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Identifying the quiet areas of a small urban setting: The case of Mytilene

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Abstract

The aim of this study is to achieve a greater insight regarding quiet areas in agglomerations and contribute to their identification. The small urban setting of Mytilene located in the island of Lesvos (North Aegean, Greece), was the case study of this research. Based on citizen contribution, a number of "places" derived that are perceived as "quieter" than others, by the permanent residents of Mytilene. The "places" mentioned from this procedure were checked by means of acoustic measurements, concerning the noise levels that occurred within the 24h period. A novel method regarding the duration, repetition, check spot and the positioning of measurement was used, in order to calculate the day, evening and night period's noise levels (L_{den}). A performance matrix was then created in order to compare the results, in relation to acoustical, functional and visual criteria. Furthermore, by incorporating perceptual criteria we assisted the quiet area selection procedure. The provision of quietness, as a direct ecosystem service, is a major indicator of environmental quality. Nevertheless, the way that city inhabitants perceive their acoustic surroundings could determine the character of the landscape along with the quality of the soundscape and define the meaning of quietness that still remains vague.

Keywords: Strategic Noise Map, Noise Measurements, Citizen Science, Soundwalk, Performance Matrix

1. Introduction

1.1. Quiet Areas

Unlike many other environmental problems, public complaints regarding environmental noise have increased dramatically in recent years (Gidlöf-Gunnarsson and Öhrström, 2007). According to WHO (World Health Organization), about half of all European Union citizens live in areas that do not provide acoustic comfort to its residents (World Health Organization, Guidelines for Community Noise, 1999). Numerous studies have concluded that the existence of quiet public areas could protect urban dwellers from unwanted sounds (Chiesura, 2004) and the adverse health effects directly related to noise.

Quietness is considered to be a major aspect of a healthy soundscape and areas that provide such a service are essential for the wellbeing of urban dwellers and the quality of the urban environment. The kind of space that is required on each type of quiet area differentiates according to the user of space and the entity that requires protection. A quiet urban area retains an anthropocentric profile, offering an acoustic "relief" to city inhabitants from environmental noise. The acoustic perception of individuals holds an important role regarding attitudes on "healthy" urban soundscapes (Jeon and Hong, 2015). The psychoacoustic terms, "liveliness", "vibrancy" "positive or negative sound" are often used in order to describe a soundscape from a human perspective. Recent research shows that it is the quality of a sound that shapes a soundscape in a negative or a positive way and not the intensity of the sounds present (Bruce and Davies, 2014). Human beings are considered to be both the source and the receiver, making the efforts of noise control in an agglomeration, a tail chasing procedure.

A rural quiet area serves different vital purposes, mainly concerning conservation policies for natural protected areas. Therefore, the issue of acoustic perception of individuals in rural quiet areas is unrelated, for the reason that human beings are considered indirect beneficiaries. A very effective way to locate rural quiet areas is to calculate the distance that noise from various sources like the road network propagates (Votsi *et al.*, 2012). These distance-based criteria, are probably not useful in urban areas due to the compact structure of most agglomerations.

1.2. Acoustic Perception of Quietness

Soundscapes are directly associated with the landscape and the type of land use. The need for quietness is linked to noise sensitivity and the sound perception of individuals. If urban sounds are perceived as a negative factor the need for quietness is higher, but if perceived as a positive factor, in terms of liveliness and vibrancy, that need is reduced (Booi and Van den Berg, 2012). The spatial and temporal variability in sound perception is associated with the landscape structure that is formulated by human activities, biological processes and geophysical attitudes (Matsinos *et al.,* 2008).

A method to assess the acoustic perception of individuals is the soundwalk. It is a way of understanding on how soundscapes are being perceived by their users (Davies *et al.*, 2013). Along with the term soundscape, soundwalk is also originally attributed to R. Murray Schafer. A good example is the soundwalk conducted in the "*positive soundscape projec*t" (Davies *et al.*, 2013) that highlighted both the negative and positive acoustic aspects of Manchester, UK. The soundwalking practice has proven to be a valuable tool for soundscape studies and could set the ground for future soundscape planning. The flexibility of its methodology allows novel inspired alterations that could serve different purposes regarding the scope of each research. The common Soundwalk practices, even though they are evolving, consist of several identical "steps". A pre-designed route for the participants to follow, with structured questionnaires and stops in predefined checkpoints, are some of the common soundwalk characteristics.

