

# TRACC

## Transport Accessibility at Regional/Local Scale and Patterns in Europe

Applied Research 2013/1/10

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**Volume 3**

**TRACC Regional Case Study Book**

**Part C**

**Bavaria case study**



This report presents a more detailed overview of the analytical approach to be applied by the project. This Applied Research Project is conducted within the framework of the ESPON 2013 Programme, partly financed by the European Regional Development Fund.

The partnership behind the ESPON Programme consists of the EU Commission and the Member States of the EU27, plus Iceland, Liechtenstein, Norway and Switzerland. Each partner is represented in the ESPON Monitoring Committee.

This report does not necessarily reflect the opinion of the members of the Monitoring Committee.

Information on the ESPON Programme and projects can be found on [www.espon.eu](http://www.espon.eu)

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

This basic report exists only in an electronic version.

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## 1 Introduction

The ESPON project TRACC (**TR**ansport **ACC**essibility at regional/local scale and patterns in Europe) aimed at taking up and updating the results of previous studies on accessibility at the European scale, to extend the range of accessibility indicators by further indicators responding to new policy questions, to extend the spatial resolution of accessibility indicators and to explore the likely impacts of policies at the European and national scale to improve global, European and regional accessibility in the light of new challenges, such as globalisation, energy scarcity and climate change.

The Transnational Project Group (TPG) for the ESPON project TRACC consisted of the following seven Project Partners:

- Spiekermann & Wegener, Urban and Regional Research (S&W), Dortmund, Germany (Lead Partner)
- Charles University of Prague, Faculty of Science, Department of Social Geography and Regional Development (PrF UK), Prague, Czech Republic
- RRG Spatial Planning and Geoinformation, Oldenburg i.H., Germany
- MCRIT, Barcelona, Spain
- University of Oulu, Department of Geography (FOGIS), Oulu, Finland
- TRT Trasporti e Territorio, Milan, Italy
- S. Leszczycki Institute of Geography and Spatial Organisation, Polish Academy of Sciences (IGIPZ PAN), Warsaw, Poland

This report is part of the TRACC Final Report. The TRACC Final Report is composed of four volumes.

- Volume 1 contains the Executive Summary and a short version of the Final Report
- Volume 2 contains the TRACC Scientific Report, i.e. a comprehensive overview on state of the art, methodology and concept, and in particular results on the global, Europe-wide and regional accessibility analyses and subsequent conclusions of the TRACC project.
- Volume 3 contains the TRACC Regional Case Study Book. Here, each of the seven case studies conducted within the project is reported in full length.
- Volume 4 contains the TRACC Accessibility Indicator Factsheets, i.e. detailed descriptions of all accessibility indicators used in the project.

This report on the Bavaria case study region is one of the major parts of Volume 3 TRACC Regional Case Study Book. The report starts with a short description of the case study region. Then, the results for six different accessibility indicators will be presented and discussed, first for the whole case study region and then in more detail for selected subregions, so called zoom-in regions. This analysis of the current accessibility conditions in the region for car travel as well as for public transport is followed by an analysis of how the planned trans-European transport networks would change the accessibility pattern within the region.

The design of the case study analysis was made in a way that all seven case studies are highly comparable as the definition of the accessibility indicators and its implementation were handled in a rather strict way. Also, the way results are presented in maps, diagrams and more general in the case study reports is highly comparable. A comparable analysis across all case studies is provided in Volume 2, the TRACC Scientific Report. All reports are available at the ESPON website [www.espon.eu](http://www.espon.eu).

## **2 The Bavaria case study region**

The Federal State of Bavaria is located in the southern part of Germany. With an area of about 70,500 km<sup>2</sup>, Bavaria is the largest NUTS-1 region in Germany. With a total population of 12.5 million people it is the second largest state of Germany, only the high-density state of North Rhine-Westphalia has more inhabitants. Bavaria consists of seven NUTS-2 regions, 96 NUTS-3 regions and 2056 municipalities.

In the macro region of Bavaria there are very different types of regions ranging from a high-density monocentric agglomeration and medium-sized polycentric agglomerations via semi-urban surroundings of the agglomerations to rural structures with small and medium-sized cities which include also mountainous areas, in particular the Alps (Figure 1).

The accessibility analysis for the case study macro region of Bavaria and the zoom-in areas will provide understanding of regional and local accessibility patterns for a variety of regional types including large agglomerations, urban-rural settings, rural areas and mountain areas. By a precise representation of road and public transport networks, the differences of accessibility patterns by the two modes of transport in the different types of regions will become visible.

### **2.1 Spatial structure**

Munich is the capital of Bavaria and the largest city with a population of more than 1.3 million in the municipality and about 2.5 million in the agglomeration. Nuremberg with about 0.5 million inhabitants and Augsburg with 250,000 inhabitants follow next, but are clearly smaller in size. There are only five more cities with a population of slightly more than 100,000. Two thirds of the population live in small and medium-sized cities and rural areas of less than 20,000 inhabitants per municipality.

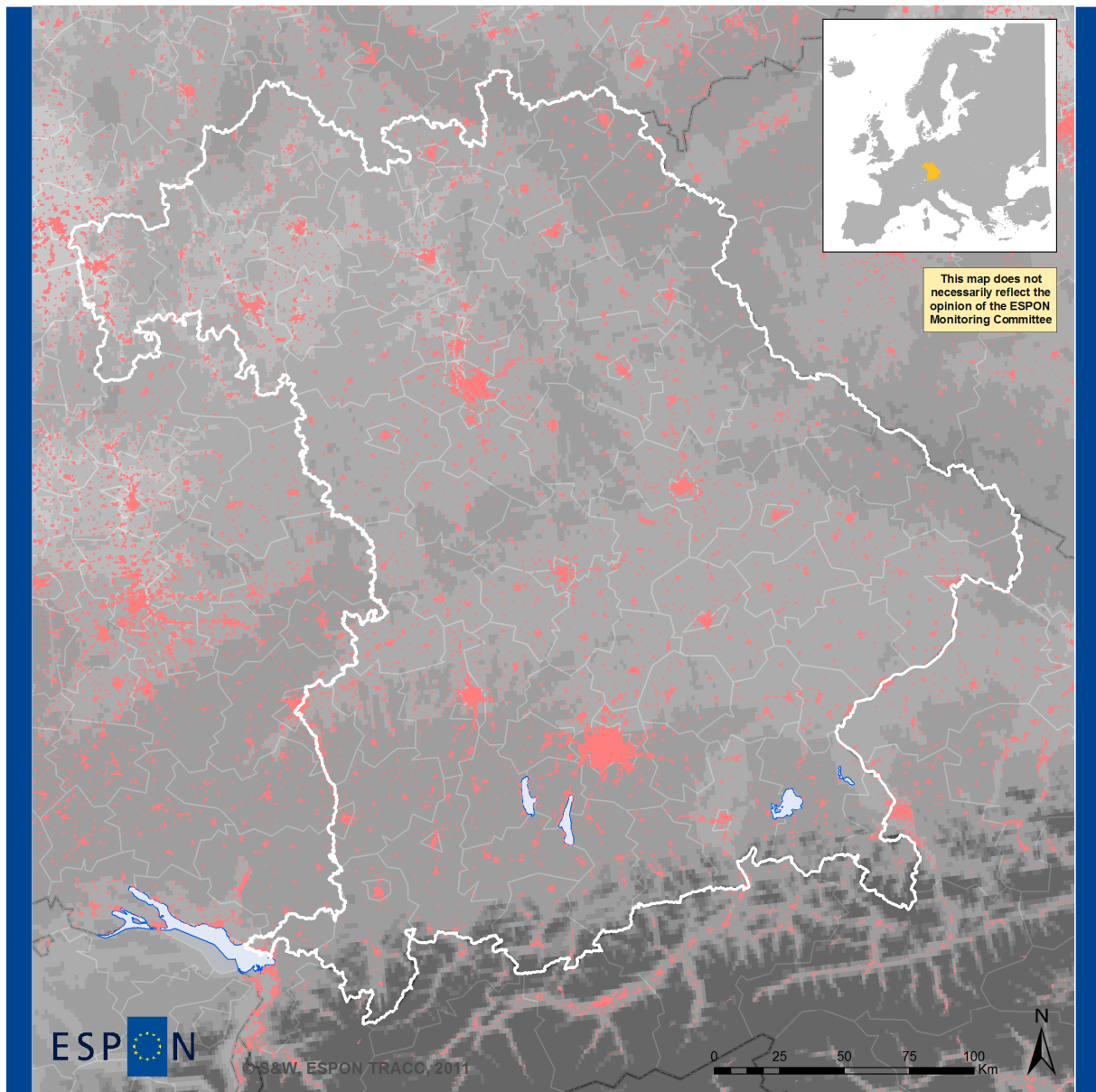
Consequently, the spatial structure of the macro region of Bavaria is very heterogeneous. The agglomerations of Munich and Nuremberg are major centres in a more urbanised arc starting in the north-west of Bavaria and running through the two agglomerations towards the south. From this arc towards the outer boundaries of Bavaria, the regions are getting less dense, more rural and peripheral. In terms of area size, rural areas are dominating the macro region of Bavaria.

The heterogeneity is also reflected in the different ESPON typologies. In the urban-rural typology, almost ten percent of the 96 NUTS-3 regions is classified as urban, about 45 percent as intermediate and another 45 percent as rural. Almost one third of the regions is classified as metropolitan, of which 20 percent of all regions belong to big metropolitan areas. More than one quarter of the regions is classified as border regions. Also one quarter of the regions is classified as mountainous, most of them under urban influence.

### **2.2 Socioeconomic situation**

Bavaria is considered to be one of the most successful regions of Germany during the economic transformation in the last decades. Since World War II Bavaria developed from an agrarian economy to a high-tech economy with a concentration of modern industries in and around the larger cities. GDP growth rates of Bavaria have been usually higher than for Germany as a whole. Compared to the average GDP (in PPS) of EU 27 the index for Bavaria is about 135. Unemployment rates in Bavaria are the lowest in Germany and currently little above 4 percent. Consequently, Bavaria has experienced steady population increases during the last decades based on a positive migration balance, also with all other German states.






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Bavaria Case Study  
Topography





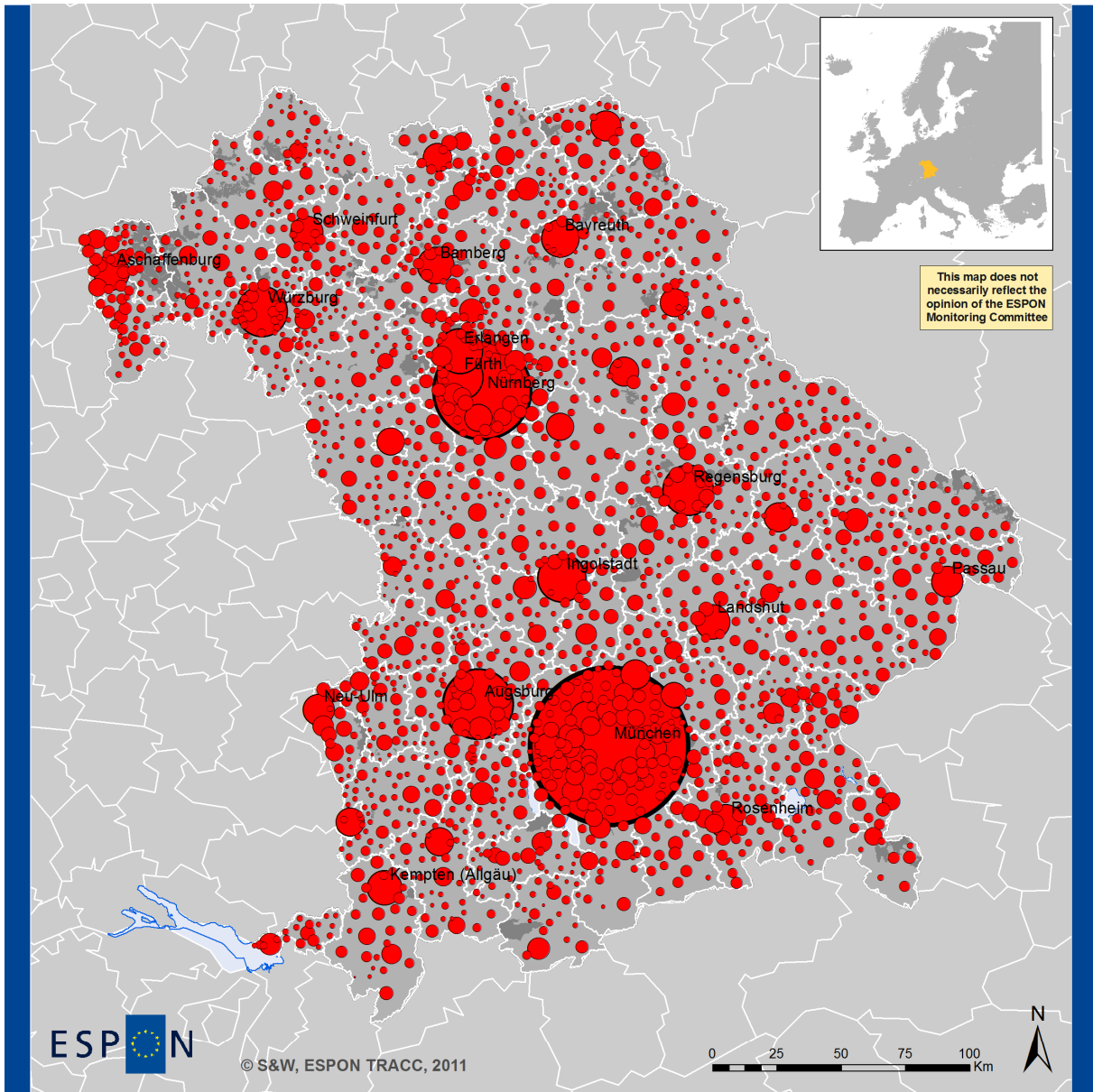
-  Settlement area
-  Lakes
-  Case study region
-  National borders

Figure 1. The Bavaria case study region.



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## Bavaria Case Study Population

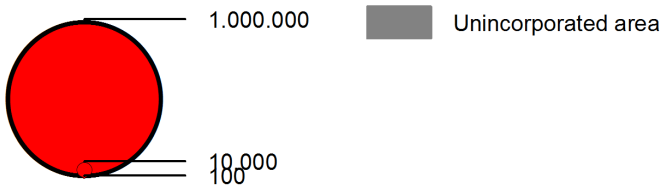
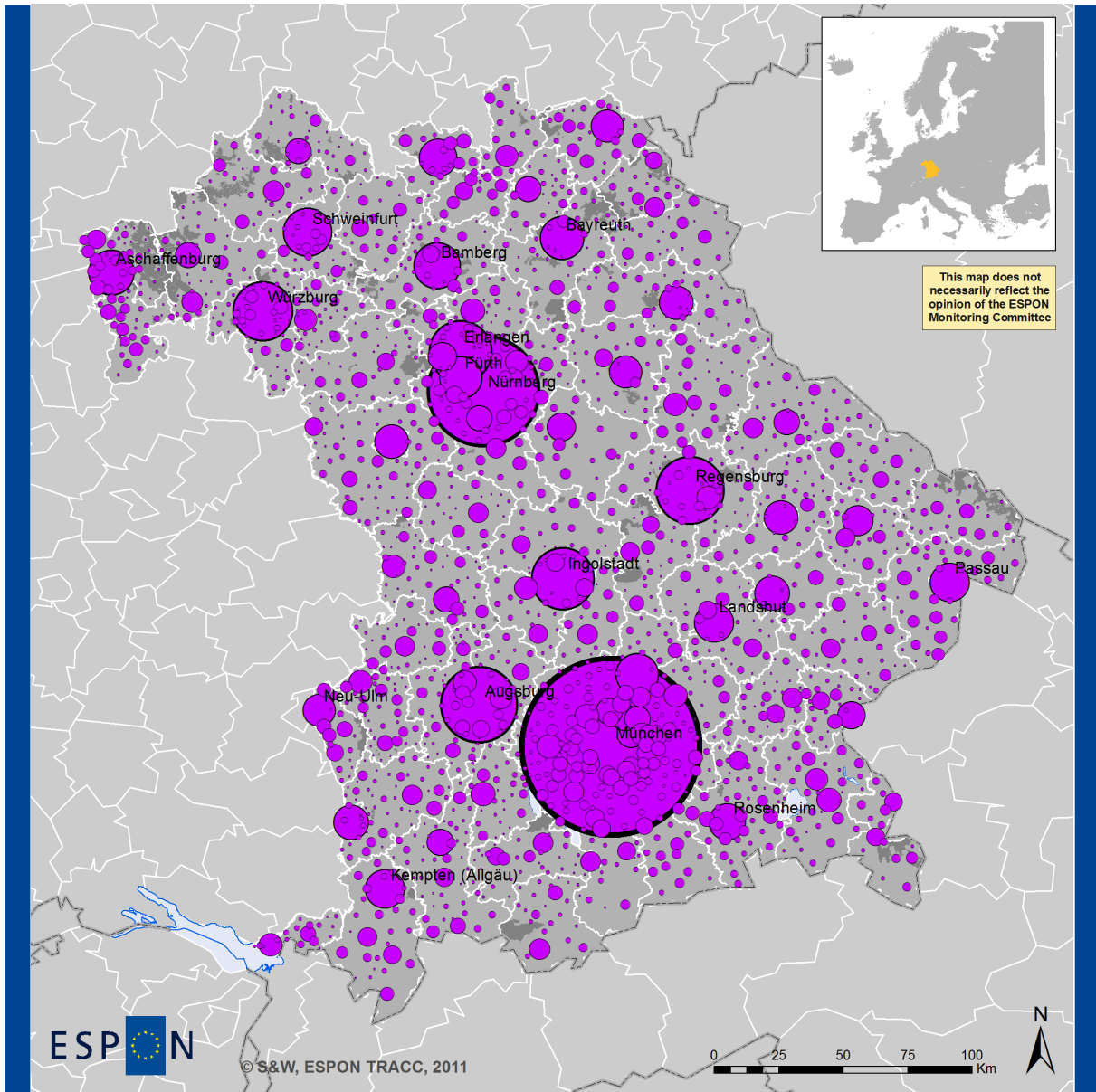


Figure 2. Population distribution



## Bavaria Case Study Number of employees

Insgesamt

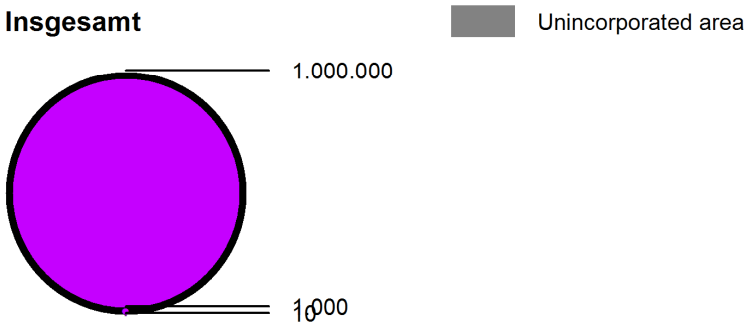


Figure 3. Job distribution

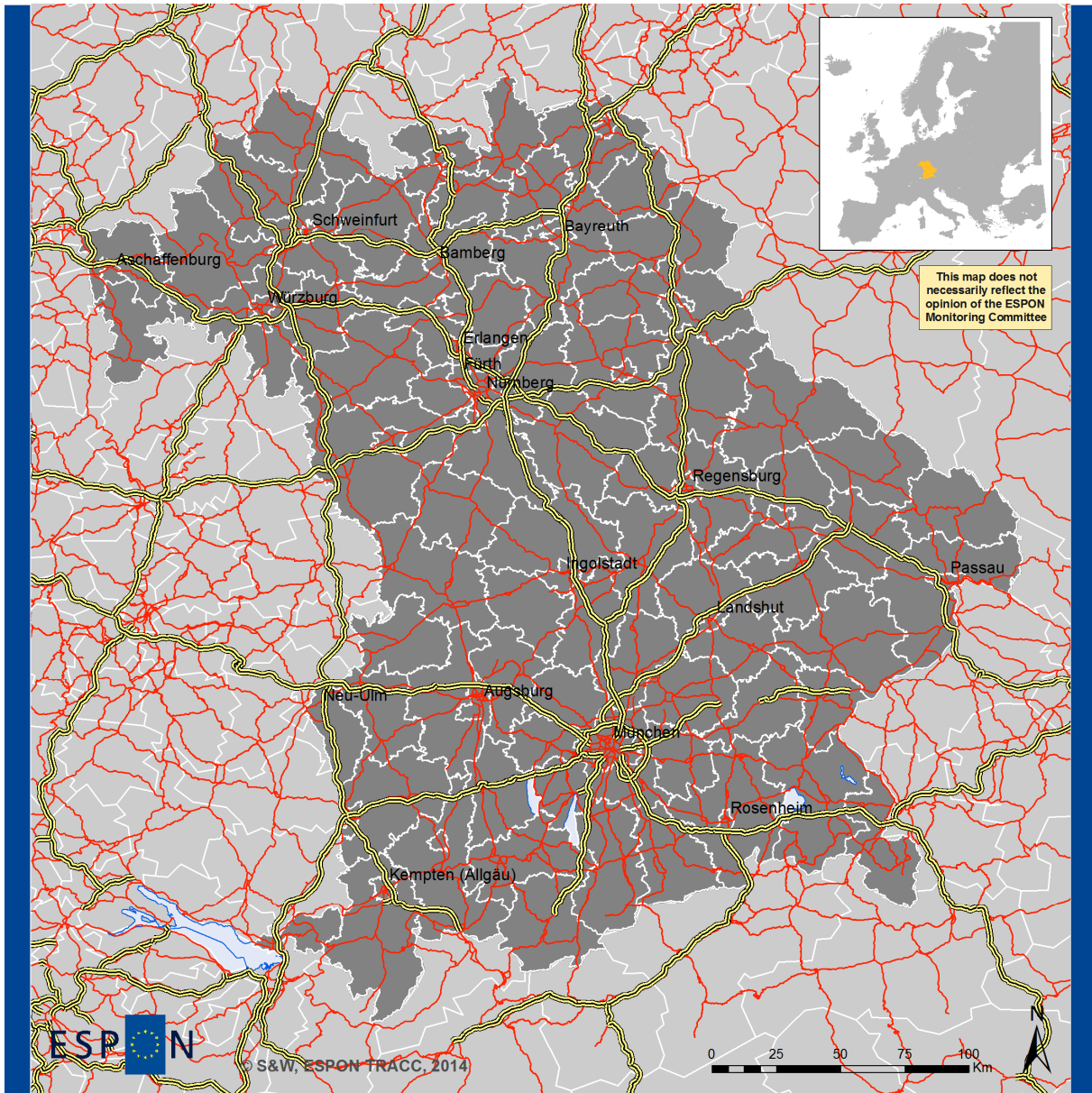
## 2.3 Transport aspects

As most German regions, the macro region of Bavaria is very well served by the national motorway network in which major investments have been made during the last decades. Within Bavaria, a mesh-like motorway structure with only very few remaining gaps is connecting the different parts of the state. Several motorways lead to other parts of Germany as well as to international destinations such as Prague, Vienna or via the Brenner motorway to northern Italy. The motorway network is amended by a dense system of national and state roads connecting also small and medium-sized towns.

