

Quiet areas in Europe

The environment unaffected by noise pollution

ISSN 1977-8449



Quiet areas in Europe

The environment unaffected by noise pollution



Cover design: EEA
Cover photo: © Leyla Emektar, Picture2050/EEA
Small photos: © Colin Nugent
Layout: Pia Schmidt

Legal notice

The contents of this publication do not necessarily reflect the official opinions of the European Commission or other institutions of the European Union. Neither the European Environment Agency nor any person or company acting on behalf of the Agency is responsible for the use that may be made of the information contained in this report.

Copyright notice

© European Environment Agency, 2016
Reproduction is authorised provided the source is acknowledged.

More information on the European Union is available on the Internet (<http://europa.eu>).

Luxembourg: Publications Office of the European Union, 2016

ISBN 978-92-9213-745-8
ISSN 1977-8449
doi:10.2800/7586

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: +45 33 36 71 00
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

Contents

Executive summary	5
1 Introduction	6
1.1 The policy context for quiet areas.....	8
1.2 The impact of noise in Europe.....	10
1.3 The benefits of quiet areas	10
1.4 Contents of this report	11
2 Methodological approach	12
2.1 Identifying quiet.....	12
2.2 The Quietness Suitability Index (QSI).....	12
2.3 Accessibility of quiet areas in open country	14
3 Quiet areas in Europe	17
3.1 The European overview.....	17
3.2 Accessing quiet areas in Europe.....	21
3.3 Potential quiet, protected areas and green infrastructure.....	22
4 Management, good practice and policy	25
4.1 Implementation at national level	25
5 Conclusion	29
References	30
Annex 1 Quietness Suitability Index by country	33
Annex 2 Overview of the QSI calculation methodology	66
Annex 3 Overview of the methodology applied to the calculation of accessibility	73

Acknowledgements

This report has been written by the European Environment Agency (EEA) and the European Topic Centre on Air pollution and Climate Change Mitigation (ETC-ACM).

The authors are Colin Nugent (EEA), Núria Blanes, Jaume Fons and Miquel Sáinz de la Maza (ETC-ACM).

Additional review has been provided by Martin Adams and Paul McAleavey (EEA), Roman Ortner, Annemarie van Beek and Frank de Leeuw (ETC/ACM).



Photo: © Pawel Kazmierczyk

Executive summary

This report explores to what extent Europe's rural environment can be considered as healthy and undisturbed by noise pollution. Noise pollution is a significant problem for Europe's environment, particularly from long-term exposure to noise from transport and industry, which can damage human health and adversely affect ecosystems. The Environmental Noise Directive (END) aims to reduce noise pollution while also highlighting the need to preserve quiet areas. These quiet areas may be found not only in rural areas but also inside some of Europe's busiest cities. The END defines a quiet area in open country as an area, defined by the respective local or national authority, that is largely undisturbed by noise from traffic, industry or recreational activities.

This report builds upon the 'Good practice guide on quiet areas' (GPG), published by the European Environment Agency (EEA) in 2014. In that report, the EEA Expert Panel on Noise (EPoN) presented options that may be considered by competent authorities when designating and protecting quiet areas. The GPG concluded that the issue of quiet areas remained under development, and while many examples of interesting work to protect quiet could be found in urban areas, fewer examples were found in rural areas. The report recommended that quiet areas in agglomerations may require different selection and protection criteria than quiet areas situated in open country. In particular, it was considered that no single set of criteria could be set for all quiet areas and that issues such as accessibility and the benefit to biodiversity need to be considered. The GPG also introduced a methodology assessing potential quiet areas outside urban areas, the Quietness Suitability Index (QSI).

In this second report on quiet areas, the QSI has been elaborated and combined with END-related data to present a quietness index for Europe as a whole and for individual EEA member countries. Progress in

dealing with quiet areas is also reported by analysing country responses to an Eionet survey conducted in conjunction with this report. This report, therefore, provides a first assessment of the potential quiet areas in Europe's open country. The key messages it delivers are:

- noise pollution has a major impact on human health and the environment in Europe;
- protecting areas that are not yet affected by noise can bring significant environmental health benefits;
- outside cities, approximately 18 % of Europe can be considered quiet, but 33 % remain potentially adversely affected by noise pollution;
- the distribution of quiet areas in Europe is strongly related to population density and transport;
- other factors such as elevation, distance from the coast and land use greatly influence the presence of human activity and, therefore, noise;
- for protecting wildlife and human health, accessibility to quiet areas is important;
- accessibility to potential quiet areas varies across Europe and reflects different settlement patterns;
- almost 27 % of Europe's protected Natura 2000 sites are havens of quiet;
- conversely, nearly 20 % of protected areas are potentially adversely affected by noise pollution;
- although some actions have been taken to protect quiet areas in open country, there remains much that could be done to reduce noise pollution and help to protect human health and biodiversity.

1 Introduction

This report by the European Environment Agency (EEA) presents a first spatial assessment of those areas in Europe that are potentially unaffected by noise pollution brought about by human activity. The basis for the report are data reported to the EEA by its member and cooperating countries. These data relate mainly to noise sources and exposure information as prescribed by European Union (EU) Directive 2002/49/EC (EU, 2002) relating to the assessment and management of environmental noise, more commonly referred to as the Environmental Noise Directive (END). In addition, information reported to the EEA regarding industrial activity, urban areas, land use and areas specially protected for the benefit of nature has been used in this assessment. Collectively, the analysis provides a picture of not only the extent of the noise impact in Europe, but also where noise pollution has not yet made an impact and, therefore, which areas might be considered for protection, especially those quiet areas in open country.

In order to understand the concept of quietness and its potential benefits, it is helpful to look more closely at what is known about noise and the drivers behind tackling this form of pollution.

The World Health Organization (WHO) has defined 'environmental' noise as noise emitted by all sources apart from in the workplace. It also prescribes a guideline value for avoiding moderate annoyance during the daytime and evening periods in outdoor living environments, namely 50 dB $L_{Aeq\ 16hour}$ (WHO, 1999). For night periods, the WHO recommended guideline level for Europe is 40 dB $L_{night-outside}$.

European legislation offers a more specific definition for noise. The END considers environmental noise as unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, road traffic, rail traffic and air traffic and

Table 1.1 Potential selection criteria for quiet areas

Type	Indicator	Range criteria Urban (dB)	Range criteria Open country (dB)
Acoustic indicators	$L_{eq\ (24hour)}$	40	25–45
	L_{den}	50–55	–
	L_{50}	–	35–45
	L_{90}	–	30
	L_{95}	30	–
	L_{day}	45–55	30–40
Functional	Recreation	Moderate intensive activity	Passive activity
	Nature protection	Moderate	Priority
	Health protection/restoration	Health protection	Restoration priority
Distance	From motorway	–	4–15 km
	From agglomeration	–	1–4 km
Soundscape	Perceived acoustic quality/appreciation	–	–
Size	–	100–100 000 m ²	0.1–100 km ²
Visual	Areas with established values in official documents, e.g. land use plans or nature conservation plans	–	–

Source: EEA, 2014a.

from sites of industrial activity. The thresholds for noise mapping and action planning as required by the END are 55 dB L_{den} (day, evening and night periods) and 50 dB L_{night} .

Where quiet areas is concerned, the END defines a quiet area in open country as one delimited by

the competent authority that is undisturbed by noise from traffic, industry or recreational activities. Analysis of current practice shows that approaches, methods and indicators used to identify quiet areas vary widely, as do the physical and effect-oriented definitions or selection criteria, which are illustrated in Table 1.1.

Box 1.1 Calm or quiet: guidance from the EEA Expert Panel on Noise (EPoN)

The 'Good practice guide on quiet areas' sought to place the notion of quiet areas into a practical context:

Context

The designation 'quiet' may accidentally lead to the assumption that a quiet area is an area with a very low noise level. In urban situations noise levels below 45 dB L_{day} or 40 dB L_{night} are hardly ever found.

Quiet would not be the right designation for the general public. Absolute silence tends to frighten most people. Therefore, we are not searching for silence, we are searching for relaxation. Most people feel the need to compensate their busy, noisy city life with an occasional or more regular calm and relaxing day. So, instead of searching for quiet, we should be searching for calm. Defining a quiet area only by the noise level is therefore not adequate. Below is a list of alternative criteria that can be used to identify and qualify quiet urban areas. As a start, the designation 'calm area' or 'tranquil area' would fit more closely to what the public experiences.

Definitions

The best definition for a calm area is that it is an area where noise, i.e. unwanted sound, is absent or at least not dominant. Note that there are no noise level figures whatsoever in this definition. Nevertheless, the residents would understand this definition and would be able to indicate areas in their neighbourhood or in their town which would be a candidate for calm areas.

Such areas could be found in towns in parks, within building blocks, in courtyards, in gardens, in leisure areas etc. In rural areas they could coincide with natural parks or protected areas, but they may also be part of an agricultural area or unused land outside the city.

Effects

There is only marginal evidence that calm really compensates the negative effects from too much noise. We do not really know for certain, that staying in a calm environment is good for our health. What we do know is that most people value a calm environment from time to time, for relaxation, for rest, for peace of mind. Then maybe we should not bother too much about the quantitative health effects to be achieved, but instead we should offer people the opportunity to find calm, possibly in the vicinity of their homes, or else inside their homes, in the suburbs, on extensively used leisure areas, or out in the country.

Practical guidelines

Calm areas need to be identified, designated and protected. But this is not necessarily a legislative action nor necessarily a task for the authorities. Once people are made aware of the significance of calm, they should be able to point at calm areas or calm spots near their homes. They will probably be more than happy to engage in an 'official' designation of these spots as calm areas, areas intended for relaxation, possibly with some restrictions. In a calm area there is room to play an occasional game of football, there is room to talk and listen to music, as long as it is not too loud or as long as it is restricted to certain previously designated periods for loud activities. A task for the authorities would be to keep the noise from the major sources away from the calm areas. This would apply to busy roads, railway lines, industrial activities, etc. All the rest could be regulated by the residents themselves, who would be motivated to take the responsibility for the calm area.

Source: EEA, 2014a.

It is considered that defining a quiet area according to decibel levels alone is not an adequate approach to designating or protecting quiet areas in the context of the END (EEA, 2014a).

1.1 The policy context for quiet areas

The END has a clearly stated aim: to 'define a common approach intended to avoid, prevent or reduce on a prioritized basis the harmful effects, including annoyance, due to exposure to environmental noise'. Thus, the END acknowledges the need for preventing or reducing environmental noise levels that may negatively affect human health, including annoyance and sleep disturbance. In addition, it highlights the need to preserve 'environmental noise quality where it is good', as well as to preserve quiet areas, primarily in agglomerations.

The foundation for preserving these quiet areas was laid out in the Green Paper on Future Noise Policy (EC, 1996), which highlighted that by mapping environmental noise it became easier to recognise where there was exposure to high levels of environmental noise. Not only that, but noise maps

could thereby identify areas where action is required to reduce noise, and so too identify quiet areas where exposure to noise should not be permitted to increase.

The END defines quiet areas, both inside and outside agglomerations, as follows:

A quiet area in an agglomeration shall mean an area, delimited by the competent authority, for instance which is not exposed to a value of L_{den} or of another appropriate noise indicator greater than a certain value set by the Member State, from any noise source.

A quiet area in open country shall mean an area, delimited by the competent authority, that is undisturbed by noise from traffic, industry or recreational activities.

With regard to action plans, the END states that such plans for agglomerations shall also aim to protect quiet areas against an increase in noise. This is followed up by the requirement to report on actions or measures that the competent authorities intend to take to preserve quiet areas. Actions may include

Box 1.2 The Environmental Noise Directive (END)

Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise has the aim of defining a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to exposure to environmental noise. To that end, the following actions are required:

- the determination of exposure to environmental noise, through noise mapping, by methods of assessment common to the Member States;
- ensuring that information on environmental noise and its effects is made available to the public;
- adoption of action plans by the Member States, based upon noise mapping results, with a view to preventing and reducing environmental noise where necessary and particularly where exposure levels can induce harmful effects on human health and to preserving environmental noise quality where it is good.

This shall apply to environmental noise to which humans are exposed, in particular in built-up areas, in public parks or other quiet areas in an agglomeration, in quiet areas in open country, and near schools, hospitals and other noise-sensitive buildings and areas.

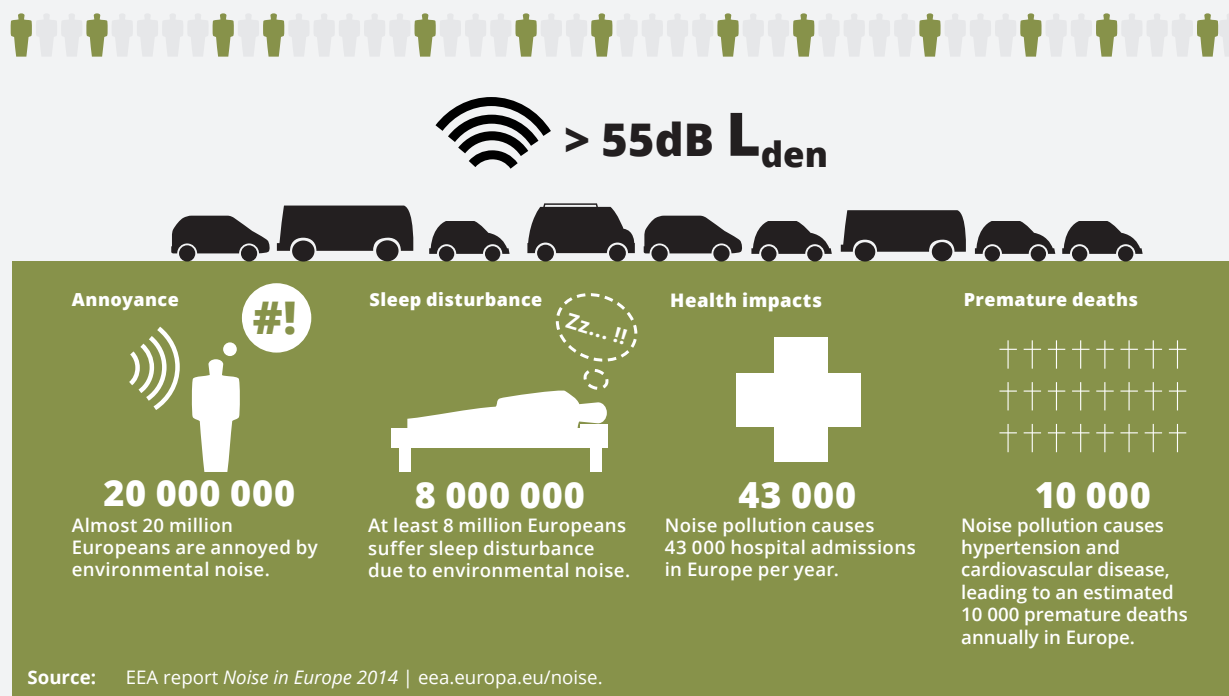
The major transport sources addressed are roads with more than 3 million vehicles per year, railways with more than 30 000 trains per year and airports with more than 50 000 air traffic movements per year.

Agglomerations are territories delimited by the Member State that have a population in excess of 100 000 persons and a population density such that it is considered an urban area. Strategic noise maps for agglomerations shall put a special emphasis on the noise emitted by road and rail traffic, airports and industry, including ports. The requirements for noise mapping and action planning recur every 5 years, with the first round of mapping implemented in 2007, then again in 2012; they are expected to be reported for a third round by 30 December 2017.

Box 1.3 Noise pollution in Europe**Noise pollution in Europe**

Noise pollution is a growing environmental concern caused by a varied number of sources. The adverse effects of noise pollution can be found in the well-being of exposed human populations, in the health and distribution of wildlife, as well as in the abilities of our children to learn at school.

Noise levels from road traffic that are greater than 55 dB L_{den} affect an estimated **125 million people** — **one in four Europeans**.



The EEA's first assessment of noise exposure and impacts in Europe, the 'Noise in Europe 2014' report (EEA, 2014b), was based upon all data related to noise mapping reported to the EEA by its member and cooperating countries up to 28 August 2013. Some of the key findings of that report are presented in the above graphic, while more recently reported data may be accessed by visiting the Noise Observation & Information Service for Europe (EEA, 2016).

land-use planning, systems engineering for traffic, and planning and noise control of sources. The END does not specify any requirements for the protection of quiet areas in open country. It does, however, state that the 5-yearly review of implementation of the END undertaken by the Commission shall assess the need for further Community actions on environmental noise and, if appropriate, propose implementing strategies on aspects such as the protection of quiet areas in open country.

In the 2011 review of the implementation of the END, the European Commission identified that many EU Member States had highlighted the absence of any guidance on

dealing with quiet areas, which was one area where technical improvement could be made (EC, 2011).

In a report published in 2012, the European Parliament made recommendations for the development of a more comprehensive noise strategy for the EU. The vague definition of quiet areas by the END was highlighted as leaving ample discretion for interpretation to Member States, which led to some confusion and divergence in the approaches taken in the protection of quiet areas (EU, 2012). Soon after, the EEA published the 'Good practice guide on quiet areas' (GPG), which sought to offer assistance to competent authorities in the process of identifying and managing quiet areas (EEA, 2014a).

1.2 The impact of noise in Europe

1.2.1 Human health

Environmental pollution by noise has long been regarded as having a direct effect on quality of life and well-being. Its emergence as a major public health issue was highlighted by the quantification of healthy life years lost in Europe as reported by the WHO and EC-JRC report *Burden of Disease from Environmental Noise* published in 2011. Therein, noise from road traffic alone was described as causing at least 1 million healthy life years to be lost every year in Western Europe. Furthermore, the WHO categorised noise as the second worst environmental cause of ill health in Europe, behind only ambient air pollution (WHO, 2011).

The harmful effects of noise pollution on humans include annoyance and sleep disturbance, which in turn can result in negative health end points such as hypertension, heart disease, mental health disorders and cognitive impairment (EEA, 2010). In publishing its first European impact assessment for environmental noise, the EEA estimated that at least one in four European citizens is exposed to noise from road traffic above the END threshold of 55 dB $L_{den,r}$, a total of more than 125 million people. In terms of sleep disturbance, it is estimated that at least 8 million people are affected, while at least 43 000 hospitalisations per year could be attributed to noise. Ultimately, it is expected that these effects result in over 10 000 premature deaths every year due to noise.

Furthermore, the EEA estimates that the reading ability of at least 8 000 children aged between 8 and 17 years is adversely affected by noise from aircraft operations near airports (EEA, 2014b).

This estimation was based upon information provided to the EEA by its member countries up to 28 August 2013 and is only partially complete in terms of END requirements. The scale of the impacts is, therefore, likely to be much more severe than estimated (EEA, 2014b).

This does illustrate the dominance of transport noise where detrimental health effects are concerned, but it has also been observed that other sources have been identified as emerging risks, particularly in rural environments. For such areas that are affected by noise, the proportion of people highly annoyed is greater than that for noisy urban areas. This suggests that unnatural sound, such as that from wind turbines, is more annoying in the context of rural areas and perhaps masks other, more beneficial, natural sounds (Shepherd et al., 2013).

1.2.2 Biodiversity

There is also increasing scientific evidence regarding the harmful effects of anthropogenic noise upon wildlife. In nature, many species rely upon acoustic communication for important aspects of life, such as finding food or locating a mate. Noise pollution can potentially interfere with these functions and, therefore, adversely affect species richness, reproductive success, population size and distribution. It is also known that interference from man-made noise can directly affect behaviour in certain species (Dutilleul, 2012).

1.3 The benefits of quiet areas

1.3.1 Health benefits

As the knowledge of the damaging effects of noise are well established, so too is the positive influence a lack of noise has on human health and well-being. People living in quiet areas suffer fewer of the negative health effects commonly associated with those exposed to sound levels experienced in an average urban environment. Quiet areas benefit not only the health and well-being of residents, but also that of regular visitors, such as those visiting a national park or nature reserve (EEA, 2014a).

Where direct comparative studies have been made of both quiet and noisy urban and rural areas, it is found that quality of life increases as noise levels decrease — health-related quality of life is highest in quiet rural locations (Shepherd et al., 2013).

Similarly, access to the quiet facade of a building (e.g. less than 45 dB $L_{Aeq,24hour}$) reduces annoyance in the resident population. In addition, easily accessible quiet areas near to noisy areas seem to reduce annoyance levels. In fact, it is the criterion of 'accessibility' that seems to improve well-being (Öhrström et al., 2006; Gidlöf-Gunnarsson and Öhrström, 2007).

The restorative benefits of quietness have also been observed. People who have suffered from illness recover faster in natural surroundings, an effect that seems applicable to quietness and natural sounds as well (Ulrich, 1984; Kaplan, 1995; Alvarsson et al., 2010).

The importance of soundscape type on well-being should not be underestimated. People are found to become finely attuned to the sounds that most disturb them, heightening their annoyance. In essence, pleasant sounds promote and annoying sounds impede health (Andringa and Lanser, 2013).

1.3.2 Biodiversity

The drive to protect quiet areas in policy domains such as the END presents a key opportunity to benefit biodiversity in Europe. Indeed, there remains a symbiotic interaction between quiet and biodiversity. Natural sounds are valued by visitors to natural areas, and these may serve as indicators of a low level of disturbance by traffic (EEA, 2014a).

With respect to limiting biodiversity loss, quiet areas are of benefit for several reasons. First, one of the major causes of biodiversity loss in Europe is habitat destruction and fragmentation (EEA, 2015). Quiet areas may contribute to green infrastructure by offering natural corridors without disturbing sound sources. In addition, a significant cause of wildlife mortality is collision with vehicles. Quiet areas designated and protected by, for example, synergy with the END may offer safer habitats for animals. In addition, the reduced interference with vital acoustic communication in quieter areas can benefit wildlife (Dutilleux, 2012).

1.3.3 Economic benefits

The high financial burden caused by noise pollution can mean that reducing its effects can bring significant monetary benefit, and this includes the preservation of quiet areas. In the United Kingdom, for example, it has been estimated that protecting the quiet areas of major cities in England could be valued at as much as GBP 1.4 billion per year to the economy (Defra, 2011).

The benefit of quiet areas can also be reflected in an increase in property prices. For instance, the direct

effect of lower sound pressure levels in an area has been estimated to be approximately 0.5 % of property prices per decibel (RIVM, 2007).

1.4 Contents of this report

This report presents an assessment of the areas in Europe likely to be free from the effects of man-made noise pollution. It applies only to rural areas outside cities and towns and is based upon noise maps and associated data that have been reported to the EEA by its member and cooperating countries by 10 June 2014. This includes END-related noise data for major roads, railways and airports. For major airports, it is worth noting that the data related to noise mapping are relevant only for take-off and landing movements at a relevant airport. Overflights are acknowledged as potentially important sources of noise, but are not included in this analysis.

Data concerning land use, industrial sites and urban extent have also been used. Concerning policy actions and management practice, the latest measures in place at country level have also been reviewed.

The following chapters outline the data sources in more detail and describe the methodology applied in order to arrive at the final assessment.

Although the objective of the analysis has been to make an assessment at European scale, the report also includes country-specific annexes, where data from each country have been used to estimate the extent of quiet areas. These results may inform the EEA member and cooperating countries in managing potentially quiet areas in the rural environment.

Box 1.2 Glossary of acoustical terminology

This report refers to many varied indicators that can be applied to the assessment of environmental noise. A brief and simplified explanation of those indicators is as follows:

L_{Aeq}	Equivalent continuous sound pressure level presented with A-weighting to account for the parameters of human hearing. A reference time interval is often added to this indicator, e.g. $L_{Aeq(24hour)}$.
L_{den}	Long-term average indicator designed to assess annoyance and defined by the END. It refers to an annual average day, evening and night period of exposure.
L_{night}	Long-term average indicator designed to assess sleep disturbance and defined by the END. It refers to an annual average night period of exposure.
dB	Shortened reference to the decibel, a unit of measurement for sound.

2 Methodological approach

2.1 Identifying quiet

The concept of quietness encompasses other factors beyond the sound-pressure levels in a defined area, namely human perceptions, visual interactions and the expectations of people when visiting an area. This includes the balance between wanted and unwanted sound and the area's recreational value, or how appropriate the sounds present are to the area and its use (EEA, 2014a).

Tranquillity may often be found in natural outdoor environments where man-made noise is at a low level, although natural sounds can be at a relatively high level. Factors that promote tranquillity are the presence of vegetation, low levels of man-made sounds and the dominance of natural sounds (Watts et al., 2013). Moreover, the concept of tranquillity is also influenced by visual intrusion of man-made structures and buildings into an otherwise perceived natural landscape (Watts et al., 2015).

One essential aspect in safeguarding existing, or developing new, 'tranquil space' is understanding the optimum relationship between the soundscape and the visual composition of a location (Pheasant et al., 2010). This research represents a first step in understanding the effects of audio-visual interaction on the perception of tranquillity and identifies how the interpretation of acoustic information is an integral part of this process.

Subjective references to quietness and its perception are widely referred to in the literature (Waugh et al., 2003; MacFarlane et al., 2004; Botteldooren and De Coensel, 2006). They are linked to environmental and socio-cultural factors, such as low population density, low intensity agriculture, environmental quality and landscape quality (i.e. non-visual intrusion of transport infrastructures, culturally valued landscapes and 'natural' landscapes). Public consultations have shown the subjective nature of quietness, with a different meaning for each person. However, there is a common element that arises continuously: quietness as related to nature (green elements, water, animals and wildlife, remoteness, panoramic views, weather, etc.) (Rendel, 2005; Cordeau and Gourlot, 2006; Pheasant et al., 2006).

Perception of the landscape, therefore, has been considered crucial to identifying potential quiet areas, meaning that the distance to the noise sources and the degree of naturalness of the landscape are both important factors to be taken into consideration.

2.2 The Quietness Suitability Index (QSI)

The identification of potential quiet areas in open country at European level proposed in this assessment follows two main premises: the results obtained should be applicable to all Europe, integrating the diversity of landscapes and existing situations and, at the same time, should be easy to understand and replicable at member country and local level.

Based on the multidimensional character of the notion of quietness, it can be defined according to objective criteria (noise levels), which are measured by quantitative data, but also according to a subjective component linked to perception. In this way, and beyond noise exposure, quietness is described in the Quietness Suitability Index or QSI (EEA, 2014a) as a combination of noise limit values (contour maps delivered under END requests) and land use and land cover elements that is perceived as positive and usually related to human cultural construction of naturalness.

The QSI is composed of two main elements:

- Noise disturbance as a result of distance to noise sources (objective criteria, quantitative data): threshold distances are determined considering noise levels determined by noise contours maps (END areas exposed to less than 55 dB L_{den}).
- The perceptive dimension of quietness by human beings (subjective criteria, qualitative data): this dimension is related to the importance given to natural elements and to landscape configuration. This dimension has been introduced in the QSI formula as a reclassification of the Corine Land Cover database based on the hemeroby index (Jalas, 1955; Blume and Sukopp, 1976).

To establish the distance values to the different noise sources, the noise contour maps for the main transport infrastructures and also the location of the major noise sources have been used as the main input information. These data have been provided by the Member States following the END requirements, accounting for main transport networks at European level and urban areas above 100 000 inhabitants.

The QSI is based on the thresholds specified in the END. Therefore, it has been assumed that, below the threshold specified in the END ($L_{den} < 55$ dB), the acoustic quality would be sufficient and, therefore, important to be preserved.

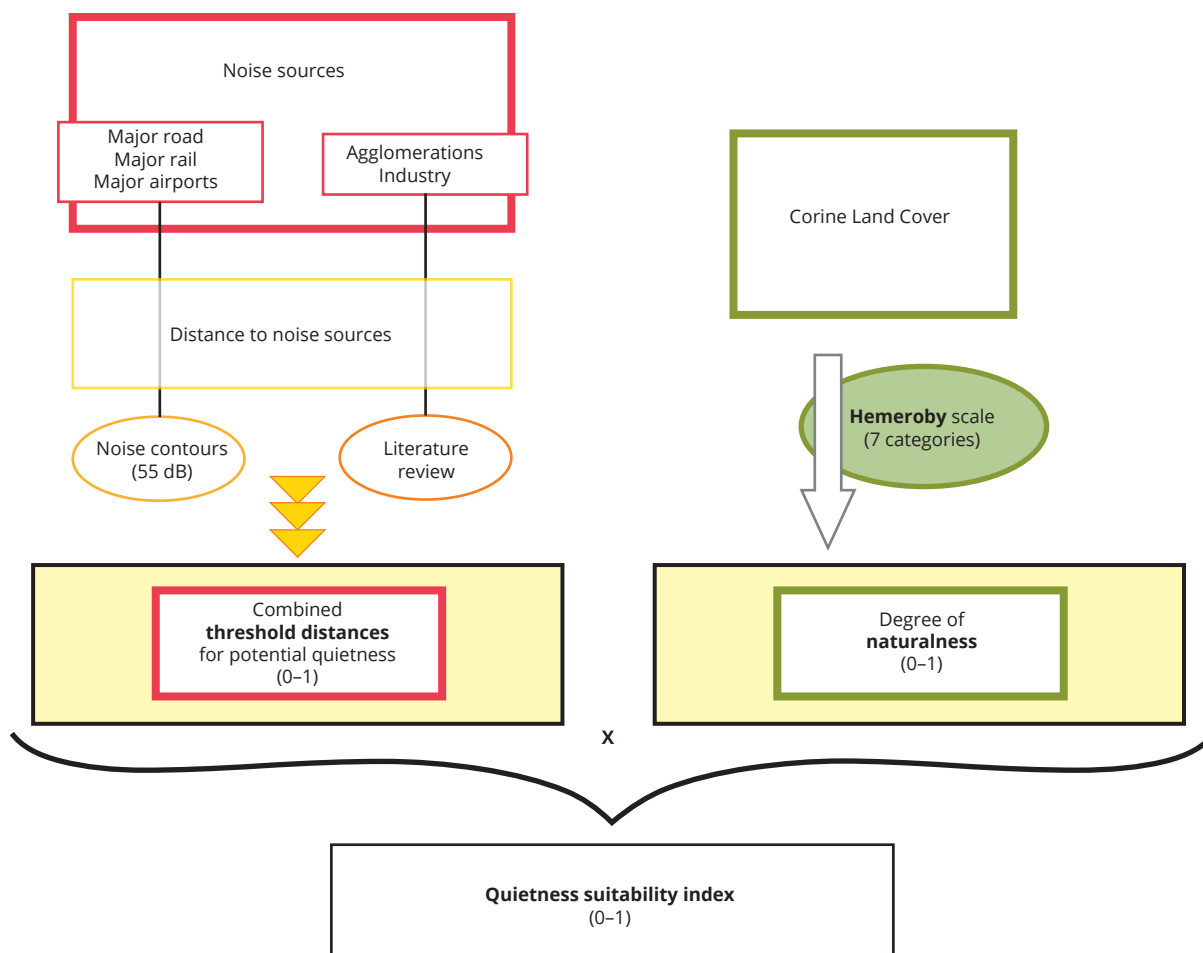
The threshold of 55 dB L_{den} is one of the main constraints of the current END data if the adaptation from Nilsson (2007) developed in the GPG is taken into account. With that consideration, the modelling of the relationship between sound-pressure levels and perceived acoustic quality of green areas gives

the value that 100 % of visitors perceived the acoustic quality as 'good' or 'very good' when the sound pressure level is lower than 40 dB. Visitors' perception of the quality of a place decreases with higher noise levels. For noise levels below or above 55 dB L_{den} , contour maps are used as input values for the calculation of the threshold distance map. This equates to the noise mapping and action planning threshold introduced by the END.

The END-defined threshold value of 55 dB L_{den} is that applied to noise contour maps as officially reported by Member States under the legal obligation. Therefore, that is the value used for the calculation of the threshold distance map as an input factor to the QSI.

Finally, since the data reported under the END do not directly cover the whole European territory, additional sources of information have been included in the calculation to obtain a threshold distance map that is more representative of Europe as a whole.

Figure 2.1 Methodological schema for the QSI



These other sources of information are:

- cities with more than 50 000 inhabitants
- secondary roads
- industrial sites outside urban areas
- all airports mapped in the Corine Land Cover database.

In order to cover the perception aspect in the QSI, the degree of naturalness derived from the hemeroby index has been used. This index is based on Corine Land Cover information and, therefore, it is available throughout all Europe. Areas where some human activities are developed (in some agricultural areas or managed forest) are rated with lower values in the hemeroby index than those areas without human activities. The reclassification table that displays which hemeroby index has been allocated to each Corine Land Cover class can be found in Annex 2.

The results obtained on the QSI range from 0 to 1, where 0 values are considered noisy areas and 1 values are considered potential quiet areas in open country. The values in between cover the whole range of situations in the European territory. QSI values above 0.5 are already considered high values of the index, covering areas such as forests or land principally occupied by agriculture, with significant areas of natural vegetation. The calculated index then provides certain flexibility in establishing thresholds for quietness (areas with values of 0.75 or 0.63 could also be considered quiet).

The elevation breakdown is used to allocate land cover changes into homogeneous areas as a function of height, slope and distance to the sea. It defines five relief typologies:

1. Low coasts: areas next to the sea (less than 10 km from the coastline) and less than 50 m above sea level.
2. High coasts: areas next to the sea (less than 10 km from the coastline) and more than 50 m above sea level.
3. Inlands: areas between 0 and 200 m outside the coastal strip.
4. Uplands: zones between 200 and 500 m above sea level plus the flat areas between 500 and 1 000 m above sea level.

5. Mountains: steep areas between 500 and 1 000 m above sea level and all the areas over 1 000 m above sea level.

One additional factor relevant to the definition of a quiet area is its size. This approach provides an average value for 1 km² cells. In this report, the size of patches has not been taken into consideration. In general, minimum size, when defined, is variable depending on the country and, very often, is related to other regulatory aspects of the Member State.

2.2.1 QSI analysis per reporting unit

In applying the QSI methodology to Europe, it is possible to identify where potential quiet areas are, the landscape characteristics that such areas exhibit and if regional patterns are evident in their distribution.

Such analysis may demonstrate that some countries have greater potential for designating quiet areas in open country than others. The competency for noise mapping, action planning and reporting data in accordance with the END lies with Member States. Therefore, the QSI data are also available for country level.

2.3 Accessibility of quiet areas in open country

It has been observed that the very fact of being able to access relatively quiet areas can lead to an increase in well-being; therefore, an analysis of the accessibility of Europe's potential quiet areas has been included in this assessment.

A network service area is a region that encompasses all streets and roads that can be accessed within a given distance or travel time from one or more urban areas. Service areas are commonly used to visualise and measure accessibility. The analysis is carried out by considering four different drive-time polygons around cities with more than 50 000 inhabitants and by determining which residents are able to reach the potentially quiet areas within 15, 30, 45 and 60 minute drive-times.

It is acknowledged that people may use a wide variety of transport methods to arrive at potentially quiet areas in open country, but, for the purposes of this assessment, road transport by car has been the method applied. Other types of transport (e.g. railway transport) could not be included in the analysis because of a lack of data available at European level.

One of the main difficulties for the implementation of this model for road transport is obtaining reliable sources of information regarding average car user speeds for Europe. Therefore, the maximum permissible speed on different road types has been applied in order to calculate the distance at which potential quiet areas are accessible by road. The speeds taken into consideration are detailed in Annex 3.

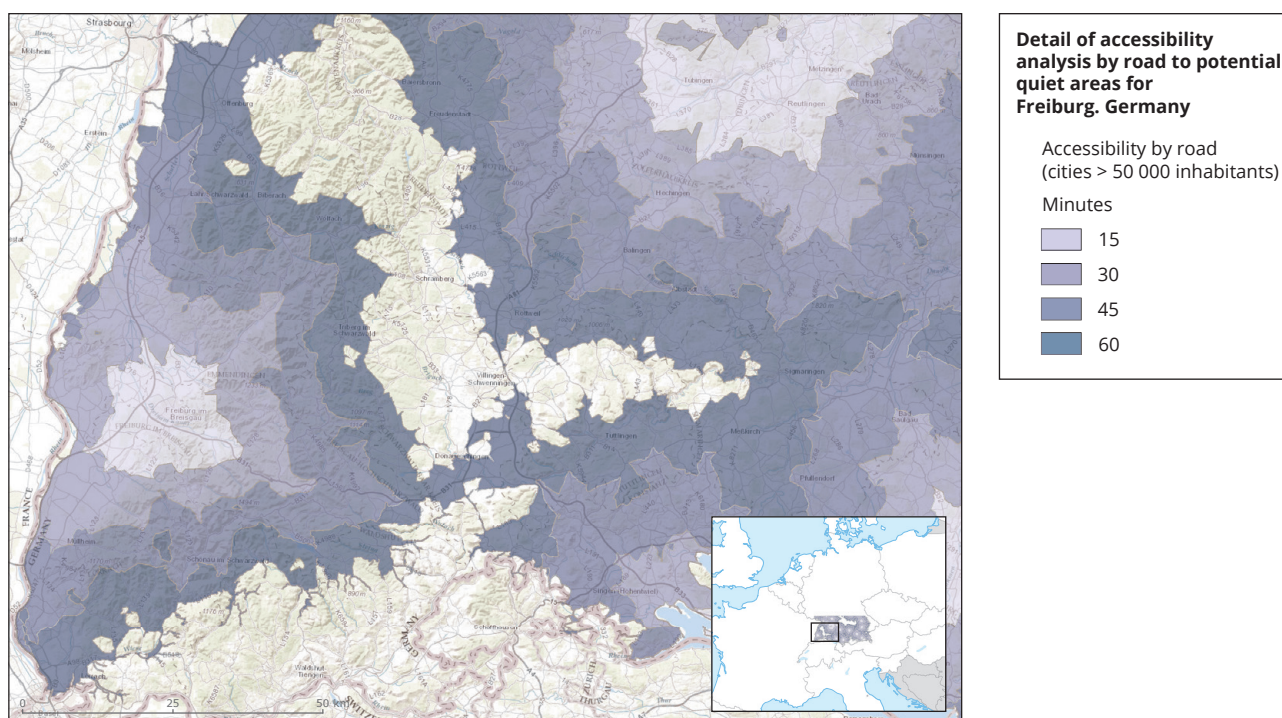
For this analysis, the temporal criteria are divided into values of 15, 30, 45 and 60 minutes in order gauge the degree of accessibility from populated areas. Map 2.1 illustrates the accessibility by road from the city of Freiburg, Germany, from light blue (0- to 15-minute car trip) to dark blue (1-hour car trip). The city centre is considered the starting point of the accessibility

analysis. The most distant part of the accessibility zone from the urban area is frequently overlapped by the accessibility zone of a neighbouring city.

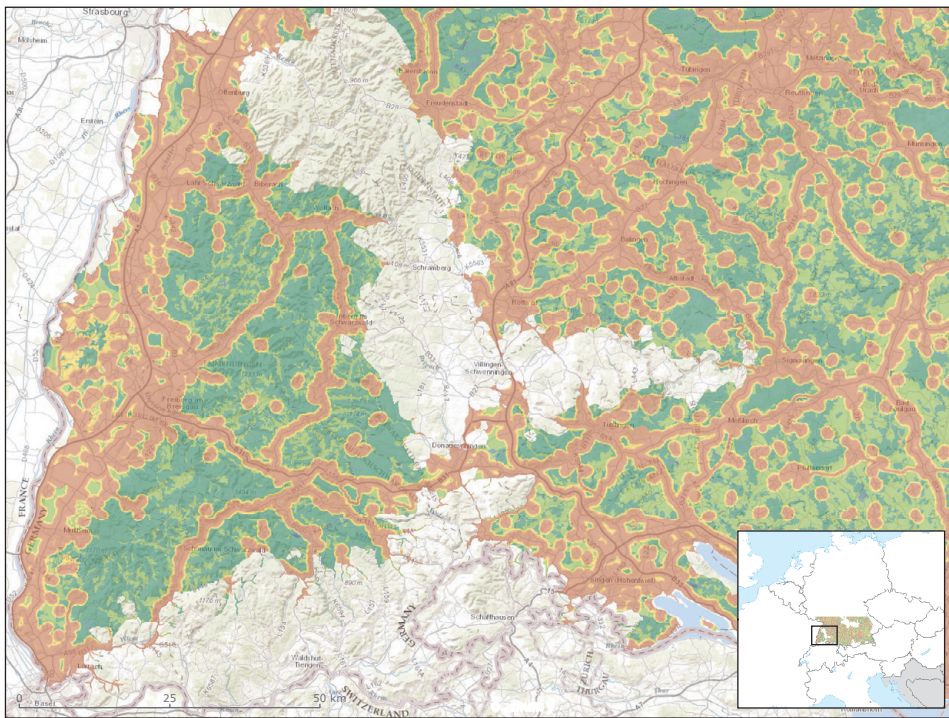
By analysing the type of QSI values that are present in the accessibility zones of a specific urban area, it will be possible to assess how many people from that urban area would be able to benefit from potential quiet areas outside urban areas, and the travelling distances at which those areas are.