The way that individuals perceive soundscapes, strongly relates with the activity of the listener on each occasion. The three states of listening, listening in search, listening in readiness and background listening (Jennings, 2013) could contribute to a better understanding, of the personal act of listening to a broader scale.

1.3. Quiet Area Selection Criteria

The selection criteria for the identification of quiet areas even though they are not limitative, differ between urban and rural areas due to different priorities and purposes that they serve. The dissimilarity regarding the acoustic indicators used and the limitations proposed is another example that highlights the different "audiences" on each type of quiet area. The day – evening – night noise level indicator (L_{den}) is used solely for quiet areas in agglomerations and a noise threshold of 50 – 55 dB(A) is proposed.

Nature protection and health protection are considered to be major aspects of both urban and rural quiet areas. Urban green spaces that are directly associated with biodiversity levels, are often correlated with healthy soundscapes, creating a positive perception on its acoustic condition. Therefore, urban parks are placed amongst the top preferences of quiet area selection (Brambilla *et al.*, 2013). The visual criteria, refers to the existence of natural or cultural established values in official documents. Furthermore, recreation as an activity varies between moderate, intensive and passive in urban and rural areas. The ideal size of a quiet urban area varies between 100-100.000 m^2, while in rural quiet areas 0.1–100 km^2. Finally, criteria regarding the user's acoustic perception are yet to be assessed (European Environment Agency, 2014).

1.4. Citizen Contribution and Awareness

All cities have areas quieter than others. City inhabitants use them in order to escape from their noisy surroundings, but in most cases there is no official documentation delimiting and protecting them. The use of local knowledge could navigate the efforts of area identification, without necessarily searching for "places" with low noise levels. This Citizen Science project, promotes participation in scientific research by members of the public mainly through observation and personal experience (Silvertown, 2009).

Citizen Science projects and Community-Based Monitoring (CBM) network programs, contribute with a vast amount of data regarding various ecological scientific goals such as animal appearances and abundance (e.g. bird watching), plant populations, fisheries, invasive species detection, climatic anomalies and environmental pollutants (Whitelaw *et al.*, 2003; Cohn, 2008; Conrad and Hilchey, 2011; Resnik *et al.,* 2015; Loss *et al.,* 2015). Furthermore, these projects promote awareness and provide communities with numerous benefits regarding the Increase of environmental democracy (Conrad and Hilchey, 2011).

2. Methodology – Case Study Area – Scope

The city of Mytilene, located in the island of Lesvos, according to the latest census (Hellenic Statistical Authority), has a population of 85.330 residents and a population density of 52, 26 per square kilometer. The specific city was chosen due to the diversity of its landscape, where urban and rural gradients coexist. Furthermore, islands and coastal cities are fragile systems with many ecological peculiarities. The rigorous human intervention on these systems, strongly affects the quality of the soundscape increasing the need for protection (Farina and Pieretti, 2012).

This study presents a novel approach, regarding the identification of potential quiet areas in small urban settlements. Acoustic measurements and noise propagation software could sufficiently aid research on areas with increased noise levels. In contrast, research on areas with decreased noise levels could be a subject that is best known by the agglomeration's residents. The urban fabric of a city, meaning its structural individuality that shapes and differentiates neighborhoods physically, along with the socioeconomic inequalities that may occur, are a major reason for acoustic uniqueness in various scales. The citizen's knowledge about areas or spots that due to several structural and population density reasons remain unaffected by environmental noise, could navigate the scientific efforts towards the recognition of urban quiet areas.

2.1. Citizen Science Contribution - Interviews

Acoustically themed sociological surveys could provide with valuable data for numerous purposes. Nevertheless, the differentiation in their objectives fails to give the opportunity for comparison on the acoustic quality of a city, or the levels of exposure of its residents, with those of another city (Brown and Lam, 1987). The use of local knowledge aided the identification of the areas that are perceived as quiet. A total of 55 members of the academic community permanently inhabiting the city of Mytilene, were asked in advance to monitor their daily routine by mainly observing their acoustic surroundings. The next step

was a follow up interview for each individual with the help of a semi structured questionnaire. The purpose of this procedure was to highlight the areas perceived as quiet in order to incorporate them in the measurement process. Furthermore, their sensitivity to noise at city, neighborhood and home level was discussed. The final issue of the survey was the feeling of safety concerning the areas mentioned.

