



Pushing the Boundaries with Research in Forest Engineering

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The evolution of a mountain road network from the original war-use to the forest one and its current management

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Introduction

- During the First World War period most of the front between Italian and Austro-Hungarian Armies lay on the Alpine areas
- The lack of transportation infrastructures forced to design and build a wide road network necessary for troops displacement and material supply
- The most of the roads are still present and used as forest road network



Introduction

- During the First World War period most of the front between Italian and Austro-Hungarian Armies lay on the Alpine areas
- The lack of transportation infrastructures forced to design and build a wide road network necessary for troops displacement and material supply
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Aims

- Road Network (RN) extension from the 1st WW to nowadays
- The evaluation of the original transport network according to its re-engineered condition and its current use

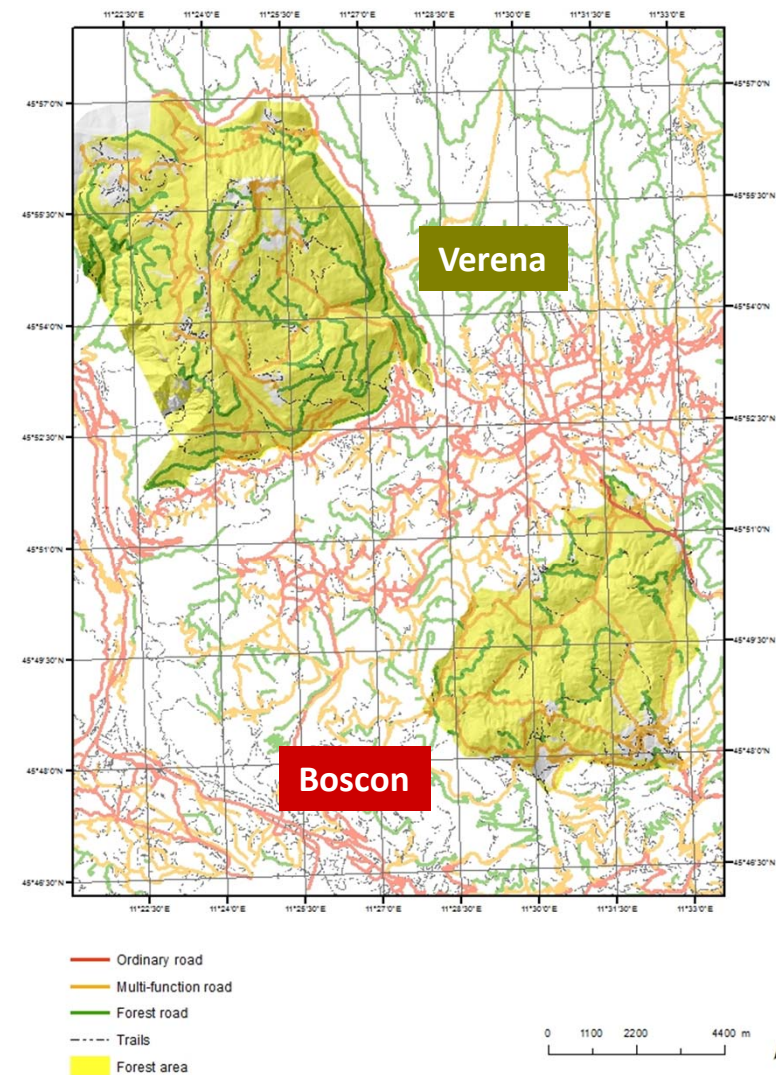


Material and methods

Studied sites

- Two sites were selected in the Altopiano dei Sette Comuni (NE of Italy)
- The two sites differed mainly for the terrain slope gradient

A first analysis focused on the status of the **current Road Network (2010-11 RN)** by GPS surveys during the 2010 and 2011



