The forgotten vulnerability: a geology- and history-based approach for ranking the seismic risk of earthquake-prone communities of the Italian Apennines

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Abstract

The 2016-2017 Central Italy earthquakes have shown that the local seismic risk is dominated by the extreme vulnerability of the building stock. We attempt to rank the vulnerability of Apennines' settlements based on a combined geological-historical approach. We first discuss the reasons of the apparent paradox caused by the very different seismic response of Amatrice and Norcia, both strongly hit by the 24 August 2016 earthquake (M_w 6.0). Based on the awareness that strong earthquakes force building reconstructions and changes in the individual and societal perception of seismic risk, we assume that the global vulnerability of Italian settlements increases with time since the last significant earthquake. We focus on the very active seismogenic areas straddling Italy's Apennines. We then use data on the local seismogenic sources and earthquake history to 1) select the municipalities that are more likely to suffer from destructive ground shaking, and 2) rank them as a function of the time elapsed since the latest earthquake, i.e. in terms of increasing vulnerability. We hence identified 716 municipalities, totaling about 5% of the Italian population, over 50% of which have not experienced destructive shaking since 1861, when the Kingdom of Italy reunited a number of smaller states. As such they are primary candidates to a poor performance in future significant earthquakes ($M_w > 5.5$) and should be given priority in any statewide vulnerability reduction plan. All results and elaborations, including the seismic history of each selected locality, are also supplied in a specifically designed web-GIS.

1. The 2016 Central Italy earthquake sequence

For over two millennia the Italian Apennines have been known for their large earthquake potential. An extraordinary large number of scholars have left accounts on Apennines earthquakes, to the point that the very word "Seismology" is credited to Robert Mallet, an Irish civil engineer, after his long visit to Val d'Agri, a region of southern Italy struck by a M≈7.0 earthquake on 16 December 1857 (*Mallet*, 1862). The earthquake potential of this youthful mountain chain is well portrayed in the official seismic hazard map of Italy (*MPS Working Group*, 2004; *Stucchi et al.*, 2011), where the Apennines seismogenic zone is shown as the largest hazard portion of the entire country. Hence, the M_w 6.0 earthquake that on 24 August 2016 shattered a sparsely inhabited area of the Central Apennines at the crossroad of the Abruzzo, Lazio, Marche and Umbria administrative regions (see Figure 1 and Table 1) was all but unexpected.

The earthquake took 299 lives and caused extensive damage in a 20x40 km region elongated parallel to the axis of the mountain chain. In particular, it destroyed the majority of buildings in Amatrice, a quiet mountain village that in summer increases the number of its residents nearly tenfold. In marked contrast, Norcia, a small ancient town dating back to pre-Roman times and located a mere 25 km to the NW, was rather mildly affected. Preliminary engineering analyses (*Cimellaro*, 2016; *Lanzano et al.*, 2016) have shown that in terms of PGA, PGV (Peak Ground Acceleration, Peak Ground Velocity) and frequency contents the ground motion was only slightly stronger in Amatrice than in Norcia (Table 2). According to *Lanzano et al.* (2016) and *Pischiutta et al.* (2016), the rupture exhibits along-strike directivity towards the NW, i.e. towards Norcia. Despite its limited size, however, the source of this earthquake has been shown to comprise two well-separated slip patches (*Tinti et al.*, 2016); the southernmost patch exhibits a strong up-dip directivity, thus justifying a short but strong acceleration pulse toward Amatrice. This finding is supported also by *Calderoni et al.* (submitted). Whatever the case, no sizable directivity effect can be invoked to justify major differences in the earthquake response of these two localities: yet Amatrice was assigned an intensity X-XI - a cumulative effect of the mainshock and of the largest aftershocks - while Norcia did not exceed intensity VI (*Azzaro et al.*, 2016; *Galli et al.*, 2016: unless otherwise noted, all intensities are supplied according to the Mercalli-Cancani-Sieberg [MCS] scale). See also *Zimmaro et al.* (2016) for a comprehensive summary of the earthquake effects.

Earthquake date	Origin time (UTC)	M_w	Epicentral area/ Municipality (Region)	Hypocentral Depth (km)	Lat N (°)	Lon E (°)
24 August 2016	01:36:32	6.0	Accumoli (L)	8.0	42.70	13.23
24 August 2016	02:33:28	5.4	Norcia (U)	7.5	42.79	13.15
26 October 2016	17:10:36	5.4	Visso (M)	8.7	42.88	13.13
26 October 2016	19:18:05	5.9	Visso (M)	8.0	42.91	13.13
30 October 2016	06:40:17	6.5	Norcia (U)	9.0	42.83	13.11
18 January 2017	10:14:09	5.5	Montereale (A)	10.0	42.53	13.28
18 January 2017	10:25:23	5.4	Montereale (A)	9.0	42.49	13.31

Table 1 – Summary of parameters of the seven largest shock of the earthquake sequence (M_w 5.4 and larger: all data from *ISIDE Working Group*, 2016). The complete sequence includes a large number of strong aftershocks (at least 65 earthquakes in the M_w range 4.0 to 5.3 have been reported to date). Administrative regions: A – Abruzzo; L – Latium; M – Marche; U – Umbria.

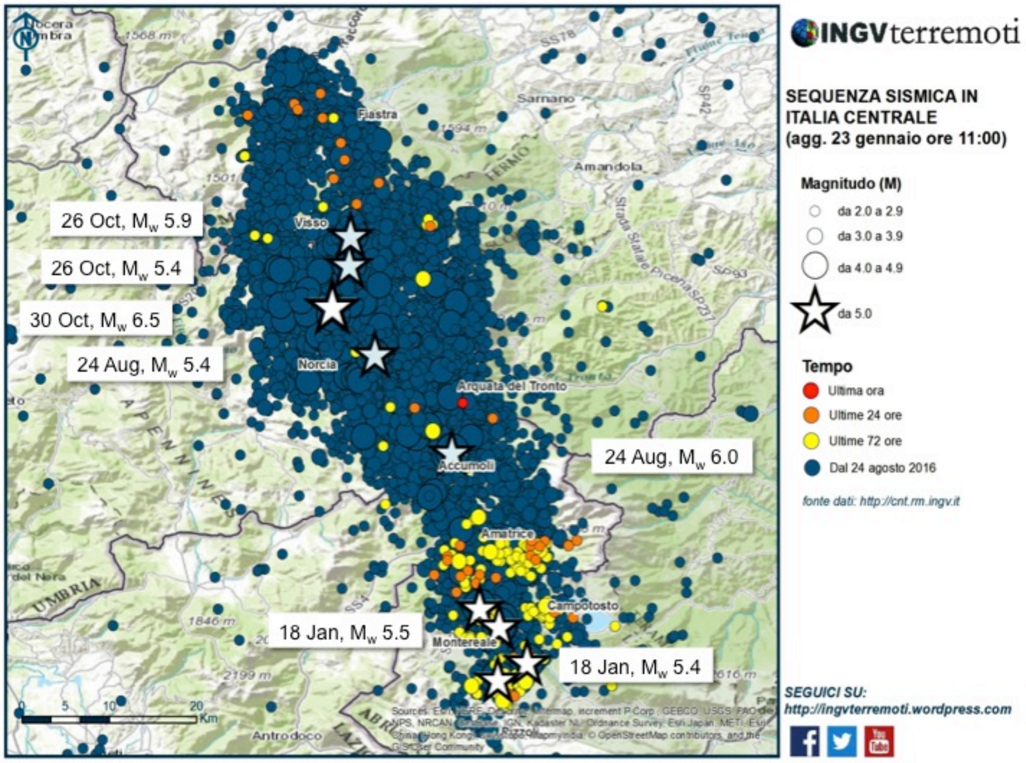


Figure 1 – Evolution of the 2016-2017 earthquake sequence as of 23 January 2017 (see also Table 1), showing the location of all mainshocks of M_w 5.4 and larger. All in all, the sequence affected an area that extends for about 80 km, straddling the axis of the Central Apennines and encompassing four administrative regions (Abruzzo, Lazio, Marche, Umbria).

On 26 October a M_w 5.9 shock hit a region northwest of the area struck by the August quake, causing extensive damage in many municipalities of the southern Marche region, and on 30 October a M_w 6.5 struck the region in between the epicentral areas of the two previous shocks (Figure 1). The epicenter of the latter and largest shock falls very close to Norcia, and its epicentral area encompasses many of the localities already shattered by the first two largest shocks and by a vigorous aftershock sequence. Unsurprisingly, the sequence continued into 2017 (Figure 1): on 18 January two further shocks of M_w 5.5 and 5.4 hit the region of Montereale-Campotosto, about 10 km southeast of Amatrice, raising concerns that additional ruptures could take place further to the southeast, towards and into the area hit by the 6 April 2009, L'Aquila event (M_w 6.3).

The 24 August shock was not preceded by foreshocks, which are rather common in Central Apennines earthquakes sequences (*Amato and Ciaccio*, 2011); nevertheless, the global complexity of the 2016-2017 sequence is reminiscent of other earthquake sequences that have struck this portion of the Italian peninsula (*Guidoboni and Valensise*, 2015).

Figure 2 – Aerial views of Amatrice and Norcia taken at the beginning of November 2016. In Amatrice (above) very few buildings were left standing by the combined effect of the 24 August and 30 October shocks. In Norcia, (below) the 30 October shock wrecked most of the St. Benedict church (its façade is still visible in the middle of the picture), but the rest of the town appears largely unscathed, including the Palazzo Comunale (Town Hall), located to the left of the church, along with its superb clock tower.

The 30 October shock was the largest earthquake to have occurred in Italy since the catastrophic 23 November 1980, M_w 6.9, Campania-Basilicata earthquake (southern Italy), which claimed over 2,900 victims. In contrast, no people were killed in the 26 and 30 October shocks, largely due to the limited number of residents still living in their homes by then, but almost all localities suffered additional damage with respect to the effects of the 24 August shock. Amatrice was reported totally destroyed by this further strong shock (XI MCS: *Tertulliani and Azzaro*, 2016a; Figure 2 above), while Norcia, which effectively sits on the portion of the seismogenic fault that released most of the seismic moment, suffered an estimated intensity VIII-IX (*Tertulliani and Azzaro*, 2016b). The quake indeed demolished the St. Benedict cathedral (Figure 2 below) and damaged several other churches: but much to the surprise of local residents, civil protection officers and scientists, it left many historical buildings of the medieval part of the town largely unscathed. In fact, by the end of December 2016 - i.e. just two months after the 30 October shock - the center of Norcia was reopened to the public, whereas in the center of Amatrice the few portions of buildings which survived the four largest shocks were demolished.

2. The Amatrice-Norcia apparent paradox: a lesson to be learned

There are at least two outstanding observations stemming from the 2016-2017 Central Italy earthquakes. The first observation concerns the drastically different response shown by the historical centers of Norcia and Amatrice, following both the 24 August, M_w 6.0 quake, located halfway between the two towns, and the 30 October, M_w 6.5 quake, located much closer to Norcia. Having verified that the ground shaking was roughly comparable in the two towns both on 24 August and on 30 October (Table 2), and that preliminary analyses show little evidence for significant and systematic amplifications of the ground motion in Amatrice with respect to Norcia, what is the reason for such a large discrepancy?

Earthquake Date (M_w)	Station/ Comp	Epicentral distance (km)	PGA (cm/s²)	PGV (cm/s)	PGD (cm)	PSA03 (cm/s²)	Td (s)	Arias intensity (cm/s)	Intensity MCS	Intensity EMS98
24 Aug (6.0)	AMT/E-W	9.58	915.97	44.25	2.96	1,786.88	3.89	171.23	X-XI*	X**
	AMT/N-S		445.59	39.11	7.03	566.87	3.60	65.80		
	NRC/E-W	14.25	331.61	29.20	6.25	711.12	6.31	94.72	VI*	V-VI**
	NRC/N-S		376.96	19.16	5.67	631.13	7.51	75.39		
26 Oct (5.9)	AMT/E-W	34.06	104.89	6.20	0.85	348.21	10.10	5.74	---	---
	AMT/N-S		60.60	3.77	0.89	164.23	11.59	2.42	---	---
	NRC/E-W	13.91	242.27	18.99	2.00	357.20	12.13	27.60	---	---
	NRC/N-S		346.67	19.95	1.74	397.90	9.40	49.79	---	---
30 Oct (6.5)	AMT/E-W	27.20	607.01	26.36	5.68	698.40	5.58	144.51	XI***	XI***
	AMT/N-S		440.07	29.71	4.20	1,335.17	6.00	63.08		
	NRC/E-W	5.39	477.19	47.05	10.22	1,894.83	10.47	327.02	VIII-IX ***	VIII-IX***
	NRC/N-S		326.71	38.81	8.40	1,130.05	10.45	218.22		

Table 2 – Summary of strong motion parameters recorded at the stations Amatrice (AMT) and Norcia (NRC) of the Italian Strong Motion Network (RAN: http://ran.protezionecivile.it/EN/index.php) and estimated intensities for the three largest shocks of the earthquake sequence. Key: PSA03 = Pseudo Spectral Acceleration at 0.3 s; Td = 5%-95% duration of Arias intensity (*Trifunac and Brady*, 1975). Intensity data are from: * *Galli et al.* (2016); ** *Tertulliani and Azzaro* (2016b); ****Tertulliani and Azzaro* (2016a). The symbol "---" indicates lack of information.

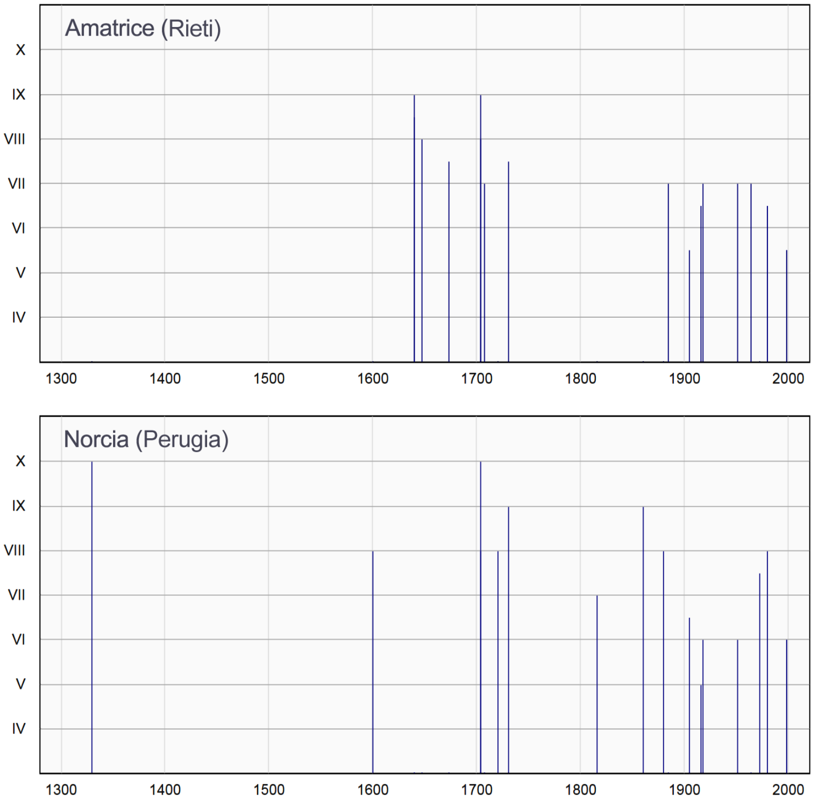
The second observation is more relevant for seismologists, though it is largely a consequence of the first. All the earthquakes of the 2016-2017 sequence occurred in the same tectonic regime, and their causative sources exhibit similar geometry, comparable hypocentral depth and presumably similar stress drop (e.g. *Chiaraluce et al.*, 2017). Yet a M_w 6.0 earthquake caused an estimated MCS intensity X-XI at one site and VI at a nearby site, and the latter site suffered only an intensity VIII-IX as a result of a M_w 6.5 shock occurring at a very short distance from it. How can these circumstances be reconciled? Is there a lesson to be learned from these observations? In other words, do these differences and discrepancies teach us a lesson that can be used to prevent the destructions and the casualties that will inevitably be caused by future earthquakes in nearby areas, or in Italy in general?

We believe the keywords to understand the essence of such differences and discrepancies are *vulnerability* and *time*. The *vulnerability* is the only component of seismic risk that may explain the striking difference between the complete destruction suffered by Amatrice and the comparatively modest damage suffered by Norcia: a circumstance which we will refer to as the *Amatrice-Norcia apparent paradox*. In the debate that followed the summer-fall 2016 earthquakes on the Italian media as well as in the international arena (see for example Temblor.net, a website and an app that enable users to assess their seismic exposure and earthquake preparedness) there is an overwhelming consensus that this paradox is only apparent and is largely the result of drastic differences in the vulnerability of Amatrice and Norcia.