The public transport network is based on a relatively dense rail network composed of high-speed train services and regional and local train services. However, as in other parts of Germany, the rail services in Bavaria have been reduced in rural areas whereas agglomerations partly have seen investments in new infrastructure and services. The rail network is amended by tram and underground networks in the agglomerations and by a dense bus network serving small and medium-sized cities and rural areas. However, the frequency of many bus lines serving rural areas is rather low so that some areas are only served by school buses taking also ordinary passengers on board.

Less important for the analysis of regional and local accessibility patterns are the air and waterway connections of Bavaria. The Munich airport located more than 30 km northeast of the city centre is one of the major German airport hubs serving many national, international and intercontinental destinations. Though located far away from the sea, Bavaria is well integrated into the European inland waterway system. Via the navigable rivers of the Main flowing into the Rhine and the Danube and the connecting Main-Danube-Canal, Bavaria has waterway links to ports located at the North Sea as well as at the Black Sea and the eastern parts of the Mediterranean Sea.






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## Bavaria Case Study Road network



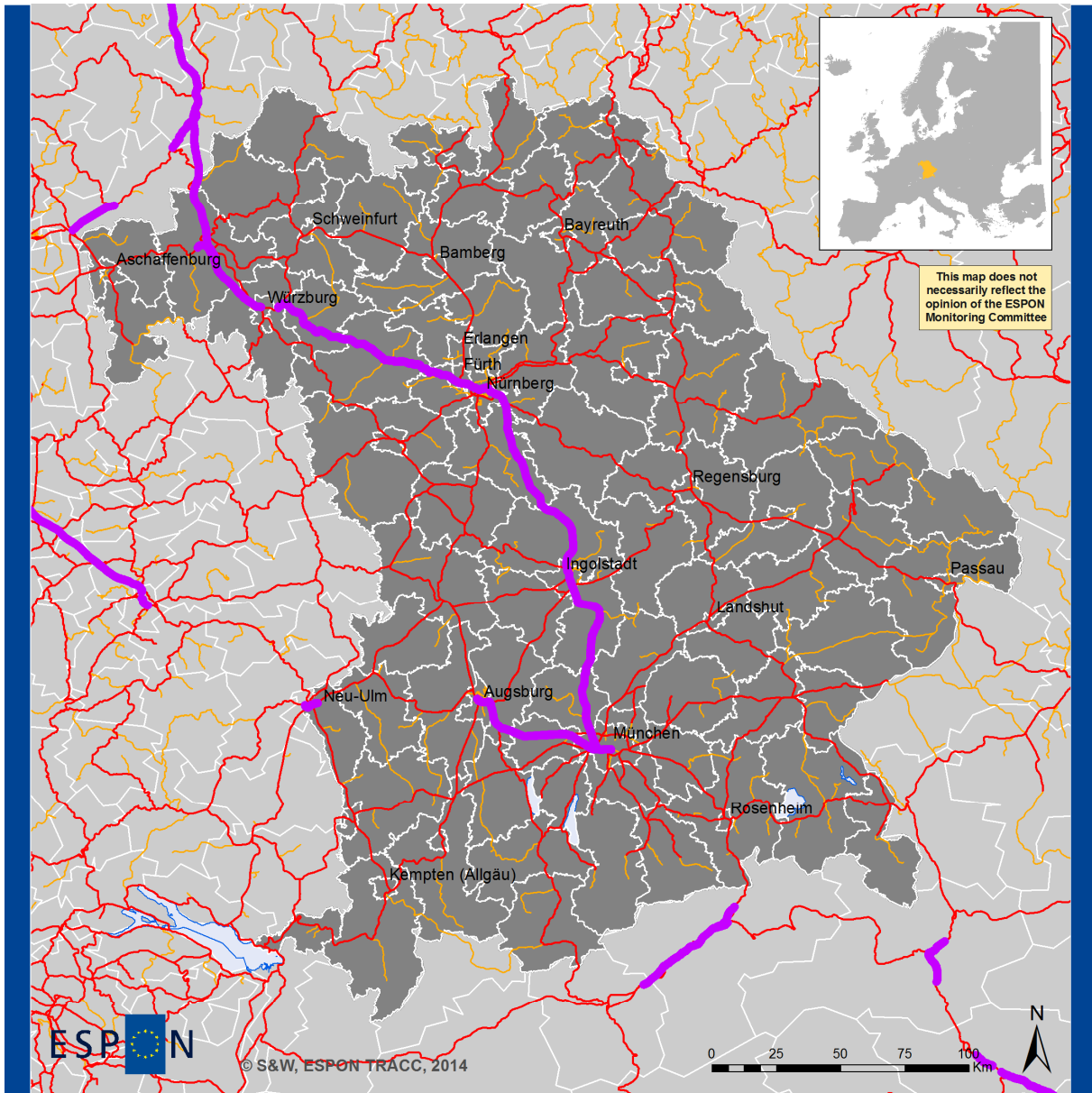
-  Motorway
-  Main road

Figure 4. Road network



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## Bavaria Case Study Rail network

- High speed rail link
- Main rail link
- Secondary rail link

Figure 5. Rail network

### 3 Accessibility patterns at regional and local scale

For the regional case studies in TRACC, a set of six accessibility indicators has been defined for travel. Of these, the first three indicators are traditional accessibility indicators following the set of indicators calculated also at the European level. The other three indicators are more recent in as they measure access to services of general interest. The following three indicators belong to the first group:

- *Access to regional centres.* How distant or how far is the nearest regional centre? Proximity to an urban centre has often been used as a proxy for accessibility to jobs and different services such as higher education, health care, commerce etc. For each place of Bavaria, the minimum travel times by road and public transport to the nearest urban centre has been calculated.
- *Daily accessibility of jobs.* How many jobs can I reach from my place of residence? This indicator reflects the opportunities provided by the regional labour market from the point of view of the population. For each place of Bavaria, the amount of jobs reachable within maximum commuting distances of 60 minutes by car and by public transport have been estimated.
- *Regional potential accessibility.* What is the regional population potential of a municipality? In order to evaluate the different locations within Bavaria from the viewpoint of economic actors, e.g. firms assessing the regional labour market, or retail industries assessing the market area, the population potential of each place within Bavaria has been calculated. As for the other spatial levels analysed in TRACC, the population potential has been calculated as the sum of people in destination areas weighted by the travel times to go there. Modes considered have been road and public transport.

The second set of indicators calculated in the regional case studies is also for travel and considers destinations of specific relevance for daily life, i.e. services of general interest:

- *Access to health care facilities.* What is the travel time to go to the nearest hospital? Travel times for each place in Bavaria by road and by public transport have been processed to show the spatial diversity in access to this important health care facility.
- *Availability of higher secondary schools.* Is there access to higher secondary schools in reasonable travel time and is there a freedom of choice to select between different options? For each place in Bavaria, time contours of 30 minutes travel time by road and by public transport have been calculated, and it has been checked how many higher secondary schools (Gymnasium) are reachable within this maximum travel time.
- *Potential accessibility to basic health care.* What is the locational quality with respect to basic health care? Using medical doctors as destination activity in a potential accessibility indicator allows to assess the relative distribution of health care provision of different areas within Bavaria. For each place in the case study region, the potential value has been calculated as sum of medical doctors located in Bavaria weighted by travel times by road and public transport.

The accessibility indicators have been calculated for road and for public transport. The road network used covers all roads including residential streets in Bavaria. The public transport network covers all public transport stops and includes the morning hours' time table for all rail, underground, tram and bus services in Bavaria.

The indicators have been calculated first for raster cells with a resolution of 100 x 100 m. The Bavaria case study is thus subdivided into some 7 million raster cells of which about 600,000 are populated. The results for the raster cells have been aggregated to municipality level as population-weighted average. Annex 2 provides more information about the database, Annex 3 gives detailed information about the accessibility model used.

### 3.1 Access to regional centres

Regional centres offer several services and amenities to the regional population. This includes all types of services of general interest, shopping facilities or cultural opportunities for most population groups including younger and elder people that do not or not very often have access to a car. Therefore, indicators of the access to regional centres by car and by public transport reflect the possibilities for different population groups to take advantages of the opportunities offered there.

For the TRACC regional case studies, the capitals of NUTS-3 regions plus any other city with a population of more than 50,000 inhabitants are used as regional centres. In Germany, NUTS-3 regions are constituted by the counties. In Bavaria, there are 96 counties. However, the total number of regional centres considered is only 78, because the administrative capitals of some rural counties are not located within the county but in a city which forms an urban county on its own and thus hosts the administration of two districts. There is no city with more than 50,000 inhabitants that is not an administrative capital of a county. On the other hand, the population of some county capitals is less than 10,000 inhabitants.

But the inclusion of cities with comparable low population figures provides a harmonious distribution of regional centres in space. Accordingly, access times by cars to regional centres are fairly low across Bavaria (Figure 6). Access times are measured as travel time to the city centre of the regional centres. Lowest car travel times exist in the regional centres themselves and in most of the neighbouring municipalities. The travel time of about ten percent of the municipalities is less than 15 minutes, another 25 percent of municipalities have values of 15 to 20 minutes. Only less than one quarter of the municipalities has a travel time by car to the next regional centre of more than half an hour, in none of the municipalities this travel time exceeds one hour. However, there is some spatial concentration of municipalities with relatively high travel times of 45 minutes or even more. This occurs in particular in fringe areas of Bavaria, e.g. in some areas at the border to Czechia.

Access times to regional centres by public transport (which includes also walking) are much higher (Figure 7). The minimum average travel time of a municipality is 15 minutes; only three percent of the municipalities are below 20 minutes, less than 15 percent are below 30 minutes. For about one fifth of all municipalities, it takes more than 1 hour by public transport to go to the next regional centres. Maximum values for some municipalities are even beyond two hours. All over the case study area, there are clusters of municipalities from which a public transport trip into the regional centre lasts more than one hour, from some municipalities even more than 90 minutes. However, the spatial pattern of good and pure access to regional centres is similar to that of car use. All over the Bavarian territory, there are areas with good access surrounded by areas with rather long travel times by public transport. Lowest public transport travel times are in the centres and highest in almost the same areas as for car. The main differences between car and public transport are the higher travel times by public transport which are on average about twice as high as for car and the much larger spreading of travel times between the centres and remote areas.

This is confirmed by an aggregate analysis of the results as provided in Figures 8 and 9. The figures provide a differentiation of travel times for municipalities and for population by mode and by regional typology. For the latter, the ESPON typology on urban and rural areas is used; each municipality, i.e. LAU-2 region is associated to the region type of its NUTS-3 area.

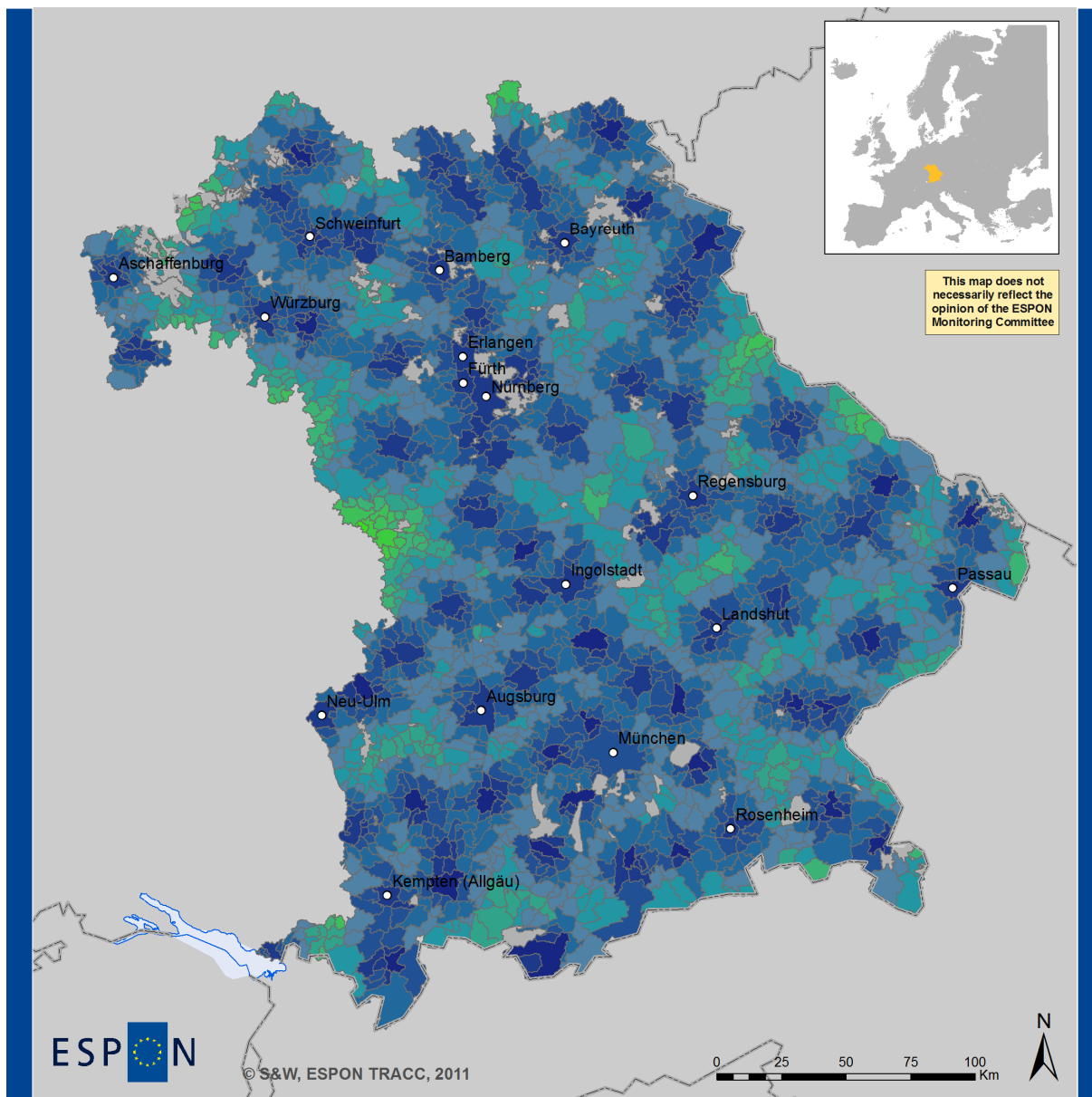
Figure 8 shows the great advantage of using car to go to a regional centre compared to the use of public transport. There are 50 percent of all municipalities that have travel times of between 20 and 30 minutes, one quarter is better and one quarter is worse; the population weighted average is about 20 minutes. For public transport the middle 50 percent of municipalities have travel times of 35 to 55 minutes; the population weighted average is almost 38 minutes and thus almost twice than that for car. The comparison of access time of different regional types of LAU-2 areas is in-



structive. The variation across types is relatively low for access times by car. Travel times for urban municipalities are only a few minutes lower than those for rural regions. Even in rural areas the middle 50 percent of municipalities has travel times of between 20 and 30 minutes, however, the spreading towards longer travel times is somewhat larger. The territorial variation for travel times by public transport is much higher. Going along the typology from urban to rural regions, also the deviation from public transport to car travel time becomes larger: Whereas in urban regions average public transport time is about twelve minutes longer, it is almost half an hour in remote rural regions. Even in rural areas, population weighted average travel time to regional centres is lower than for public transport in any type of the urban-rural typology.

About 60 percent of the population reach the next regional centre by car in less than 20 minutes and about 90 percent in less than half an hour (Figure 9). The percentages for rural areas are only slightly lower; in urban areas more than 80 percent live less than 20 minutes from a regional centre. For public transport, the travel time is much worse. Only twelve percent of the population lives closer than 20 minutes to the regional centres; for many of them this is the pure walking time. But 55 percent of the population has a public travel time of more than half an hour; ten percent need even more than one hour. The performance of public transport is slightly worse in rural areas, but somewhat better in urban areas. Here, 80 percent of the population need less than half an hour.

The analysis of access to regional centres for Bavaria shows at first the balanced distribution of administrative centres across the area and secondly the much higher travel times by public transport compared to car travel times. There exist differences between low and high travel times for both modes considered, however, the disparities in travel times are much more pronounced for public transport than for car use. For the latter, the differences between different types of regions of the ESPON urban-rural typology are very low. But for public transport, differences in travel time between urban and rural areas are high. To conclude, for a car user, the different locations in Bavaria offer almost comparable access to the opportunities provided by regional centres. For people dependent on public transport, the overall situation is worse than for car users in all areas and the disadvantage becomes much higher when going from urban to rural areas.



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### Bavaria Case Study Travel time by car to next regional centre (minutes)

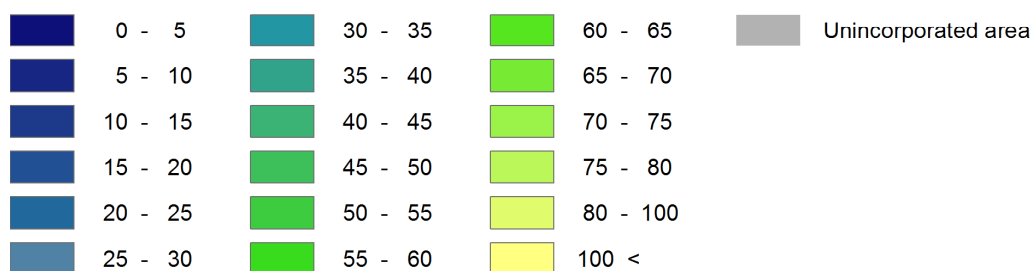
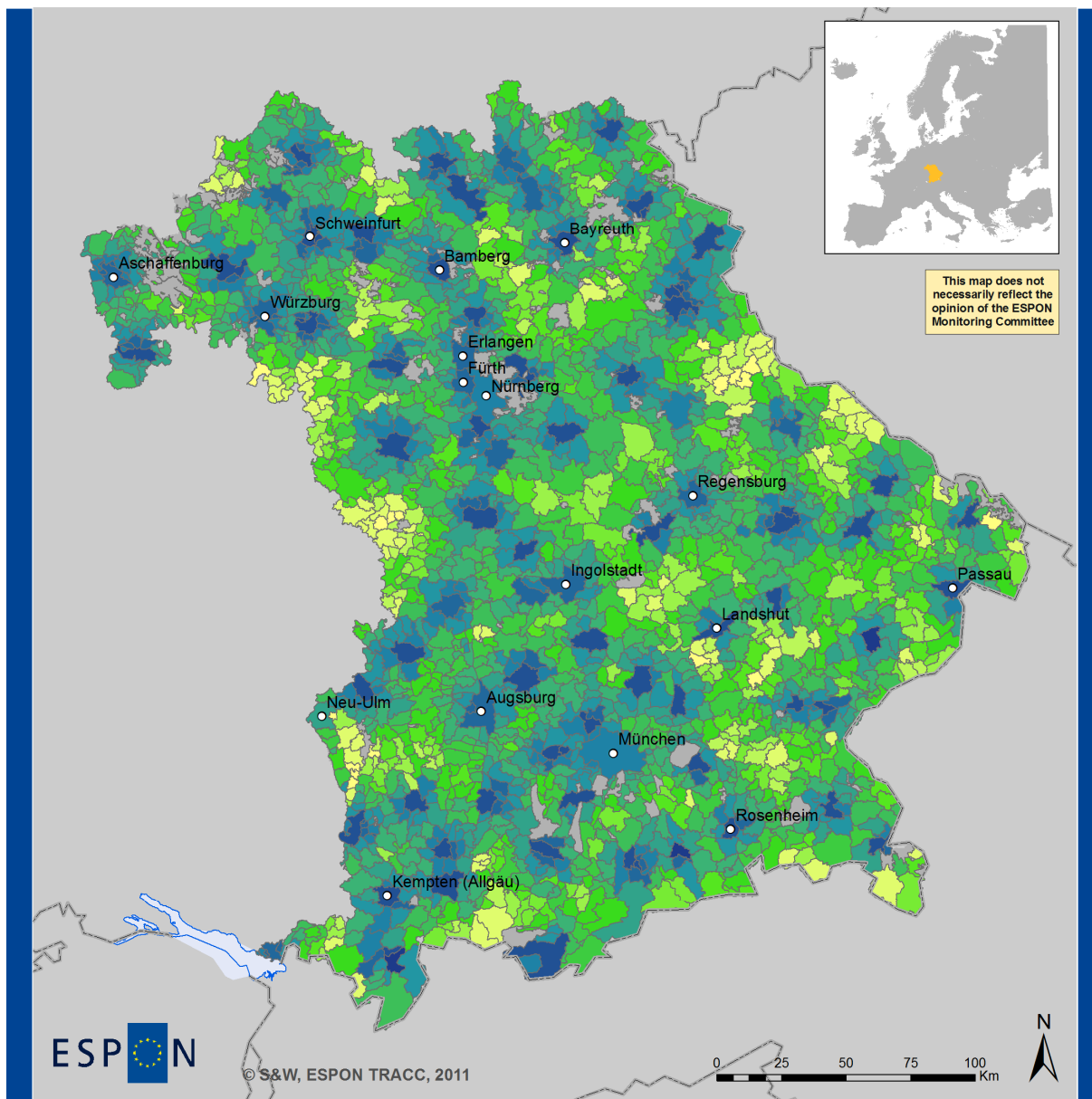