Material and methods

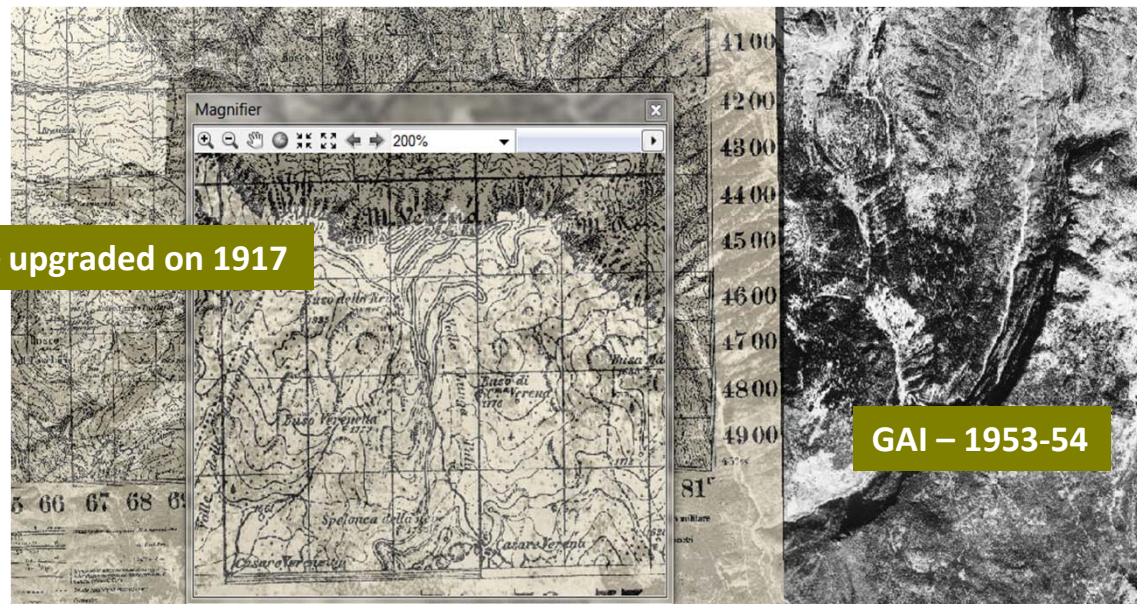
Historical RN (1915-17 RN and 1953-54 RN)

Road Network during the 1st WW (1915-17 RN)

- 9 maps of the *Carta d'Italia* revised on the 1917 with the same scale, revising time and origin (1:25 000)

Road Network at half of the XX century (1953-54 RN)

- Historical aerial-photos of the *Italian Aeronautic Group (GAI)* of the 1953-54 and corresponding cartographic maps (1:25000)



Carta d'Italia – upgraded on 1917

GAI – 1953-54



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Material and methods

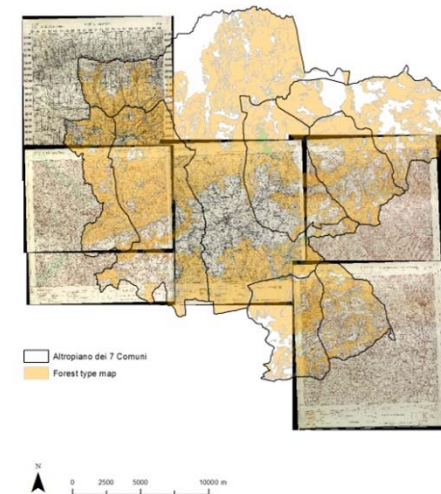
Characteristics of the 1915-17 RN

The *Carta d'Italia (1917)* divided the road network in 4 main operative classes plus one indicating permanent trails adapted to haulage by mules (*mulattiera*)

Class	Width m	Slope %	Other features
1	> 8	< 7; 7 - 12; > 12	Wall; bottlenecks and extra width
2	6 - 8	< 7; 7 - 12; > 12	Wall; bottlenecks and extra width
3	< 6	< 7; 7 - 12; > 12	Wall; bottlenecks and extra width
4	Not indicated	Not specified	Wall; bottlenecks and extra width
Mulattiera	Not indicated	Not specified	Not specified