Using this analysis, it is thereby possible to consider all urban areas with more than 50 000 inhabitants. From that, it is possible to ascertain how many people in those urban areas could benefit from potential quiet areas at country level and, indeed, throughout Europe.

Map 2.1 Detail of accessibility analysis by road to potential quiet areas for Freiburg, Germany



Map 2.2 Detail of accessibility to QSI areas for Freiburg, Germany



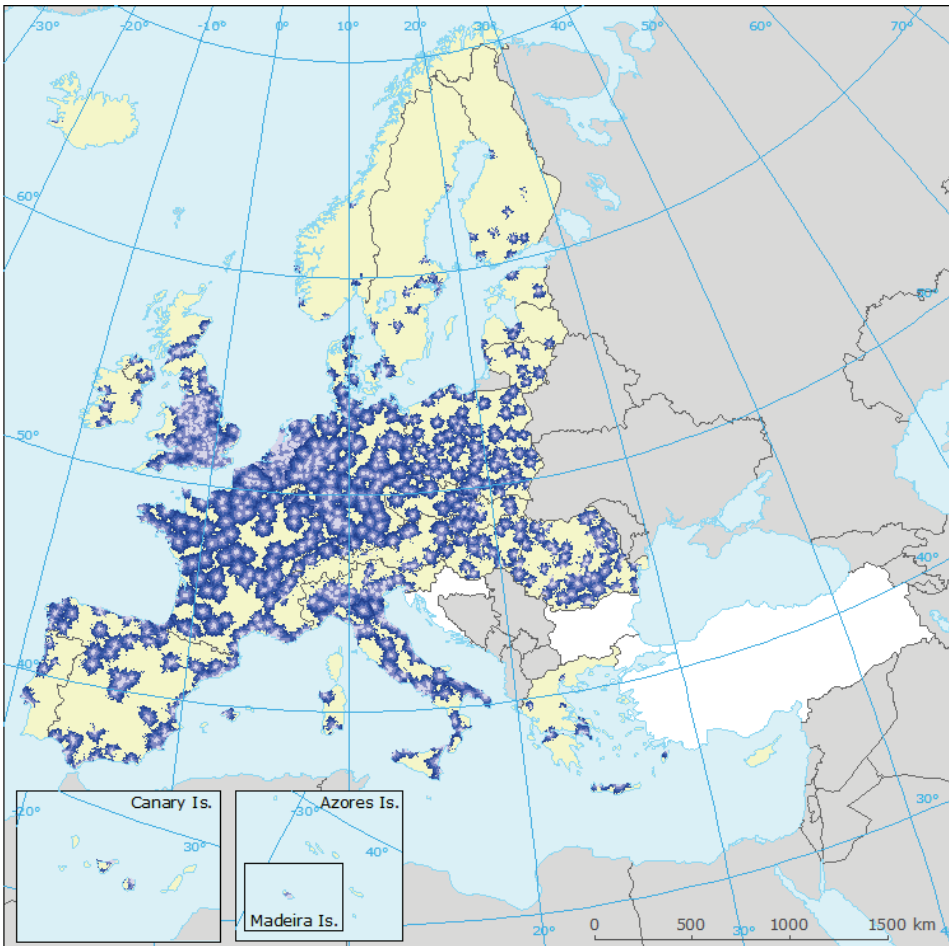
Detail of accessibility to QSI areas for Freiburg, Germany

Accessibility to quiet areas by road in 1 hour (cities > 50 000 inhabitants)

High: 1

Low: 0

Map 2.3 Accessibility to quiet areas for urban areas with more than 50 000 inhabitants



Accessibility to quiet areas for urban areas with more than 50 000 inhabitants

Time in minutes

- 0 to 15
- 0 to 30
- 0 to 45
- 0 to 60

□ Data not available

□ Outside coverage

3 Quiet areas in Europe

This chapter presents the results of the QSI analysis as described in the preceding chapters and applied to the European setting, namely the EEA member and cooperating countries, although Croatia and Turkey are excluded because of a lack of data availability at the time of the analysis. The overview of Europe's potential quiet areas is presented in Map 3.1.

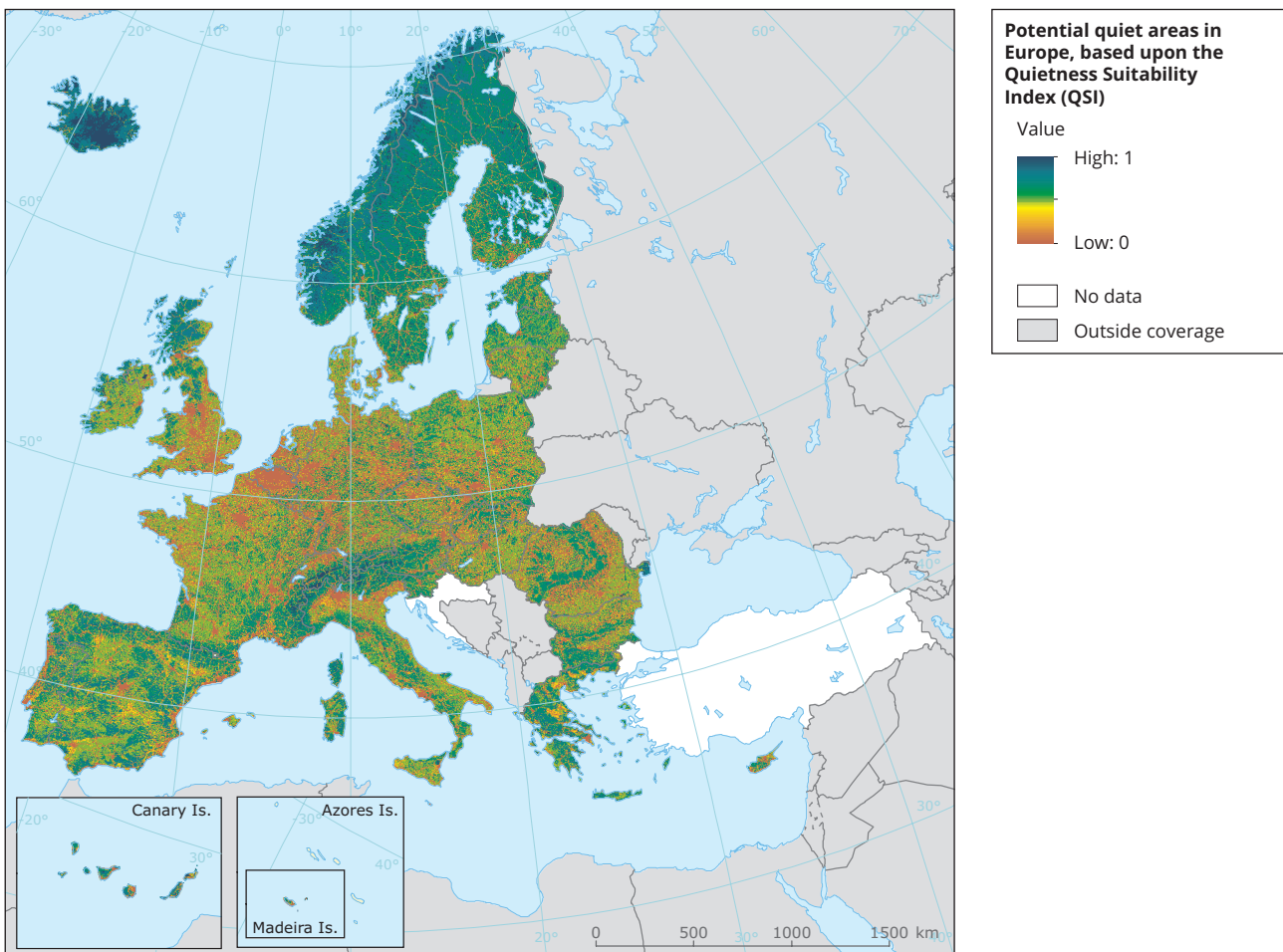
3.1 The European overview

When mapped, the QSI overview for Europe reveals the northern part of Europe to be the area with the

highest proportion of potential quiet areas (QSI = 1). On the other hand, the noisiest areas (low QSI values) tend to reflect the major transport infrastructures and areas with high population densities (major urban and metropolitan areas). Not only that, but areas with high QSI values further south are located in remote areas such as the Alpine region or near the Mediterranean coast.

As a result of the propensity of anthropogenic land use in Europe, those areas with the highest potential for quiet (QSI = 1) account for only 4 % of the territory. Those areas with less potential for quiet,

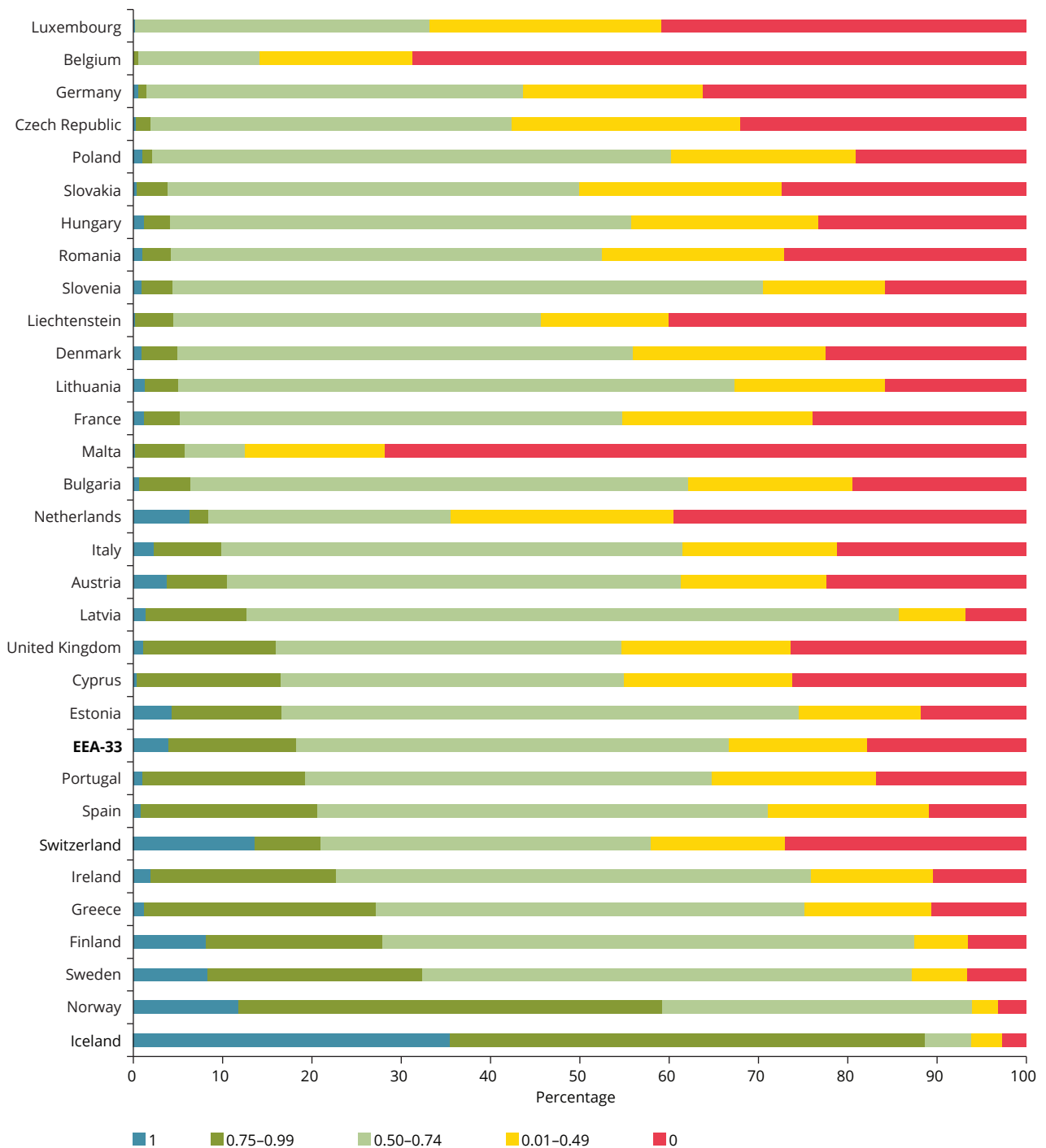
Map 3.1 Potential quiet areas in Europe based upon the Quietness Suitability Index (QSI)



with $QSI < 0.5$, account for more than 33 %. If a less strict threshold for applying a suitability for quiet is considered, i.e. $QSI > 0.75$, then the land share of areas potentially free from noise pollution increases to 18 % of Europe. A QSI value of > 0.75 can be considered as having minimal intrusion from noise pollution by the sources included in this model.

The proportion of quiet areas by country confirms the spatial pattern observed: Finland, Iceland, Norway and Sweden have the highest proportion of potential quiet areas. Switzerland also has a high proportion of quiet areas, which is explained by its particular topography. On the other hand, the cases with the highest proportions of noisy areas ($QSI < 0.5$) are

Figure 3.1 Potential for quiet (QSI) by country and aggregated for Europe



found in smaller, more densely populated countries such as Belgium, Denmark, Luxembourg, Malta and the Netherlands. However, in the Netherlands there is a remarkable situation, where quiet areas account for 9 % of the country, which is relatively high in comparison with Europe as a whole. In fact, this is a particular characteristic of the country — densely populated, but with an interior sea that is protected by Natura 2000 — and it has been included in the analysis, for example, in the wetlands in the coastal areas category. Germany and the Czech Republic each also have a proportion of potentially less quiet areas (QSI < 0.5) of more than 50 %.

In general, differences between countries are the result of several interrelated factors: the size of the country, the population density and the transport infrastructure. In fact, population density offers a robust explanation for the percentage of potential quiet areas in Europe, with a negative correlation for QSI = 1 and a positive correlation with potentially noisier areas, QSI = 0.

In addition, there are other elements such as height, slope and distance to the sea that configure different landscapes and, therefore, different human activities. These factors together are useful for identifying homogeneous regions in Europe and, finally, identifying to what extent the interwoven relationship between landscape and land use determines different patterns of quiet areas.

In that sense, quiet areas are mainly found on mountain regions, i.e. areas of high gradient between 500 and 1000 m above sea level and all the areas over 1000 m (EEA, 2006). This is in accordance with what one would expect, as mountains are some of the most remote, least accessible areas and can offer a good explanation for the relatively high proportion

of potential quiet areas in some countries, such as Switzerland.

On the other hand, low coast (coastal areas less than 50 m above sea level) and inland (regions between 0 and 200 m outside the coastal strip) areas are the regions with lowest proportion of quiet areas. These flat and easily accessible regions have a high population density and, at the same time, are crossed by a high concentration of transport networks leading to a high proportion of noisy areas (40–50 %).

Coastal areas also show a differentiated regional pattern. The Mediterranean low coast (elevation < 50 m above sea level) has the highest proportion of quiet areas, in contrast with the other sea regions. There are several factors that may explain these differences:

- **Size of the regional sea (length of the coast).** Although the Mediterranean coast is highly urbanised, this is by far the larger area, with a high proportion of protected areas and very heterogeneous topography. In general, the lower coast of the Mediterranean is where most of the protected areas are concentrated.
- **Degree of industrial development.** It has been observed that, in Europe, the Atlantic and Baltic coasts are characterised by a high degree of industrial development (EEA, 2006).

On high coasts (coastal areas more than 50 m above sea level), the situation exhibits less contrast, as the influence of typically inland land use and human activity is greater.

More in-depth analysis of the differences between high and low coasts in the European region reveals that the spatial extent of each type is not comparable.

Figure 3.2 Relationship between population density and proportion of quiet areas by country (left: QSI = 1 and right: QSI = 0)

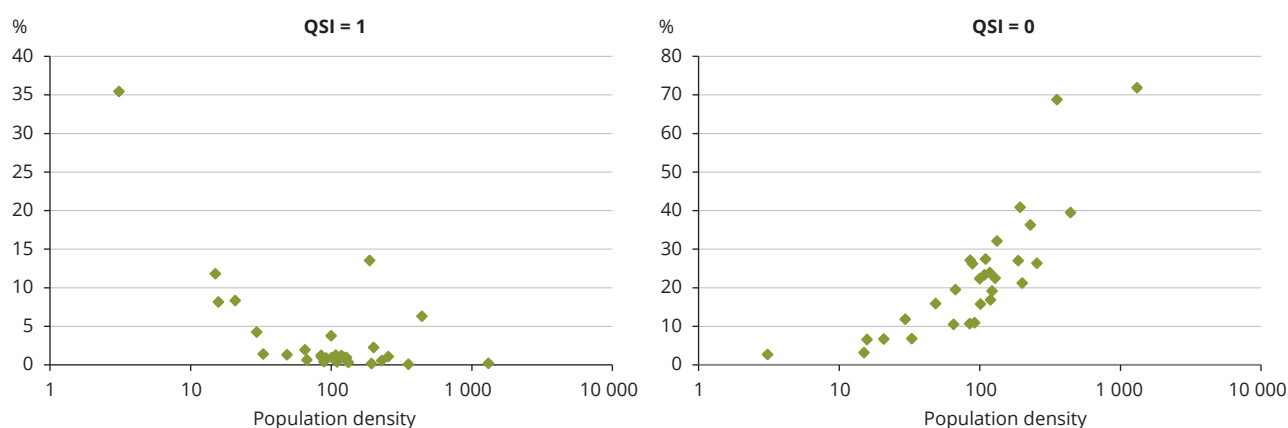
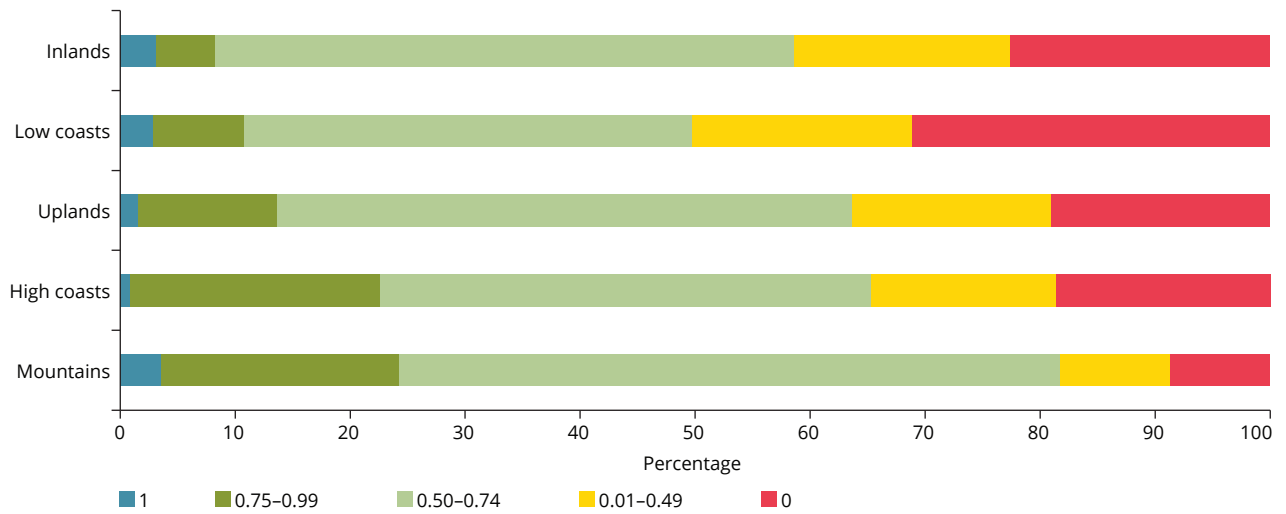


Figure 3.3 QSI by elevation breakdown for Europe

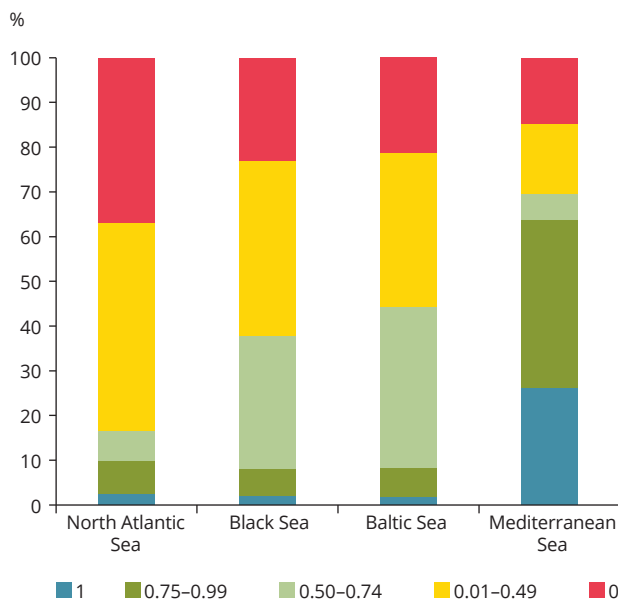


Note: Excludes Croatia, Iceland, Norway and Turkey.

While in the Mediterranean region there is quite a narrow fringe considered as low coast, the Baltic region shows relatively large areas categorised as low coast. This different classification between regions has a direct influence on the percentage of protected areas in low and high coast and, at the same time, on where the densely populated areas and urbanised areas are located.

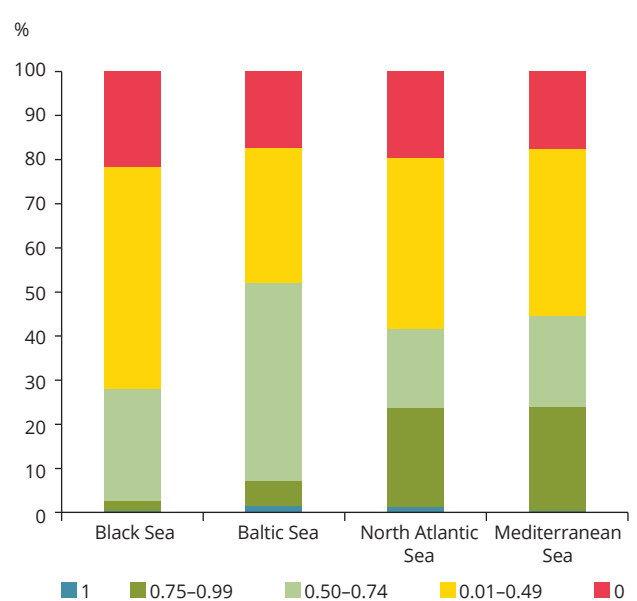
In the Mediterranean region, the densely urbanised areas are located mostly in the high coast, and the protected areas can be found in the low coast, while in the Baltic region the densely populated areas are located in the low coast with a lower percentage of protected areas. This situation is explained by the distribution of relatively quiet areas by Europe's sea regions, as shown in Figures 3.4 and 3.5.

Figure 3.4 Low coast QSI distribution by sea region



Note: Excludes Croatia, Iceland, Norway and Turkey.

Figure 3.5 High coast QSI distribution by sea region



Note: Excludes Croatia, Iceland, Norway and Turkey.

3.2 Accessing quiet areas in Europe

The definition and delineation of quiet areas is mainly intended for the benefit of people in order to improve quality of life and well-being (EEA, 2010). Indeed, people living in quiet areas do not suffer the negative health effects that befall those exposed to the average sound-pressure levels in an agglomeration; quiet areas also benefit the health and well-being of regular visitors (EEA, 2014a). Moreover, as quiet areas strongly correlate with green areas, there are non-acoustic factors such as aesthetics and sense of place that also contribute to the wellness of visitors of such places (Tzoulas et al., 2007; White et al., 2012).

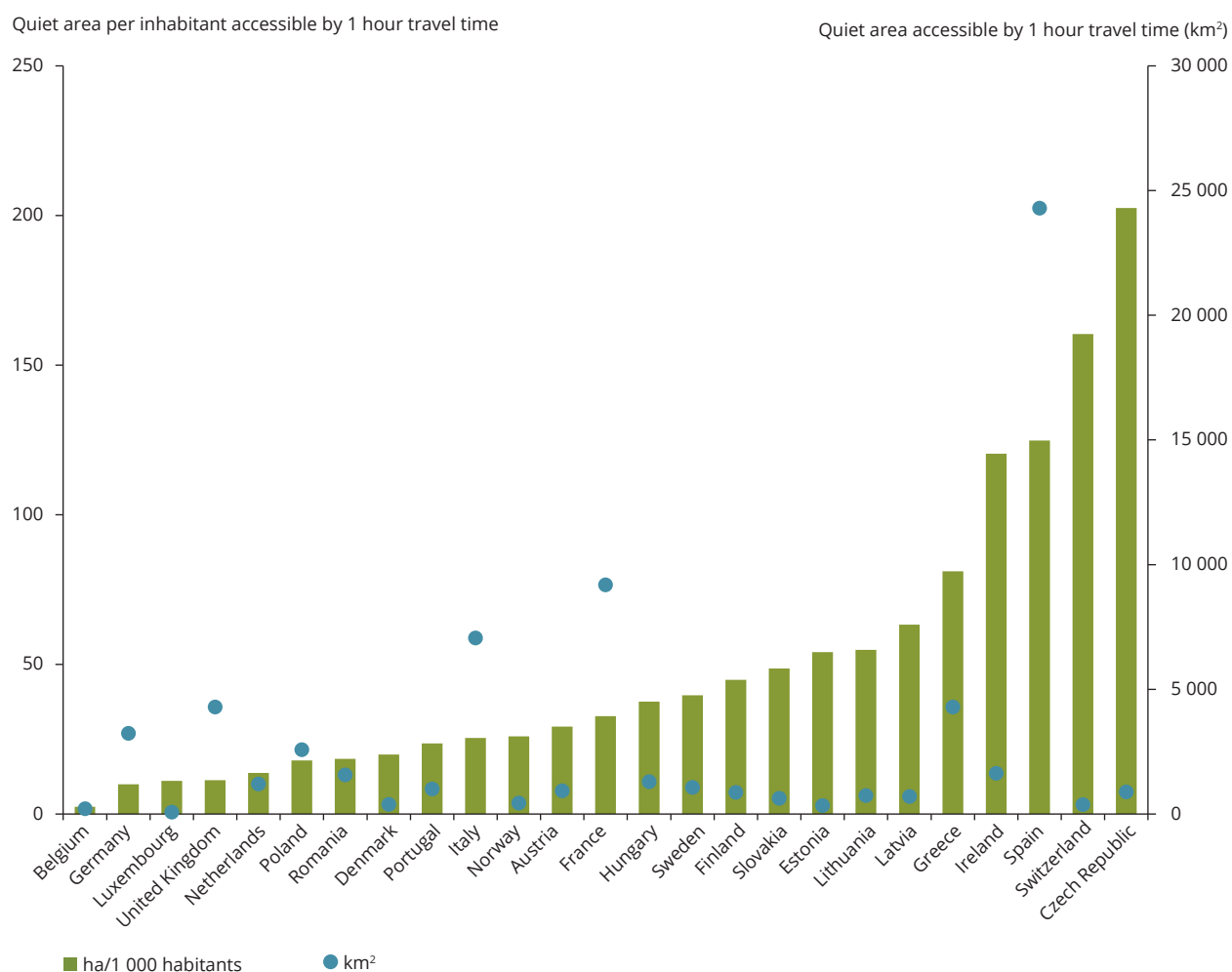
In the Netherlands, 46 % of the population consider their neighbourhood to be 'not quiet'. As a consequence, half of the population reportedly visit

quiet places on a daily or weekly basis (van den Berg, 2008). In order to do this, the population must have access to those quiet areas.

Therefore, an analysis of the extent of potentially quiet areas should also include their accessibility. If quiet areas are mainly found in remote places, their use will be limited to a certain number of people. However, this poses the dilemma of how to maintain the quietness of a place while providing this service to a wide range of the population. This aspect should be properly managed and could be reflected in action plans to reduce noise and protect quiet areas.

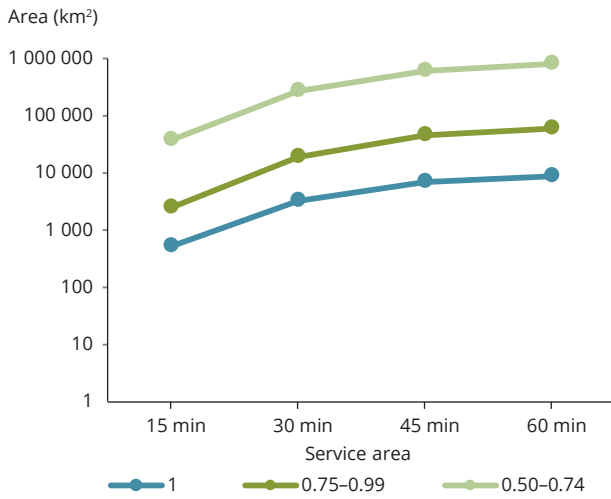
For this analysis, the accessibility of quiet areas at distances of at most 1 hour from cities with greater than 50 000 inhabitants has been analysed. This time threshold could be considered a maximum average

Figure 3.6 Accessibility to potential quiet areas (QSI > 0.75) by population living in cities above 50 000 inhabitants within 1 hour travel distance



Note: Based on urban areas with more than 50 000 inhabitants. The blue points denote the size of quiet areas accessible within 1 hour travel time (in km²). Excludes Turkey, Croatia, Liechtenstein, Cyprus, Malta, Slovenia, Iceland and Bulgaria.

Figure 3.7 Total area of quiet areas accessible from cities with more than 50 000 inhabitants



Note: Excludes Turkey, Croatia, Liechtenstein, Cyprus, Malta, Slovenia, Iceland and Bulgaria.

distance that a citizen could travel regularly for recreation purposes (ESPON FOCI, 2007). Therefore, this approach tries to identify those areas more used by people living in medium-sized to large cities in Europe, i.e. the population most exposed to noise.

The Czech Republic, Ireland, Spain and Switzerland are, by far, the countries with the highest accessibility per inhabitant (above 100 ha/inhabitant). On the other hand, small countries such as Belgium, Luxembourg and the Netherlands, but also Germany and the United Kingdom, are those with the lowest accessibility (below 15 ha/1 000 inhabitants). These patterns show that the distribution of the population and the density (more compact versus more diffuse) has an important role when comparing accessible quiet areas and accessibility by inhabitant.

3.3 Potential quiet, protected areas and green infrastructure

The sensitivity of certain species to disturbance by noise pollution means that quiet areas are important for the protection of nature in Europe. Halting the loss of biodiversity and the degradation of ecosystem services by 2020 is a target of the EU Biodiversity Strategy. The Natura 2000 network, comprising areas

protected under the Habitats Directive, embraces areas of high biodiversity value. These cover more than 18 % of European land area (EC, 2015).

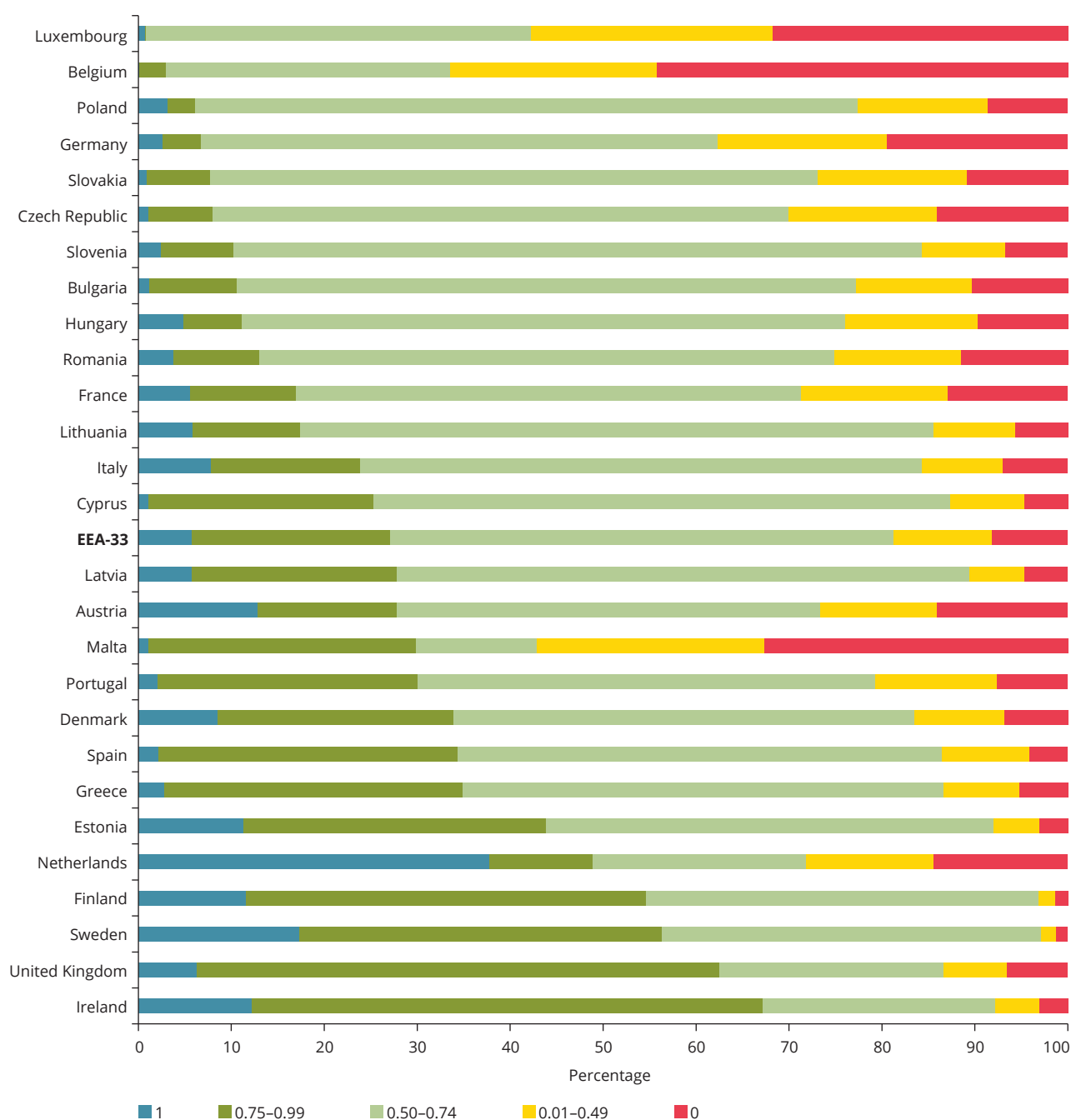
This report shows that the proportion of quiet areas inside Natura 2000 is higher than that in the whole of Europe. In Figure 3.8, it may be observed that 27 % of European protected sites are havens for quiet, while almost 20 % of protected areas are adversely affected by high levels of environmental noise.

Finland, Ireland, Sweden and the United Kingdom have the highest proportions of quiet areas (more than 50 % of each is QSI > 0.75). On the other hand, in small countries such as Belgium, Luxembourg and Malta, the proportion of quiet areas is very low and noisy areas represent a significant portion of the protected areas.



Photo: © Pawel Kazmierczyk

Figure 3.8 QSI in Natura 2000 areas by country and aggregated for Europe

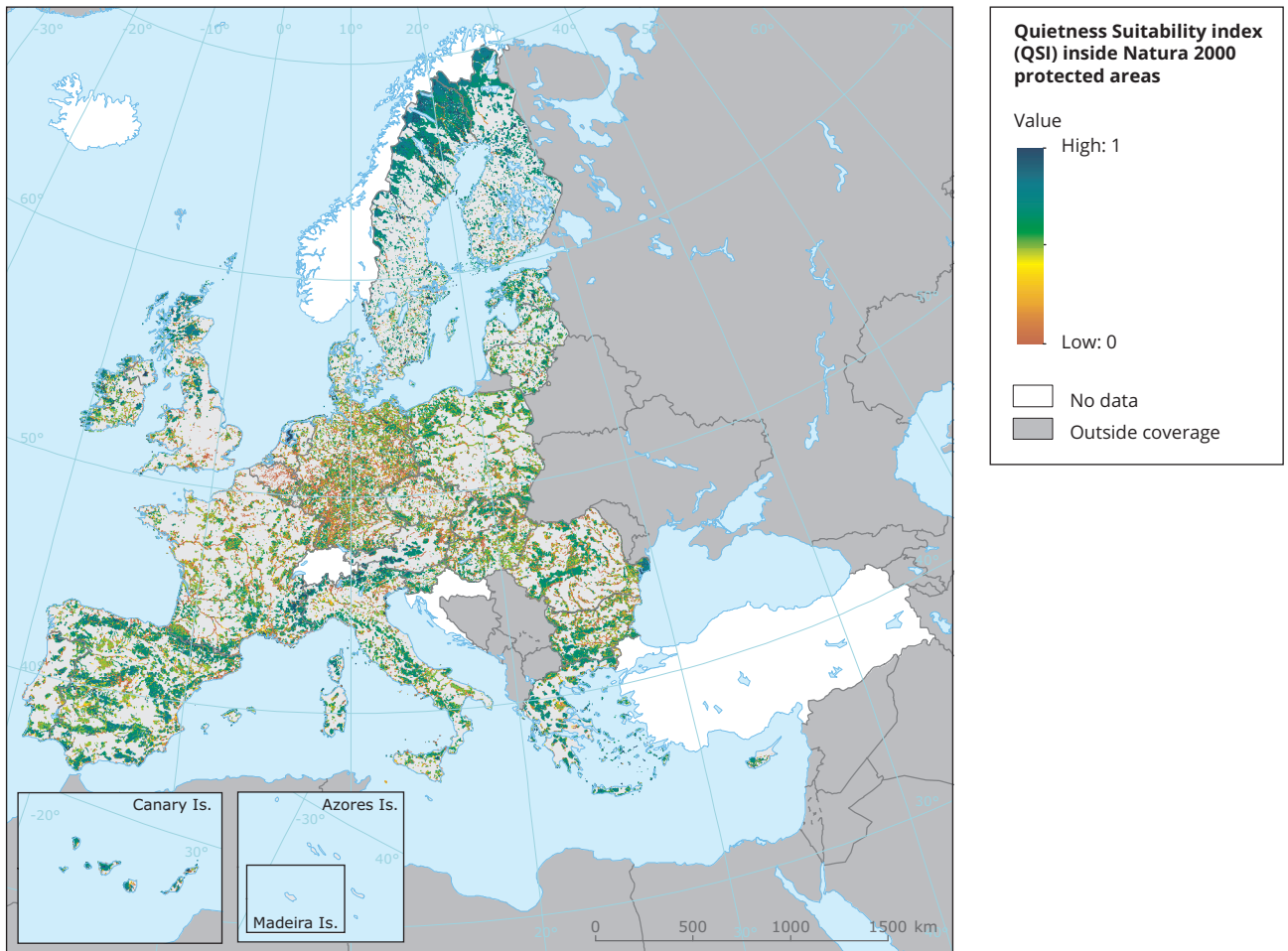


Note: Iceland, Liechtenstein, Norway and Switzerland do not have Natura 2000 areas.

