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QUALITY ASSESSMENT OF QUIET AREAS: A MULTI-CRITERIA APPROACH

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ABSTRACT

The quiet area concept has found its way to the EC environmental noise directive and the noise policy of several member states. A quiet area is generally defined as an area that is quieter than the surrounding region and has a psychological restoring effect on people visiting it. Nevertheless a clear and objective definition of what constitutes a quiet area and how its quality can be assessed is still lacking.
This paper reports on work performed for the Flemish government aiming at summarizing current state of the art knowledge on quiet areas in a multi-criteria quality assessment system. A suitable soundscape for a quiet area is defined as a background that arouses a perception of silence combined with a limited number of disturbing noise events. Natural or location typical noise events are assumed to accentuate quietness rather than to jeopardize it. This view is translated to noise level based criteria at the one hand and to perception based criteria at the other hand. The role of the human listener (both the expert and the laymen enjoying the soundscape) is nevertheless prominent in the set of criteria. Quality assessment depends on the main use of the area and results in three grades of quality, thereby introducing sufficient flexibility to accommodate rural and urban quiet areas alike.

1 INTRODUCTION

The concept of quiet area has been introduced in many countries' legislation and is more recently mentioned explicitly in the European Environmental Noise Directive. This document defines: *'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.* Similarly: *'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.* These definitions leave room for interpretation and critical reflection. In this paper we report on such a critical reflection recently performed in Flanders (Belgium).

A quiet area (QA) can be regarded as a particular type of soundscape that is worth preserving because of a unique feature: *quietness*. From this point of view, the definition of such an area is context sensitive. Preserving a QA is as such not necessarily different from preserving other (typical) soundscapes. However, the quiet soundscape may have just this additional benefit: it can have a psychological restoring effect on people visiting it [4].

To further outline the line of thought we follow in this work, two relatively common alternative interpretations are ruled out. Firstly, preservation, management, and restoration of QAs is not nature preservation. The aim of the whole process is not to guarantee high quality biotopes for animals. In many cases nature will be prominently present in a QA, but it is not the goal on itself. Secondly, a QA is not the same as a quiet living environment. In a QA, the activity of the observer (mainly recreation) is focussed on the outdoor environment. Audio-visual perception of this environment is part of the experience the visitor is looking for. In the living environment, activity can be quite diverse and only strong intrusions will trigger a - mostly distressing - feeling towards the acoustic climate or its components. This difference has a strong influence on the choice of indicators and the way the quality of the environment is assessed.

2 PERCEPTION OF QUIETNESS

The soundscape in a QA obviously has to be experienced as *quiet* by the average listener. Quietness does not mean a complete absence of sound – although on rare occasions such absence of sound may trigger a silence-noticing event. What determines quietness then? We put forward the hypothesis that *a feeling of quietness is determined by intervals of silence where silence itself is defined as the ambience of a soundscape, the gap or distance, the auditory space between sound events*. This definition was compiled based on [1][2][3]. Note that, in contrast to the physical definition of silence, the silence defined above can be heard. It is nevertheless an event-poor part of the soundscape and does not trigger much meaning.

The above made assumption has its consequence on the way an acoustic field is analysed. In Fig. 1 the acoustic field is split in its background, which is always present, and its events component. In line with the definition given above, the background largely determines the basis quality of the quiet soundscape – it determines whether it is rated silent or not. Events can disturb the soundscape but it is also possible that they accentuate the basis quality (e.g. an occasional bird sound). It is known that the perception of noise events – and possibly also the resulting annoyance – involves source recognition and associations to the effect the source

