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RESEARCH ARTICLE

Soundscape actions: A tool for noise treatment based on three workshops in landscape architecture

Gunnar Cerwén[a,*], Jacob Kreutzfeldt[b], Carola Wingren[a]

[a]*Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, SLU, Alnarp, Sweden*
[b]*Independent scholar*

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Abstract
This paper reports experiences from three workshops dealing with soundscape as a noise treatment approach in landscape architecture. The workshops were conducted between 2012 and 2016 in different contexts, for different purposes and with different participants. The paper describes the workshop approach employed and analyzes the proposals made by workshop participants to employ "soundscape action" as an operational tool in landscape architecture projects. Through a process of 'keywording' and clustering proposals from the workshops, 22 pragmatic soundscape actions emerged and are described on a general level. The paper then discusses the outcomes and experiences from the workshops and relates this to landscape architecture practice.

*Correspondence to: Sundsvägen 4-6, 230 53 Alnarp, Sweden.
E-mail address: gunnar.cerwen@slu.se (G. Cerwén).
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1. Introduction

In recent years, the study of soundscapes[1] has gained increasing attention within several fields of research, including landscape planning and design. The soundscape approach has contributed new insights into how, not only acousticians, but also landscape architects can benefit from considering sound (Brown and Muhar, 2004; Cerwén, 2016; Dee, 2012; Fowler, 2015; Hedfors, 2003; Whiston Spirn, 1998). It has been shown that landscape architects can work with soundscapes in their designs through consideration of aspects such as: acoustic properties of materials, masking, screening, location of functions, creation of biotopes for birds, and the introduction of water features.

Soundscapes influence health, experience, and quality of life. For instance, sound affects behavior (Cohen and Spacapan, 1984) and appreciation of landscapes (Anderson et al., 1983; Carles et al., 1999). Unwanted sounds, most typically noise from infrastructure and other technical sources, have been associated with negative effects on health (Basner et al., 2014; WHO, 2011), including stress, cardiovascular disease, and sleeping disorders. However, sounds may also have a positive effect on health, for example it has been shown that sounds from nature can aid recovery from stress (Alvarsson et al., 2010; Annerstedt et al., 2013).

Given the importance of soundscapes in everyday life, it is noteworthy that relatively little attention seems to have been paid to the practical implementation of soundscape thinking in landscape architecture planning and design. This shortcoming has been mentioned by a number of researchers and practitioners over the years and it has been suggested that there has been a visual dominance within the field, with other sensory impressions (including sound) not being given enough attention (Hedfors, 2003; Jakobsson, 2009; Southworth, 1969). This criticism appears to be related to the modernistic era in particular, but it has been shown that it is still relevant today (Cerwén et al., 2017).

Another criticism is that when sound is considered, it is relatively one-sided and with too much focus on negative aspects such as protection from noise (Hellström, 2003), rather than overall experiential qualities. Acousticians are likely to be involved, but they may be consulted too late in the process (Coelho, 2016), which may result in unnecessary adjustments of design proposals and/or unfit sonic environments. One of the reasons for this situation could be communication difficulties relating to the different tools and approaches in the respective profession (Brown and Muhar, 2004).

In efforts to increase consideration for soundscapes in landscape architecture, one way forward could be to formulate knowledge on soundscapes in a manner that is appropriate for landscape architects. Much of the research performed to date on soundscapes has focused on assessment of user experiences (e.g. Axelsson et al., 2010; Yang and Kang, 2005), while less attention has been devoted to practical implementation of soundscape thinking directed at disciplines such as landscape architecture. It has been suggested that, if implementation of soundscape thinking is to succeed, there is a need to further increase the collaboration between practice and academia (Payne et al., 2009).

One fruitful way to do this is through experimental workshopping, where knowledge and tools, often developed in academia, can be tested in practice. Workshops can also result in new insights, outcomes, and experiences that are useful in other situations. For instance, when reporting experiences from three workshops on landscape architecture in Melbourne, Fowler (2013) reflected on how to teach soundscape and also shared some of the students' ideas on how soundscapes can be represented visually.

In a EU COST meeting on soundscapes held in Edinburgh in 2009, tools for designing and planning soundscapes was one of the topics discussed (Kang, 2010). While it was noted that several efforts had been made in this area, the need for continuous development and improvement was emphasized. Furthermore, the need for different kinds of tools adjusted to different stages (or scales) in the process was raised. Similar calls have been made by Payne et al. (2009) and Andringa et al. (2013). In an earlier study based on interviews with urban planners in France, Raimbault and Dubois (2005) noted that these planners lacked a unidirectional language for describing sonic aspects in an urban situation. Furthermore, they noted that the planners lacked "helpful tools which were adapted for urban planning processes and therefore well defined in communicating and understanding design patterns" (Raimbault and Dubois, 2005, 346).

Previously proposed tools for landscape architects include: stepwise approaches for designing soundscapes (Brown and Muhar, 2004; Jennings and Cain, 2013; Zhang and Kang, 2007); toolboxes (Hellström et al., 2013, 47; Lacey, 2016); conceptualizations of soundscape characteristics (Axelsson et al., 2010, 2844; Cain et al., 2008, 741; Hedfors, 2003, 36; Herranz-Pascual et al., 2010, 6); tools for visual representation (mapping) of soundscapes (Aiello et al., 2016; Vogiatzis and Remy, 2014); tools for aural representations (Amini et al., 2016; Lundén et al., 2010); verbal communication (Hedfors and Howell, 2011; Siebein, 2010); and listening based approaches, such as sound walking (Schafer, 1992; Schulte-Fortkamp, 2010; Tixier, 2002). Different tools and approaches to soundscape design have also been discussed in Kang et al. (2016) Payne et al. (2009) and Axelsson (2010).

Whereas much of previous tools have been directed towards conceptualizations, prescriptions and the understanding of sonic experience, fewer have focused on the kind of changes that can be made in sound environments. Such approaches have been discussed by Brown and Muhar (2004), De Coensel and Botteldooren (2010), Fowler (2015), Hellström et al. (2013, 47), and Lacey (2016).

