

Implementation of the residency index in demographic statistics

Determining the population figure: then and now

In 2016, Statistics Estonia started carrying out the demographic analysis based on a new method, using an originally developed residency index. Why was it necessary?

The population figure is an extremely vital characteristic for the state and it is natural that all calculations, assessments and analyses feature one figure that is as accurate as possible. Traditionally, the population figure is determined in a population census. Each year, this figure is adjusted by adding the number of births and of persons having immigrated into the country and by subtracting the number of deaths and of persons having left the country. This means that the population figure is adjusted for natural increase (the difference between the number of births and deaths) and net migration (the difference between immigration and emigration).

Employing this method will yield an accurate population figure only if all the source data are correct. In the last census, Statistics Estonia managed to establish the correct population figure. The figures of natural increase are correct for all years and the external migration data are also correct for all the years in question. However, if a part of the data is incorrect, if the population number established in the census is under-covered, for example (this was the case after the 2000 census), then the estimates for the following years are also inaccurate and – worse still – the error may accumulate and become greater and greater over the years. Secondly, there were no accurate data on external migration in 2000–2011, which was another factor contributing to the inaccuracy of population estimates.

Three different population figures

After the previous Population and Housing Census (PHC 2011), there were three different population figures for Estonia. The Population Register-based figure was the highest one, followed by the population number calculated based on the 2000 census results and adjusted for vital events, and the third and lowest population figure, which was the one established in the last census. The difference between the highest and lowest figure was several thousand persons, i.e. enough to populate an average county. The reasons for the difference were clear, but the extent of errors was not known. The Population Register-based population number was bigger than the actual population figure because a part of emigration had not been registered. Therefore, a number of so-called lost souls, who had actually moved abroad a long time ago, were included in the register as residents of Estonia. Census data, on the other hand, showed that the population number was smaller than it actually was because a part of the residents of Estonia had not been enumerated for various reasons: either they were away from home or could not be contacted by enumerators or they were against being enumerated on principle. The population figure established based on current statistics combined both the under-coverage of the previous census and the missing data in registering migration.

Revision of the population figure established in the census

The fact that it will be necessary to revise the population figure established in the census became obvious immediately after the census. The revised population figure was published for the first time at the beginning of 2013. The revision was based on the data available from state registers active in Estonia. Statistical models were made to determine the average number of registers which reflect the actions of Estonian residents of various ages over the course of a year. Models were applied for all inhabitants who were registered in the Population Register as permanent residents and who had

not been found in the census. This way it was determined who among those not enumerated was likely to be still living in Estonia and who had left the country. It was found out that the persons in question could be divided almost

equally into the above-mentioned groups and those who, based on register entries, met the requirements of being a permanent resident of Estonia were added to the population of Estonia. For the purposes of demographic statistics, the population figures of the period of 2000–2011 were adjusted taking into account the estimated under-coverage of 2000 and the registered and unregistered external migration that had taken place in the meantime. Still, the total population of the census, which is 2.3% smaller than the estimated population, has been kept in all PHC 2011 data.

Residency index and the methodology of demographic statistics relying on it

In the following years, the methodology was further developed to determine the population of Estonia for each year, and to get estimates on internal and external migration as well. This methodology has been tested for four years and presented in several international forums, where it has excited interest and earned recognition. After a presentation given at Eurostat's seminar on censuses, the representatives of several other countries (Lithuania, Slovenia) considered adopting this method in their country.

The method is based on the idea that each potential inhabitant of Estonia is assigned an index which shows the person's likelihood of being a permanent inhabitant, i.e. a resident of Estonia. This is the so-called **residency index**, the value of which ranges between 0 and 1. The greater the index value, the more likely it is that a person is a resident of Estonia. If a person's residency index stands at 0, the person is definitely a non-resident. If the value of the residency index is 1, the person is definitely a resident. If the index value is somewhere in between, threshold c is used to make the distinction: persons whose residency index exceeds or is equal to the threshold are considered residents, while those whose index value is below the threshold are considered non-residents.