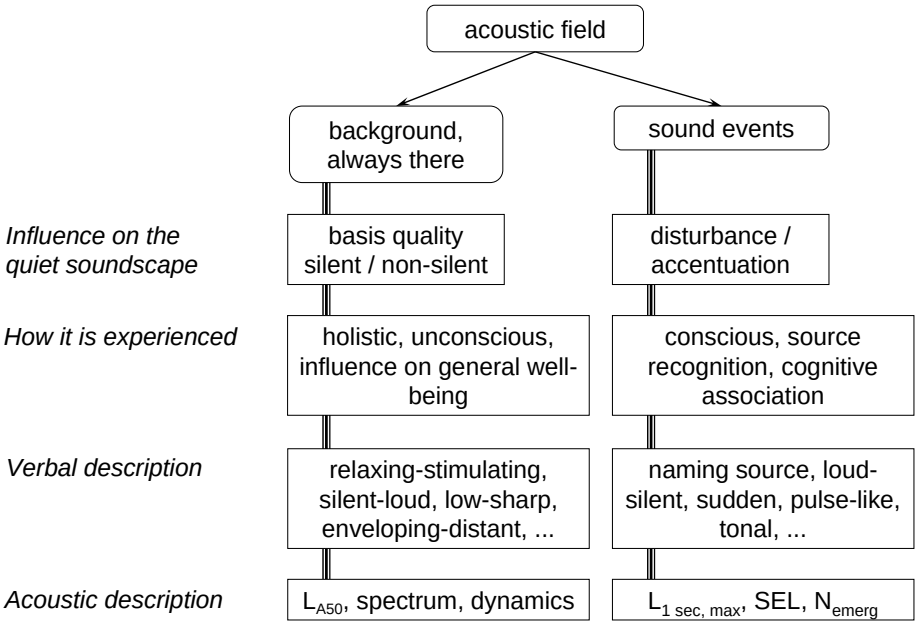

Fig. 1.scheme of various aspects related to analysing an acoustic field

has on the person-environment relationship. The background on the other hand, due to the fact that is low-fidelity, will not lead to any source recognition. It is experienced in a more holistic way and has a more direct effect on general well-being. The words expected to be related to the background and to the sound events in a verbal description of the soundscape are shown in Fig. 1. Acoustic descriptors suitable for evaluating the background can be based on statistical noise levels L_{50}, L_{95}. Including a notion of the sound spectrum and the dynamics of the sound is useful. Acoustical indicators for events of primary interest in the QA are number of emerging events (where emerging is defined relative to a measure for instantaneous background) and strength of the disturbance ($L_{1sec\ max}$, SEL).

3 AN AREA SPECIFIC APPROACH

To optimally serve its purpose, a quiet area (QA) should be within reach of the population. What is within reach depends on the time frame. The neighbourhood green is within reach for a five minute stroll while the urban or suburban park is within reach for a weekend promenade and the rural natural reserve for a short break. Thus, it makes sense to include different flavours of QAs in land-use plans, each having their particular quality requirements:

- **Q_l**: QA in open country
- **Q_{lr}**: QA in open country with joint use for low-dynamic recreation. Such areas can include infrastructure for recreation and sports compatible with quietness such as sailing, horseback riding, etc.
- **Q_v**: QA in open country with residential recreation, where nighttime needs attention.
- **U_a**: QA at the level of the urban agglomeration: urban woods, …
- **U_s**: QA at the level of the city district: parks and (semi-)public inner areas (e.g. old beguinages, …)
- **U_b**: QA at the level of the neighbourhood with more intense use: play park, …
- **U_{sr}**: urban QA with joint use for highly dynamic recreation: traffic free squares with open air cafes…

These areas are not mutually exclusive. E.g. a Q_{lr} area can be enclosed by a Q_l area or an U_b area can be attached to an U_s area. On top of the different quality requirements for these areas, a quality label may be assigned (e.g. using a number of stars).

The concept *quiet spot* is introduced to focus attention to locations within the QA where the typical soundscape can be experienced in optimal conditions. In urban QAs, quiet spots can be parts of a park that are most shielded from traffic noise and noise produced by other visitors. Active management of the soundscape in these selected spots (e.g. by stimulating natural sounds) can be envisaged. However quiet spots should not be advertised explicitly to avoid over crowding.

4 MULTI-CRITERIA

As quality assessment of quiet areas is a multi-dimensional problem, a multi-criteria evaluation is appropriate. The selection of criteria is based on Section 3, taking into account applicability and the solidity of the underlying knowledge base.

4.1 Criteria based on physical measurements.

With the exception of Q_v, the use of a QA makes an evaluation limited to daytime acceptable. Let us first discuss the quality of the *background* sound. An A-weighted equivalent level, L_{Aeq}, is strongly influenced by the sound level of events and thus not suitable. In earlier work [6] we compared the perception of quietness by a trained observer with different level indicators: L_{Aeq}, L_{A95}, L_{A50}, L_{A10}, … and came to the conclusion that statistical noise levels in the range L_{A95} to L_{A50} were the best predictors for quietness. This is in agreement with the hypotheses that quietness is related to the background noise. Theoretically, L_{A95} could be determined by short intervals of extreme silence thus the median value L_{A50} seems a better compromise. An $L_{A50,15minute}$ threshold of the order of 38 dBA was found suitable for discriminating between quiet and non-quiet areas in open country [6].

Additional indicators that allow to characterise (urban) soundscapes with respect to the ambient noise were identified in literature. Frequency spectrum, represented by the spectrum gravity centre, was proven a relevant descriptor for urban ambient noise [8]. The slope of the power spectrum of fluctuations in instantaneous noise level and pitch were found to relate to typical characteristics of music and therefore could be used to describe soundscape dynamics [9]. The body of knowledge that relates these additional indicators to perception of quietness is currently insufficient to add these indicators to a multi-criteria assessment for practical use.