Figure 6. Travel time by car to next regional centre



### Bavaria Case Study

#### Travel time by public transport to next regional centre (minutes)

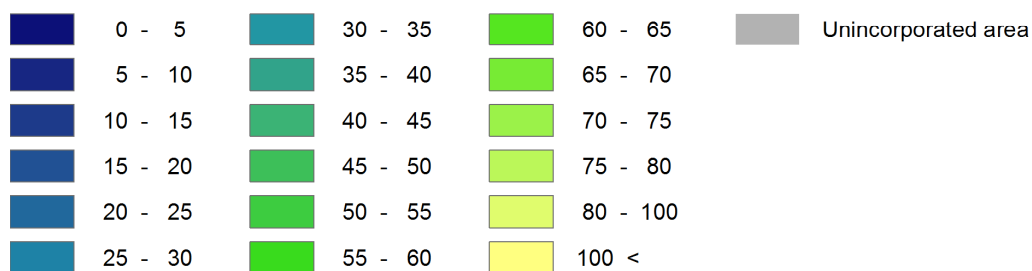


Figure 7. Travel time by public transport to next regional centre

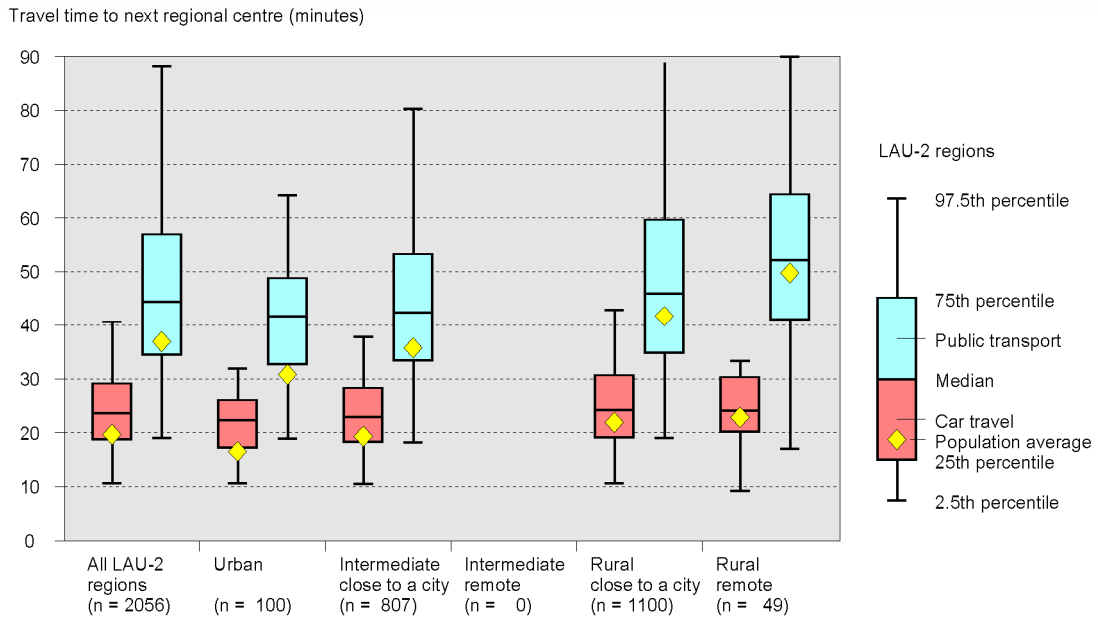


Figure 8. Travel time to next regional centre, by urban-rural typology

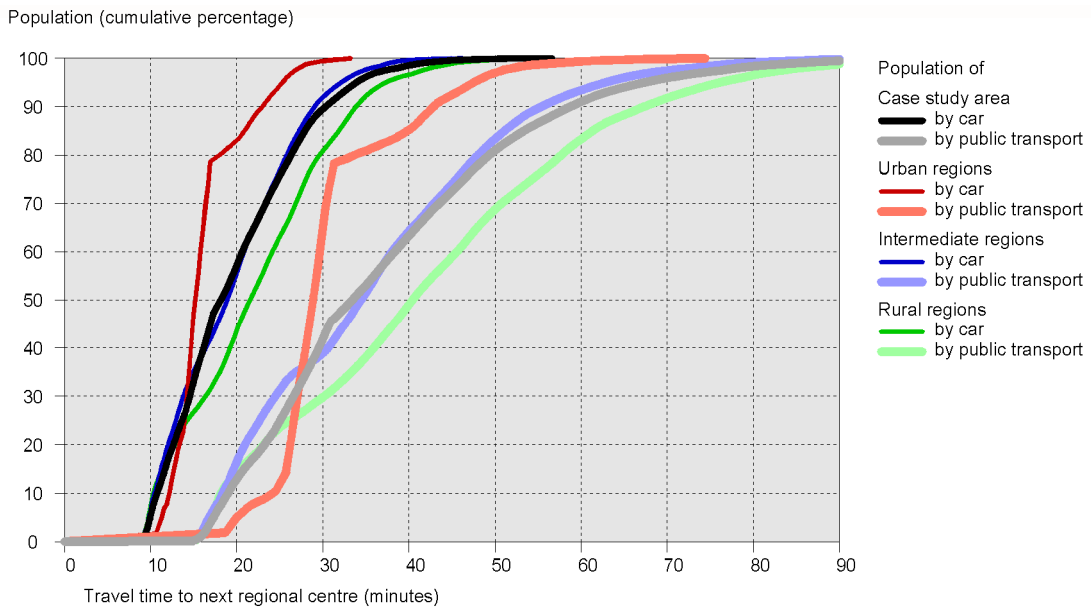


Figure 9. Travel time to next regional centre, cumulative distributions

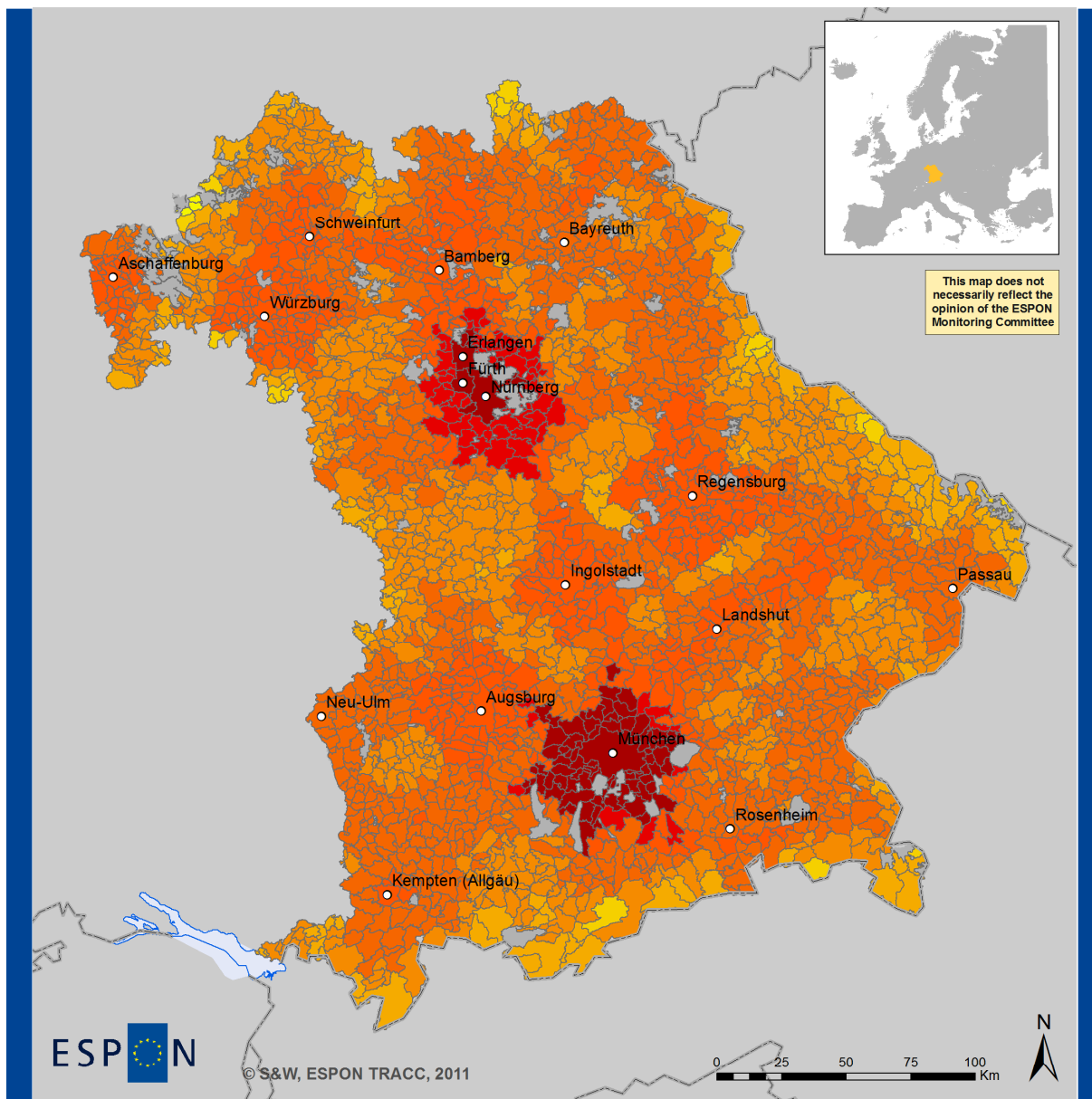
### 3.2 Daily accessibility of jobs

The consideration of the access to jobs is an important factor when making decisions concerning residential location. The indicator “daily accessibility of jobs” looks at the availability of jobs within a travel time from home of 60 minutes. This one hour travel time can be considered as a dimension which most people are willing to accept for a one-way daily commuting time. There are about 4.7 million jobs available in Bavaria, most of which are located in the cities of Munich (710,000) and Nuremberg (270,000) and their surroundings. There are only two other cities with slightly more than 100,000 jobs (Augsburg and Regensburg)

On average, each Bavarian resident has almost 300,000 jobs in reach from his residential location within one hour travel time by car. However, the spatial differences are huge (Figure 10). The agglomerations of Munich and also Nuremberg offer the highest job availability. In Munich, each resident has 1 million jobs in reach in the maximum commuting time of one hour. As most of the jobs in those agglomerations are located in the core city, daily accessibility of jobs gradually goes down towards the outer parts of the agglomeration. Residents in urban agglomerations have an average daily accessibility of jobs of about 800,000 (Figure 12). The situation is very distinct in the countryside. From locations in rural regions, only 100,000 regions are accessible, from peripheral rural regions only about 30,000 jobs. The regions between rural areas and the two big agglomerations offer a fairly good job accessibility of almost 200,000 jobs on average. Those intermediate regions do often consist of smaller agglomerations such as Augsburg, Ingolstadt or Würzburg.

The accessibility to jobs for people not having access to a car is much worse (Figure 11). On average, a Bavarian resident can only access about 70,000 jobs within 60 minutes travel time (Figure 12). The number is somewhat higher for residents of urban regions (250,000 jobs), but job access by public transport from rural sites is extremely low; about 10,000 jobs on average, but for the majority of municipalities it is less than 5,000 jobs. Figure 13 shows the huge differences in terms of accessibility to jobs for the different types of regions and for the two transport modes considered in those regional types.

The analysis of accessibility to jobs for Bavaria shows a very unbalanced spatial distribution. On the one hand, there are urban areas in which several hundred thousand jobs are in reach within one hour travel time by car and also by public transport. On the other hand, there are rural regions from which only a few ten thousand jobs are available. This is even worse for people that are depending on public transport, here from most of the municipalities located in rural regions clearly less than 5,000 jobs are in reach. That means that people in rural regions without a car are almost excluded from the labour market, at least in terms of variety of job opportunities and in terms of flexibility.



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### Bavaria Case Study

#### Jobs accessible by car within 60 minutes (in 1.000 jobs)

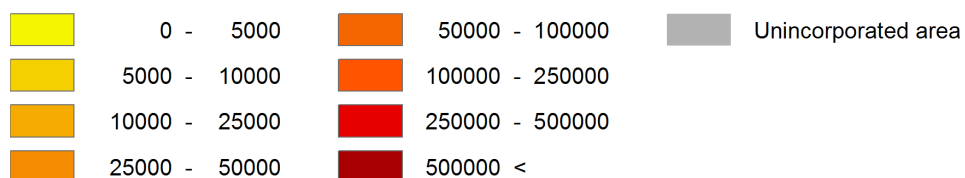
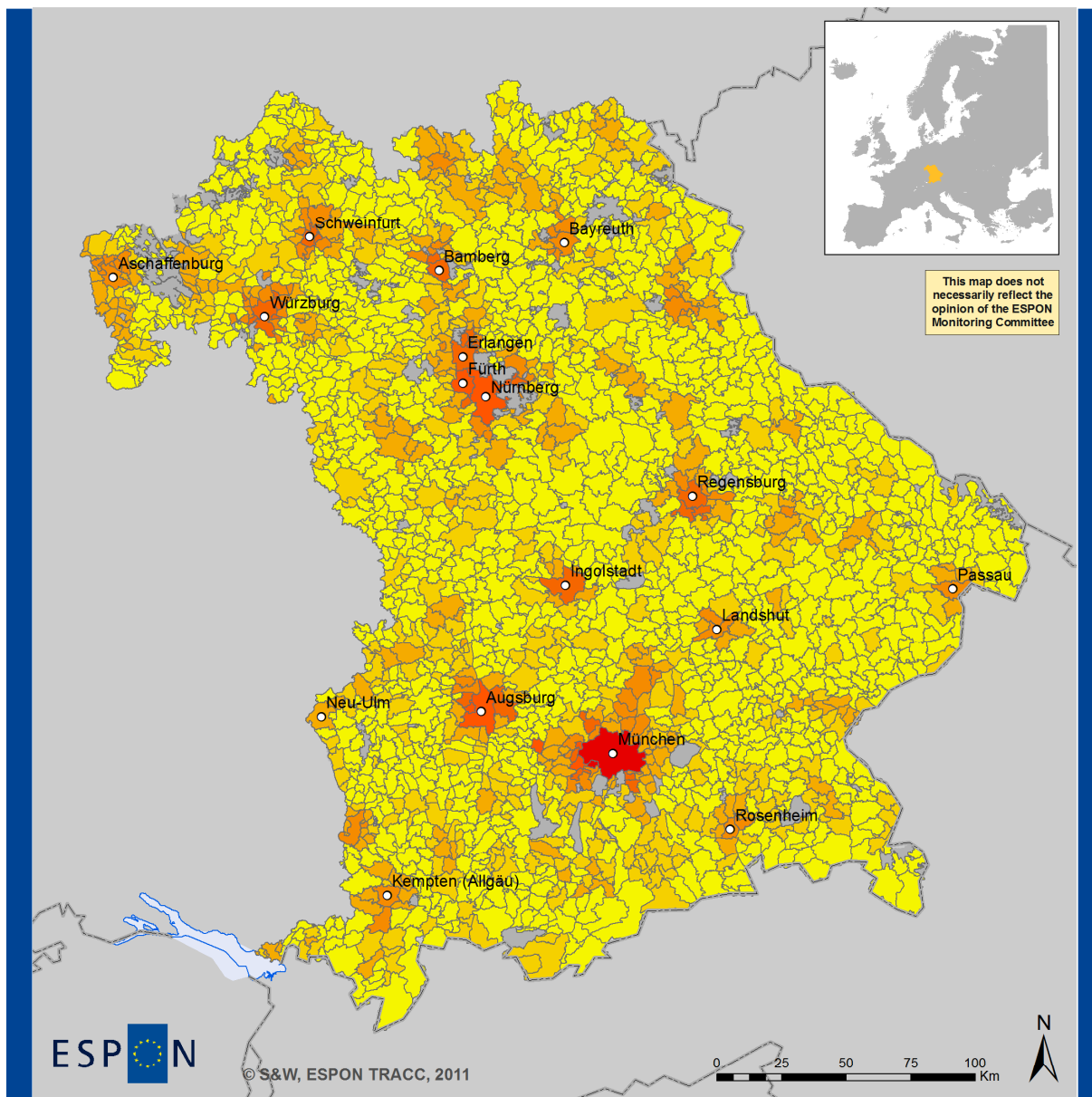