In terms of land planning and resource efficiency, it is important to consider the potential multi-functionality of specific areas, i.e. that a particular part of the territory could be used in a way that provides multiple services, not just services restricted to environmental aspects. In that sense, it is interesting to see to what extent potential quiet areas are inside Natura 2000.

This could also provide additional guidance for the planning of quiet areas. It could also be observed that most of the potential quiet areas in the countries are inside Natura 2000 sites. Finland and Sweden, which have large forest areas that are not protected, have the lowest proportions of quiet areas inside Natura 2000 sites.

Map 3.2 Potential quiet areas in Europe based upon QSI and Natura 2000 protected areas



4 Management, good practice and policy

The END highlights the need to preserve environmental noise quality where it is found to be good — the protection of quiet areas. In support of the implementation of this action, the GPG (EEA, 2014a) made recommendations in terms of the identification and management of quiet areas. The conclusion was drawn that it is perhaps too early in the policy process to determine if the action plans required by the END offer examples of good practice. Bearing this in mind, and provided that, in open country, noise action plans may not target quiet areas, the issue arises of how to manage and protect quiet areas. To address this issue, additional research is required.

To date, research has focused on determining the indicators to be considered when defining a quiet area and the measures that may be used in managing and protecting such areas. Some work has also focused on analysing the surrounding land area, mainly checking the accessibility to the areas of potential quiet. The type of activities that can be considered appropriate for development in those areas has been another approach followed in some cases. This may, from the acoustic point of view, be a preliminary step in defining what the protection of quiet areas actually means.

4.1 Implementation at national level

A study conducted for the European Parliament assessing the effectiveness of the END and legislation on noise sources has identified that the vague definition of quiet areas within the END has led to divergent approaches and confusion within member countries' implementation (EU, 2012). The EEA GPG sought to offer guidance to relevant competent authorities. Much of the content relates to the situation in agglomerations, with few examples of effective policy for open country. Isolated exceptions include Belgium, where rural areas have been given Quality Labels for Quietness (DLNE, 2016). In the United Kingdom, there have been many urban quiet areas delimited and rural areas are also addressed by the National Planning

Policy Framework for England. This framework aims to ensure that local planning authorities, in their planning policies and decisions, identify and protect areas of tranquillity that are relatively undisturbed by noise and are prized for their recreational and amenity value for this reason (DCLG, 2012).

Since the compilation of data informing the EEA GPG report, little additional information has been available on the measures subsequently introduced at national level. In order to gain this up-to-date knowledge, a survey was carried out by EEA's European Topic Centre on Air Pollution and Climate Change Mitigation in early 2015. It was addressed to the Eionet National Reference Centre for noise in the EEA member and cooperating countries.

Around half of countries (14 replies out of 26⁽¹⁾) revealed that, at that time, there was no plan concerning the protection of quiet areas in open country, highlighting at the same time the lack of initiative, interest and willingness observed at political level.

Nevertheless, although no official action has been recognised, some of the responses specified that several plans — in different stages of development — were being developed with the objective of delineating and protecting quiet areas in open country. Specific mention is made of the EEA GPG as the guidance that was followed. Other member countries mentioned that national (or regional) legislation is currently being developed with the objective to regulate quiet areas outside urban areas and define the competent authorities responsible to limit, protect and manage quiet areas.

The main reasons or obstacles being highlighted to explain this situation are listed in Table 4.1.

On the other hand, 12 replies out of 26 stated that, in their country, one could encounter actions related to the protection of quiet areas in open country. The

(¹) The 33 EEA member countries were surveyed. In total, 26 replies were received, two of which referred to a specific region, rather than the whole country.

Table 4.1 The main obstacles identified for the protection of quiet areas

General topic	Examples
Policy/legislation	Lack of support by the current legislation Lack of or very few competences in noise issues (central government, ministries, distribution of competences): only general regulations and recommendations can be established
Budget/law implementation	Lack of funding Lack of interest and lack of action by the competent authorities (mainly ministries mentioned) Distribution of competences between ministries: voluntary activities versus mandatory activities Lack of (planning) guidance Previous steps, as the strategic noise maps or the delineation of potential quiet areas are not being fulfilled yet
Research	Absence of a definition and criteria for designating quiet areas in open country
Conflicts with other policy areas/economic sectors	Potential conflicts with current renewable energy strategies, probably leading to an increase in wind turbines in rural locations, some of which will probably be located in quiet areas Integration of the quiet areas protected figure in the County Development Plans: possibility to halt future development if quiet areas are implemented and protected? Compensation to private land owners if their lands are impacted by quiet areas: by whom, is it needed?
Topic covered by another policy area	Rural areas that it is important to protect are already protected through other laws (natural parks, natural reserve areas, etc.): no need to further protect those areas regarding noise and no need to protect other areas

criteria being followed by those countries to delineate quiet areas have been:

- specifications provided in the national law (differences between countries can be observed when analysing the legislative texts being submitted);
- specifications based on physical measurements;
- specifications based on human observations.

Those criteria are present at country level either simply as recommendations to be applied if quiet areas are to be protected in open country or as legally binding obligations.

The competences or administrative units responsible for developing quiet areas in open country vary from one country to another, ranging from national to regional and even municipal levels. Given the different types and levels of administrations being responsible for this process, it was considered of importance to ask:

- What criteria were used to protect quiet areas in open country?

- What were the problems encountered in this protection?

There is much divergence, both in the criteria applied to protection and in the problems encountered. This demonstrates that common guidance on this topic is in fact very useful, providing on the one hand a general overview at European level on the current situation and, on the other hand, a first approach to the location of potential quiet areas in different EEA member countries. This first approach could serve as input information to better define quiet areas in open country at national level, by considering local specificities and the use of data that are more detailed than those available for the European level assessment presented in this report.

The criteria used for the protection of quiet areas in open country and the problems encountered as declared in the survey are presented in Tables 4.2 and 4.3.

A final question addressing the links that member countries encounter between noise legislation and the protection of quiet areas with other legislation affecting the whole territory, such as biodiversity and nature conservation legislation, reflects a distinct synergy between the thematic areas.

Table 4.2 Summary of criteria applied to the protection of quiet areas in open country

General topic	Examples
Policy/legislation	Law on noise management: <ul style="list-style-type: none"> dedicated articles to legislate about activities that are allowed in quiet areas law obliging municipalities to do noise monitoring in quiet areas Noise limit values established by law: <ul style="list-style-type: none"> quiet areas outside the agglomerations: L_{day} 40 dB(A); $L_{evening}$ 35 dB(A); L_{night} 35 dB(A) regulation of the activities through noise limit value stipulated for protected areas Environmental Protection Act Action plans (END)
Sectorial coordination	Establishment of the protection depending on priorities between different authorities and planning (e.g. siting of wind turbines or determination of flight paths near airports)
Labelling	Quality label: commitment to pay special attention to the quietness and calmness in the area

While in the majority of cases, the links and synergies mentioned refer to protected areas (natural, cultural, archaeological, architectural), landscape conservation, biodiversity and habitats protection, there is one country that emphasises that this link is considered not correct and, therefore, not needed. The main reason behind this statement is the 'elements' to be protected, which in the case of the noise legislation are human beings, while in the case of biodiversity and habitats protection, is nature (animals, flora, fauna, habitats, etc.).

The WHO has introduced guideline noise levels in order to avoid impacts on human health, but European limit values for the protection of biodiversity from noise have not yet been established. It could be considered that the protection of habitats and wild

flora and fauna from noisy human activities is already covered through requirements for Environmental Impact Assessment, so there may not be a need to further establish a link with noise legislation and nature protection.

Other synergies to be taken into account when addressing the relationships between noise legislation and other policies were identified as mobility at a large scale, air quality, Strategic Environmental Assessment, consumption of soil in agricultural areas, and land-use planning.

A recent evaluation of the first 1 000 END action plans drawn up in Germany has revealed that only about 30 % of municipalities have defined quiet areas or

Table 4.3 Summary of the problems encountered when protecting quiet areas in open country

General topic	Examples
Policy/legislation	Lack of clarity in the END: difficulties in strengthening national policies in delineating, monitoring and preserving quiet areas
Budget/law implementation	Lack of support at political level Lack of understanding of the added value of delineating and preserving quiet areas Measurements are time consuming and expensive Measurements in quiet areas not included in the annual noise monitoring programme
Research	Gap between quiet areas inside and outside urban areas. No definition for quiet areas in small urban areas (smaller than agglomerations) Problems related to identification methods, parameters, threshold limits, territorial characteristics, competent authorities, representation, methods of management and safeguarding, how to allow the access to the areas preserving the adequate distances of the transport infrastructures from the perimeters of the areas, etc.
Conflicts with other policy areas/economic sectors	Lack of compatibility with other noisy activities owing to low noise limit values: construction, leisure activities Interviews needed with specialists of municipalities (timing and practical problem)

intend to do so in the first stage of action planning. One of the difficulties that was cited in defining quiet is the limitation of noise mapping to 55 dB L_{den} . It is stated that a lower mandatory threshold would assist the management of quiet areas. Acoustics are not the only factor considered though. Around 90 % of the

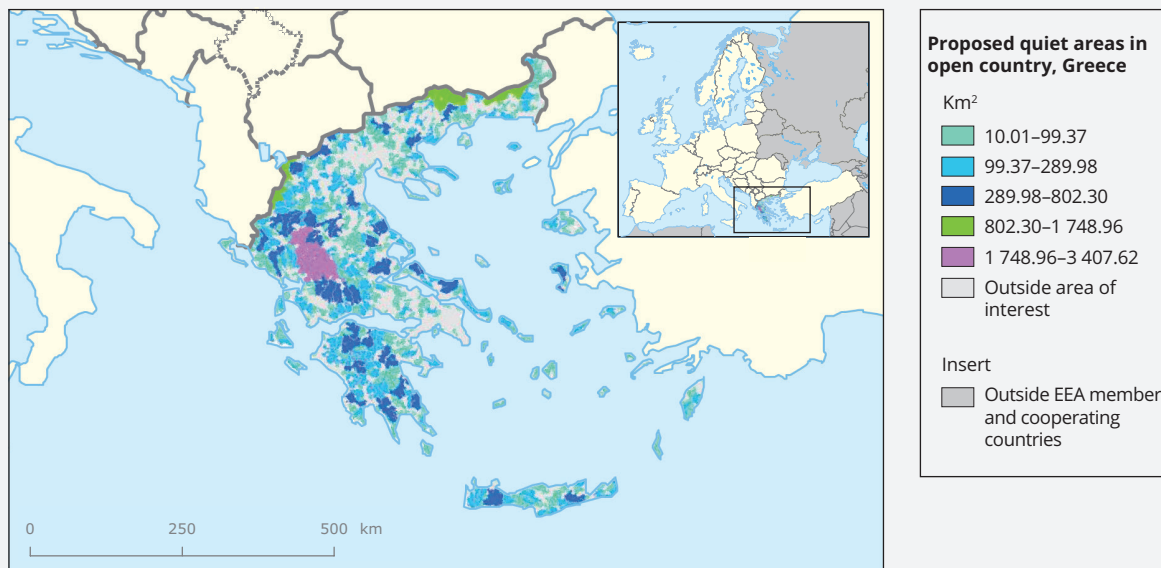
quiet areas defined were done so by also applying land use as a factor. The most commonly used land indicators for quiet were residential areas, green areas, forests, water features, moors, conservation areas (including Habitats Directive), natural monuments and agricultural land (Umweltbundesamt, 2015).

Box 4.1 Quiet areas in Greece

In recognition of the role of quietness as an important ecosystem service and the value of soundscape in preserving natural heritage, a project in Greece has led the way in mapping quiet areas in open country. The work by the Aristotle University of Thessaloniki was an early example of looking beyond decibels to identify quiet. As well as analysing noise contour maps, the project team has also applied geo-spatial data on transport, industry, construction sites, residential areas and land use to the assessment. The results revealed 765 sites of potential quiet in the country, of which 172 covered individual areas of more than 100 km². In total, almost half of Greece (47.93 %) could be considered as having a high potential for being a haven away from anthropogenic noise.

The uniqueness and replicability of this work was recognised by the EEA European Soundscape Award runner-up prize in 2014 (EEA, 2014c).

Map 4.1 Proposed quiet areas in open country, Greece



Source: Votsi et al., 2012.

5 Conclusion

This report set out to explore to what extent Europe's rural environment could be considered as healthy and undisturbed by noise pollution. Many millions of citizens are exposed to harmful levels of noise in Europe's urban environment. This study aimed to move a step forward and apply the knowledge that exists on emissions from the major transport and industrial noise sources outside urbanised areas and attempt to map the influence of this noise pollution upon the wider European soundscape, thereby identifying potential quiet areas.

The cornerstone of this analysis was the application of the QSI methodology. The resulting assessment is one that builds upon knowledge of the extent of noise pollution in the rural environment and is designed to inform the EEA member countries about those areas where noise may not yet be a problem for the environment.

For a densely populated and industrialised society, Europe can claim that 18 % of its land area is not likely to be affected by higher levels of noise. The drive to protect natural capital through the provision of protected sites is well reflected in this study. As many as 27 % of Natura 2000 sites can be considered as quiet areas, scoring highly on the QSI. On the other hand, there remains much work to be done. In total, one-third of Europe's rural area is adversely affected by noise from human activity, while one-fifth of protected areas score poorly on the QSI and are considered directly affected by noise pollution. This may represent a clear risk to noise-sensitive species that could otherwise thrive.

The survey of Eionet member countries reveals some recent progress has been made in tackling the issue

at national and regional level, but all too often a lack of clarity at the European level, specifically the articles of the END, are cited as stumbling blocks to dealing with quiet areas in open country. Encouragingly, though, the EEA GPG report (EEA, 2014a) is mentioned as having been helpful to ensuring the progress that has been made. It remains relevant to consider the recommendations from the GPG when considering the next steps required. It may be necessary to further improve knowledge of the links between quiet and health and well-being, not only of people but also for wildlife. Further guidance may also be helpful for competent authorities on dealing with quiet and also noise in rural areas.

The assessment uses datasets, many of which are provided directly by member countries, but gaps do still exist. Source data, noise maps and action plans to protect quiet have not yet been completely reported in accordance with the END. Although some sources such as roads were supplemented with other data, others were not. The influence of aircraft noise, for example, is restricted to END data concerning airports alone, so general overflights are not considered.

Nevertheless, a clear challenge remains. Noise is one of the most pervasive pollutants in Europe today. Tackling it is imperative, but so too is the need to focus on protecting areas that remain unaffected by noise pollution. Quiet areas are havens of natural soundscape that should be protected from any increase in background noise. This will involve ensuring that urban development is properly controlled, transport corridors are appropriately located and industrial sites are adequately regulated.



Photo: © Emanuele Bernardelli Curuz, Picture2050/EEA

References

- Alvarsson, J. J., Wiens, S. and Nilsson, M. E., 2010, 'Stress recovery during exposure to nature sound and environmental noise', *International Journal of Environmental Research and Public Health*, 7(3), 1 036–1 046.
- Andringa, T. C. and Lanser, J. J. L., 2013, 'How pleasant sounds promote and annoying sounds impede health: a cognitive approach', *International Journal of Environmental Research and Public Health*, 10(4), 1 439–1 461.
- Blume, H.P. and Sukopp, H., 1976, 'Ökologische Bedeutung anthropogener Bodenveränderungen', *Schriftenreihe für Vegetationskunde*, (10) 75–89.
- Defra, 2008, *An Economic Valuation of Noise Pollution — developing a tool for policy appraisal*, First report of the Interdepartmental Group on Costs and Benefits, Noise subject group.
- Defra, 2011, *The Economic Value of Quiet Areas*, Final report prepared by URS/Scott Wilson.
- DCLG, 2012, *National Planning Policy Framework, Department for Communities and Local Government*, March 2012, ISBN: 978-1-4098-3413-7.
- DLNE, 2016, *Quality labels for quietness*, Department for Environment Nature and Energy, Flemish Government (<http://www.lne.be/themas/hinder-en-risicos/stiltegebieden/beleid>) accessed 22 March 2016.
- Dutilleux, G., 2012, 'Anthropogenic outdoor sound and wildlife: it's not just bioacoustics!', *Proceedings Acoustics*, Nantes, France, 2301–2306 (hal.archives-ouvertes.fr/docs/00/81/07/95/PDF/hal-00810795.pdf) accessed 18 October 2014.
- EC, 1996, *Green Paper on Future Noise Policy*, European Commission, Brussels.
- EC, 2015, *The State of Nature in the European Union — report from the Commission to the Council and the European Parliament on the status of and trends for habitat types and species covered by the Birds and Habitats Directives for the 2007–2012 period as required under Article 17 of the Habitats Directive and Article 12 of the Birds Directive*, European Commission, Brussels (COM(2015) 219 final of 20 May 2015).
- EEA, 2006, *The changing faces of Europe's coastal areas*, EEA Report No 6/2006, European Environment Agency.
- EEA, 2009, *Ensuring quality of life in Europe's cities and towns*, EEA Report No 5/2009, European Environment Agency.
- EEA, 2010a, *Europe's ecological backbone: recognising the true value of our mountains*, EEA Report No 6/2010, European Environment Agency.
- EEA, 2010b, *Good practice guide on noise exposure and potential health effects*, EEA Technical report No 11/2010, European Environment Agency.
- EEA, 2014a, *Good practice guide on quiet areas*, EEA Technical report No 4/2014, European Environment Agency.
- EEA, 2014b, *Noise in Europe 2014*, EEA Report No 10/2014, European Environment Agency.
- EEA, 2014c, *European Soundscape Award 2014*, European Environment Agency <http://www.eea.europa.eu/highlights/reducing-noise-pollution-success-stories> accessed 3 May 2016.
- EEA, 2016, *Noise Observation & Information Service for Europe*, <http://NOISE.eionet.europa.eu/>, European Environment Agency accessed 3 May 2016.
- ESPON FOCI, 2010, *Future Orientation for Cities*, Final Scientific Report, Version 15/12/2010, ESPON & ULB.
- EU, 2002, *Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise* (OJ L 129, 18.7.2002, pp. 12–25).
- EU, 2012, *Towards a comprehensive noise strategy*, Directorate General for Internal Policies, Policy Department A: Economic and Scientific Policy.

- FOEN, 2010, *External Costs and Benefits of Transport in Switzerland 2010*, Federal Office for the Environment, Switzerland (<http://www.are.admin.ch/themen/verkehr/00252/00472/index.html?lang=en>) accessed 28 November 2014.
- Gallego, F. J., 2010, 'A population density grid of the European Union', *Population and Environment*, 31(6), 460–473.
- Gidlöf-Gunnarsson, A. and Öhrström, E., 2007, 'Noise and well-being in urban residential environments: the potential role of perceived availability to nearby green areas', *Landscape and Urban Planning*, 83, 115–126.
- Jalas, J., 1955, 'Hemerobe und hemerochore Pflanzenarten. Ein terminologischer Reformversuch', *Acta Societatis Pro Fauna et Flora Fennica*, 72, 1–15.
- Kaplan, S., 1995, 'The restorative benefits of nature: toward an integrative framework', *Journal of Environmental Psychology*, 15, 169–182.
- MacFarlane, R. et al., 2004, *Tranquility mapping: developing a robust methodology for planning support*, Report to the Campaign to Protect Rural England, Countryside Agency, North East Assembly, Northumberland Strategic Partnership, Northumberland National Park Authority and Durham County Council, Centre for Environmental & Spatial Analysis, Northumbria University.
- Naturvårdsverket, 2014, *Kartlaggning av antalet överexponerade för buller*, Uppdragsnummer 3581062000.
- Nilsson, M. E., 2007, *Soundscape quality in urban open spaces Intern-Noise 2007*, Noise Control Engineering, Paper IN07–115, Istanbul.
- Öhrström, E., Skånberg, A., Svensson, H. and Gidlöf-Gunnarsson, A., 2006, 'Effects of road traffic noise and the benefit of access to quietness', *Journal of Sound and Vibration*, 295, 40–59.
- Paracchini, M. L. and Capitani, C., 2011, 'Implementation of the EU-wide indicator for the rural-agrarian landscape', EUR 25114 EN, Joint Research Centre — Institute for Environment and Sustainability, Publications Office of the European Union, Luxembourg, 89 pp.
- Pheasant, R. et al. 2006, *The Importance of visual and acoustic factors in determining tranquillity for use in landscape management and planning*, Thirteenth International Congress on Sound and Vibration (ICSV), Vienna.
- Pheasant R. J., Fisher, M. N., Watts, G. R., Whitaker, D. J. and Horoshenkov, K. V., 2010, 'The importance of auditory-visual interaction in the construction of tranquil space', *Journal of Environmental Psychology*, 30, 501–509.
- Rendel, S. (ASH Consulting), 2005, *Chilterns Tranquillity Study. Report on the Participatory Appraisal Consultations in the Chilterns Area of Outstanding Natural Beauty*, Campaign to Protect Rural England, Countryside Agency, United Kingdom, 37 pp.
- Shepherd, D., Welch, D., Dirks, K. N. et al, 2013, 'Do quiet areas afford greater health related quality of life than noisy areas?', *International Journal of Environmental Research and Public Health*, 10, 1 284–1 303.
- Steinhardt, U., Herzog, F., Lausch, A., Müller, E., Lehmann, S., 1999, 'The hemeroby index for landscape monitoring and evaluation', in: Pykh, Y. A., Hyatt, D. E. and Lenz, R. J. M. (eds), *Environmental Indices—Systems Analysis Approach*, EOLSS Publ., Oxford, 237–254.
- Tzoulas, K. et al. 2007, Promoting Ecosystem and Human Health in Urban Areas Using Green Infrastructure: a literature review, *Landscape and Urban Planning* 81 (2007) 167–178.
- Ulrich, R. S., 1984, 'View through a window may influence recovery from surgery', *Science*, 224, 420–421.
- Umweltbundesamt, 2015, *Technical-scientific support in the amendment of the EU Environmental Noise Directive*, Work Package 3: Ruhige Gebiete (https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_74_2015_tune_ulr_technisch_wissenschaftliche_unterstuetzung_bei_der_novellierung.pdf) accessed 18 November 2015.
- van den Berg, M., 2008, 'Quiet places in Amsterdam', *Proceedings of Internoise 2008*.
- Votsi, N. P., Drakou, E. G., Mazaris, A. D., Kallimanis, A. S., Pantis, J. D., 2012, 'Distance-based assessment of open country Quiet Areas in Greece', *Landscape and Urban Planning*, 104, 279–288.
- Votsi, N. et al 2012, Assessing Quiet Areas Based on Distance Criteria, Department of Ecology, School of Biology, Aristotle University of Thessaloniki, Submission for the European Soundscape Award 2014.
- Waugh, D., Durucan, S., Korre, A., Hetherington, O. and O'Reilly, B., 2003, *Environmental Quality Objectives. Noise in Quiet Areas*, Synthesis Report 2000-MS- 14-M1, Environmental Protection Agency (EPA), 25 pp.

References

Watts, G. and Pheasant, R. J., 2013, 'Factors affecting tranquility in the countryside', *Applied Acoustics*, 74, 1 094–1 103.

Watts, G. and Pheasant, R. J., 2015, 'Identifying tranquil environments and quantifying impacts', *Applied Acoustics*, 89, 122–127.

White, M. P., Alcock, I., Wheeler, B. W. and Depledge, M. H., 2013, 'Would You Be Happier Living in a Greener Urban Area? A Fixed-Effects Analysis of Panel Data', *Psychological Science*, 24(6), pp. 920–928.

WHO, 1999, *Guidelines for Community Noise*, Berglund, B., Lindvall, T. and Schwela, D.H. (eds), World Health Organization, Geneva.

WHO, 2011, *Burden of disease from environmental noise. Quantification of healthy life years lost in Europe*, World Health Organization Regional Office for Europe, Copenhagen.

Zebisch, M., Wechsung, F. and Kenneweg, H., 2004, 'Landscape response functions for biodiversity — assessing the impact of land-use changes at the county level', *Landscape and Urban Planning*, 67, 157–172.

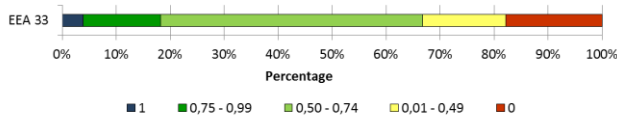
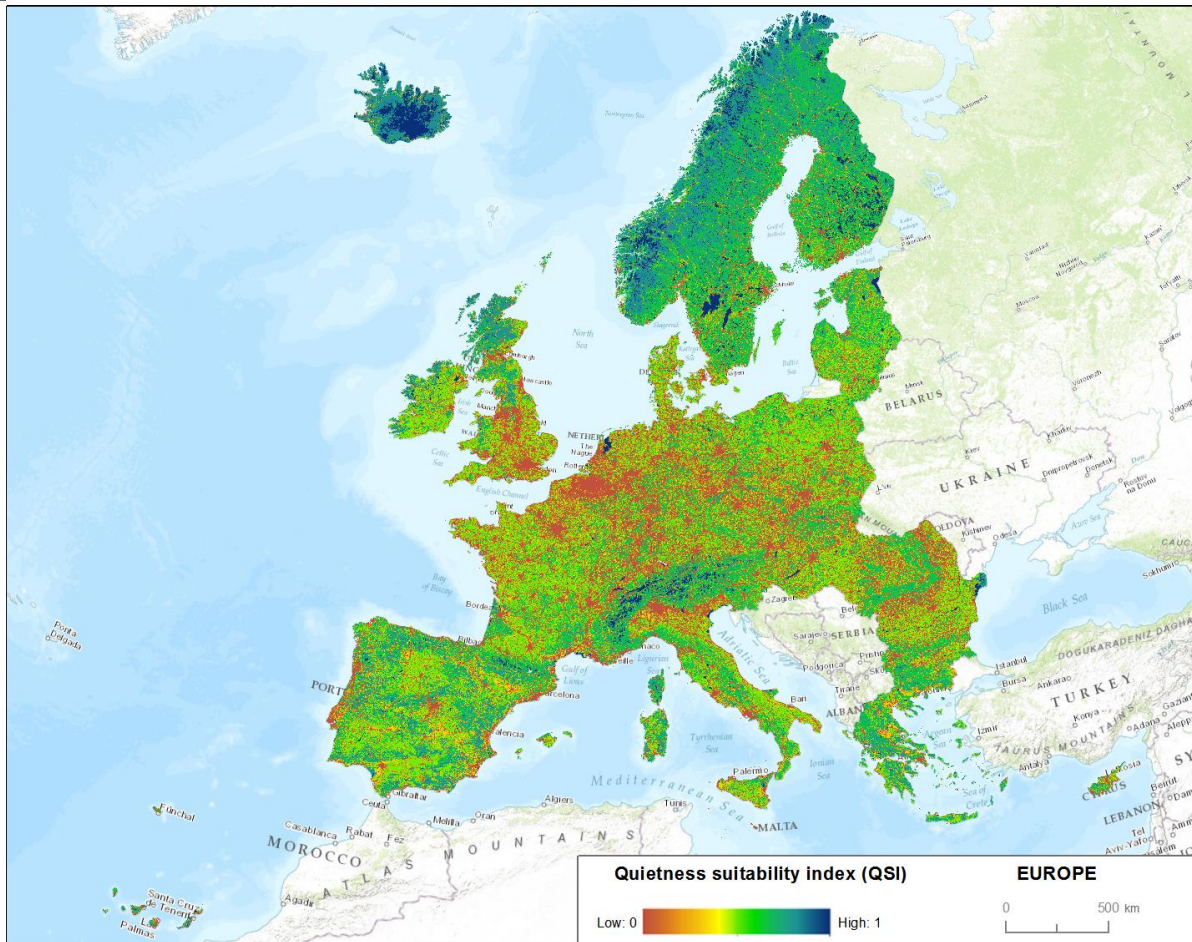
Annex 1 Quietness Suitability Index by country

The results of the Quietness Suitability Index (QSI) analysis by EEA member country are presented in the form of a country-specific QSI fiche. Each fiche is comprised of a spatial assessment presented in map form alongside associated data concerning the potential quiet areas, such as accessibility to various

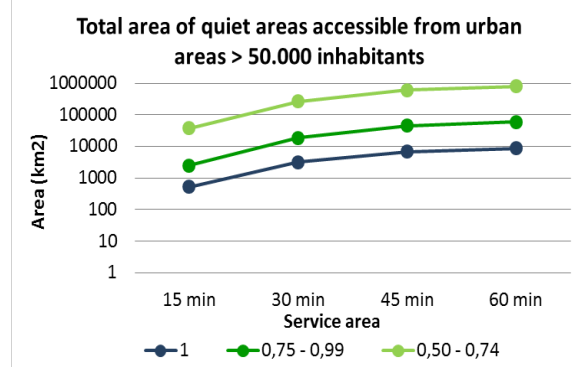
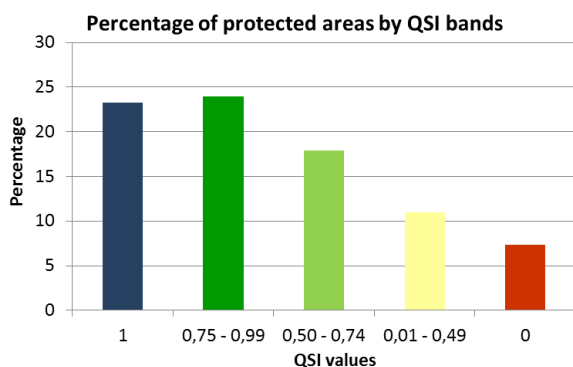
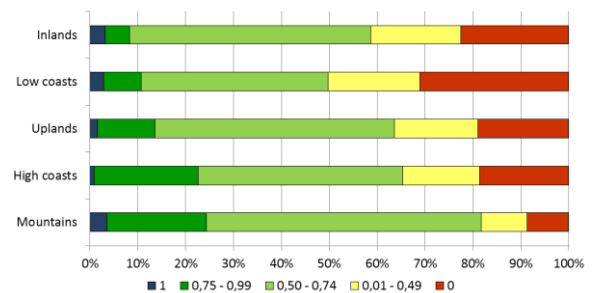
QSI areas and the degree of synergy with protected sites.

The fiches are presented for EEA member countries for which data was available at the time of assessment.

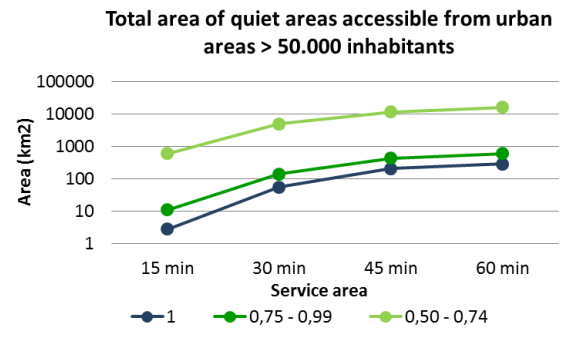
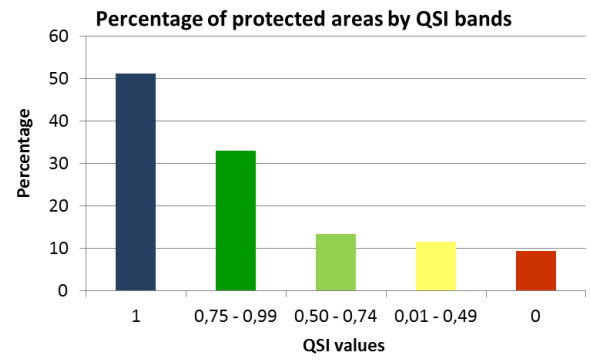
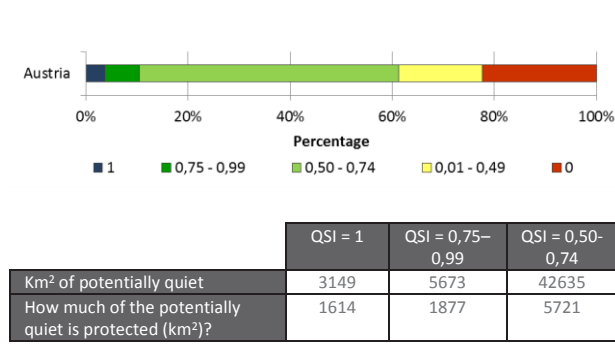
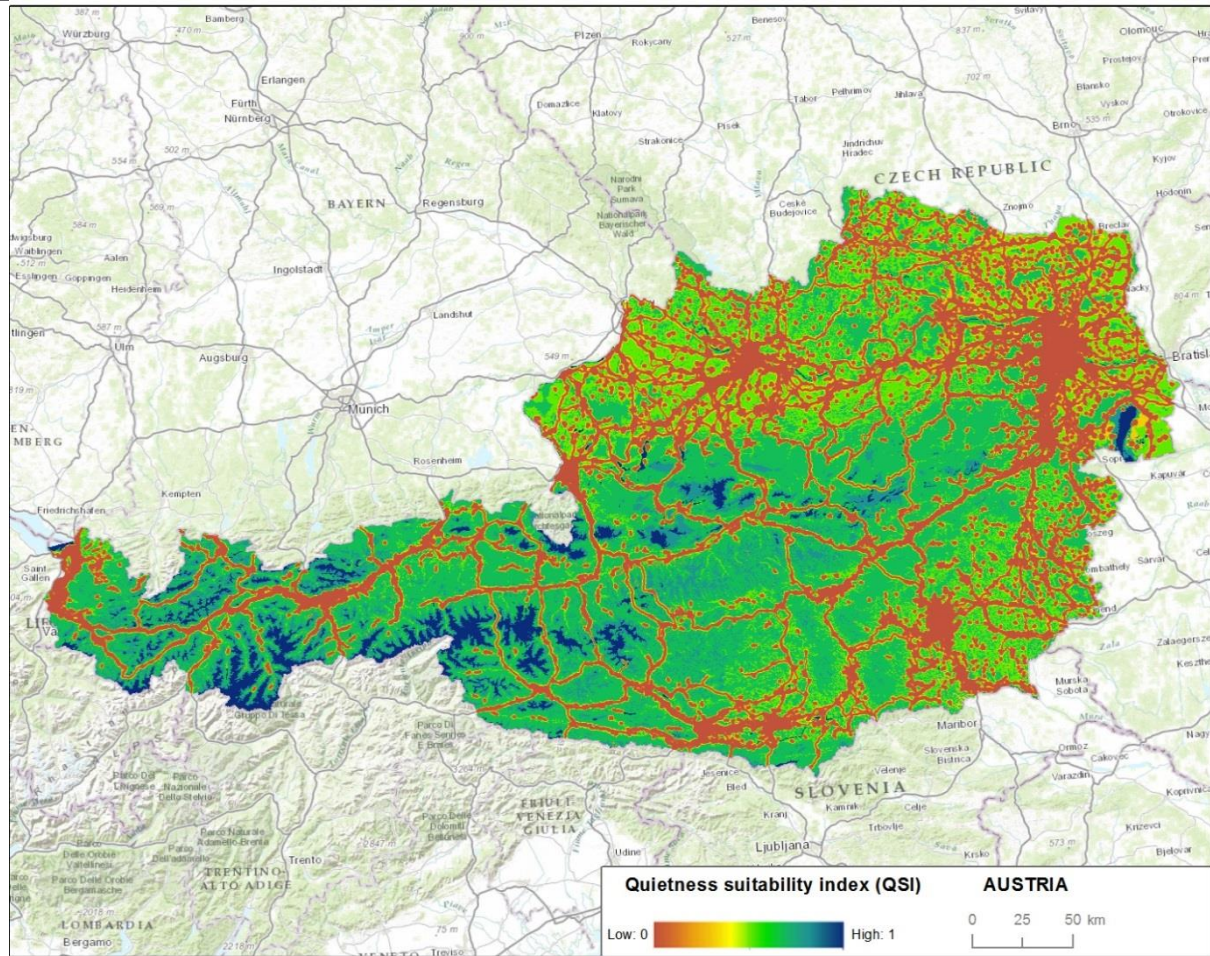
EEA-33

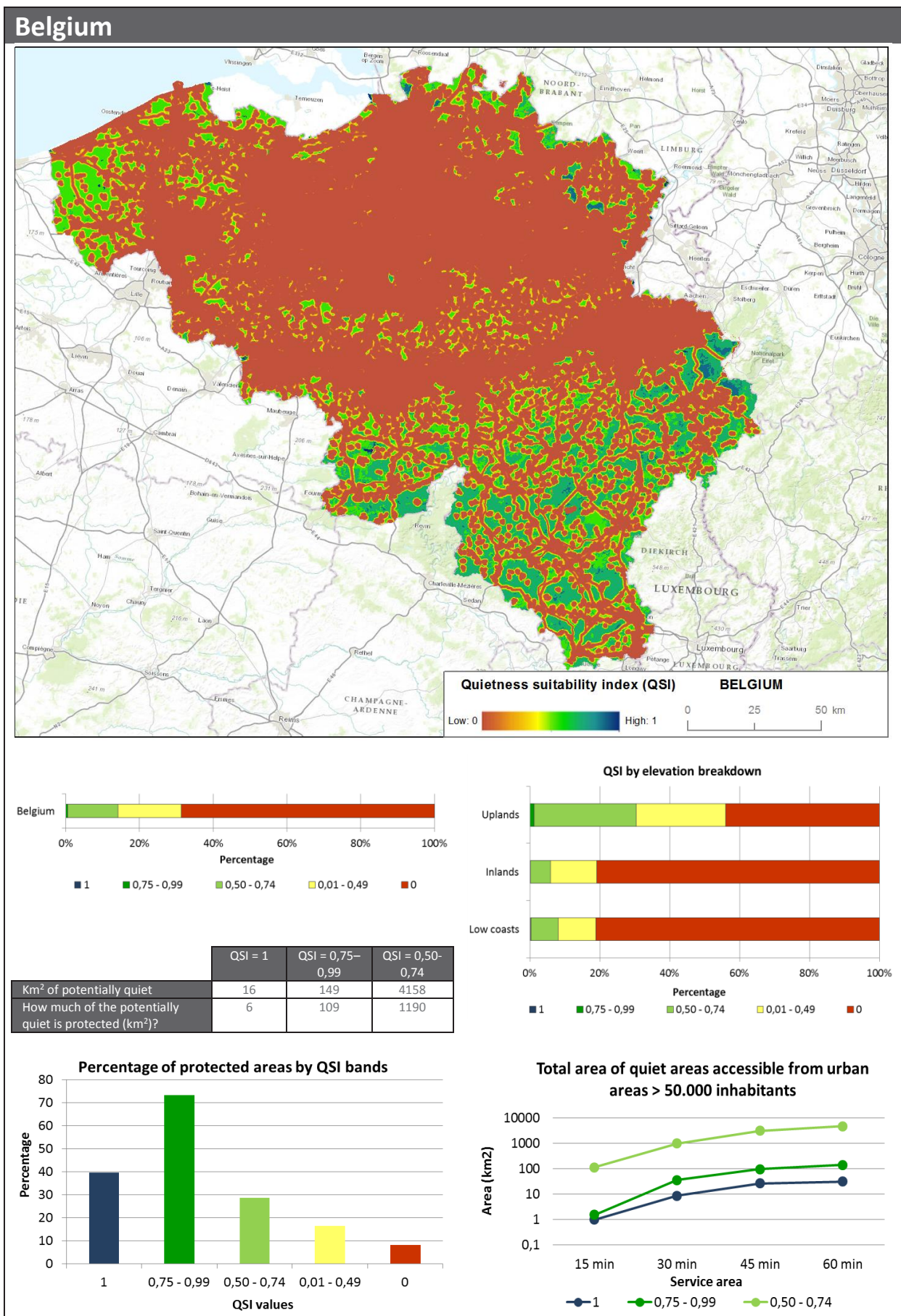


	QSI = 1	QSI = 0,75-0,99	QSI = 0,50-0,74
Km ² of potentially quiet	188905	685107	2322396
How much of the potentially quiet is protected (km ²)?	44003	163846	415219