Signs of life and the calculation of the residency index

A residency index is calculated for all persons who currently live in Estonia based on the Population Register, but also for those who have left Estonia but are still included in the Population Register (their place of residence may be registered either in Estonia or abroad or be missing altogether and they may be recorded in the so-called passive section of the Population Register). Therefore, an index value has been calculated for more than one and a half million persons. In order to calculate the index, 14 Estonian administrative registers and subregisters were used, including the Estonian Education Information System, the State Pension Insurance Register, the health insurance database, etc. Activity in registers is measured with the help of the so-called **signs of life**. Each register or subregister gives a person one sign of life if, over the course of a year, the person takes an active step which is recorded in the respective register. This way, a person can accumulate signs of life by being a court witness, receiving social benefits, serving in the army, etc. Over the course of a year, each person with an Estonian personal identification code accumulates a certain number of signs of life (with the maximum being 27), but it can also happen that no signs of life are reflected in registers.

Figure 1. Simple sum of signs of life for inhabitants of Estonia, 2014

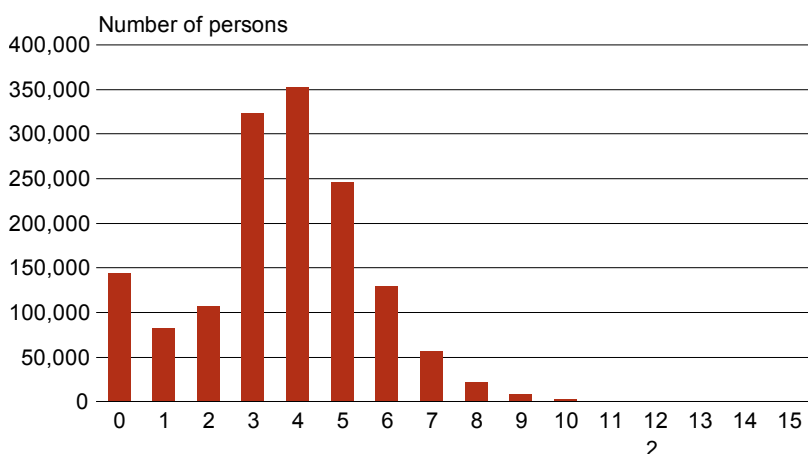


Figure 1 shows that, on average, the inhabitants of Estonia accumulate 4–5 signs of life over a year, and based on the sum of the signs of life, most of the inhabitants of Estonia can be divided into two groups. The group consisting of people who have accumulated a great number of signs of life can be assumed to be inhabitants of Estonia, i.e. residents. Others, for whom no signs of life have been recorded, do not probably live in Estonia and are non-residents. Still, this division is too inaccurate for practical use because there is a so-called grey area in between: persons with one sign of life for whom it is not possible to make a reliable decision in terms of residency. It is also possible that some inhabitants of Estonia do not accumulate any signs of life in some years and it would not be right to exclude them from among residents.

When defining the residency index, it is also vital to take into account each person's status in the previous year (and through that in earlier years as well). Taking that into consideration, the residency index $R(k)$ for a certain year k was defined as follows:

$$R(k) = d * R(k-1) + g * X(k-1),$$

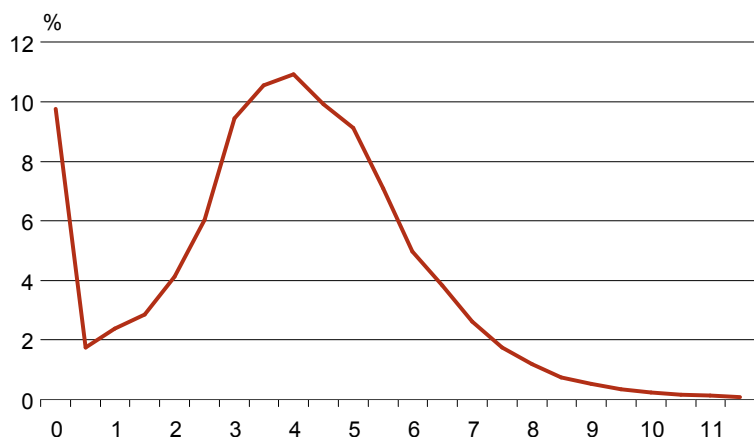
where $R(k-1)$ is a person's residency index in the previous year, $X(k-1)$ is the sum of signs of life accumulated in the previous year, and the multipliers d (stability rate) and g (signs of life rate) have the values $d = 0,8$ and $g = 0,2$, respectively. Persons whose index value is equal to or above the threshold 0.7 are considered residents. All persons for whom the index remains below 0.7 are excluded from among residents. For further use, index values greater than 1 are reduced to 1, which means that in order to decide whether a person is a resident it does not really matter if the person has accumulated many or very many signs of life.