The Class 4 is defined by width < 4 m and gradient also higher than 12%

The *mulattiera* is defined as a trail with a width variable between 1.5 to 2.5 m and a gradient higher than 10% up to 25%

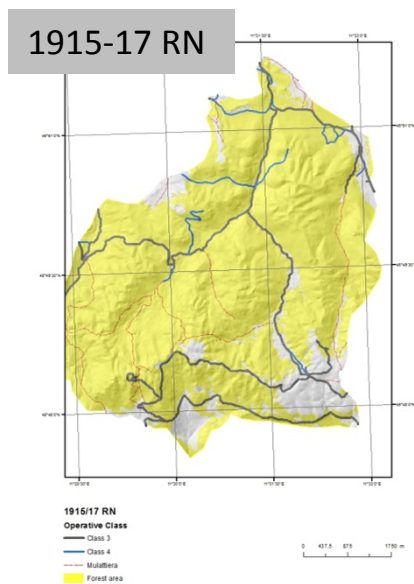


Material and methods

The RN extension database

The definition of the RN database for analyzing the upgrading of the RN considered:

1. The integration of the 1915-17 RN to the 2010-11 RN (overlapped segments)



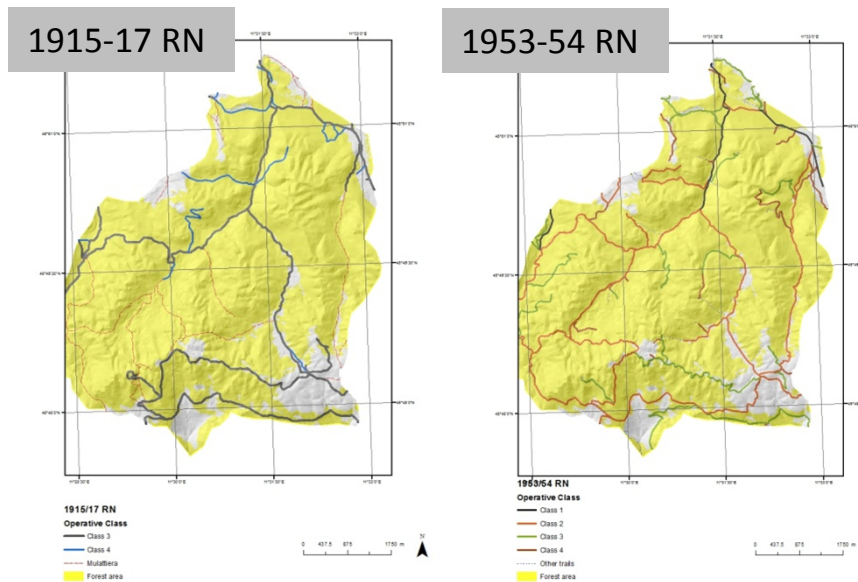
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2. The integration of the 1953-54 RN to the 2010-11 RN (overlapped segments)