To explore the origin of such differences we must first briefly elucidate how Amatrice and Norcia have developed over the past few centuries. Table 3 and Figure 3 summarize their seismic histories: despite the limited distance between the two towns – about 25 km – they have less than 50% of the events in common, suggesting that most of the earthquakes occurring along this stretch of the Central Apennines are relatively small, or rather shallow, or both. The main exception is the catastrophic 14 January 1703 earthquake (estimated M_w 6.9), which ruined both towns. This was the first large shock of a complex sequence that evolved with subsequent ruptures culminating on 2 February 1703 with an estimated M_w 6.7 earthquake; this shock destroyed L'Aquila, located about 32 km south-southeast of Amatrice and 55 km southeast of Norcia (see *Guidoboni and Valensise*, 2015, for a comprehensive report on this sequence). A summary of the damage suffered by these two localities following the 14 January 1703 shock is given in the Catalogue of Strong Italian Earthquakes (*Guidoboni et al.*, 2007). In Amatrice (MCS intensity IX) the shock caused "… the collapse of most of the buildings. Most of the 90 'casali' of Amatrice also collapsed, killing 200 people. In the town center there were 25 victims, but a different source mentions 84 people killed. The community obtained a tax exemption of four or five years…". For Norcia (MCS intensity X) the Catalogue reports that "… the town was heavily damaged by the earthquake and suffered extensive collapses…. In his report dated 25 February 1703 the Apostolic legate De Carolis described Norcia as being almost completely razed to the ground… Over 3,000 buildings collapsed, whereas the estimates of the casualties vary greatly according to the source: from 800 over a population of 2,800 (29%), to 2,000 over a population of 7,000. The latter figure might include all the 'ville' in the surroundings of Norcia, however, thus explaining the discrepancy….". Therefore there exists ample evidence to assume that both towns were similarly destroyed following the 14 January 1703 earthquake, and hence that the building stock of both localities was largely rebuilt. On this basis one could assume that the quality of buildings – and hence the global vulnerability – of Amatrice and Norcia may be evaluated with reference to the post-1703 earthquake reconstructions and to all subsequent earthquakes and ensuing restorations.

Date (yyyy-mm-dd)	Source	Epicentral area	Number of data	Epicentral intensity	M_w	Intensity **Amatrice**	Intensity **Norcia**
1328 12 04	CFTI	Valnerina	13	X	6.4	---	X
1599 11 06	CFTI	Valnerina	20	IX	6.0	---	VIII
1639 10 08	CFTI	Monti della Laga	17	X	6.1	IX	---
1639 10 15	CFTI	Monti della Laga	15	X	6.2	VIII-IX	---
1646 04 28	DBMI	Monti della Laga	10	IX	5.9	VIII	---
1672 06 08	DBMI	Monti della Laga	10	VII-VIII	5.3	VII-VIII	---
1703 01 14	CFTI	Appennino umbro-reatino	199	XI	6.7	IX	X
1703 01 16	CFTI	Appennino umbro-reatino	22	VIII	6.0	VIII	VIII
1706 11 03	CFTI	Maiella	99	X-XI	6.8	VII	---
1719 06 27	CFTI	Alta Valnerina	16	VIII	5.5	---	VIII
1730 05 12	CFTI	Valnerina	115	IX	5.9	VII-VIII	IX
1815 09 03	CFTI	Valnerina	24	VIII	5.5	---	VII
1859 08 22	CFTI	Valnerina	18	IX	5.8	---	IX
1879 02 23	CFTI	Valnerina	15	VIII	5.6	---	VIII
1883 11 07	DBMI	Monti della Laga	4	VII	5.1	VII	---
1903 11 02	DBMI	Valnerina	33	VI	4.8	V-VI	VI-VII
1915 01 13	CFTI	Marsica	860	XI	7.0	VI-VII	V
1916 11 16	CFTI	Appennino umbro-reatino	40	VIII	5.5	VII	VI
1950 09 05	DBMI	Gran Sasso	386	VIII	5.7	VII	VI
1963 07 21	DBMI	Monti della Laga	11	VII	4.7	VII	---
1971 10 04	DBMI	Valnerina	43	V- VI	4.5	---	VI-VII
1979 09 19	CFTI	Valnerina	694	VIII-IX	5.8	VI-VII	VIII
1997 09 26(a)	CFTI	Appennino umbro-marchigiano	760	VII-VIII	5.6	V-VI	V-VI
1997 09 26(b)	CFTI	Appennino umbro-marchigiano	891	VIII	5.7	V	VI
1997 10 14	CFTI	Valnerina	786	VII-VIII	5.5	V-VI	VI

Table 3 – Seismic histories of Amatrice and Norcia, showing all reported MCS intensities > V for at least one of the two localities. Data from CFTI (CFTI4Med: *Guidoboni et al.*, 2007), and from DBMI (DBMI15: *Locati et al.*, 2016) for some of the smaller events. [(a)] 00.33 UTC shock; [(b)] 09:40 GMT shock. The symbol "---" indicates lack of information.


Amatrice (Rieti)

Norcia (Perugia)

Figure 3 – Histograms showing the seismic history of Amatrice and Norcia, based on the data of Table 3.

3. A working hypothesis

This reasoning takes us straight to the issue of *time* and to the role it plays in modulating the seismic response. First of all, basic seismic hazard principles dictate that in any earthquake-prone area the long-term probability of strong ground shaking increases with time, most likely following an exponential trend. In other words, the lack of strong ground-shaking events in an area overlying a major seismogenic fault increases the local seismic hazard in a time-dependent perspective. But time is also expected to crucially control - and in fact increase - the building vulnerability - and hence the damage potentially suffered by any locality falling in an earthquake prone-area - in at least three different ways:

1) due to the natural evolution of economical conditions and of construction styles, older buildings are generally more fragile than more recent buildings;
2) older buildings are more likely to suffer from lack of maintenance or from degradation of building materials than newer buildings, even if built using the same materials and construction styles;
3) the time elapsed since the last major strong ground shaking event is likely to act as a deterrent towards a significant improvement of the building stock, thus increasing - or at least not reducing - its vulnerability. On the contrary, the need to rebuild significant portions of a settlement as a result of repeated earthquakes may be assumed to have kept the local building stock in better shape while increasing the citizens' awareness of seismic risk, thus reducing the overall vulnerability.

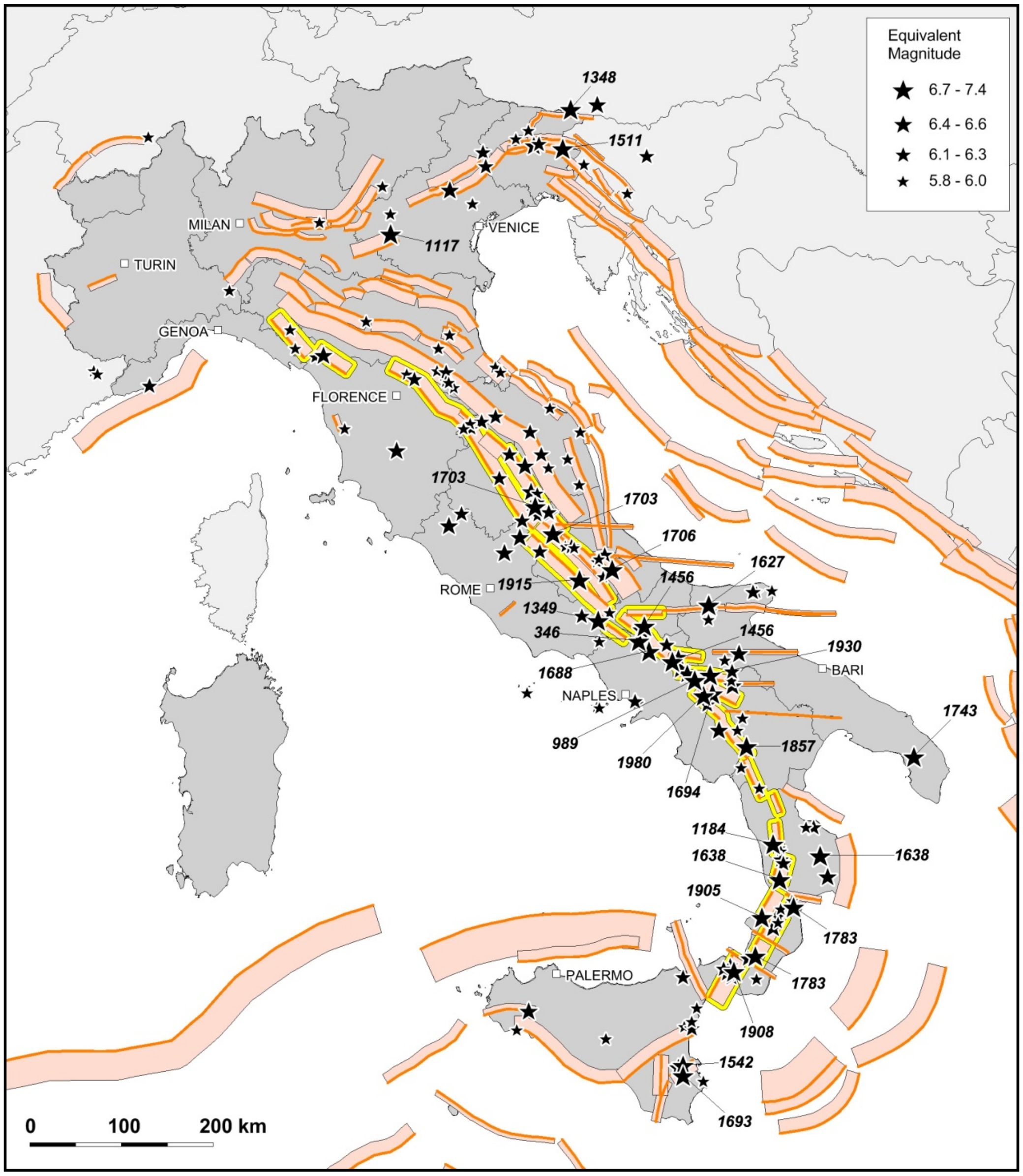


Figure 4 – Composite Seismogenic Sources from the DISS database (*DISS Working Group*, 2015: http://diss.rm.ingv.it/diss/) plotted along with the largest earthquakes reported in the CFTI4Med catalogue (M_w 5.8 and larger: *Guidoboni et al.*, 2007). Each source represents the surface projection of the presumed extent of the fault at seismogenic depth. The sources encircled in yellow delineate the system of large active extensional faults running on top of the Apennines and used for this study. This system originated the earthquakes of the 2016-2017 sequence and is responsible for the majority of the earthquakes occurring in the Italian peninsula. Each source of this system is plotted along with a 5 km buffer encircling it, intended to capture the uncertainties in the actual location of the seismogenic sources with respect to the population centers which may be affected by their activity. DISS is part of - and in fact the starting point of – The European Database of Seismogenic Faults (EDSF: *Basili et al.*, 2013: http://diss.rm.ingv.it/share-edsf/), implying that in principle the exercise can be replicated in other countries of southern Europe.

Table 3 and Figure 3 show that after 1703 Norcia has suffered significant damage as a result of the 1730 (M_w 5.9, Intensity IX), 1859 (M_w 5.8, Intensity VIII-IX), 1879 (M_w 5.6, Intensity VIII) and 1979 (M_w 5.8, Intensity VIII) earthquakes, all located within very few km of the urban center. In contrast, Amatrice has moderately suffered from the 1730 earthquake (Intensity VII-VIII) and has been only mildly affected by all subsequent events, including the 1859, 1879 and 1979 events, all of which caused substantial damage in Norcia.

Our working hypothesis is that the difference in the response of Amatrice and Norcia to the 24 August and

30 October 2016 earthquakes is due to the combined effect of three main causes.

The first cause results from the observation that over the time elapsed since 1703 the building stock of Norcia has undergone at least three major renovations. When the 1859 earthquake struck, Norcia was part of the Papal State. Following this earthquake Pope Pio IX appointed a committee formed by architect Luigi Poletti and by Jesuit astronomer Angelo Secchi (*Secchi*, 1860) with the specific goal to devise new antiseismic rules and recommendations. It is known that the Norcia municipality refused to conform fully to such new rules, possibly because the city was about to join the Kingdom of Italy (1861) along with the whole Umbria region. Nevertheless, there is no question that the seismic response of most buildings was improved on that occasion, one way or the other. The main and decisive improvements, however, were made following the 19 September 1979 earthquake, a M_w 5.8 event that occurred very close to Norcia. A further round of upgrades was triggered by the 14 October 1997 earthquake, the last damaging event (M_w 5.5) of a sequence that had started on 26 September near Colfiorito with two significant shocks (M_w 5.6-5.7); the second of these quakes caused the partial collapse of one vault of the San Francesco basilica in Assisi.

The second cause stems from the circumstance that for centuries Norcia has been the dominant economic, cultural and political center of a large stretch of the Apennines, in the vast mountainous area that lies in between the similarly important centers of Foligno, to the northwest, and L'Aquila, to the southeast. These circumstances have always promoted the restoration and maintenance of public and private buildings, ultimately preventing Norcia from suffering heavier damage in the 2016 earthquakes. In fact, owing to the good overall performance of the urban structure and to the lack of victims (partly due to the post-24 August and post-26 October evacuations), the 30 October 2016, Norcia shock will be remembered for being the least harmful M_w 6.5 earthquake in Italy's long seismic history.

The third and last cause consists in the circumstance that over the past three centuries Amatrice has not been reconstructed, nor has it received any specific earthquake preparedness attention - in marked contrast with Norcia - having been shaken only by moderate-size earthquakes. Up to the end of World-War II Amatrice – in contrast again with Norcia – developed as a largely rural settlement and did not benefit from targeted funding by public agencies or by wealthy residents. To make things worse, over the past few decades Amatrice has become a booming holiday destination both for second or third generation "amatriciani" who now live in large cities such as Rome or in nearby Rieti, and for budget-conscious tourists from Rome and from central Italy in general. In most instances their second homes were obtained from the remodeling of former rural buildings or even stables; most of these houses were precariously built with unreinforced masonry - generally using cobblestones - and had no foundations. In many instances the remodeling of simply built masonry buildings involved the replacement of timber with reinforced concrete beams in the structure of the roof, which increased its weight and hence the load on the external walls, often leading to failure under strong ground shaking. In other instances the remodeling was purely cosmetic, involving only heavy plastering of irregular cobblestone walls.

In short, time and circumstances have worked in favor of Norcia and against Amatrice. We maintain that the combination of all these pre-conditions with the occurrence of the 24 August earthquake just at the end of the peak holiday season conspired in turning a M_w 6.0 quake into a disaster for Amatrice, while leaving Norcia relatively safe.

4. Assessing the "forgotten vulnerability": a geology- and history-based approach

Through history at least 900 Italian cities, towns and villages have suffered partial or total damage - from intensity IX to XI MCS – and several have been destroyed more than once (*Guidoboni et al.*, 2007). Is this sufficient to preserve the memory of large earthquakes and to assume that the populations have developed an earthquake culture that is appropriate for the level of risk they face? Probably not. In fact, based on our reasoning we believe that the case of Amatrice makes a tragic example of "forgotten vulnerability", a living representation of how the loss of memory and awareness may affect future generations: a case that is stressed even further by the comparison with neighboring Norcia.

How many such cases exist in Italy? Probably hundreds, especially in areas where the return period of strong ground shaking is quite long. The MPS04 Seismic Hazard Map of Italy (*MPS Working Group*, 2004; *Stucchi et al.*, 2011) provides the expected levels of ground shaking for different return periods and spectral amplitudes (*Montaldo and Meletti*, 2007: http://esse1.mi.ingv.it/d3.html). Assuming that the most vulnerable buildings of a typical central Apennines town or village are unreinforced masonry structures, 2-3 stories in height, we must concentrate on spectral amplitudes in the range 3-6 Hz. The MPS04 map shows that over most of the Apennines seismogenic zone spectral accelerations in this frequency range are expected to reach a PGA in the range 0.4-1.0 g - a ground shaking level that is likely to induce collapse in such buildings - with a return period ranging from a few centuries to about 1,000 years: with very few exceptions, such as Norcia itself, damaging Italian earthquakes are hence rare enough to be easily forgotten by the local culture and building customs.

Assessing the vulnerability of Italian cities, towns and villages is a complex task that requires a large coordinated effort and may take years to be completed. In this paper we propose to use the extraordinary record of Italian historical seismicity combined with the most up-to-date knowledge on the location of seismogenic sources to make inferences on the vulnerability of the country's population centers at all scales. More specifically our analysis relies (Figure 4):

1) on the Catalogue of Strong Earthquakes in Italy, or CFTI4Med (*Guidoboni et al.*, 2007), a large compilation that summarizes the knowledge acquired throughout nearly three decades of modern research in historical seismology, which in its turn rests on a long tradition of studies on Italy's historical seismicity (e.g. *Guidoboni and Ebel*, 2009); and

2) on version 3.2.0 of the Database of Individual Seismogenic Sources (DISS: *Basili et al.*, 2008; *DISS Working Group*, 2015), which contains the most accurate geological and tectonic information available to date on the location of the potential sources of M 5.5+ earthquakes; more specifically, it relies on its Composite Seismogenic Sources (CSSs), defined as the surface projections of a simplified 3D representation of crustal faults. Each CSS contains an unspecified number of seismogenic sources that cannot be singled out and is not associated with a specific set of earthquakes or earthquake distribution.

Our fundamental goal is to combine these two large, established and independent datasets with the aim to:

(a) identify Italian localities that lie directly above large seismogenic faults, and as such are expected to experience potentially destructive shaking, sooner or later; and

(b) rank them according to their presumed vulnerability, obtained taking into account the time elapsed since the most recent destructive earthquake.

We deliberately adopted a very simple scheme, to minimize the impact of questionable *a priori* choices while capturing the essence of the problem. More in detail we make the following two basic assumptions;

- according to the DISS database, all seismogenic faults running along the axis of the Apennines are capable of a M_w 6.0 or larger earthquake; and, as shown by *Zonno et al.* [2012], all settlements lying above the footprint of these seismogenic faults will sooner or later experience strong ground shaking equivalent to a PGA > 0.49 g or intensity IX and larger (Figure 5);

- as we elucidated earlier on, the aftertime vulnerability of a settlement of any size increases progressively as a function of time, and specifically of the time elapsed since the most recent destructive earthquake, i.e. since the time of the most recent reconstruction of a substantial fraction of the settlement itself.