When recalculating the index, all regular vital events are taken into account: if in year $k-1$ a person is born or registers an immigration event, then his/her index obtains the value $R(k) = 1$, if a person officially leaves the country, his/her index obtains the value $R(k) = 0$, but the person will still be included among potential residents; if a person dies, he/she is excluded from among potential residents.

The weighting of signs of life

The disadvantage of the above-mentioned formula is that all signs of life do not carry the same weight in distinguishing between residents and non-residents. For example, if a person permanently lives in a care home in Estonia, he/she is definitely a resident, but a driving licence may also be issued to a person who has come here for a shorter period.

Figure 2. Distribution of sum of weighted signs of life for all potential residents (1.52 million persons), 2014

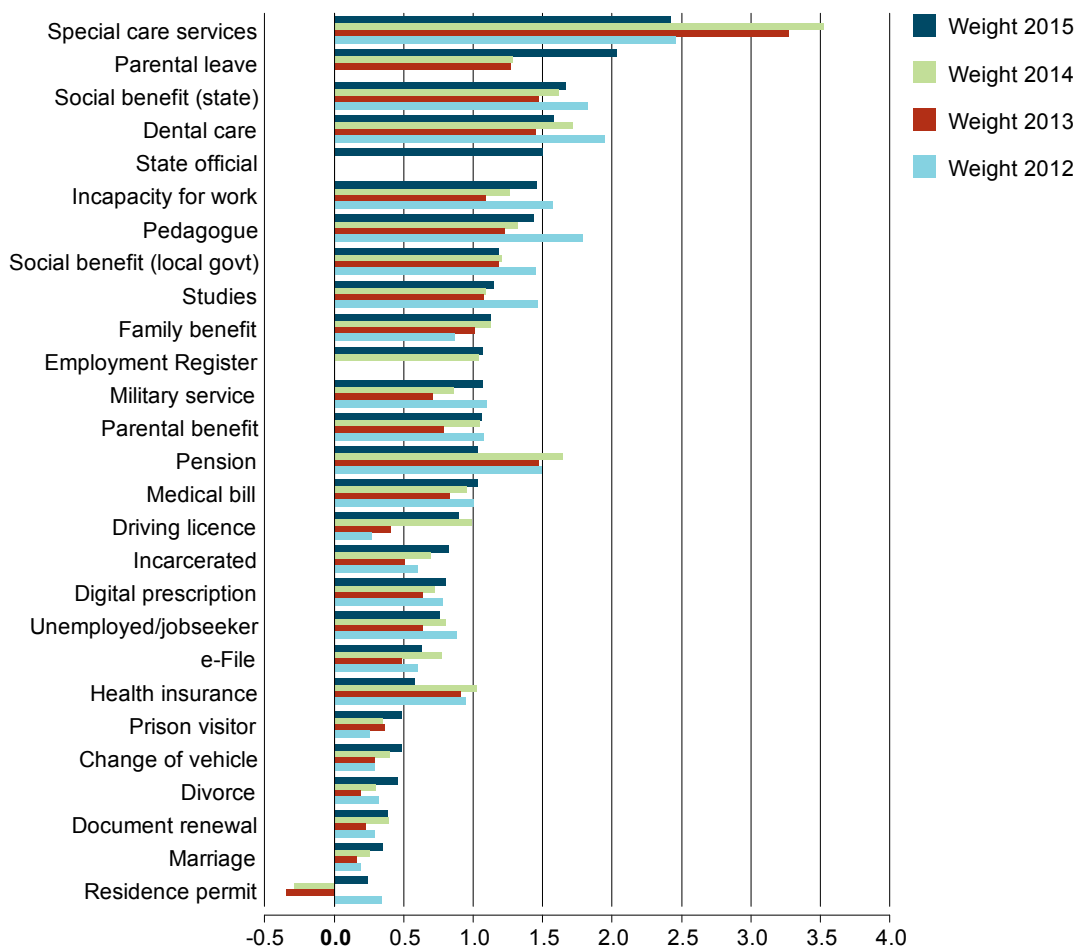


Thus, signs of life need to be assigned weights which differentiate reliable signs of life from unreliable ones. These weights are calculated based on the previous year's data. For each sign of life, its average occurrence among definite residents and definite non-residents is calculated. It turned out that the occurrence ratios differed significantly, in some cases as much as a hundred times. The signs of life which have a high ratio are reliable, while those with a low ratio are unreliable. Nevertheless, unreliable signs of life occur several

times more frequently among residents than among non-residents. When the simple sum of signs of life (which were simply aggregated) were replaced by the weighted sum of signs of life, then the distinctiveness of residents and non-residents improved (see Figure 2).