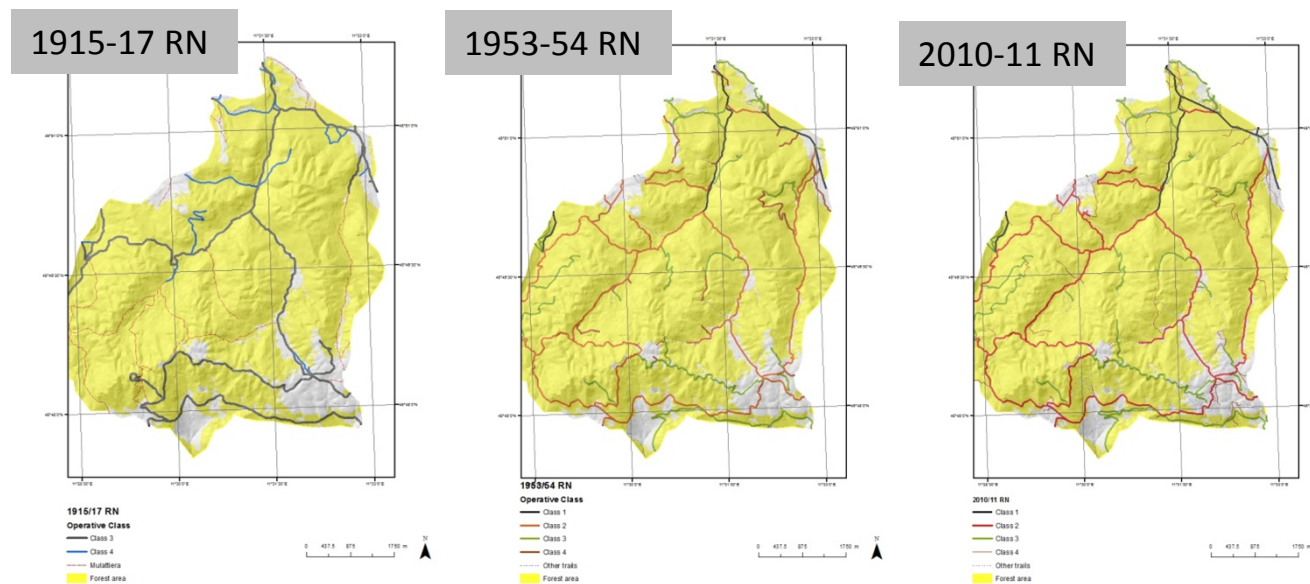


Material and methods

The RN extension database

The definition of the RN database for analyzing the upgrading of the RN considered:

1. The integration of the 1915-17 RN to the 2010-11 RN (overlapped segments)
2. The integration of the 1953-54 RN to the 2010-11 RN (overlapped segments)
3. The creation of the final RN database reporting the existence of the road segment during the 1915-1917, 1953-1954 and 2010-2011



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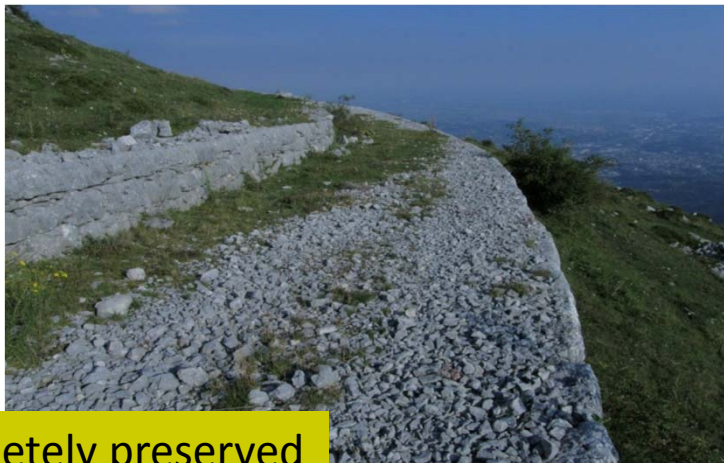
Material and methods

Evaluation of the 1915-17 RN condition

- The analysis attempted to survey the 2010-11 RN currently overlapping 1915-17 RN
- The surveyed sections (25 m length) were randomly extracted

In each section the survey focus on:

1. The 2010-11 RN compared to the 1915-17 RN: completely re-engineered, partially re-engineered, partially preserved, completely preserved
2. The deterioration of the historical artifacts: high, medium, low, not valuable