The approach in the present paper is related to these, but in contrast to previous work, it is based on a systematic collection of design ideas developed in collaboration with practicing landscape architects and other professionals

[1]Soundscape is a broad and multidisciplinary term (Schafer, 1994 [1977]) that can be used to describe anything from film sound to musical compositions and art. In the present context, soundscape is used to refer to the experience of the acoustic outdoor environment. Soundscape in this meaning has also been described as an auditory counterpart to the more visual term, landscape (Brown, 2012). Soundscape has been defined by the International Standards Organization (ISO) as an "acoustic environment as perceived or experienced and/or understood by a person or people, in context" (ISO, 2014).

through workshopping. It is argued that such an approach would increase validity of the resulting tool, as the thoughts and challenges posed by practice would be represented (cf. Cross, 2001).

1.1. Research approach and purpose

This study is based on experiences from three workshops in Sweden that focused on soundscape within the area of landscape architecture. The workshops were conducted in different contexts, sites and with different participants, but were all situated in an urban environment where traffic noise was perceived as disturbing and unwanted.

The purpose of this paper is to describe and share experiences from the three workshops and analyze and structure the workshop proposals in a way that summarizes the outcomes as a tool, so that they may be used as inspiration for practitioners.

Choosing to work with environments where sound is identified as "problematic" from the outset risks reinforcing the current focus on negative effects of sound. However, we believe that focusing on challenges that already have an auditory nature makes it easier for participants to activate and articulate sound in design and planning. The noise context was also considered a fruitful situation in which collaboration between landscape architects and acousticians could be enabled. Our focus on noise did not exclude creative approaches and suggestions that could potentially be useful in other contexts.

In order to emphasize that the knowledge production in our research was generated through design actions in landscape architecture, we chose to position the work as "Research through design" (van den Brink and Bruns, 2014). The design workshops are further described under "2. Case description: Three workshops " and the methodology and research process under "3. Process of analysis". The tool is presented in "4. Results: Descriptions of soundscape actions" and the paper is discussed and concluded in "5. Concluding discussion".

2. Case description: Three workshops

The three workshops all had different backgrounds and contexts, and were designed in relation to the specific task or problem that they were intended to deal with. These problems were: noise management in urban squares, noise management in a cemetery, and noise management in a small urban park (see Table 1). However, the workshops were all conducted using similar basic approaches. The first workshop (in 2012) was carried out as part of a collaborative project between the university, a municipality, and a consultancy agency, and investigated the potential of working with soundscape considerations in city planning. The second workshop (in 2015) was part of a research project that investigated sound in cemetery environments. The third workshop (in 2016) formed part of a Master's course in landscape architecture.

The workshops were structured into four basic steps: (a) Listening exercise, (b) presentation of task, (c) design process, and (d) presentation. The listening exercise (a) was conducted as a sound walk, with the intention of opening up participants' senses to listening, and typically included a visit to all the sites the groups could choose to work with. The task was presented (b) to participants orally and in written material. The design process (c) was conducted in small groups working indoors with access to sketching materials (see Figure 1). Each group then presented their proposals (d), after which questions were raised and discussions were held. The total presentation time per group varied between 10 and 20 min.

The specific tasks and sites were different in all workshops, but generally involved 2–3 themes that the groups were asked to follow. For instance, in the third workshop each group was asked to come up with one *tranquil* proposal and one *activity* proposal and present these on an A3 sheet. In addition to drawings, in two of the workshops participants were asked for keywords, and in one workshop they were asked for a model. The time available to the participants for this work varied between workshops and ranged from 40 min to 4 h. The specificities of each workshop are overviewed in Table 1.

3. Process of analysis

3.1. Summarizing the workshops

The first step in our analysis of the empirical material collected in workshops was to establish a departure point and a general understanding. As the structure of the workshops differed to some extent, the empirical material was re-organized to make it comparable. A summary was then written for each of the workshops, including background and particularities of the workshop, description of participants, the specific task, and finally, a reflection on the outcomes. These summaries acted as the basis for Table 1.

3.2. Finding an analytical approach

In the next step, we examined possible tools and approaches to use for analyzing the workshop material. The choice fell on a tripartite model (see Figure 2) specifically developed to evaluate soundscape intentions in landscape architecture (Cerwén et al., 2017). The context in which the model was developed involved noise from infrastructure, as was also the case in the present study. The model is straightforward in its division into three key areas, which we considered to be a suitable starting point for structuring the workshop results.

3.3. Summarizing the proposals: Formulation of "keyword summaries"

Each workshop proposal was analyzed and condensed through one or several keywords describing how the sound environment was proposed to be changed. Each "keyword summary" was formulated using as few words as possible, the intention being to retain the focus on the essence of each proposal, while excluding unnecessary and detracting details. The summary typically included a verb describing the desired effect, such as "masking", "screening", "attracting" or "moving" sound sources. The summary also included words

Table 1 Overview of the prerequisites and context for each of the three workshops analyzed.

Workshop, year, date:	First, 2012,1 June	Second, 2015, 2-3 November	Third, 2016, 12 April
Location:	Malmö municipality.	Woodland cemetery, Stockholm.	SLU, Alnarp.
Context:	A collaborative project seeking to investigate the potential of soundscape design in urban situations.	A research project called "The sustainable soundscape of the city" that focused on how to improve soundscapes, particularly in cemetery environments.	The Master's course LK0073 Design Project – Composition and Materiality is given each year in SLU Alnarp, Sweden and contains (in total) four days of soundscaping.
Task:	Two elaborated proposals, encouraging use of models.	4+4+4 (12) short ideas on post-its. One more elaborated.	6+6 (12) short ideas on post-its. Two more elaborated.
Task themes:	a) Tranquility b) Intensity and/or c) Interaction	a) Existing conditions (realistic) b) Reconstruction of the cemetery c) Free creativity	a) Tranquil space b) Activity area
Sites that were studied:	1) St. Knuts Torg, Malmö (urban square, 0.38 ha). 2) Nobeltorget, Malmö (urban square, 0.63 ha). 3) Small urban space at the intersection Ystadgatan/ Hörbygatan in Malmö (0.08 ha).	UNESCO heritage site, Woodland cemetery, Stockholm (4.05 ha).	Falsterboplan (a.k.a. Jesusparken) in Malmö (0.68 ha).
Number of participants:	19	15	35
Participants' background:	Landscape architects, acousticians, sound artists.	Cemetery experts, landscape architects, acousticians, soundscape researchers.	Master's students in landscape architecture (advanced level).
Group constellation:	3–4 participants with differing expertise in each group (5 groups).	3–4 participants with different backgrounds in each group (4 groups).	7 students in each group (5 groups).
Documentation:	Video documentation of the whole day and of all proposed drawings and models. One researcher in each group followed the process with notes.	Pictures, field recordings and video. All presented proposals (post-its and drawings).	Pictures. Detailed notes from presentations. All presented proposals (post-its and drawings).
Available material:	Basic sketching material. A3 sheets. Model material.	Basic sketching material. Post-it notes. A3 sheets.	Basic sketching material. Post-it notes. A3 sheets.
Time allowed for design process:	4 h.	40 min.	1.5 h.