We are aware that the aftertime vulnerability depends also on a complex arrangement of social and administrative circumstances that would deserve to be investigated case by case by local historians (see discussion in Section 6). Similarly, the vulnerability could – and perhaps should, sooner or later – be assessed by trained professionals, again on a case-by-case basis. As we will discuss more extensively later on, Italy is a country of ancient civilization, where many settlements date back to Medieval or even earlier times and many residents live in historical buildings, whose architectural record may be incomplete or missing altogether. Plus, Italy boasts the largest number of UNESCO World Heritage sites worldwide (47 sites as of 2016) and is credited with 60% of the global cultural and artistic patrimony. A proper countrywide assessment of Italy's vulnerability should hence consider several hundred settlements, would entail uncommon expertise and would require perhaps decades to be completed. Nevertheless we believe that combining geological and historical data may serve the purpose of ranking Italian municipalities by increasing vulnerability, which does not mean assessing their vulnerability *per se* but simply devising a priority criterion that may be useful for a number of applications; from establishing priorities in the retrofitting of historical centers to calibrating a civil protection plan. Our ranking should hence be regarded as the result of a coarse filtering based on existing seismological evidence; in no case it is meant to substitute a more complete analysis.

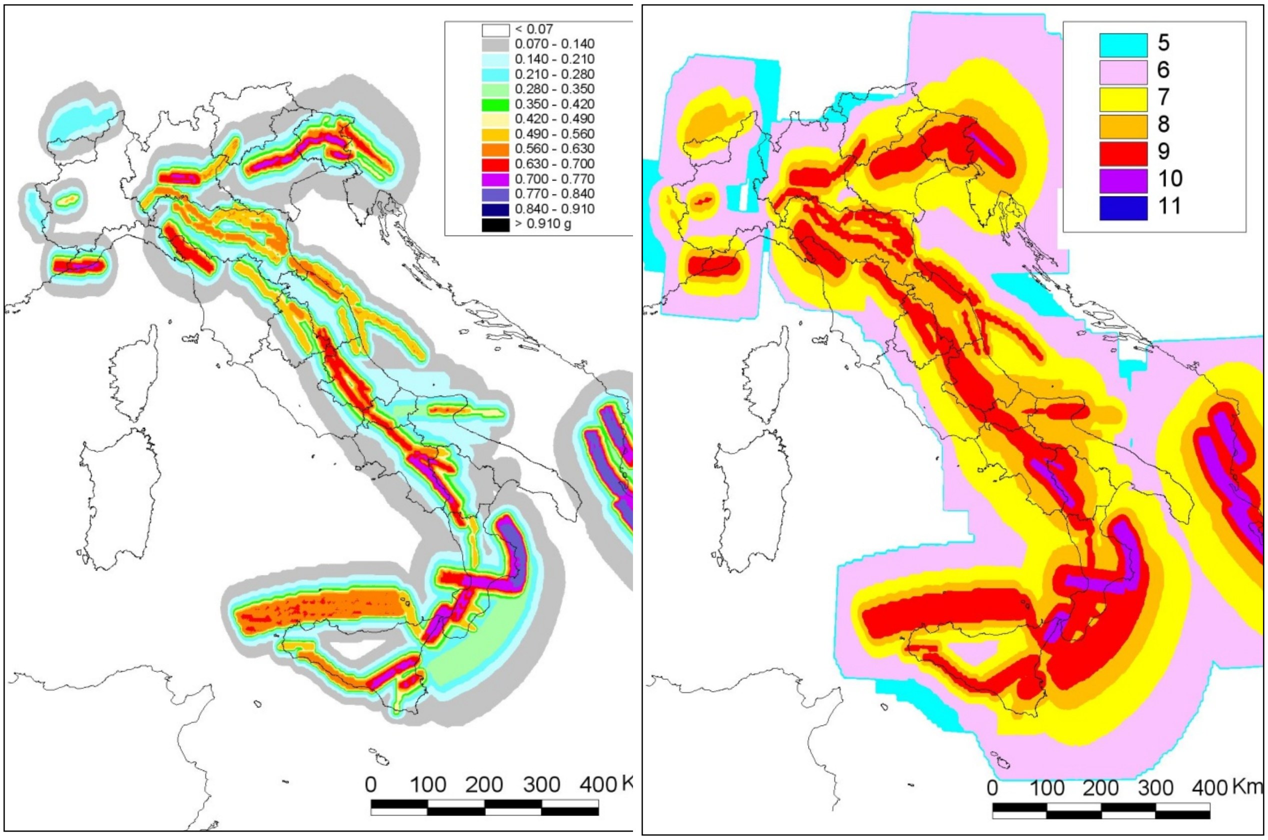


Figure 5 – Maximum Observable Shaking maps of Italy obtained by *Zonno et al.* [2012] from modeling seismogenic sources of the DISS database (version 3.1.1). (left) Map expressed in terms of PGA (g) using a random slip distribution on each seismogenic source. (right) Map converted into macroseismic intensity using the PGV-intensity relationship proposed by *Faenza and Michelini* (2010).

Unlike conventional seismic hazard estimates our approach is inherently *time-dependent*. This has two motivations, which are independent yet strictly related on to another. Both motivations have to do with the time elapsed since the last destructive earthquake: as we discussed earlier on, a longer quiescence in an active seismogenic zone increases the chances of experiencing a strong earthquake, and a prolonged quiescence may lead to a memory loss and hence to an increase of the vulnerability. In this respect it should be recalled that Italian seismic codes apply only to new constructions, not to existing buildings. The improvement of their earthquake resistance is left to the owner with little control by the administrations, although new legislation passed in 2013 has introduced a substantial tax break (up to 80% of the total cost) for homeowners willing to reduce the risk class of their buildings.

Although we regard our approach as inherently large-scale, given the geodynamic and tectonic complexity of the Italian peninsula we did not attempt to extend the analysis to the entire country. Rather we focused on the Apennines chain, a mountain range that encompasses about 25% of the Italian territory and about 70% of the seismic moment released over the past three centuries countrywide (*Carafa et al.*, 2017; Figure 4). The Apennines form a 1,000 km-long extensional seismogenic zone that exhibits a remarkable homogeneity of fault size and depth (e.g. *Basili et al.*, 2008; *Carafa et al.*, 2015). Seismogenic sources of the Apennines extensional domain are expected to be comparably better investigated and more complete than seismogenic sources from other tectonic domains of Italy, that are prevalently characterized by blind or elusive faulting, or lie offshore (*Valensise and Pantosti*, 2001). And, most importantly, Apennines' faults are expected to exhibit a seismic coupling close to 1.0 (*Carafa et al.*, 2017): since the coupling is defined as the ratio between the total seismic strain inferred from the historical record and the total tectonic strain expected from known faults, this implies that all tectonic strain will sooner or later be turned into earthquake activity.

5. Selection procedure and ranking

Our analysis involves a number of subsequent steps, it is based on published datasets and is fully automatic, implying that once the procedure is launched there can be no artificial modification of the results. Following is a summary of the different steps:

1) as mentioned earlier, we first selected all extensional Composite Seismogenic Sources (CSSs) that run along the axis of the Apennines. Our subset includes 25 large Composite Sources, encompassing 33,351 km^2 of Italian territory (out of a total of 167 Composite Sources, encompassing 52,819 km^2), corresponding to about 11% of the country's emerged portion;

2) we drew a buffer of 5 km around the outline of all selected CSSs (Figure 4), effectively broadening their footprint. This buffer is intended to capture the uncertainties in the actual location of the seismogenic sources with respect to the population centers that may be affected by their activity. The envelope formed by the CSSs plus the buffer comprises our *area of relevance*;

3) we selected all *comuni* (the Italian word for municipality: singular, *comune*; plural, *comuni*) - the smallest administrative unit in the current Italian legislation - whose territory overlaps the area of relevance for at least 20%. An exception was made for a handful of *comuni* that exhibit a lesser overlap but where the principal settlement ("capoluogo" in Italian) - usually the largest or the oldest of all settlements - falls within that small overlap zone. By definition of the structure and geometry of the CSSs, all selected localities fall not only in the near-field of potential future earthquakes, but also in the hangingwall of the identified fault systems, where peak accelerations are expected to be substantially larger than in the footwall (e.g. *Abrahamson and Somerville*, 1996; *Grimaz and Malisan*, 2014);

4) this step yielded 716 *comuni*, 8.9% of the total countrywide, for each of which we supply the population (from the 2015 census: *ISTAT* [2015]) and the % of pre-1918 buildings (from the 2011 census: *ISTAT* [2011]). In all subsequent steps we will refer to the coordinates of the *capoluogo* as representative of the entire *comune*;

5) we evaluated the seismic history of each of the 716 *comuni* using information from the CFTI4Med. The site histories were complemented by data from DBMI (*Locati et al.*, 2016) for a handful of moderate-size earthquakes not listed in CFTI4Med. At this stage we had to cope with the possible incompleteness of the earthquake record, for example due to the fact that the *capoluogo* was founded more recently than the time of occurrence of a large earthquake, or simply due to information gaps in the available historical sources. To this end we used SASHA, a code originally developed to assess seismic hazard from local site seismic histories (*D'Amico and Albarello*, 2008). We used a version that was adapted and simplified by its authors to provide only the synthetic intensities, i.e. the intensities that are expected to be felt at any given site for any given large earthquake. This procedure was performed only for sites for which the observed intensity is rated as "not classified" or is missing altogether;

6) finally, we ordered the 716 *comuni* according to the following ranking criteria:

a) the first 38 *comuni* (Table 4) are those that never experienced intensity VIII or above and were listed by growing felt intensity. This implies that the first *comune* is one that experienced the smallest intensity in historical earthquakes. As such it may be presumed to be i) closer in time to the future occurrence of strong ground shaking with respect to other localities, and ii) more prone to be highly vulnerable as a result of total loss of memory of past earthquakes. If two *comuni* have the same felt intensity they were ordered by decreasing age of the ground shaking, i.e. the *comune* that experienced that level of shaking in more remote times goes first;

b) the remaining 67*8 comuni* (Table 5) were then ordered by increasing time distance of the latest intensity > VIII report, based on the principle discussed earlier, i.e. that the vulnerability may be expected to increase as a function of the time elapsed since the last significant earthquake. If two *comuni* share the same reference earthquake, we listed first the one having the larger population.

All in all, the total number of residents in the Apennines localities listed in Tables 4 and 5 is 3.2 million people, slightly over 5% of the Italian population, currently estimated around 60 million people. Although the Apennines seismicity accounts for only 70% of the seismic moment released over the entire country, in itself this is an indication that, even accounting for the remainder of the seimic release, probably less than 10% of the Italian population is exposed to potentially destructive ground shaking.

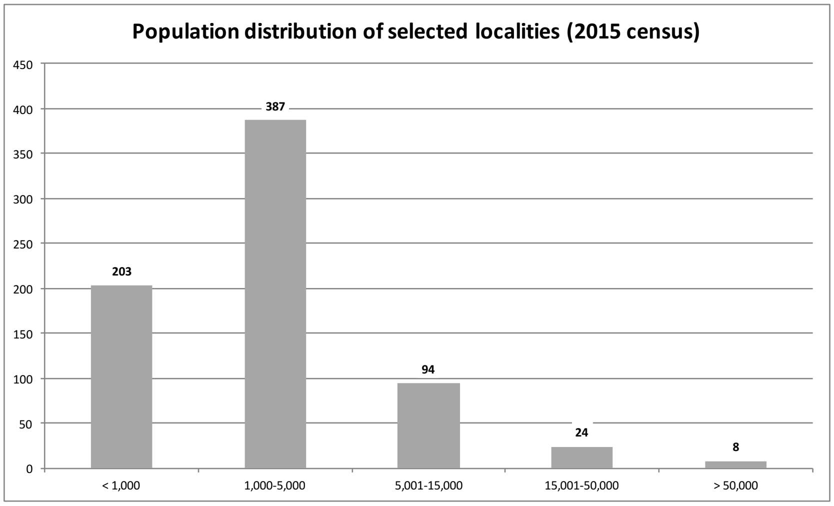


Figure 6 – Distribution of the population in the whole sample of 716 *comuni*. Data from *ISTAT* (2015).

Figure 6 shows the distribution of the population of our 716 *comuni* using five classes (≤1,000, 1,001-5,000, 5,001-15,000, 15,001-50,000, and > 50,000). Table 6 lists a subsample of our selection with localities having a population in excess of 15,000. We remark that on the one hand, larger concentrations of people increase their own exposure and that of their dwellings, thus leading to increased risk; this is due to a number of concomitant reasons ranging from the size and height of buildings, to the larger population density, to the presence of critical infrastructures, such as hospitals. On the other hand it should be recalled that the origin of at least 60% of the smaller Italian *comuni* located in the Apennines – between 300 and 400, as shown in Figure 6 - dates back to the Middle Ages: they correspond to *borghi* rather than to ordinary villages. Akin to the Greek *πύργος* ("tower" or "fortress"), to the German *burg* and to the English *borough* and *burgh*, the Italian term *borgo* (plural: *borghi*) indicates a village that developed in ancient times around a castle or a fortification. As such, many *borghi* preserve the vestiges of walls, towers, gates and specialized buildings, displaying variable characters from north to south of the Italian peninsula. The Italian *borghi* are a central and vital element of the landscape of the Italian Apennines and have been defined "...some of the most humane cities in the world..." (*Carver*, 1979). They comprise a unique treasure of history and beauty that has received endless admiration by scholars and travelers of the *Grand Tour* for over two centuries. As such, their immaterial value goes well beyond their mere real-estate value; their conservation deserves special attention and requires moving beyond the concept of "useful life" normally adopted for ordinary buildings.

6. Living with earthquakes in a fragile country: reasons for an enhanced vulnerability

In this paper we have chosen to focus on vulnerability as the most significant contribution to seismic risk. This choice, however, implies specific attention to additional, local causes of vulnerability which may add to the basic relationship adopted in this work, i.e. that vulnerability increases as a function of the time elapsed since the last significant episode of strong ground-shaking. We wish to discuss at least four such causes: 1) corruption in the building industry; 2) modifications in the original reconstruction plans following a large earthquake and expansion of built areas; 3) the cunning reduction in seismic code provisions, or the infringement of local building regulations; and 4) the consequences of engineering misconceptions.

Is the large vulnerability of Italian buildings only a matter of corruption? The Italian public opinion was very impressed by the partial collapse of an Amatrice school that had been retrofitted a year earlier, in 2015. Has the building been improved by corrupted people? Is corruption closely related to the number of casualties and collapsed buildings? The latter issue was raised by Ambraseys and Bilham (2011), who established a straightforward relationship between the number of casualties and corruption indexes in a number of large earthquakes of the past 30 years worldwide. The authors elucidated how this phenomenon worked for Japan but did not say much about Italy. In an on-line comment, however, *Guidoboni and Roda* (2011) stated that Ambraseys and Bilham's view was too simplistic, at least for Italy, and that at least two additional circumstances affect the number of victims of Italian earthquakes: the large amount of historical buildings countrywide, and the quality of entrepreneurship in the building industry.

As for the former point, *Guidoboni and Roda* remarked that over 65% of Italian buildings are historical: for the past six centuries, until the mid 20th century, they were made of brickwork or stonework, and currently include residences but also monuments and public buildings, such as schools. The current Italian legislation makes a clear distinction between the *full compliance* with seismic code provisions and the *seismic improvement*, intended as an acceptable balance between the need to improve the seismic performance of historical buildings and the technical difficulties involved in making them fully compliant.

As for the latter point, *Guidoboni and Roda* contended that most problems are caused by small businesses, striving to survive on a very competitive market. Resorting to second-quality, unskilled workers may be the only chance for them to break even, a circumstance that similarly to corruption may explain the poor seismic performance of a building, but that strictly speaking does not amount to corruption. Unfortunately price is the key factor to winning a public tender for public infrastructure projects, a business where quality should be the top priority but often ends up being totally neglected. In 2016 the Italian government passed a law implying new procedures for public tenders, but it may take years to understand if this will ultimately force a long-expected and strongly needed change.

A more recent paper by Escaleras and Register (2016) showed on a statistically significant basis that corruption in the public sector effectively contributes to turning potentially harmless natural hazards into full-fledged disasters.

From post-earthquake town planning to the actual reconstruction. From the point of view of seismic codes Italy is unfortunately – but also traditionally – characterized by a systematic "loss of memory" of the generally wise rules devised after a large earthquake, starting with the end of the XVII century. This is often explained by changes in the administrative and political framework (recall the experience of Norcia after the 1859 earthquake, discussed earlier on), but may also be a result of the endemic instability and of the weakness of Italian institutions (see discussion in *Guidoboni and Valensise*, 2011, p. 411-416). The lack of effective supervision and sanctions often allowed people to ignore well-thought town plans and build additional storeys or introduce other modifications, ultimately leading to an increased vulnerability. A good case in point is the reconstruction of Messina and Reggio Calabria after the 28 December 1908, Messina Straits earthquake (M_w 7.1). The two town plans were devised by prominent architects and featured highly innovative anti-seismic solutions for balancing urban decor, proportions and seismic safety; but later modifications have made these provisions difficult to identify in the current landscape of Messina and Reggio Calabria (*Ceradini*, 2008).