2.2. Measurement areas and check spots

Urban settlements have been spatially divided into districts and neighborhoods since the distant past. These places or zones retain social, economic and spatial significance hence creating different urban environments (Smith, 2010; Sharifi, 2015) and soundscapes. A place can be defined as "a small, three-dimensional urban space that is cherished by the people who inhabit it for all that it represents or means to them" (Friedmann, 2010). That cherished uniqueness could also be attributed to the specific soundmarks that shape the character of each neighborhood.

In order to obtain a realistic outcome regarding Mytilene's acoustic existing condition, a scaling down system was proposed, from city, to neighborhood, to check spot. The city of Mytilene was segregated in 10 neighborhoods (the city Centre, Sinikismos, Epano Skala, Kastro, Kioski, Limani, Chrisomallousa, Kallithea, the Stadium area and the local university area). These neighborhoods differ both acoustically and visually, while most of them include, urban green spaces, parks, hospitals, schools and archeological sites.

2.2.1. Measurement procedure

All measurements were conducted using the same protocol during the spring and summer season of 2012 (May 1st to July 30th). According to the European directive 2002/49 relating to the assessment and management of environmental noise, the day period lasts 12 hours, the evening period 4 hours, and the night period 8 hours. In order to obtain a realistic result regarding L_{den}, three measurements for each period were conducted (*table 1*).

Table 1. Measurement Time Schedule

Measurement Protocol			
L_{den}	**Time of Measurement**		
L_{day} (07:00 – 19:00)	09:00	13:00	17:00
$L_{evening}$ (19:00 – 23:00)	20:00	21:00	22:00
L_{night} (23:00 – 07:00)	24:00	02:00	06:00

The mean of the measurements for each period was calculated in order to obtain a single number that represented the period's equivalent continuous sound level (L_{Aeq}). The outcome was then integrated in the L_{den} formula, after the necessary adjustments needed for the calculation. In order to predict unexpected sonic events, the 2002/49/EC directive proposes a 5 dB(A) penalty added for the evening period and a 10 dB(A) penalty added for the night period. The question arises whether these penalties statistically affect the results. In order to compare results, a second set of results was produced without calculating L_{den}. Instead, the mean of the day, evening and night equivalent continuous sound level outcome ($L_{Aeq\ Mean}$) was calculated.

2.2.2. Positioning

The exact spot of each measurement was chosen regarding the topography and the urban structure of each area. The most preferable spots, considering that they were available, were open spaces far from high walls, or sharp urban structures. The notion was to keep the measurements unaffected as much as possible, from factors like sound reflection, refraction and diffraction. Strategic positioning during the measurement, considering the size and the topography of the area, in combination with consistency to the aforementioned protocol, could result to a realistic outcome. Finally, each 10 minute measurement was carried out at a height of 1,5 meters above the ground.

2.3. Mapping

The 2002/49 directive on the management and assessment of environmental noise has given the necessary definitions that highlight the difference between noise mapping and strategic noise mapping. A strategic noise map could pose as a visual aid regarding all noise sources that shape an area, in order for strategic action plans to take place. Specific noise source identification (e.g. road traffic noise) and the visualization of their propagation using various noise modeling software could be a stand-alone noise map.

The data used to create the city's strategic noise map were the results from the noise measurements. The purpose of this map is to highlight neighborhoods with increased sound pressure levels, using realistic data from the check spots selected, in order to aid future decision making. A coloring system was used in order to visually assist the detection of the neighborhoods with the highest noise levels and therefore the areas with the highest need for quietness.

2.4. Acoustic Performance Matrix

Following the data collection from the measurements, a performance matrix was created in order to determine the best option for a candidate quiet area. By utilizing the criteria given through the EEA's (European Environment Agency) technical report on quiet areas, a performance matrix was created in order to conclude on which proposed area could be the best option.

The five criteria chosen in order to assess the candidate quiet areas were the acoustic indicator's levels, the promotion of nature on each location, the size of each area considering it is delimited by local authorities, the opportunities for recreation activities and the visual established values of each area. For each criterion, the available options (proposed areas), were scored on a 0-1 scale, where zero is the worst – case outcome and 1 is the best – case outcome (Steele *et al.,* 2009). The goal of this method was to simplify the complicated procedure of area selection, by establishing each area's acoustic performance.