In order to make the weights more stable, ratio logarithms were adopted instead of ratio weights. The resulting rule was tested in 2013–2016, with a detailed analysis being made as to its difference from the methodology of demographic statistics used thus far, especially in estimating immigration and emigration.

Figure 3. Signs of life and their weight values (ratio logarithm), 2012–2015



In summary, it turned out that the index helps to better estimate unregistered migration, including the return migration of persons who had left the country without registering the act. Each year, the weights are recalculated in order to take into account potential shifts in policies and in the maintenance of registers. Figure 3 shows that, in the case of some registers, the weight changes considerably year over year. Also, one sign of life – being issued a residence and work permit – is more characteristic of non-residents than residents, which is why the ratio logarithm of this sign of life is negative.

The calculation of the population figure using the residency index

In order to check the residency index-based methodology, the population figure has been calculated since 2012 in several different ways, incl. with the help of the residency index

Figure 4. Population figure calculated in different ways as at 1 January , 2012–2016

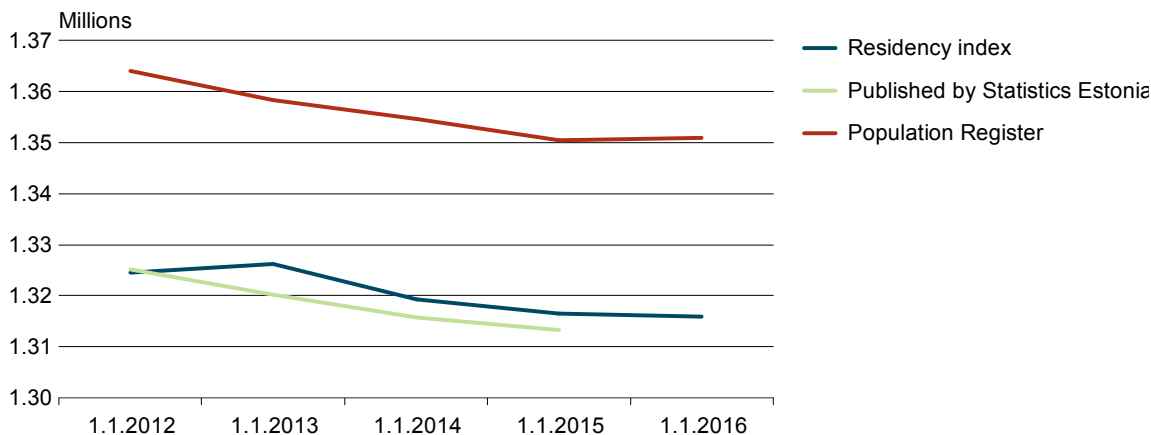


Figure 4 shows that using an index calculated based on the signs of life with logarithmic weights produces a result which is fairly close to the population figure calculated using the regular method. This means that the adoption of a new methodology changes the population figure calculated using the earlier method by only a few percentage points. Due to the stability of the index arising from its definition, the result is not entirely accurate for the second year of implementation (2013) because no index-based migration events have occurred yet. Therefore the population figure for 2013 is somewhat over-estimated. This error has been corrected for the following years.