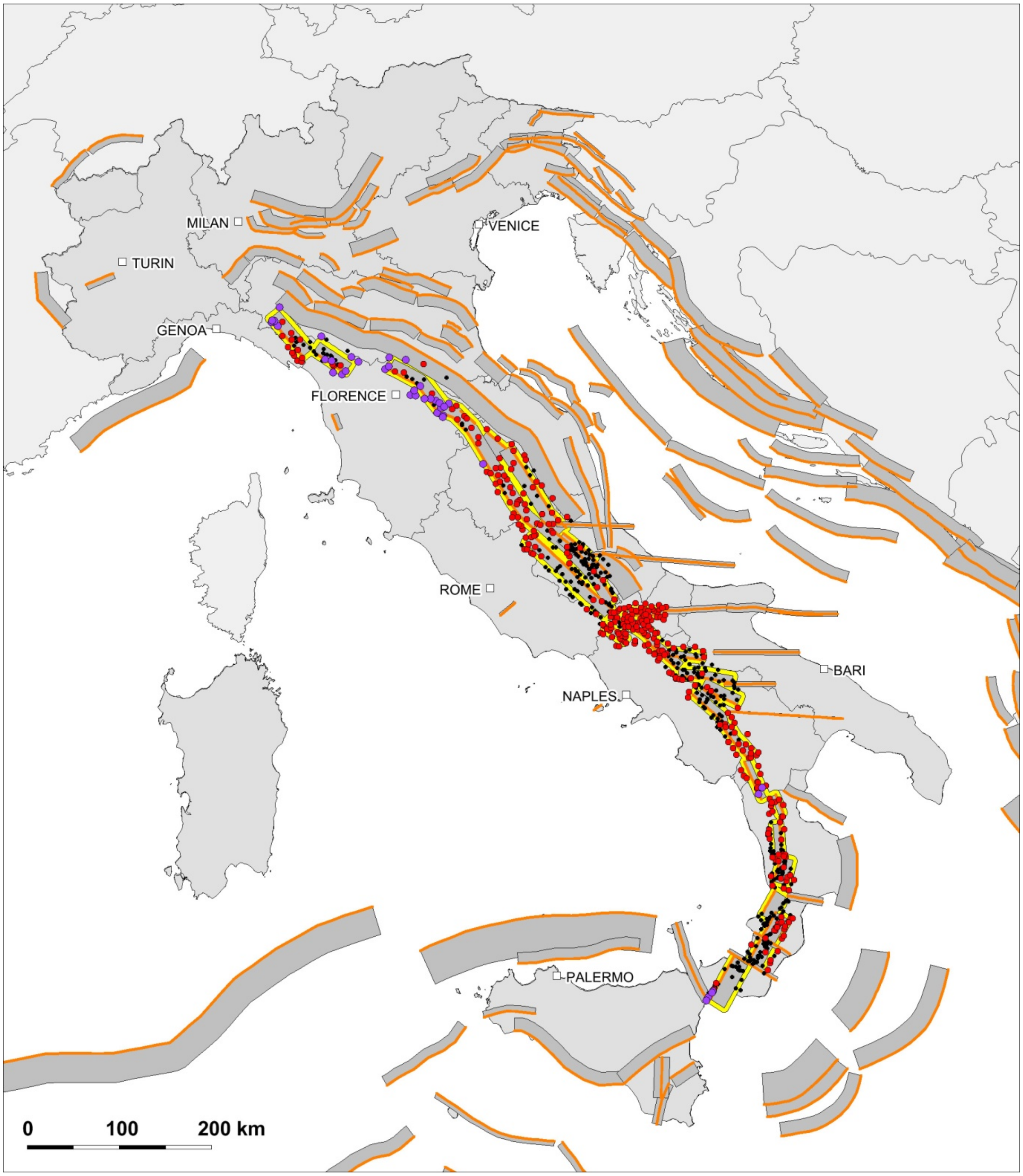


Figure 7 – Distribution of the 716 *capoluoghi* of *comuni* that were selected with the procedure described in the text. Violet dots indicate the 38 localities that have never experienced intensity VIII or above, from Table 4. Red dots indicate the 315 localities that in our ranking of Table 5 correspond to *comuni* that have not experienced destructive shaking at least since 1861, i.e. since the unification of the Kingdom of Italy. Black dots indicate the remainder of the 363 *comuni* of Table 5.

As mentioned earlier in this paper, a further source of increased vulnerability is the use of building areas that were classified as "unstable" and "risky" in previous earthquakes, and hence tagged as "unsuitable for buildings" in post-earthquake town planning. The 6 April 2009 earthquake (M_w 6.3) caused a concentration of collapses - and hence of casualties – in an area of L'Aquila named "Campo di Fossa" (literally "the field of the pit") after the large 2 February 1703 earthquake, the penultimate disastrous event to strike the city. This area was a sort of deep ravine that had been used to accumulate rubble from collapsed buildings, thus reducing natural topographic irregularities, and no building was allowed in it. This wise provision was relaxed - or simply forgotten - partially following the 13 January 1915 Marsica earthquake and definitely after World-War II, during Italy's economic miracle, causing the foundations of a number of multi-story condominiums to be laid on the worst possible ground, i.e. on made-land.

From seismic declassification to the infringement of local building regulations.
There is little doubt that these two circumstances have contributed to increasing the vulnerability of the Italian building stock: in specific – and fortunately rather limited – areas in the first case, but on a nationwide basis, with an ill-fated concentration in some of the most seismic-prone areas of the country, in the second case.

The declassification was often invoked between 1936 and 1962 by individual municipalities on the grounds that such regulations would be too costly and would ultimately limit the booming building and tourism industries. Several important centers, including Rimini, Vittorio Veneto, Pesaro and Urbino, were granted this "privilege" and have subsequently been developed in the absence of antiseismic rules. It has taken nearly 50 years, until 1984, for most of these localities to be re-classified according to more considerate anti-seismic principles.

In its turn, the practice of illegal building started in the 1970s and continued well into the 1990s and beyond. Many governments deliberately turned a blind eye to the expansion of this practice, on the grounds that it helped fighting poverty and allowed more people to build their own residence at budget prices. This practice is alarming and dangerous as it has legalized buildings and infrastructures through administrative procedures giving no consideration to the actual characteristics of what had been illegally built. The real issue is that this matter ceased being under the control of the central government in 1970, following the implementation of regional autonomies. The regions of Italy ("regioni", in Italian) are the first-level administrative divisions of Italy, and are traditionally less severe than the central government in fighting the infringement of building regulations. Testing by future earthquakes will reveal how much this practice contributed to increasing the vulnerability of the Italian building stock, especially in the most earthquake-prone areas of the country.

Engineering misconceptions and their consequences. A further cause of vulnerability enhancement rests in the extensive use of concrete in the restoration of the roof of older buildings. This has been commonly done in order to obtain rigid diafragms and to allow the redistribution of seismic loads on shear walls, often without improving the wall integrity and resistance capacity. This practice has been unwisely encouraged by the antiseismic codes enforced following the M_w 7.1, 28 December 1908, Messina Straits (southern Italy) and the M_w 6.5, 7 September 1920, northern Apennines earthquakes. Subsequent provisions eventually reversed this trend, but many owners of older buildings have kept adding heavy concrete roofs on top of poorly constructed masonry buildings, on the grounds that a concrete roof is easier and cheaper to lay and maintain; or have added additional storys on structures designed as single-story. Every earthquake of the past 40 years has demonstrated that this practice of "vernacular building", combined with the absence of control by the public administrations, caused a net increase in the vulnerability of the building stock, especially in smaller mountain villages.

7. Discussion and conclusions

In this paper we aim at providing a tool for addressing the critical trade-off that exists between safety and conservation in countries like Italy. We meant to supply a priority scheme for supporting the decision-making in any intervention of vulnerability reduction. As such our results are specifically addressed to administrators and public sector planners, the sole individuals in charge of deciding the timing, the goals and the modes of such interventions.

We have used publicly available information on the seismogenic sources and the earthquake history of the Apennines region to 1) select the municipalities that are more likely to suffer from strong ground shaking in future earthquakes, and 2) rank them in terms of decreasing vulnerability, i.e. in terms of the risk stemming from the same seismic input. As strong earthquakes force building reconstructions and changes in the individual and societal perception of seismic risk, our approach rests on the assumption that the global vulnerability of Apennines settlements increases with the time elapsed since the last significant episode of strong ground shaking (see Section 3). Starting from the experience gained from the 2016-2017 earthquakes (Section 1), and in particular from the apparent paradox caused by the very different seismic response of Amatrice and Norcia (Section 2), we contend that time promotes not only the aging of all structures, but also a sort of "loss of memory" that may alter people's awareness of the local seismic hazard (Sections 3 and 4).

The results of our ranking are illustrated in Section 5 (Tables 4-6 and Figure 7). We identified 716 municipalities exposed to potentially destructive ground shaking along the Apennines, totaling about 5% of the Italian population. They are distributed along the entire Apennines belt, and – not surprisingly - concentrate in high-seismic hazard areas that have been seismically silent for the longest time. In particular, we found that 353 of these municipalities - about 49% of the total - have not experienced destructive shaking since 1861, when the Kingdom of Italy reunited a number of smaller states. Since then Italy started flourishing as an influential European political power, and its municipalities grew bigger, increasingly concentrating population from the countryside. As such these 353 municipalities are ideal candidates to perform poorly in future potentially damaging earthquakes ($M_w > 5.5$) and should hence be given top priority in any state-wide vulnerability reduction plan.

In Section 6 we discussed at length why Italian settlements are so vulnerable, listing a number of closely intertwined historical, cultural and economical circumstances that may locally increase the vulnerability. Dealing with such circumstances, however, requires consideration of elements that have little or nothing to do with the proneness to earthquake damage of each locality. In addition, most of the conditions that were discussed apply to all settlements in a statistically similar manner, whereas we meant to stress the existence of a "differential vulnerability" due to the seismic history of each locality, and to illustrate how we can evaluate it, at least in relative terms.

As full-time scientists we are not in a position to provide guidelines for reducing the vulnerability of Italian municipalities, and hence for mitigating the country's seismic risk. Nevertheless, and based on our own experience, we discuss here a few relevant goals and some recommendations on how to accomplish them.

We believe that there are at least two urgent tasks to be pursued by the Italian government and by local authorities: 1) to exert a much tighter control on the status of the building stock in the most vulnerable municipalities, and 2) to build up a new, pervasive and more effective culture of risk prevention and perception (*Alexander*, 2005, 2015).

As for the first goal, the identification of the most vulnerable municipalities - and hence of a priority scheme for devising appropriate countermeasures - could be based on the method proposed in this work for the Italian Apennines. This task could be accomplished by the "Struttura di missione *Casa Italia*", a task force appointed by the Italian government in the aftermath of the 2016 earthquakes (http://presidenza.governo.it/AmministrazioneTrasparente/Organizzazione/ArticolazioneUffici/StruttureMissioni/SM_casa_italia.html). *Casa Italia* has been meant to foster new forms of interaction and data exchange among scientists from different disciplines. Unfortunately, nearly a year after its creation the new task force does not appear to have fully set its own goals; for instance, it has not even attempted to favor the inbreeding among historical seismologists, earthquake geologists and engineers that we deem necessary to interact effectively with the building culture and with the societal evolution of earthquake-prone areas.

As for the second goal, we firmly believe that building up a culture of earthquake disasters should be based on preserving the memory of the past seismic history, reflecting on the impact of past disasters and delving into the societal and institutional response (e.g. *Teti*, 2017). Despite Italy's frequent and widespread seismicity, public awareness of the risks posed by major earthquakes (or floods, or landslides) is extremely limited, as neither the school nor the university systems have paid much attention to this fundamental characteristic of the national territory. Over the past few years civil protection authorities at national and regional level have undertaken a number of programs for raising public awareness on potential disasters. Although we fully acknowledge such efforts, we remark that these programs are generally use a very simplistic communication approach based on rather outdated and recurrent background information.

On top of all that it must be recalled that Italian mass-media are seldom interested in promoting sound scientific knowledge and contributing to build a culture of disasters, being mostly attracted by extreme events and by their tragic outcomes. As a result of these circumstances, the coverage of the most recent Italian earthquakes has overstressed their unavoidable and most spectacular consequences, but failed to highlight what the scientific community can do to prevent future disasters and what should be the role of each individual in the process.

In keeping with the contemporary Italian culture and attitude, the combination of all these circumstances has originated a sort of "fatalist drift", a state of mind that is blind to the country's precarious geology and deaf to the lessons taught by history.

We maintain that the national institutions should build on the great upheaval caused by the 2016-2017 earthquakes and on the expertise held by Italian disaster scientists to promote a modern culture of disasters and resilience, removing the fences that separate the disciplines involved and fostering a new education syllabus at all levels.

Italian history tells us that a damaging earthquake is due every five years on average. Anyone who is familiar with Italy knows that the forgotten vulnerability of Amatrice is hardly an isolated occurrence, and time is short.

Acknowledgments

We are indebted to a number of earthquake engineers from various institutions - in particular to Prof. Paolo Bazzurro, Istituto Universitario di Studi Superiori (IUSS), Pavia, and Prof. Stefano Grimaz, University of Udine - for their constructive comments on the proposed working scheme, and to Paola Vannoli, INGV, for a thorough revision of an early version of the manuscript. We also acknowledge useful recommendations and suggestions by two anonymous reviewers. This work has been supported by INGV internal funding.

Supplementary materials

Tables 4 and 5 are presented in an interactive form at the following web page, that also allows all data presented in the paper to be accessed through a Web-GIS:
http://storing.ingv.it/cfti/cftilab/forgotten_vulnerability/.

References

Abrahamson, N. A., and P. G. Somerville (1996). Effects of hanging wall and footwall on ground motions recorded during the Northridge earthquake, *Bull. Seism. Soc. Am.*, 86(1B), S93-S99.

Alexander, D. E. (2005). An interpretation of disaster in terms of changes in culture, society and international relations. In: Perry, R. W., and Quarantelli, E. L. (eds): What is a Disaster? New Answers to Old Questions. Xlibris Press, Philadelphia, 1-15.

Alexander, D. E. (2015). Disastri possibili: prevedere dove portano le tendenze attuali e il ruolo della teoria. In: Guidoboni, E., Mulargia, F., Teti, V. (eds): Prevedibile /Imprevedibile. Eventi estremi nel prossimo futuro, Rubbettino Editore (publ.), 11-30.

Amato, A., and M. G. Ciaccio (2011) Earthquake sequences of the last millennium in L’Aquila and surrounding regions (central Italy), Terra Nova, 24, 52–61, doi: 10.1111/j.1365-3121.2011.01037.x.

Ambraseys, N., and R. Bilham (2011). Corruptions kills, Nature, 469, 153–155 (13 January 2011), doi:10.1038/469153a

Azzaro, R., and QUEST Working Group (2016). The 24 August 2016 Amatrice earthquake: macroseismic survey in the damage area and EMS intensity assessment, Annals of Geophysics, 59, Fast Track 5, 2016 doi: 10.4401/ag-7287.

Basili, R., Valensise G., Vannoli P., Burrato P., Fracassi U., Mariano S., Tiberti M.M. and Boschi E. (2008). The Database of Individual Seismogenic Sources (DISS), version 3: summarizing 20 years of research on Italy's earthquake geology, *Tectonophysics*, 453, 20–43.

Basili, R., and 27 others (2013). The Euro- pean Database of Seismo- genic Faults (EDSF) compiled in the framework of the Project SHARE, available at: http: //diss.rm.ingv.it/share-edsf/. Last accessed on 2 April 2017, doi:10.6092/INGV.IT-SHARE- EDSF.

Calderoni, G., Rovelli, R., Di Giovambattista, R. (2017). Rupture directivity of the strongest 2016-2017 central Italy earthquakes. Submitted to JGR, March 2017.

Carafa, M. M. C., S. Barba, and P. Bird (2015). Neotectonics and long-term seismicity in Europe and the Mediterranean region, *J. Geophys. Res. Solid Earth*, 120, 5311–5342, doi:10.1002/2014JB011751.

Carafa, M. M. C., G. Valensise and P. Bird (2017). Assessing the seismic coupling of shallow continental faults and its impact on seismic hazard estimates: a case-study from Italy, *Geophys. J. Int.*, doi: 10.1093/gji/ggx002

Carver, N. F. (1979) Italian hilltowns. Documan Press, Ltd., Kalamazoo (Michigan, U.S.A.), 192 pp., ISBN 0-932076-01-7. Some of the illustrations available from: http://www.normancarver.com/GALLERIES/ITALY/index.html.

Ceradini, V. (2008). Dopo il terremoto del 1908: Reggio Calabria, città laboratorio. In: Bertolaso, G., E. Boschi, E. Guidoboni e G. Valensise (eds.), 2008, "Il terremoto e il maremoto del 28 dicembre 1908: analisi sismologica, impatto, prospettive", published by INGV and Dept. of Italian Civil Protection, Rome-Bologna, 813 pp. and a DVD, ISBN: 978888521315, 393-404.

CFTI4Med: see Guidoboni et al., 2007.

Chiaraluce, L., R. Di Stefano, E. Tinti, L. Scognamiglio, M. Michele, E. Casarotti, M. Cattaneo, P. De Gori, C. Chiarabba, G. Monachesi, A. Lombardi, L. Valoroso, D. Latorre and S. Marzorati (2017). The 2016 Central Italy seismic sequence: a first look at the mainshocks, aftershocks and source models. Seism. Res. Lett., 88, 3, 757-771. doi: 10.1785/0220160221.

Cimellaro, G. P. (2016). Field reconnaissance on August 25th, after August 24th, 2016 Central Italy Earthquake, Pacific Earthquake Engineering Research center and Politecnico di Torino, http://peer.berkeley.edu/pdf/160829_Central%20Italy_earthquake.pdf

D'Amico, V., and D. Albarello (2008). SASHA: a computer program to assess seismic Hazard from intensity data, Seism. Res. Lett., 79(5), 663-671, doi: 10.1785/gssrl.79.5.663

DISS Working Group (2015). Database of Individual Seismogenic Sources (DISS), Version 3.2.0: A compilation of potential sources for earthquakes larger than M 5.5 in Italy and surrounding areas. http://diss.rm.ingv.it/diss/ © INGV 2015 - Istituto Nazionale di Geofisica e Vulcanologia - All rights reserved, doi: 10.6092/INGV.IT-DISS3.2.0.