completely preserved

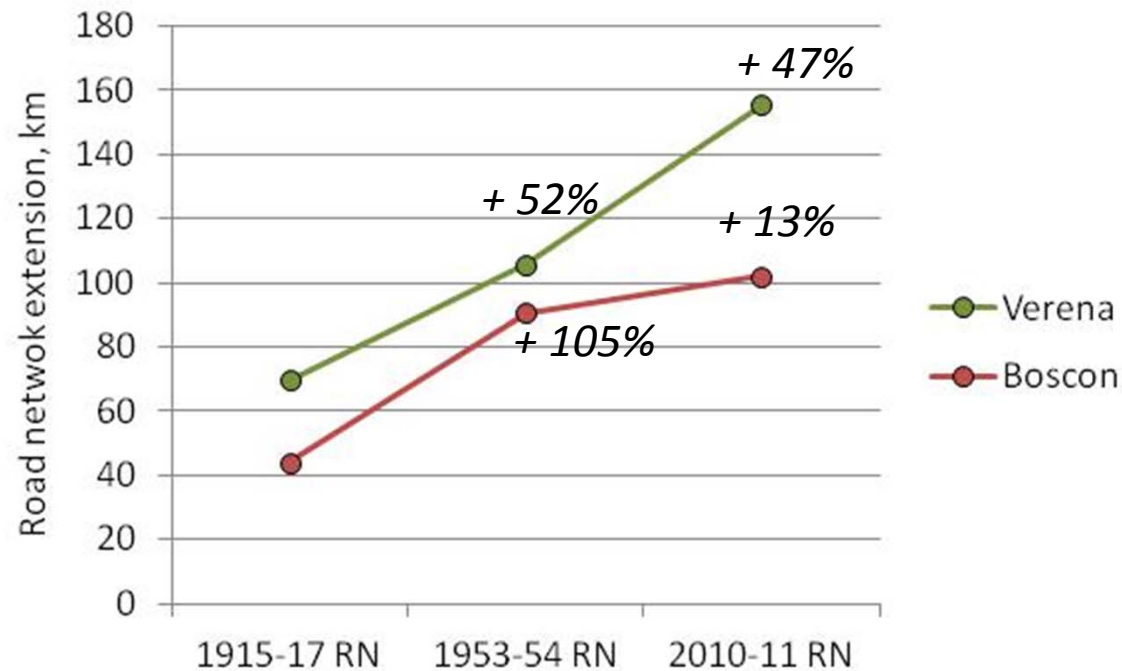


completely re-engineered

Results

Increment of the RN from 1915 to 2011

The analysis on the improvement of the RN indicated a considerable increment (+126%) of its extension from the 1st WW (1915-17 RN) to nowadays (2010-11 RN)