describing the means by which to achieve the desired effect, such as "vegetation", "water" or "speakers". Where applicable, the description also included keywords describing the location or other particularities, such as "in zones", or "next to the road". Examples of keyword summaries are illustrated in Table 2, which presents a list of all keyword summaries that materialized from the analysis of one of the group presentations in the second workshop.

The analysis of all three workshops resulted in 189 keyword summaries, 7 of these were excluded as they were not considered relevant for landscape architects.[2] As a result, 182 keyword summaries were used as base for analysis (38 of these were derived from the first workshop, 64 from the second workshop and 80 from the third workshop).

[2]The excluded summaries were typically relating to technological development pertaining to other disciplines, such as improvement of tires.

Figure 1 Image depicting one of the groups in the first workshop in action. A setting similar to this was employed in all three workshops.

3.4. First sorting of keyword summaries

In a first stage of sorting, each keyword summary was compared to the model (Figure 2) and assigned to at least one of the model's three categories (I-III, see Table 2). Some of the keyword summaries (n = 23) corresponded to more than one of the model's categories and such proposals were copied and given an additional position. For instance, a proposal suggesting a noise screen covered with water included both reduction of sound and introduction of sound, and such a proposal was allocated to categories II and III.

All the workshop proposals were plotted in the model in this way (see Figure 3 for an overview). As a result of the first sorting, 24 keyword summaries were located in

Table 2 All keyword summaries identified for one of the groups (group 4) in the second workshop and the category/-ies assigned in the analysis.

Keyword summaries	Assigned categories
Contrasting sonic oasis with e.g., water	I, III
Move cemetery from road	I
Only silent maintenance	II
Dome to screen noise	II
Lower the road	II
Topographical modification	II
Locate cemetery in valley and add screens	I, II
Build sonic crystal noise screens	II
Add vegetation to attract birds	III
Noise-cancelling earphones	II
Change local road surfacing from asphalt to gravel	III

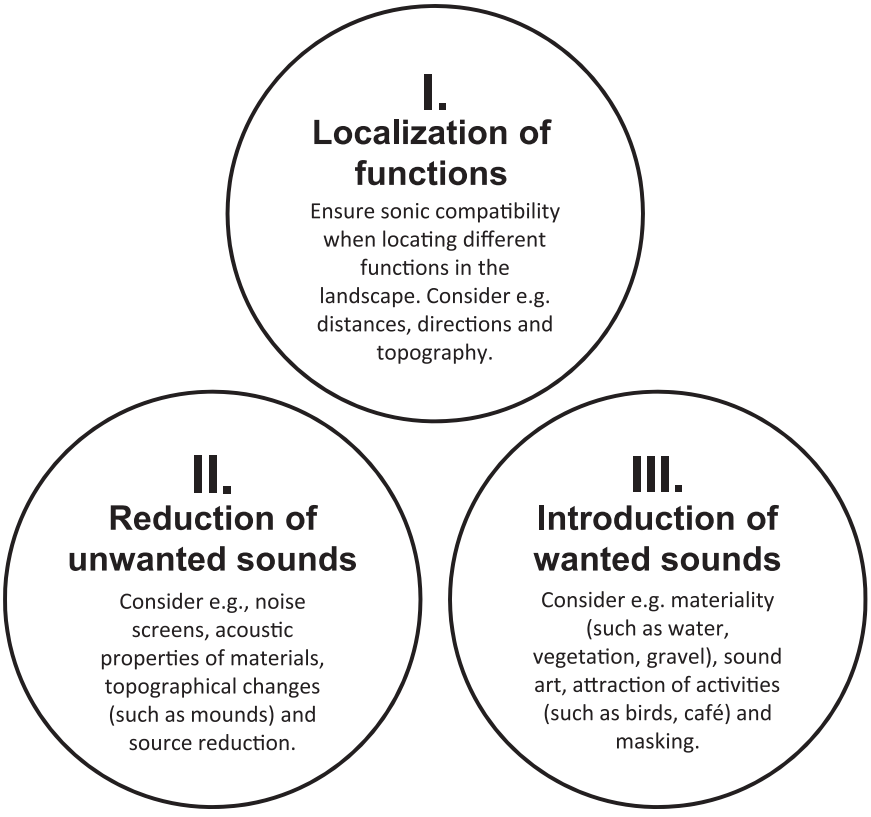

Figure 2 The model used as a starting point in the present analysis is based on three key categories for landscape architects to consider in noise-exposed developments; I) Localization of functions II) Reduction of unwanted sounds. III) Introduction of wanted sounds. The image is reproduced by courtesy of Cerwén et al. (2017).