Physical measurements are not very well suited to quantify disturbance by *sound events*. It is indeed still rather bothersome to distinguish between natural sound events that could accentuate the silence and intruding sound events in situations where the noise levels of events are very low. Table 1 shows the correlation between observations made by a trained listener and several easy-to-measure indicators. The number of cars heard by the trained observer (where distant murmur of traffic is not included) correlates reasonably well with the number of noise events N_{cn} if the detection threshold is set at 10 dBA above L_{A95} or if it is set at 3 dBA above L_{A50}. The duration of the events, T_{cn}, correlates somewhat less. The table also shows that it is very difficult to estimate the time that foreign sounds (that is sounds not typical for the rural environment) are heard based on these physical indices. Because L_{A50} was already chosen as an indicator for the background, it makes most sense to add, as a second

Table 1 Correlation between detection of intruding sound by the trained listener and measured indicators

	number of cars R^2 (quadratic)	duration foreign sounds R^2 (quadratic)
L_{50}	0,36	0,01
L_{10}	0,35	0,01
w.r.t. L_{95}		
$N_{cn}(10)$	0,53	0,09
$N_{cn}(3)$	0,1	0,32
$T_{cn}(10)$	0,28	0,07
$T_{cn}(3)$	0,32	0,12
w.r.t. L_{50}		
$N_{cn}(10)$	0,2	0,12
$N_{cn}(3)$	0,74	0,19
$T_{cn}(10)$	0,05	0,07
$T_{cn}(3)$	0,26	0,12

physical criterion a limitation on the number of events more than 3 dBA above the $L_{A50,15minute}$. Reachable limits are of the order of 5 to 20 events per 15 minutes depending on the type of QA.

4.2 Criteria based on observations by a trained listener

Rather than using sophisticated methods to try extracting source information from physical measurement, it is suggested to add criteria based on observations by a trained listener since they still seem more cost-effective. The trained listener is the best instrument for a disturbance indicator such as the duration of hearing sounds that are foreign to the desired soundscape in a QA essentially because the listener can decide which sound belong to the rural soundscape.

4.3 Criteria based on the appreciation by the visitors

In the approach to QAs followed here, the visitor is the customer and thus has a decisive voice. Surveys with passers-by can include direct questions about silence, e.g. “When you think about the area where you were walking, cycling, how silent would you say this area is” [5]. This leads to a criterion stating e.g. that a rating of 8 on an 11-point scale is required for the highest quality area.

Nevertheless this direct question leads to some ambiguity with some of those questioned due to the presence of e.g. natural sound. An assessment based on a semantic differential is more subtle [4]. The number of dimensions sampled is for this application kept as low as 9: *sharp-low*, *loud-silent*, *unnatural-natural*, *stressing-relaxing*, *rough-soft*, *complex-simple*, *boring-exciting*, *enveloping-open* (free translation from Dutch). To test the approach, approximately 200 people were interviewed, half of them in a QA type Q_l. Principle component analyses was performed on the data, resulting in 2 factors explaining 68% of variance. The first factor contains *silent*, *natural*, *relaxing*, *soft*, *exciting*, and *open*. It was labelled pleasant. The second factor focuses on *not sharp* and *complex* but contains a mix of other dimensions as well. It is labelled eventful following [4]. A quiet soundscape thus seems to be pleasant and rather uneventful. The criterion is expressed as the sum of the 7 variables in the semantic differential being higher than 0.7/0.8/0.9 for a Q_l of respectively one, two, three star quality. Similar thresholds can be extracted for an urban QA.

4.4 Non-acoustic criteria

Non-acoustic factors can be included as separate criteria. They are related to the multi-sensory perception of the environment and to the function of the quiet area. We include natural and landscape value at the one hand, sufficiently large congruent area at the other.

5 CONCLUSIONS

Based on existing knowledge on perception of the QA soundscape, we propose a multi-criteria quality assessment that differentiates between different types of QA. It is a extracted as a balance between feasibility in the field and accuracy. Both physical measures, manned observation and surveys with visitors are included in the set of criteria. Moreover the criteria focus both on basic quality and limited disturbance. This paper reports on the highlights of this system which is more extended and detailed than could be included on six pages.

ACKNOWLEDGEMENTS

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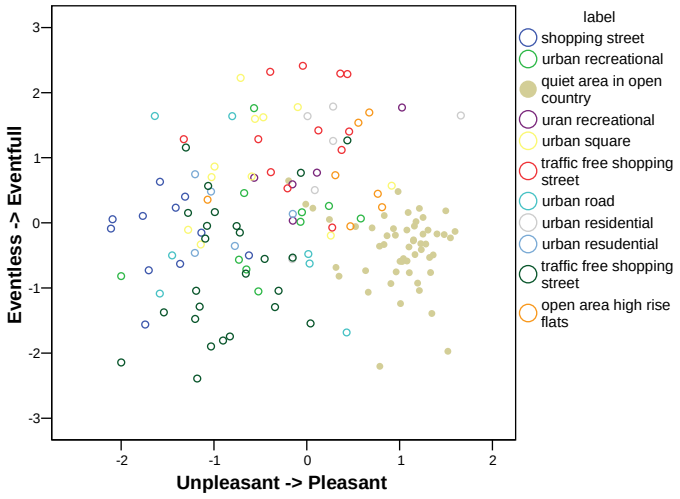

Figure 1 Results of semantic differential evaluation of soundscapes shown on principle factors

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