Figure 10. Jobs accessible by car within 60 minutes





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### Bavaria Case Study

#### Jobs accessible by car within 60 minutes (in 1.000 jobs)

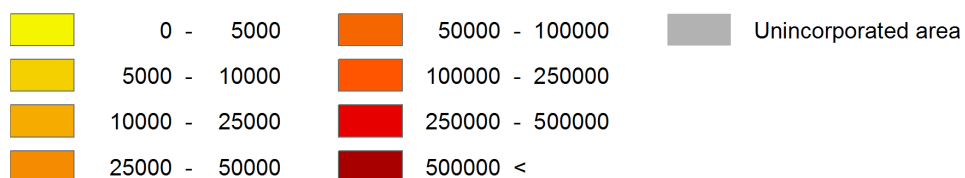


Figure 11. Jobs accessible by public transport within 60 minutes

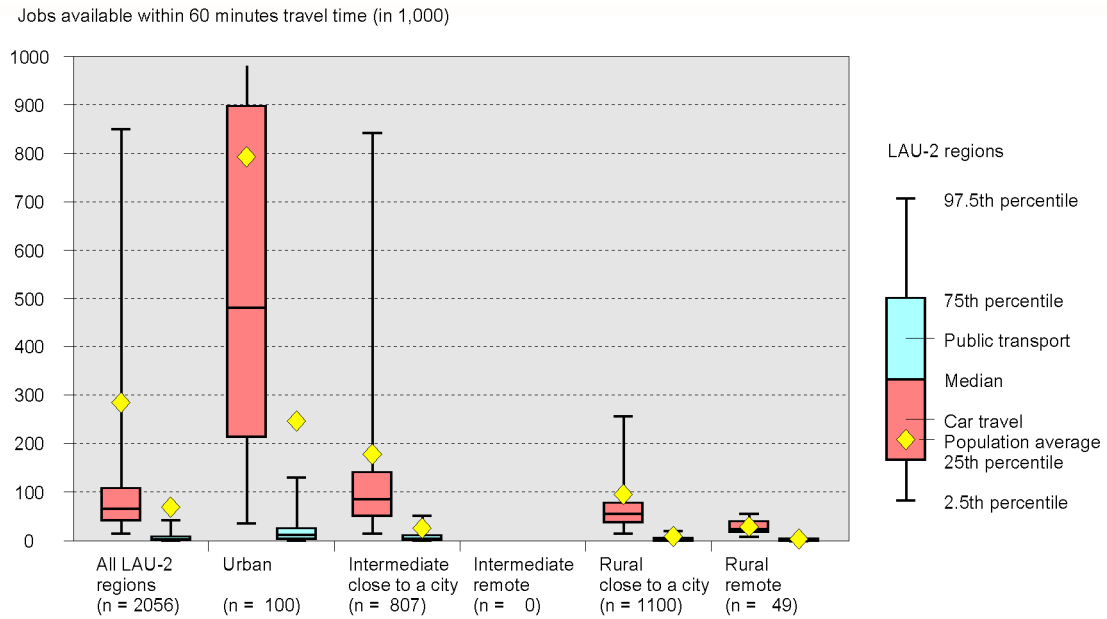


Figure 12. Jobs accessible within 60 minutes, by urban-rural typology

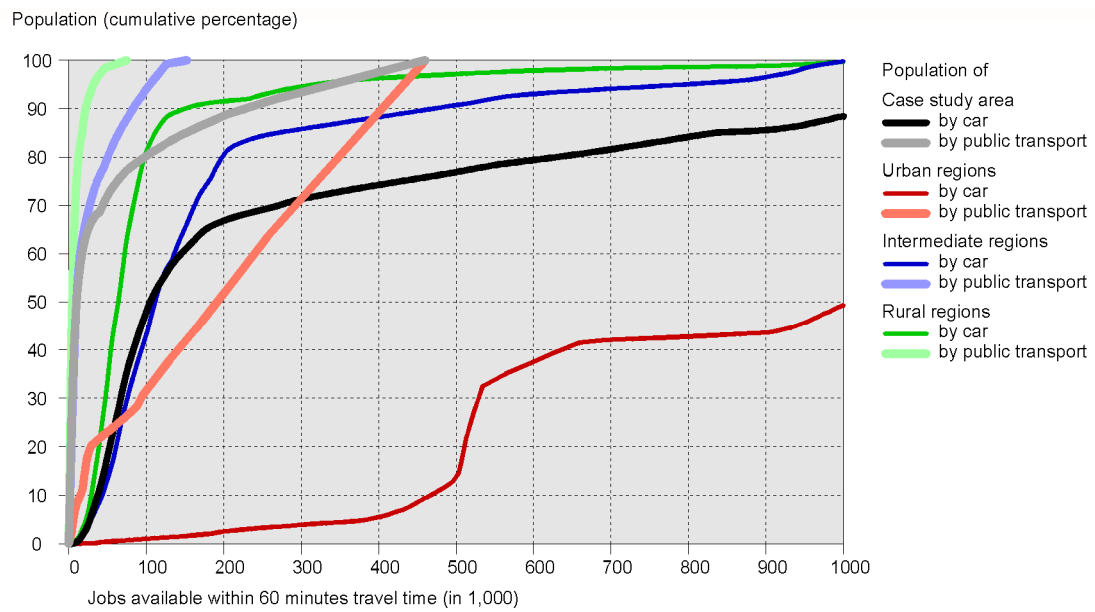


Figure 13. Jobs accessible within 60 minutes, cumulative distributions



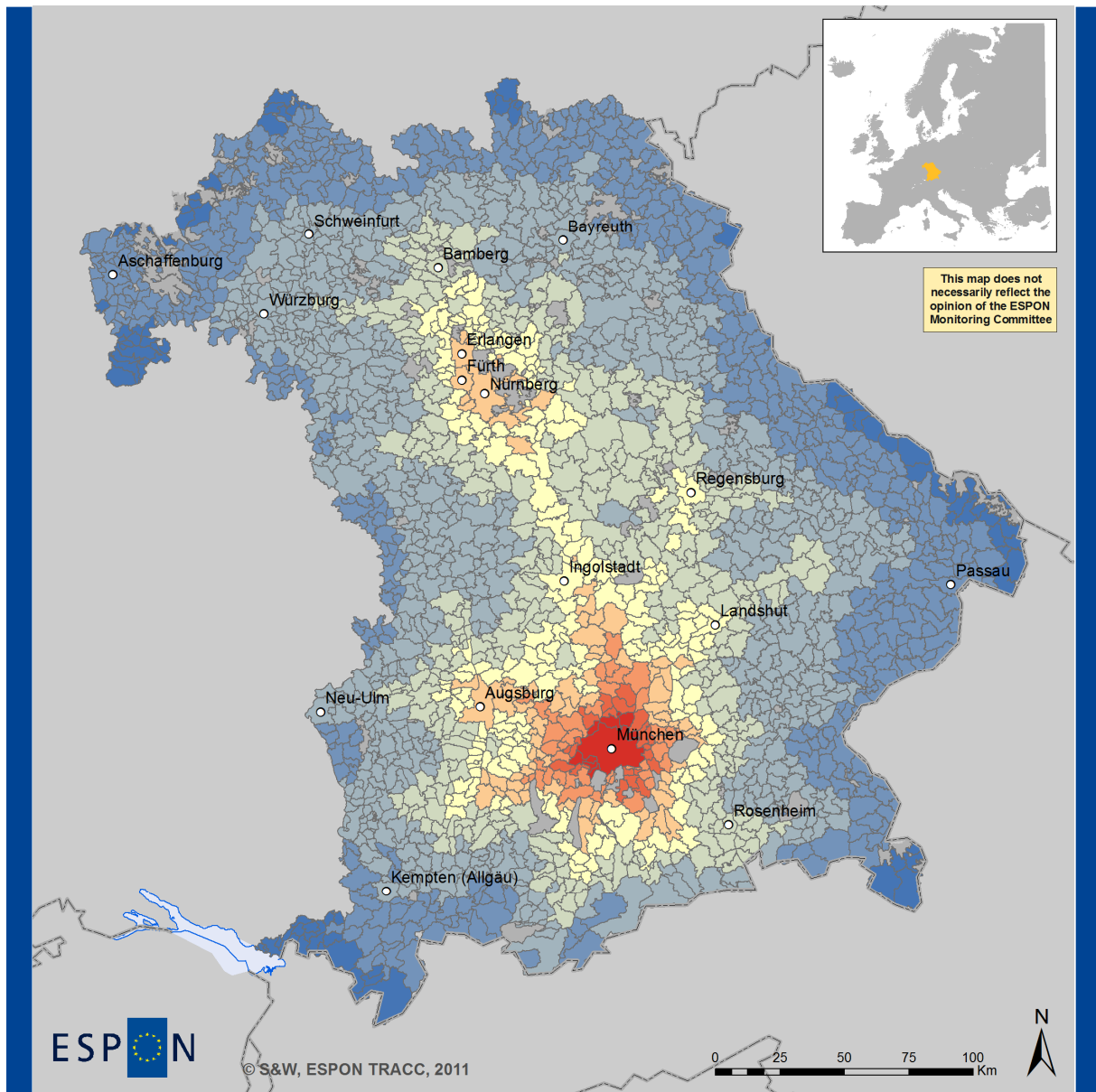
### 3.3 Regional accessibility potential

The indicator “Potential accessibility by car” uses population as destination activity. The indicator is calculated for a given place as the sum of the population in all other places which are weighted by the respective car or public transport travel time to that place by using a negative exponential function. In this way, potential accessibility can be interpreted as the market potential of an area or seen differently as the contact potential of the population.

The spatial pattern of the accessibility potential by car is shown in Figure 14. The indicator is presented for the municipalities as index values by which the Bavarian average is set to 100. Not surprisingly, highest accessibility potential can be found in the Munich agglomeration. In the city of Munich the indicator value is more than twice the average. Due to the dense road network, the area of above average accessibility around Munich is relatively wide. The radial motorways push the areas of higher potential accessibility to the outside and form corridors with high market potential. The Nuremberg region forms the second accessibility peak in Bavaria, however, the maximum values are much lower due to less population living in that agglomeration. From the two agglomerations, accessibility potential goes down when moving to more remote areas. But due to the more smoothing character of the indicator definition, the disparities are less pronounced and the average of rural areas is about 70 percent of the Bavarian average.

Again, the situation for public transport users is much worse. When using the car average as benchmark (i.e. car average is set to 100 and is used for public transport accessibility), no municipality is above car average, even Munich is slightly below (Figure 15a). The average accessibility potential by public transport is only about 30 percent of the car average (Figure 16). Even in urban agglomerations, the public transport average goes only up to 70 percent. In rural areas it is as low as 15 percent of the Bavarian accessibility potential by car. However, the spatial pattern is rather similar. This becomes visible when standardising the accessibility values to the average of public transport potential accessibility (Figure 15b). There are pronounced peaks of potential accessibility by public transport in Munich and Nuremberg and rail services extending the area of higher accessibility to the surrounding cities. This is in particular true for Augsburg which benefits in terms of potential accessibility from high-speed train connections to Munich. In the Munich agglomeration, also the effects of the rapid regional and local train system are visible which push the areas of high-above accessibility to the suburban municipalities. Outside those agglomerations, accessibility potential by public transport rapidly goes down. In particular those numerous municipalities in rural areas that are not served by rail, but by bus services, do have index values of less than a quarter of the Bavarian public transport average.

The advantage of the car over public transport in terms of potential accessibility becomes also visible in the cumulative distributions (Figure 17). The accessibility by public transport in all types of the territorial typology is much lower than accessibility by car. It becomes even clear that a car in an average rural setting offers a degree of accessibility potential that is higher than that of an average urban setting.



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### Bavaria Case Study Potential accessibility to population by car (Index: car average = 100)

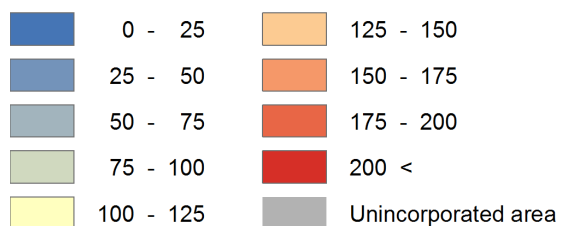
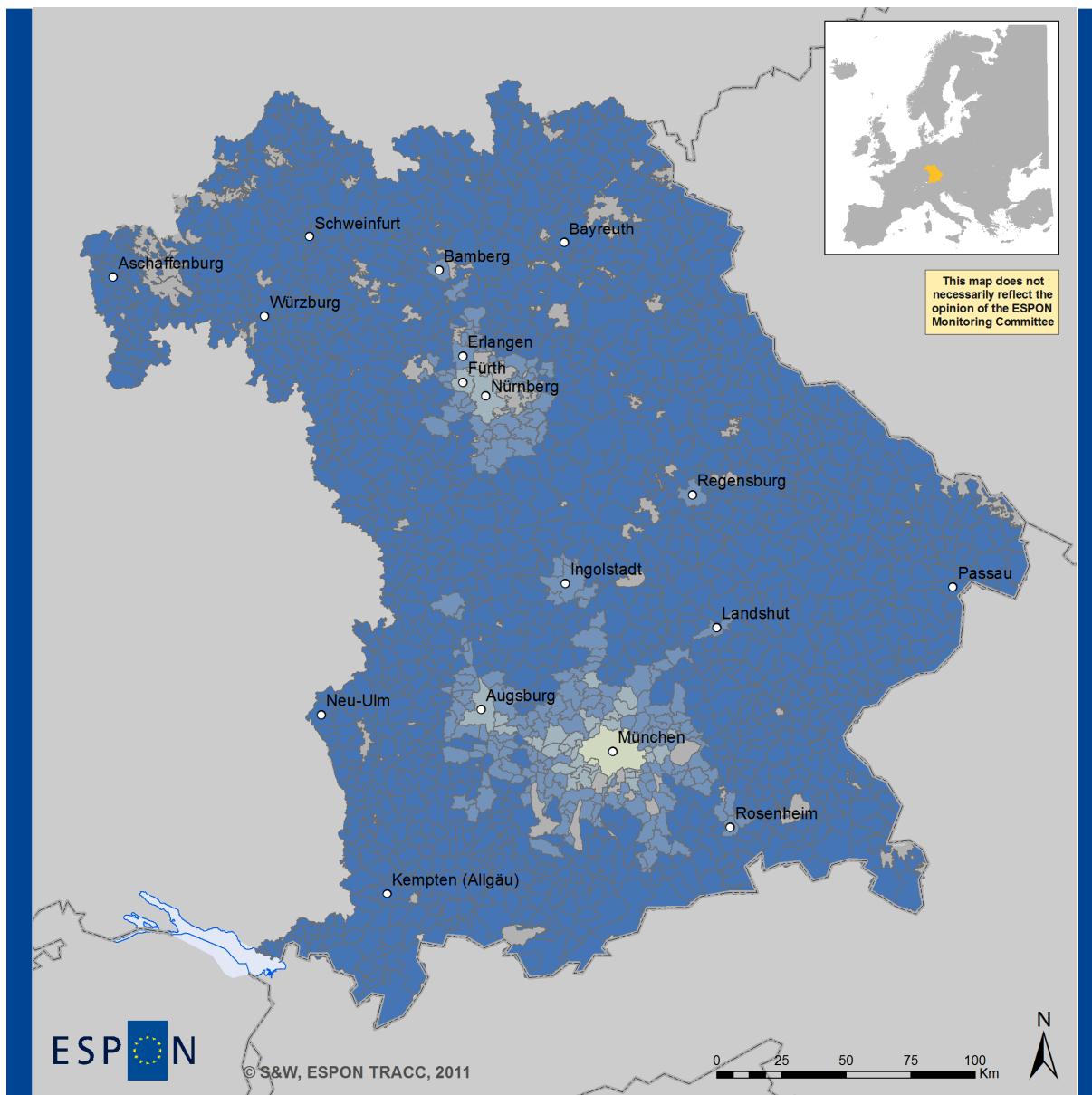


Figure 14. Potential accessibility to population by car




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**Bavaria Case Study**  
**Potential accessibility to population**  
**by public transport**  
**(Index: car average = 100)**

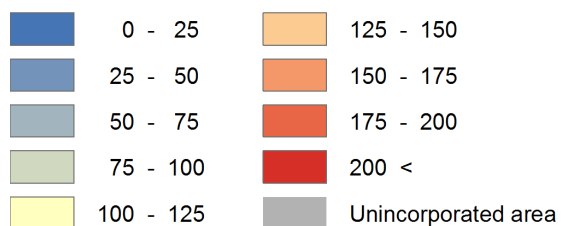
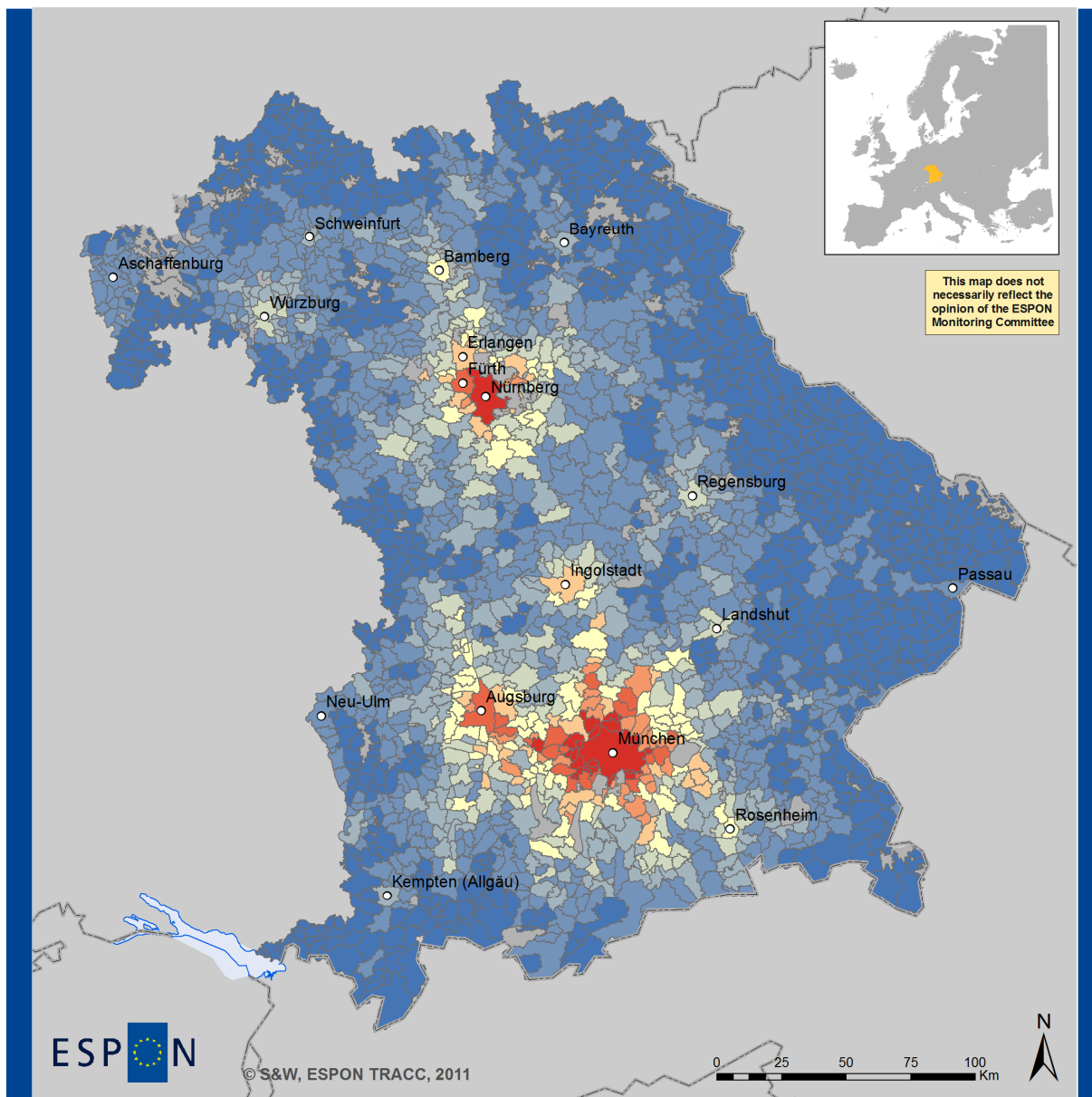


Figure 15a. Potential accessibility to population by public transport (Index: car average = 100)



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### Bavaria Case Study

#### Potential accessibility to population by public transport (Index: public transport average = 100)

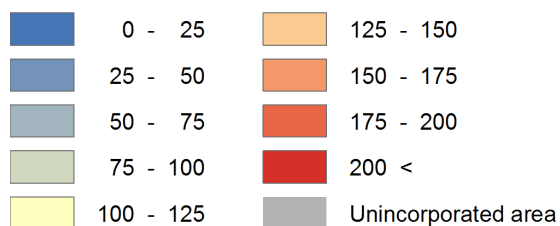


Figure 15b. Potential accessibility to population by public transport (Index: public transport average = 100)

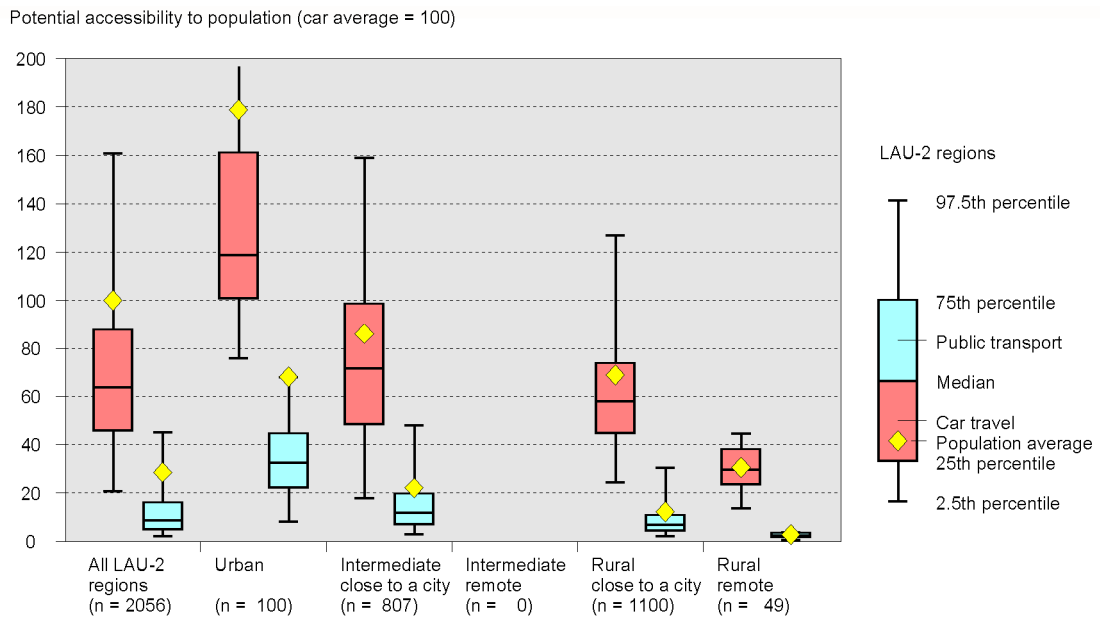


Figure 16. Potential accessibility to population, by urban-rural typology

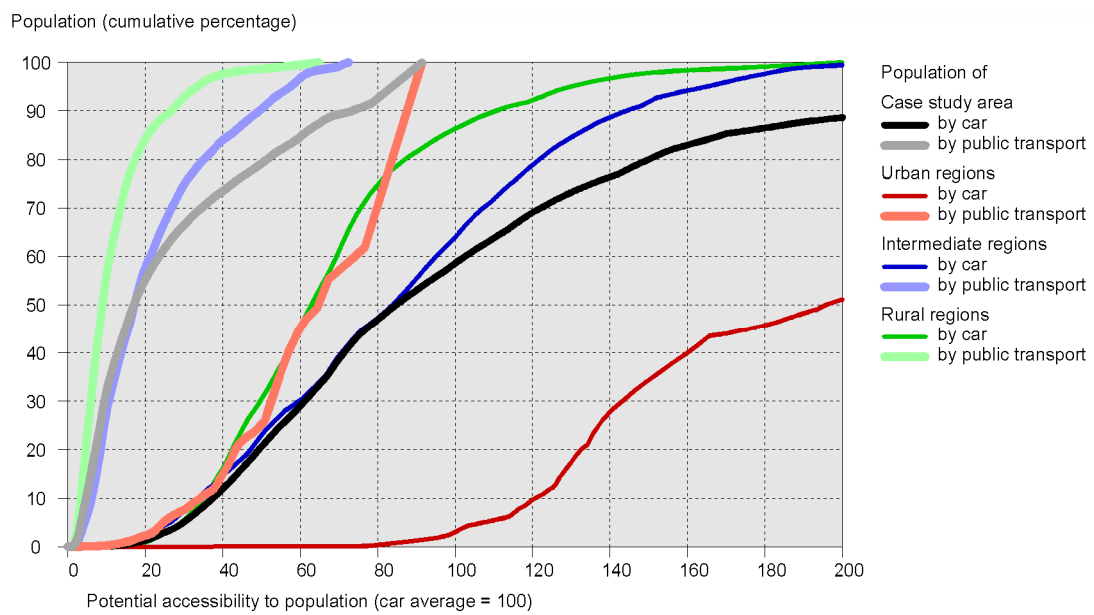


Figure 17. Potential accessibility to population, cumulative distributions

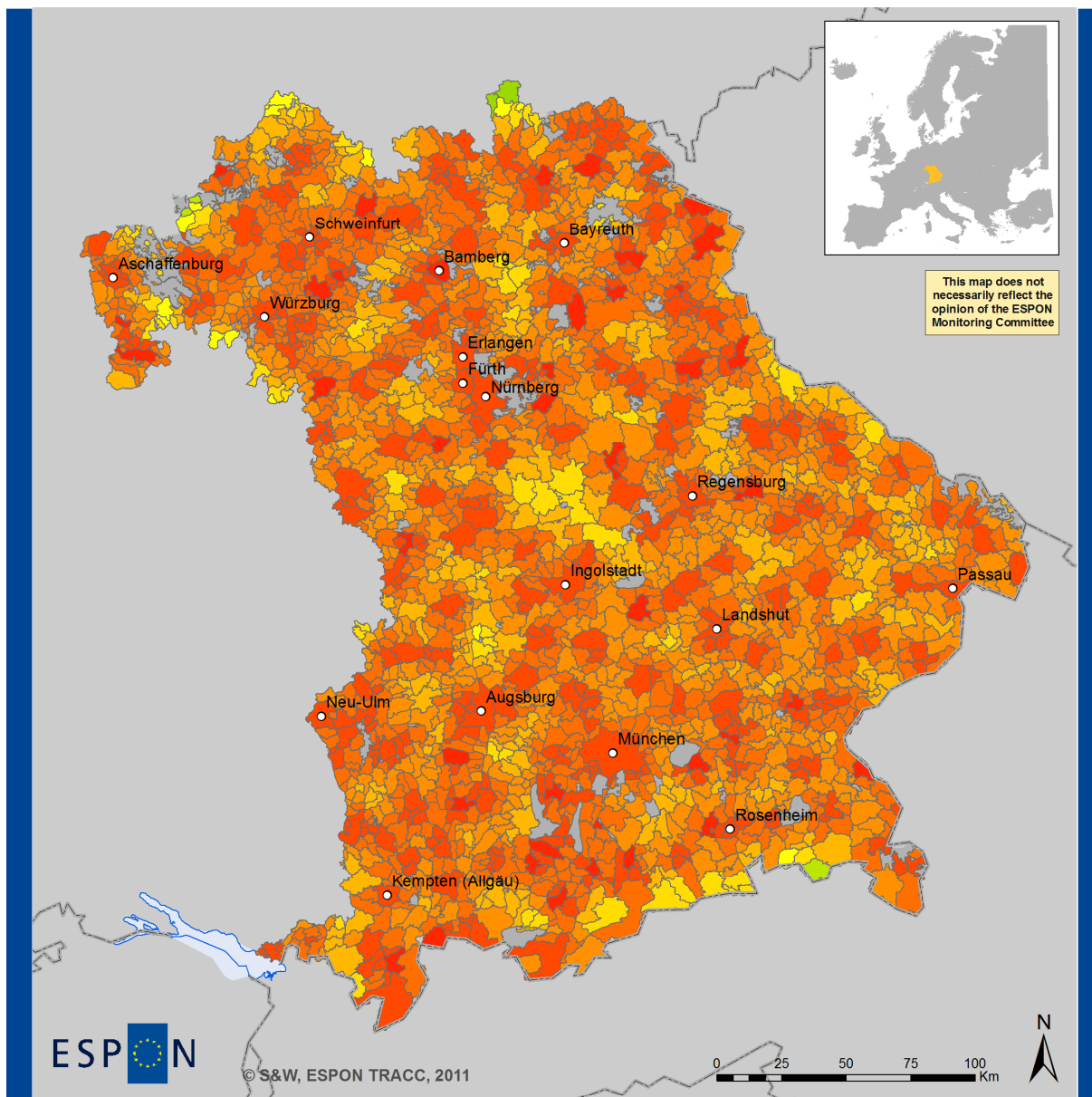
### **3.4 Access to health care facilities**

The access to services of general interest is an important factor for the quality of life. The nearby availability of Kindergartens, schools, health care facilities such as different kinds of doctors and hospitals or public service agencies is an important location factor for residents and decisive for the daily mobility effort to be taken. As a first indicator describing the accessibility to this group of relevant destinations, the access time to the next hospital is used. There are about 220 hospitals in Bavaria that offer public health services, specialised and rehabilitation clinics were not considered in the accessibility analysis.