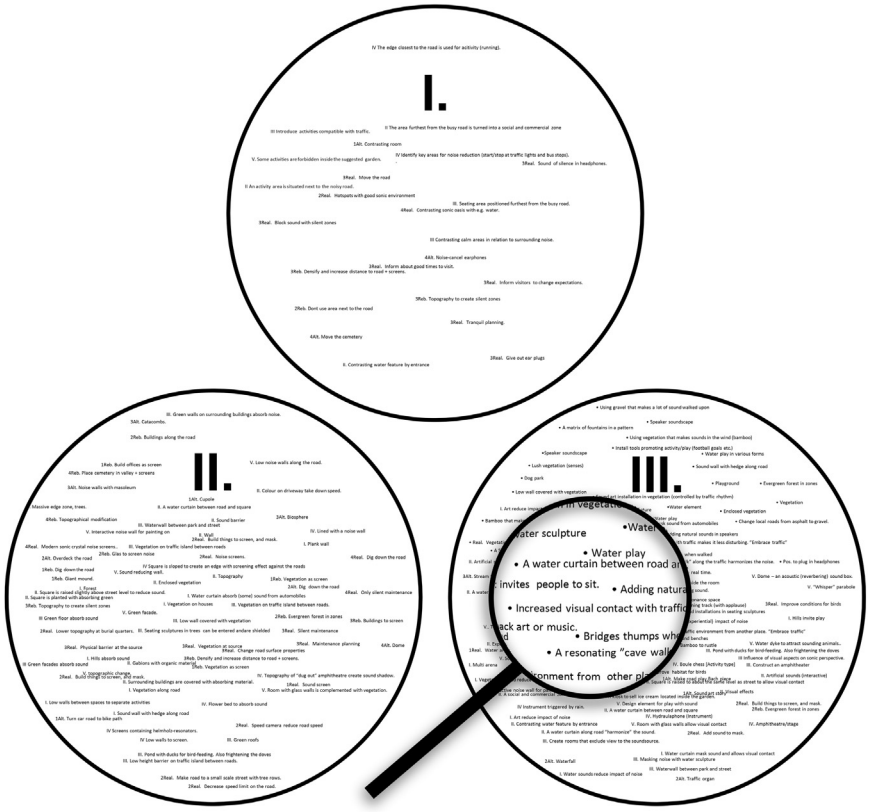

Figure 3 Overview diagram illustrating how the model's three categories were used to sort keyword summaries. All keyword summaries are included, but significantly reduced in font size for the purposes of the overview. The magnifying glass highlights some of the keyword summaries found in Category III (cf. Figure 4).

Category I, 79 in Category II and 102 in Category III. (These numbers include the 23 copies indicated above, and ads up to a total number of 205 keyword summaries).

3.5. Second sorting of keyword summaries: Clustering

After all proposals had been given a position within the model, the keyword summaries were compared with each other in order to evaluate similarities and differences and identify potential structures. Keyword summaries that were considered to be similar in approach were clustered together. For instance, all summaries that suggested a water feature were grouped together (see Figure 4). As a result of this process, 22 clusters materialized in the analysis.

3.6. Defining the clusters: Introducing soundscape actions

All the keyword summaries were divided into 22 clusters, which we decided to call *soundscape actions*. A soundscape action constitutes a group of acts that can be taken with the intention of designing a soundscape (for instance; *vegetation for masking*). The concept "soundscape action", focusing on the design action rather than the experience, highlights the practical and applicable aspect of the tool. Each cluster was then defined by giving it a short name.

3.7. Listing and describing soundscape actions

Each soundscape action was listed and described based on the workshop findings and on previous research in the field (see Section 4). All descriptions were formulated with the intention that professional landscape architects and planners would find them useful in practice. This means that the descriptions were practice-oriented and prioritized aspects considered valuable for this purpose.

4. Results: Descriptions of soundscape actions

This section lists the 22 soundscape actions that were identified in the analysis. Each soundscape action is first described briefly. Following this description, the experiences from the workshops are summarized. Where applicable, the soundscape action is then discussed in relation to previous research and challenges in landscape architecture.

4.1. Soundscape actions in Category I: Localization of functions

4.1.1. Compensation/Variation

The human sensory apparatus responds to contrast, a fact that can be exploited to accomplish experiential effects in the soundscape. For instance, a park can seem quieter if the

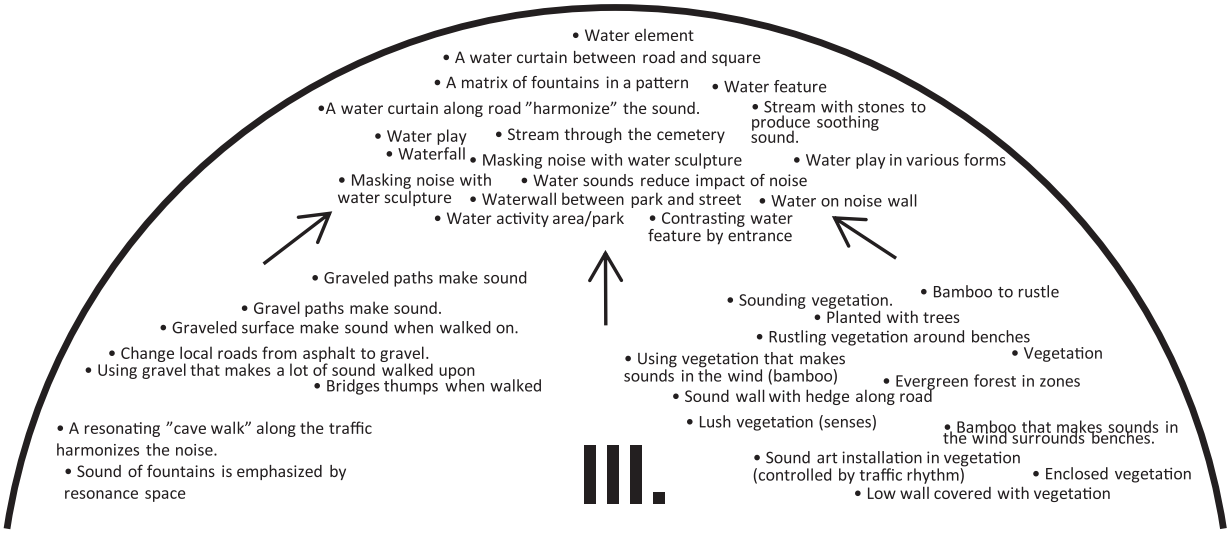

Figure 4 Image displaying how keyword summaries in category III relating to water were collected to form a cluster.

surrounding area involves exposure to noise. Similarly, an active urban area can seem more intense if there are also contrasting, relatively quiet areas in the proximity. This soundscape action therefore concerns variation in the soundscape, and how different soundscapes can be planned to reinforce each other.

