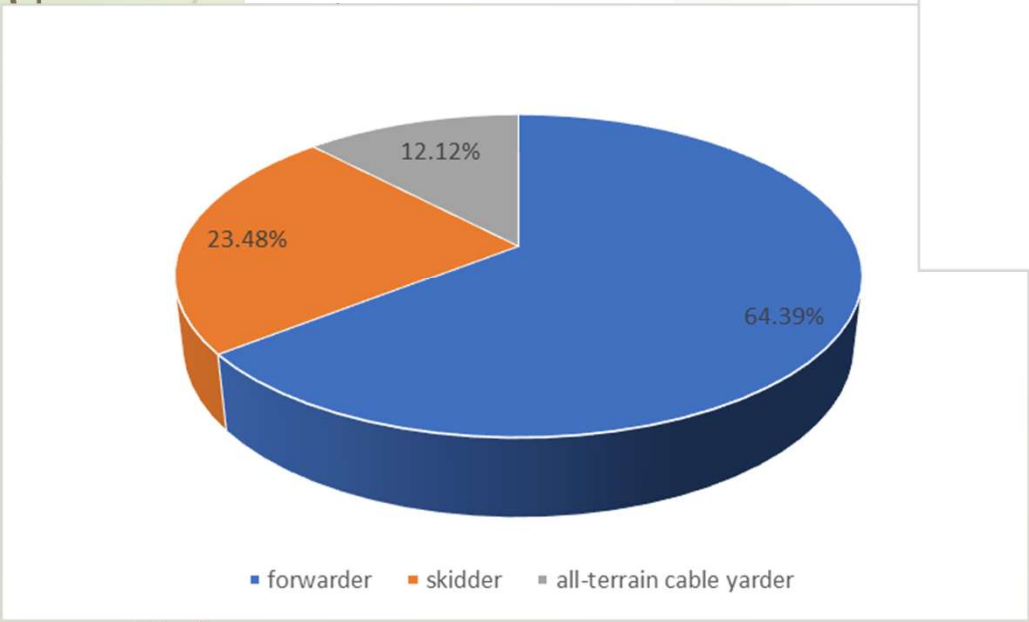


Results: forest harvesting plan

Surface percentage



Sub-compartments percentage



Discussion

- The most important parameter for selecting a forwarder for timber extraction resulted to be soil bearing capacity
- To select a cable skidder the most influencing parameters were the ones related to the presence of current viability (viability density and extraction distance)
- For all-terrain cable yarder the most important parameter resulted to be the amount of extracted timber
- Forwarder resulted the system most suitable for the major part of the surface, cable skidder resulted suitable along the existing viability while all-terrain cable yarders resulted suitable in the presence of the highest extracted timber amount and in conditions of low soil bearing capacity