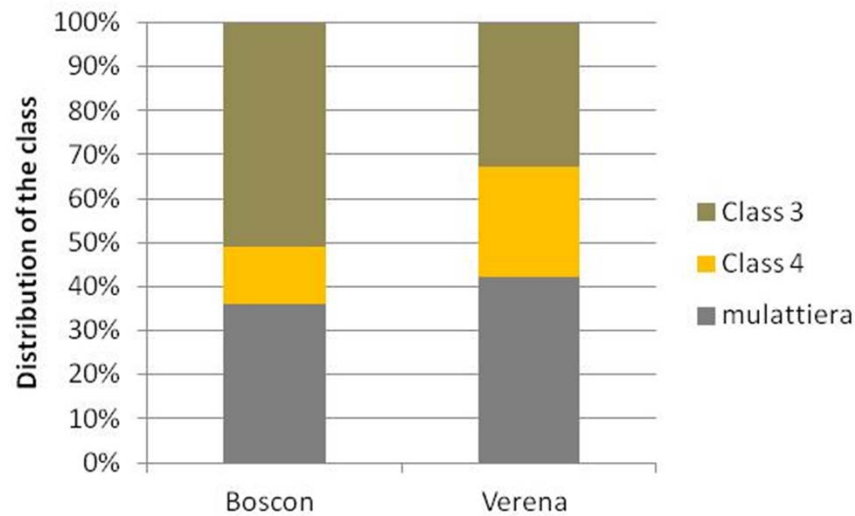


Results

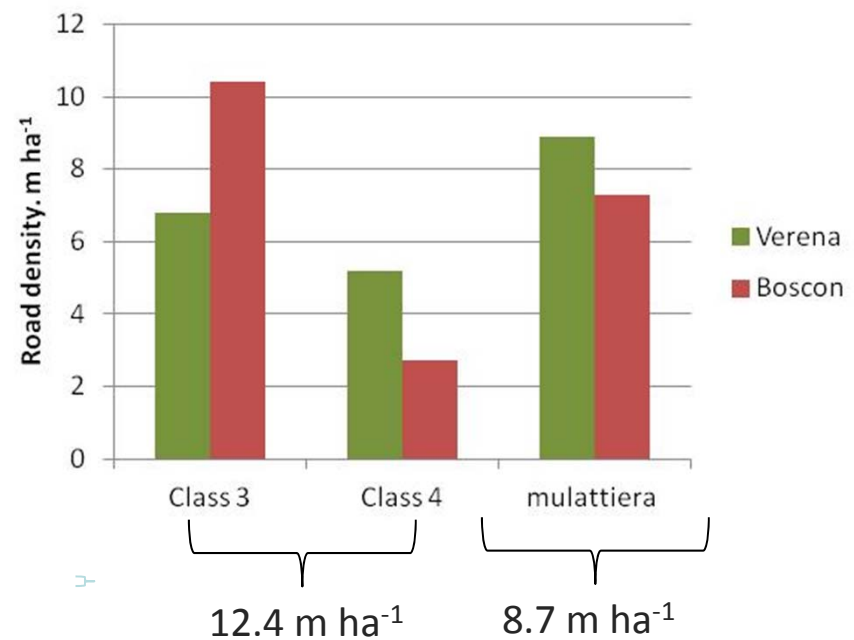
Original 1915-17 RN

The only class present in the 1915-17 RN were Class 3, Class 4 and *mulattiera*.

The roads were characterized generally by a width smaller than 6 m (including shoulders and carriageway) and the *mulattiera* was a considerable element of the 1915-17 RN



Terrain slope 28.8% 40.3%



Results

Original 1915-17 RN

The Analysis of Variance lets to compare the means of the road gradient between the operative classes for 214 segments extracted from 1915-17 RN

A	B	Road Gradient (VG)
		A-B
Class 3	Class 4	-1.0
	<i>mulattiera</i>	-4.3*
Class 4	Class 3	+1.0
	<i>mulattiera</i>	-3.3*
<i>mulattiera</i>	Class 3	+4.3*
	Class 4	+3.3*

(*the difference of the mean is significant at the 0.05 level)

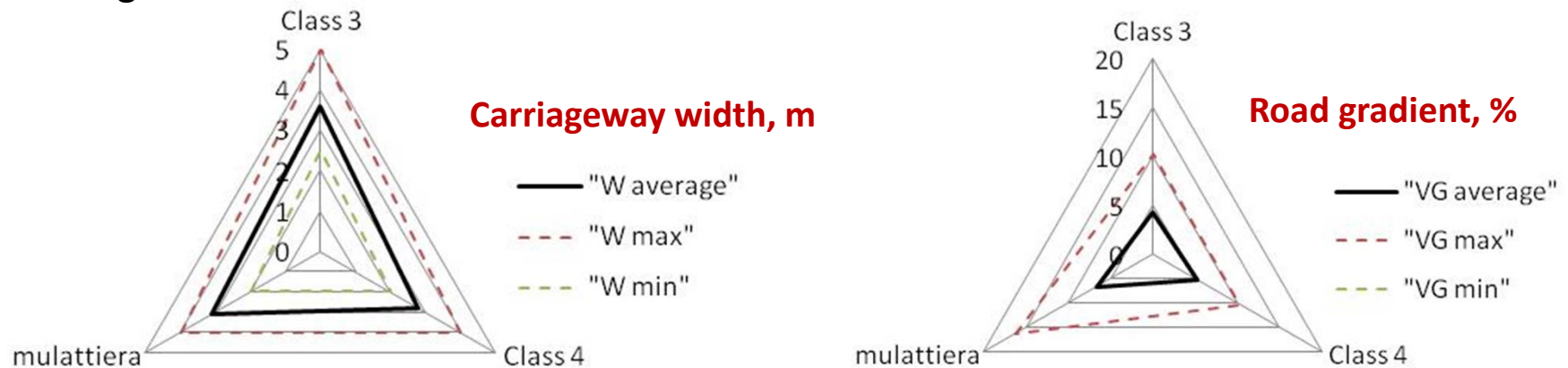
- The RN segments of Class 3 and Class 4 showed an average gradient of 5.75% and 6.72% with a maximum value of 18.8%
- The *mulattiera* was the element of the 1915-17 RN with the higher gradient (mean 10.0%, max 23.8%)



