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UNIVERSITÀ DEGLI STUDI DELLA Tuscia

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Section: Forest Operations and Engineering

"Comparing accuracy of three remote sensing methods to evaluate soil impact related to forest operations"

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Aim of the study

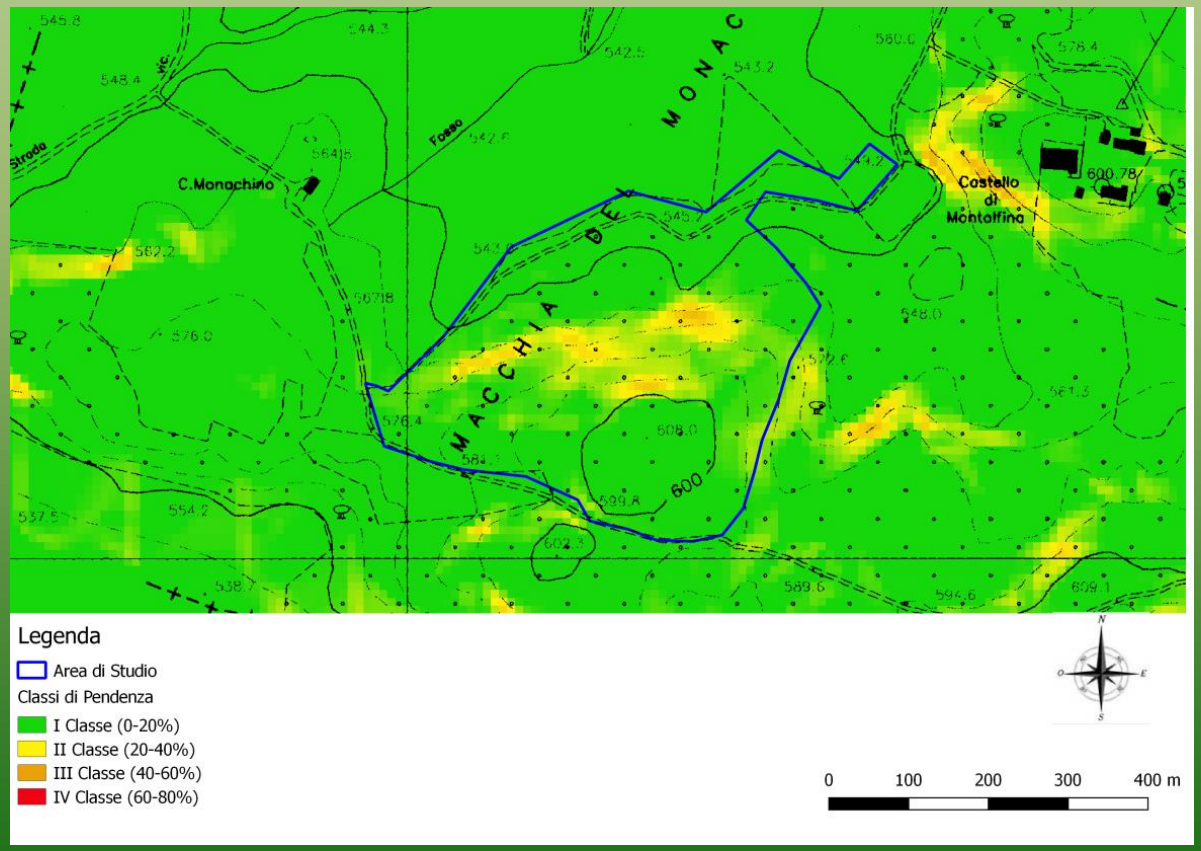
The aim of the present work was the **evaluation** of reliability of three different remote and proximal sensing tools for the assessment of **soil impact** related to **forest operations**