In Bavaria, the distribution of hospitals across the territory is relatively even. Travel times by car to municipalities are for many municipalities rather short with less than 15 minutes (Figure 18). However, there are also areas in Bavaria that are more apart from hospitals with car travel times up to half an hour or even slightly above in some smaller areas. The Bavarian average travel time to a hospital by car is about 16 minutes (Figure 20). The variation across types of regions is very little. The average of urban areas is twelve minutes, the average of rural areas is 18 minutes.

Access to hospitals by public transport is for most areas in Bavaria much longer (Figure 19). Even for most of the urban areas, public transport travel time is more than 20 minutes. The map shows a majority of green coloured municipalities indicating that the next hospital is almost one hour or even more apart by public transport. Access times by public transport might not so relevant for patients, but it is an important issue for relatives and friends without a car available. The Bavarian average is beyond half an hour-(Figure 20). Lowest average is in urban areas with about 25 minutes, the average access time value goes up to about 35 minutes in rural areas. Similar to car access, the variation across types of regions is relatively little (see also Figure 21).





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### Bavaria Case Study Car travel time to next hospital (minutes)

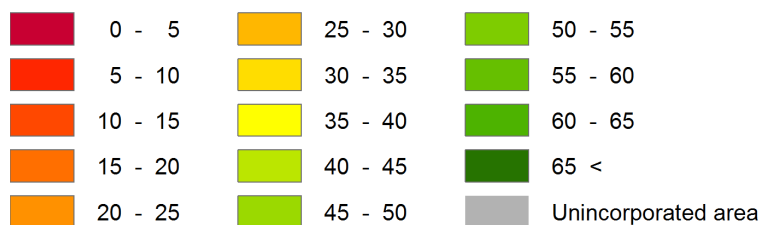
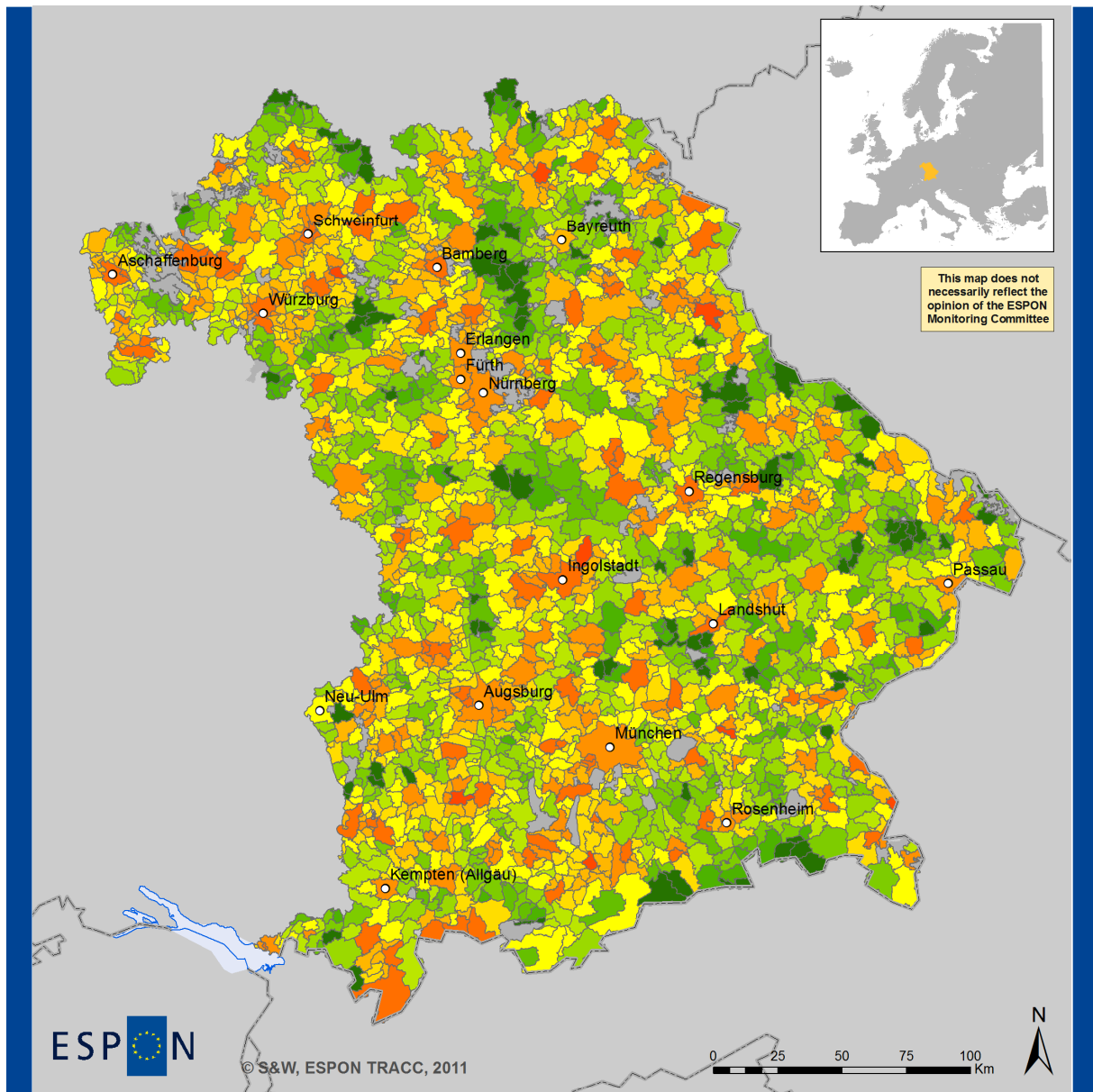


Figure 18. Car travel time to next hospital



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### Bavaria Case Study Public transport travel time to next hospital (minutes)

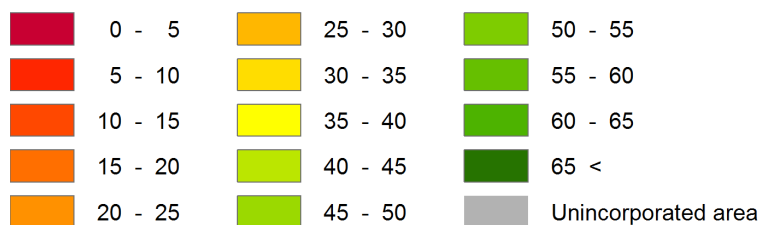


Figure 19. Public transport travel time to next hospital



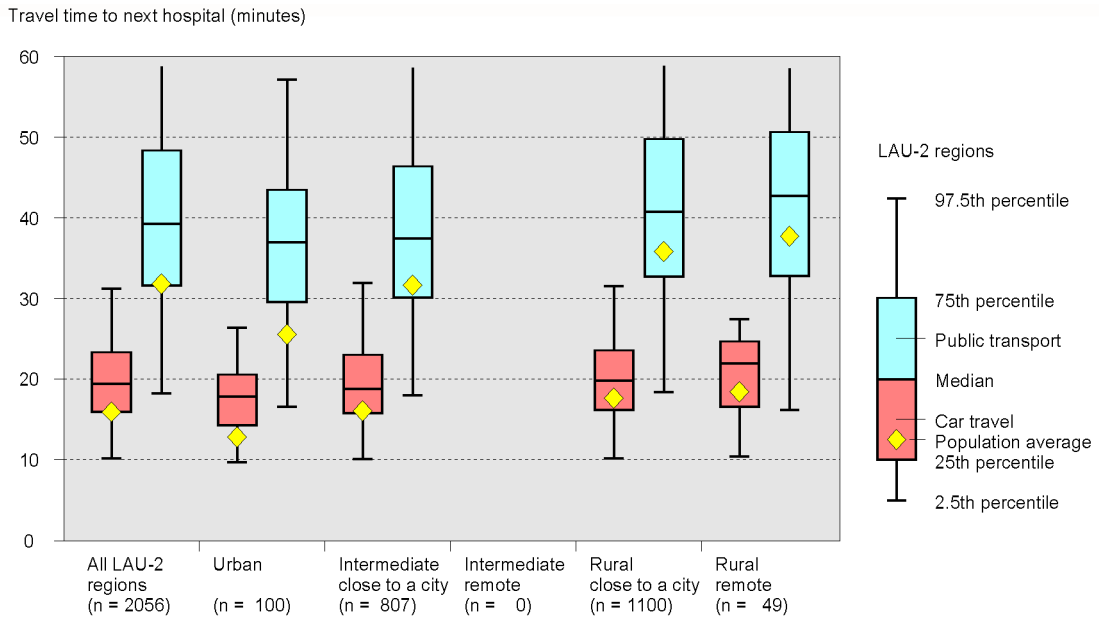


Figure 20. Travel time to next hospital, by urban-rural typology

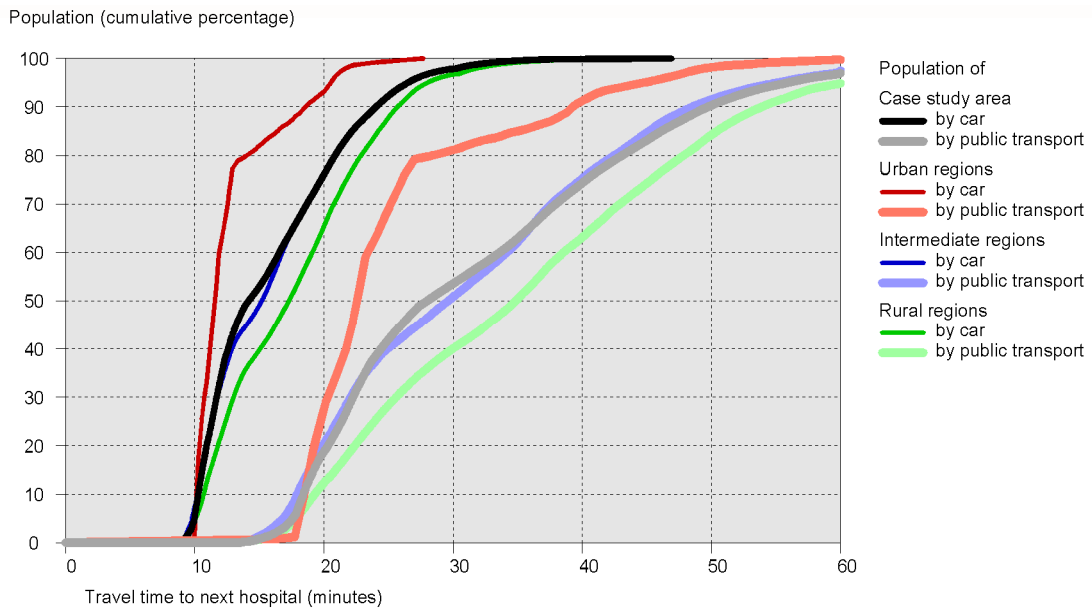


Figure 21. Travel time to next hospital, cumulative distributions

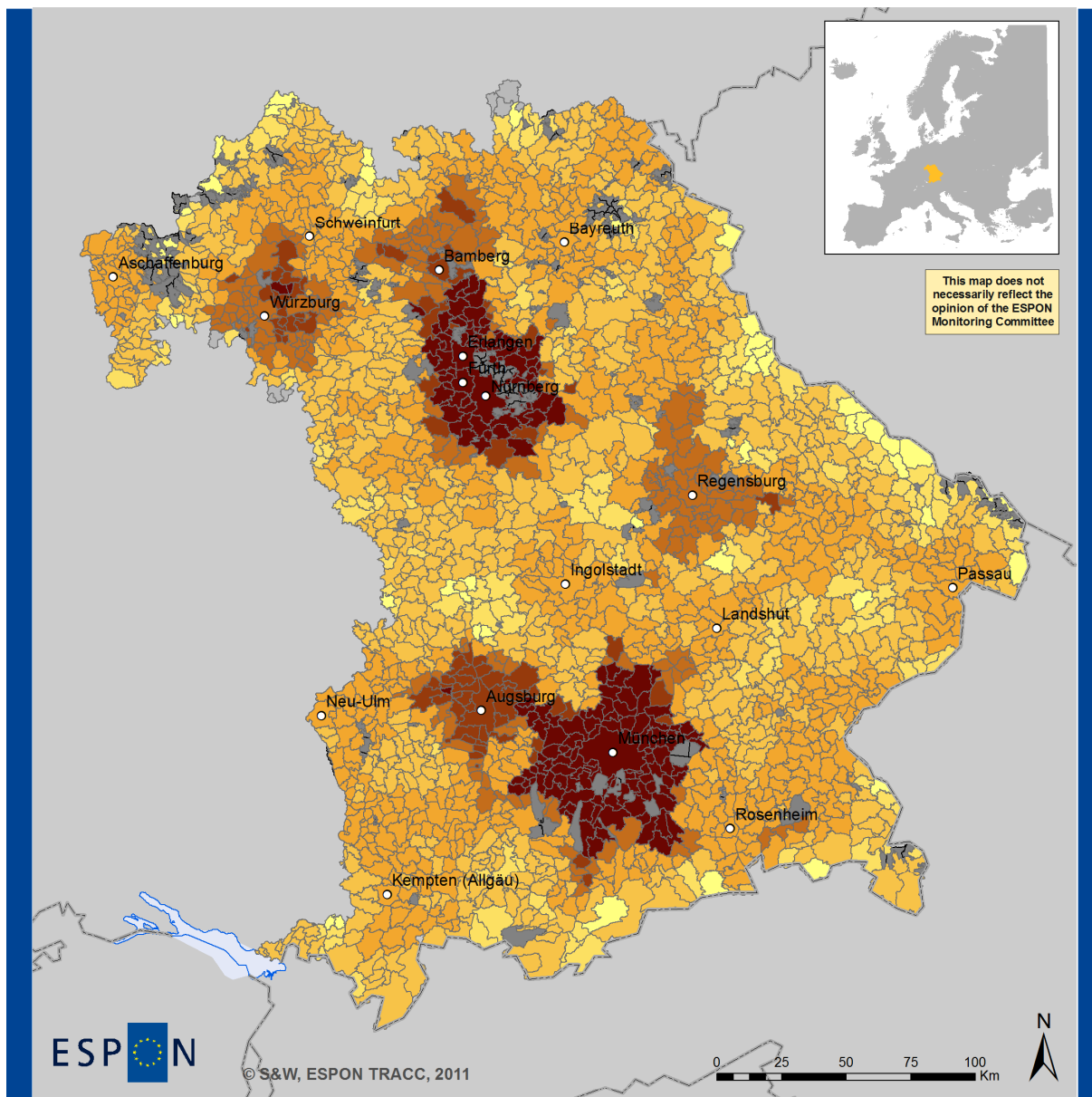
### 3.5 Availability of higher secondary schools

Access to education is another important location factor. The focus of the analysis here was on higher secondary schools (Gymnasium) offering a degree to continue study at the university. It was checked whether there is access to higher secondary schools in reasonable travel time and whether there is a freedom of choice to select between different options. There are about 420 Gymnasiums in Bavaria. However, they are located in only 240 municipalities, i.e. about 90 percent of the municipalities do not have a Gymnasium. To assess the availability of higher secondary schools, time contours of 30 minutes travel time by road and by public transport have been calculated for each place in Bavaria, and it has been checked how many Gymnasiums are reachable within this maximum travel time. The calculation was first done at the raster cell level, the maps in this section show average, population weighted values by municipality, i.e. are not in whole numbers.

There is a very distinct spatial pattern for the availability of higher secondary schools within 30 minutes travel time by car (Figure 22). Highest values are in the large agglomerations, including the suburban municipalities. Number of Gymnasiums goes up to more than 80 in Munich and some neighbouring communities. Second peak is in and around Nuremberg with up to 40 options. The Augsburg, Würzburg and Regensburg urban agglomerations form the next peaks with about 10 to twenty Gymnasiums. Most other municipalities have at least two options available, only for a handful of municipalities, there is no Gymnasium at all in reach within half an hour car travel time. The Bavarian average is slightly above 20, the average in rural municipalities is about 8 (Figure 24).

However, a car is not the standard transport mode to go to school. When looking at availability of higher secondary schools within half an hour by public transport the picture becomes much worse (Figure 23). Given the spatial distribution of the locations of the Gymnasiums, the overall spatial pattern in terms of accessibility is similar, however, on a much lower level concerning the number of available options. Now, outside the agglomerations, the better-off municipalities have only one Gymnasium within 30 minutes public transport travel time, but from most of the rural communities a Gymnasium is not reachable by public transport within that travel time maximum at all. Though the population weighted average is about 9 Gymnasiums in reach (Figure 24), but this is mainly due to the population concentration in the urban parts.

So, for the accessibility to higher secondary schools it is first of all decisive in which type of region a pupil lives (Figure 25). Then, it is relevant whether one might go (or will be driven) to school by car which is superior to be dependent on public transport.