Results

Current status of the 1915-17 RN

- The 1915-17 RN still in use covers the 31.3% of the current 2010-11 RN
- The current carriageway widths (m) and road gradient (VG, %) were verified for 87 segments



A	B	Carraigeway (W, m)	Road Gradient (VG, %)
		A-B	A-B
Class 3	Class 4	+0.8 *	-0.9
	<i>mulattiera</i>	+0.6 *	-2.3
Class 4	Class 3	-0.8 *	+0.9
	<i>mulattiera</i>	-0.3	-1.4
<i>mulattiera</i>	Class 3	-0.6 *	+2.3
	Class 4	+0.3	+1.4

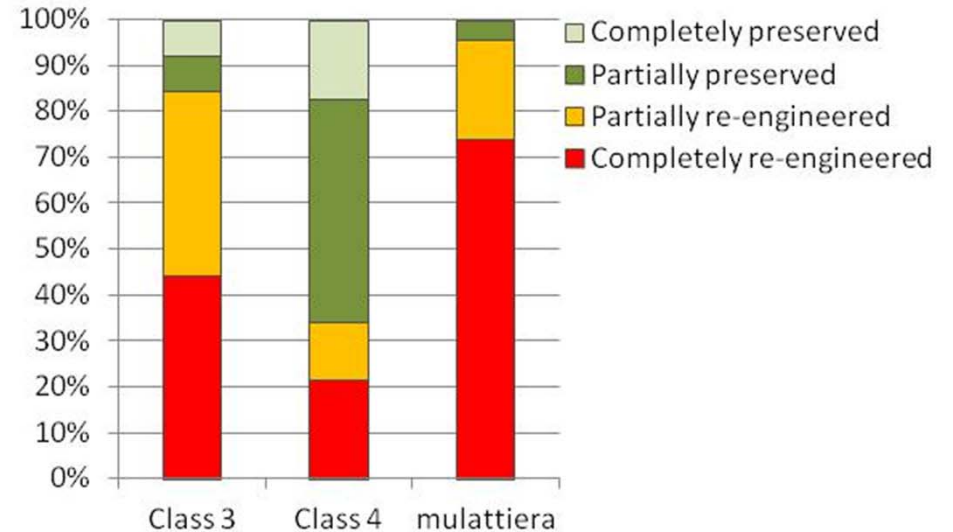
(*the difference of the mean is significant at the 0.05 level)