2.5. Soundwalk

A very important aspect of the resulted candidate quiet area is the way that is being perceived by its users. For this research a novel soundwalk practice is suggested. It is an effort to remove the participants from a biased "mold" activity and "tune them in" to the soundscape under consideration. 5 members of the academic community contributed on the issue of acoustic perception, by participating to the candidate quiet area soundwalk. The way to familiarize the participants with the soundscape consisted of a pre designed route with 5 stops, each one with unique soundmark and landmark capabilities, in order to introduce the full spectrum of the landscape. This first part of the soundwalk was conducted as a "tour" through the landscape, by following the rule of "silence" during the walk. During every 1 minute stop, measurements were conducted using the sound level noise meter PRO-DX Vocis of Castle Group. The use of all senses was important for the deconstruction of the characteristics of each checkpoint, with emphasis to what could be audited. The second part of the soundwalk was a "free roam" for the participants and for the first time were introduced to a questionnaire that included open ended questions regarding on what could be audited at that specific moment and what would be the preferable sound for each location. The participants had the freedom of choice to walk through the park with no stop order or time limitation, individually or as a group. This freedom of choice contributed to the "tuning in" of the soundwalkers with their surrounding soundscape. Even though the soundwalkers were free to explore the area, all the questions concerned specific checkpoints.

3. Results and Discussion

3.1. Citizen Science Contribution

In terms of "noisy" as it was perceived by the residents that contributed to this research, the city level and home level were the top choices. Hence, most participants perceived their neighborhood as a "quiet" place in contrast to the other two options. The lowest score concerning quietness holds the city of Mytilene, while the wavering between noisy and quiet answers, kept a low score in the overall results (Figure 1).