In the workshop proposals, there were examples of predominantly small and delimited areas that offered relative quietness. These areas were generally described as contrasting, and sometimes also tranquil or calm. In two cases, the contrasting areas proposed in workshops included a water feature. One of these proposals was referred to as a "sonic oasis", the use of that noun also implying a relationship to the surrounding environment.

Provision of contrasting spaces in the sonic environment has previously been referred to as auditory refuges (Hedfors, 2003), or tranquil spaces (Pheasant et al., 2008). A related effect described by Augoyard and Torgue (2005) is a sonic effect denoted "cut out". Variation in a soundscape is beneficial, as it increases the possibility for people to choose the kind of soundscape to attend to (Cerwén, 2016).

4.1.2. Avoid unwanted sounds

This soundscape action concerns strategic localization of functions away from existing noise sources. This entails consideration for distance to the noise source, as well as use of areas shielded by existing topography, or structures such as buildings or walls.

In our study of the workshop proposals, we found a recurring strategy to ensure distance to roads. This general tendency seemed to be considered the ideal in most cases, but for some activities, such as areas intended for tranquility and contemplation, its importance seemed to be even more pronounced.

There is convincing support in research for the relevance of this soundscape action, as noise exposure has been associated with negative effects on health (Basner et al., 2014), acoustic comfort (Yang and Kang, 2005) as well as willingness to help other people (Cohen and Spacapan, 1984). Noise has been found to affect sleep already at low levels and negative health effects can be observed from around 40 dB(A) (WHO, 2009), thus making this action an important consideration when planning living quarters. Furthermore, quietness has been identified as a key feature (along with natural elements) in tranquil environments (Pheasant et al., 2008), such as parks, pocket parks and recreational areas.

4.1.3. Embrace unwanted sounds

To "embrace unwanted sounds" is to acknowledge pre-existing noise sources when assigning functions to an area. Areas exposed to noise can be more suitable for certain activities, like markets or other intense activities. In some cases, existing noise can even be considered as a quality to enforce an urban character.

We found that areas exposed to noise tended to be used in workshop proposals to locate "activity" areas, such as multi-sport arenas, skateboard areas, or urban playgrounds. In several of these cases, noise was not perceived of as a quality, but rather that this kind of function would be less likely to suffer from noise exposure than other activities. However, there were also a couple of proposals that chose to "embrace" traffic noise as an urban quality in itself, through enhanced visual connection and a design that encouraged "urban activities".

This soundscape action seems particularly pertinent when considering the modern city planning discourse, in which densification has become a key aspect. In densified cities, areas that are exposed to noise may need to be increasingly used in the future, thus calling for "noise-compatible" uses along with other solutions. Noise may even enhance some urban qualities, as was suggested in the workshops, and has been shown in previous research. For instance, in his observations of social behavior in New York, Whyte (1980) found that there was a positive correlation between social qualities in urban space and exposure to noise. Whyte argued that noise was associated with lively areas and that this was a quality that attracted people. Similar connections between noise and urban life have been identified by Anderson et al. (1983) and Cerwén (2016). However, there is also a social aspect, i.e. that noise reduces the possibility to communicate with other people (Gehl, 2006).

4.2. Soundscape actions in Category II: Reduction of unwanted sounds

4.2.1. Vegetation for noise reduction

This soundscape action concerns vegetation and its potential to reduce sound pressure level (SPL) in different ways (Van Renterghem et al., 2015).

In the three workshops, vegetation was suggested frequently, and for multiple purposes. Sometimes the purpose was specified, such as in the rustling of leaves or the absorbing effect of soil substrate for trees and/or green facades. Vegetation was commonly proposed to be used as belts (for noise reduction and/or visual screening). In many cases, vegetation was introduced with no reference to specific effects, but with the general intention of improving the perceived soundscape (implying multiple effects).

The actual effect of vegetation in reducing noise has been debated and can be limited if the belt is narrow and/or sparsely planted. An aspect that deserves to be emphasized in this context is the acoustically beneficial properties of soil, which is good at absorbing sound, particularly in comparison to acoustically hard materials such as concrete, stone, or glass (cf. HOSANNA, 2013).

Besides reducing the measurable SPL, vegetation has been shown to have an experiential effect, e.g., through auditory masking by rustling leaves and decreased visual connection with unwanted sources (cf. "4.3.2. Visual masking and 4.3.1. Auditory masking"). Introduction of vegetation may thus have multiple experiential effects on perception of noise, even in cases where the actual reduction in SPL is limited.

4.2.2. High noise screens

High noise screens introduced for the purpose of noise reduction are generally above approximately 1.8 m in height (cf. Hellström et al., 2013, 32).

In the workshops, the screens proposed were often designed for site-specific effects that became part of a (visual) experience, as well as reducing the impact of noise. Different materials were used, including glass, concrete, and wood. One student group in the third workshop proposed a noise screen that could also be used for artists to draw on. Several groups proposed the use of vegetation and water as an integral part of the screen. In these cases, the screens would have a double effect of noise reduction and introduction of sound for noise masking (cf. 4.3.1. Auditory masking). The vegetation, including the soil substrate, could also work to scatter and absorb sound for increased effects (HOSANNA, 2013).

The basic principle in noise screening is to interrupt the path of a sonic wave. The effect of screens to reduce noise varies depending on a number of properties where height is the most determinant. (HOSANNA, 2013). In order to be as efficient as possible, noise screens should be positioned either close to the source or the experience position (Forssén et al., 2015). Downwind can reduce effect of noise screens substantially, but this can be counteracted if trees are planted in connection with the screen. Another potential benefit of screens is that the visual connection with the noise can be broken (unless the screen is made from permeable material, such as Plexiglas). However, this effect is debated (cf. 4.3.2. Visual masking).

4.2.3. Low noise screens

Low noise screens are up to around 1 m in height (cf. Defrance et al., 2015).

In the workshops, there were several different examples where low screens were incorporated, especially in the third (student) workshop, where combinations with water and/or vegetation were common. The vegetation could climb on the walls, or as with one group's proposal, grow in the organic material from which the screen was constructed. The screens were positioned with varying distance to the road or used as a divider in the middle of the road. One group in the first workshop developed a conceptual product called '*Murabs*' that could be used to separate traffic lanes. The group proposed that these low noise screens could be used in certain hotspots, such as by traffic lights, where the resulting "avenues" for traffic would reduce the impact of noise caused by acceleration and braking.