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### Bavaria Case Study Higher secondary schools within 30 minutes travel time by car (number of schools)

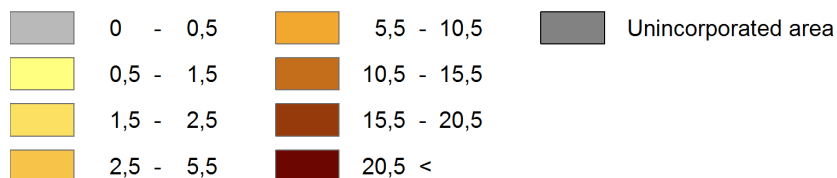
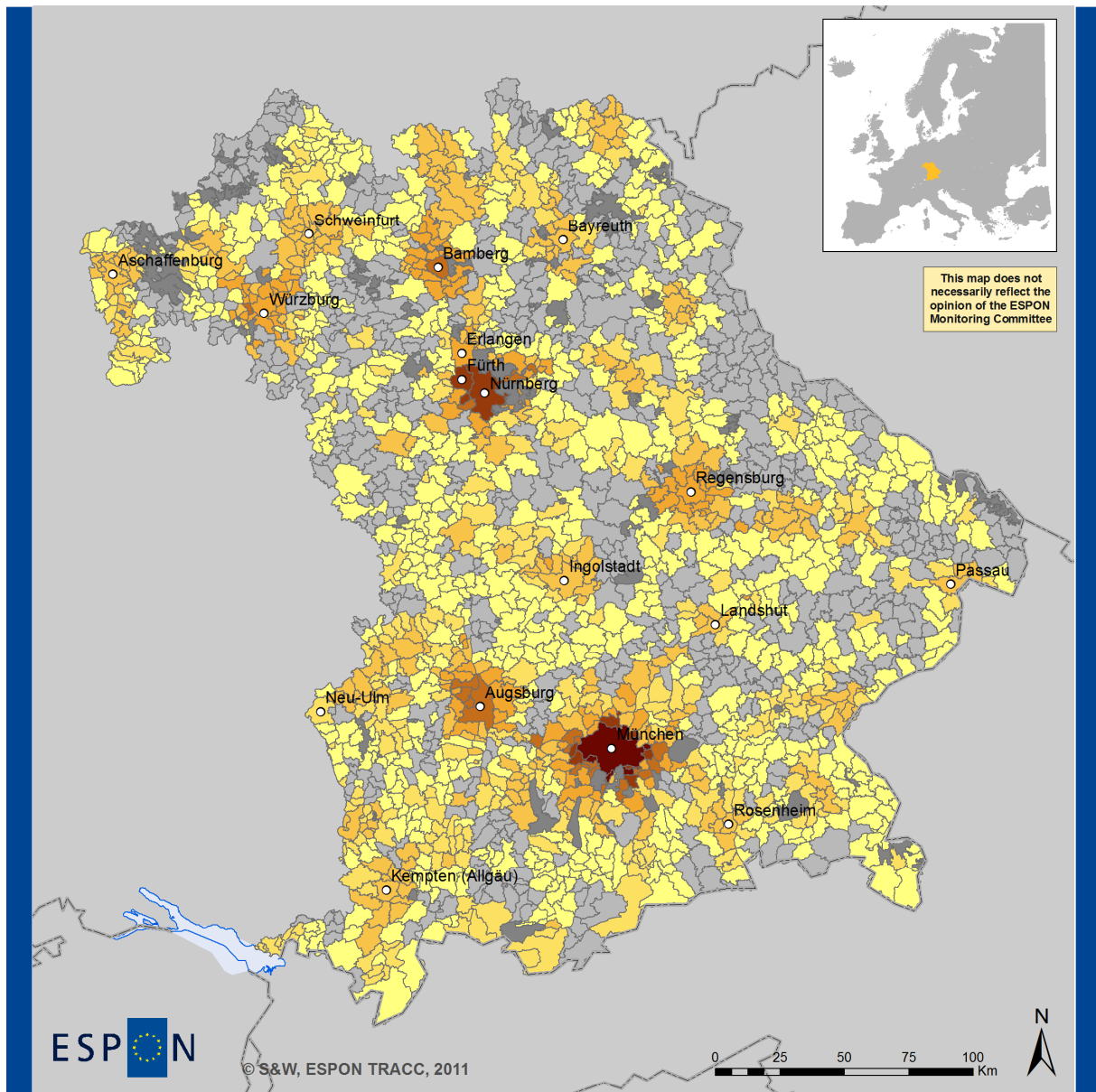


Figure 22. Higher secondary schools within 30 minutes travel time by car



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### Bavaria Case Study Higher secondary schools within 30 minutes travel time by public transport (number of schools)

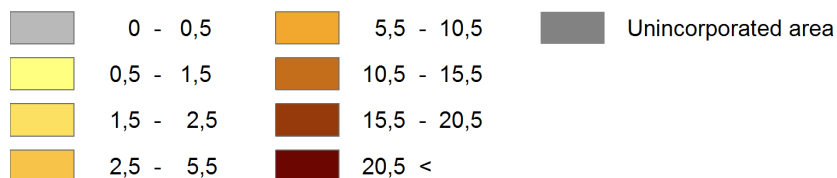


Figure 23. Higher secondary schools within 30 minutes travel time by public transport

Higher secondary schools available within 30 minutes travel time

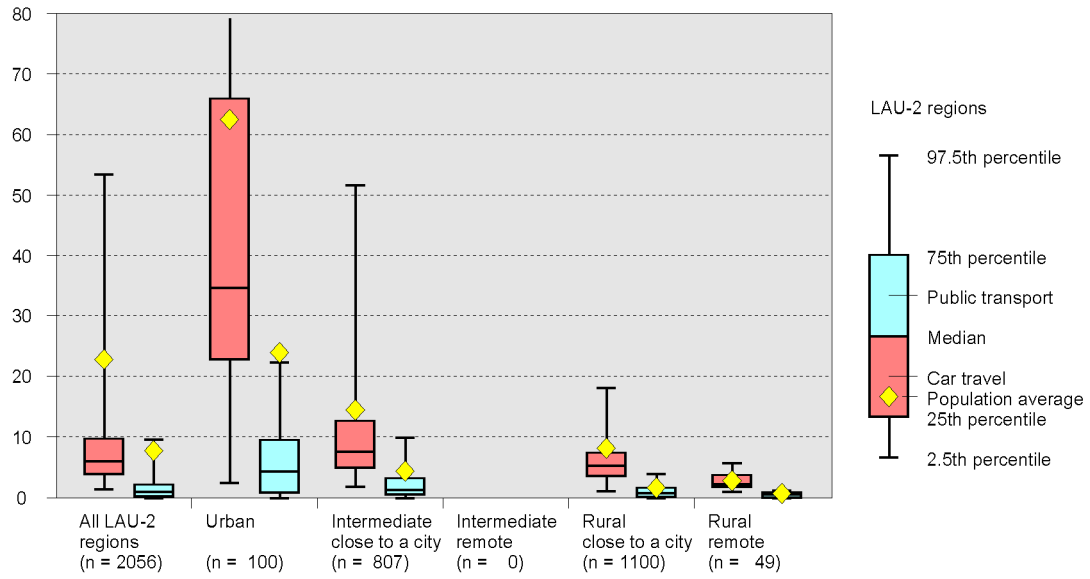


Figure 24. Higher secondary schools within 30 minutes travel time, by urban-rural typology

Population (cumulative percentage)

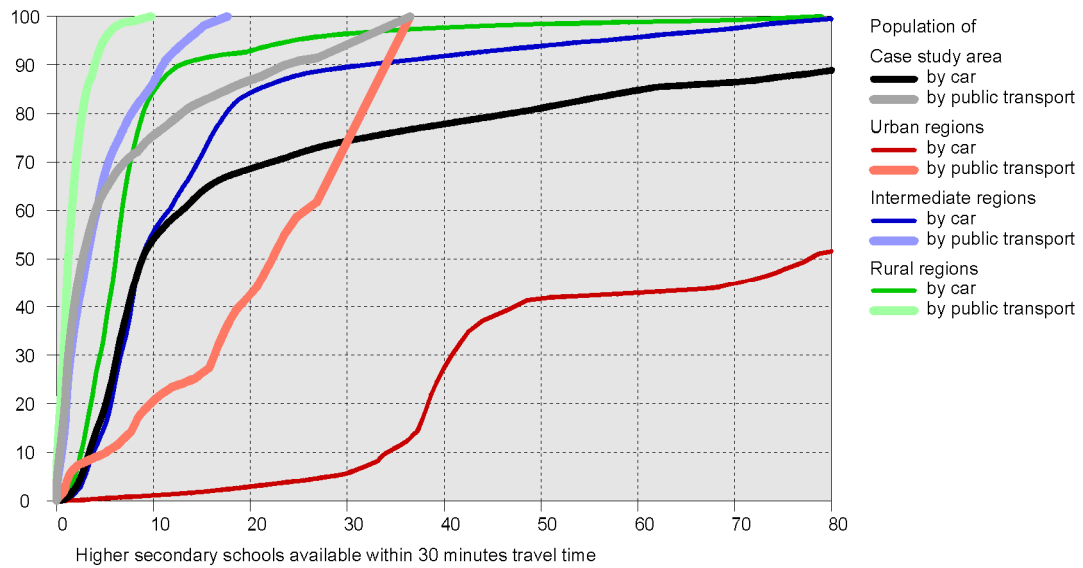
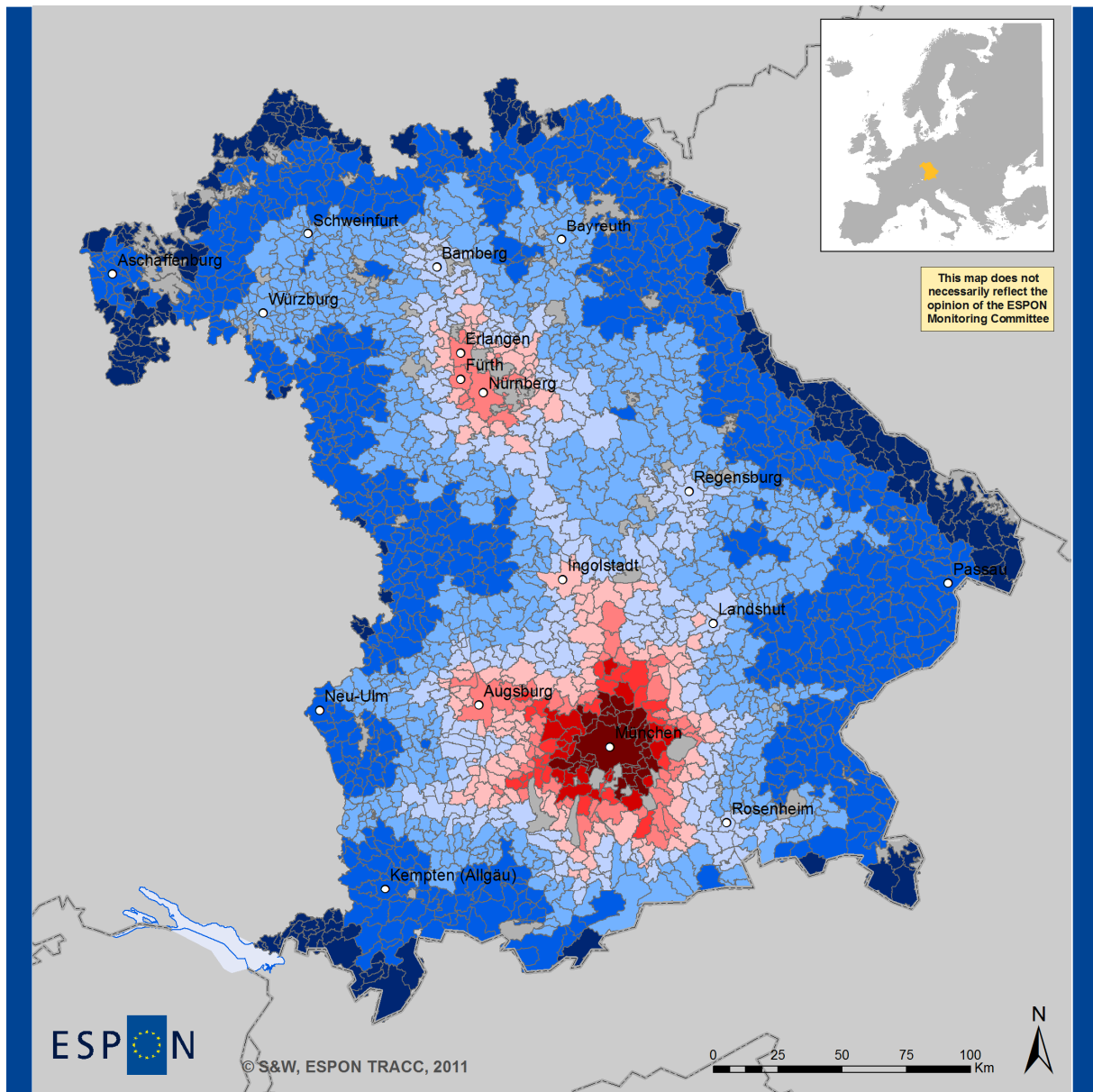


Figure 25. Higher secondary schools within 30 minutes travel time, cumulative distributions

### **3.6 Accessibility potential to basic health care**

The final accessibility indicator is somewhat experimental as it tries to treat basic health care service in a potential accessibility type indicator. Using medical doctors as destination activity in a potential accessibility indicator might allow to assess the relative distribution of health care provision of different areas within Bavaria. For each place in the case study region, the accessibility potential to basic health care has been calculated by summing up the medical doctors located in Bavaria each weighted by travel time by road and public transport.

The results of this experiment are very similar to that of accessibility potential to population (Figures 26-29). Accessibility potential to medical doctors is high in agglomerations and goes down to rather low values in rural areas. Accessibility by public transport is much beyond accessibility by car. This similarity with accessibility population to population is due to the fact, that more or less the density of medical doctors follows the population distribution.



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### Bavaria Case Study Potential accessibility to medical doctors by car (Index: car average = 100)

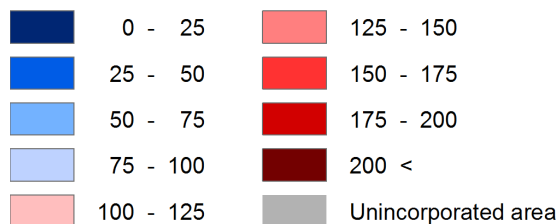
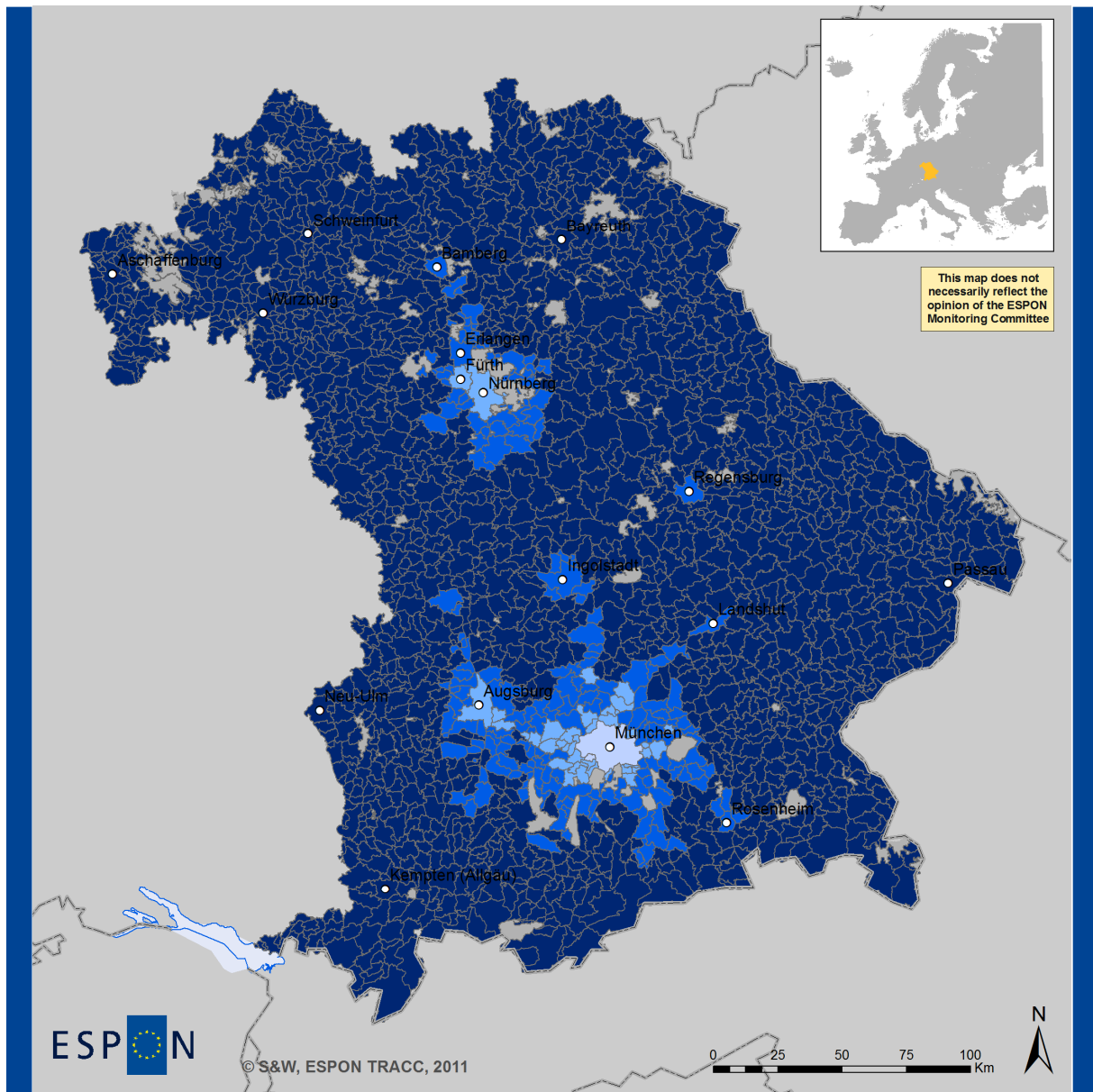


Figure 26. Potential accessibility to medical doctors by car





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### Bavaria Case Study

#### Potential accessibility to medical doctors by public transport (Index: car average = 100)

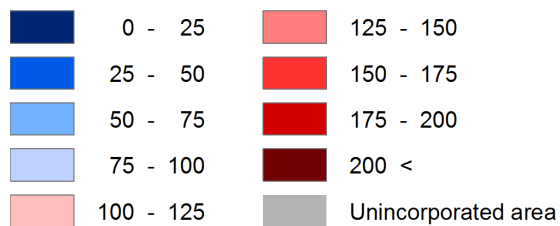
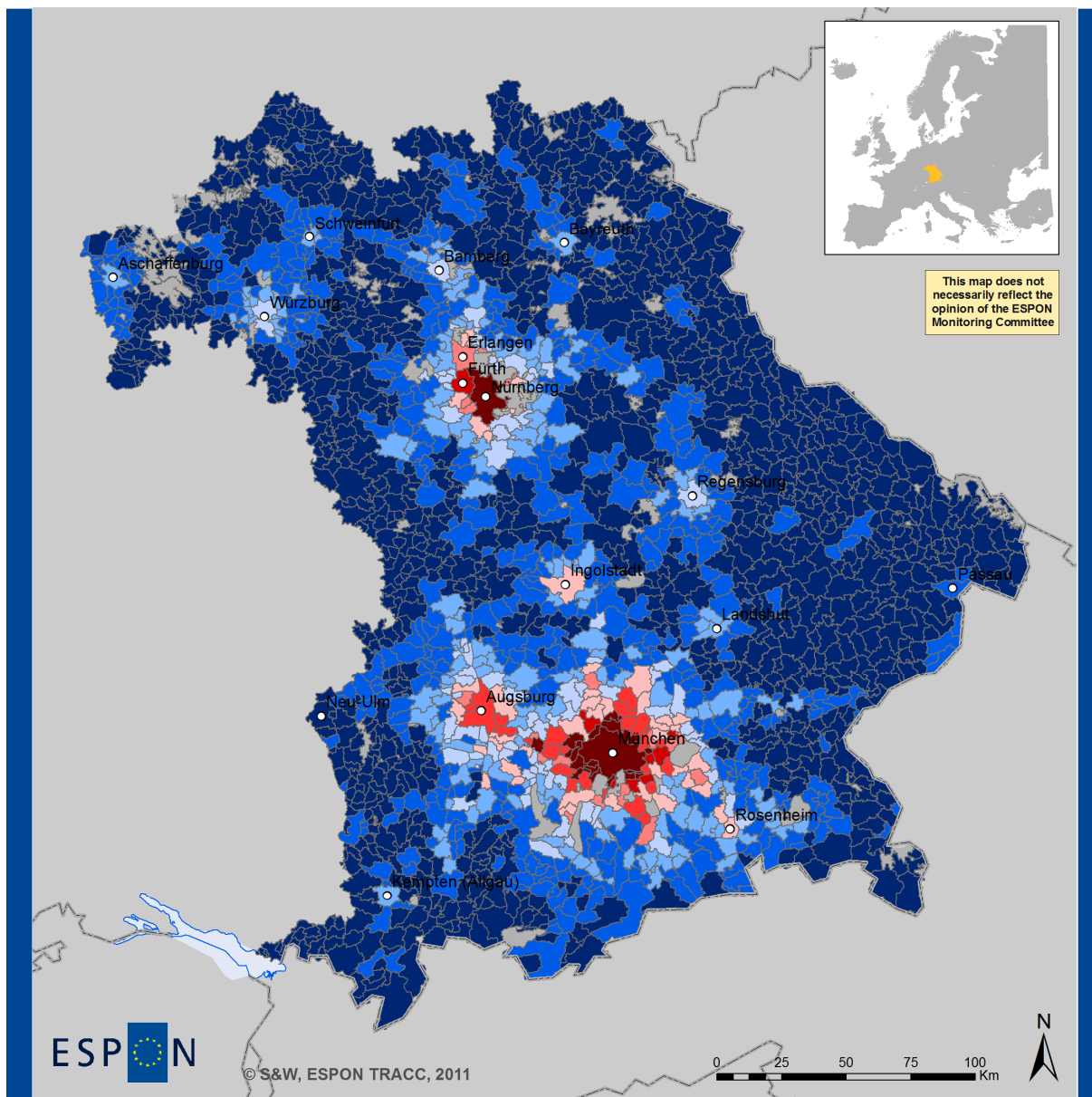


Figure 27a. Potential accessibility to medical doctors by public transport (Index: car average = 100)





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### Bavaria Case Study

#### Potential accessibility to medical doctor by public transport (Index: public transport average = 100)

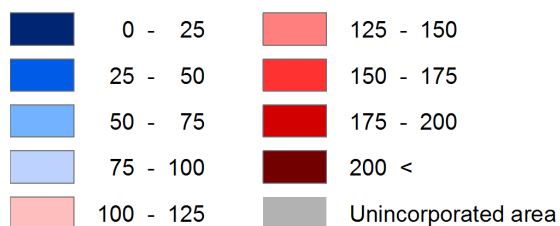


Figure 27b. Potential accessibility to medical doctors by public transport (Index: public transport average = 100)