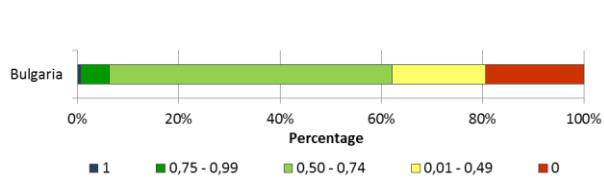
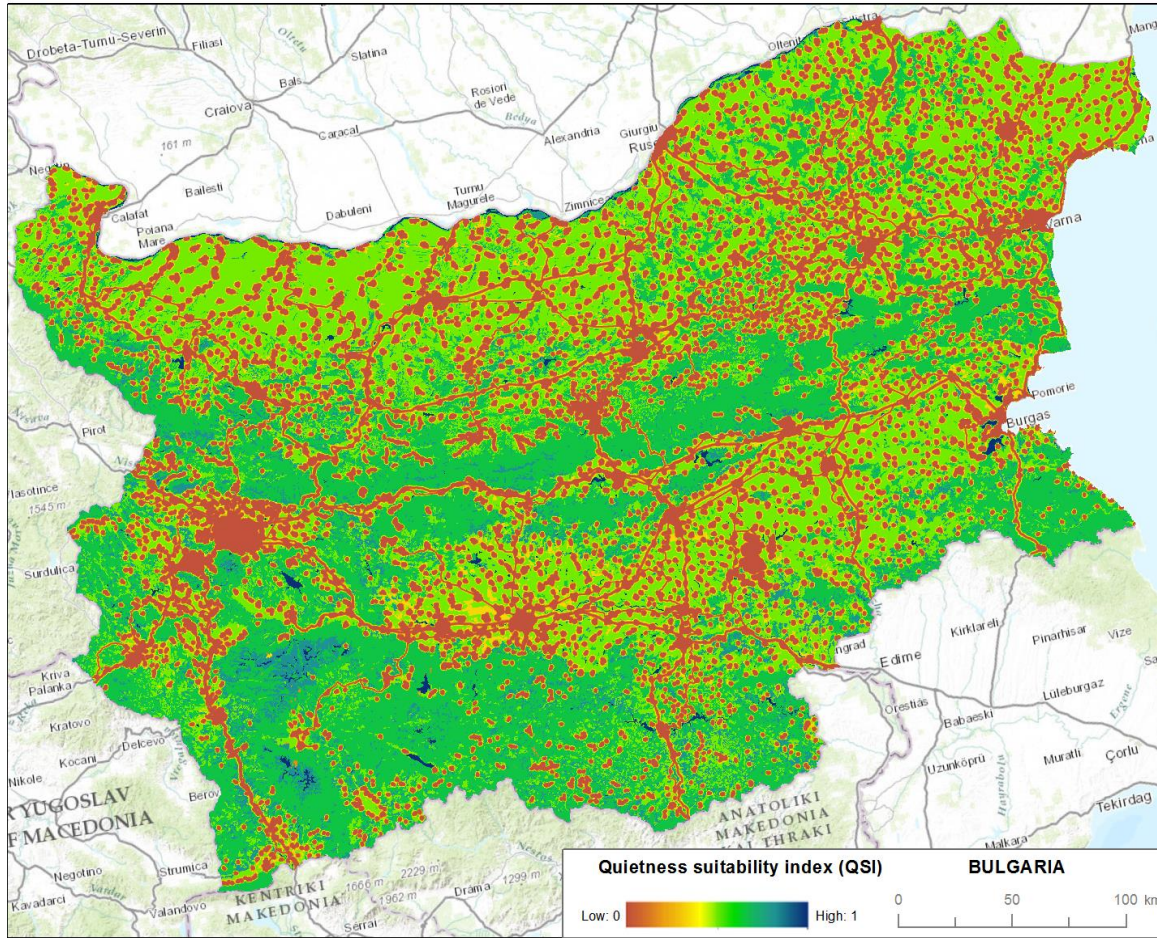


Austria

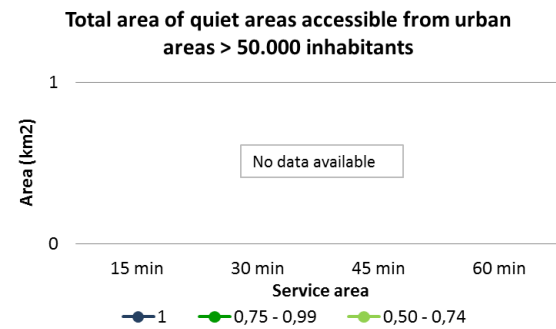
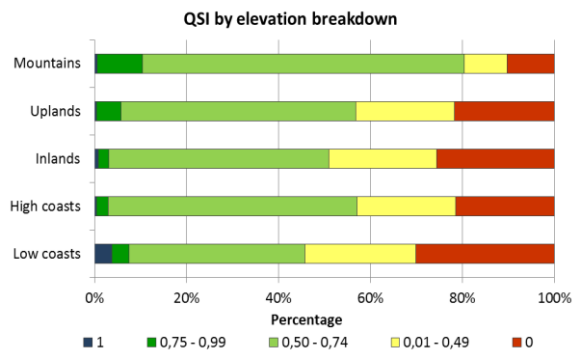
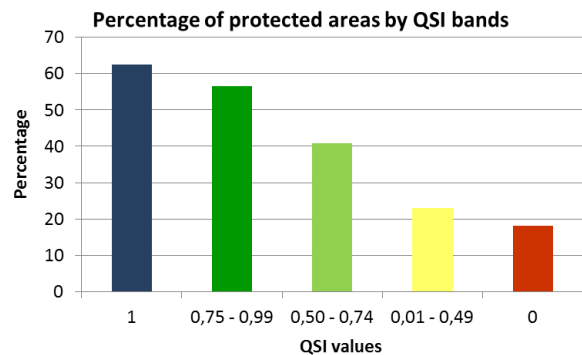


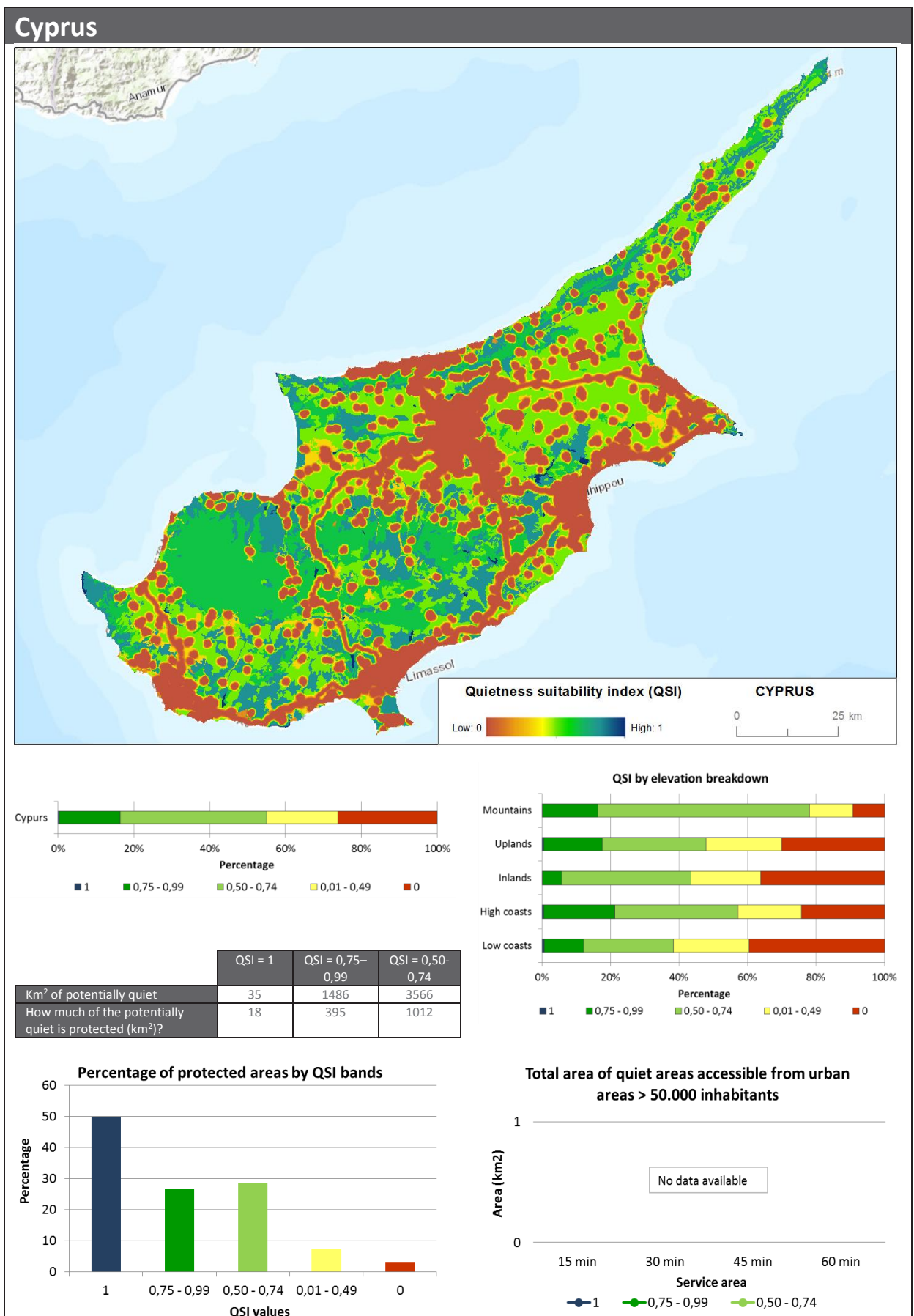


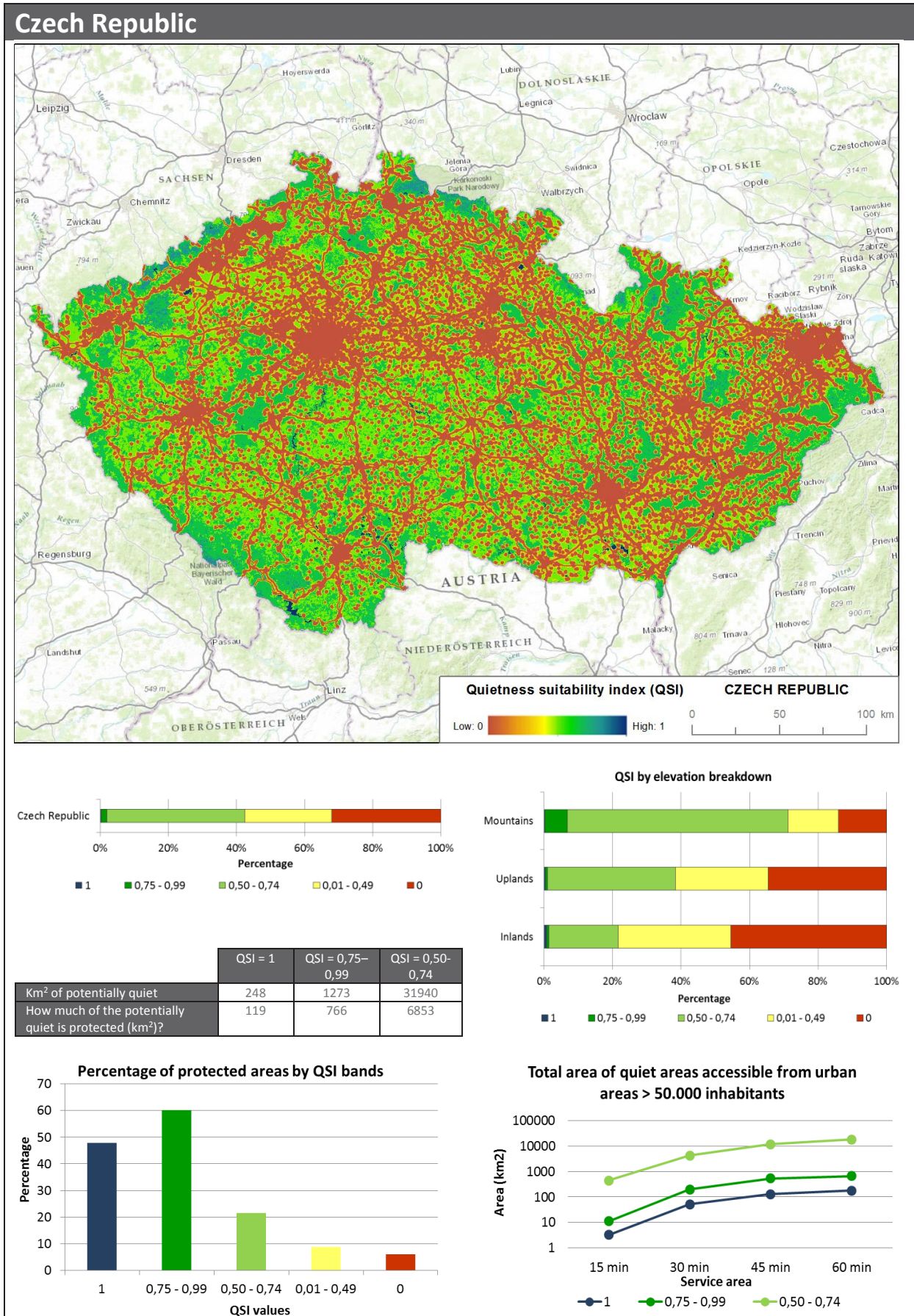
Bulgaria



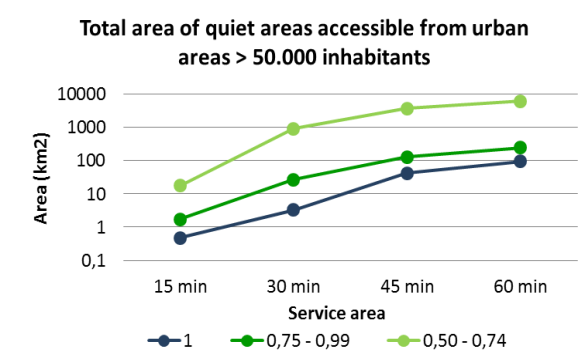
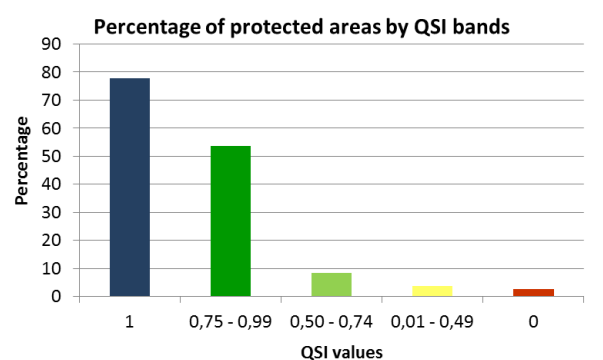
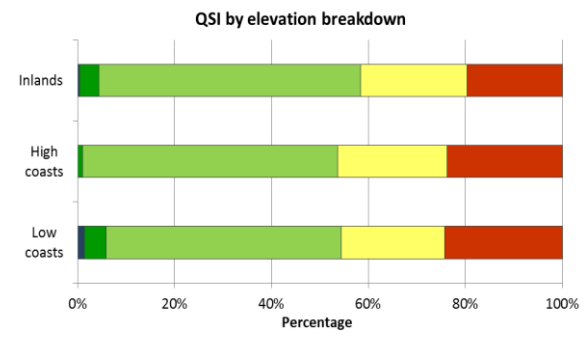
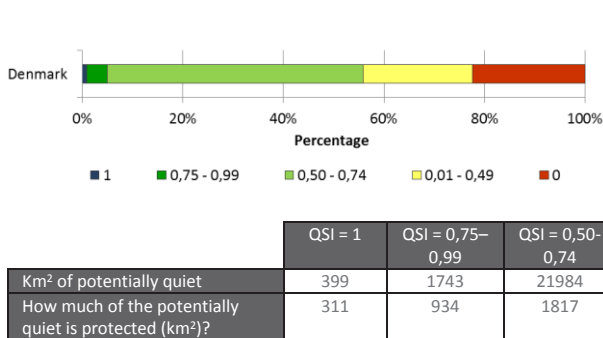
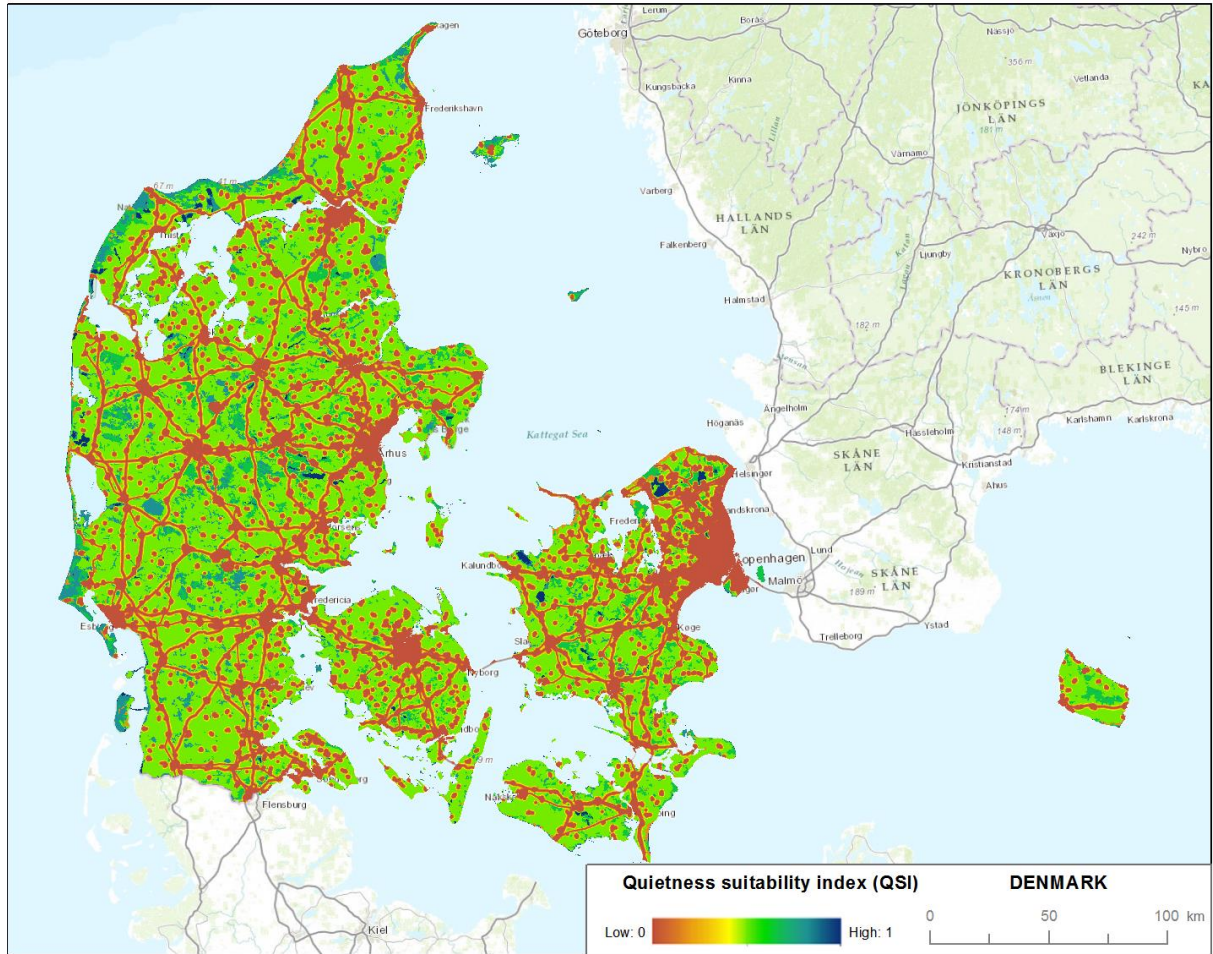
	QSI = 1	QSI = 0,75-0,99	QSI = 0,50-0,74
Km ² of potentially quiet	719	6335	61810
How much of the potentially quiet is protected (km ²)?	449	3577	25273



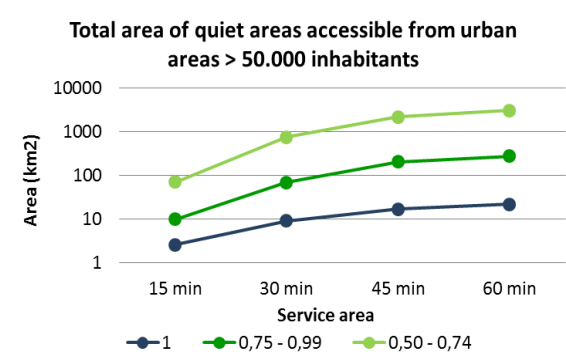
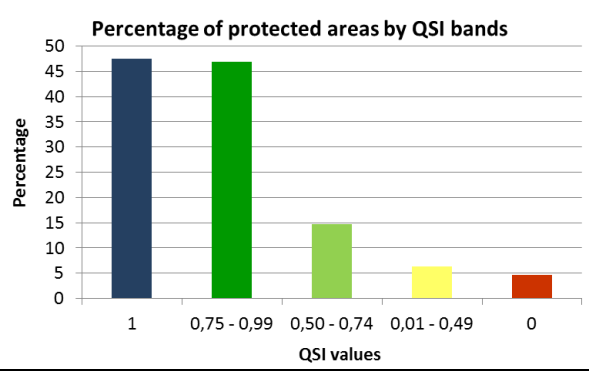
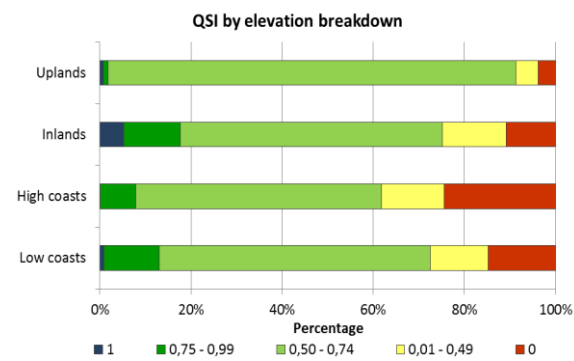
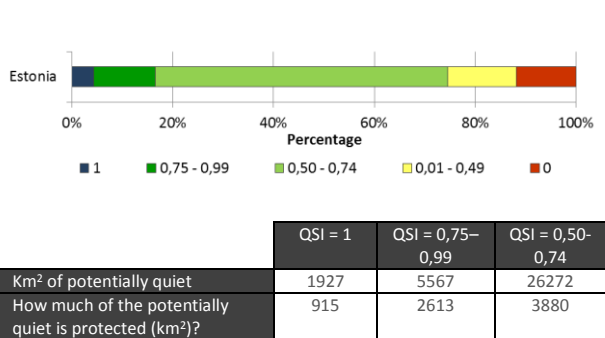
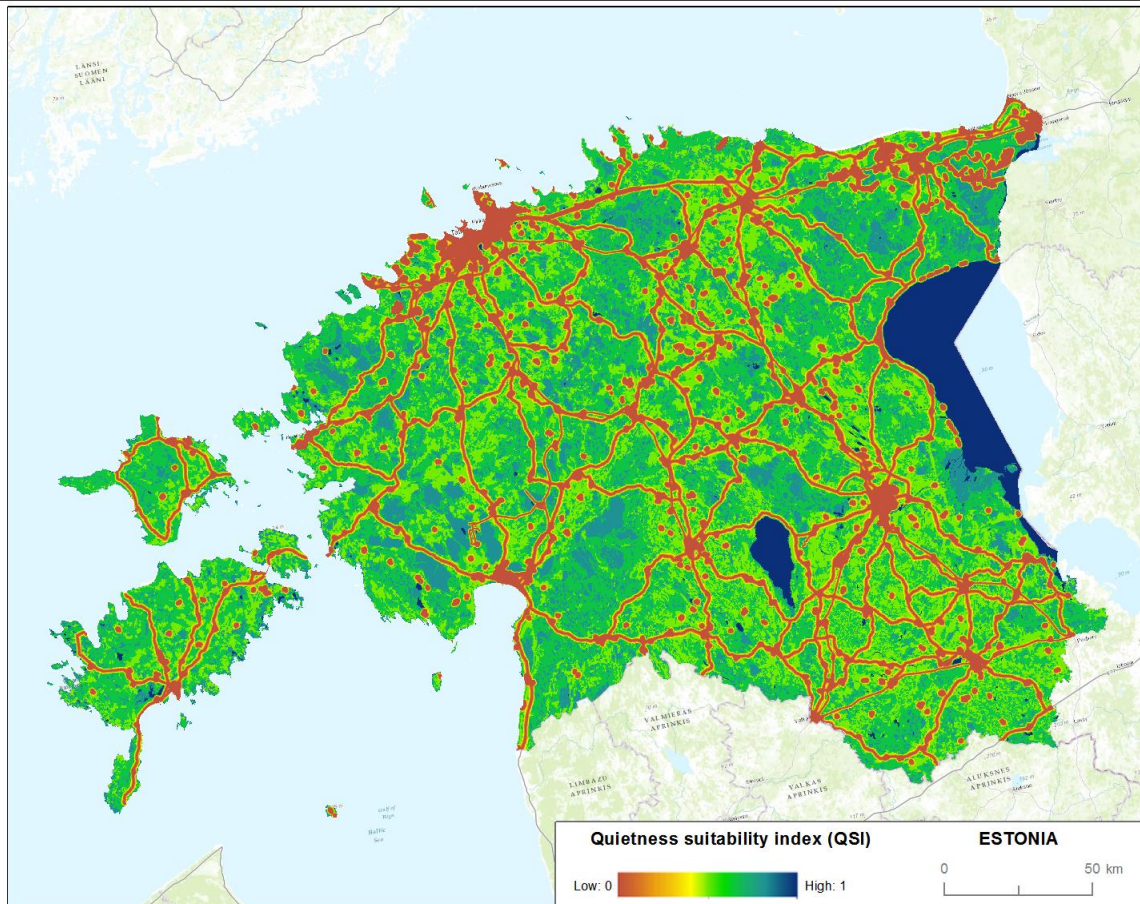




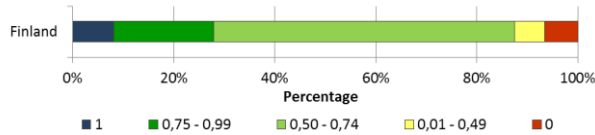
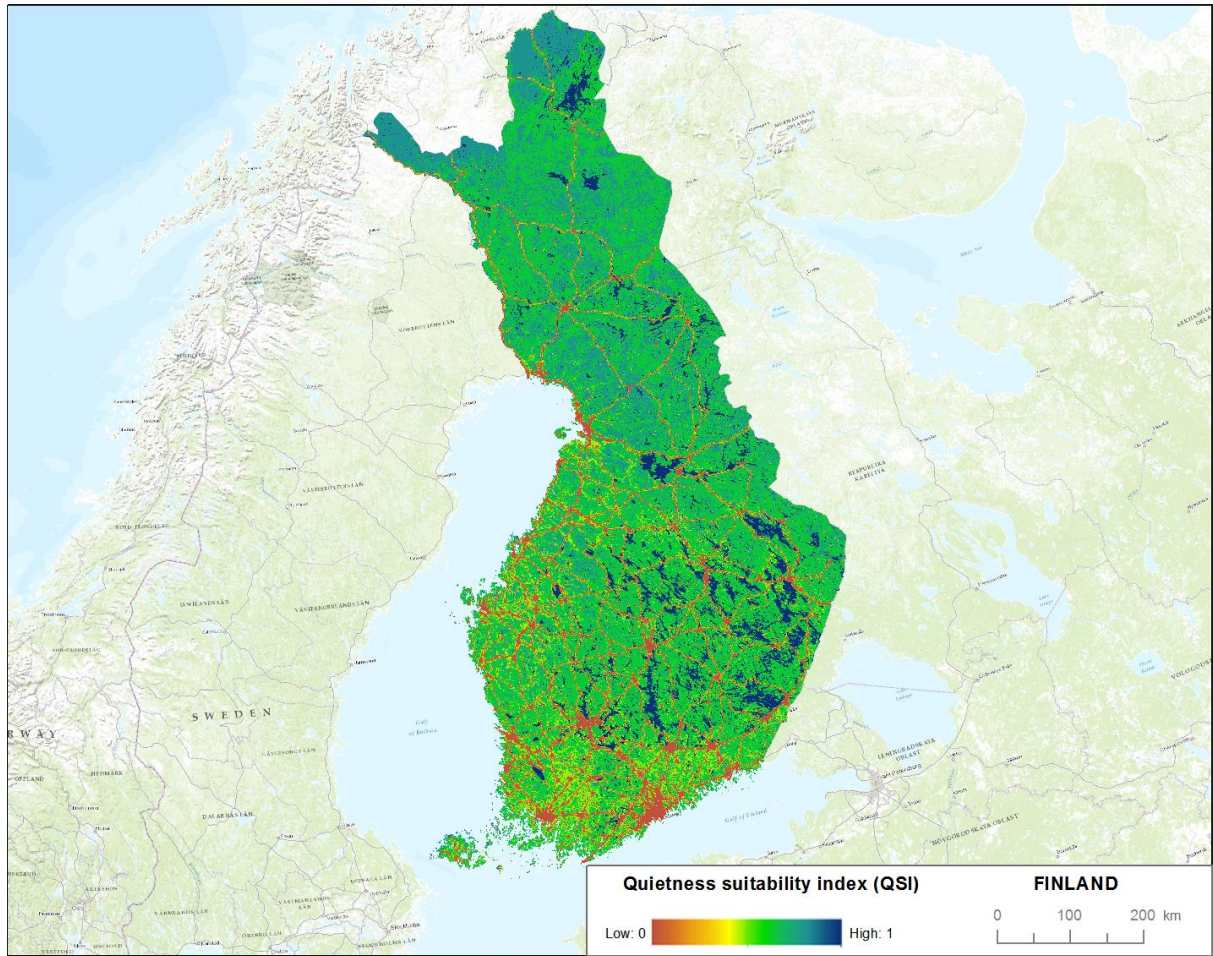
Denmark



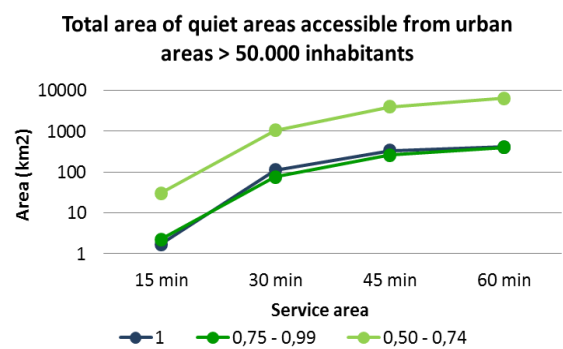
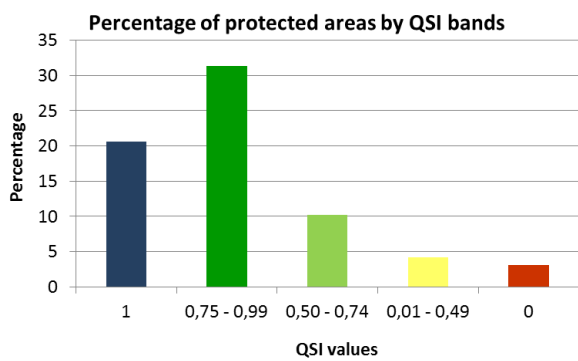
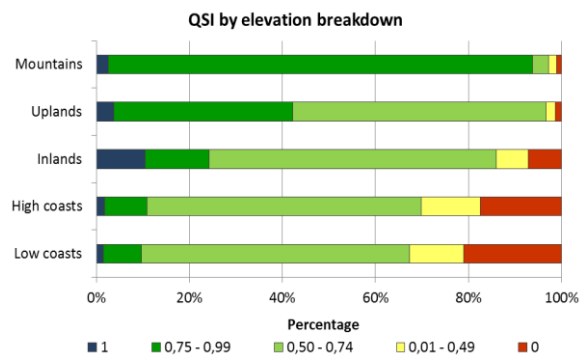
Estonia



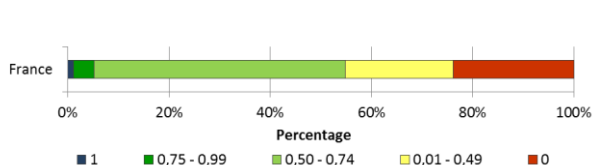
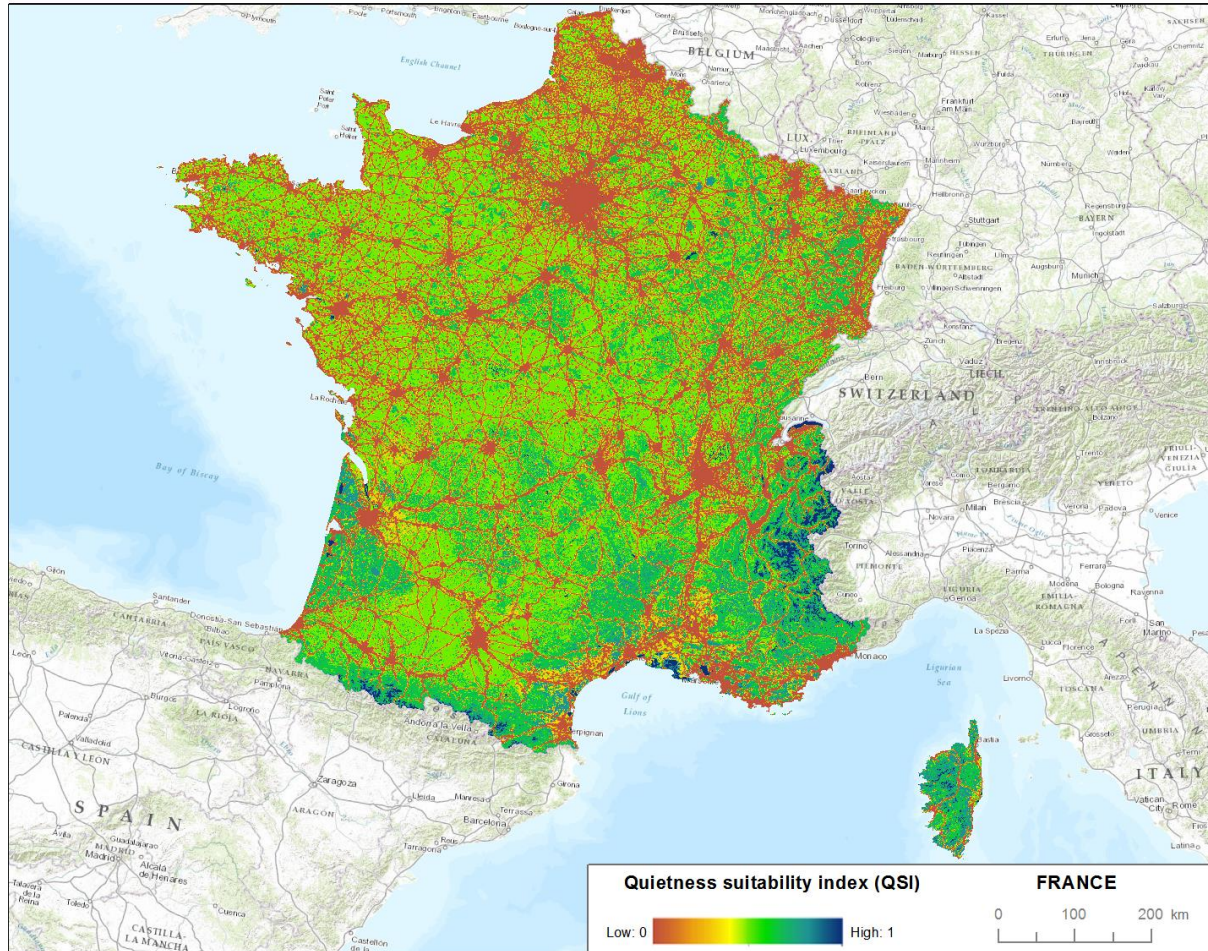
Finland



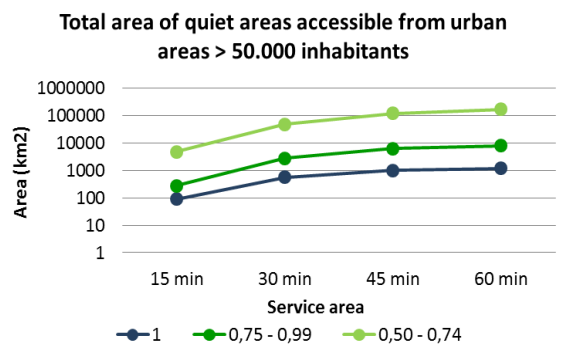
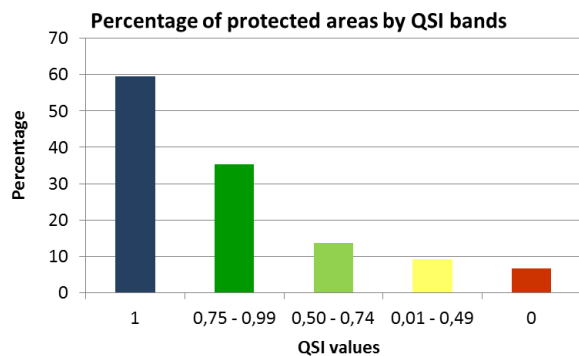
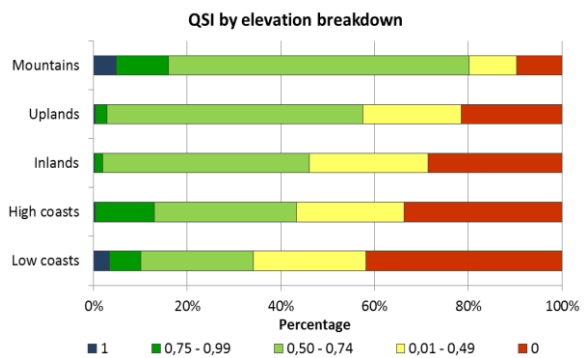
	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	27667	67153	201947
How much of the potentially quiet is protected (km ²)?	5690	21063	20705