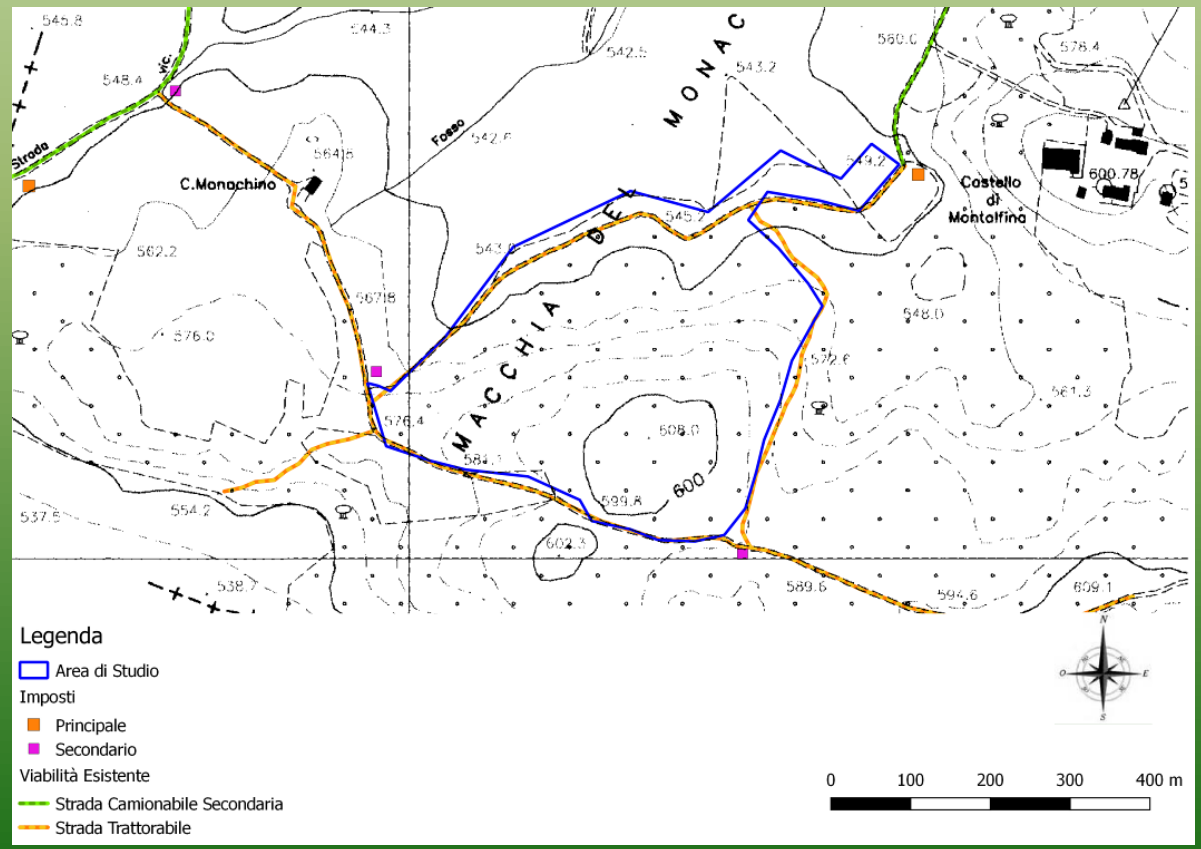
In particular: **Sentinel-2** images, **Google Earth** images, high resolution RGB images obtained through **UAV**