The calculation of external migration using the residency index

Parameters c , d and g of the residency index have been selected with the help of theoretical calculations (based on the simple sum of signs of life) in a way that a person cannot transition from being a resident to being a non-resident (and vice versa) too easily and too fast. A definite resident who accumulates no signs of life is excluded from among residents within two years. In order for a non-resident to become a resident, one sign of life in a succession of years is not enough. The same rules apply in the case of the weighted signs of life because the weights have been standardised according to average values. Based on the residency index, migration acts are generally defined in a simple and logical manner:

An **immigration event** has occurred if a person's residency index for year $k-1$ is zero and in year k obtains the value 1; i.e. the following equations apply:

$$R(k-1) = 0 \text{ and } R(k) = 1$$

and it is not a birth event.

An **emigration event** has occurred if a person's residency index, which in year $k-1$ was 1, obtains the value 0 in year k ; i.e. if:

$$R(k-1) = 1 \text{ and } R(k) = 0$$

and it is not a death event.

In the case of immigration, it is also important to determine a person's place of residence in Estonia. If a person has not officially registered a migration event, his/her previous place of residence (based on the Population Register or census data) can be recorded as his/her place of residence. If a person does not have a registered place of residence at the beginning or end of the year of migration, he/she will be put on hold (so to say) for a year. This means that he/she will not be included among residents that year (he/she is not considered a permanent resident). If, in the following year, his/her residency index is once again 1, i.e. $R(k+1) = 1$, then the person is considered a permanent resident with an unknown place of residence. The new methodology does not require having information on the migrants' previous country of residence: the country of origin can be unknown.

The calculation of internal migration using the residency index

Since persons who have been included among residents based on the index are assigned a place of residence in Estonia, the new methodology enables calculating the population figure for each local government unit, city and county. As of 2016, the place of residence is determined preferably based on the place of residence (if the person has one) officially registered in the Population Register. If these data are missing, the place of residence recorded in the census will be used (for children – the mother's place of residence), but if these are also missing, the person's place of residence will be marked as "unknown". In 2016, there were more than 1,500 inhabitants (0.12%) in Estonia whose county of residence was unknown.

Using the new method, internal migration is calculated in a similar manner as external migration.

A resident is considered having left a county or local government unit if he/she was a resident in year $k-1$ and his/her place of residence was in the county or local government unit, but in year k he/she is no longer a resident or continues to be a resident but resides in another county or local government unit.

A resident is considered having arrived in a county or local government unit if he/she was not a resident in year $k-1$, but became a resident by year k with a place of residence in that county or local government unit, or if he/she is a resident in both year $k-1$ and year k , but his/her place of residence was elsewhere but in year k it is in the county or local government unit in question.

Arrival in a county or local government unit due to birth and leaving as a result of death is not included in internal migration. However, an event of external migration may happen at the same time as internal migration if a person simultaneously crosses the state border.

The methodological shift causes changes in population figures on the county and local government unit level

Since the new methodology prefers using the place of residence recorded in the Population Register, it caused additional changes in residence data, which are not directly linked to the migration events of the previous year. Although the information about people's actual places of residence that was collected in census interviews was as accurate as possible, this information goes out of date over time because it is not renewed. Registering one's actual place of residence is specified in law, so the place of residence recorded in the Population Register should match the actual residence for all law-abiding citizens, and this is what demographic statistics shall presume from now on.

Thus, when determining the population figure and the places of residence for the beginning of 2016, the place of residence recorded in the Population Register was given priority in the case of all residents. Together with the migration data calculated based on the new methodology, it caused further changes in people's residence data. These changes are presented in the table appended below.