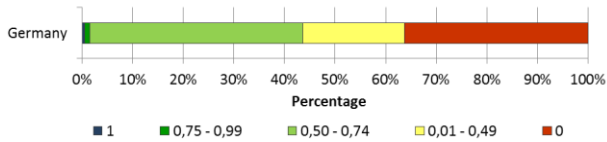
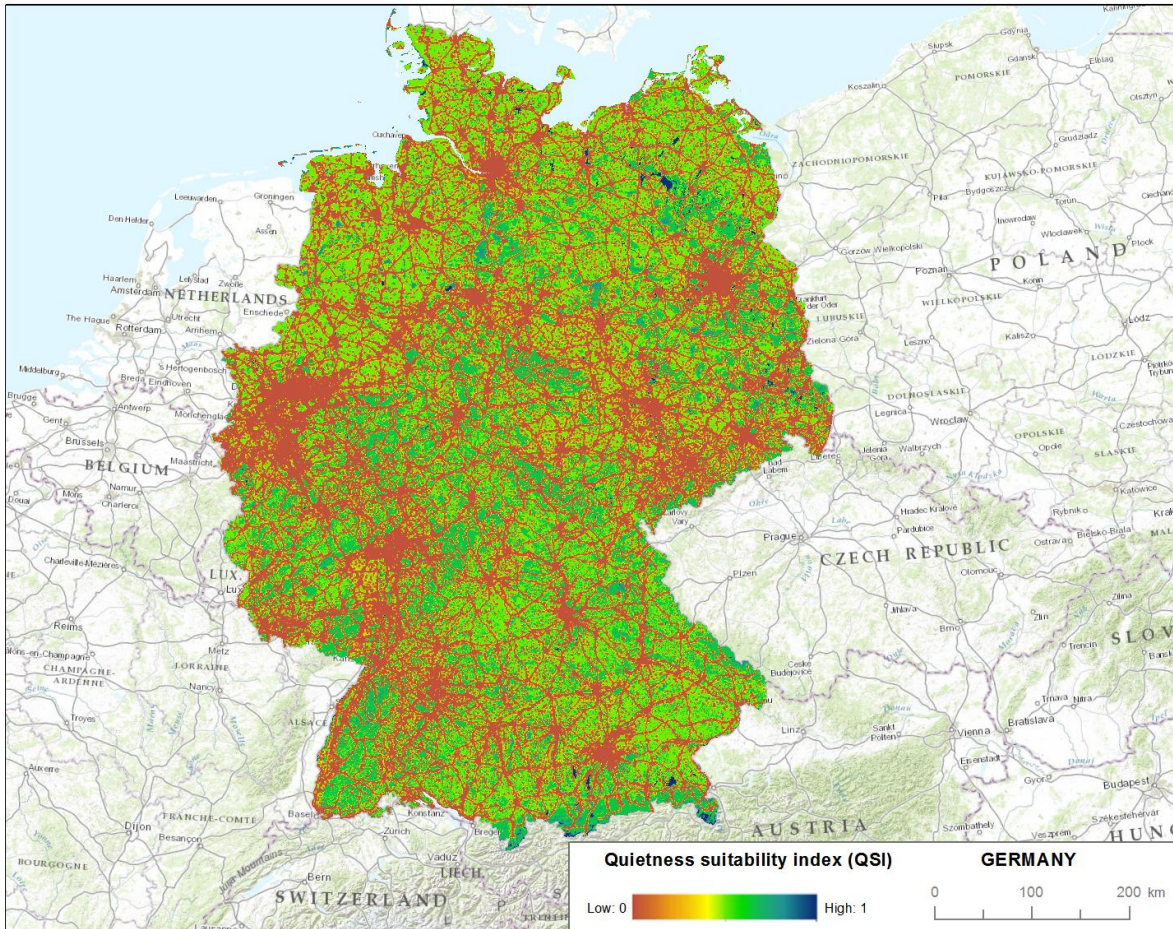
France



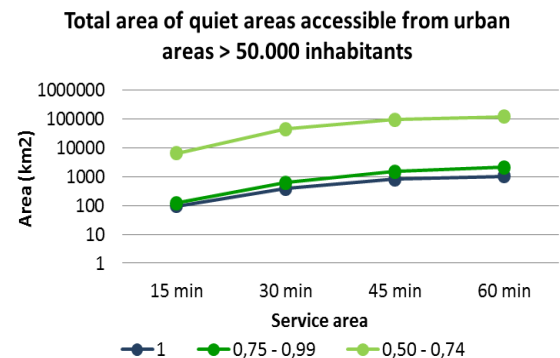
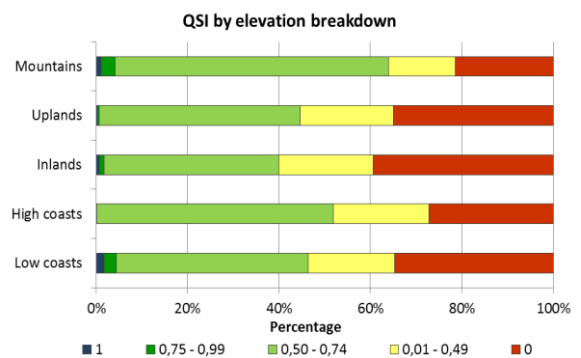
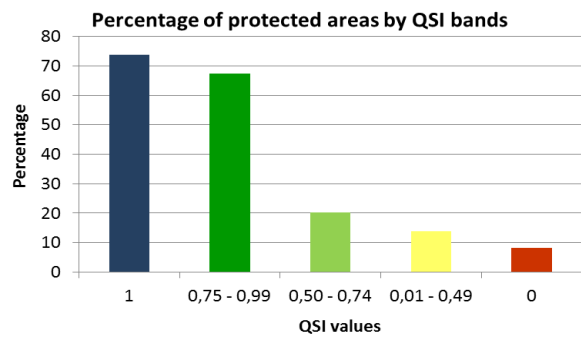
	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	6493	22155	272173
How much of the potentially quiet is protected (km ²)?	3860	7822	37464



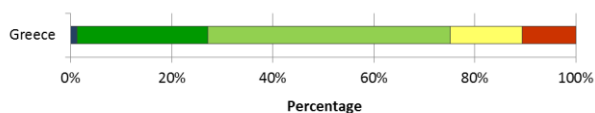
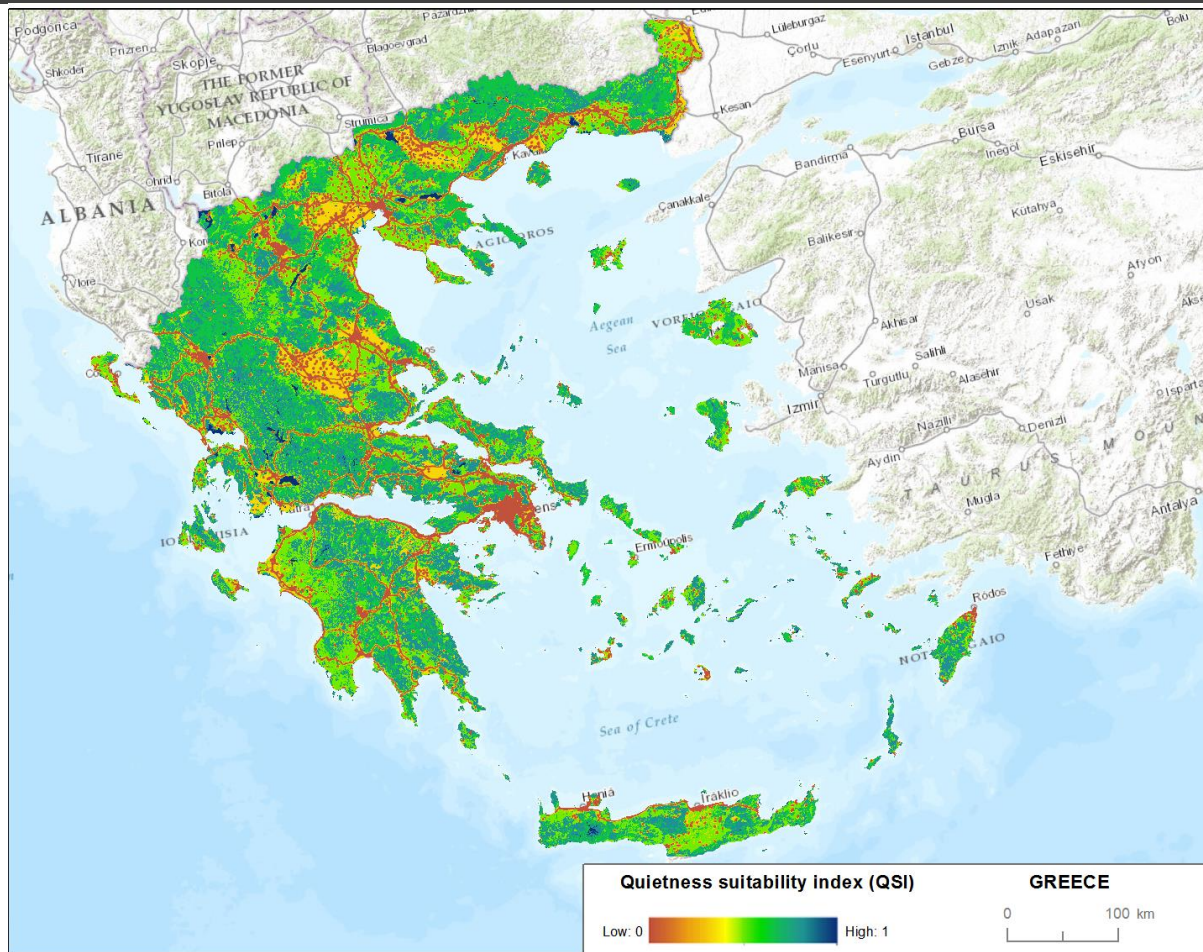
Germany



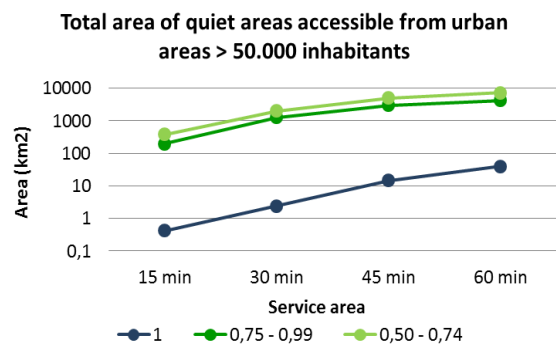
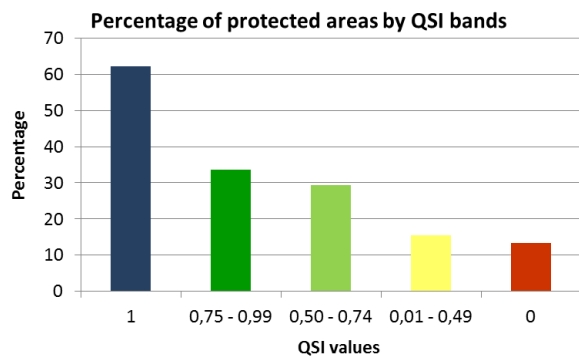
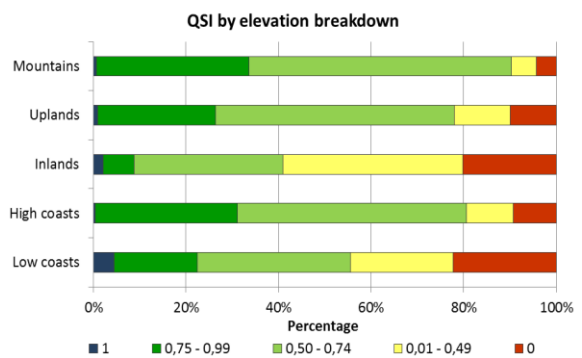
	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	1924	3419	150581
How much of the potentially quiet is protected (km ²)?	1419	2306	30571

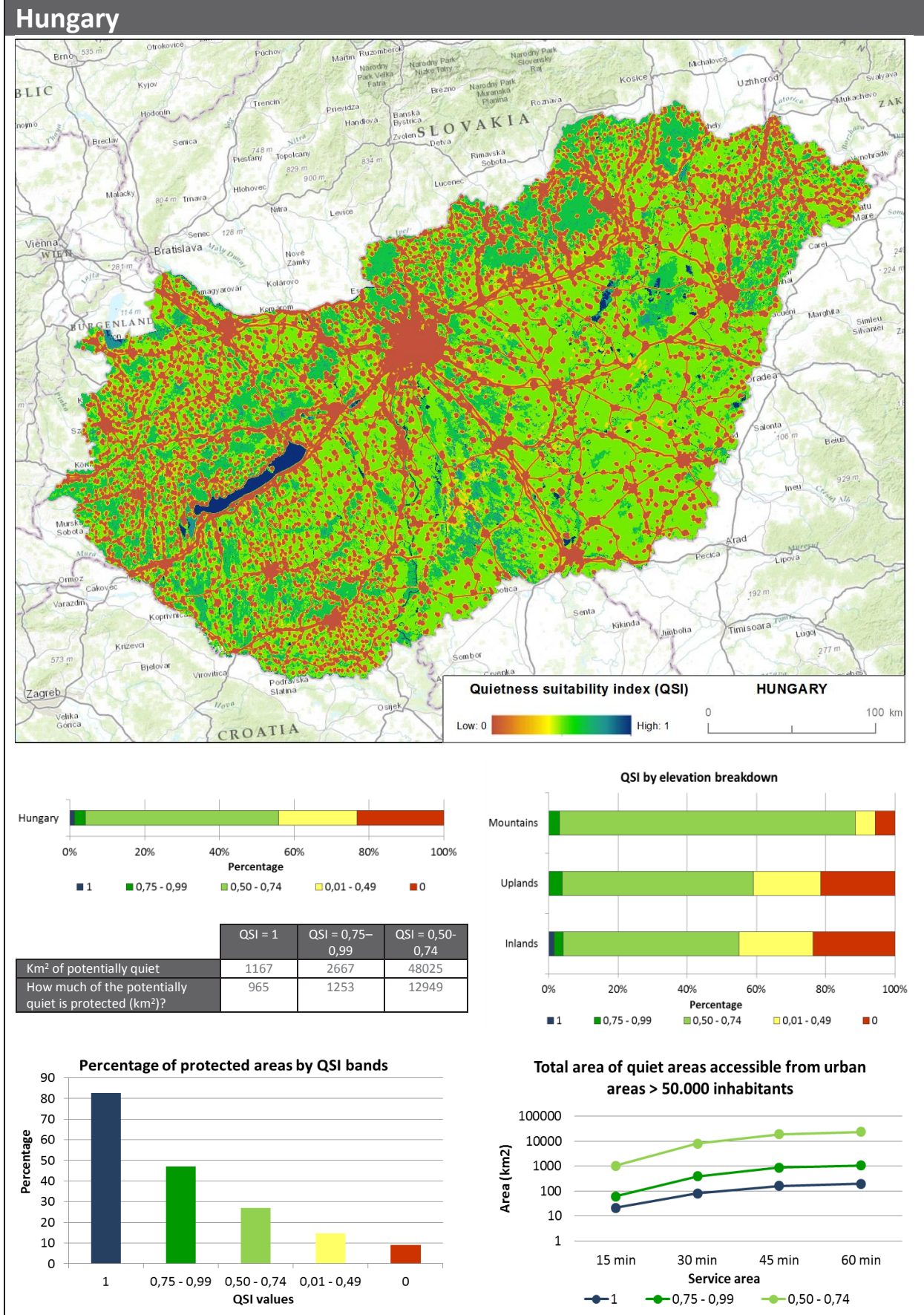


Greece

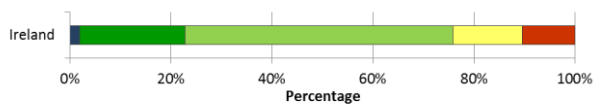
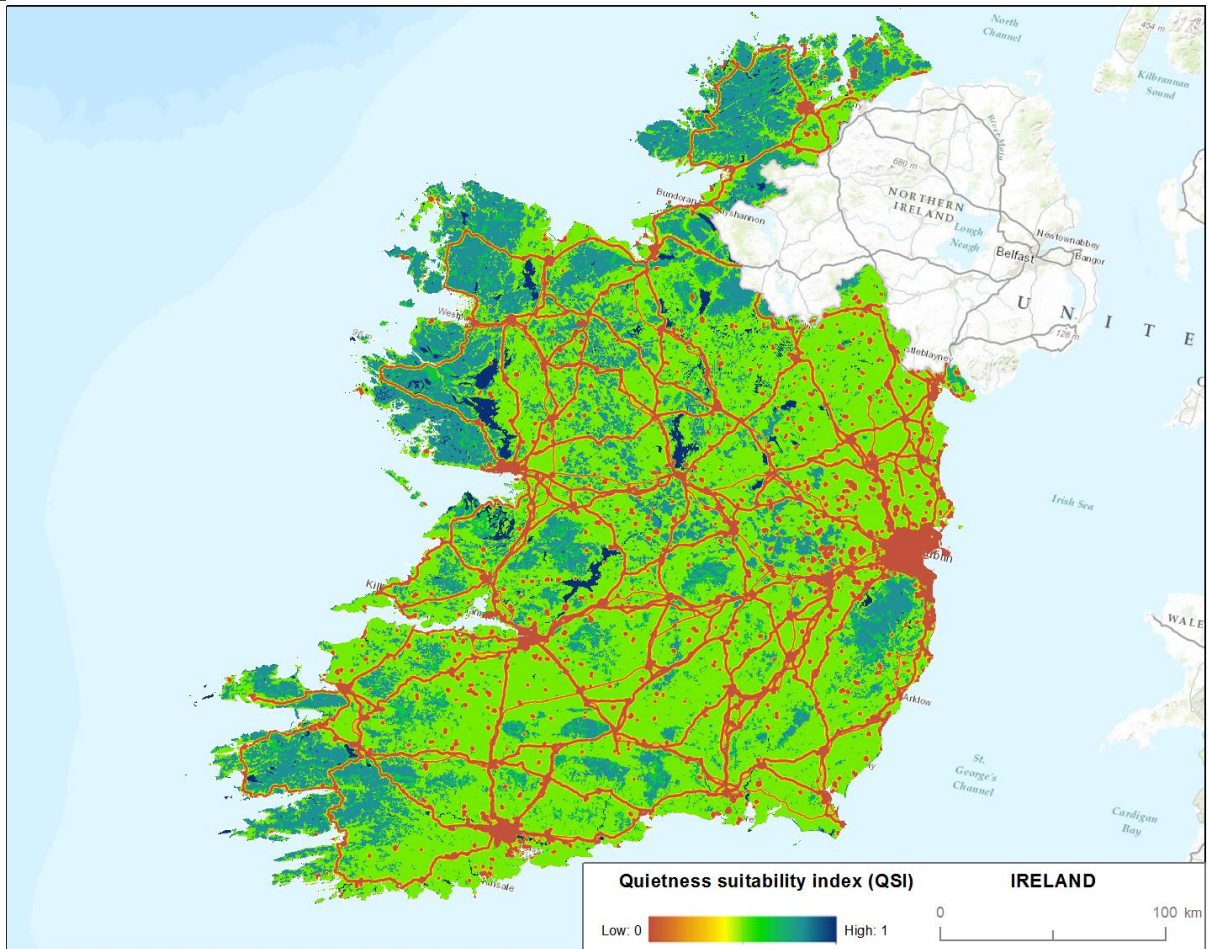


	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	1604	34225	63259
How much of the potentially quiet is protected (km ²)?	999	11499	18567

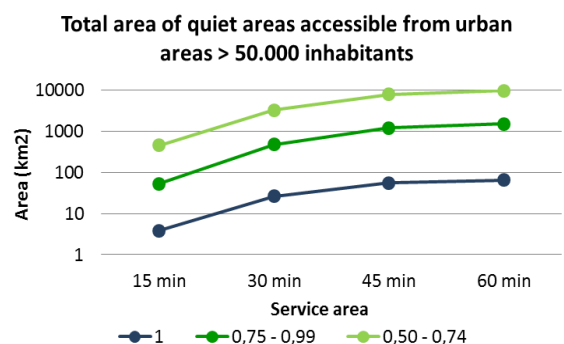
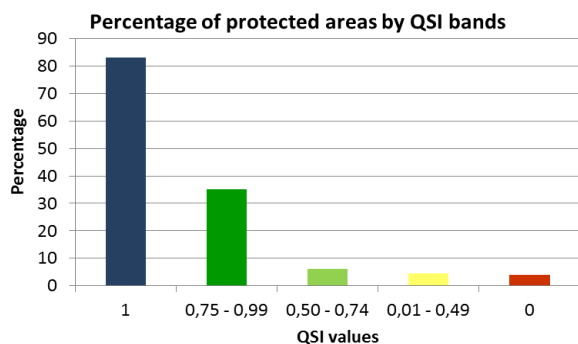
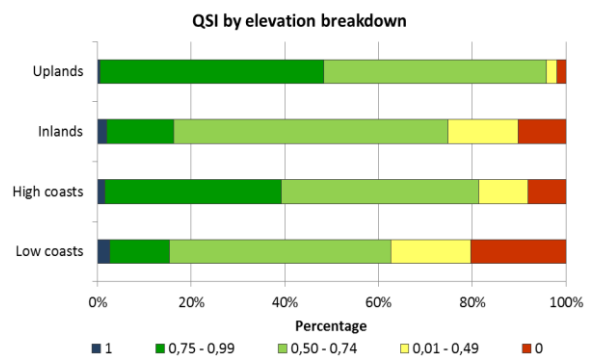


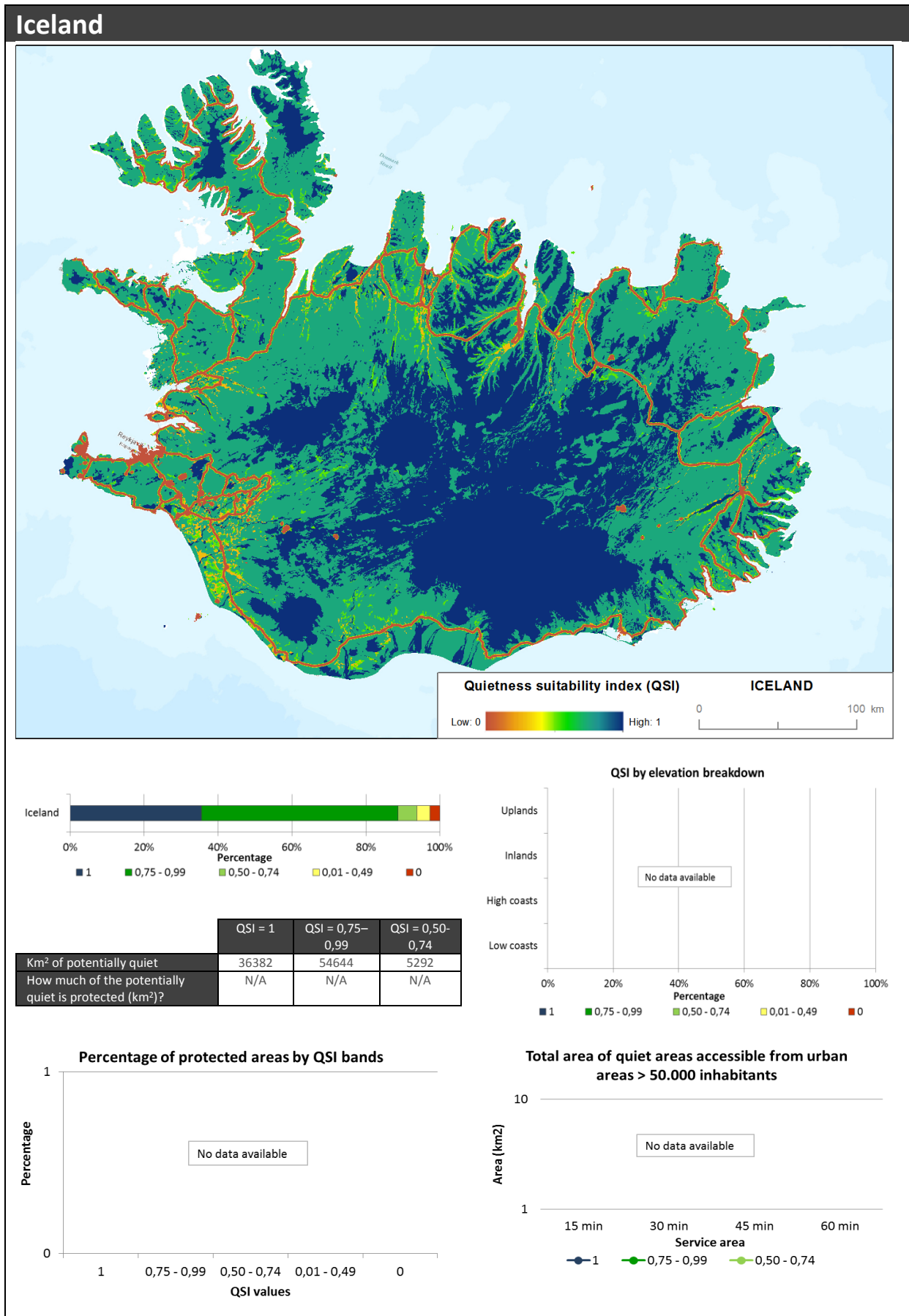


Ireland

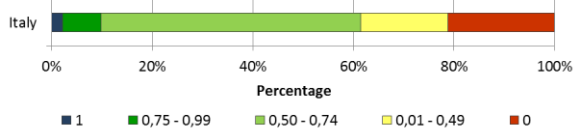
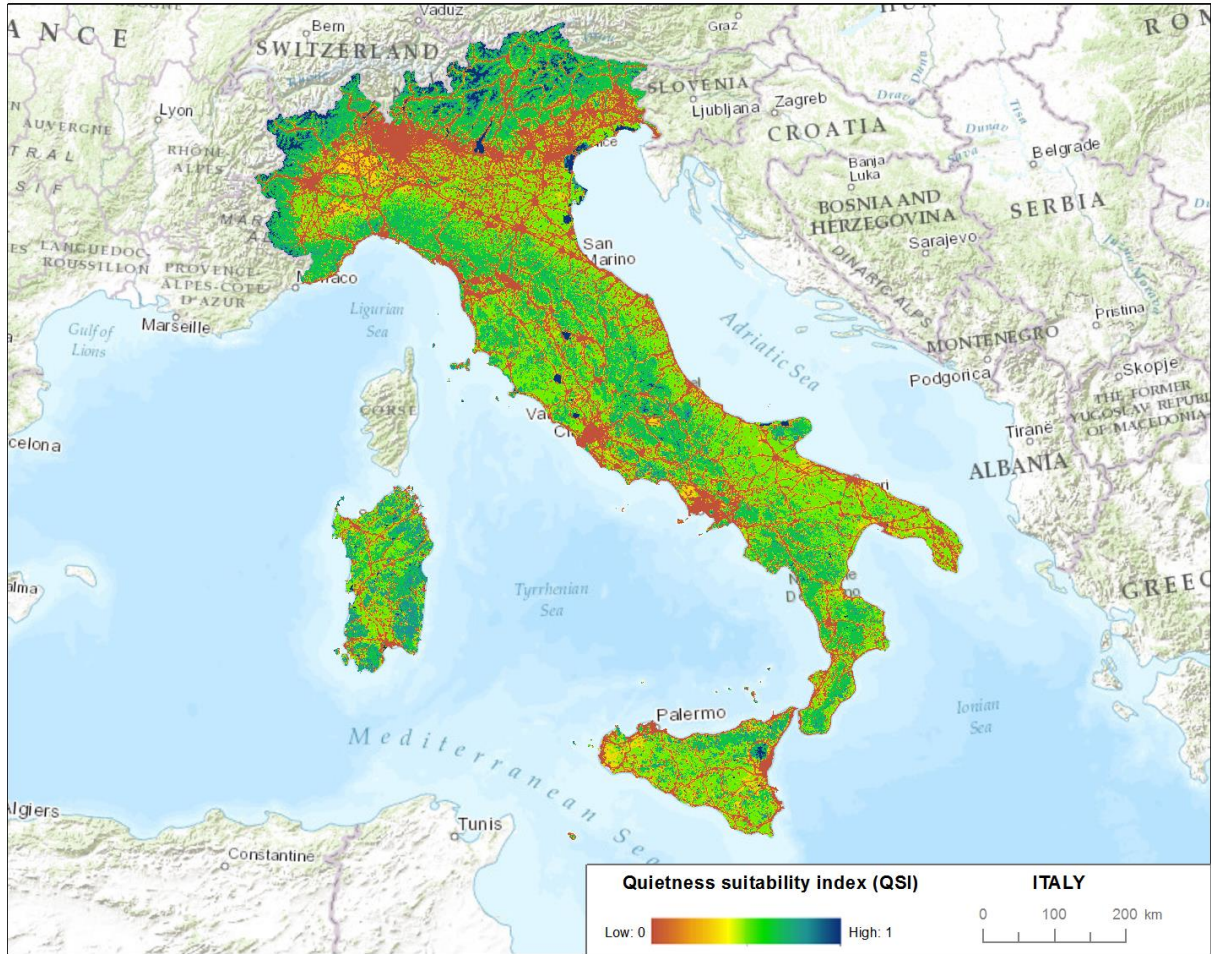


	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	1354	14528	37192
How much of the potentially quiet is protected (km ²)?	1125	5091	2307

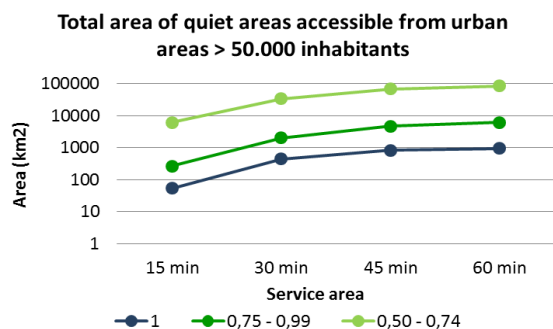
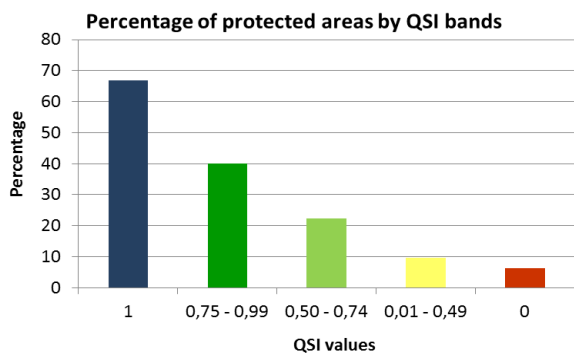
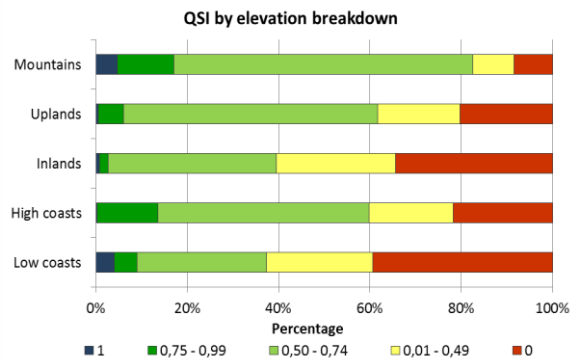




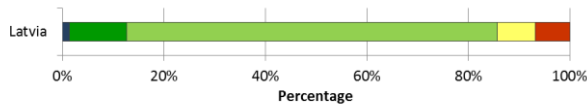
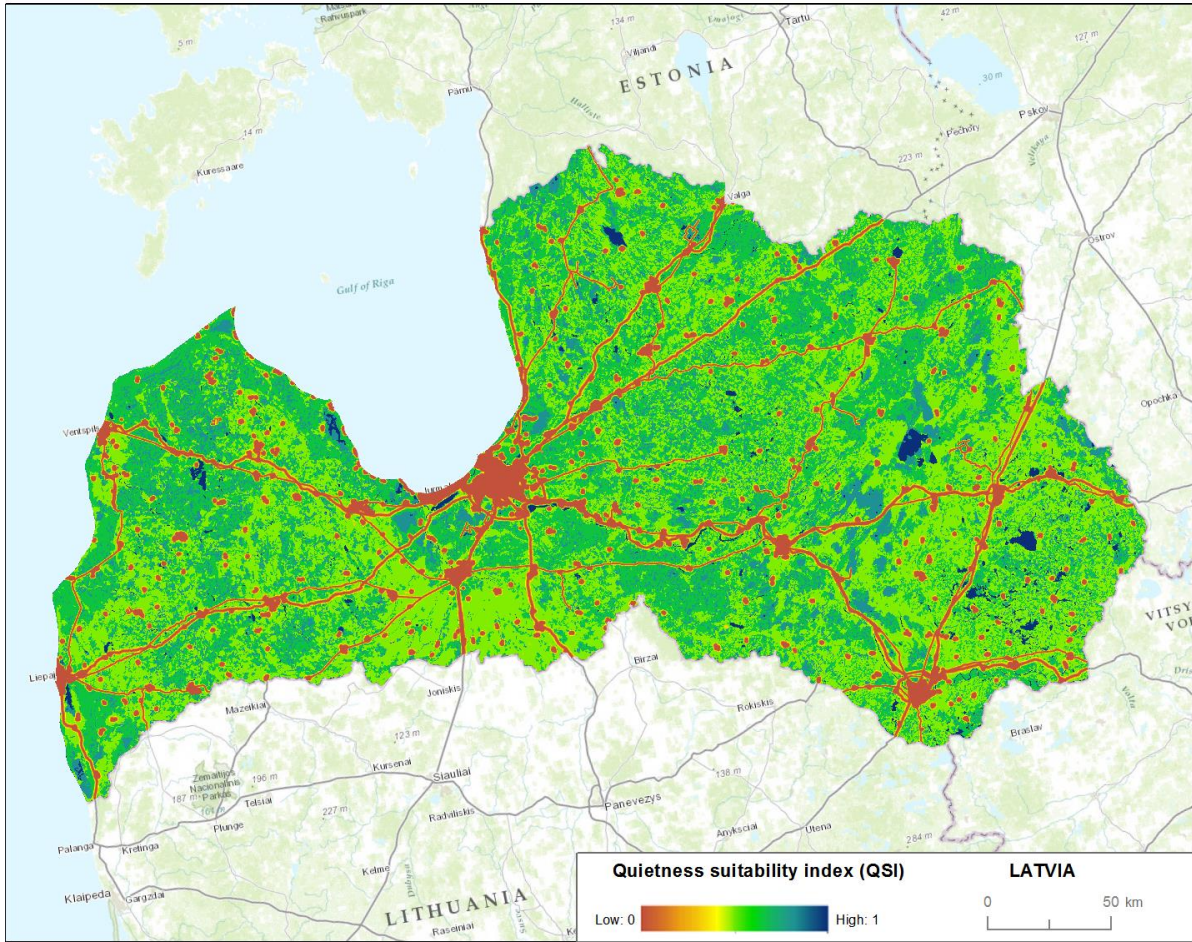
Italy



	QSI = 1	QSI = 0,75-0,99	QSI = 0,50-0,74
Km ² of potentially quiet	6780	23101	155391
How much of the potentially quiet is protected (km ²)?	4537	9236	34875

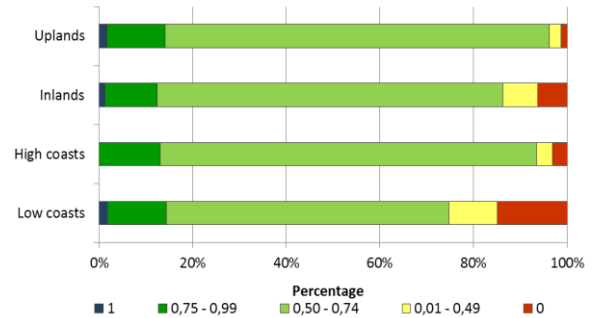


Latvia

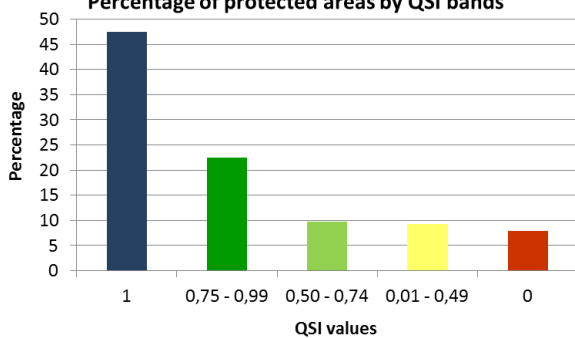


	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	898	7277	47152
How much of the potentially quiet is protected (km ²)?	426	1640	4576

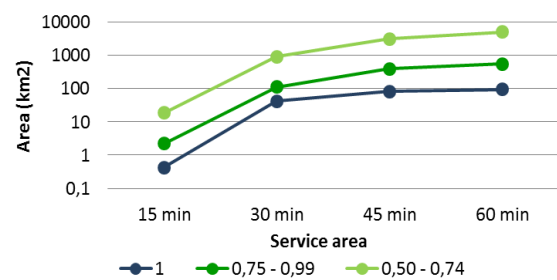
QSI by elevation breakdown



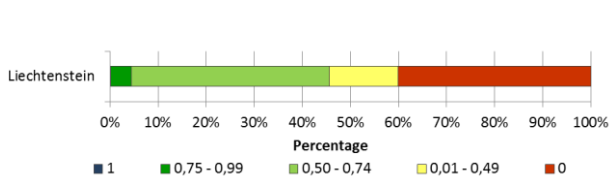
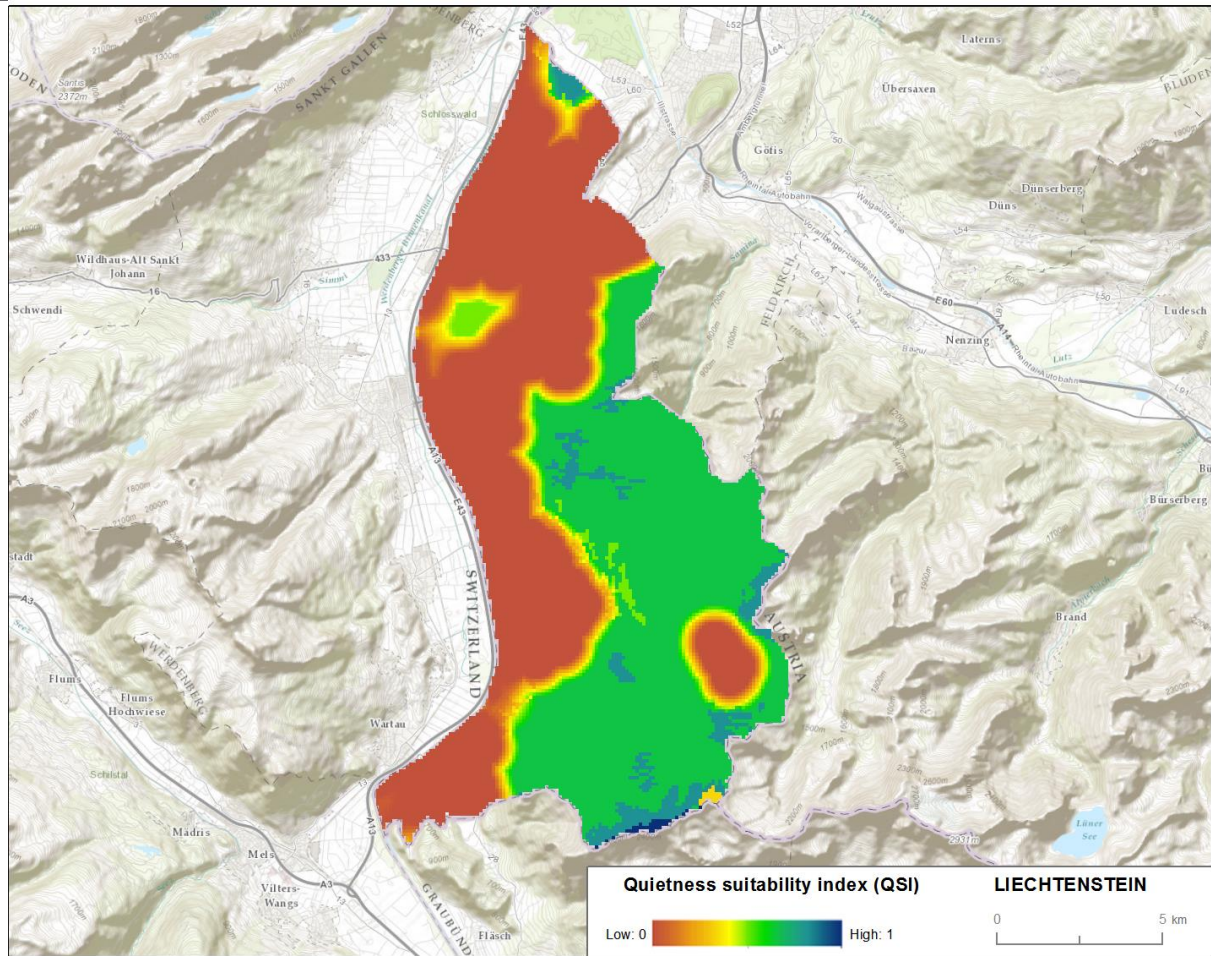
Percentage of protected areas by QSI bands