Study area

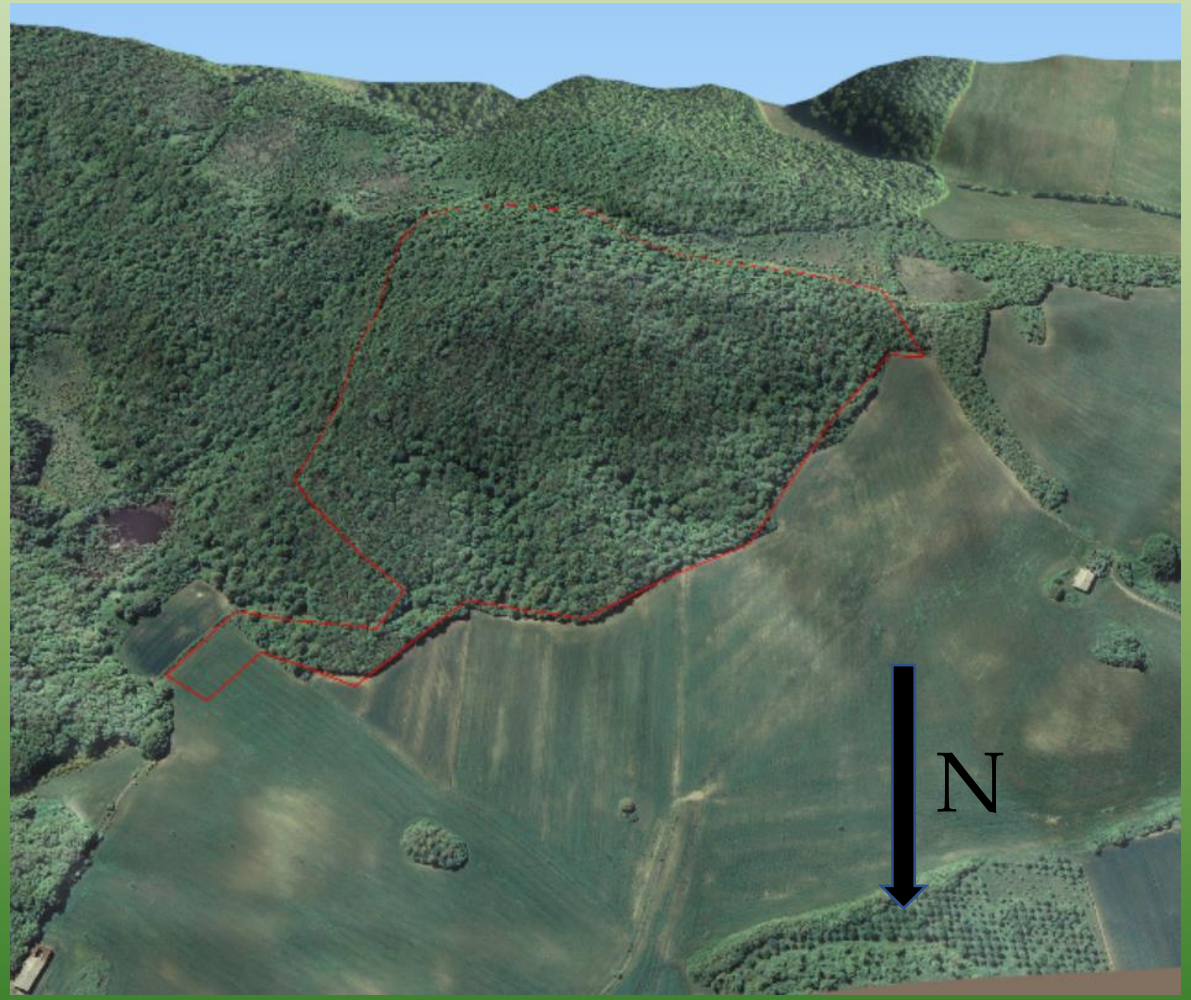
- Castel Giorgio Municipality, Umbria Region, Italy