Escaleras, M., and C. Register (2016). Public sector corruption and natural hazards. Public Finance Review, 44(6), 746-768, doi: 10.1177/1091142115613155.

Faenza, L., and A. Michelini (2010). Regression analysis of MCS intensity and ground motion parameters in Italy and its application in ShakeMap, *Geoph. J. Int.*, 180, 1138–1152, doi:10.1111/j.1365-246X.2009.04467.x

Galli, P., E. Peronace, F. Bramerini, S. Castenetto, G. Naso, F. Cassone, and F. Pallone (2016). The MCS intensity distribution of the devastating 24 August 2016 earthquake in central Italy (M_W 6.2), *Annals of Geophysics*, 59, Fast Track 5, 2016 doi: 10.4401/ag-7287.

Grimaz, S., and P. Malisan (2014). Near field domain effects and their consideration in the international and Italian seismic codes, *Bollettino di Geofisica Teorica ed Applicata*, 55 (4), 717-738, doi: 10.4430/bgta0130.

Guidoboni E., G. Ferrari, D. Mariotti, A. Comastri, G. Tarabusi and G. Valensise (2007). CFTI4Med, Catalogue of Strong Earthquakes in Italy (461 B.C.-1997) and Mediterranean Area (760 B.C.- 1500), INGV-SGA, http://storing.ingv.it/cfti4med/.

Guidoboni, E., and J. E. Ebel (2009). Earthquakes and tsunamis in the past: a guide to techniques in historical seismology. Cambridge University Press, 604 pp., ISBN: 978-0-521-83795-8.

Guidoboni, E., and C. Roda (2011). On-line comment to: N. Ambraseys and R. Bilham, Corruptions kills, Nature, 469, 13 January 2011, http://www.nature.com/nature/report/index.html?comment=19549&doi=10.1038/469153a.

Guidoboni, E., and G. Valensise (2011). Il peso economico e sociale dei disastri sismici in Italia negli ultimi 150 anni. Bononia University Press (publ.), Bologna, 2011, 552 pp., ISBN: 88-7395-683-1.

Guidoboni, E., and G. Valensise (2015). On the complexity of earthquake sequences: A historical seismology perspective based on the L'Aquila seismicity (Abruzzo, Central Italy), 1315-1915, Earthquakes and Structures, 8, 153-184, doi: 10.12989/eas.2015.8.1.153.

ISIDe Working Group (2016). Italian Seismological Instrumental and parametric Data-basE (ISIDE), version 1.0, http:// http://iside.rm.ingv.it//, doi: 10.13127/ISIDe.

ISTAT-Istituto Nazionale di Statistica (2011). 15° Censimento della popolazione e delle abitazioni 2011: http://www.istat.it/it/censimenti-permanenti/censimenti-precedenti/popolazione-e-abitazioni/popolazione-2011.

ISTAT-Istituto Nazionale di Statistica (2015). Censimento permanente della popolazione e delle abitazioni, http://www.istat.it/it/censimenti-permanenti/popolazione-e-abitazioni.

Lanzano, G., L. Luzi, F. Pacor, R. Puglia, M. D'amico, C. Felicetta, and E. Russo (2016). Preliminary analysis of the accelerometric recordings of the August 24th, 2016 M_W 6.0 Amatrice earthquake, *Annals of Geophysics*, 59, Fast Track 5, 2016, doi: 10.4401/ag-7201.

Locati M., Camassi R., Rovida A., Ercolani E., Bernardini F., Castelli V., Caracciolo C.H., Tertulliani A., Rossi A., Azzaro R., D'Amico S., Conte S., Rocchetti E. (2016). DBMI15, the 2015 version of the Italian Macroseismic Database. Istituto Nazionale di Geofisica e Vulcanologia. doi: 10.6092/INGV.IT-DBMI15.

Mallet, R. (1862). The great Neapolitan earthquake of 1857. The first principles of observational seismology. Chapman and Hill (Publ.), London.

Montaldo, V., and C. Meletti (2007). Valutazione del valore della ordinata spettrale a 1sec e ad altri periodi di interesse ingegneristico. Progetto DPC-INGV S1, Deliverable D3, http://esse1.mi.ingv.it/d3.html.

MPS Working Group (2004). Redazione della mappa di pericolosità sismica prevista dall'Ordinanza PCM 3274 del 20 marzo 2003. Final report for the Department of Civil Protection, INGV, Milan, April 2004, 65 pp. + 5 Appendices, http://zonesismiche.mi.ingv.it.

Pischiutta, M., A. Akinci, L. Malagnini, and A. Herrero (2016). Characteristics of the Strong Ground Motion from the 24th August 2016 Amatrice Earthquake. Annals of Geophysics, 59, Fast Track 5, 2016, doi: 10.4401/ag-7219.

QUEST Working Group (2016a). The 24 August 2016 Amatrice earthquake: macroseismic survey in the damage area and EMS intensity assessment. Annals of Geophysics, 59, Fast Track 5, 2016 doi: 10.4401/ag-7203.

QUEST Working Group (2016b). Rilievo macrosismico in EMS98 per il terremoto di Amatrice del 24 agosto 2016, 6 pp., doi: 10.5281/zenodo.160707,

Secchi, A. (1860). Escursione scientifica fatta a Norcia ad occasione dei Terremoti del 22 agosto 1859. Rome, Tipografia Delle Belle Arti, 1860, 44 pp.

Stucchi, M., C. Meletti, V. Montaldo, H. Crowley, G. M. Calvi and E. Boschi (2011). Seismic hazard assessment (2003–2009) for the Italian building code. Bull. Seism. Soc. Am., 101, 1885–1911, doi: 10.1785/0120100130.

Tertulliani, A. and R. Azzaro (eds.) (2016a). QUEST - Rilievo macrosismico per i terremoti nell'Italia centrale. Aggiornamento dopo le scosse del 26 e 30 ottobre 2016. INGV Internal Report, 29 November 2016 update, 14 pp., doi:10.5281/zenodo.182694.

Teti, V. (2017) Quel che resta. L'Italia dei paesi, fra abbandoni e ritorni. Donzelli Editore (publ.), Roma, pp. XII-308, ISBN: 9788868436230.

Tinti, E., L. Scognamiglio, A. Michelini and M. Cocco (2016). Slip heterogeneity and directivity of the M_L 6.0, 2016, Amatrice earthquake estimated with rapid finite-fault inversion. Geophys. Res. Lett., doi: 10.1002/2016GL071263

Trifunac, M. D., and A. G. Brady (1975). A study on the duration of strong earthquake ground motion, *Bull. Seism. Soc. Am.*, 65, 581-626.

Valensise, G., and D. Pantosti (2001). The investigation of potential earthquake sources in peninsular Italy: a review. J. Seismol., 5, 287-306.

Zimmaro, P., and J. P. Stewart and GEER Team (2016). Engineering reconnaissance of the 24 August 2016 Central Italy e arthquake. Version 2, 285 pp., Geotechnical Extreme Events Reconnaissance Association Report No. GEER-050, 22 November 2016, doi:10.18118/G61S3Z.

Zonno, G., R. Basili, F. Meroni, G. Musacchio, P. M. Mai and G. Valensise (2012). High-frequency Maximum Observable Shaking map of Italy from fault sources, Bulletin of Earthquake Engineering, 10(4), 1075-1107, doi: 10.1007/s10518-012-9346-y

Table 4 – List of 38 *comuni* which never experienced intensity VIII or above, ordered by growing felt intensity (and according to the age of the latest earthquake in case of equal intensity). The first *comune* is one that experienced the smallest intensity during historical earthquakes. * indicates that the intensity was estimated using SASHA (see text).

Rank	Municipality - Province	Population (2015)	Max. MCS Intensity (date)	% of pre-1918 buildings (as of 2011)
1	Talla - AR	1062	VI-VII (1919 06 29)	40.4%
2	Bardi - PR	2227	VI-VII (1985 08 15)	33.9%
3	Cutigliano - PT	1488	VII (1501 06 05)*	24.4%
4	Poppi - AR	6160	VII (1504 11 01)*	42.5%
5	Castiglione dei Pepoli - BO	5648	VII (1542 06 13)*	21.8%
6	Cantagallo - PO	3105	VII (1542 06 13)*	31.4%
7	Tornolo - PR	1010	VII (1545 06 09)*	15.4%
8	Castel Focognano - AR	3149	VII (1VII31 03 29)*	47.9%
9	Chiusi della Verna - AR	2023	VII (1731 03 29)*	37.5%
10	Subbiano - AR	6331	VII (1796 02 05)	28.9%
11	Capolona - AR	5438	VII (1796 02 05)*	28.4%
12	Albareto - PR	2156	VII (1834 02 14)	12.6%
13	Compiano - PR	1112	VII (1834 02 14)	43.1%
14	Bibbiena - AR	12241	VII (1919 06 29)	23.2%
15	Castel San Niccolò - AR	2707	VII (1919 06 29)	17.3%
16	Chitignano - AR	899	VII (1919 06 29)	47.6%
17	Montemignaio - AR	566	VII (1919 06 29)	27.9%
18	Bedonia - PR	3482	VII (1920 09 07)	22.6%
19	Abetone - PT	621	VII (1920 09 07)*	18.7%
20	Careggine - LU	564	VII (1920 09 07)	38.3%
21	Firenzuola - FI	4726	VII (1931 09 05)	38.9%
22	Perugia - PG	166134	VII (1984 04 29)	15.0%
23	Furci Siculo - ME	3382	VII-VIII (361 00 00)*	4.5%
24	Collagna - RE	942	VII-VIII (1481 05 07)*	24.0%
25	Pontassieve - FI	20603	VII-VIII (1542 06 13)*	23.7%
26	Pelago - FI	7660	VII-VIII (1542 06 13)*	31.8%
27	Vernio - PO	6060	VII-VIII (1542 06 13)	21.2%
28	Londa - FI	1840	VII-VIII (1542 06 13)*	32.4%
29	Mormanno - CS	3027	VII-VIII (1693 01 08)	50.3%
30	Rotonda - PZ	3494	VII-VIII (1708 01 26)	23.2%
31	Borgo a Mozzano - LU	6994	VII-VIII (1740 03 06)*	66.3%
32	Bagni di Lucca - LU	6161	VII-VIII (1740 03 06)*	68.1%
33	Fabbriche di Vergemoli - LU	768	VII-VIII (1740 03 06)*	74.7%
34	Castelnuovo di Garfagnana - LU	5950	VII-VIII (1746 07 23)	32.4%
35	Roccalumera - ME	4141	VII-VIII (1908 12 28)	12.0%
36	Letojanni - ME	2861	VII-VIII (1908 12 28)	5.8%
37	Forza d'Agrò - ME	911	VII-VIII (1908 12 28)	6.0%
38	Rufina - FI	7346	VII-VIII (1919 06 29)	49.4%
	Total	**314,989**		

Table 5 – List of 678 comuni ordered by the time elapsed since the last damaging earthquake (intensity VIII and above). This implies that the first comune is one that experienced a damaging earthquake in a very remote time, while the last experienced a damaging earthquake in recent years. * indicates that the intensity was estimated using SASHA (see text).

Rank	Municipality - Province	Population (2015)	Date of Intensity ≥ VIII	% of pre-1918 buildings (as of 2011)
39	Nizza di Sicilia - ME	3667	361 00 00 (VIII)*	2.3%
40	Cassano all'Ionio - CS	18495	1184 05 24 (VIII)*	9.5%
41	Altomonte - CS	4488	1184 05 24 (IX)*	11.2%
42	San Lorenzo del Vallo - CS	3394	1184 05 24 (IX)*	0.1%
43	Firmo - CS	2115	1184 05 24 (IX)*	25.7%
44	Visso - MC	1107	1328 12 04 (VIII-IX)	71.7%
45	Campello sul Clitunno - PG	2442	1328 12 04 (IX)*	7.2%
46	San Vittore del Lazio - FR	2636	1349 09 09 (VIII)	14.5%
47	Castel Sant'Angelo - RI	1308	1349 09 09 (VIII-IX)*	38.3%
48	Picinisco - FR	1218	1349 09 09 (X)*	23.8%
49	Pieve Santo Stefano - AR	3183	1353 01 01 (VIII)*	27.8%
50	Caprese Michelangelo - AR	1426	1353 01 01 (VIII)*	25.5%
51	Vairano Patenora - CE	6594	1456 12 05 (VIII)	9.4%
52	Venafro - IS	11280	1456 12 05 (VIII-IX)	7.1%
53	Montagano - CB	1086	1456 12 05 (VIII-IX)*	75.3%
54	San Pietro Infine - CE	944	1456 12 05 (VIII-IX)*	0.0%
55	San Giovanni in Galdo - CB	580	1456 12 05 (VIII-IX)*	46.6%
56	Viticuso - FR	353	1456 12 05 (VIII-IX)*	0.3%
57	Acquafondata - FR	263	1456 12 05 (VIII-IX)*	4.0%
58	Petrella Tifernina - CB	1170	1456 12 05 (IX)*	59.0%
59	Rocchetta a Volturno - IS	1113	1456 12 05 (IX)	9.5%
60	Campolieto - CB	839	1456 12 05 (IX)*	48.1%
61	Limosano - CB	768	1456 12 05 (IX)	6.7%
62	Lucito - CB	696	1456 12 05 (IX)*	53.8%
63	Salcito - CB	683	1456 12 05 (IX)*	14.0%
64	Scapoli - IS	680	1456 12 05 (IX)	19.9%
65	Morrone del Sannio - CB	587	1456 12 05 (IX)*	66.2%
66	Castellino del Biferno - CB	545	1456 12 05 (IX)	79.6%
67	Sant'Angelo Limosano - CB	352	1456 12 05 (IX)	54.9%
68	San Biase - CB	189	1456 12 05 (IX)*	4.3%
69	Sarzana - SP	21976	1497 03 03 (VIII)*	18.0%
70	Aulla - MS	11263	1497 03 03 (VIII)*	19.4%
71	Santo Stefano di Magra - SP	9360	1497 03 03 (VIII)*	20.0%
72	Castelnuovo Magra - SP	8415	1497 03 03 (VIII)*	19.5%
73	Bolano - SP	7813	1497 03 03 (VIII)*	20.1%
74	Fosdinovo - MS	4883	1497 03 03 (VIII)*	25.3%
75	Mulazzo - MS	2424	1497 03 03 (VIII)*	49.5%
76	Bagnone - MS	1887	1497 03 03 (VIII)*	32.7%
77	Calice al Cornoviglio - SP	1138	1497 03 03 (VIII)*	10.0%