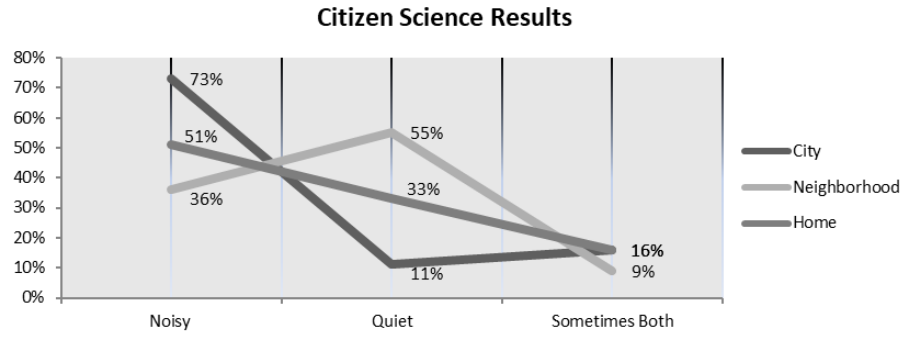

Figure 1. Citizen science results

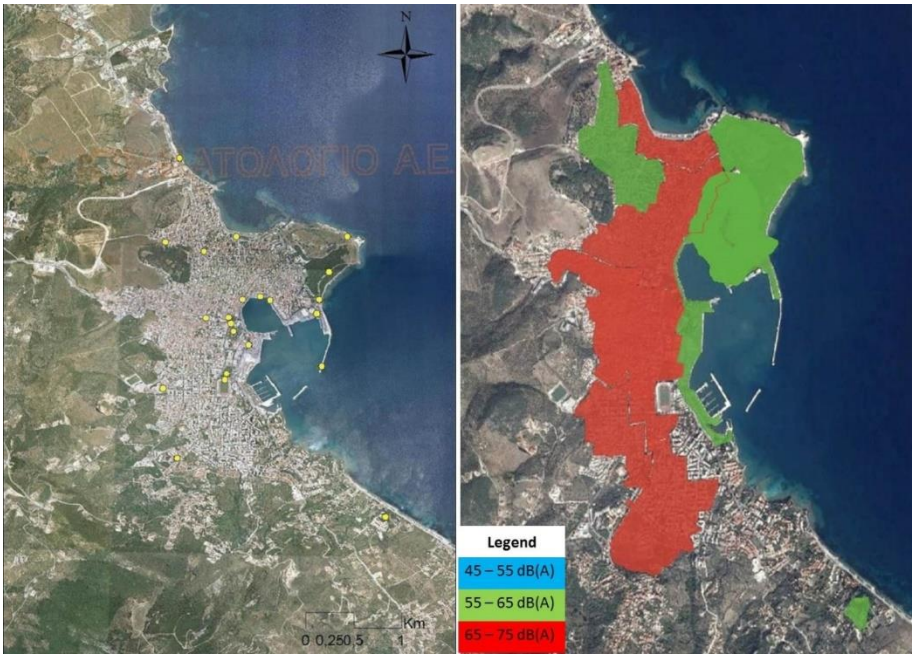

Image 1. Check Spot Map and Neighborhood Strategic Noise Map

The participants were asked, whether they could recall an area they use, that stands out for its acoustic quality. The areas that emerged through this question were incorporated in the measurement procedure. The harbors lighthouse was amongst the top choices made by the participants. Apart from its original purpose, the lighthouse serves as a meeting place for Mytilene's youth, due to its reasonable walking distance from the noisy streets. Nevertheless, due to its small size and lack of other important criteria, such a place could not be characterized as a "quiet area". The second most popular choice was an urban green space, located in the center of the city, the Agias Eirinis Park. The specific urban green space is a highly visited park that also serves as a recreation area. All the areas mentioned were incorporated in the measurement procedure in order to construct the acoustic profile of Mytilene (image 1), by scaling up from check spot, to neighborhood and finally to city level. The feeling of safety that was discussed during the interviews could easily be correlated with the visual isolation of an area. The 47% of the participants answered that they do not feel safe in the place they mentioned proposed. Safety in an area comes with high levels of imageability, meaning a clearly understood visual environment (Luymes and Tamminga, 1995). The issue of safety in public spaces could be a problem concerning urban quiet areas as well.

Table 2. Measurement Results

Measurement Results					
Neighborhood	**Check Spot**	**Land Use**	**$L_{Aeq\ Mean}$**	**Check Spot L_{den}**	**Neighborhood L_{den}**
City center	Municipal Theater Garden	Mytilene's Theater	69,3	74	69,2
	Walkway Central Market	Mytilene's Central Market	65,6	70,8	
	Central Square	Open public space	63,8	68,8	
	Restaurant facilities	Recreational area	67,2	72,4	
	Middle School Yard	School /Recreational area	68,5	74,8	
	Agios Therapontas Church	Mytilene's Central Church/Landmark	68,7	73,7	
	Agias Eirinis Park	Urban green area	56,1	61	
	Karapanagioti Park	Urban green area	53,5	58,5	
Sinikismos	Primary School Yard	School / Recreational Area	54	59,7	59,1
	Ancient Theatre	Archeological Site	52	58,5	
Epano Skala	Ruins of ancient breakwater	Archeological Site	61,8	66,9	66,1
	Epano Skala's Park	Residential Area	60,8	65,4	
Kastro	Byzantine Castle	Archeological Site/Recreational Area	45,8	50	56.5
	Tsamakia beach	Urban green/Recreational Area	57,5	63,1	
Kioski	Statue of Liberty	Aesthetic Landmark	56,9	61.7	61.7
Limani	Harbor	Artificial Harbor and Port	62,7	67,5	62,7
	Lighthouse	Navigational Aesthetic Value	52,9	57,9	
Chrisomallousa	Hospital	Hospital / Residential Area	62,4	70,2	68,2
Kallithea	High School Yard	School / Recreational Area	62,1	67	67
Stadium Area	Agiou Konstantinou Park	Archeological Site	61,1	66,3	66,3
Xenia Hill	University Campus	University Campus	51,9	56,9	56,9

From the statistical analysis that followed the data collection it resulted that both data sets (L_{den} & $L_{Aeq\ Mean}$), are normally distributed (Shapiro-Wilk Test, L_{den}: sig. 0.345 > 0.05, $L_{Aeq\ Mean}$ sig. 0. 466 > 0.05). Furthermore, both data sets present a strong positive correlation (Pearson's r = 0.938, significant at the 0.01 level). The results from the measurements conducted in every check spot along with the areas land use are presented in *table 2*. It is obvious that most of Mytilene's neighborhoods exceed the 55 dB(A) L_{den} limitation and therefore the need for quiet areas is undeniable (image 1).

The performance matrix that was created in order assessed each check spot in relation with the criteria given by the EEA regarding the identification of quiet areas (table 3). According to the results, the Agias Eirinis Park is the best option for quiet area delimitation due to its high score. The specific park was highlighted as it satisfies almost every criterion set, apart from the noise threshold. Amongst the rest check spots, the Karapanagioti Park could be the next best option. Overall, Mytilene is characterized by a plethora of cultural and natural values, while recreation seems to be a very important aspect of the city.