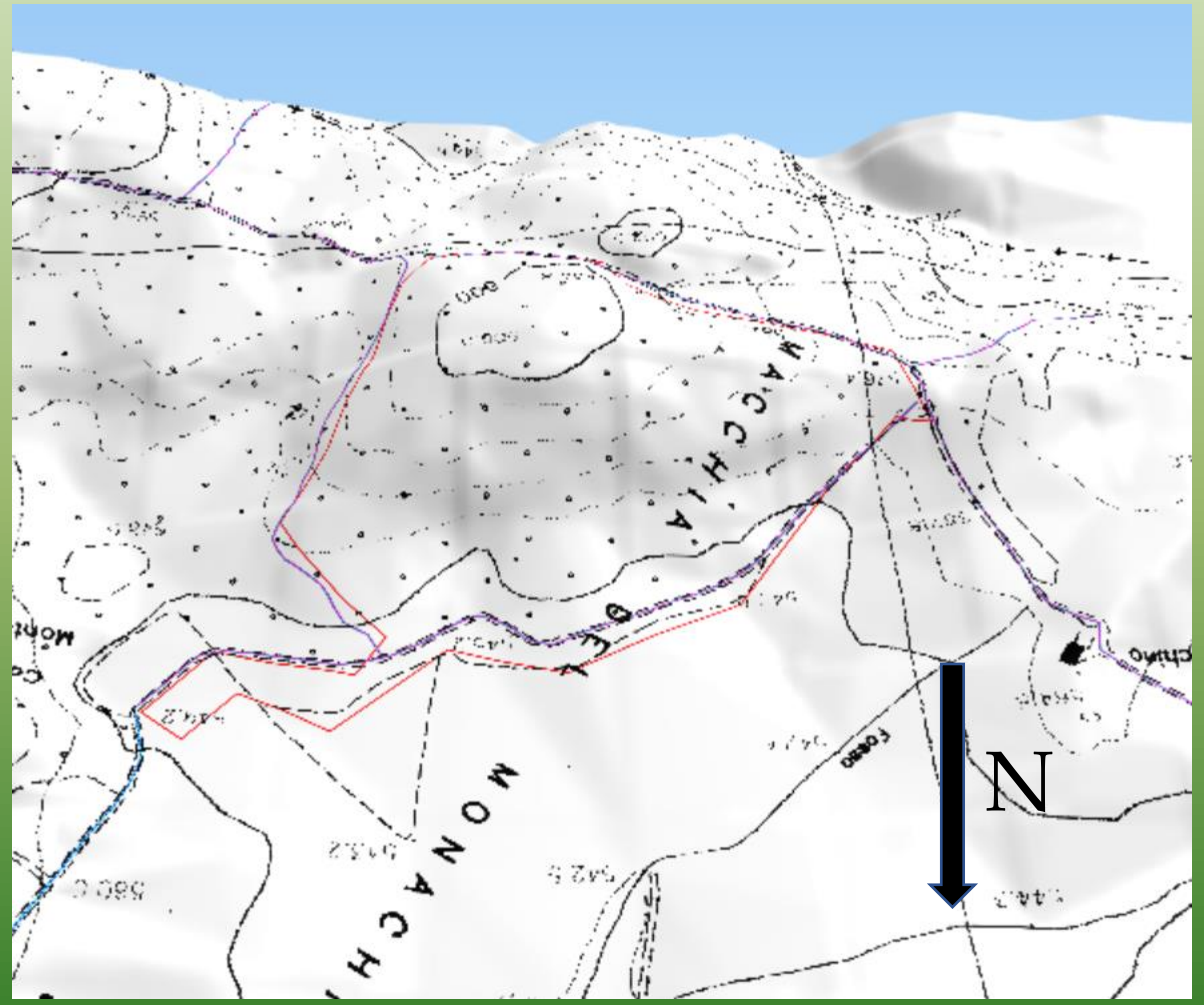
- Chestnut and turkey oak coppice with standards
-Average altitude 580 m a.s.l.
-Average slope 10%, maximum slope 35%





Study area





Materials and Methods

-GNSS field survey for the identification and recording of the all skid trails opened during the extraction operation

-UAV survey to obtain high resolution RGB images

Materials and Methods

-The tracks recorded through the GNSS receiver were imported in Quantum GIS 2.18 software

-Google Earth images of the area were imported into QGIS software interface through the plugin "Quick Map Service" and, by a photo-interpretation process, a line shapefile bearing the "new" skid trails detectable through satellite images was created.

-A similar procedure was applied for the high-resolution images provided by the UAV

-Sentinel-2 images were imported in QGIS, then a real-color image of the area was created to perform the photo-interpretation process, as applied for the other investigated systems

-It is important to underline that for Google earth and Sentinel-2 images it was possible to investigate all the study area, while for the UAV the analysis was limited to only 4 ha

-Twenty virtual sample plots with round shape of 1256 m^2 each (radius 20 m) were randomly identified within the intervention surface, to make possible the comparison between the real skid trails network (obtained by GNSS relief) and the theoretical network obtained by Google Earth and Sentinel-2 images