Low screens constitute a relatively new concept for use in urban environments and other places where visibility above the screen is important (for instance, for reasons of security). To compensate for the low height, the screens are located as close to the source of noise as possible. The concept has been shown to have the potential to reduce noise substantially in some contexts (Defrance et al., 2015), yet there is a need to develop the practical applications. Because of the proximity to the source, the low screen raises a number of practical issues, such as maintenance and traffic safety.

4.2.4. Buildings as screens

When strategically positioned in relation to a noise source, buildings can function as screens that produce a "sound shadow" behind them.

There were relatively few proposals in the workshops that included buildings as screens, probably owing in part to the relatively small size of the areas where the workshops were held. Most of the proposed buildings materialized in the second workshop, which was conducted in the largest area – a cemetery. The proposals included conventional offices along the road, as well as more spectacular features made of glass, like a dome. One group proposed a structure that could be described as a combination of a building and a noise wall – a mausoleum stretching along the road.

Buildings can have a substantial effect to reduce noise, as buildings are generally taller than noise screens. Care needs be taken for noise exposure in the buildings however, especially if the buildings are intended for living quarters (FHWA, 1976). The reduction effect is depending on aspects such as the general shape of the building in relation to the noise source (including length and height), the shape of the roof, and material choices (Hellström et al., 2013). While noise screens in isolation may call attention to noise as a problem, the combination of buildings and screens should be less likely to have this effect. Isolated buildings can also be combined with walls to make continuous, yet subtle, "screens" against roads.

4.2.5. Change topography

This soundscape action concerns the modification of landscape topography as a way to influence noise transmission, the most typical example being earth berms along roads (cf. Defrance et al., 2015; MTH, 1997).

In the workshop proposals, trafficked roads were often subject to changes in topography, typically including berms or mounds stretching along the road and/or lowering of the road surface. One student group proposed the use of small hills next to a road as a way to absorb the noise from it. Farther away from the roads, the topography was sometimes suggested to be lowered in order to avoid noise. However, in a couple of the proposals, it was apparent that the measures would not be sufficient to achieve the desired effect of noise reduction, thus raising the need to incorporate acousticians in the design process.

Berms require more land than screens, but can be a good option as they are integrated in the landscape (MTH, 1997). Furthermore, if the soil is soft, the acoustic properties of the berm can be beneficial to absorb sound rather than reflect it (cf. 4.2.9. Absorbing qualities of materials). Berms are less sensitive to wind effects than screens, but the location of higher trees should be carefully considered (HOSANNA, 2013).

4.2.6. Reduce source activity

This soundscape action concerns adjustment of the way in which a sound-producing activity is performed, so that the impact of the sound is reduced.

Given the context of the workshops, it was not surprising that proposed reductions mainly concerned traffic noise and, more specifically, reduction of traffic speed. Reduction of speed could be related either to regulations (reduced speed limit and speed cameras) or to design considerations that would encourage reduced speed, including: shared space solutions, reduction of space width, visual aesthetics, and reduced coherence (encouraging cars to drive more slowly). In addition to traffic speed, consideration for traffic flow, traffic light rhythm, or rerouting of traffic (number of vehicles) was touched upon in some proposals.

Based on the workshops, it seems that source activity can be controlled either through enforcement of rules or through physical design that (indirectly) encourage certain behavior. In the latter case, a connection can be made to the notion of environmental affordances (cf. Gibson, 1986), a term which is also applicable to understand the role of sound environments (Thibaud, 1998).

While the workshops were dealing predominantly with traffic, the notion of reduced source activity is applicable in other contexts as well, such as adjustment of ventilation systems.

4.2.7. Abolish certain functions

This soundscape action is similar to “reduce source activity”, but here the intention is to take away the activity that produces the unwanted sound altogether. In other words, this soundscape action is about the abolition of certain functions.

There were relatively few examples in the workshops that concerned abolition; the proposals mostly concerned “apparent” solutions such as prohibition (or movement) of roads. One group in the second workshop took this a step further when they replaced a trafficked road with a bicycle path. A group in the first workshop proposed formulation of rules for how the tranquil space they envisaged should be used and suggested a ban on certain activities, such as children playing within the space.

It seems reasonable to assume that sustainable development of cities will lead to a reduction of road traffic. This could open up for new expressions like green paths with potential benefits for the soundscape (cf. 4.3.8. Biotope design and 4.2.9. Absorbing qualities of materials).

4.2.8. Maintenance

This soundscape action concerns the way in which landscapes are managed on a day-to-day basis. It therefore borders on issues for other professions to consider, but is nevertheless pertinent also for landscape architects.

Some of the workshop proposals, particularly in the second workshop, were discussing maintenance in terms of strategic planning for low-noise maintenance, focusing on the use of silent/electrical equipment. It was also suggested in a few proposals that information about the maintenance could reduce the impact. The argument was that if visitors were informed about the purpose of the noise, the annoyance could be reduced.

For landscape architects, maintenance can be regulated in maintenance plans. However, the actual design solution also influences maintenance, as the character of spaces dictates the maintenance needed. A meadow, for instance, is more extensive in terms of maintenance than a mown lawn.

4.2.9. Absorbing qualities of materials

Acoustic properties of materials influence how well sound is transmitted in space. Designs can thus make use of absorbing qualities of materials in strategic locations.

In the workshops, the most commonly proposed action was the use of vegetation soil/substrate, the absorbing qualities of which were emphasized by some groups in connection with introducing vegetation. In particular, the third workshop with Master's students resulted in several proposals that incorporated vegetation for this purpose. This absorbing vegetation was proposed on building facades, on rooftops, and on the ground. Two separate groups proposed that vegetation be used on traffic islands between street lanes. Apart from planting soil, few other materials were mentioned in terms of their acoustic qualities, but one group in the second workshop proposed the use of silent asphalt. Absorbing qualities of materials were also mentioned as part of noise screens and incorporated in some proposals.