	2015 (old)	2015 (new)	2016 (new)
Estonia, total	1,313,271	1,314,870	1,315,944
Harju county			
Aegviidu rural municipality	712	717	709
Anija rural municipality	5,685	5,539	5,474
Harku rural municipality	14,505	13,052	13,456
Jõelähtme rural municipality	6,547	6,024	6,095
Keila city	9,758	9,571	9,577
Keila rural municipality	5,312	4,636	4,681
Kernu rural municipality	2,315	1,953	1,990
Kiili rural municipality	5,229	4,640	4,945
Kose rural municipality	7,209	7,011	7,066
Kuusalu rural municipality	6,435	6,481	6,496
Loksa city	2,665	2,628	2,634
Maardu city	17,141	15,215	15,128
Nissi rural municipality	2,866	2,830	2,832

	2015 (old)	2015 (new)	2016 (new)
Padise rural municipality	1,583	1,700	1,713
Paldiski city	4,056	3,837	3,767
Raasiku rural municipality	4,749	4,631	4,625
Rae rural municipality	16,859	14,955	15,794
Saku rural municipality	9,843	9,159	9,276
Saue city	5,631	5,758	5,779
Saue rural municipality	10,907	9,936	10,301
Tallinn	413,782	418,583	423,420
Vasalemma rural municipality	2,613	2,507	2,466
Viimsi rural municipality	19,199	17,784	18,041
Hiiu county			
Emmaste rural municipality	1,108	1,222	1,200
Hiiu rural municipality	4,159	4,648	4,544
Käina rural municipality	1,878	2,068	2,074
Pühalepa rural municipality	1,437	1,547	1,530
Ida-Viru county			
Alajõe rural municipality	416	592	581
Aseri rural municipality	1,643	1,645	1,598
Avinurme rural municipality	1,247	1,300	1,267
Iisaku rural municipality	1,174	1,223	1,213
Illuka rural municipality	920	997	1,000
Jõhvi rural municipality	12,567	12,015	11,786
Kiviõli city	5,504	5,520	5,429
Kohtla rural municipality	1,450	1,583	1,554
Kohtla-Järve city	36,622	36,464	35,928
Kohtla-Nõmme rural municipality	998	1,014	998
Lohusuu rural municipality	687	738	707
Lüganuse rural municipality	2,941	3,045	2,945
Mäetaguse rural municipality	1,523	1,740	1,748
Narva city	58,375	58,881	58,204
Narva-Jõesuu city	2,630	2,669	2,619
Sillamäe city	13,964	13,906	13,686
Sonda rural municipality	789	867	844
Toila rural municipality	2,161	2,263	2,267
Tudulinna rural municipality	459	456	432
Vaivara rural municipality	1,527	1,725	1,700
Jõgeva county			
Jõgeva city	5,477	5,434	5,340
Jõgeva rural municipality	4,139	4,383	4,344
Kasepää rural municipality	1,162	1,219	1,187
Mustvee city	1,320	1,376	1,315
Pajusi rural municipality	1,153	1,274	1,285
Pala rural municipality	1,040	1,091	1,096
Palamuse rural municipality	2,058	2,149	2,130
Puurmani rural municipality	1,391	1,510	1,509
Põltsamaa city	4,111	4,224	4,174
Põltsamaa rural municipality	3,740	3,693	3,650
Saare rural municipality	1,149	1,149	1,116
Tabivere rural municipality	2,210	2,198	2,198
Torma rural municipality	1,891	1,972	1,954
Järva county			
Albu rural municipality	1,123	1,209	1,176
Ambla rural municipality	1,915	2,035	2,013
Imavere rural municipality	857	911	897
Järva-Jaani rural municipality	1,500	1,592	1,554
Kareda rural municipality	601	610	582
Koeru rural municipality	2,126	2,127	2,110
Koigi rural municipality	892	945	955