Materials and Methods

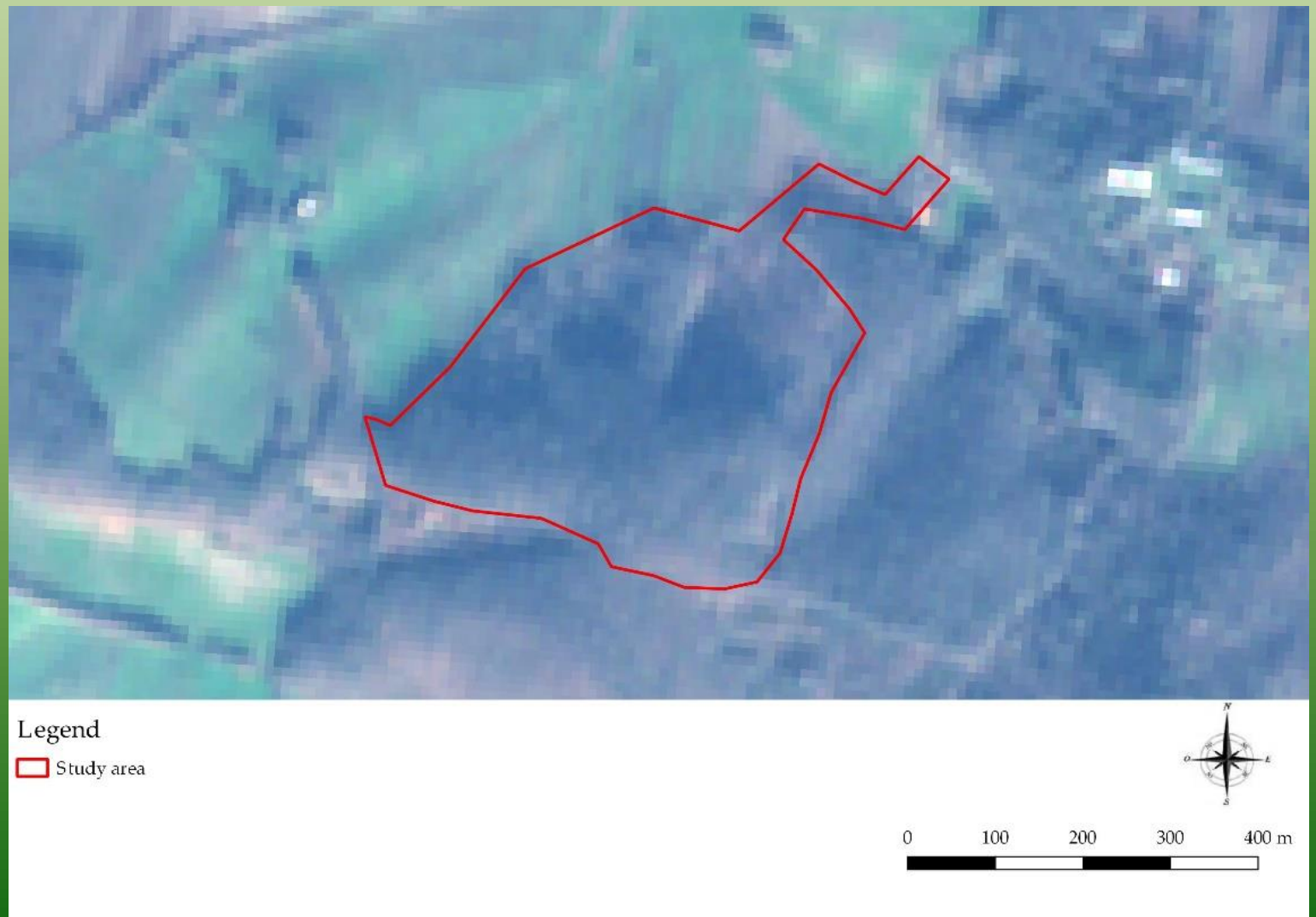
-A similar procedure was applied for the UAV skid trails network, but the dimension of the virtual sample plots was reduced to 314 m^2 each (radius of 10 m)

-Within each virtual sample plot, the skid trails length was identified in order to estimate the forest road density (m ha^{-1}) and the impacted surface (%), this last considering the average width of skid trails detected in the previous field relief

-Dependent samples T-test was performed to detect the presence of statistically significant differences between the “control” skid trails, obtained through GNSS, and the skid trails obtained through the different investigated approaches.