The acoustic properties of ground materials, wall surfaces, and roofs, especially in proximity to the sound source, influence SPL in adjacent areas (cf. Forssén et al., 2015). Materials with absorbing qualities (such as vegetation soil or mineral wool) can thus be used to reduce the impact

from noise compared with materials with better reflection (such as tiles, concrete, or glass). The acoustic properties varies depending on situation and the capacity of soil can for instance be reduced if compacted (MTH, 1997). The collaboration between acousticians and landscape architects should be emphasized, as it can lead to new and innovative solutions (cf. HOSANNA, 2013).

4.3. Soundscape actions in Category III: Introduction of wanted sounds

4.3.1. Auditory masking

Auditory masking is an effect that occurs when one sound (masker) is introduced with the intention to reduce impact or shift the focus from another sound (target).[3]

In the workshops, auditory masking was a popular approach to abate noise. The sources that were typically suggested for this purpose included water, vegetation and speaker sounds. In many proposals, the masking effect was combined with reductive measures, such as screening. The strategies for the masking effects that were proposed generally lacked detailed descriptions, except in the first workshop, where the participants had more time to elaborate. A group in this workshop proposed a water curtain and argued that, as the sounds of the water were similar to those of traffic, the visually striking water feature would draw attention from traffic – thus creating the illusion that the traffic sound came from the water feature. The water feature would also add harmonizing frequencies as a tint to the noise from traffic, to create a more pleasant atmosphere.

Research has shown that masking is a complex phenomenon that depends on many different aspects such as SPL, frequency, distance, direction, and visual cues. Introduction of new sounds does therefore not necessarily result in an improved soundscape (cf. Rådsten Ekman, 2015). For instance, Zhang and Kang (2007) suggest that, as all sounds are disturbing from around 65–70 dBA upwards, this should be a general limit at which to consider introduction of new sounds. In order to achieve tranquil qualities, however, lower levels than this are probably necessary (Pheasant et al., 2008).

4.3.2. Visual masking

The general idea in visual masking is that, by hiding an unwanted sound source visually, the experiential impact of the noise is reduced (even if the actual SPL is not necessarily reduced at the same time). This is based on the fact that experience of sound depends on many contextual cues, such as visual input, expectation and relevance (Hong and Jeon, 2014; Preis et al., 2015).

In the three workshops, the ability to see the source of the noise (a road) was a recurring theme for discussion. Two different approaches could be distinguished: The most common suggestion was to hide the source of the unwanted sound with elements such as vegetation, screens, and/or a water curtain. The intention in these cases was to divert as much attention as possible from the traffic. In other proposals, however, the visual connection was emphasized instead (cf. “4.1.3. Embrace unwanted sounds”). This was justified by reference to the interplay between senses and the lack of relevance for the presence of a sound that could not be seen (cf. Anderson et al., 1983).

It has been suggested previously that the proper approach in terms of visual masking should be decided upon based on how salient the unwanted sound is (Botteldooren et al., 2016). Those authors argue that if the sound is not so salient, visual masking is more likely to be successful as it becomes easier to accept the “illusion”. When the noise is salient, on the other hand, the masking effect of visual impressions is less likely to work; meaning the incongruence between visual and auditory stimuli will become obvious. In addition to the lack of congruence, the comparatively poor sound environment might also cause an effect of disappointment when the sound does not live up to the (visual) expectations, causing a negative effect.

4.3.3. Materiality (water)

Water features constitute an element that offers many possibilities in terms of soundscape design and multi-sensory experiences.

In the workshops, there were many proposals for water features of different kinds, like fountains, streams, a river, water plays, sculptures, waterfalls, water art, and water curtains. In many cases, water was used for multiple purposes, e.g., for a positive experience and for masking purposes. In some suggestions, water features were also combined with screens.

The proposals were generally conceptual and with no consideration of the actual detail of water sound characteristics with some exceptions. One group in the third workshop mentioned how the stream they proposed should be lined with stones in strategic positions in order to produce a more characteristic sound. Another group in the first workshop talked about construction of a resonating chamber in order to amplify the water sounds being produced (cf. “4.3.10. Resonance and reflections”). In the first and third workshops, there were some examples of water play features, for instance incorporating several interconnected and programmed fountains. These installations were intended to attract children's play, an interactivity that would therefore also add the sound of children to the general soundscape.

The sound of water features is a “sound of nature” that can be designed to vary in terms of strength, rhythmic qualities, and timbre (cf. Halprin, 1973 [1963]; Nikolajew, 2003). Water features are also commonly used to mask traffic noise (cf. 4.3.1. Auditory masking) (cf. Brown and Rutherford, 1994; Rådsten Ekman, 2015; Whyte, 1980).

[3]There are two kinds of auditory masking – energetic masking and informational masking (Moore, 2012). Energetic masking occurs when the target becomes inaudible (or less loud) with the introduction of a masker sound, i.e., the masker sound is literally covering the target sound energetically. Most typically, this means a difference in sound pressure levels (SPL) of 8–10 dbA (Brown and Rutherford, 1994). Informational masking, on the other hand, happens when both sounds can be heard, but the focus is shifted from the target sound to the masker sound. Informational masking, therefore, relates to visual masking; in both cases, the idea is to shift focus.

4.3.4. Materiality (vegetation)

The sound of vegetation can be considered as a quality to influence design decisions, as in the rustling of leaves in the wind, or the sound of rain on leaves.

In the workshops, some groups referred directly to the sonic qualities of vegetation. In most cases, however, this particular benefit of vegetation was not described, but implied (as one of several positive effects of vegetation). In some examples where sonic qualities of vegetation were specifically discussed, bamboo was used to surround benches in a seating area, thus bringing the sound close to and around the visitor.

The characteristic sound of rustling vegetation is dependent on wind. Windy positions thus constitute good strategic positions for vegetation from a soundscape point of view. The localization of trees in windy areas also works to reduce the wind, thus potentially contributing with multiple beneficial effects (if the wind was disturbing). Strategic windy positions include open areas, places with higher topography (such as berms and mounds), near tall buildings or by wind tunnels (e.g., streets). Certain tree species are known to produce stronger sounds in wind than others, for instance poplars, bamboo, and (wintertime) beech (Cerwén et al., 2016; DeGroot, 2015; Yang et al., 2016). The sound of rain can be enhanced by certain species, like plantain, lotus and bamboo (Yang et al., 2016).