Results

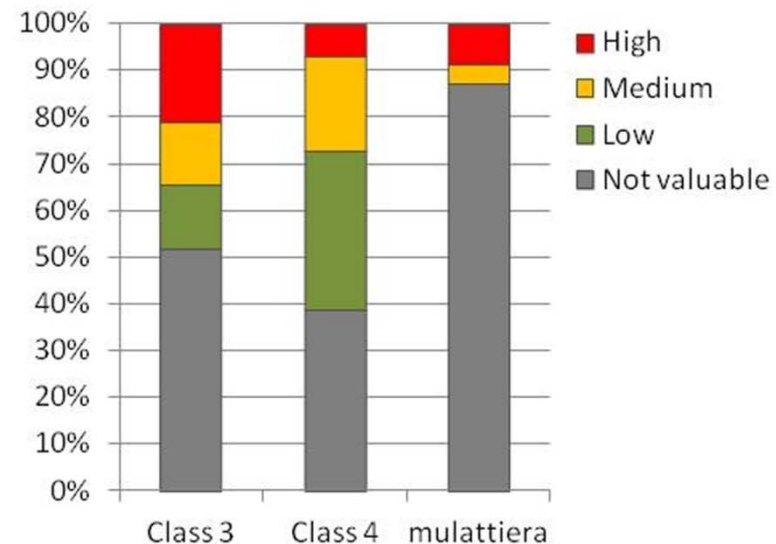
Current status of the 1915-17 RN

According to the *Carta d'Italia* classification

Upgrading of the 1915-17 RN



Deterioration of the alignment and artifacts of the 1915-17 RN

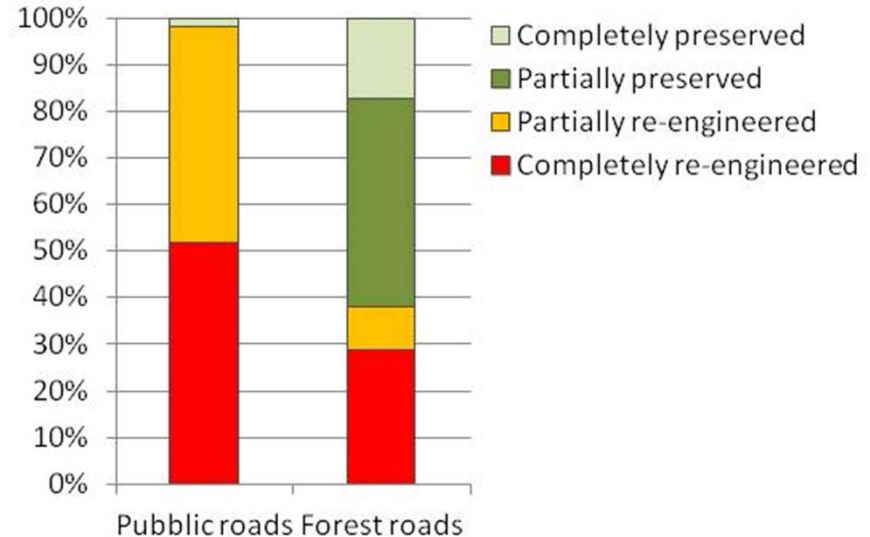


Results

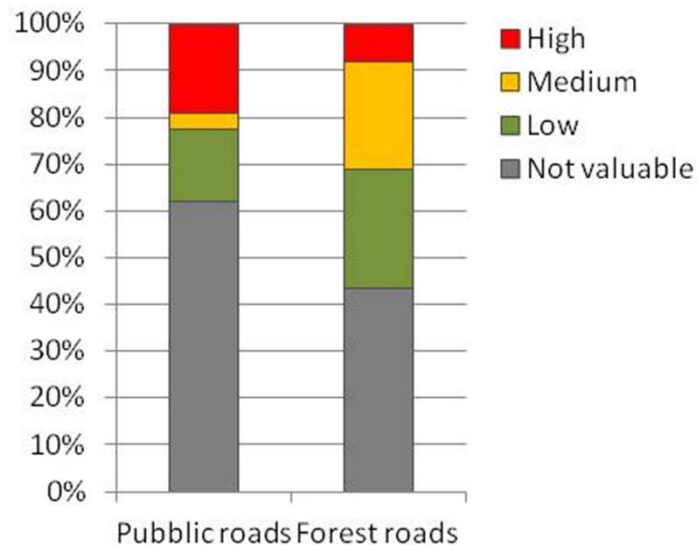
Current status of the 1915-17 RN

According to the current use

Upgrading of the 1915-17 RN



Deterioration of the alignment and artifacts of the 1915-17 RN



Conclusions

- The results confirms that an appreciable part of the 1915-17 RN is still in use
- A part of the 1915-17 RN has been substantially re-engineered in order to support the ordinary traffic related to agriculture and forest activities and nowadays also summer and winter recreational activities
- Part of the 1915-17 RN remained partially preserved because only used for low intensive forest activities

Further works

- Original detailed planning projects will be collected during the 2012 in order to get more details on the original road construction technique and materials
- The area will be covered by Lidar data which could support a more detailed analysis on the historical RN





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Thank you for your attention

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