Results

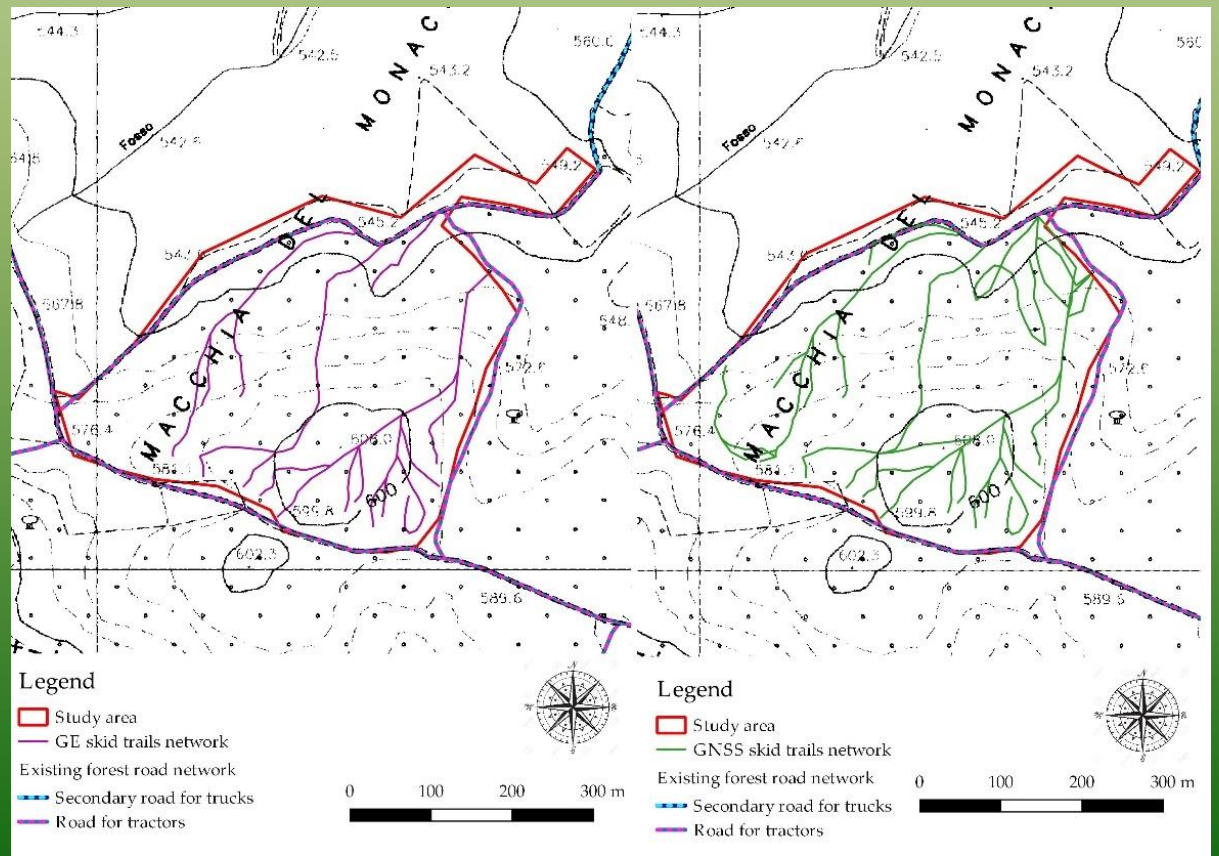
The first result of the work concerns the remark about the uselessness of Sentinel-2 images for impacted surface detection during forest operations. Indeed, the 10 m pixel of Sentinel-2 images does not allow the skid trail identification on the pattern



Results

	GE		GNSS	
	Avg.	St.Dev	Avg.	St.Dev.
Impacted surface (%)*	7.96	6.41	10.58	7.56
Road density (m ha^{-1})*	227	183	302	216