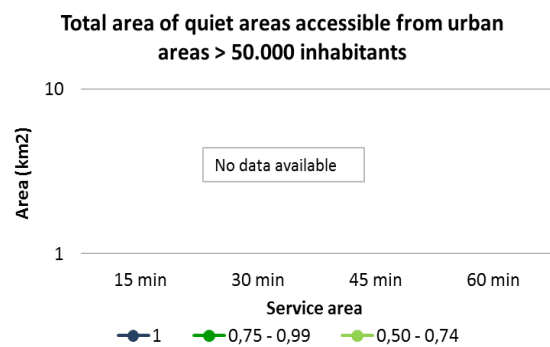
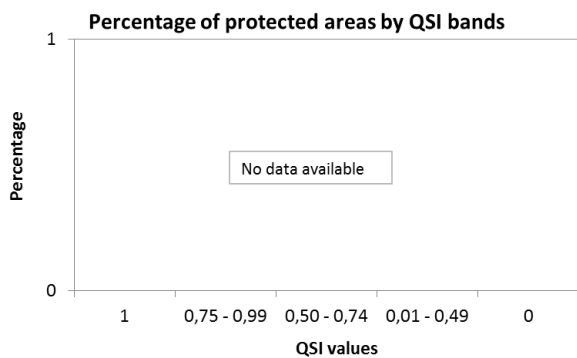
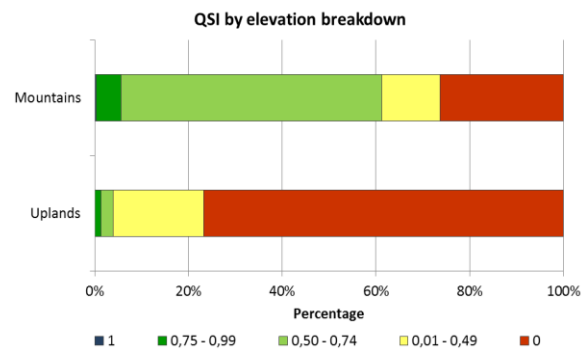
Total area of quiet areas accessible from urban areas > 50.000 inhabitants

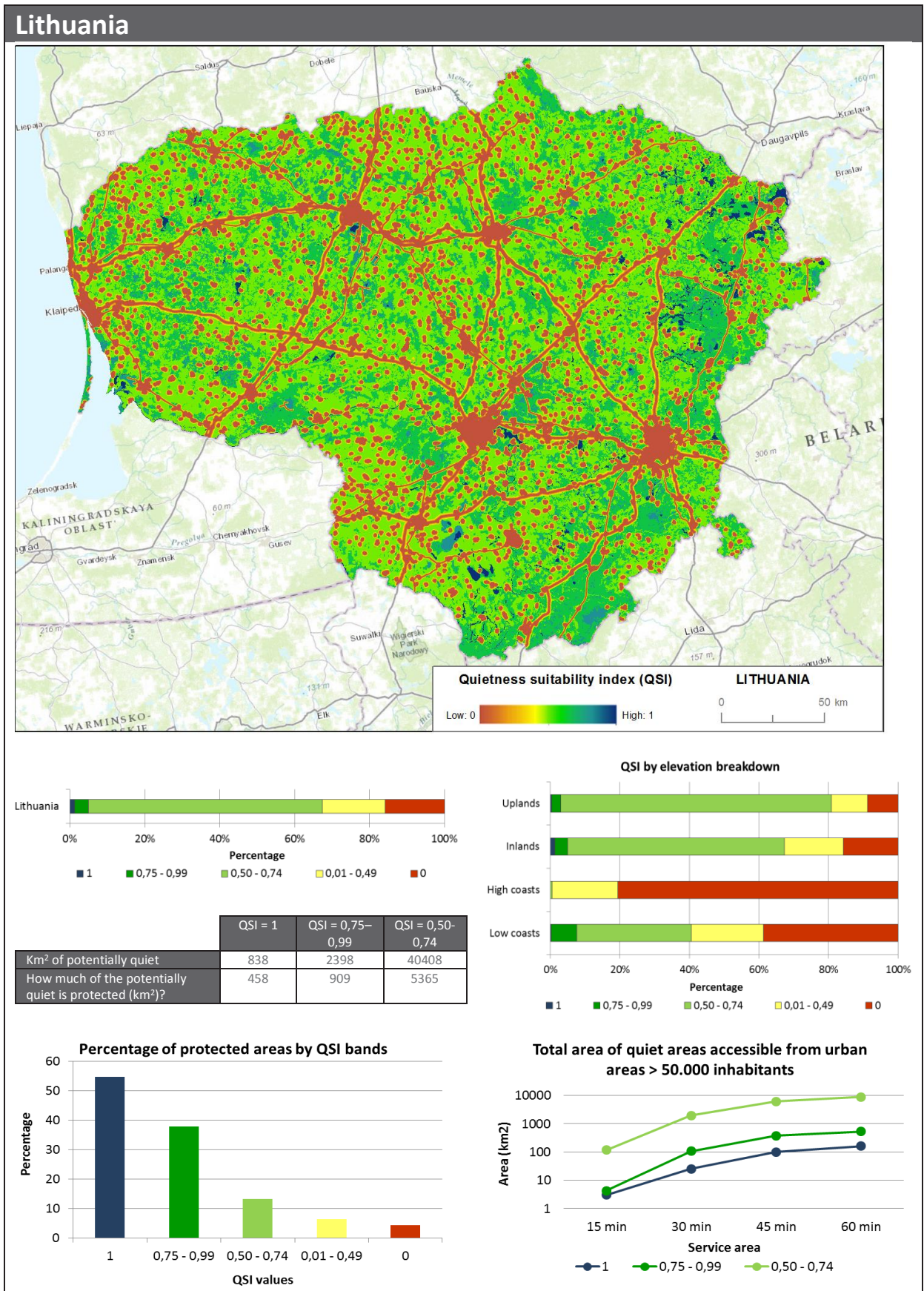


Liechtenstein

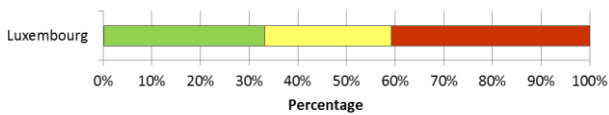
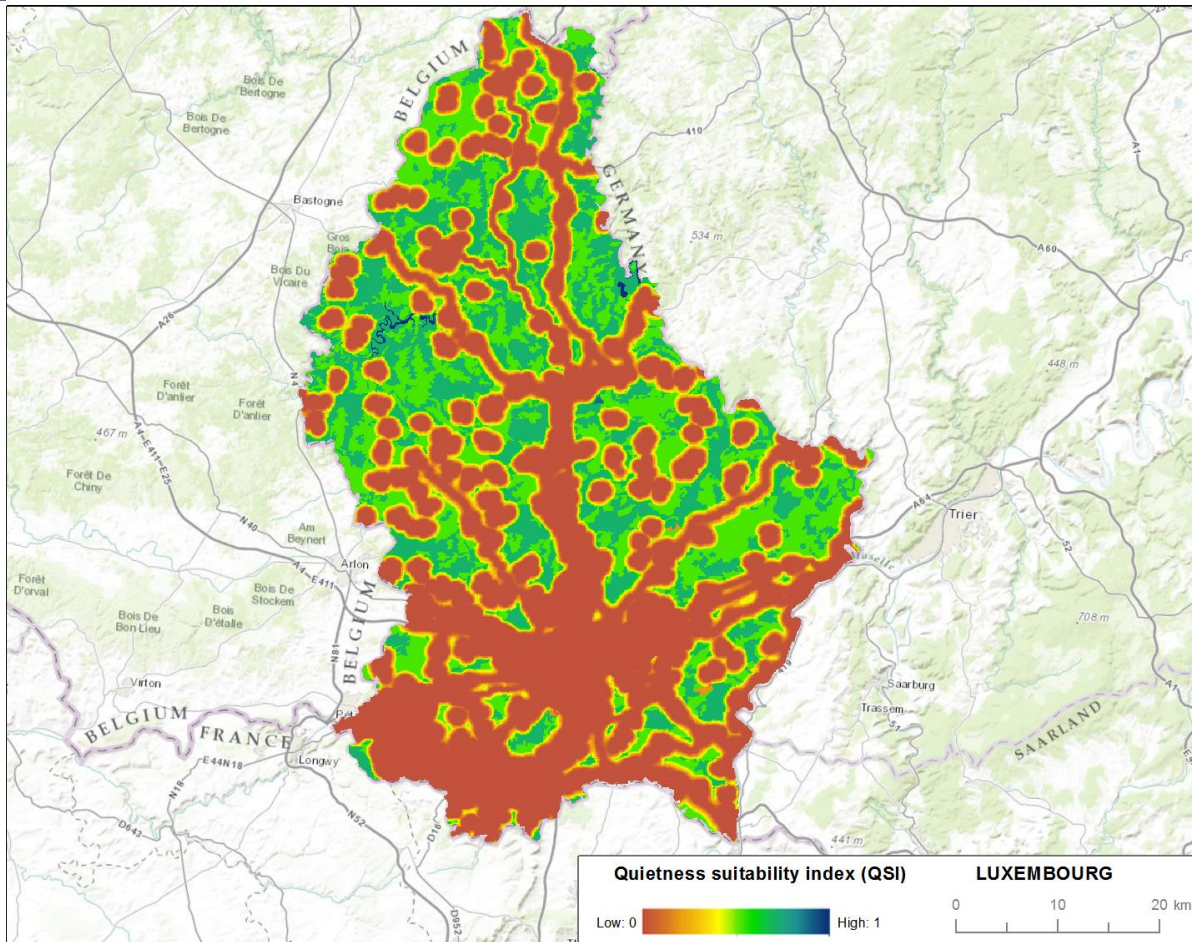


	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	0	7	66
How much of the potentially quiet is protected (km ²)?	N/A	N/A	N/A



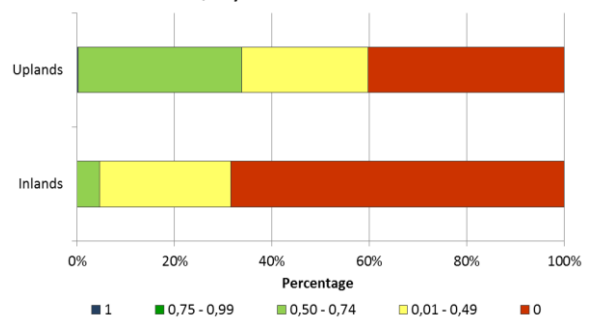


Luxembourg

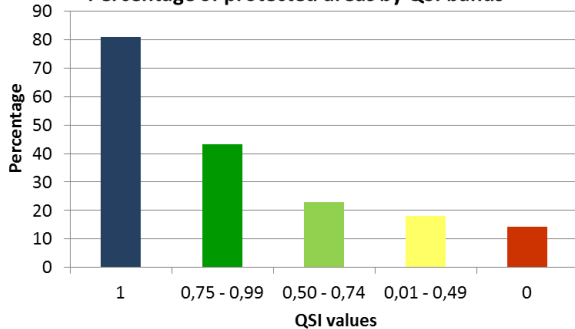


	QSI = 1	QSI = 0,75-0,99	QSI = 0,50-0,74
Km ² of potentially quiet	4	1	857
How much of the potentially quiet is protected (km ²)?	3	0	196

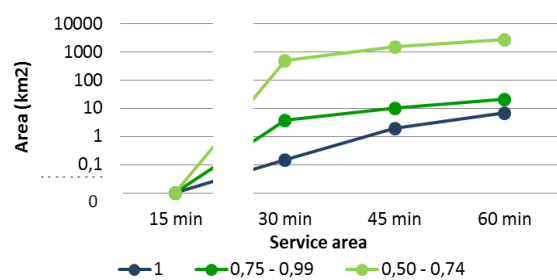
QSI by elevation breakdown



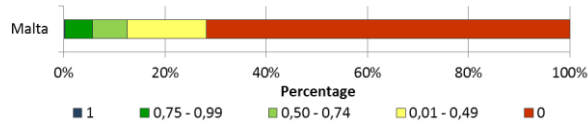
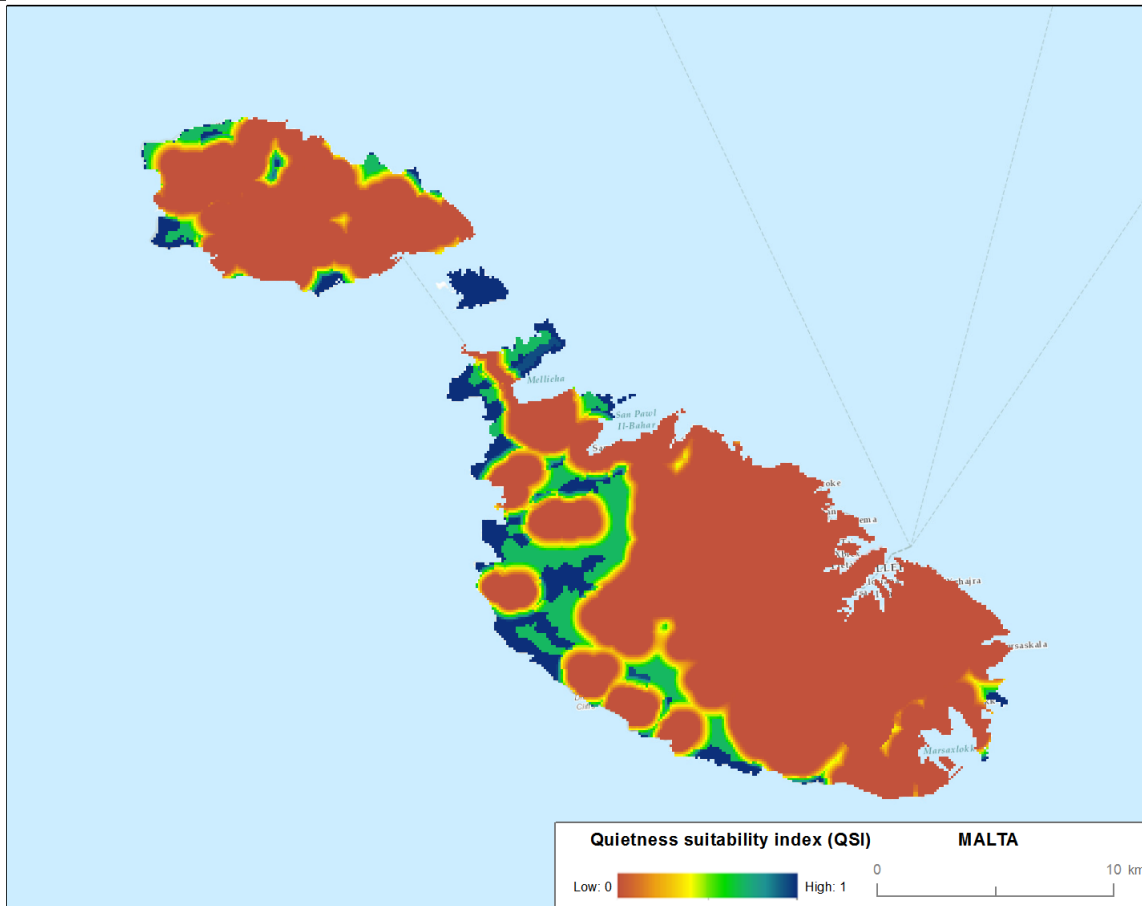
Percentage of protected areas by QSI bands



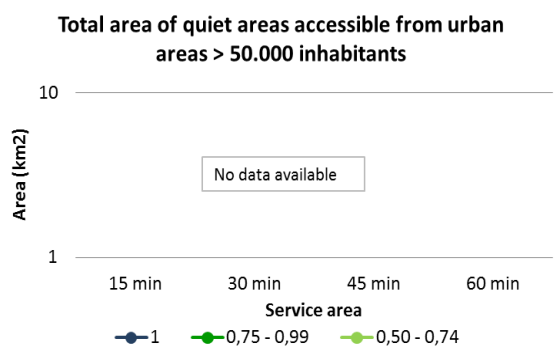
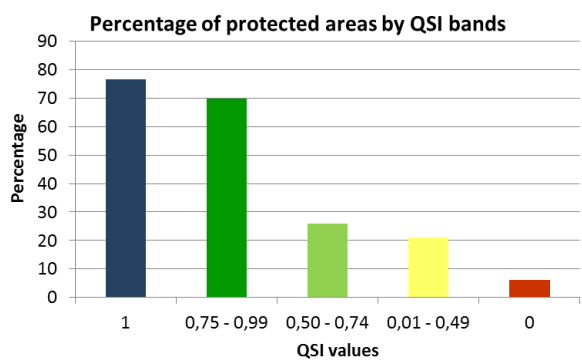
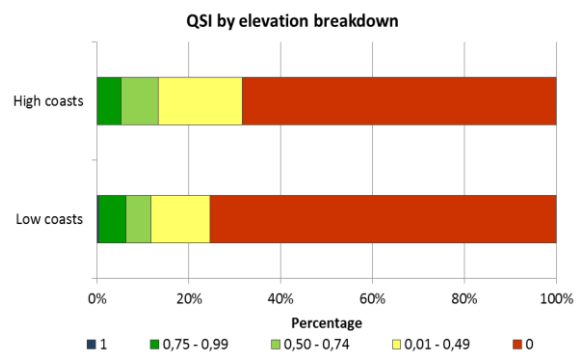
Total area of quiet areas accessible from urban areas > 50.000 inhabitants



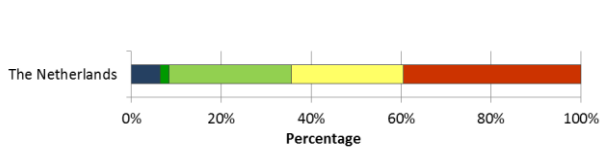
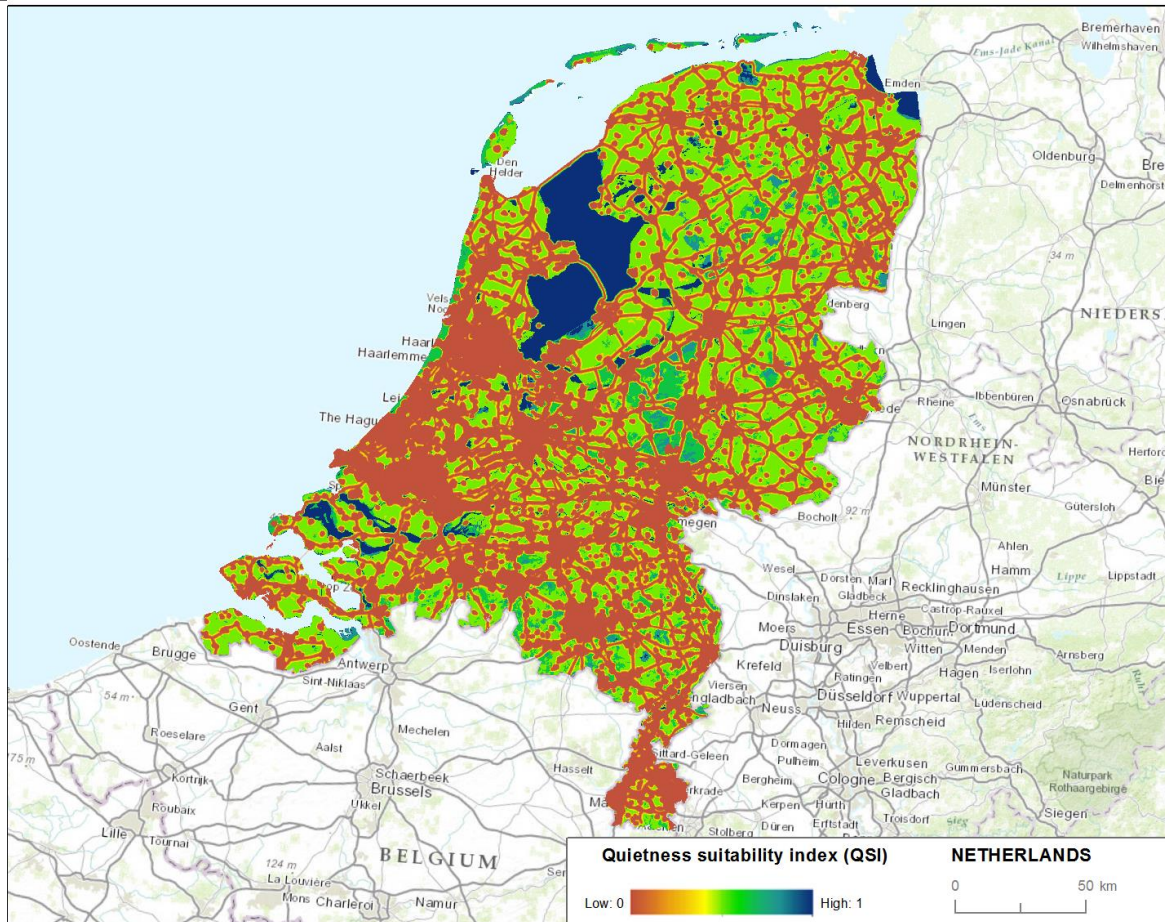
Malta



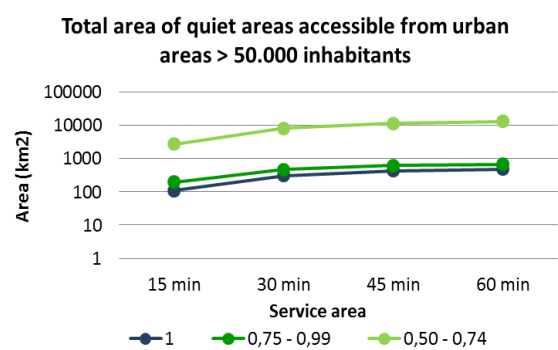
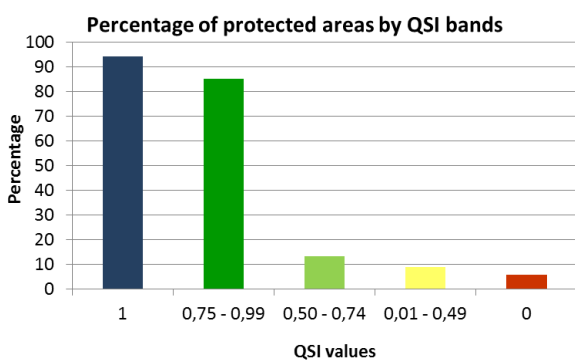
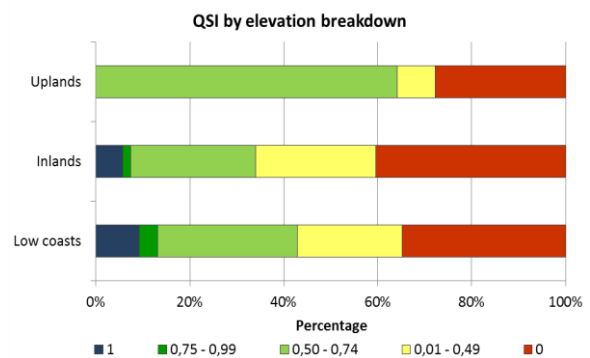
	QSI = 1	QSI = 0,75-0,99	QSI = 0,50-0,74
Km ² of potentially quiet	1	18	21
How much of the potentially quiet is protected (km ²)?	0	12	6



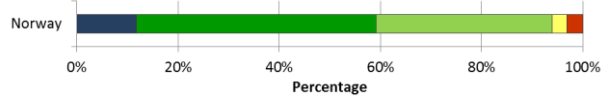
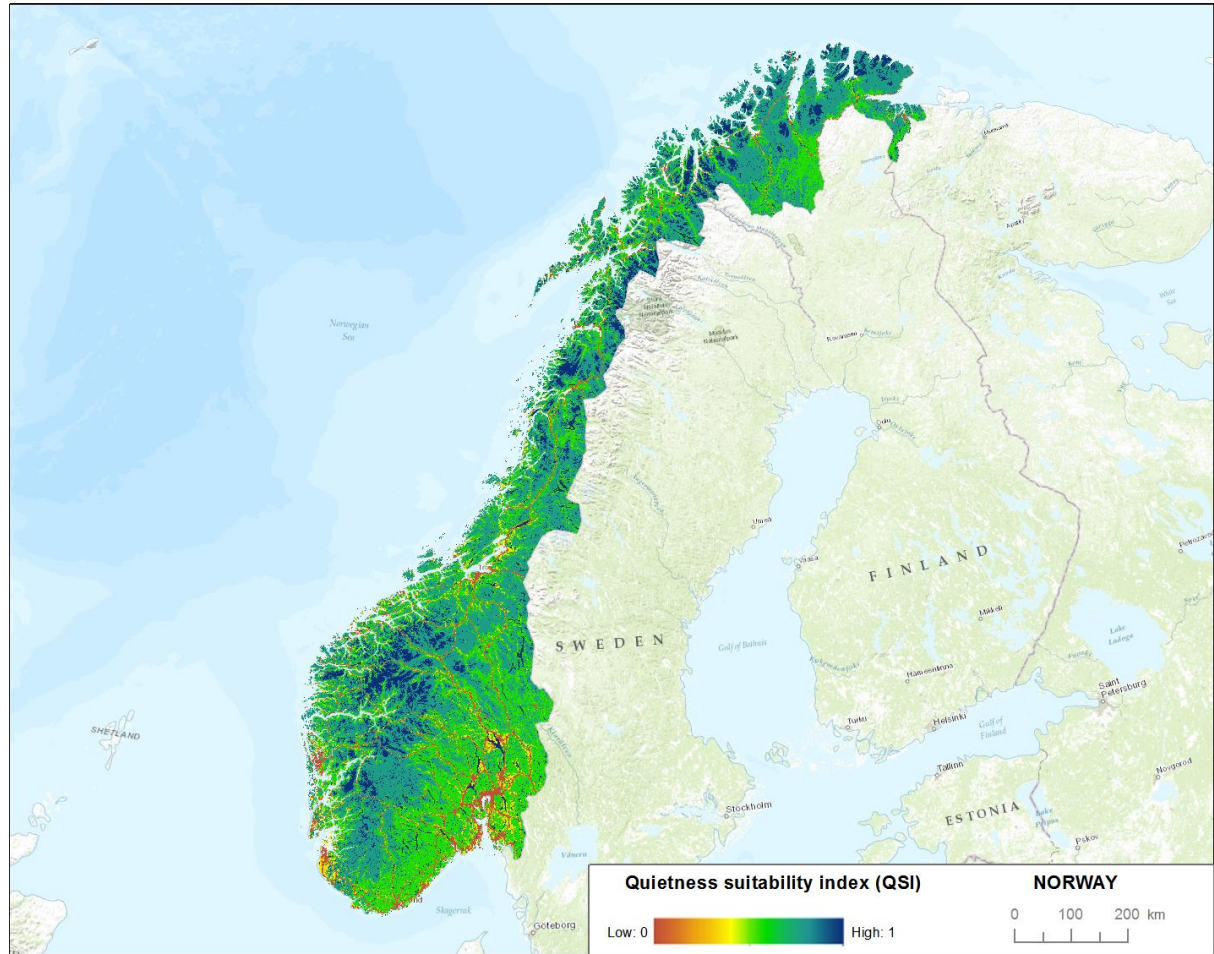
The Netherlands



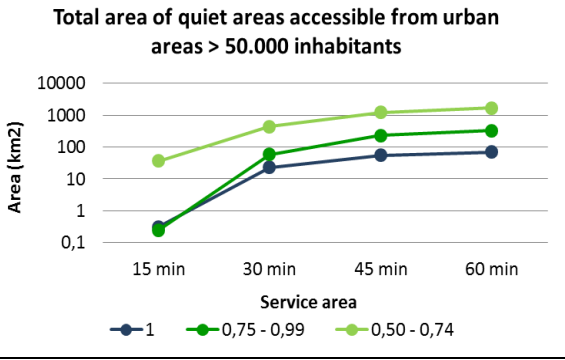
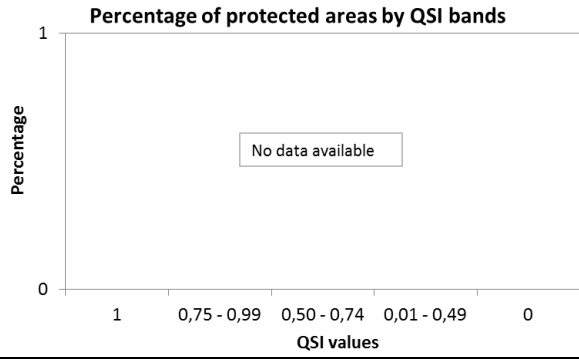
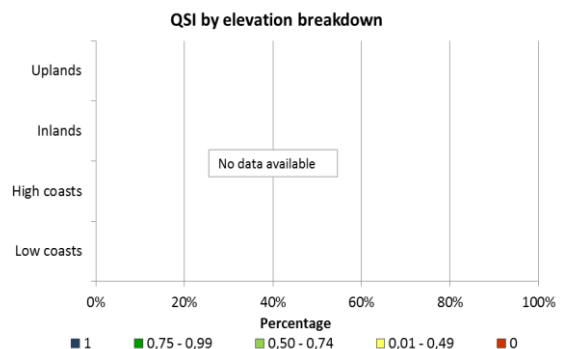
	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	2367	777	10184
How much of the potentially quiet is protected (km ²)?	2231	660	1355



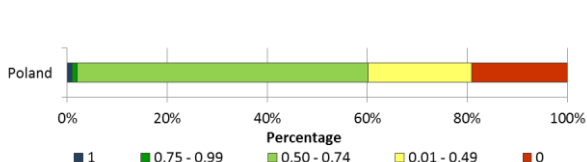
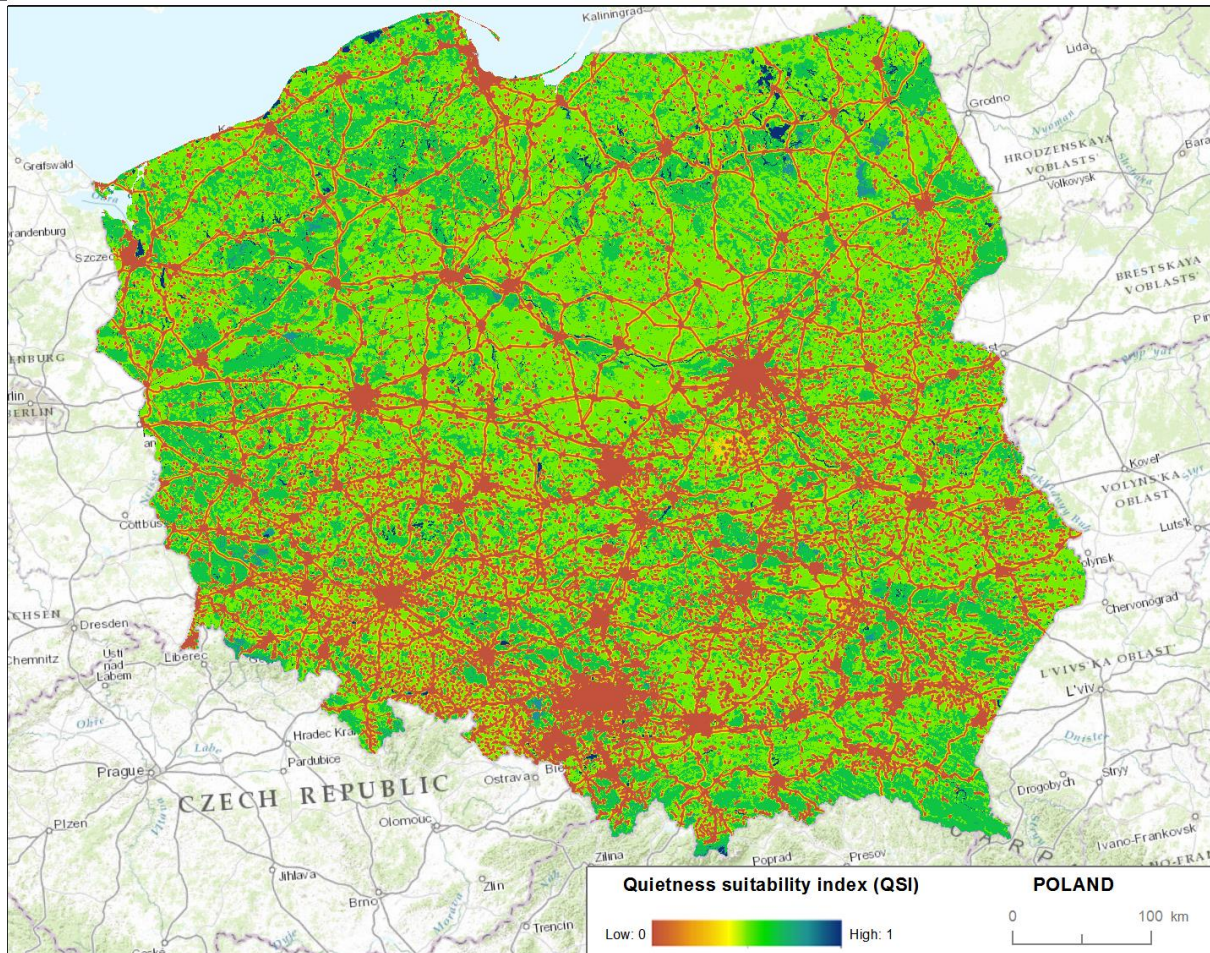
Norway



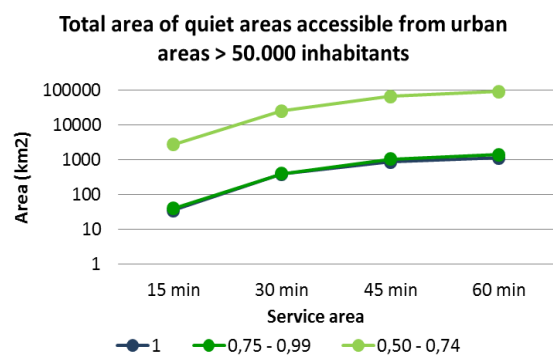
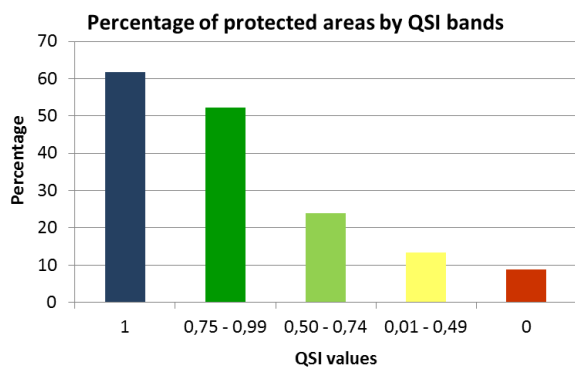
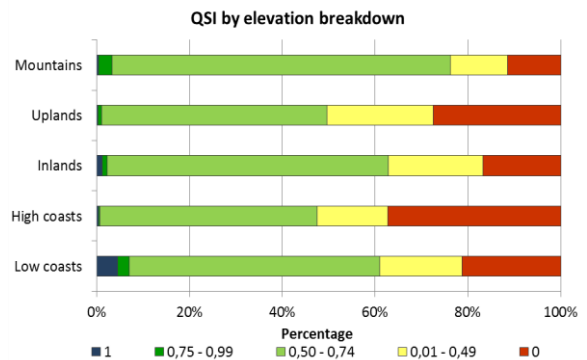
	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	38183	153434	112399
How much of the potentially quiet is protected (km ²)?	N/A	N/A	N/A



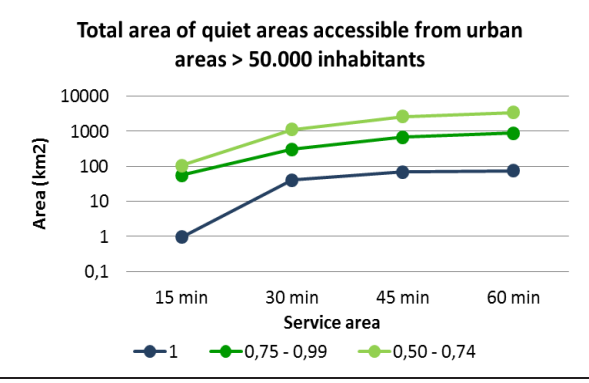
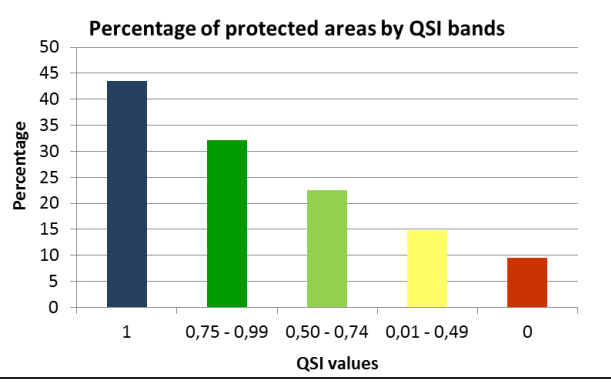
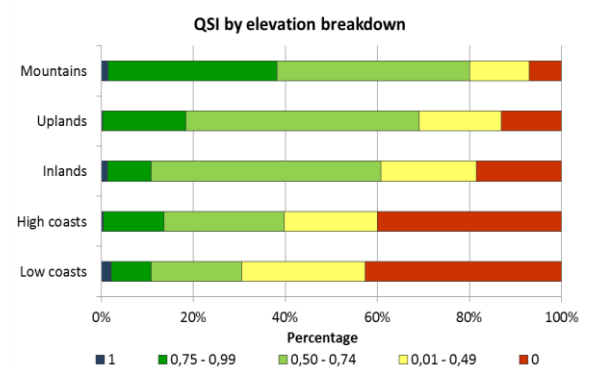
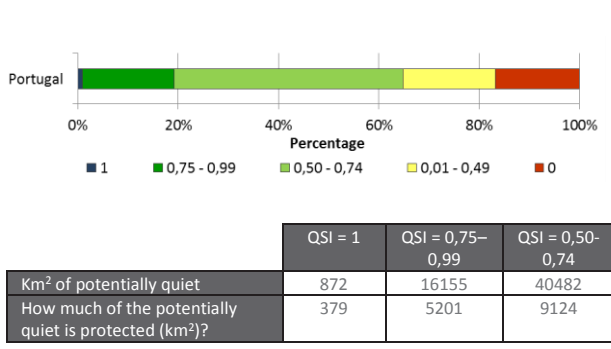
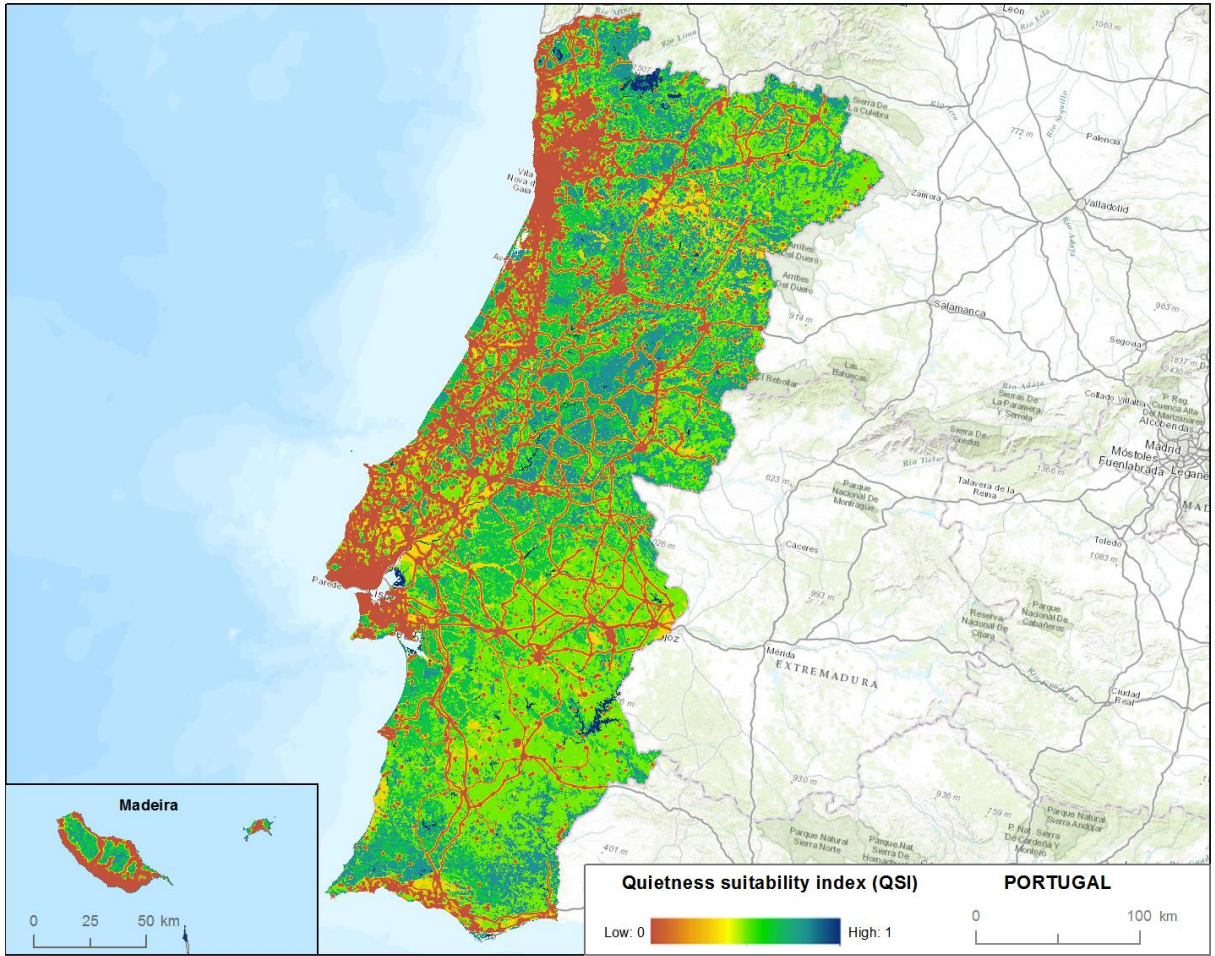
Poland