	2015 (old)	2015 (new)	2016 (new)
Paide city	8,056	8,238	8,127
Paide rural municipality	1,556	1,630	1,627
Roosna-Alliku rural municipality	972	1,053	1,037
Türi rural municipality	9,246	9,497	9,351
Väätsa rural municipality	1,265	1,314	1,280
Lääne county			
Haapsalu city	10,160	10,292	10,146
Hanila rural municipality	1,346	1,451	1,428
Kullamaa rural municipality	1,121	1,127	1,111
Lihula rural municipality	2,195	2,300	2,267
Lääne-Nigula rural municipality	3,951	4,083	4,054
Martna rural municipality	756	780	760
Noarootsi rural municipality	707	823	815
Nõva rural municipality	338	359	357
Ridala rural municipality	3,219	3,252	3,245
Vormsi rural municipality	277	398	397
Lääne-Viru county			
Haljala rural municipality	2,441	2,523	2,470
Kadrina rural municipality	4,897	4,964	4,896
Kunda city	3,224	3,246	3,136
Laekvere rural municipality	1,457	1,527	1,512
Rakke rural municipality	1,569	1,624	1,631
Rakvere city	15,303	15,898	15,747
Rakvere rural municipality	2,116	2,054	2,056
Rägavere rural municipality	852	850	821
Sõmeru rural municipality	3,666	3,464	3,424
Tamsalu rural municipality	3,767	3,884	3,820
Tapa rural municipality	7,739	7,723	7,578
Vihula rural municipality	1,684	1,861	1,918
Vinni rural municipality	4,806	4,740	4,689
Viru-Nigula rural municipality	1,222	1,263	1,288
Väike-Maarja rural municipality	4,296	4,506	4,481
Põlva county			
Ahja rural municipality	963	1,006	998
Kanepi rural municipality	2,278	2,440	2,390
Kõlleste rural municipality	1,001	996	1,022
Laheda rural municipality	1,215	1,183	1,183
Mikitamäe rural municipality	900	952	939
Mooste rural municipality	1,371	1,474	1,457
Orava rural municipality	682	730	719
Põlva rural municipality	9,399	9,788	9,575
Räpina rural municipality	4,629	4,808	4,686
Valgjärve rural municipality	1,372	1,397	1,396
Vastse-Kuuste rural municipality	1,136	1,171	1,165
Veriora rural municipality	1,324	1,386	1,366
Värskä rural municipality	1,168	1,345	1,322
Pärnu county			
Are rural municipality	1,216	1,269	1,279
Audru rural municipality	5,658	5,720	5,726
Halinga rural municipality	2,863	2,924	2,871
Häädemeeste rural municipality	2,388	2,531	2,522
Kihnu rural municipality	502	677	682
Koonga rural municipality	1,008	1,078	1,051
Paikuse rural municipality	3,634	3,767	3,838
Pärnu city	39,784	40,130	39,828
Saarde rural municipality	3,733	3,963	3,895
Sauga rural municipality	4,459	4,026	4,071
Sindi city	4,003	3,944	3,891