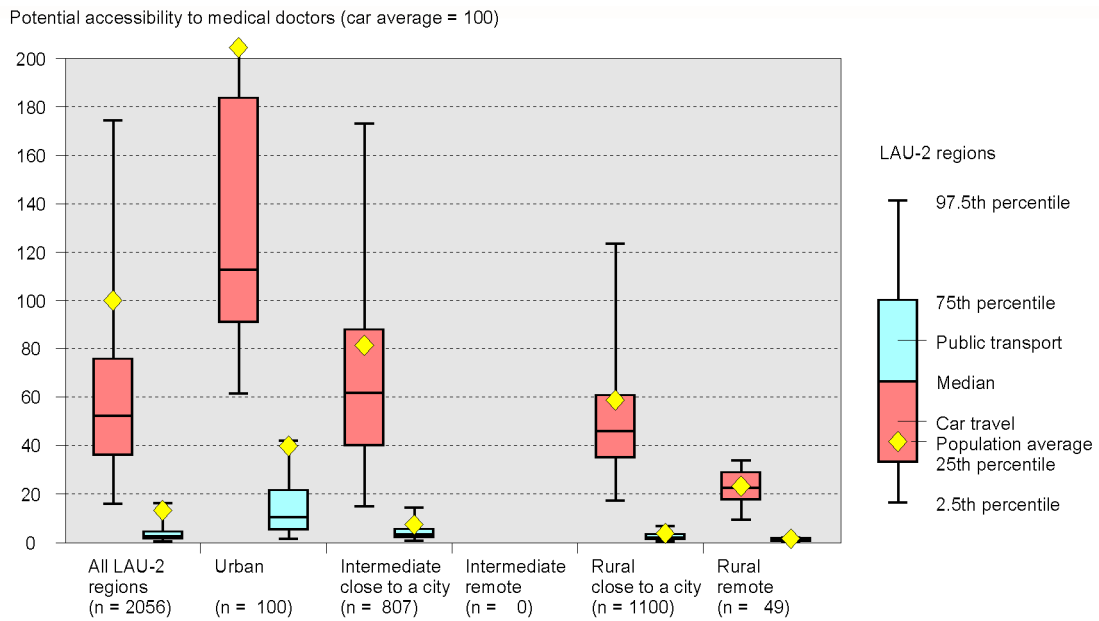


Figure 28. Potential accessibility to medical doctors, by urban-rural typology

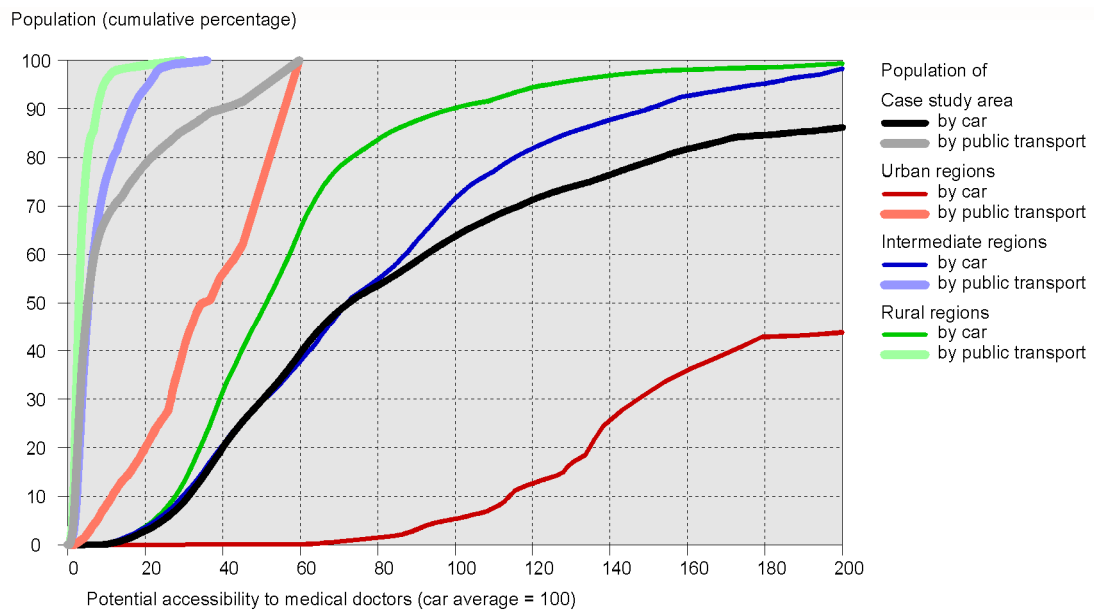


Figure 29. Potential accessibility to medical doctors, cumulative distributions

#### 4 Accessibility situation at different regional subtypes

The accessibility analysis for the case study of Bavaria as presented in the previous chapter gives already information about the different situation of accessibility in different region types of the ESPON urban-rural typology. This chapter gives additional information on different types of regions by aggregating the results for four different zoom-in areas in Bavaria (see Figure 30):

- The Munich region gives insights into accessibility patterns in a large urban area with a mono-centric spatial structure.
- The Nuremberg region provides knowledge about accessibility patterns in a medium-sized urban area with a polycentric spatial structure.
- The Allgäu region in the south-western parts of Bavaria including parts of the Alps and its foot-hills depicts accessibility patterns of rural and mountainous areas.
- The Donau-Wald region in the eastern parts of Bavaria provides information about the accessibility situation of rural areas.

The indicator of travel time to next regional centre yields in all four zoom-in regions the same observation (Figures 31 and 32). The average travel time by car is across all four regions rather similar and about 20 minutes. The average travel time by public transport is clearly higher and is slightly below 35 minutes in the first three regions and more than 40 minutes in the rather rural region of Donau-Wald. About twenty percent of that regions need more than half an hour by car and more than one hour by public transport to go to the next regional centre.

The indicator of availability of jobs within 60 minutes travel time demonstrates that the region type is important for the magnitude available (Figures 33 and 34). For the two agglomerations the indicator values are very high, with some reservation even for public transport. In the two rural zoom-in regions the availability of jobs is comparable low, in particular if job seekers are dependent on public transport.

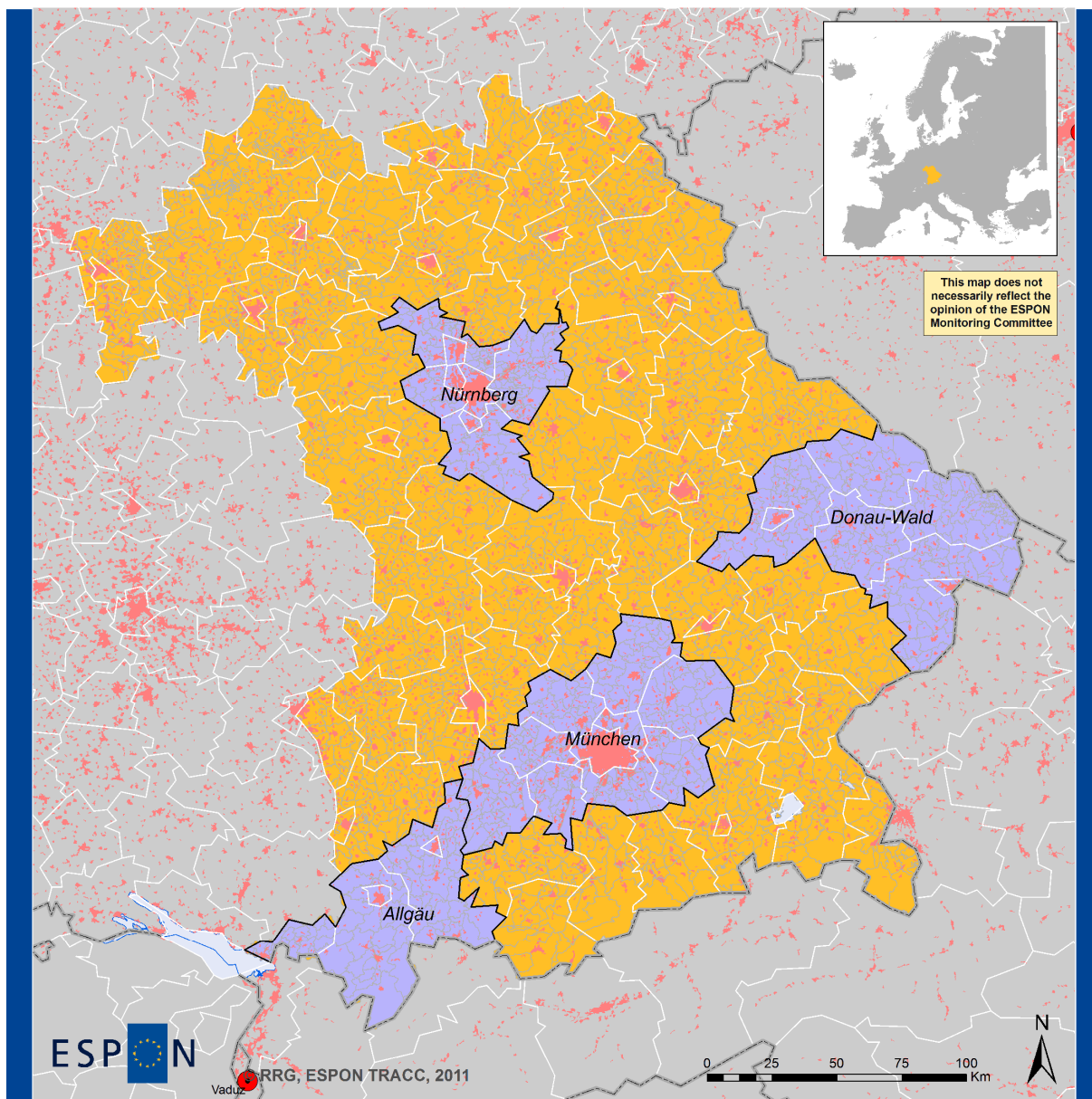
The potential accessibility to population is highest in the Munich region and goes clearly down to the rural regions of Allgäu and Donau-Wald (Figures 35 and 36). This ranking is valid for accessibility by car and by public transport.

A different picture emerges again when analysing travel times to next hospital (37 and 38). Average travel times are rather similar across the different zoom-in regions. Average car travel time to the next hospital is around 15 minutes, but slightly higher in Donau-Wald. Average public transport travel time is about 30 minutes, and again higher in Donau-Wald with almost 40 minutes.

Very distinct are the indicator values in the four zoom-in regions for the availability of higher secondary schools within 30 minutes of travel time (Figures 39 and 40). The average values by using car are 65 in Munich, 29 in Nuremberg, and about 5 in the two rural zoom-in regions of Allgäu and Donau-Wald. The average values by public transport are 20 in Munich, 9 in Nuremberg, and about 2 in the two rural regions. However, for most of the municipalities in the four zoom-in regions, in particular for those with lower population figures, the number of available schools within half an hour by public transport is much lower.

The indicator values of accessibility potential to medical doctors (Figures 41 and 42) follow the accessibility potential to population with regards to the ranking of the four zoom-in regions and with regards to the role of public transport in relation to car.

Aggregate results for the four zoom-in regions are presented in Table 1 and Table 2.



## Bavaria Case Study Macro region and zoom-in regions

- Macro-region: municipalities
- Zoom-in regions
- Capital city
- Settlement area
- NUTS-3 region boundary

Figure 30. Zoom-in regions

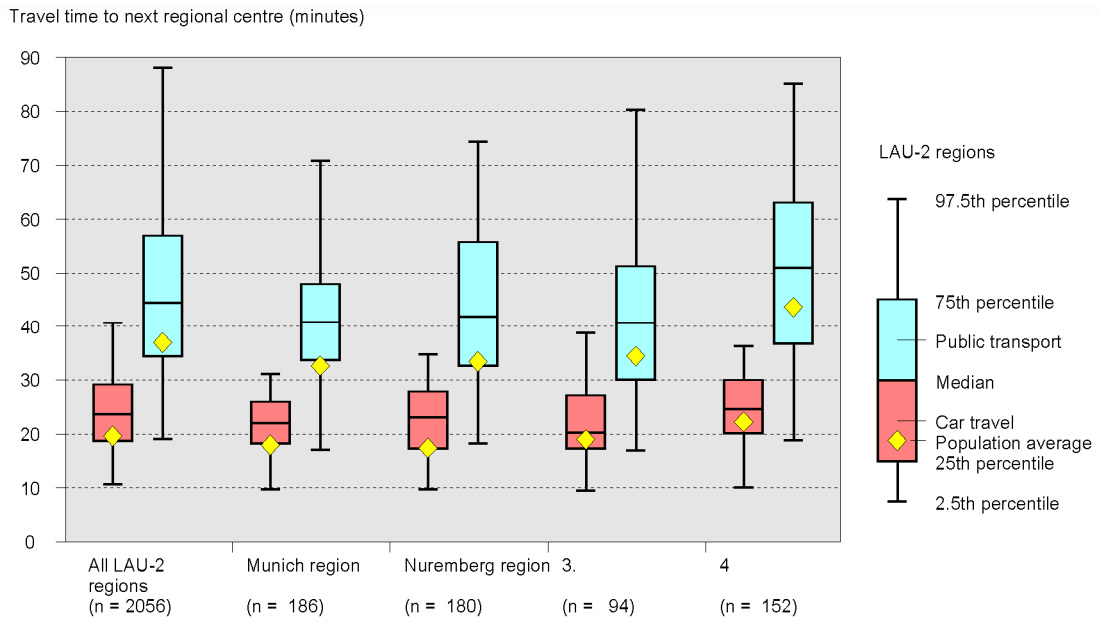


Figure 31. Travel time to next regional centre, by zoom-in region

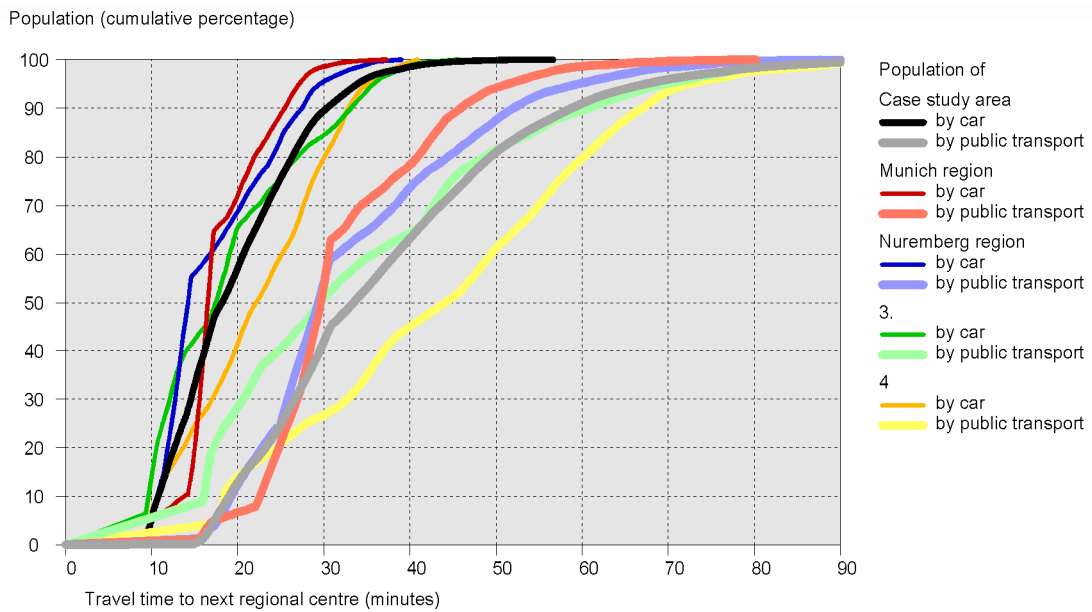


Figure 32. Travel time to next regional centre, cumulative distributions by zoom-in region

Jobs available within 60 minutes travel time (in 1,000)

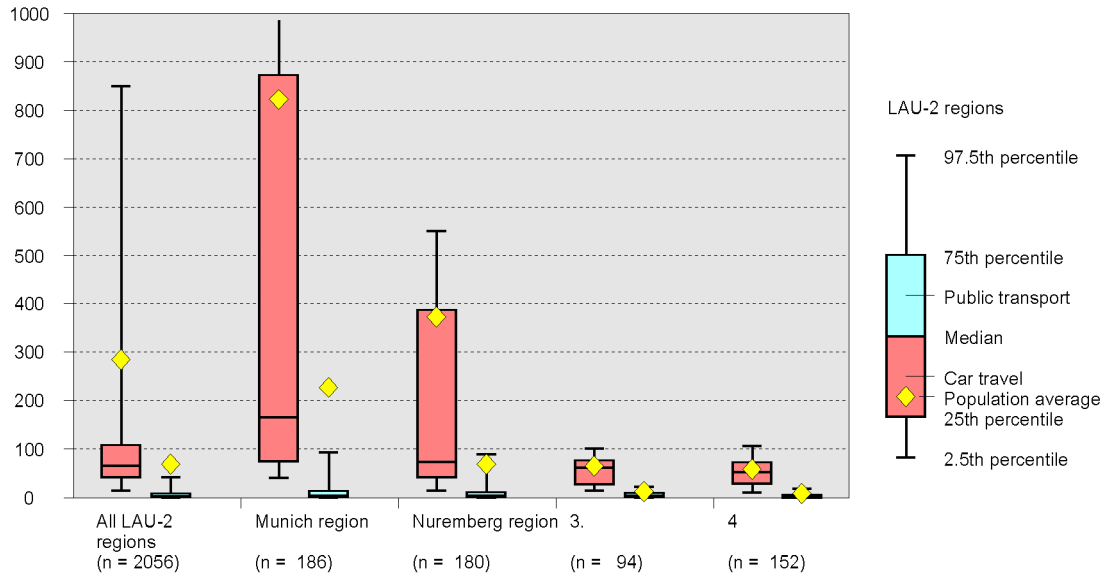


Figure 33. Jobs accessible within 60 minutes, by zoom-in region

Population (cumulative percentage)

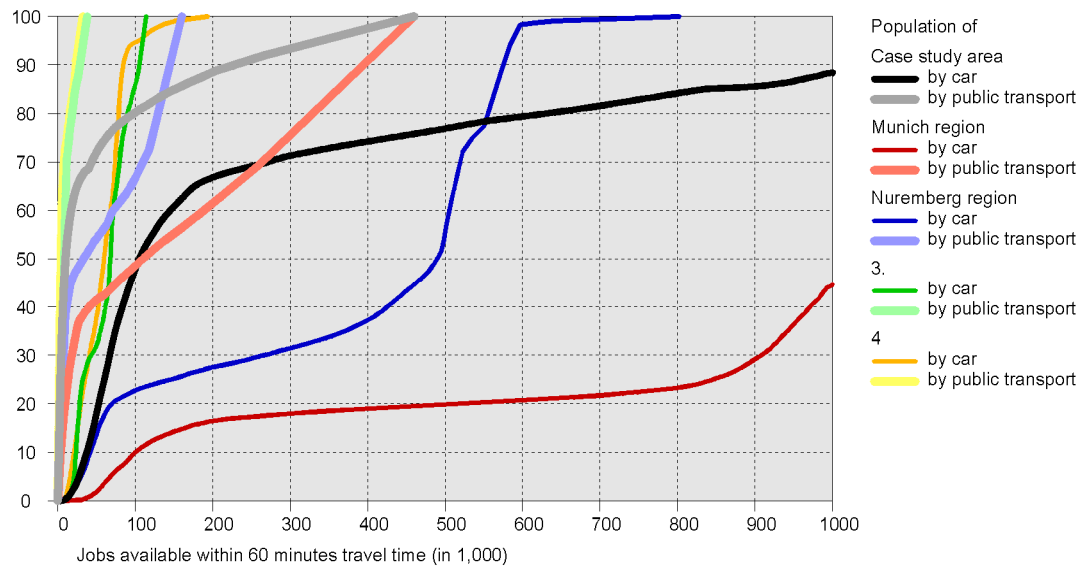


Figure 34. Jobs accessible within 60 minutes, cumulative distributions by zoom-in region

Potential accessibility to population (car average = 100)

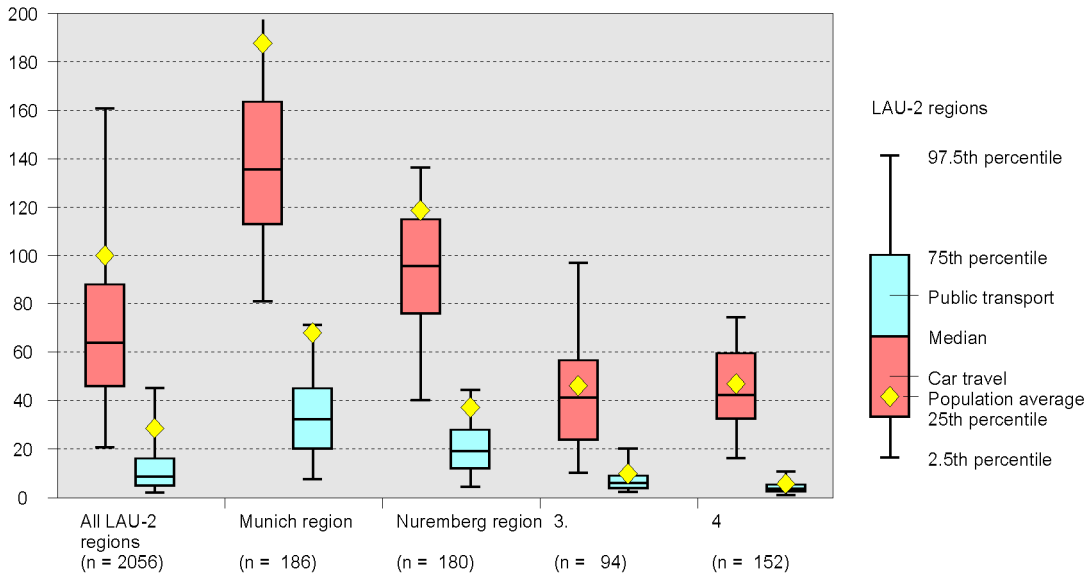


Figure 35. Potential accessibility to population, by zoom-in region

Population (cumulative percentage)