78	Zeri - MS	1094	1497 03 03 (VIII)*	27.4%
79	Barberino di Mugello - FI	10836	1542 06 13 (VIII-IX)	39.1%
80	Scarperia e San Piero - FI	12217	1542 06 13 (IX)	24.5%
81	Avigliano - PZ	11577	1561 08 19 (VIII)	10.8%
82	Castelsantangelo sul Nera - MC	281	1599 11 06 (VIII)*	57.3%
83	Falerna - CZ	4028	1638 03 27 (X)*	5.6%
84	Cleto - CS	1301	1638 03 27 (X)*	18.8%
85	Rogliano - CS	5637	1638 03 27 (X-XI)	30.1%
86	Lamezia Terme - CZ	70714	1638 03 27 (XI)	9.4%
87	Conflenti - CZ	1392	1638 03 27 (XI)*	28.3%
88	Carlopoli - CZ	1516	1638 06 08 (VIII-IX)*	28.1%
89	Alvito - FR	2713	1654 07 24 (IX)	50.8%
90	Oratino - CB	1641	1688 06 05 (VIII)*	40.9%
91	Castello del Matese - CE	1494	1688 06 05 (VIII)	45.8%
92	Castropignano - CB	947	1688 06 05 (VIII)*	35.2%
93	Civitanova del Sannio - IS	945	1688 06 05 (VIII)*	46.9%
94	Roccamandolfi - IS	938	1688 06 05 (VIII)*	48.0%
95	Bagnoli del Trigno - IS	735	1688 06 05 (VIII)*	9.8%
96	Pietracupa - CB	215	1688 06 05 (VIII)*	40.4%
97	Conca Casale - IS	200	1688 06 05 (VIII)	29.8%
98	Molise - CB	167	1688 06 05 (VIII)*	71.6%
99	Piedimonte Matese - CE	11297	1688 06 05 (IX)*	27.2%
100	Pietravairano - CE	2984	1688 06 05 (IX)*	24.4%
101	Sant'Angelo d'Alife - CE	2270	1688 06 05 (IX)*	50.4%
102	Ailano - CE	1369	1688 06 05 (IX)	36.4%
103	Raviscanina - CE	1319	1688 06 05 (IX)*	36.5%
104	San Gregorio Matese - CE	988	1688 06 05 (IX)	33.3%
105	Castrovillari - CS	22240	1693 01 08 (VIII)	15.8%
106	Morano Calabro - CS	4576	1693 01 08 (VIII)	52.4%
107	Saracena - CS	3828	1693 01 08 (VIII)*	24.9%
108	Frascineto - CS	2154	1693 01 08 (VIII)*	1.8%
109	San Basile - CS	1055	1693 01 08 (VIII)*	26.8%
110	Montemiletto - AV	5313	1694 09 08 (VIII)*	13.1%
111	Bagnoli Irpino - AV	3217	1694 09 08 (VIII)	20.9%
112	Nusco - AV	4203	1694 09 08 (VIII-IX)	2.4%
113	Andretta - AV	1927	1694 09 08 (IX)	37.1%
114	Cairano - AV	326	1694 09 08 (X)	10.9%
115	Cusano Mutri - BN	4091	1702 03 14 (VIII)*	31.0%
116	Cerreto Sannita - BN	3940	1702 03 14 (VIII)	45.2%
117	Circello - BN	2388	1702 03 14 (VIII)*	4.1%
118	San Lorenzo Maggiore - BN	2154	1702 03 14 (VIII)*	11.2%
119	San Lupo - BN	801	1702 03 14 (VIII)*	44.2%
120	Cercepiccola - CB	681	1702 03 14 (VIII)*	0.2%
121	Pietraroja - BN	545	1702 03 14 (VIII)*	89.1%
122	Fragneto l'Abate - BN	1049	1702 03 14 (VIII-IX)	12.4%
123	San Marco dei Cavoti - BN	3371	1702 03 14 (IX)*	0.4%
124	Torre Le Nocelle - AV	1324	1702 03 14 (IX)*	0.8%
125	Campolattaro - BN	1072	1702 03 14 (IX)*	14.2%
126	Vallo di Nera - PG	364	1703 01 14 (IX)*	21.7%
127	Sant'Anatolia di Narco - PG	564	1703 01 16 (VIII)*	57.6%
128	Cittaducale - RI	6828	1703 02 02 (VIII)*	30.7%
129	Cantalice - RI	2755	1703 02 02 (VIII)*	31.9%
130	Antrodoco - RI	2588	1703 02 02 (VIII)	53.2%
131	Poggio Bustone - RI	2055	1703 02 02 (VIII)*	2.9%
132	Ferentillo - TR	1913	1703 02 02 (VIII)*	52.2%
133	Rocca di Mezzo - AQ	1526	1703 02 02 (VIII)*	20.1%
134	Crognaleto - TE	1297	1703 02 02 (VIII)*	22.6%
135	Rivodutri - RI	1253	1703 02 02 (VIII)*	13.5%
136	Ovindoli - AQ	1227	1703 02 02 (VIII)*	41.0%
137	Arquata del Tronto - AP	1178	1703 02 02 (VIII)*	32.2%
138	Borgo Velino - RI	972	1703 02 02 (VIII)*	49.2%
139	Rocca Sinibalda - RI	815	1703 02 02 (VIII)*	31.3%
140	Longone Sabino - RI	597	1703 02 02 (VIII)*	52.5%
141	Campotosto - AQ	542	1703 02 02 (VIII)	18.5%
142	Rocca di Cambio - AQ	533	1703 02 02 (VIII)*	41.7%
143	Scheggino - PG	461	1703 02 02 (VIII)*	70.4%
144	Concerviano - RI	291	1703 02 02 (VIII)*	64.4%
145	Varco Sabino - RI	187	1703 02 02 (VIII)*	56.3%
146	Micigliano - RI	127	1703 02 02 (VIII)*	62.9%
147	Poggiodomo - PG	117	1703 02 02 (VIII)*	0.4%
148	Marcetelli - RI	89	1703 02 02 (VIII)*	77.3%
149	Pescorocchiano - RI	2075	1703 02 02 (VIII-IX)*	21.8%
150	Capitignano - AQ	665	1703 02 02 (VIII-IX)*	4.5%
151	Arrone - TR	2763	1703 02 02 (IX)*	42.8%
152	Montereale - AQ	2581	1703 02 02 (IX)*	19.1%
153	Petrella Salto - RI	1197	1703 02 02 (IX)*	40.0%
154	Posta - RI	694	1703 02 02 (IX)*	55.7%
155	Borbona - RI	617	1703 02 02 (IX)*	25.1%
156	Monteleone di Spoleto - PG	599	1703 02 02 (IX)*	74.3%
157	Polino - TR	233	1703 02 02 (IX)*	22.5%
158	Amatrice - RI	2657	1703 02 02 (IX-X)*	27.1%
159	Cittareale - RI	482	1703 02 02 (IX-X)*	46.8%
160	Pizzoli - AQ	4326	1703 02 02 (X)	6.8%
161	Barete - AQ	737	1703 02 02 (X)	26.0%
162	Fornelli - IS	1909	1706 11 03 (VIII)	34.2%
163	Pettorano sul Gizio - AQ	1376	1706 11 03 (VIII)*	56.0%
164	Carovilli - IS	1359	1706 11 03 (VIII)*	37.3%
165	Miranda - IS	1047	1706 11 03 (VIII)	66.0%
166	Pescolanciano - IS	855	1706 11 03 (VIII)*	17.0%
167	Pietrabbondante - IS	759	1706 11 03 (VIII)*	23.0%
168	Roccasicura - IS	550	1706 11 03 (VIII)	34.8%
169	Acquaviva d'Isernia - IS	425	1706 11 03 (VIII)*	12.2%
170	Opi - AQ	420	1706 11 03 (VIII)*	56.8%
171	Castel di Sangro - AQ	6538	1706 11 03 (VIII-IX)	0.2%
172	Scanno - AQ	1847	1706 11 03 (VIII-IX)	54.5%
173	Prezza - AQ	945	1706 11 03 (VIII-IX)	51.4%

174	Castel San Vincenzo - IS	516	1706 11 03 (IX)*	25.6%
175	Civitella Alfedena - AQ	296	1706 11 03 (IX)*	41.4%
176	Laino Castello - CS	848	1708 01 26 (VIII)*	4.3%
177	Castelluccio Superiore - PZ	824	1708 01 26 (VIII)*	62.6%
178	Viggianello - PZ	3025	1708 01 26 (VIII-IX)	17.7%
179	Castelluccio Inferiore - PZ	2131	1708 01 26 (VIII-IX)	35.3%
180	Marradi - FI	3139	1725 10 29 (VIII)	61.1%
181	Leonessa - RI	2435	1730 05 12 (VIII)	47.8%
182	Orsara di Puglia - FG	2767	1731 03 20 (VIII)	58.8%
183	Panni - FG	804	1731 03 20 (VIII)*	8.1%
184	Faeto - FG	627	1731 03 20 (VIII)*	15.2%
185	Taurasi - AV	2377	1732 11 29 (VIII)	4.8%
186	Rocca San Felice - AV	851	1732 11 29 (VIII)	0.0%
187	Sant'Angelo all'Esca - AV	801	1732 11 29 (VIII)	0.4%
188	San Giorgio del Sannio - BN	10022	1732 11 29 (VIII-IX)*	0.5%
189	San Nicola Manfredi - BN	3722	1732 11 29 (VIII-IX)	5.0%
190	Sturno - AV	3080	1732 11 29 (IX)*	0.1%
191	Vallesaccarda - AV	1386	1732 11 29 (IX)*	0.1%
192	Coreglia Antelminelli - LU	5215	1740 03 06 (VIII)*	39.7%
193	Gallicano - LU	3807	1740 03 06 (VIII)*	45.3%
194	Molazzana - LU	1043	1740 03 06 (VIII)*	32.5%
195	Spoleto - PG	38218	1745 03 00 (VIII)	23.5%
196	Gubbio - PG	32216	1747 04 17 (VIII)*	17.4%
197	Nocera Umbra - PG	5839	1751 07 27 (VIII)	12.6%
198	Fossato di Vico - PG	2840	1751 07 27 (VIII)	31.7%
199	Gualdo Tadino - PG	15208	1751 07 27 (IX)	11.7%
200	Fossa - AQ	721	1762 10 06 (IX)*	10.6%
201	San Pio delle Camere - AQ	661	1762 10 06 (IX)*	36.8%
202	Lattarico - CS	4013	1767 07 14 (VIII)*	13.5%
203	Santa Sofia d'Epiro - CS	2628	1767 07 14 (VIII)*	5.1%
204	Tarsia - CS	2054	1767 07 14 (VIII)*	9.6%
205	Cerzeto - CS	1373	1767 07 14 (VIII)*	24.5%
206	Cervicati - CS	829	1767 07 14 (VIII)*	7.6%
207	Luzzi - CS	9396	1767 07 14 (VIII-IX)	7.9%
208	Pratovecchio Stia - AR	5845	1768 10 19 (VIII)*	27.0%
209	Careri - RC	2360	1783 02 05 (VIII)	0.1%
210	Ciminà - RC	568	1783 02 05 (VIII)	0.2%
211	Mammola - RC	2847	1783 02 05 (VIII-IX)	15.2%
212	Cittanova - RC	10410	1783 02 05 (X)*	13.4%
213	Itala - ME	1640	1783 02 06 (VIII)*	6.0%
214	Gioia Tauro - RC	19864	1783 02 07 (VIII)*	3.1%
215	Antonimina - RC	1317	1783 02 07 (VIII)*	3.8%
216	Laureana di Borrello - RC	5174	1783 02 07 (VIII-IX)	25.0%
217	Decollatura - CZ	3159	1783 03 28 (VIII)*	20.0%
218	Soveria Mannelli - CZ	3076	1783 03 28 (VIII)*	21.2%
219	Fabrizia - VV	2195	1783 03 28 (VIII)	14.2%
220	Bianchi - CS	1305	1783 03 28 (VIII)*	29.6%
221	Mongiana - VV	740	1783 03 28 (VIII)*	70.7%
222	Pianopoli - CZ	2589	1783 03 28 (VIII-IX)*	2.5%
223	Gerocarne - VV	2248	1783 03 28 (IX)*	20.8%
224	Umbertide - PG	16681	1789 09 30 (VIII)*	20.3%
225	Sansepolcro - AR	15884	1789 09 30 (VIII)*	37.2%
226	Anghiari - AR	5638	1789 09 30 (VIII)*	43.6%
227	Pietralunga - PG	2111	1789 09 30 (VIII)*	17.1%
228	Montone - PG	1680	1789 09 30 (VIII)*	13.8%
229	Città di Castello - PG	39913	1789 09 30 (IX)	28.6%
230	Chiaravalle Centrale - CZ	5759	1791 10 13 (VIII)	11.8%
231	Cardinale - CZ	2188	1791 10 13 (VIII)*	24.5%
232	Arena - VV	1456	1791 10 13 (VIII)	18.1%
233	Dasà - VV	1208	1791 10 13 (VIII)	50.0%
234	Pizzoni - VV	1143	1791 10 13 (VIII)	14.4%
235	Vazzano - VV	1067	1791 10 13 (VIII)	12.4%
236	Capistrano - VV	1042	1791 10 13 (VIII)	32.5%
237	Vallelonga - VV	706	1791 10 13 (VIII)*	0.2%
238	Argusto - CZ	522	1791 10 13 (VIII)*	47.2%
239	Serra San Bruno - VV	6734	1791 10 13 (VIII-IX)	10.9%
240	Brognaturo - VV	735	1791 10 13 (VIII-IX)	18.1%
241	Soriano Calabro - VV	2421	1791 10 13 (IX)	7.2%
242	Sorianello - VV	1176	1791 10 13 (IX)*	17.3%
243	Spadola - VV	825	1791 10 13 (IX)	18.0%
244	Fiuminata - MC	1402	1799 07 28 (VIII)*	29.2%
245	Sefro - MC	422	1799 07 28 (VIII)*	0.3%
246	Morcone - BN	4932	1805 07 26 (VIII)	24.1%
247	Torrecuso - BN	3407	1805 07 26 (VIII)	6.7%
248	Ponte - BN	2580	1805 07 26 (VIII)*	13.1%
249	Montaquila - IS	2456	1805 07 26 (VIII)*	10.5%
250	Sesto Campano - IS	2388	1805 07 26 (VIII)*	15.4%
251	Pozzilli - IS	2380	1805 07 26 (VIII)*	6.5%
252	Pontelandolfo - BN	2167	1805 07 26 (VIII)*	16.8%
253	Pratella - CE	1565	1805 07 26 (VIII)*	17.3%
254	Capriati a Volturno - CE	1541	1805 07 26 (VIII)*	15.3%
255	Montefalcone di Val Fortore - BN	1525	1805 07 26 (VIII)*	29.5%
256	Prata Sannita - CE	1502	1805 07 26 (VIII)*	29.0%
257	Sant'Agapito - IS	1496	1805 07 26 (VIII)	25.1%
258	Casalduni - BN	1378	1805 07 26 (VIII)*	4.3%
259	Fossalto - CB	1345	1805 07 26 (VIII)*	5.4%
260	Cerro al Volturno - IS	1281	1805 07 26 (VIII)*	32.9%
261	Valle Agricola - CE	890	1805 07 26 (VIII)*	39.1%
262	Fontegreca - CE	811	1805 07 26 (VIII)*	3.3%
263	Longano - IS	690	1805 07 26 (VIII)*	37.1%
264	Forlì del Sannio - IS	675	1805 07 26 (VIII)*	73.0%
265	Filignano - IS	648	1805 07 26 (VIII)*	20.3%
266	Gallo Matese - CE	579	1805 07 26 (VIII)*	5.9%
267	Pettoranello del Molise - IS	460	1805 07 26 (VIII)*	27.7%
268	Ciorlano - CE	426	1805 07 26 (VIII)*	50.6%
269	Duronia - CB	405	1805 07 26 (VIII)*	24.6%

270	Chiauci - IS	233	1805 07 26 (VIII)*	25.5%
271	Ripalimosani - CB	3114	1805 07 26 (VIII-IX)*	29.8%
272	Matrice - CB	1115	1805 07 26 (VIII-IX)*	24.9%
273	Torella del Sannio - CB	795	1805 07 26 (VIII-IX)	41.3%
274	Letino - CE	712	1805 07 26 (VIII-IX)*	53.0%
275	Campochiaro - CB	646	1805 07 26 (VIII-IX)	40.9%
276	Castelpizzuto - IS	155	1805 07 26 (VIII-IX)	51.6%
277	Bojano - CB	8058	1805 07 26 (IX)	19.0%
278	Sepino - CB	1964	1805 07 26 (IX)	58.2%
279	Macchiagodena - IS	1854	1805 07 26 (IX)	19.4%
280	Fragneto Monforte - BN	1840	1805 07 26 (IX)	5.2%
281	San Giuliano del Sannio - CB	1029	1805 07 26 (IX)	79.4%
282	Colle d'Anchise - CB	807	1805 07 26 (IX)	47.4%
283	Sessano del Molise - IS	727	1805 07 26 (IX)	23.6%
284	Santa Maria del Molise - IS	665	1805 07 26 (IX)*	70.0%
285	Sant'Elena Sannita - IS	275	1805 07 26 (IX)*	39.7%
286	Isernia - IS	21842	1805 07 26 (IX-X)	10.0%
287	Vinchiaturo - CB	3324	1805 07 26 (IX-X)	15.5%
288	Castelpetroso - IS	1680	1805 07 26 (IX-X)	22.8%
289	Pesche - IS	1661	1805 07 26 (IX-X)	33.4%
290	Spinete - CB	1320	1805 07 26 (IX-X)	25.7%
291	Sassinoro - BN	618	1805 07 26 (IX-X)	51.2%
292	Casalciprano - CB	564	1805 07 26 (IX-X)	39.3%
293	Frosolone - IS	3170	1805 07 26 (X)	19.9%
294	Baranello - CB	2673	1805 07 26 (X)	34.5%
295	Carpinone - IS	1157	1805 07 26 (X)	75.8%
296	San Massimo - CB	855	1805 07 26 (X)	35.6%
297	Guardiaregia - CB	801	1805 07 26 (X)	26.8%
298	Cantalupo nel Sannio - IS	739	1805 07 26 (X)	27.8%
299	San Polo Matese - CB	470	1805 07 26 (X)	15.9%
300	Savoia di Lucania - PZ	1127	1826 02 01 (VIII)*	11.2%
301	Foligno - PG	57155	1832 01 13 (VIII)	14.5%
302	Assisi - PG	28299	1832 01 13 (VIII)	17.8%
303	San Giustino - PG	11297	1832 01 13 (VIII)	15.8%
304	Trevi - PG	8469	1832 01 13 (VIII)	25.4%
305	Torgiano - PG	6725	1832 01 13 (VIII)*	15.6%
306	Bettona - PG	4367	1832 01 13 (VIII)	8.9%
307	Giano dell'Umbria - PG	3846	1832 01 13 (VIII)*	31.5%
308	Valfabbrica - PG	3389	1832 01 13 (VIII)*	15.4%
309	Valtopina - PG	1398	1832 01 13 (VIII)*	0.7%
310	Spello - PG	8645	1832 01 13 (VIII-IX)	16.2%
311	Gualdo Cattaneo - PG	6155	1832 01 13 (IX)*	15.4%
312	Bevagna - PG	5081	1832 01 13 (IX)	35.4%
313	Spezzano Albanese - CS	7028	1832 03 08 (VIII)	16.6%
314	Pontremoli - MS	7357	1834 02 14 (VIII)	63.0%
315	Borgo Val di Taro - PR	6999	1834 02 14 (VIII)	19.4%
316	Serra Pedace - CS	986	1835 10 12 (VIII)*	50.4%
317	Nemoli - PZ	1495	1836 11 20 (VIII)	0.6%
318	Lagonegro - PZ	5584	1836 11 20 (IX)	36.3%
319	Cosenza - CS	67546	1854 02 12 (VIII)	17.4%
320	Bastia Umbra - PG	21874	1854 02 12 (VIII)	6.5%
321	Spezzano della Sila - CS	4541	1854 02 12 (VIII)*	15.0%
322	Cannara - PG	4305	1854 02 12 (VIII)	15.7%
323	Carolei - CS	3330	1854 02 12 (VIII)	19.0%
324	Cerisano - CS	3196	1854 02 12 (VIII)	18.6%
325	Rovito - CS	3158	1854 02 12 (VIII)*	13.4%
326	Trenta - CS	2633	1854 02 12 (VIII)	18.6%
327	Dipignano - CS	4376	1854 02 12 (VIII-IX)	25.5%
328	Lauria - PZ	12919	1857 12 16 (VIII)	6.8%
329	Sala Consilina - SA	12664	1857 12 16 (VIII)	19.3%
330	Latronico - PZ	4556	1857 12 16 (VIII)	17.0%
331	Moliterno - PZ	4062	1857 12 16 (VIII)	29.3%
332	Baragiano - PZ	2671	1857 12 16 (VIII)	0.1%
333	Laino Borgo - CS	1921	1857 12 16 (VIII)*	61.8%
334	Sasso di Castalda - PZ	835	1857 12 16 (VIII)	0.2%
335	Montesano sulla Marcellana - SA	6704	1857 12 16 (VIII-IX)	11.0%
336	Caggiano - SA	2765	1857 12 16 (VIII-IX)	6.1%
337	Picerno - PZ	5985	1857 12 16 (IX)	3.1%
338	Padula - SA	5368	1857 12 16 (IX)	33.5%
339	Satriano di Lucania - PZ	2374	1857 12 16 (IX)*	0.1%
340	Marsicovetere - PZ	5546	1857 12 16 (IX-X)	6.9%
341	Tito - PZ	7332	1857 12 16 (X)	0.5%
342	Paterno - PZ	3368	1857 12 16 (X)	6.8%
343	Viggiano - PZ	3329	1857 12 16 (X)	40.6%
344	Tramutola - PZ	3089	1857 12 16 (X)	4.4%
345	Calvello - PZ	1948	1857 12 16 (X)	40.1%
346	Spinoso - PZ	1462	1857 12 16 (X)	34.5%
347	Sant'Angelo Le Fratte - PZ	1429	1857 12 16 (X)	0.2%
348	Sarconi - PZ	1404	1857 12 16 (X)	8.2%
349	Castelsaraceno - PZ	1384	1857 12 16 (X)	44.3%
350	Grumento Nova - PZ	1700	1857 12 16 (XI)*	13.8%
351	Montemurro - PZ	1235	1857 12 16 (XI)	24.2%
352	Cerreto di Spoleto - PG	1075	1859 08 22 (VIII)*	28.3%
353	Preci - PG	724	1859 08 22 (VIII)*	10.1%
1861 – Unification of the Kingdom of Italy				
354	San Pietro in Guarano - CS	3663	1870 10 04 (VIII)*	26.1%
355	Celico - CS	2802	1870 10 04 (VIII)	37.0%
356	Zumpano - CS	2570	1870 10 04 (VIII)	13.3%
357	Parenti - CS	2188	1870 10 04 (VIII)*	14.8%
358	Grimaldi - CS	1680	1870 10 04 (VIII)*	54.0%
359	Colosimi - CS	1247	1870 10 04 (VIII)*	19.5%
360	Scigliano - CS	1226	1870 10 04 (VIII)*	26.9%
361	Marzi - CS	989	1870 10 04 (VIII)*	54.0%
362	Lappano - CS	941	1870 10 04 (VIII)*	2.9%
363	Belsito - CS	923	1870 10 04 (VIII)*	18.5%
364	Pedivigliano - CS	831	1870 10 04 (VIII)*	50.3%