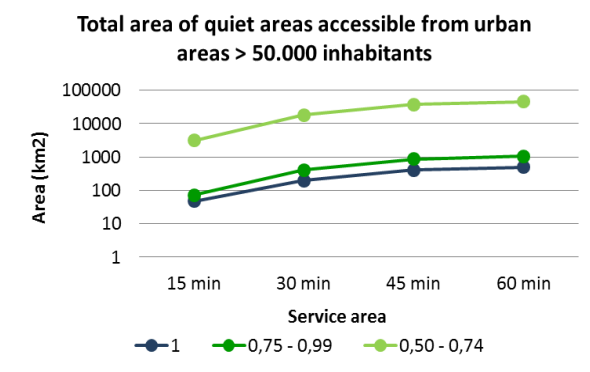
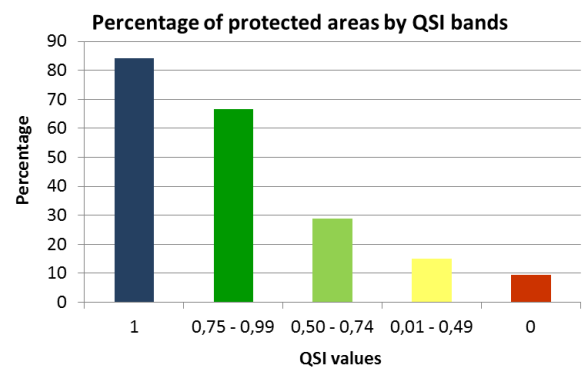
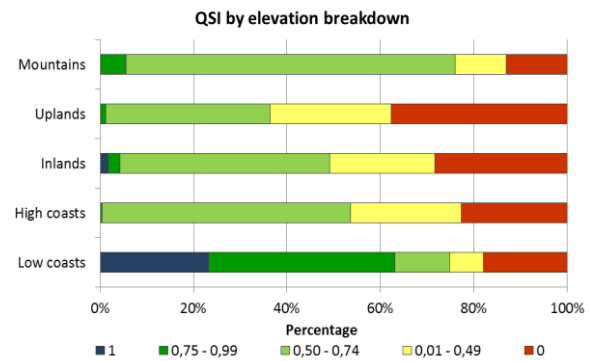
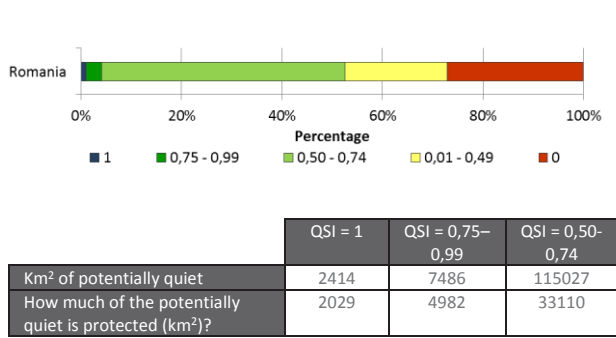
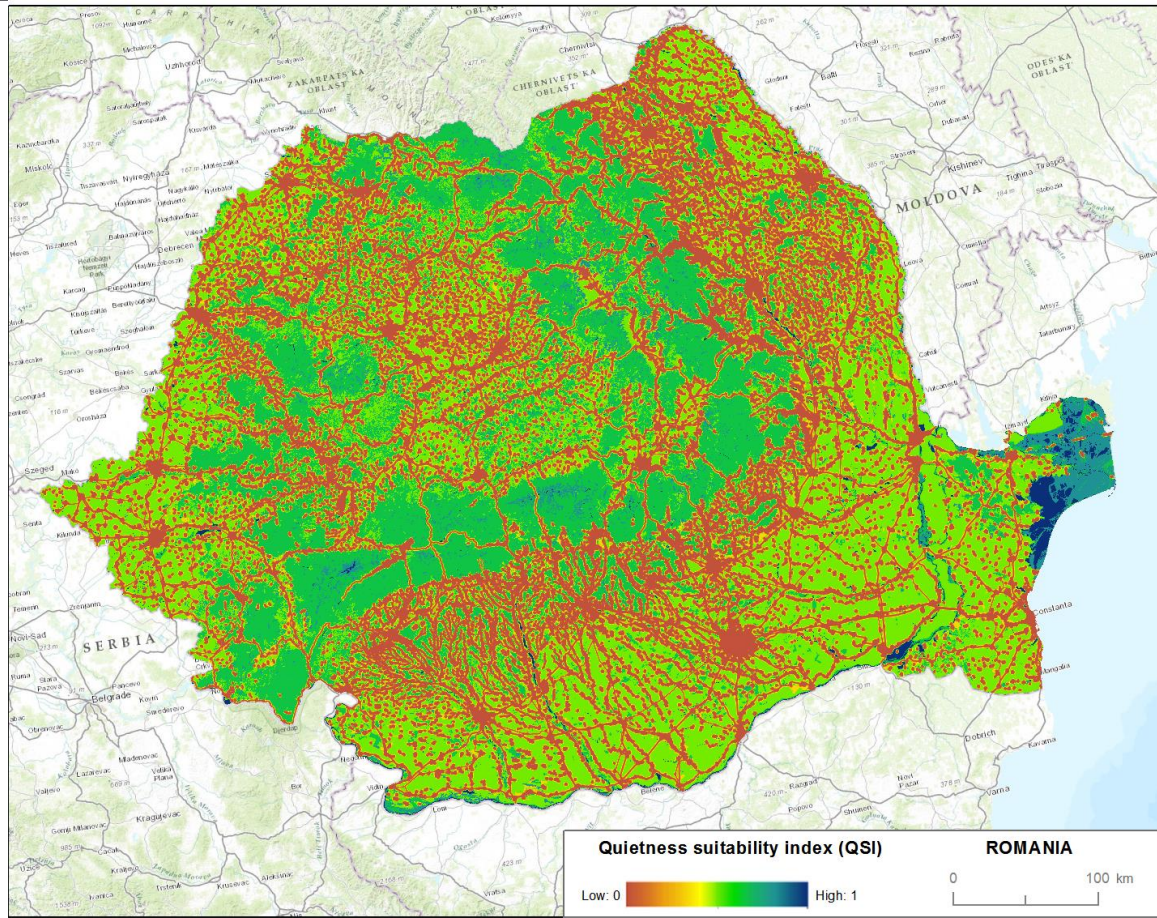
	QSI = 1	QSI = 0,75–0,99	QSI = 0,50–0,74
Km ² of potentially quiet	3110	3408	181345
How much of the potentially quiet is protected (km ²)?	1923	1782	43501



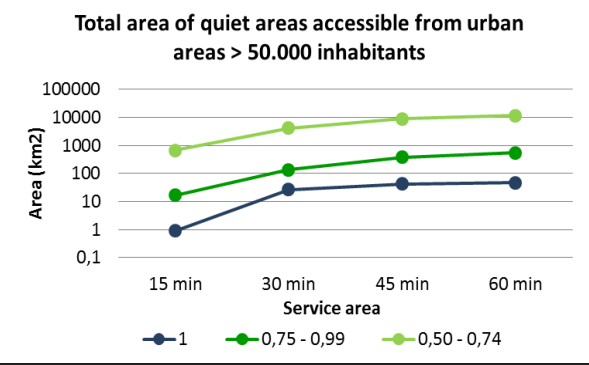
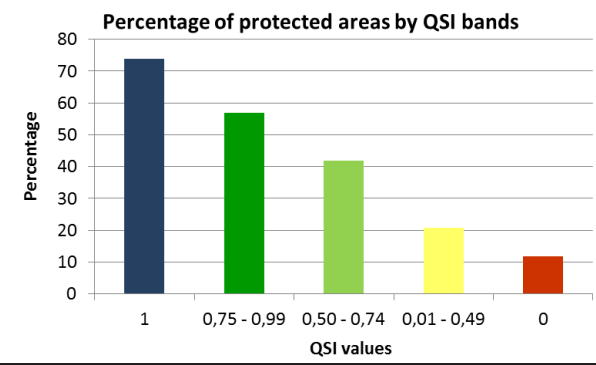
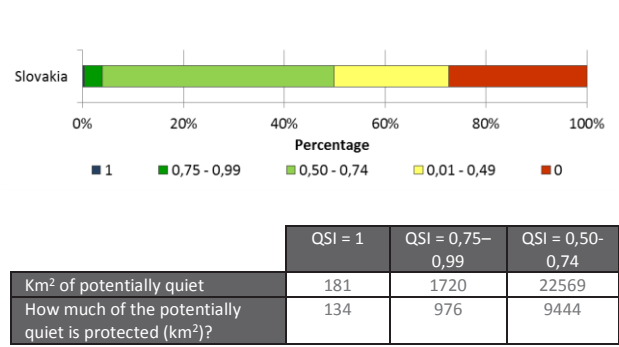
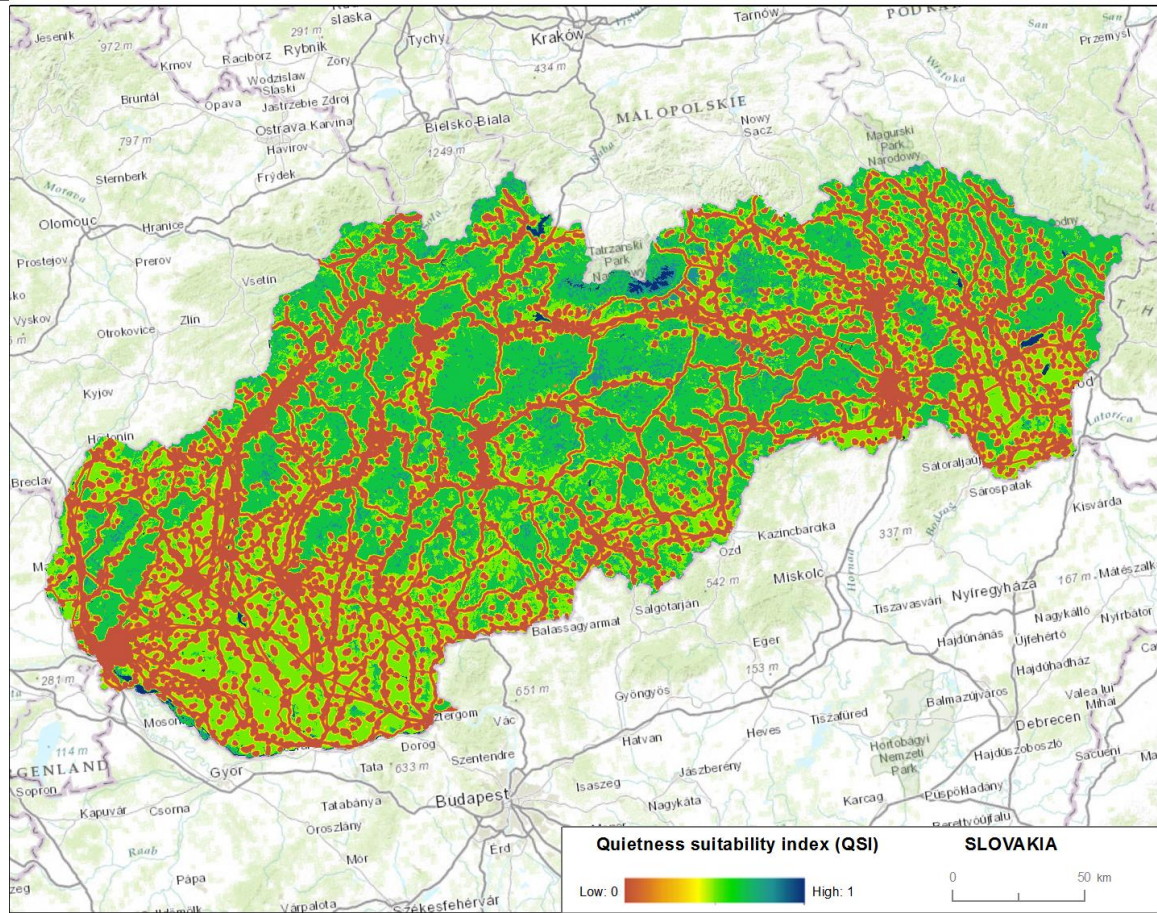
Portugal



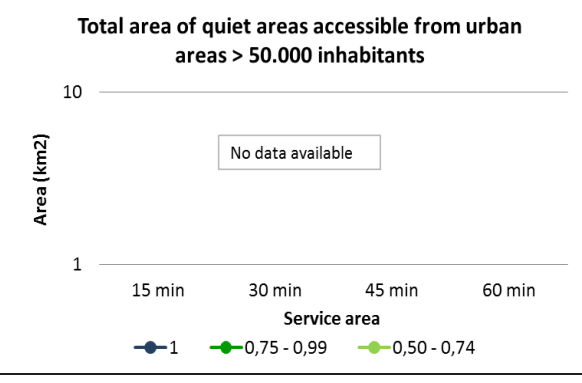
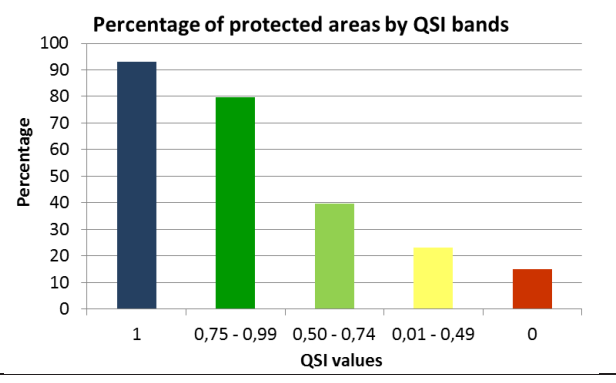
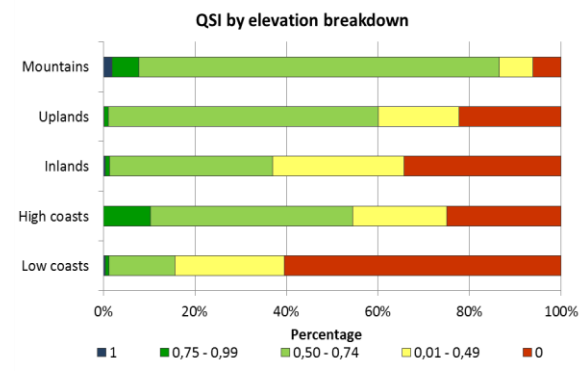
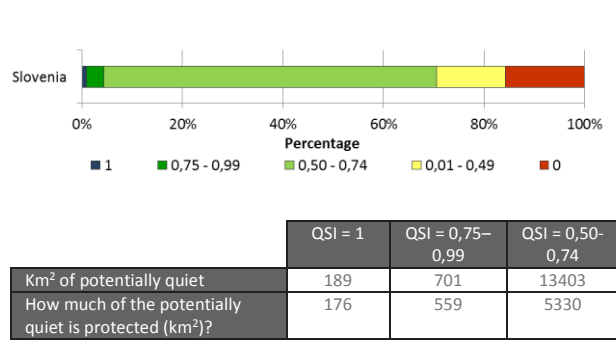
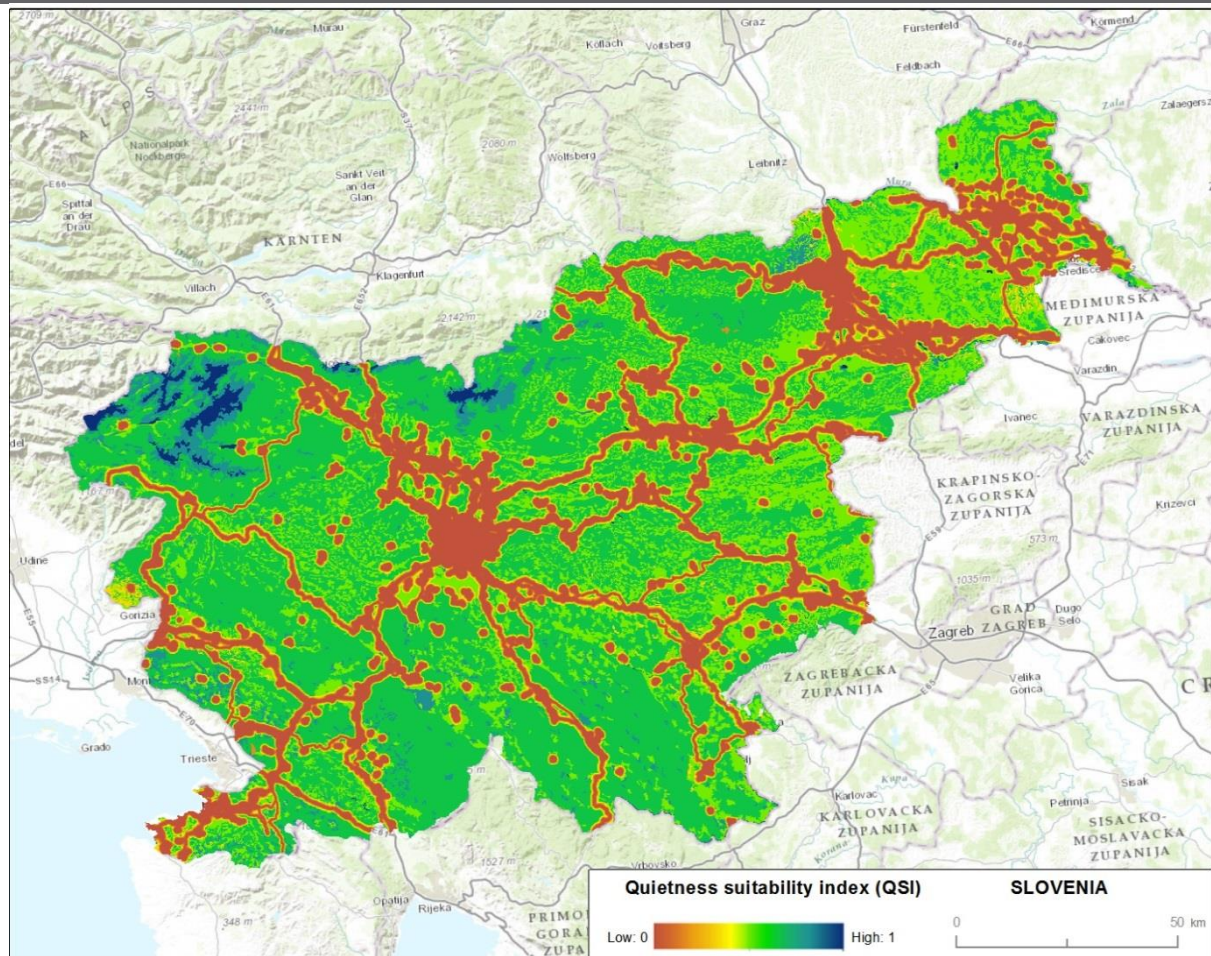
Romania

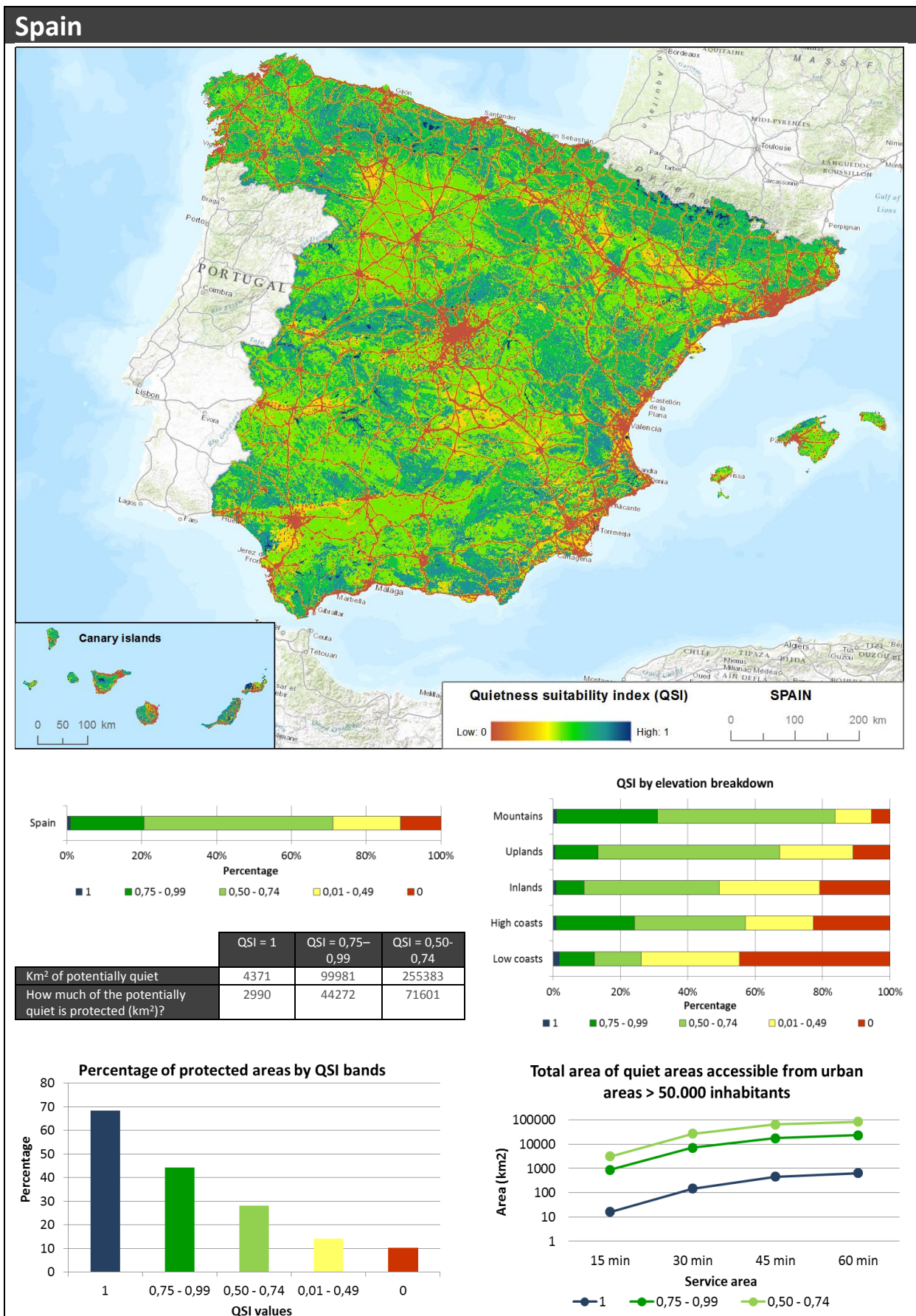


Slovakia

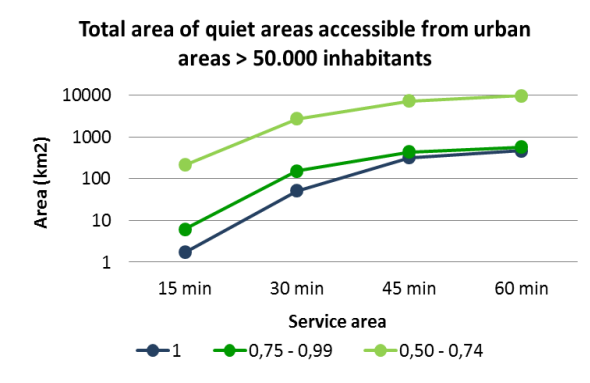
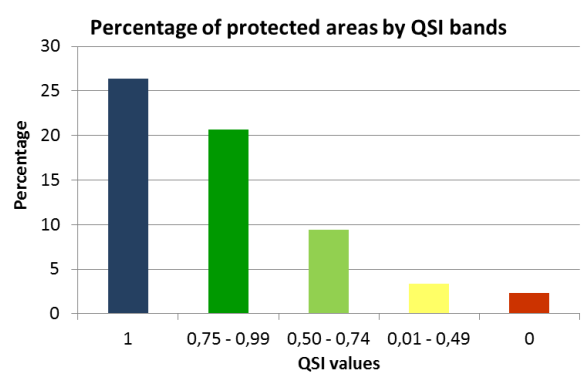
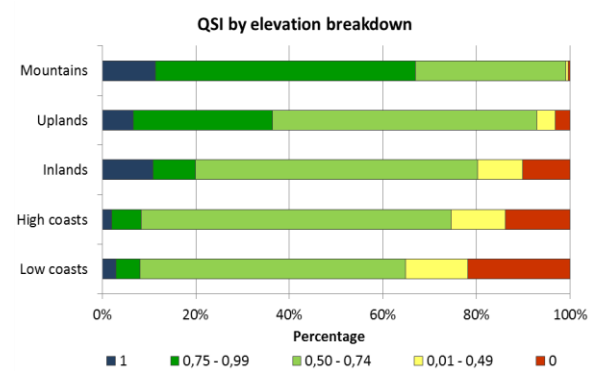
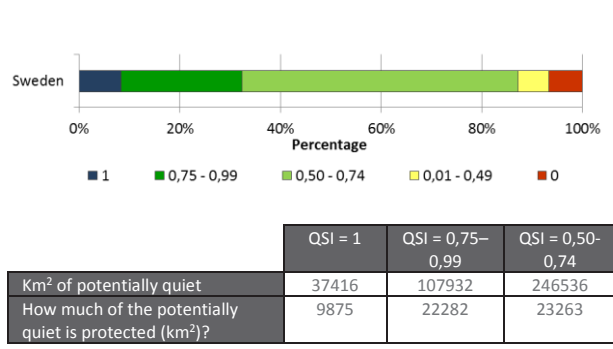
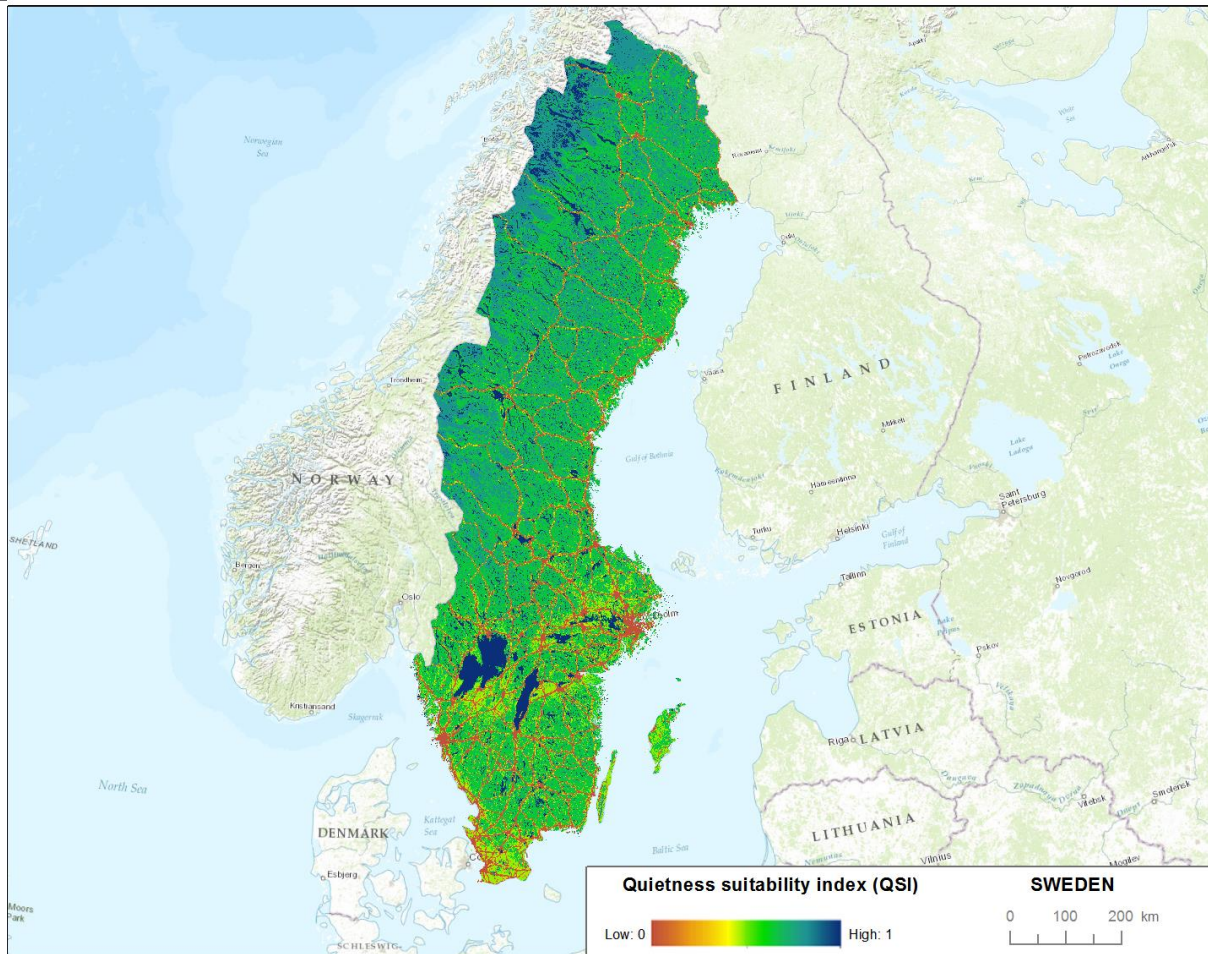


Slovenia

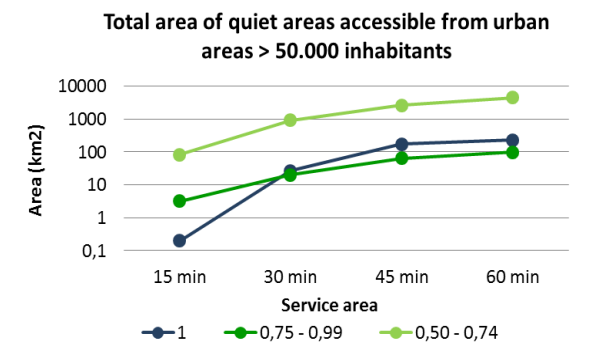
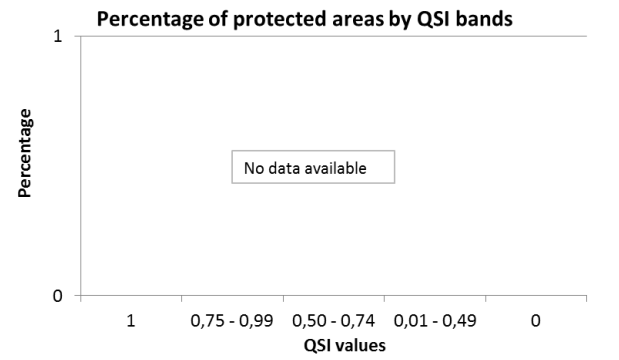
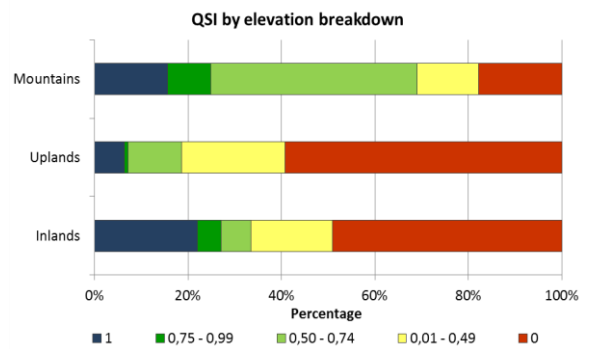
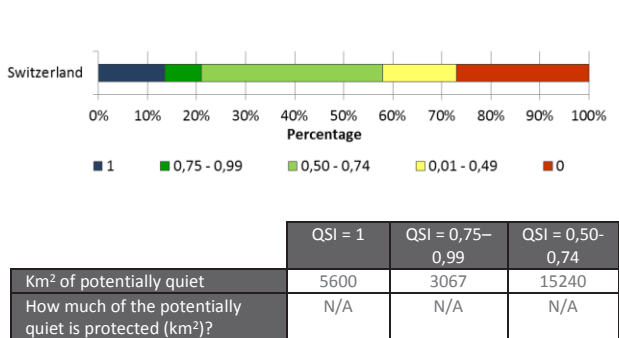
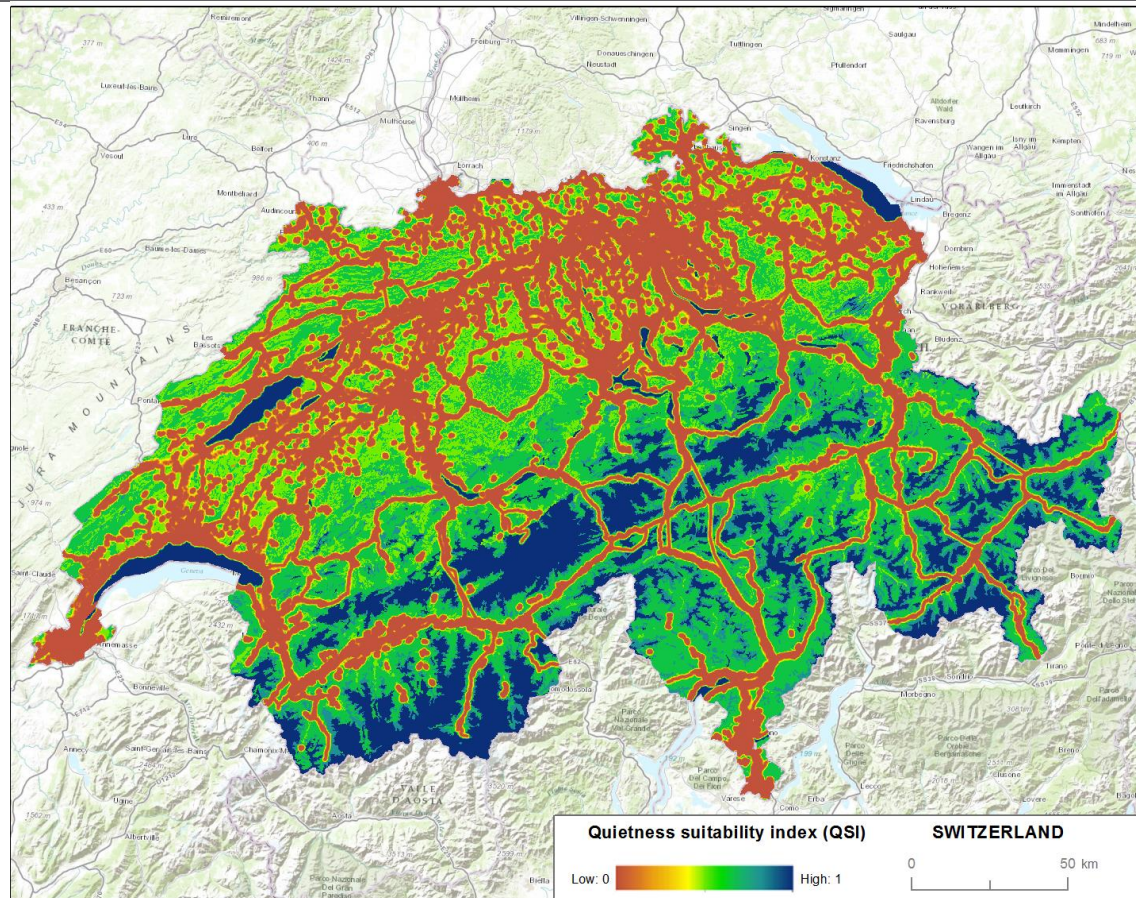




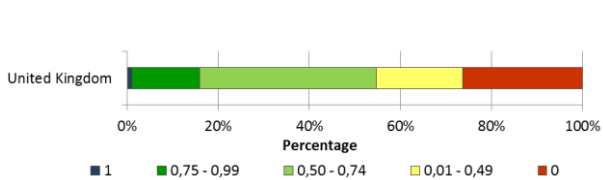
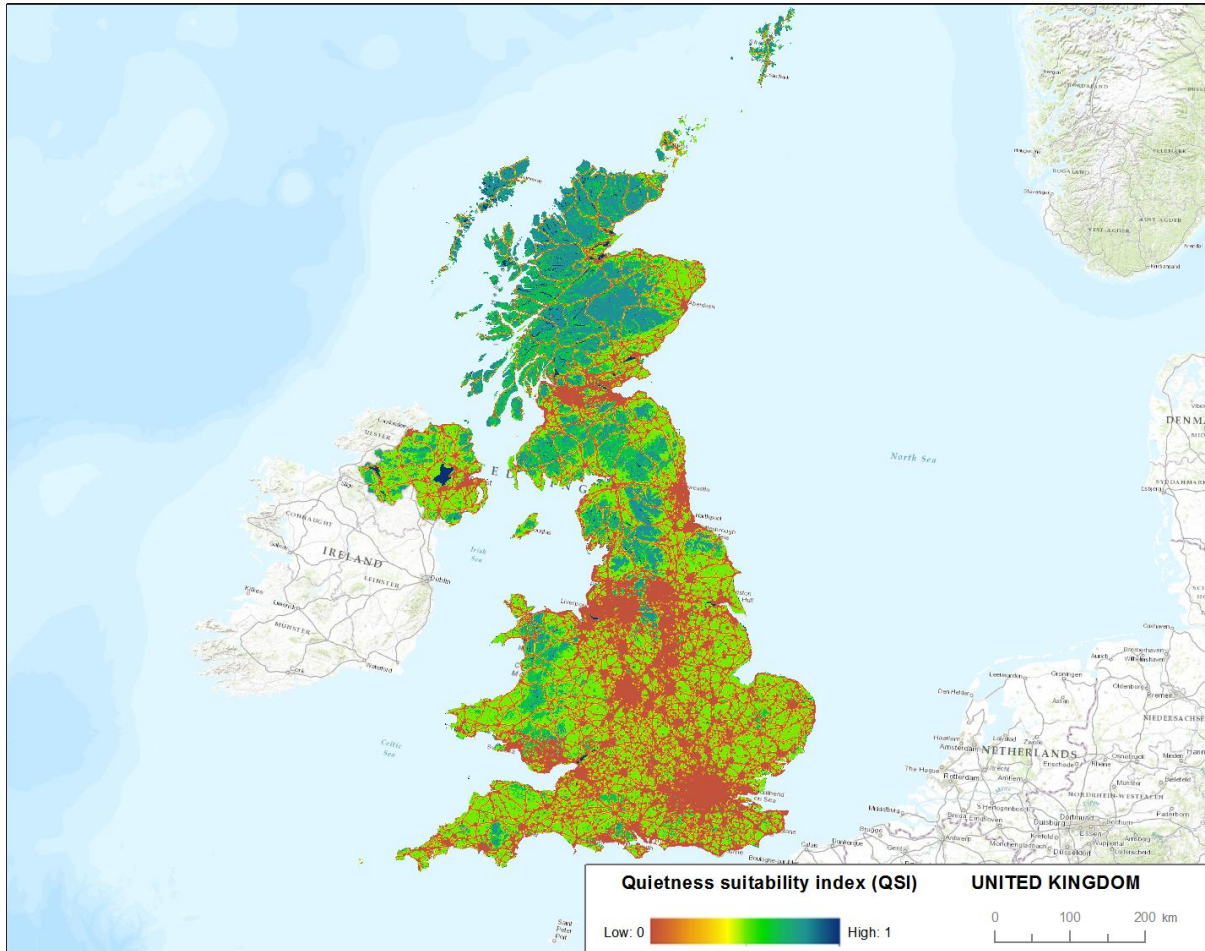
Sweden