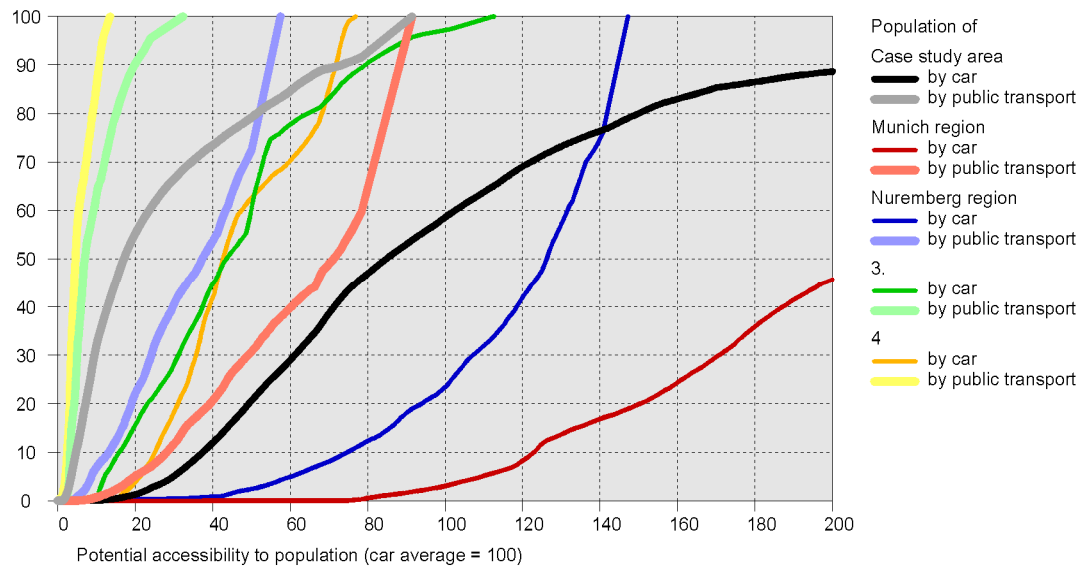


Figure 36. Potential accessibility to population, cumulative distributions by zoom-in region



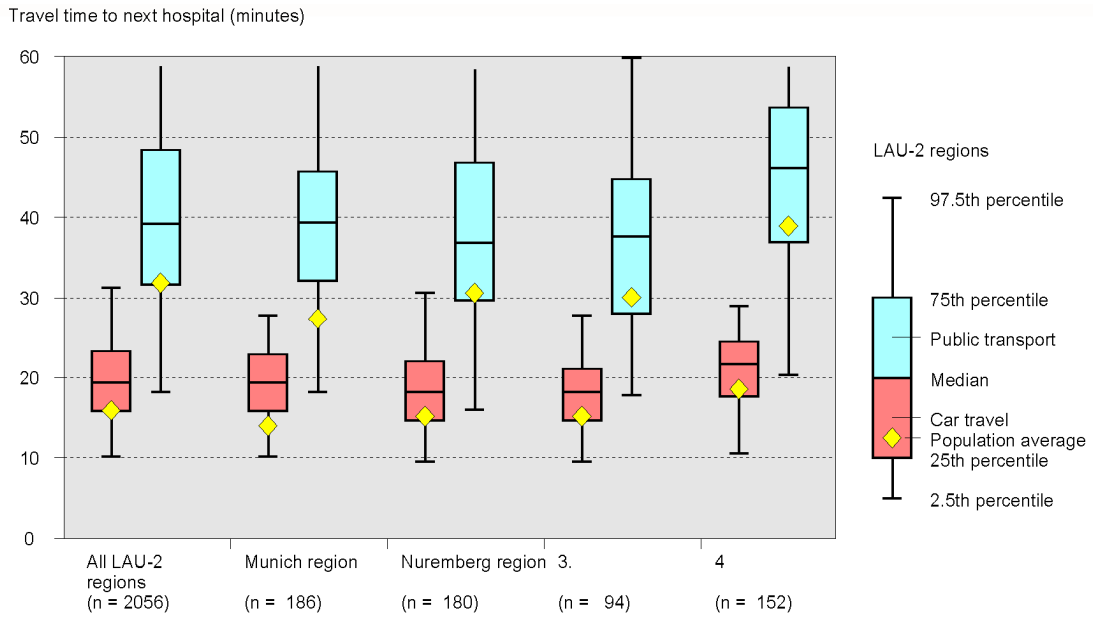


Figure 37. Travel time to next hospital, by zoom-in region

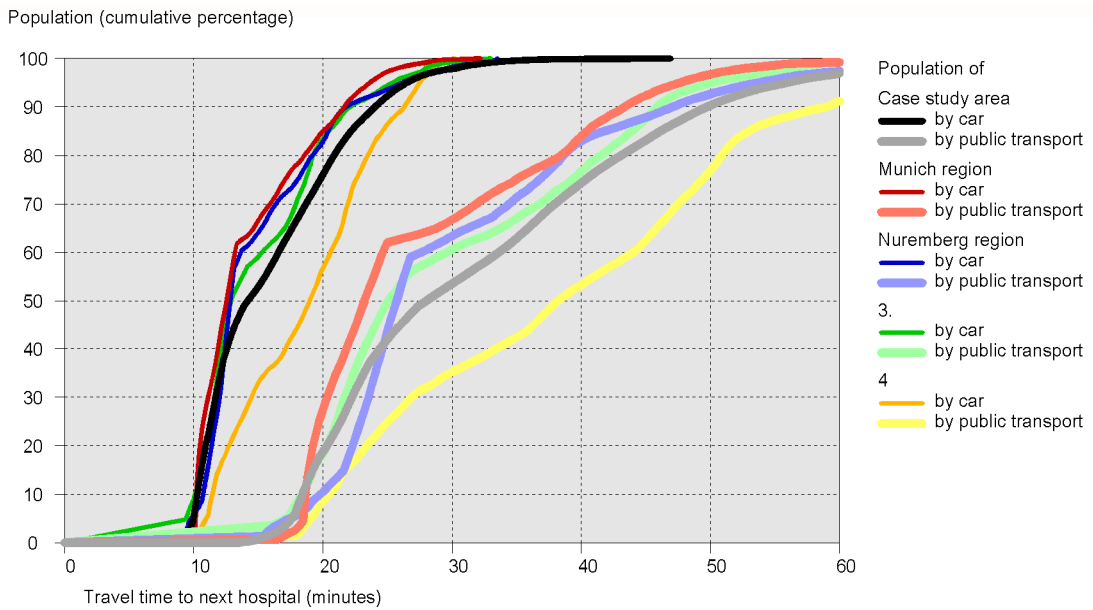


Figure 38. Travel time to next hospital, cumulative distributions by zoom-in region

Higher secondary schools available within 30 minutes travel time

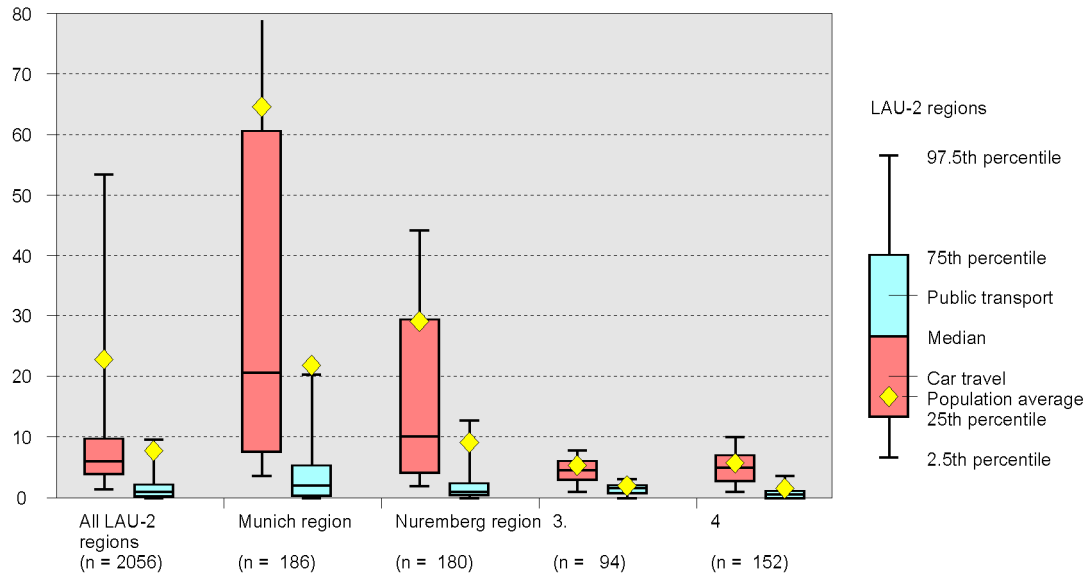


Figure 39. Higher secondary schools within 30 minutes travel time, by zoom-in region

Population (cumulative percentage)

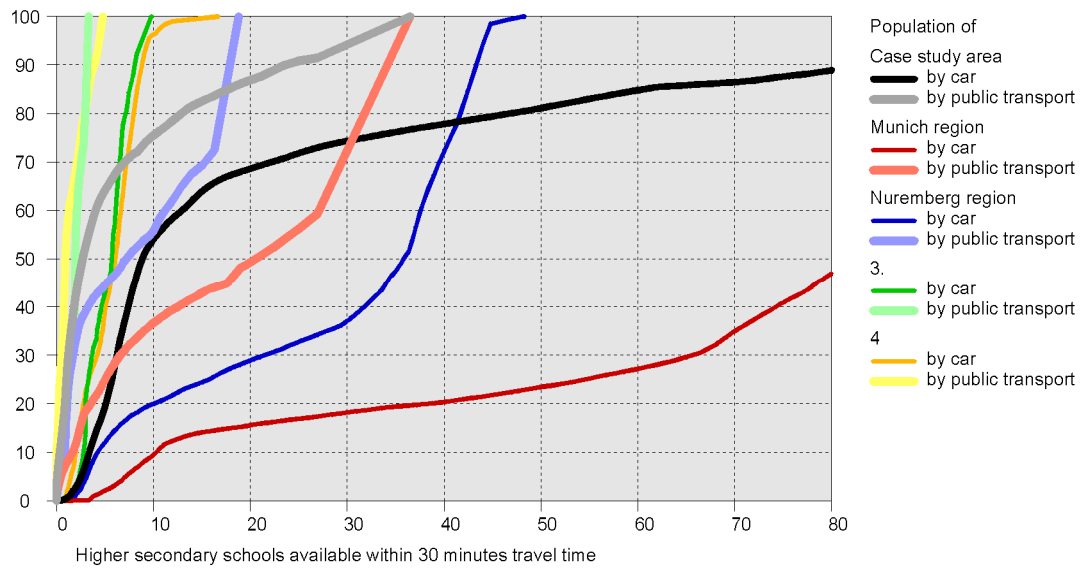


Figure 40. Higher secondary schools within 30 minutes travel time, cumulative distributions by zoom-in region

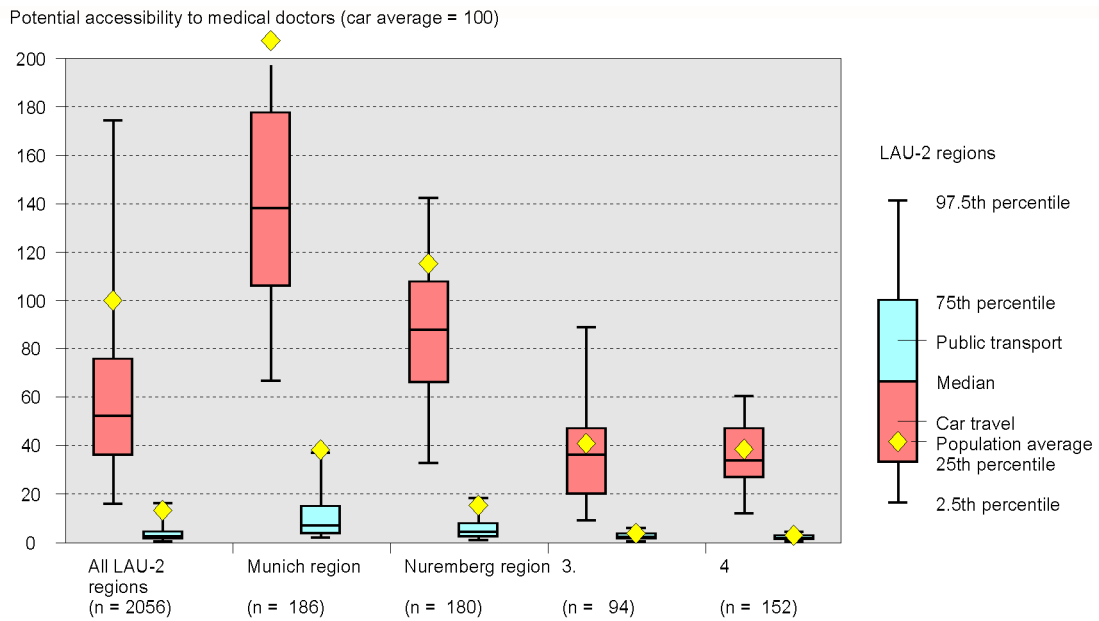


Figure 41. Potential accessibility to medical doctors, by zoom-in region

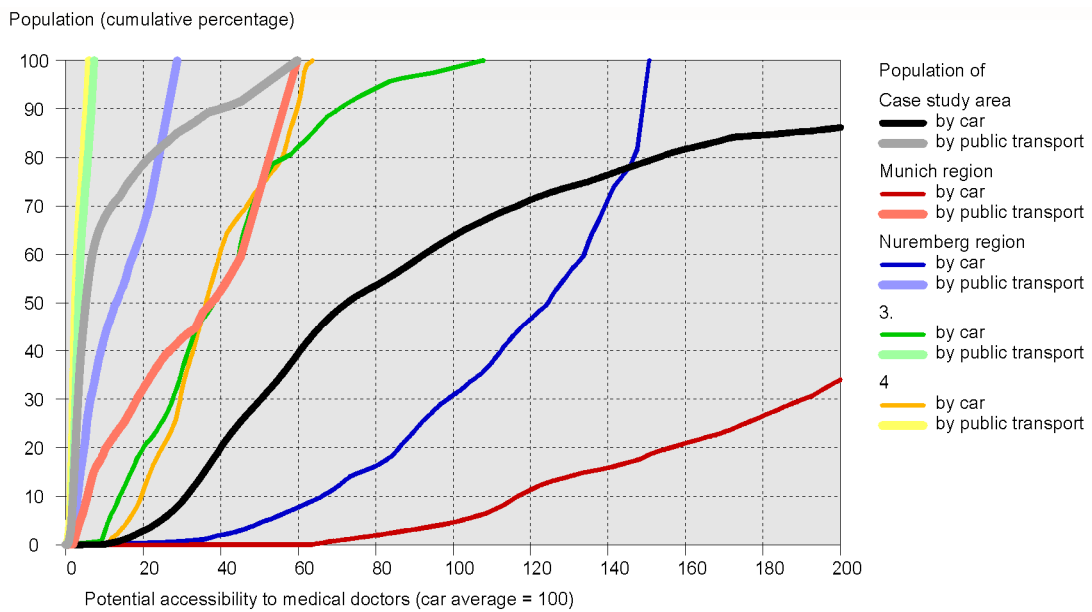


Figure 42. Potential accessibility to medical doctors, cumulative distributions by zoom-in region

Table 1. Accessibility by car, deviations of zoom-in regions from case study averages

| Area                     | Travel time to next regional centre |            | Jobs accessible within 60 minutes |            | Potential accessibility to population | Travel time to next hospital |            | Higher secondary schools within 60 minutes |            | Potential accessibility to medical doctors |
|--------------------------|-------------------------------------|------------|-----------------------------------|------------|---------------------------------------|------------------------------|------------|--|------------|--|
|                          | Minutes                             | Index      | In 1,000                          | Index      | Index                                 | Minutes                      | Index      | Number                                     | Index      | Index                                      |
| Munich region            | 17.9                                | 91         | 822                               | 289        | 188                                   | 14.0                         | 88         | 65   | 283        | 219  |
| Nuremberg region         | 17.4                                | 87         | 372                               | 131        | 119                                   | 15.1                         | 95         | 29   | 171        | 115  |
| Allgäu region            | 19.0                                | 96         | 65                                | 23         | 46                                    | 15.2                         | 96         | 5  | 23         | 41   |
| Donau-Wald region        | 22.3                                | 113        | 58                                | 21         | 47                                    | 18.5                         | 116        | 6  | 25         | 39   |
| <b>Case study region</b> | <b>19.6</b>                         | <b>100</b> | <b>284</b>                        | <b>100</b> | <b>100</b>                            | <b>15.9</b>                  | <b>100</b> | <b>23</b>                                  | <b>100</b> | <b>100</b>                                 |

Table 2. Accessibility by public transport, deviations of zoom-in regions from case study averages

| Area                     | Travel time to next regional centre |            | Jobs accessible within 60 minutes |            | Potential accessibility to population | Travel time to next hospital |            | Higher secondary schools within 60 minutes |            | Potential accessibility to medical doctors |
|--------------------------|-------------------------------------|------------|-----------------------------------|------------|---------------------------------------|------------------------------|------------|--|------------|--|
|                          | Minutes                             | Index      | In 1,000                          | Index      | Index                                 | Minutes                      | Index      | Number                                     | Index      | Index                                      |
| Munich region            | 32.7                                | 88         | 227                               | 331        | 237                                   | 27.4                         | 88         | 22   | 283        | 288  |
| Nuremberg region         | 33.5                                | 91         | 69                                | 101        | 130                                   | 30.6                         | 98         | 9  | 118        | 116  |
| Allgäu region            | 34.4                                | 93         | 12                                | 18         | 35                                    | 30.1                         | 96         | 2  | 26         | 29   |
| Donau-Wald region        | 43.7                                | 118        | 9                                 | 12         | 20                                    | 39.0                         | 125        | 2  | 19         | 23   |
| <b>Case study region</b> | <b>36.9</b>                         | <b>100</b> | <b>69</b>                         | <b>100</b> | <b>100</b>                            | <b>31.2</b>                  | <b>100</b> | <b>8</b>                                   | <b>100</b> | <b>100</b>                                 |

## 5 Conclusions

The spatial differentiation of a case study region such as Bavaria from an accessibility point of view is very much depending on the type of destination opportunity under consideration. Accessibility of opportunities of basic needs seems to be rather balanced. However, accessibility of higher level services such as hospitals is less even distributed across the region. For such facilities, there are only some hundred locations in Bavaria and those are primarily located in cities that have a higher position in the city hierarchy. Between those central places there are often wide areas with a clearly lower accessibility situation. This is especially pronounced when talking about accessibility by public transport.

However, the spatial or temporal proximity, i.e. accessibility, is not the only criterion when deciding about travel and destination decisions. Other features of the destinations such as quantity and quality of the possible supply, individual evaluations and preferences of the potential users often prevent from travelling to the next opportunity. However, the degree to which the population has a real choice in selecting opportunities to visit varies strongly between services fulfilling basic needs and such matching advanced demand. For opportunities matching basic needs, population mostly has different choices, even in rural parts of Bavaria. However, for opportunities serving higher demand there is a clear differentiation of the Bavarian territory. Whereas the municipalities in urban agglomerations, in particular the core cities, offer a high degree of freedom to choose a certain facility, this does not exist in rural areas. Here, sometimes population must be happy if there is an opportunity in reasonable reach at all.

Remarkable are the huge accessibility differences between car and public transport. This is in particular true if longer trips have to be made to reach the destinations of interest. On average, public transport travel time are twice as high as those for trips by car. This gap is even higher in rural areas.

It has to be taken into consideration that the accessibility analysis presented here briefly is a snapshot of the current situation. Accessibility is not static, but varies over time. Demographic change, economic pressure, political decisions and individual choices change the overall situation. In particular, the expected closure and concentration of several facilities of services of general interest such as schools or hospitals will have a negative influence on accessibility situation of the population, in particular of the population living in rural and remote municipalities. This leads to the conclusion that in future an integrated planning of locations of services of general interest, of public transport services, of new residential areas is decisive in order to guarantee a minimum level of accessibility also for rural areas.

## **Annexes**

### **Annex 1 References**

Schürmann, C., Spiekermann, K. (2010): Erreichbarkeit ausgewählter zentralörtlicher Einrichtungen in Bayern. Studie für das Bayerische Staatsministerium für Wirtschaft, Infrastruktur, Verkehr und Technologie (StMWIVT), Abteilung Landesentwicklung. Dortmund und Oldenburg i.H.: S&W and RRG.

### **Annex 2 Database**

The network database matches the detailed spatial representation of the region in the accessibility model (see Annex 3). Modes addressed are road and public transport. The road network includes all roads of the region including all residential streets. The public transport network is derived from digital public transport time table information. It covers all public transport services in Bavaria including all rail, underground, tram and bus services.

### **Annex 3 Accessibility model used**

The accessibility model was set up for the entire macro region of Bavaria in a previous study (Schürmann and Spiekermann, 2010). The main characteristic of the model is its spatial detail. The accessibility model includes a raster cell representation of Bavaria. The region is subdivided into some 7 million raster cells each of 1 ha in size. The population is allocated to the raster cells by appropriate disaggregation techniques. This means that starting from municipality population figures, each person has got an “address” in form of a raster cell in a microsimulation exercise. The disaggregation is controlled by information on land use type, building footprint- The result of the disaggregation is a raster representation of the population in which for each raster cell the number of inhabitants and their age are known. This synthetic population at raster cells constitute the origins of the accessibility modelling.

To calculate travel time between the origins, i.e. population at raster cell level, a minimum path algorithm is applied. The travel time is a approximation of door-to-door travel time. Car travel time include a time at the beginning to get the car started, the time across the network and a time at the end to place the car. Public transport travel time include walking time to the public transport stop, waiting time, travel time with public transport including any waiting and transfer time, and a walking time from the last stop to the final destination.

The accessibility model for the Bavarian macro region was used to compute the variety of accessibility indicators. Results can be presented for the raster level and can be aggregated to municipalities and presented at that level as it is done for this report. Aggregation from raster cells to municipalities is done population-weighted.

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