365	Malito - CS	783	1870 10 04 (VIII)*	61.7%
366	Altilia - CS	711	1870 10 04 (VIII)*	8.3%
367	Carpanzano - CS	255	1870 10 04 (VIII)*	24.0%
368	Aprigliano - CS	2890	1870 10 04 (VIII-IX)	29.7%
369	Figline Vegliaturo - CS	1137	1870 10 04 (IX)	4.2%
370	Cellara - CS	504	1870 10 04 (IX-X)	32.5%
371	Mangone - CS	1891	1870 10 04 (X)	44.6%
372	Pieve Torina - MC	1458	1873 03 12 (VIII)*	28.3%
373	Monte Cavallo - MC	145	1873 03 12 (VIII)*	8.8%
374	Montefalco - PG	5679	1878 09 15 (VIII)	5.3%
375	Castel Ritaldi - PG	3278	1878 09 15 (VIII)	13.1%
376	Monteroduni - IS	2264	1882 06 06 (VIII)	15.5%
377	Macchia d'Isernia - IS	1035	1882 06 06 (VIII)*	14.6%
378	Rende - CS	35338	1905 09 08 (VIII)	5.7%
379	Montalto Uffugo - CS	19669	1905 09 08 (VIII)	14.5%
380	Bisignano - CS	10203	1905 09 08 (VIII)	5.2%
381	Mendicino - CS	9450	1905 09 08 (VIII)	18.0%
382	Pizzo - VV	9278	1905 09 08 (VIII)	24.8%
383	San Marco Argentano - CS	7424	1905 09 08 (VIII)	11.4%
384	Filadelfia - VV	5384	1905 09 08 (VIII)	14.9%
385	Gizzeria - CZ	4982	1905 09 08 (VIII)	4.2%
386	Nocera Terinese - CZ	4731	1905 09 08 (VIII)	17.7%
387	Rose - CS	4373	1905 09 08 (VIII)	18.1%
388	San Pietro a Maida - CZ	4200	1905 09 08 (VIII)	14.5%
389	Marano Marchesato - CS	3553	1905 09 08 (VIII)	31.7%
390	Cessaniti - VV	3290	1905 09 08 (VIII)	9.2%
391	Marano Principato - CS	3180	1905 09 08 (VIII)	31.4%
392	Serrastretta - CZ	3176	1905 09 08 (VIII)	18.8%
393	San Fili - CS	2719	1905 09 08 (VIII)	57.4%
394	Casole Bruzio - CS	2578	1905 09 08 (VIII)	19.6%
395	San Gregorio d'Ippona - VV	2527	1905 09 08 (VIII)	2.7%
396	San Vincenzo La Costa - CS	2195	1905 09 08 (VIII)	19.8%
397	Platania - CZ	2172	1905 09 08 (VIII)	41.5%
398	Feroleto Antico - CZ	2171	1905 09 08 (VIII)	10.9%
399	Spezzano Piccolo - CS	2079	1905 09 08 (VIII)	37.9%
400	Pedace - CS	1907	1905 09 08 (VIII)	36.3%
401	San Vito sullo Ionio - CZ	1811	1905 09 08 (VIII)	5.5%
402	Santo Stefano di Rogliano - CS	1725	1905 09 08 (VIII)	39.0%
403	Mongrassano - CS	1607	1905 09 08 (VIII)	50.4%
404	San Mango d'Aquino - CZ	1564	1905 09 08 (VIII)	13.8%
405	Piane Crati - CS	1423	1905 09 08 (VIII)	15.0%
406	Filogaso - VV	1417	1905 09 08 (VIII)	2.1%
407	Paterno Calabro - CS	1398	1905 09 08 (VIII)	39.0%
408	San Nicola da Crissa - VV	1335	1905 09 08 (VIII)	48.6%
409	Pietrafitta - CS	1310	1905 09 08 (VIII)	36.0%
410	San Pietro di Caridà - RC	1195	1905 09 08 (VIII)*	17.7%
411	San Martino di Finita - CS	1100	1905 09 08 (VIII)	33.6%
412	Torre di Ruggiero - CZ	1033	1905 09 08 (VIII)	28.4%
413	Simbario - VV	966	1905 09 08 (VIII)	37.9%
414	Domanico - CS	943	1905 09 08 (VIII)	28.6%
415	Cosoleto - RC	859	1905 09 08 (VIII)	2.0%
416	Motta Santa Lucia - CZ	845	1905 09 08 (VIII)	30.6%
417	Curinga - CZ	6779	1905 09 08 (VIII-IX)	8.3%
418	Ionadi - VV	4238	1905 09 08 (VIII-IX)	6.1%
419	Castiglione Cosentino - CS	2896	1905 09 08 (VIII-IX)	16.6%
420	Francavilla Angitola - VV	1939	1905 09 08 (VIII-IX)	14.0%
421	Monterosso Calabro - VV	1729	1905 09 08 (VIII-IX)	71.7%
422	Vibo Valentia - VV	33941	1905 09 08 (IX)*	6.9%
423	Castrolibero - CS	9894	1905 09 08 (IX)	4.7%
424	Maierato - VV	2188	1905 09 08 (IX)	28.0%
425	Zambrone - VV	1775	1905 09 08 (IX)	0.1%
426	Aiello Calabro - CS	1729	1905 09 08 (IX)	4.0%
427	Martirano Lombardo - CZ	1112	1905 09 08 (IX)*	31.5%
428	Martirano - CZ	884	1905 09 08 (X)	20.5%
429	Melicuccà - RC	930	1907 10 23 (VIII)	7.0%
430	Taurianova - RC	15636	1908 12 28 (VIII)*	9.1%
431	Rosarno - RC	14841	1908 12 28 (VIII)	0.0%
432	Polistena - RC	10496	1908 12 28 (VIII)	7.2%
433	Santa Teresa di Riva - ME	9377	1908 12 28 (VIII)*	2.5%
434	Rizziconi - RC	7829	1908 12 28 (VIII)	0.3%
435	Mileto - VV	6763	1908 12 28 (VIII)	3.9%
436	Cinquefrondi - RC	6539	1908 12 28 (VIII)	25.5%
437	Montebello Ionico - RC	6214	1908 12 28 (VIII)	4.4%
438	Oppido Mamertina - RC	5332	1908 12 28 (VIII)	1.9%
439	Melicucco - RC	5101	1908 12 28 (VIII)*	1.3%
440	Scilla - RC	4964	1908 12 28 (VIII)	3.1%
441	Maida - CZ	4566	1908 12 28 (VIII)	20.6%
442	San Calogero - VV	4315	1908 12 28 (VIII)	0.7%
443	Delianuova - RC	3352	1908 12 28 (VIII)	12.8%
444	San Giorgio Morgeto - RC	3058	1908 12 28 (VIII)	19.8%
445	Molochio - RC	2564	1908 12 28 (VIII)	8.5%
446	Stefanaconi - VV	2494	1908 12 28 (VIII)	2.9%
447	Acquaro - VV	2484	1908 12 28 (VIII)	0.8%
448	San Costantino Calabro - VV	2239	1908 12 28 (VIII)	2.8%
449	Anoia - RC	2212	1908 12 28 (VIII)*	9.7%
450	Dinami - VV	2168	1908 12 28 (VIII)	5.4%
451	Varapodio - RC	2160	1908 12 28 (VIII)	8.9%
452	Giffone - RC	1907	1908 12 28 (VIII)	0.1%
453	Savoca - ME	1732	1908 12 28 (VIII)	5.9%
454	Galatro - RC	1709	1908 12 28 (VIII)	0.1%
455	Feroleto della Chiesa - RC	1695	1908 12 28 (VIII)	2.2%
456	Francica - VV	1651	1908 12 28 (VIII)	0.1%
457	Sant'Alessio Siculo - ME	1554	1908 12 28 (VIII)*	4.5%
458	Maropati - RC	1524	1908 12 28 (VIII)	6.4%
459	Polia - VV	1023	1908 12 28 (VIII)	5.8%
460	Serrata - RC	845	1908 12 28 (VIII)	3.3%

461	Canolo - RC	746	1908 12 28 (VIII)	0.4%
462	Jacurso - CZ	624	1908 12 28 (VIII)	38.3%
463	Terranova Sappo Minulio - RC	523	1908 12 28 (VIII)	0.4%
464	Candidoni - RC	416	1908 12 28 (VIII)	0.4%
465	Gallodoro - ME	367	1908 12 28 (VIII)	0.6%
466	Palmi - RC	18930	1908 12 28 (VIII-IX)	1.4%
467	San Luca - RC	3881	1908 12 28 (VIII-IX)	0.1%
468	Seminara - RC	2811	1908 12 28 (VIII-IX)	1.2%
469	Alì Terme - ME	2539	1908 12 28 (VIII-IX)*	1.0%
470	Scaletta Zanclea - ME	2140	1908 12 28 (VIII-IX)*	10.5%
471	Scido - RC	931	1908 12 28 (VIII-IX)	0.0%
472	Santa Cristina d'Aspromonte - RC	929	1908 12 28 (VIII-IX)	13.8%
473	Alì - ME	768	1908 12 28 (VIII-IX)*	53.1%
474	San Procopio - RC	534	1908 12 28 (VIII-IX)	1.9%
475	Bagnara Calabra - RC	10255	1908 12 28 (IX)	1.7%
476	Platì - RC	3812	1908 12 28 (IX)	0.1%
477	Sinopoli - RC	2089	1908 12 28 (IX)*	0.1%
478	Cardeto - RC	1641	1908 12 28 (IX)	0.0%
479	Santo Stefano d'Aspromonte - RC	1263	1908 12 28 (IX)	0.5%
480	Laganadi - RC	413	1908 12 28 (IX)	0.3%
481	Motta San Giovanni - RC	6208	1908 12 28 (IX-X)	1.3%
482	Reggio di Calabria - RC	183035	1908 12 28 (X)	2.4%
483	Villa San Giovanni - RC	13784	1908 12 28 (X)	1.2%
484	Sant'Eufemia d'Aspromonte - RC	4120	1908 12 28 (X)	2.4%
485	Fiumara - RC	1018	1908 12 28 (X)*	22.9%
486	Calanna - RC	934	1908 12 28 (X)	5.1%
487	Messina - ME	238439	1908 12 28 (X-XI)	8.2%
488	Campo Calabro - RC	4536	1908 12 28 (X-XI)	0.7%
489	San Roberto - RC	1750	1908 12 28 (X-XI)	0.1%
490	Sant'Alessio in Aspromonte - RC	343	1908 12 28 (X-XI)	0.4%
491	Rapone - PZ	990	1910 06 07 (VIII)	40.5%
492	Torano Castello - CS	4614	1913 06 28 (VIII)	9.6%
493	Roggiano Gravina - CS	7208	1913 06 28 (VIII-IX)	10.6%
494	L'Aquila - AQ	69753	1915 01 13 (VIII)	24.1%
495	Pratola Peligna - AQ	7577	1915 01 13 (VIII)	23.9%
496	Tagliacozzo - AQ	6889	1915 01 13 (VIII)	30.9%
497	Popoli - PE	5172	1915 01 13 (VIII)	37.2%
498	Scoppito - AQ	3727	1915 01 13 (VIII)	11.0%
499	Tornimparte - AQ	3187	1915 01 13 (VIII)	21.4%
500	Raiano - AQ	2815	1915 01 13 (VIII)	30.1%
501	Tocco da Casauria - PE	2688	1915 01 13 (VIII)	42.9%
502	Introdacqua - AQ	2126	1915 01 13 (VIII)	10.9%
503	San Donato Val di Comino - FR	2107	1915 01 13 (VIII)	43.9%
504	San Demetrio ne' Vestini - AQ	1854	1915 01 13 (VIII)	26.3%
505	Barisciano - AQ	1828	1915 01 13 (VIII)	34.9%
506	Campoli Appennino - FR	1725	1915 01 13 (VIII)	28.0%
507	Roccaraso - AQ	1627	1915 01 13 (VIII)*	0.4%
508	Vallerotonda - FR	1581	1915 01 13 (VIII)	10.5%
509	Gallinaro - FR	1269	1915 01 13 (VIII)*	14.6%
510	Pacentro - AQ	1174	1915 01 13 (VIII)*	62.2%
511	Ocre - AQ	1167	1915 01 13 (VIII)*	20.2%
512	Sante Marie - AQ	1166	1915 01 13 (VIII)	23.4%
513	Poggio Picenze - AQ	1136	1915 01 13 (VIII)	35.3%
514	Pescocostanzo - AQ	1128	1915 01 13 (VIII)*	48.4%
515	Bugnara - AQ	1125	1915 01 13 (VIII)	38.2%
516	Lucoli - AQ	1011	1915 01 13 (VIII)*	62.7%
517	Castelvecchio Subequo - AQ	982	1915 01 13 (VIII)	30.6%
518	Capestrano - AQ	884	1915 01 13 (VIII)	27.4%
519	Vittorito - AQ	873	1915 01 13 (VIII)	7.2%
520	Campo di Giove - AQ	803	1915 01 13 (VIII)*	11.4%
521	Settefrati - FR	728	1915 01 13 (VIII)	44.0%
522	Barrea - AQ	726	1915 01 13 (VIII)	29.5%
523	Rivisondoli - AQ	700	1915 01 13 (VIII)*	46.2%
524	Roccacasale - AQ	693	1915 01 13 (VIII)	21.5%
525	Villetta Barrea - AQ	653	1915 01 13 (VIII)	53.9%
526	Belmonte in Sabina - RI	636	1915 01 13 (VIII)	6.2%
527	Scontrone - AQ	574	1915 01 13 (VIII)*	50.0%
528	Goriano Sicoli - AQ	569	1915 01 13 (VIII)	18.3%
529	Navelli - AQ	554	1915 01 13 (VIII)*	63.4%
530	Montenero Val Cocchiara - IS	538	1915 01 13 (VIII)*	55.7%
531	Prata d'Ansidonia - AQ	496	1915 01 13 (VIII)*	52.5%
532	Fagnano Alto - AQ	418	1915 01 13 (VIII)*	16.2%
533	Fontecchio - AQ	369	1915 01 13 (VIII)*	65.8%
534	San Biagio Saracinisco - FR	349	1915 01 13 (VIII)*	0.9%
535	Anversa degli Abruzzi - AQ	341	1915 01 13 (VIII)	79.3%
536	Tione degli Abruzzi - AQ	310	1915 01 13 (VIII)*	74.1%
537	Castel di Ieri - AQ	303	1915 01 13 (VIII)	39.2%
538	Sant'Eufemia a Maiella - PE	278	1915 01 13 (VIII)*	0.2%
539	Cansano - AQ	274	1915 01 13 (VIII)*	46.0%
540	Caporciano - AQ	230	1915 01 13 (VIII)*	67.1%
541	Rocca Pia - AQ	178	1915 01 13 (VIII)	83.4%
542	Castelvecchio Calvisio - AQ	153	1915 01 13 (VIII)*	81.7%
543	Calascio - AQ	137	1915 01 13 (VIII)*	97.9%
544	San Benedetto in Perillis - AQ	113	1915 01 13 (VIII)*	20.6%
545	Santo Stefano di Sessanio - AQ	111	1915 01 13 (VIII)*	68.7%
546	Carapelle Calvisio - AQ	87	1915 01 13 (VIII)*	75.6%
547	Trasacco - AQ	6246	1915 01 13 (VIII-IX)	11.6%
548	Capistrello - AQ	5252	1915 01 13 (VIII-IX)	22.5%
549	Borgorose - RI	4591	1915 01 13 (VIII-IX)*	22.7%
550	Pescasseroli - AQ	2203	1915 01 13 (VIII-IX)	29.8%
551	Collelongo - AQ	1233	1915 01 13 (VIII-IX)	34.0%
552	Corfinio - AQ	1051	1915 01 13 (VIII-IX)*	40.4%
553	Villalago - AQ	568	1915 01 13 (VIII-IX)	51.1%
554	Ortona dei Marsi - AQ	542	1915 01 13 (VIII-IX)	68.4%
555	Molina Aterno - AQ	386	1915 01 13 (VIII-IX)*	34.6%
556	Acciano - AQ	327	1915 01 13 (VIII-IX)*	54.6%