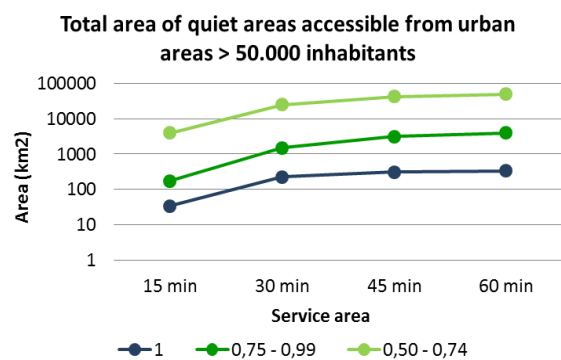
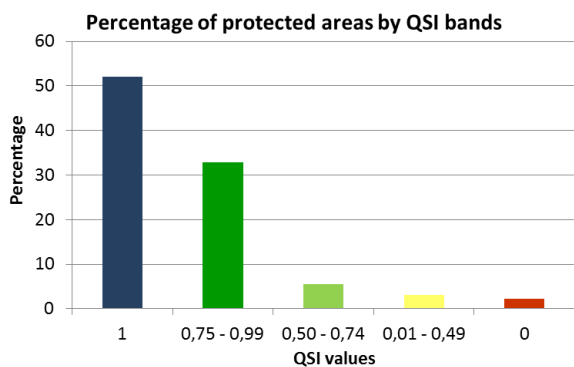
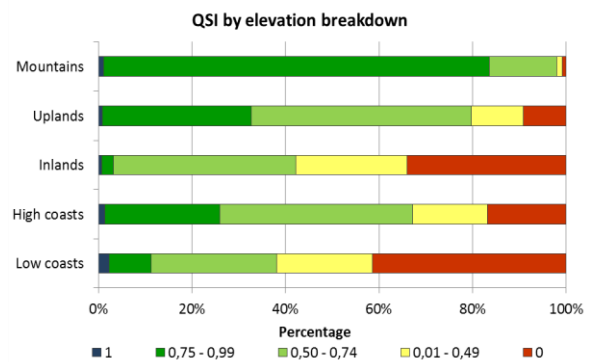
Switzerland



United Kingdom



	QSI = 1	QSI = 0,75-0,99	QSI = 0,50-0,74
Km ² of potentially quiet	2597	36633	95097
How much of the potentially quiet is protected (km ²)?	1353	12028	5166



Annex 2 Overview of the QSI calculation methodology

The stepped approach followed in order to generate the QSI is as follows:

1. Selection of input data;
2. Analysis of the threshold distances to the different noise sources, based on available noise contour maps;
3. Fuzzy approach to calculate the final distance layer;
4. Corine Land Cover (CLC) reclassification to the hemeroby scale;

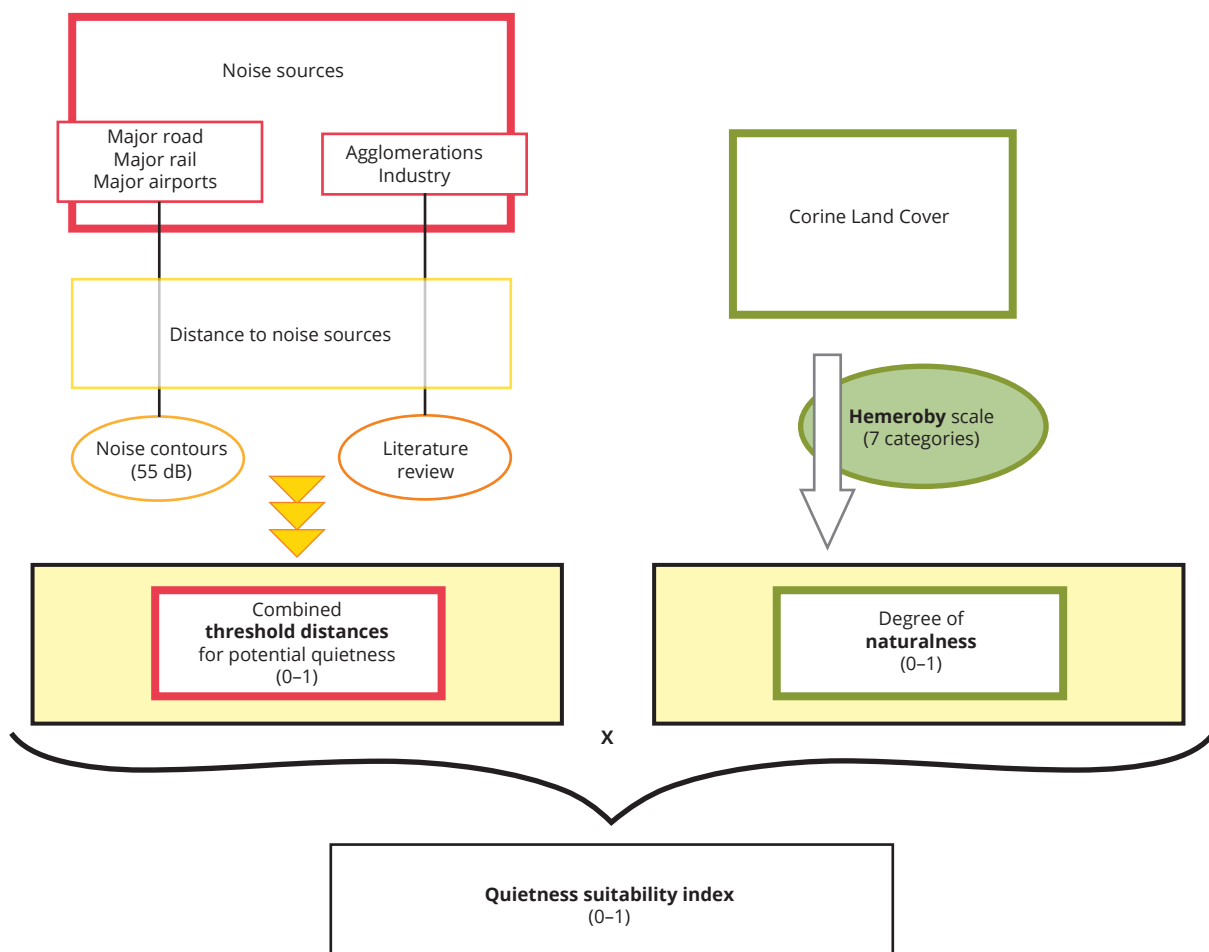
5. Calculation of the QSI.

A detailed description of the implementation of the methodology is given below.

A2.1 Input data

- END: major roads, major railways and major airports noise contour maps
- END: location of major roads and major railways and major airports

Figure A2.1 Methodological schema for the QSI



- Urban morphological zones (UMZ)
- E-PRTR register: industries' location and attributes
- Corine Land Cover and Land Use data 2006 (CLC) (100 × 100 m grid)
- EuroRegionalMap v. 6.0: roads, railways and airports infrastructure.

A2.2 Calculation of the threshold distances to the different noise sources being considered: major roads, major railways, airports, industries and agglomerations

Threshold distances to the corresponding noise sources are calculated considering noise levels determined by noise contours maps (assuming that the rest of the territory not covered by noise contour maps are (END) areas exposed to less than 55 dB L_{den}).

The analysis has been done taking into account the countries that provided suitable noise contour maps data.

These calculations will be used as proxies to be applied to databases covering the whole European territory.

A2.2.1 Threshold distances to noise transport sources: major roads, major railways ⁽²⁾

- An Euclidean distance map (pixel size = 100 m) has been calculated for each noise transport source: major roads and major railways
- Overlay of the Euclidean distance map with noise contour maps for each source to calculate basic statistics concerning distance to noise source per decibel band: minimum distance and maximum distance
- Mean and maximum distances to noise source for the 55 dB noise contour are calculated for the different countries
- Mean values at EEA level for the maximum distance and the mean distance are calculated
- Distances above the EEA mean of the maximum distances are considered suitable (= 1) and distances below the EEA mean of the mean distances are considered not suitable (= 0)
- Results: distances between noise sources from 55 dB contour maps (in metres).

Table A2.1 Threshold distances to noise transport sources from 55 dB isophone (major roads and major railways)

Country	Major road distances		Major rail distances	
	Maximum	Mean	Maximum	Mean
Switzerland	1 310	140	1 000	262
Germany	1 082	459	447	103
Spain	1 400	290	200	59
Ireland	1 005	386	632	59
Lithuania	1 393	269	876	115
Luxembourg	1 105	347	361	87
Malta	640	132	No major railways > 30 000 train passages	
Norway	728	107	707	254
Poland	1 487	171	539	107
Sweden	1 044	272	1 200	312
EEA mean	1 119	257	662	151

Source: ETC/SIA, UAB, 2013.

(²) It should be taken into consideration that information concerning the location of noise barriers is not being requested by the END specifically and, therefore, was not taken into consideration for the development of this index. The QSI could be further refined at country level if information on noise abatement measures (and its location) is available at national or regional scale.

A2.2.2 Threshold distances to major airports

Countries delivering major airports' noise contour maps:

- 55 dB L_{den} noise contour used as a mask: area outside the 55 dB is considered suitable (= 1) and area above 55 dB is considered not suitable (= 0).

Countries not delivering major airports' noise contour maps:

- Selection of CLC 2006 class 124, related to airports
- Overlay of END major airports layer and CLC class 124 class layer to distinguish between (END) major airports and all airports
- Buffer of 1 500 m applied to CLC class 124 polygons considered major airports and buffer of 900 m applied to the rest of CLC class 124 polygons (distances applied extracted from literature: Votsi et al., 2012)
- Buffers used as a mask: areas in the buffered area considered not suitable (= 0) and areas outside the buffered area considered suitable (= 1).

A2.2.3 Threshold distances to industrial noise ^(?)

- Selection of CLC 2006 classes labelled as industry, mine, dump and construction sites

- Selection of E-PRTR point data
- An Euclidean distance map (pixel size = 100 m) has been calculated from the geo-referenced E-PRTR database and from the CLC polygons selected
- Distance values below 500 m will be considered not suitable (= 0) and distance values above 1 100 m will be considered suitable (= 1) (Distances applied extracted from literature: Votsi et al., 2012.)

A2.2.4 Threshold distances to agglomerations

- Selection of UMZ with more than 50 000 inhabitants (END urban agglomerations have been discarded because of the great variation of delineations reported by the different EEA member countries, ranging from administrative delineations to detailed urban polygons)
- An Euclidean distance map has been calculated based on the UMZ polygons
- Distance values below 1 000 m will be considered not suitable (= 0) and distance values above 1 500 m will be considered suitable (= 1).

A2.2.5 Result

Mean and maximum distances per noise source that will be applied to create the distances' layer to each noise source are outlined below:

Table A2.2 Mean and maximum distances per noise source to create the distances' layer to each noise source

Noise source	Suitable values	Not suitable values
Major roads	> 1 119	< 257
Major railways	> 662	< 151
Major airports	Area outside 55 dB L_{den} contours: > 1 500 m for major airports > 900 m for the rest of the airports	Areas inside 55 dB L_{den} contours: < 1 500 m for major airports < 900 m for the rest of the airports
Industrial sites	> 1 100 m	< 500 m
Urban areas	> 1 500 m	< 1 000 m

(?) In the case of industrial sites, noise contour maps are only available for industrial areas located inside agglomerations and, therefore, it is not appropriate for them to be taken into consideration for this analysis.

A2.3 Fuzzy approach to calculate the final distance layers

Suitable distance layers from noise sources were built following a fuzzy approach, calculating the 'membership' to the quietness range (0–1) by means of a linear relationship. The fuzzy approach reclassifies the input data to a 0–1 scale based on the possibility of being a member of a specified set. In this way, 0 is assigned to those locations that are definitely not a member of the specified set, 1 is assigned to those values that are definitely a member of the specified set (quiet area), and the entire range of possibilities between 0 and 1 are assigned to some level of possible membership following a linear equation (the larger the number, the greater the possibility).

The five layers obtained have been merged together by multiplying them in order to obtain the resulting combined threshold distances for potential quietness.

The output layer ranges from 0 to 1 values. It should be taken into consideration that a value of 0 in any of the five layers directly results in a value of 0 in the final output (although some other layers could have a suitable value in the specific pixel).

A2.4 CLC reclassification to the hemeroby scale

The subjective dimension of quietness is covered by the degree of naturalness of the landscape, as a proxy of the different studies related to perception and quiet areas being undertaken.

The natural character of land covers is addressed through the hemeroby concept (Jalas, 1955; Blume and Sukopp, 1976), which measures the degree of artificiality of land after human activities have altered the ecosystem from the potential natural condition. The hemeroby scale ranges from level 1 ('ahemerob', i.e. no human impact) to level 7 ('metahemerob', i.e. destroyed, originally biocenosis). So, in order to reclassify CLC data into the hemeroby scale, the following steps have been applied:

1. Translation of the Corine dataset to the hemeroby scale, following the process established by Steinhardt et al. (1999), Zebisch et al. (2004) and Paracchini and Capitani (2011).

Figure A2.2 Example of the combination of five layers containing threshold distances for each noise source



Table A2.3 Reclassification of Corine Land Cover categories into the hemeroby scale

Hemeroby	CLC class	Label 1	Label 2	Label 3
7	111	Artificial surfaces	Urban fabric	Continuous urban fabric
7	112	Artificial surfaces	Urban fabric	Discontinuous urban fabric
7	121	Artificial surfaces	Industrial, commercial and transport units	Industrial or commercial units
7	122	Artificial surfaces	Industrial, commercial and transport units	Road and rail networks and associated land
7	123	Artificial surfaces	Industrial, commercial and transport units	Port areas
7	124	Artificial surfaces	Industrial, commercial and transport units	Airports
6	131	Artificial surfaces	Mine, dump and construction sites	Mineral extraction sites
6	132	Artificial surfaces	Mine, dump and construction sites	Dump sites
6	133	Artificial surfaces	Mine, dump and construction sites	Construction sites
6	141	Artificial surfaces	Artificial, non-agricultural vegetated areas	Green urban areas
6	142	Artificial surfaces	Artificial, non-agricultural vegetated areas	Sport and leisure facilities
4	211	Agricultural areas	Arable land	Non-irrigated arable land
5	212	Agricultural areas	Arable land	Permanently irrigated land
5	213	Agricultural areas	Arable land	Rice fields
5	221	Agricultural areas	Permanent crops	Vineyards
5	222	Agricultural areas	Permanent crops	Fruit trees and berry plantations
4	223	Agricultural areas	Permanent crops	Olive groves
4	231	Agricultural areas	Pastures	Pastures
4	241	Agricultural areas	Heterogeneous agricultural areas	Annual crops associated with permanent crops
4	242	Agricultural areas	Heterogeneous agricultural areas	Complex cultivation patterns
4	243	Agricultural areas	Heterogeneous agricultural areas	Land principally occupied by agriculture, with significant areas of natural vegetation
4	244	Agricultural areas	Heterogeneous agricultural areas	Agro-forestry areas
3	311	Forest and semi-natural areas	Forests	Broad-leaved forest
3	312	Forest and semi-natural areas	Forests	Coniferous forest
3	313	Forest and semi-natural areas	Forests	Mixed forest
3	321	Forest and semi-natural areas	Scrub and/or herbaceous vegetation associations	Natural grasslands
2	322	Forest and semi-natural areas	Scrub and/or herbaceous vegetation associations	Moors and heathland
2	323	Forest and semi-natural areas	Scrub and/or herbaceous vegetation associations	Sclerophyllous vegetation
2	324	Forest and semi-natural areas	Scrub and/or herbaceous vegetation associations	Transitional woodland-shrub
2	331	Forest and semi-natural areas	Open spaces with little or no vegetation	Beaches, dunes, sands
1	332	Forest and semi-natural areas	Open spaces with little or no vegetation	Bare rocks

Table A2.3 Reclassification of Corine Land Cover categories into the hemeroby scale (cont.)

2	333	Forest and semi-natural areas	Open spaces with little or no vegetation	Sparsely vegetated areas
5	334	Forest and semi-natural areas	Open spaces with little or no vegetation	Burnt areas
1	335	Forest and semi-natural areas	Open spaces with little or no vegetation	Glaciers and perpetual snow
2	411	Wetlands	Inland wetlands	Inland marshes
2	412	Wetlands	Inland wetlands	Peat bogs
2	421	Wetlands	Maritime wetlands	Salt marshes
5	422	Wetlands	Maritime wetlands	Salines
1	423	Wetlands	Maritime wetlands	Intertidal flats
1	511	Water bodies	Inland waters	Water courses
1	512	Water bodies	Inland waters	Water bodies
1	521	Water bodies	Marine waters	Coastal lagoons
1	522	Water bodies	Marine waters	Estuaries
1	523	Water bodies	Marine waters	Sea and ocean

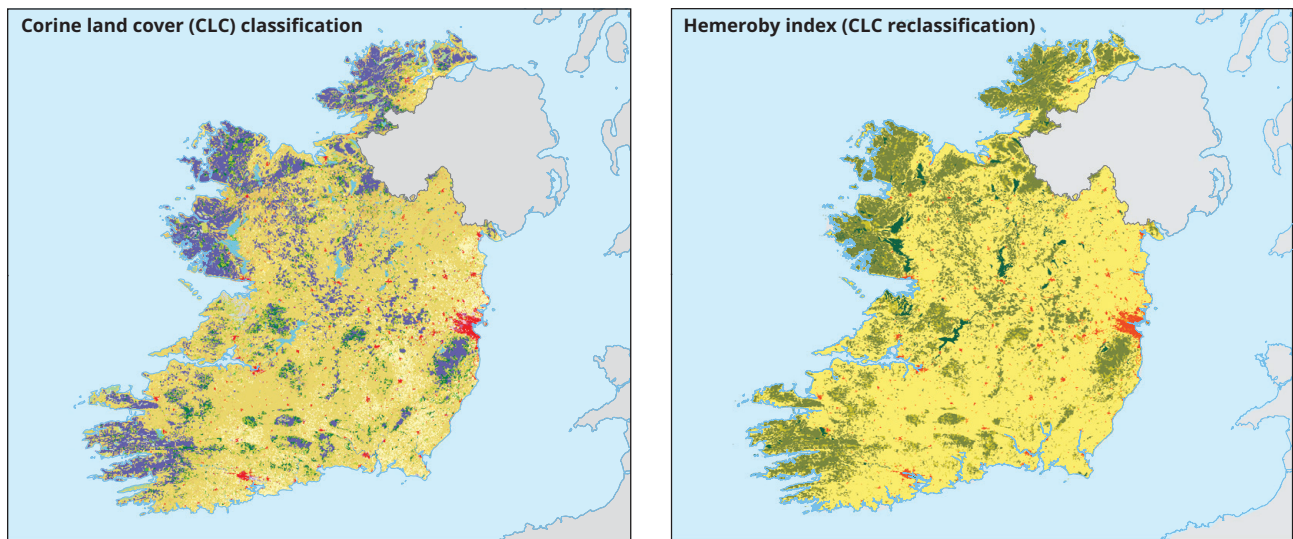
2. Hemeroby re-scaled between 0 to 1 to combine with the rest of variables. Hemeroby index has been normalised with the min-max method to a 0-1 range, where higher scores represent higher degrees of naturalness:

$$\text{Re-scaling: } \frac{xi - \min(x)}{\max(x) - \min(x)}$$

Index	Hemeroby	Re-scaling
Artificial	7	0
	6	0.17
	5	0.33
	4	0.50
	3	0.67
	2	0.83
Natural	1	1

3. Results (below): Corine Land Cover (left) reclassified according to the hemeroby scale (right), adjusted to 0 to 1 values (from lower to higher hemeroby: red to dark green, respectively).

Map A2.1 Corine Land Cover (left) reclassified according to the hemeroby scale (right), adjusted to 0 to 1 values (from lower to higher hemeroby: red to dark green, respectively)



Reclassification of Corine Land Cover categories into the hemeroby scale (1 to 7)

0 100 200 km

Hemeroby index (right map)

- 1: Water bodies, coastal lagoons, water courses, estuaries, bare rocks
- 2: Peat bogs, marshes, moors, heathland, scrub
- 3: Natural grasslands, mixed forest, broad-leaved forest, coniferous forest
- 4: Pastures, dry grasslands, agriculture, agro-forestry areas
- 5: Permanently irrigated land, fruit and berry plantations, burnt areas
- 6: Green urban areas, leisure facilities, construction sites
- 7: Urban fabric, airports, ports, roads, railways, industrial or commercial units

Note: Left map is based on the CLC classification, see Table A2.3 label 3

A2.5 Calculation of the QSI

1. Multiplication of the combined threshold distances layer with the degree of naturalness
2. Result: QSI with values ranging from 0 (not suitable at all) to 1 (maximum suitability).

Annex 3 Overview of the methodology applied to the calculation of accessibility

The stepped approach followed in order to calculate the accessibility for quiet areas is as follows:

1. Selection of input data
2. Data preparation for accessibility calculation
3. Analysis of accessibility areas
4. Spatial analysis with QSI index
5. Evaluation of constraints.

A3.1 Input data

The UMZ are composed of continuously built-up areas related to several modes of Land Cover in the Corine nomenclature: the category 'urban fabric' (continuous or discontinuous), but also 'industrial commercial units', 'green urban areas', certain forest spaces, port areas; airports, sports and leisure facilities, and road and rail networks.

Selection of urban agglomerations of > 50 000 inhabitants. The population of each UMZ in 2000 (year of reference) was added by using the last version (v. 5) of the population density grid constructed by the European Commission research centre (Gallego, 2010).

EuroRegionalMap v. 6.0 is a pan-European dataset containing topo-geographic information at the scale 1:250 000 covering 33 European states: 26 EU Member States (Bulgaria and Croatia not currently included).

A3.2 Data preparation for accessibility calculation

The first step to delimitate accessibility areas in ArcGIS is building a network dataset on which the service area analysis will be performed. The network dataset needs at least one time-based and one distance-based cost attribute.

Thereafter, the attributes can be assigned to the network by road type. The speeds taken into consideration are detailed Table A3.1.

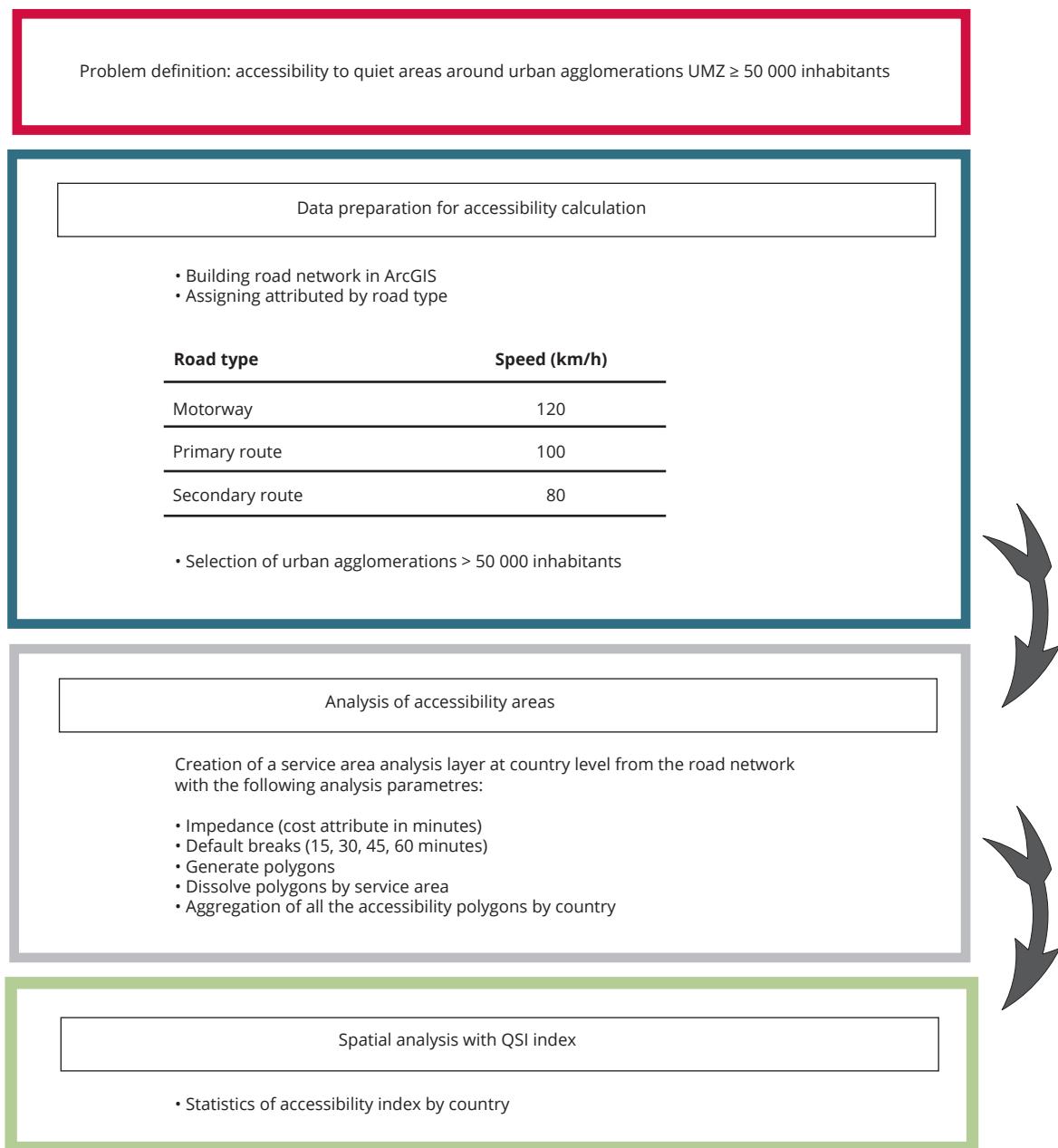
This attribute is needed to assign the cost of every road segment (all the road database geometries). This cost represents the driving time needed to cover a distance of the different breaks. This is the parameter *impedance* (cost attribute in minutes, i.e. time):

$$\text{Time} = \text{length of the segment} / \text{speed in that segment}$$

Table A3.1 Speed per road type as applied to accessibility analysis

Road type	Speed (km/h)
Motorway	120
Primary route	100
Secondary route	80
Local road	50

Figure A3.1 Methodological schema for accessibility calculation



A3.3 Analysis of accessibility areas

The ArcGIS software (ESRI) and the Generate Service Areas tool (included in Network Analyst extension) are used to calculate accessibility. The Generate Service Areas tool chooses whether to use the network cost attribute specified in the Time Attribute or Distance Attribute parameter, depending on whether the units you specify here are time or distance based.

Break Values in minutes. This specifies the size and number of service area polygons to generate for each urban agglomeration. Break Values define how far the service area should extend around the urban area. We decided to use 15, 30, 45 and 60 minutes in order to know the accessible quiet areas in a day trip or less.

In this analysis, we assign to the *Facility class* the points representing the UMZ > 50 000 inhabitants. This

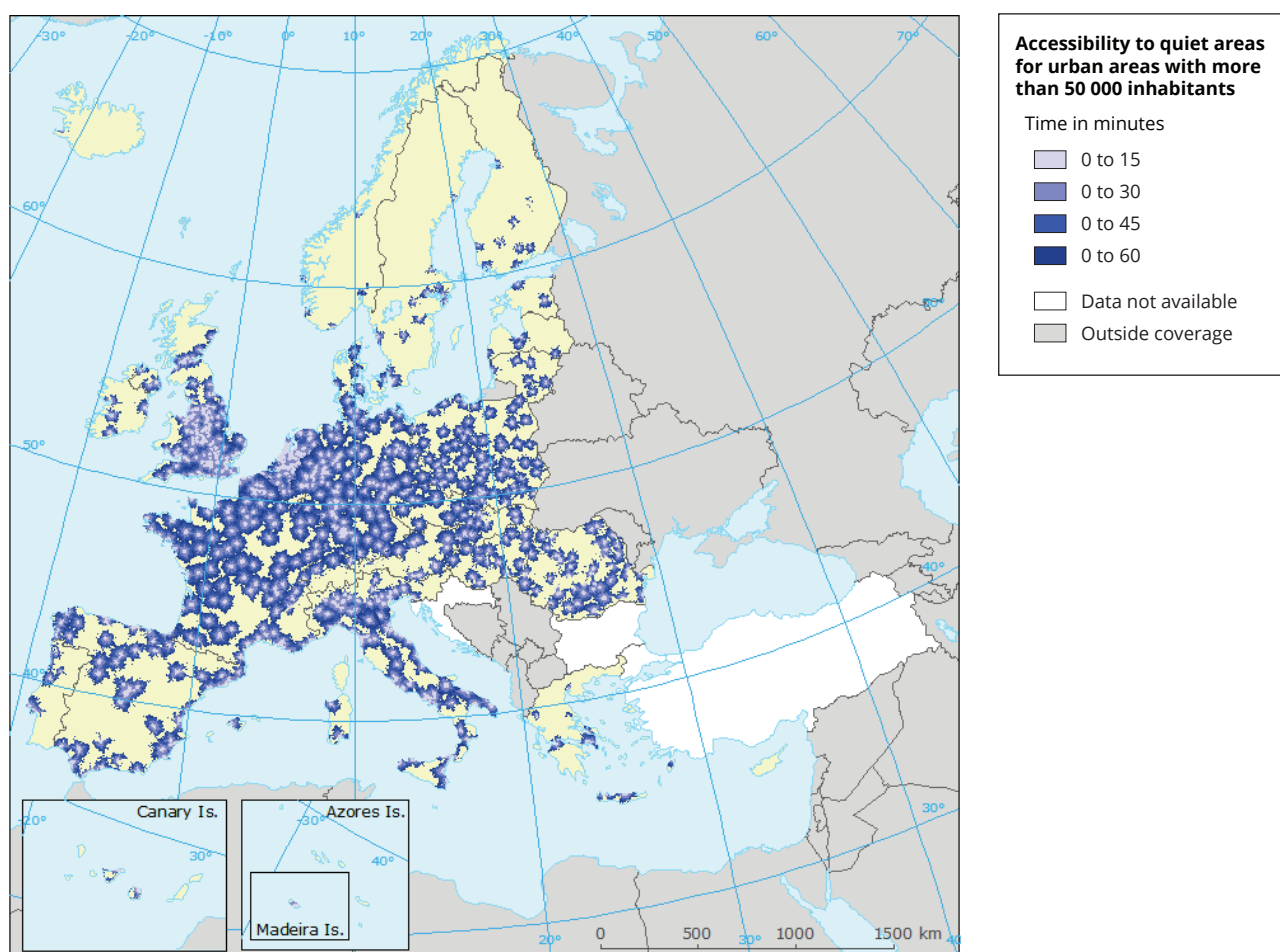
network analysis class stores the network locations that are used as facilities in service area analysis.

Once the service area analysis layer is finalised, polygons are created in the database.

Concentric service area polygons may be generated as discs or rings. Discs are polygons going from a facility to a break. That means that from 0- to 60-minute service areas, every time break area includes the previous one. The option *Merge* by break value was chosen because it joins the polygons of multiple facilities that have the same break value.

Aggregation of all the accessibility polygons by country is done by urban agglomeration and country but also considers trans-boundary accessibility. This allows calculation of the accessibility to quiet areas for urban zones near to borders.

Map A3.1 Accessibility to quiet areas for urban areas with more than 50 000 inhabitants



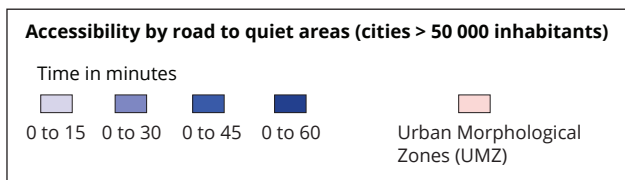
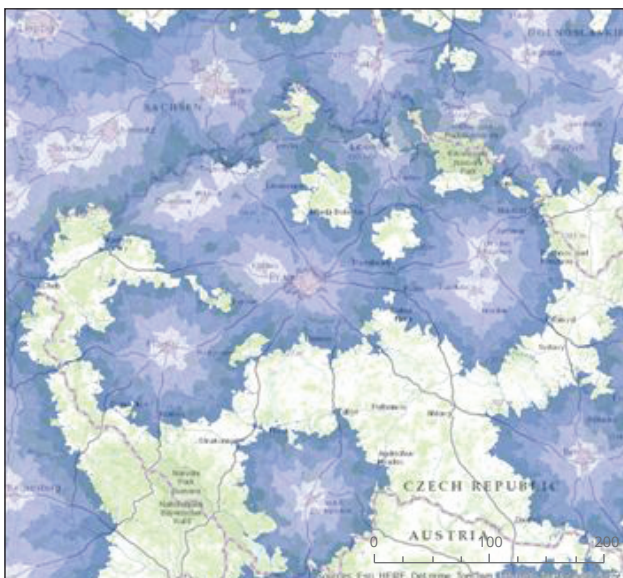
A3.4 Spatial analysis with QSI layer

The overlay of the service area polygons by time break area with the European QSI layer give us the result by country and the following extraction and exploitation of the statistics of accessibility index by country. The results describe the class and number of quiet areas accessible from urban agglomerations of over 50 000 people per country.

A3.5 Evaluation of constraints

A key issue in accessibility measurement is the definition of the cost surface. This surface can be created by reporting many different cost units (e.g. distance or time), and it establishes the impedance for crossing each individual road segment. In order to facilitate this analysis, the maximum permissible speed limit was applied based on the road type. A constraint of this method is that it takes into account only transport by road. Other types of transport, such as railways, have not been included in the analysis.

Map A3.2 Detail of accessibility by road to quiet areas



European Environment Agency

Quiet areas in Europe

The environment unaffected by noise pollution

2016 — 76 pp. — 21 x 29.7 cm

ISBN 978-92-9213-745-8

doi:10.2800/7586

HOW TO OBTAIN EU PUBLICATIONS

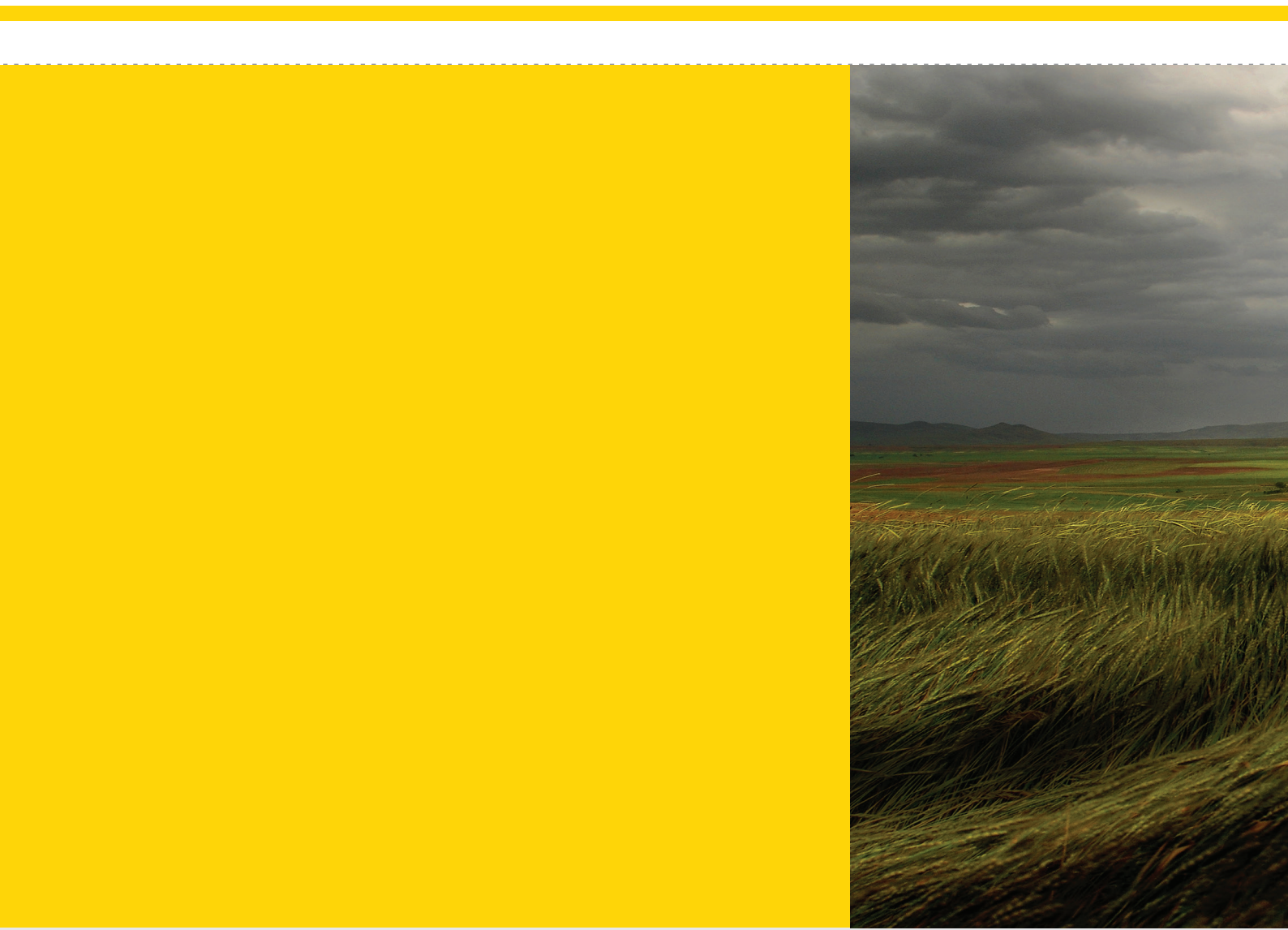
Free publications:

- one copy:
via EU Bookshop (<http://bookshop.europa.eu>);
- more than one copy or posters/maps:
from the European Union's representations (http://ec.europa.eu/represent_en.htm);
from the delegations in non-EU countries (http://eeas.europa.eu/delegations/index_en.htm);
by contacting the Europe Direct service (http://europa.eu/eurodirect/index_en.htm) or calling 00 800 6 7 8 9 10 11 (freephone number from anywhere in the EU) (*).

(*). The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

Priced publications:

- via EU Bookshop (<http://bookshop.europa.eu>).



European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: +45 33 36 71 00
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