	2015 (old)	2015 (new)	2016 (new)
Surju rural municipality	934	958	942
Tahkuranna rural municipality	2,392	2,314	2,352
Tootsi rural municipality	736	799	775
Tori rural municipality	2,279	2,322	2,286
Tõstamaa rural municipality	1,237	1,328	1,305
Varbla rural municipality	786	852	823
Vändra rural municipality	2,520	2,648	2,669
Vändra rural municipality (alev)	2,217	2,255	2,191
Rapla county			
Juuru rural municipality	1,475	1,429	1,429
Järvakandi rural municipality	1,228	1,279	1,256
Kaiu rural municipality	1,230	1,269	1,253
Kehtna rural municipality	4,333	4,389	4,405
Kohila rural municipality	7,270	6,770	6,770
Käru rural municipality	620	627	609
Märjamaa rural municipality	6,494	6,606	6,515
Raikküla rural municipality	1,549	1,556	1,519
Rapla rural municipality	9,051	9,228	9,170
Vigala rural municipality	1,186	1,254	1,222
Saare county			
Kihelkonna rural municipality	639	728	750
Kuressaare city	13,009	13,552	13,449
Laimjala rural municipality	628	695	692
Leisi rural municipality	1,810	1,997	1,974
Lääne-Saare rural municipality	6,996	7,117	7,086
Muhu rural municipality	1,558	1,812	1,802
Mustjala rural municipality	608	667	660
Orissaare rural municipality	1,712	1,873	1,827
Pihtla rural municipality	1,347	1,370	1,392
Põide rural municipality	791	891	880
Ruhnu rural municipality	97	139	138
Salme rural municipality	1,019	1,192	1,168
Torgu rural municipality	289	344	339
Valjala rural municipality	1,203	1,342	1,324
Tartu county			
Alatskivi rural municipality	1,287	1,301	1,279
Elva city	5,666	5,681	5,679
Haaslava rural municipality	2,030	1,911	1,971
Kallaste city	819	849	808
Kambja rural municipality	2,680	2,584	2,599
Konguta rural municipality	1,366	1,434	1,428
Laeva rural municipality	778	774	746
Luunja rural municipality	4,399	3,875	4,000
Meeksi rural municipality	530	598	583
Mäksa rural municipality	1,668	1,615	1,598
Nõo rural municipality	4,018	3,889	3,922
Peipsiääre rural municipality	676	686	660
Piirissaare rural municipality	63	101	99
Puhja rural municipality	2,219	2,264	2,226
Rannu rural municipality	1,527	1,597	1,581
Rõngu rural municipality	2,811	2,703	2,688
Tartu city	97,332	93,807	93,687
Tartu rural municipality	7,418	6,666	6,908
Tähtvere rural municipality	2,915	2,505	2,525
Vara rural municipality	1,888	1,865	1,839
Võnnu rural municipality	1,150	1,085	1,110
Ülenurme rural municipality	8,137	6,756	7,067

		2015 (old)	2015 (new)	2016 (new)	
Valga county	Helme rural municipality	1,863	2,021	1,985	
	Hummuli rural municipality	812	843	829	
	Karula rural municipality	954	983	959	
	Otepää rural municipality	3,727	3,920	3,872	
	Palupera rural municipality	1,256	1,077	1,044	
	Puka rural municipality	1,529	1,597	1,573	
	Põdrala rural municipality	718	776	751	
	Sangaste rural municipality	1,271	1,293	1,268	
	Taheva rural municipality	734	743	736	
	Tõlliste rural municipality	1,592	1,628	1,588	
	Tõrva city	2,690	2,808	2,820	
	Valga city	12,352	12,834	12,632	
	Õru rural municipality	446	461	467	
	Viljandi county	Abja rural municipality	2,061	2,194	2,159
Halliste rural municipality		1,395	1,502	1,479	
Karksi rural municipality		3,113	3,374	3,333	
Kolga-Jaani rural municipality		1,307	1,426	1,429	
Kõo rural municipality		1,009	1,093	1,047	
Kõpu rural municipality		665	653	633	
Mõisaküla city		789	820	790	
Suure-Jaani rural municipality		5,105	5,309	5,248	
Tarvastu rural municipality		3,215	3,392	3,321	
Viljandi city		17,549	17,966	17,860	
Viljandi rural municipality		9,517	9,267	9,240	
Võhma city		1,285	1,324	1,314	
Võru county		Antsla rural municipality	3,263	3,380	3,325
		Haanja rural municipality	969	1,081	1,084
	Lasva rural municipality	1,593	1,647	1,684	
	Meremäe rural municipality	939	1,039	1,032	
	Misso rural municipality	591	662	631	
	Mõniste rural municipality	808	881	859	
	Rõuge rural municipality	1,980	2,175	2,157	
	Sõmerpalu rural municipality	1,717	1,781	1,771	
	Urvaste rural municipality	1,131	1,260	1,269	
	Varstu rural municipality	1,017	1,084	1,050	
	Vastseliina rural municipality	1,835	2,003	1,970	
	Võru city	12,458	12,717	12,430	
	Võru rural municipality	4,871	4,671	4,711	
	County unknown		0	1,232	1,574

Ene-Margit Tiit, Ethel Maasing, 12.05.2016