557	Celano - AQ	11017	1915 01 13 (IX)	13.8%
558	Luco dei Marsi - AQ	6079	1915 01 13 (IX)	26.1%
559	Scurcola Marsicana - AQ	2824	1915 01 13 (IX)	25.7%
560	Bussi sul Tirino - PE	2518	1915 01 13 (IX)	19.4%
561	San Vincenzo Valle Roveto - AQ	2347	1915 01 13 (IX)*	12.4%
562	Lecce nei Marsi - AQ	1702	1915 01 13 (IX)	2.6%
563	Pescosolido - FR	1555	1915 01 13 (IX)	44.8%
564	Aielli - AQ	1475	1915 01 13 (IX)	30.7%
565	Fiamignano - RI	1413	1915 01 13 (IX)	36.4%
566	Cagnano Amiterno - AQ	1369	1915 01 13 (IX)	29.4%
567	Civita d'Antino - AQ	979	1915 01 13 (IX)	4.2%
568	Villavallelonga - AQ	919	1915 01 13 (IX)	58.0%
569	Villa Sant'Angelo - AQ	424	1915 01 13 (IX)*	10.2%
570	Sant'Eusanio Forconese - AQ	394	1915 01 13 (IX)	10.2%
571	Secinaro - AQ	359	1915 01 13 (IX)*	20.8%
572	Gagliano Aterno - AQ	254	1915 01 13 (IX)	92.7%
573	Collepietro - AQ	237	1915 01 13 (IX)*	58.4%
574	Cocullo - AQ	230	1915 01 13 (IX)	48.8%
575	Bisegna - AQ	223	1915 01 13 (IX)	36.4%
576	Magliano de' Marsi - AQ	3690	1915 01 13 (IX-X)	29.3%
577	Cerchio - AQ	1635	1915 01 13 (IX-X)	16.1%
578	Pescina - AQ	4133	1915 01 13 (X)	16.2%
579	Balsorano - AQ	3569	1915 01 13 (X)*	5.1%
580	Massa d'Albe - AQ	1476	1915 01 13 (X)	9.0%
581	Collarmele - AQ	894	1915 01 13 (X)	36.0%
582	Avezzano - AQ	42515	1915 01 13 (XI)	0.6%
583	San Benedetto dei Marsi - AQ	3909	1915 01 13 (XI)	1.7%
584	Gioia dei Marsi - AQ	1989	1915 01 13 (XI)	5.0%
585	Ortucchio - AQ	1860	1915 01 13 (XI)	0.1%
586	Citerna - PG	3531	1917 04 26 (IX)	20.5%
587	Monte Santa Maria Tiberina - PG	1183	1917 04 26 (IX)	54.2%
588	Monterchi - AR	1757	1917 04 26 (IX-X)	51.0%
589	Ortignano Raggiolo - AR	878	1918 11 10 (VIII)	54.9%
590	Santa Sofia - FC	4136	1918 11 10 (IX)	15.5%
591	Dicomano - FI	5515	1919 06 29 (VIII)	34.9%
592	San Godenzo - FI	1167	1919 06 29 (VIII)	21.1%
593	Borgo San Lorenzo - FI	18211	1919 06 29 (VIII-IX)	38.9%
594	Vicchio - FI	8044	1919 06 29 (IX)	36.2%
595	Barga - LU	10034	1920 09 07 (VIII)	37.3%
596	Licciana Nardi - MS	4949	1920 09 07 (VIII)	12.9%
597	Villafranca in Lunigiana - MS	4770	1920 09 07 (VIII)	23.7%
598	Pieve Fosciana - LU	2414	1920 09 07 (VIII)	51.6%
599	Filattiera - MS	2309	1920 09 07 (VIII)	44.5%
600	Pievepelago - MO	2222	1920 09 07 (VIII)	35.3%
601	Podenzana - MS	2180	1920 09 07 (VIII)*	8.8%
602	Tresana - MS	2044	1920 09 07 (VIII)	43.2%
603	Ligonchio - RE	819	1920 09 07 (VIII)	8.1%
604	Fosciandora - LU	602	1920 09 07 (VIII)	76.0%
605	Castiglione di Garfagnana - LU	1818	1920 09 07 (VIII-IX)	54.4%
606	San Romano in Garfagnana - LU	1410	1920 09 07 (VIII-IX)	13.2%
607	Sillano Giuncugnano - LU	1085	1920 09 07 (VIII-IX)	58.8%
608	Vagli Sotto - LU	939	1920 09 07 (VIII-IX)	34.1%
609	Fivizzano - MS	7925	1920 09 07 (IX)	42.1%
610	Piazza al Serchio - LU	2367	1920 09 07 (IX)	27.5%
611	Camporgiano - LU	2176	1920 09 07 (IX)	15.3%
612	Minucciano - LU	2102	1920 09 07 (IX)	28.9%
613	Casola in Lunigiana - MS	988	1920 09 07 (IX)	10.6%
614	Comano - MS	714	1920 09 07 (IX)*	53.7%
615	Villa Collemandina - LU	1334	1920 09 07 (X)	39.6%
616	Briatico - VV	4053	1928 03 07 (VIII)	2.0%
617	Sant'Onofrio - VV	3067	1928 03 07 (VIII)	1.1%
618	Benevento - BN	60091	1930 07 23 (VIII)	4.6%
619	Rionero in Vulture - PZ	13230	1930 07 23 (VIII)	13.6%
620	Rapolla - PZ	4432	1930 07 23 (VIII)	31.9%
621	Atella - PZ	3827	1930 07 23 (VIII)	4.9%
622	Frigento - AV	3780	1930 07 23 (VIII)	0.1%
623	Gesualdo - AV	3516	1930 07 23 (VIII)	9.6%
624	Fontanarosa - AV	3170	1930 07 23 (VIII)*	1.1%
625	Filiano - PZ	2926	1930 07 23 (VIII)	0.8%
626	Vallata - AV	2714	1930 07 23 (VIII)	4.6%
627	Calvi - BN	2682	1930 07 23 (VIII)	0.1%
628	Venticano - AV	2537	1930 07 23 (VIII)*	1.4%
629	Pietradefusi - AV	2348	1930 07 23 (VIII)*	1.7%
630	Sant'Agata di Puglia - FG	1959	1930 07 23 (VIII)	31.2%
631	Ripacandida - PZ	1744	1930 07 23 (VIII)	51.5%
632	San Sossio Baronia - AV	1643	1930 07 23 (VIII)	3.1%
633	Carife - AV	1408	1930 07 23 (VIII)	2.6%
634	Savignano Irpino - AV	1140	1930 07 23 (VIII)*	13.9%
635	Zungoli - AV	1099	1930 07 23 (VIII)	36.0%
636	Monteleone di Puglia - FG	1021	1930 07 23 (VIII)	14.3%
637	Castelfranco in Miscano - BN	916	1930 07 23 (VIII)	38.1%
638	Monteverde - AV	784	1930 07 23 (VIII)	48.0%
639	Greci - AV	691	1930 07 23 (VIII)	46.7%
640	Montaguto - AV	423	1930 07 23 (VIII)	5.7%
641	San Fele - PZ	3004	1930 07 23 (VIII-IX)	11.1%
642	Flumeri - AV	2963	1930 07 23 (VIII-IX)	0.1%
643	Barile - PZ	2785	1930 07 23 (VIII-IX)	0.6%
644	Melfi - PZ	17767	1930 07 23 (IX)	23.5%
645	Rocchetta Sant'Antonio - FG	1875	1930 07 23 (IX)	16.4%
646	Trevico - AV	993	1930 07 23 (IX)	2.6%
647	Anzano di Puglia - FG	1284	1930 07 23 (IX-X)*	3.6%
648	Scampitella - AV	1234	1930 07 23 (IX-X)	0.3%
649	Lacedonia - AV	2340	1930 07 23 (X)	0.4%
650	Aquilonia - AV	1739	1930 07 23 (X)*	1.0%
651	Villanova del Battista - AV	1690	1930 07 23 (X)	0.1%
652	Sulmona - AQ	24557	1933 09 26 (VIII)	21.0%

653	Salle - PE	308	1933 09 26 (VIII)*	0.5%
654	Accumoli - RI	667	1950 09 05 (VIII)	35.9%
655	Fano Adriano - TE	296	1950 09 05 (VIII)	42.0%
656	Ariano Irpino - AV	22700	1962 08 21 (VIII)	2.6%
657	Grottaminarda - AV	8137	1962 08 21 (VIII)	0.7%
658	Apice - BN	5686	1962 08 21 (VIII)	0.5%
659	Montecalvo Irpino - AV	3725	1962 08 21 (VIII)	2.8%
660	Pietrelcina - BN	3114	1962 08 21 (VIII)	18.2%
661	San Giorgio La Molara - BN	2994	1962 08 21 (VIII)	14.7%
662	Pesco Sannita - BN	1972	1962 08 21 (VIII)	5.4%
663	Castel Baronia - AV	1129	1962 08 21 (VIII)	0.4%
664	Santa Croce del Sannio - BN	927	1962 08 21 (VIII)*	24.6%
665	San Nicola Baronia - AV	771	1962 08 21 (VIII)	0.3%
666	Paduli - BN	3978	1962 08 21 (VIII-IX)	0.6%
667	Bonito - AV	2448	1962 08 21 (VIII-IX)	0.4%
668	Pago Veiano - BN	2406	1962 08 21 (VIII-IX)	2.5%
669	Buonalbergo - BN	1730	1962 08 21 (VIII-IX)	6.7%
670	Ginestra degli Schiavoni - BN	476	1962 08 21 (VIII-IX)	0.0%
671	Melito Irpino - AV	1920	1962 08 21 (IX)	0.0%
672	Casalbore - AV	1800	1962 08 21 (IX)	3.9%
673	Molinara - BN	1618	1962 08 21 (IX)	0.2%
674	Reino - BN	1210	1962 08 21 (IX)	1.0%
675	Sant'Arcangelo Trimonte - BN	573	1962 08 21 (IX)	2.6%
676	Norcia - PG	4957	1979 09 19 (VIII)	41.2%
677	Cascia - PG	3217	1979 09 19 (VIII)	14.1%
678	Mirabella Eclano - AV	7684	1980 11 23 (VIII)	0.4%
679	Muro Lucano - PZ	5497	1980 11 23 (VIII)	9.6%
680	Polla - SA	5279	1980 11 23 (VIII)	19.1%
681	Bella - PZ	5171	1980 11 23 (VIII)	0.1%
682	Buccino - SA	5047	1980 11 23 (VIII)	15.2%
683	Calitri - AV	4666	1980 11 23 (VIII)	20.4%
684	San Gregorio Magno - SA	4286	1980 11 23 (VIII)	0.5%
685	Marsico Nuovo - PZ	4098	1980 11 23 (VIII)	10.0%
686	Brienza - PZ	4078	1980 11 23 (VIII)	7.3%
687	Bisaccia - AV	3831	1980 11 23 (VIII)	9.0%
688	Vietri di Potenza - PZ	2832	1980 11 23 (VIII)	1.6%
689	Atena Lucana - SA	2336	1980 11 23 (VIII)	2.1%
690	Valva - SA	1643	1980 11 23 (VIII)	6.3%
691	Sant'Andrea di Conza - AV	1539	1980 11 23 (VIII)	34.8%
692	Morra De Sanctis - AV	1297	1980 11 23 (VIII)	0.5%
693	Ricigliano - SA	1144	1980 11 23 (VIII)	0.0%
694	Ruvo del Monte - PZ	1083	1980 11 23 (VIII)	37.5%
695	Castelgrande - PZ	943	1980 11 23 (VIII)	10.5%
696	Pertosa - SA	690	1980 11 23 (VIII)	3.9%
697	Colliano - SA	3638	1980 11 23 (VIII-IX)	1.8%
698	Salvitelle - SA	560	1980 11 23 (VIII-IX)	19.0%
699	Romagnano al Monte - SA	368	1980 11 23 (VIII-IX)	1.1%
700	Caposele - AV	3483	1980 11 23 (IX)	1.2%
701	Calabritto - AV	2391	1980 11 23 (IX)	0.1%
702	Pescopagano - PZ	1910	1980 11 23 (IX)	5.4%
703	Balvano - PZ	1830	1980 11 23 (IX)	0.8%
704	Guardia Lombardi - AV	1718	1980 11 23 (IX)	0.3%
705	Teora - AV	1537	1980 11 23 (IX)	0.0%
706	Lioni - AV	6201	1980 11 23 (X)	0.2%
707	Sant'Angelo dei Lombardi - AV	4250	1980 11 23 (X)	0.6%
708	Laviano - SA	1438	1980 11 23 (X)	0.5%
709	Conza della Campania - AV	1373	1980 11 23 (X)	0.0%
710	Castelnuovo di Conza - SA	619	1980 11 23 (X)	3.1%
711	Santomenna - SA	443	1980 11 23 (X)	26.2%
712	Colli a Volturno - IS	1349	1984 05 07 (VIII)	29.4%
713	Alfedena - AQ	864	1984 05 07 (VIII)	1.4%
714	Pizzone - IS	329	1984 05 07 (VIII)	68.1%
715	Serravalle di Chienti - MC	1070	1997 09 26 (VIII-IX)	35.8%
716	Sellano - PG	1079	1997 10 14 (VIII-IX)	38.8%
	Total	**2,929,583**		

Table 6 – List the largest *comuni* of our sample (pop>15,000), orderded by decreasing population. * indicates that the intensity was estimated using SASHA (see text).

Rank	**Municipality - Province**	**Population (2015)**	**Date of Intensity ≥ VIII**	**% of pre-1918 buildings (as of 2011)**
487	Messina - ME	238439	1908 12 28 (X-XI)	8,2%
482	Reggio di Calabria - RC	183035	1908 12 28 (X)	2,4%
22	Perugia - PG	166134	--	15,0%
86	Lamezia Terme - CZ	70714	1638 03 27 (XI)	9,4%
494	L'Aquila - AQ	69753	1915 01 13 (VIII)	24,1%
319	Cosenza - CS	67546	1854 02 12 (VIII)	17,4%
618	Benevento - BN	60091	1930 07 23 (VIII)	4,6%
301	Foligno - PG	57155	1832 01 13 (VIII)	14,5%
582	Avezzano - AQ	42515	1915 01 13 (XI)	0,6%
229	Città di Castello - PG	39913	1789 09 30 (IX)	28,6%
195	Spoleto - PG	38218	1745 03 00 (VIII)	23,5%
378	Rende - CS	35338	1905 09 08 (VIII)	5,7%
422	Vibo Valentia - VV	33941	1905 09 08 (IX)*	6,9%
196	Gubbio - PG	32216	1747 04 17 (VIII)*	17,4%
302	Assisi - PG	28299	1832 01 13 (VIII)	17,8%
652	Sulmona - AQ	24557	1933 09 26 (VIII)	21,0%
656	Ariano Irpino - AV	22700	1962 08 21 (VIII)	2,6%
105	Castrovillari - CS	22240	1693 01 08 (VIII)	15,8%
69	Sarzana - SP	21976	1497 03 03 (VIII)*	18,0%
320	Bastia Umbra - PG	21874	1854 02 12 (VIII)	6,5%
286	Isernia - IS	21842	1805 07 26 (IX-X)	10,0%
25	Pontassieve - FI	20603	--	23,7%
214	Gioia Tauro - RC	19864	1783 02 07 (VIII)*	3,1%

379	Montalto Uffugo - CS	19669	1905 09 08 (VIII)	14,5%
466	Palmi - RC	18930	1908 12 28 (VIII-IX)	1,4%
40	Cassano all'Ionio - CS	18495	1184 05 24 (VIII)*	9,5%
593	Borgo San Lorenzo - FI	18211	1919 06 29 (VIII-IX)	38,9%
644	Melfi - PZ	17767	1930 07 23 (IX)	23,5%
224	Umbertide - PG	16681	1789 09 30 (VIII)*	20,3%
225	Sansepolcro - AR	15884	1789 09 30 (VIII)*	37,2%
430	Taurianova - RC	15636	1908 12 28 (VIII)*	9,1%
199	Gualdo Tadino - PG	15208	1751 07 27 (IX)	11,7%
	Total	**1,495,444**		