3.2. Soundwalk Results

The resulted candidate quiet area was the "Agias Eirinis Park" and therefore a soundwalk was specifically designed (*image 2*) in order to assess the acoustic perception of individuals. The soundwalk conducted practically involved city residents, in order to address environmental noise. The participant's acoustic preferences compose a new more agreeable soundscape and therefore reshape the landscape. Furthermore, the information on what could be heard during the soundwalk could be used in future research in order to detect acoustic differences that may occur in time (table 4).

Table 3. Performance Matrix of Candidate Quiet Areas in Agglomeration

Performance Matrix						
Check Spot	**Noise Indicator**	**Recreation**	**Nature Protection**	**Size**	**Cultural/Natural Value**	**Total Out of 5**
Municipal Theater Garden	0	1	0	0	1	**2**
Walkway Central Market	0	1	0	0	1	**2**
Central Square	0	1	0	1	1	**3**
Restaurant facilities	0	1	0	0	0	**1**
Middle School Yard	0	0	0	0	1	**1**
Agios Therapontas Church	0	1	0	0	1	**2**
Agias Eirinis Park	0	1	1	1	1	**4**
Karapanagioti Park	0	0	1	1	1	**3**
Primary School Yard	0	0	0	0	1	**1**
Ancient Theatre	0	0	0	0	1	**1**
Ruins of ancient breakwater	0	0	0	0	1	**1**
Epano Skala's Park	0	0	0	1	0	**1**
Byzantine Castle	1	0	0	0	1	**2**
Statue of Liberty	1	1	0	0	0	**2**
Tsamakia beach	0	1	0	0	0	**1**
Harbor	0	0	0	0	0	**0**
Lighthouse	0	1	0	0	0	**1**
Hospital	0	0	0	0	0	**0**
High School Yard	0	0	0	0	0	**0**
Agiou Konstantinou Park	0	0	0	0	1	**1**
University Campus	1	0	0	0	0	**1**
Total	**3**	**9**	**2**	**4**	**11**	

Image 2. Agias Eirinis Park Soundwalk Route, Source: Google Maps

Table 4. Soundwalk Results

City Park "Agias Eirinis" Soundwalk					
	Stop 1	**Stop 2**	**Stop 3**	**Stop 4**	**Stop 5**
What Could Be Heard	*Car Engine* Swing Squeak Children Airplane People Talking Birds	*Car Engine* People Talking Birds Rustling Leaves Footsteps Insects	*Car Engine* Footsteps People Talking Birds Motorbike Wind Brewing	*Car Engine* Children People Talking Wind Brewing Birds Footsteps	*Car Engine* Children Laughter Birds Motorbike Footsteps Vehicle Horns Wind Brewing
Land Use	Church	Resting Area	Entrance	Playground	Park Center/Cafe
Dominant Sound	Anthrophony	Anthrophony	Anthrophony	Biophony	Biophony
Preferable Sound	Birds	Water Sounds	Birds	Music	Water Sounds
Measured L_{eq} dB(A)	63,6	60,9	64,3	61,4	63.7

The presence of road traffic noise was in all cases noticeable. From the responses given by the soundwalkers on the quality of noise at each stop, it resulted that the least favorite noises were dominant, but less diverse. It is obvious that vital auditory information about an area's soundscape could derive through careful listening.

4. Conclusions

The necessary steps that must be taken, to preserve and protect quiet areas, do not concern these areas alone, but mainly, the areas surrounding them. Once a quiet area is delimited by the member state, it is of obvious importance the proper design and promotion of peace outside this area in order to create a zone of protection from environmental noise. "Quietness" in an area could be achieved not only by controlling noise emissions but also by enhancing positive sounds. In order to improve the area selection procedure, information regarding the ecology of each area should be included. Biophony and geophony are directly associated with the ecological aspects of a candidate quiet area. Vegetation and bird species should be identified, in order to highlight the positive effects, they might have on the overall soundscape (Irvine *et al.*, 2009). Furthermore, research on other forms of life (e.g. insects) on each area under consideration could contribute to the classification of the biodiversity levels and therefore properly assess nature protection.

The goal of this paper was to create an easy to use and cost effective quiet area identification procedure. Nevertheless, "quietness", as a concept still remains vague and further research is needed in order to conclude whether it is an attribute that could be created or simply and preferably, preserved.

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