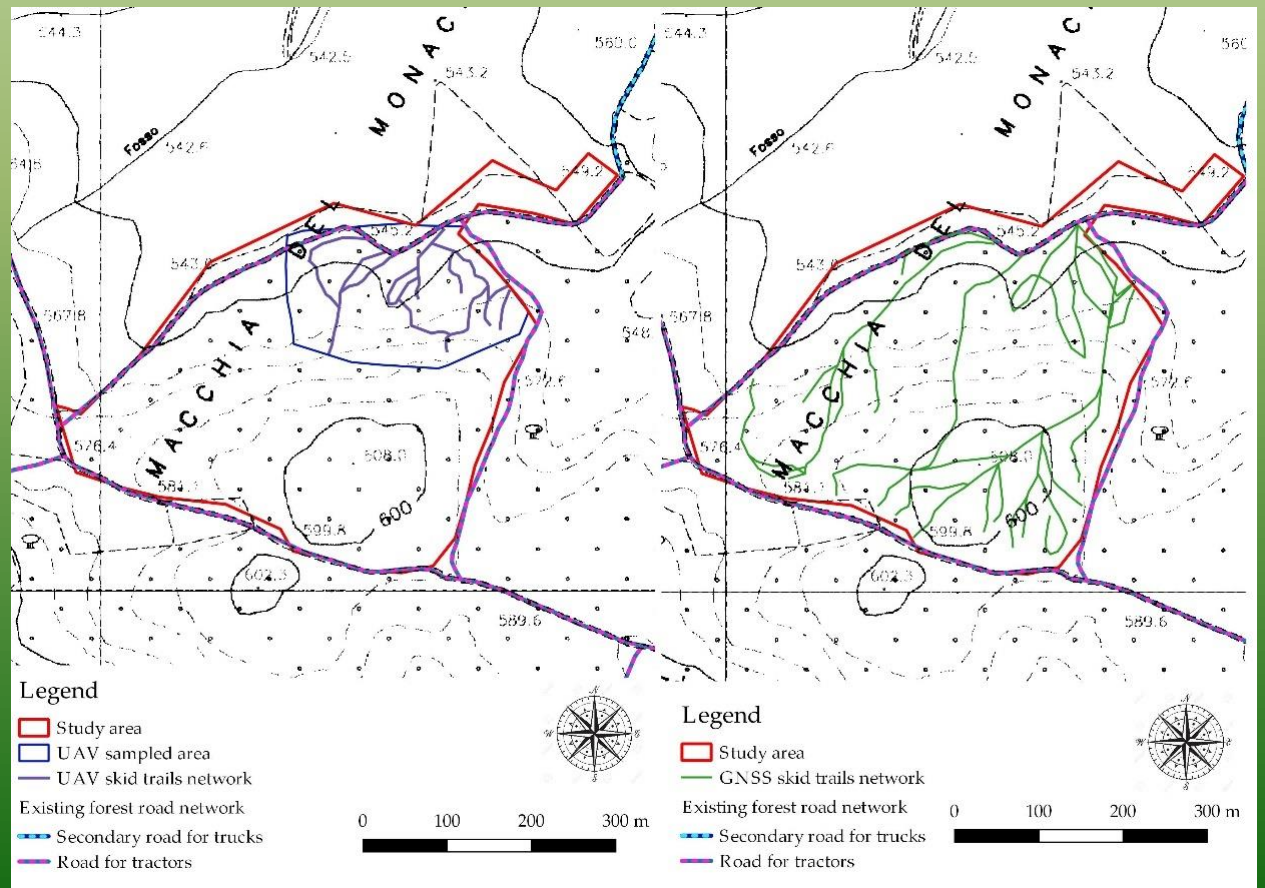
* Represents a statistically significant difference at p>0.05 according to dependent samples T-test



Results

	UAV		GNSS	
	Avg.	St.Dev	Avg.	St.Dev.
Impacted surface (%)*	14.04	12.34	10.58	7.56
Road density (m ha^{-1})*	401	353	302	216

* Represents a statistically significant difference at p>0.05 according to dependent samples T-test



Discussions and conclusions

-The first evidence, which was predictable, is that Sentinel-2 images, which are the highest resolution images freely available with short time lag (few days), are not suitable for the detection of forest soil impact related to machinery passing. The 10-m pixel is indeed not enough accurate to detect the tracks. So, even if Sentinel-2 is a very powerful tool for several forest application, it is not effective in soil impact monitoring.

-As a consequence, to deal with remote sensing in forest utilization, higher definition images are needed, which are generally not free to use. A partial exception consists in Google earth images, which are freely available, even if the updating time is about 1-2 years, which is obviously a substantial limit to carry out the monitoring of forest soil impacts.

-On the other hand, even if the statistical analysis revealed a significant underestimation of the impacted surface in comparison with the control skid trails pattern, Google Earth images seem to be a useful instrument.

-For what concerning the UAV with RGB sensor, it certainly revealed to be an interesting instrument, even if it with some limitations. The main limit consisted in the limited battery life which, currently, does not allow the relief of areas in accordance with the typical dimension of forest yards in Central Italy

Discussions and conclusions

To summarize:

- Currently, the best remote sensing system to monitor soil impacts related to forest utilization consists of high-resolution satellite images, which however are not freely available according to the needed short time lag

- UAV is a very interesting technology, which however needs to be further improved to be efficient in the conditions of Central Italy forestry

- GNSS field relief, even if costly and time consuming, is currently the best solution to monitor soil impacts related to forest operations

Thank You for the Attention