4.3.5. Materiality (walking)

This soundscape action stems from the fact that different materials make different sound when walked upon. Such material qualities can be considered when designing areas for walking (e.g. gravel paths).

In the workshops, the predominant measure mentioned was introduction of gravel paths. Proposals for gravel paths were made in all three workshops and were all conceptual, with no specific details (concerning for instance type of gravel). One group in the third workshop suggested introducing wooden bridges that would produce a thumping sound when walked upon.

The sound of walking is relatively louder on a path made of gravel or wood compared with one made from asphalt. The SPL and character of the sound is affected, which have been shown to have bearing on preference (Aletta et al., 2016). For the person/s walking, the sound that is created is interactive, meaning that it is produced as a result of the person's own movement. The sound could therefore be regarded as a sort of interaction between visitor and landscape (cf. Pallasmaa, 2006). It has been shown previously that the soundscape can have an influence on walking pace (Maculewicz et al., 2016).

4.3.6. Atmospheric design (loudspeaker-based)

This soundscape action concerns speaker sounds. Loudspeakers have become increasingly common in public spaces, not only for playing music or for making speaker announcements, but also for creating atmospheres (Hellström et al., 2014). This particular soundscape action concerns occasions when speakers are used as a "tint" with the intention of improving the character of a site in subtle installations, for instance adding the sound of nature to the background atmosphere or transferring a sonic environment from one place to another place.

Atmospheric installations were proposed in all three workshops and were mostly conceptual, describing, for instance, "natural sound through speakers", "masking of traffic with technical solutions", or the creation of a "speaker soundscape". Some proposals were more specific and included descriptions of how the sounds were to be triggered, for instance based on traffic noise levels, wind movement, or through interaction by visitors. The first workshop included a proposal in which a matrix of speakers was used to reproduce an intense urban soundscape from a different location; in this manner, the group wanted to "embrace" the urban environment at their given site (cf. "4.1.3. Embrace unwanted sounds").

Atmospheric installations, as we define them here, have predominantly architectonic purposes, i.e., they are created in order to improve functionality or experience without necessarily being noticed. For the same reason, atmospheric design can be difficult to assess in research, yet a couple of studies have concluded that there is potential to explore this method further (Billström and Atienza, 2012; Hellström et al., 2014). These kinds of installations are sometimes referred to as "acousmatic" installations or "acoustic design" (Hellström et al., 2014).

4.3.7. Sound sculpture and urban furniture

Sound sculptures are related to the "Atmospheric design" approach described above, as both actions could be conceived of as interventions. However, while "atmospheric design" tends to be subtle, the "Sound sculpture and urban furniture" is more easily noticed. In a sound sculpture, the added sound is integrated in a physical sculpture to create a "combined" experience. The sculptures can be used actively, for sitting in or playing on, or passively, as a sonic "embellishment". The sculptures may or may not incorporate speakers.

We found several different and varied examples of sound sculptures in the workshops, thus indicating potential for varied and rich use of this kind of embellishment in public spaces. The workshops included proposals for talking benches, sculptures, places to plug in smartphones, storytelling devices, and musical instruments. Some of the proposed musical instruments were interactive types for visitors to play on, such as the hydraulophone (a cross between a flute and a fountain), while others were controlled by other cues, such as rain, wind, or even traffic. One group in the second workshop proposed a traffic organ to be used for masking (cf. "Harmonic Bridge" by Bruce Odland and Sam Auinger). In the third workshop, one of the student groups proposed speakers to enhance the sound of vegetation in a tree, while at the same time giving the trees a kind of tonal hint (cf. "Klangwäldchen" by Åsa Stjerna).

The first workshop included several proposals in which different combinations of seating furniture and sound sculptures were used. In one of these, several small private rooms were created when egg-shaped sculptures reminiscent of Eero Aarnio's "ball chair" were hung from trees. The egg sculptures included a speaker installation system into which visitors could plug their own music, thus creating a personal soundscape shielded from the urban surroundings.

Another group in the same workshop proposed a bench with a speaker voice that invited visitors to come and sit.

In 2015, a sound sculpture called "Musikiosk" was built in a pocket park in Montreal. The intervention, which allowed visitors to plug in their own music, was evaluated in research. The researchers found that this intervention could enhance mood (Steele et al., 2016) as well as social dynamics (Bild et al., 2016). Speaker installations have also been shown to work to detract focus from noise (Cerwén, 2016).

4.3.8. Biotope design

Birds and other animals can be attracted through the construction of suitable biotopes (Dawson, 1988; DeGraaf, 2002), thus offering possibilities to enhance the soundscape. Sounds of nature, like birdsong, are generally perceived as pleasant (Axelsson et al., 2010).

The workshops included some references to attracting birds, but all mentions were general and mainly concerned the introduction of vegetation, but also the introduction of a pond for ducks and a water dam.

A biotope constitutes a system of animals, plants, and environment. The term sonotope (Hedfors, 2003) can be used to emphasize the sonic characteristics of a biotope. Conditions to attract singing birds can be created through considering aspects such as access to water (including shallow strips and e.g., stepping stones), dense and varied vegetation in several layers (to hide and live in), and access to food (DeGraaf, 2002; Forman, 2014). Use of older (and dead) vegetation could be beneficial, as stand maturity has been found to correlate with bird species diversity (Gil-tena et al., 2009).

4.3.9. Attract activities

This soundscape action concerns the construction of areas that attract certain human activities that influence the soundscape, for instance a café or a playground.

A wide range of activities were proposed in the workshops, especially in the third workshop. There were proposals that encouraged everyday social activities, such as a kiosk, a café, or a playground. Equally common were proposals that incorporated more "striking" features, such as an amphitheater or multi-sport arena. One proposal also included a running track that would create applause when people ran, to encourage activity (cf. "4.3.7. Sound sculpture and urban furniture"). Skateboarding was another proposed activity intended to contribute a specific soundscape.

Activities communicate through sound, which makes it an important consideration in urban situations (cf. 4.1.3. Embrace unwanted sounds). Activities are relevant to consider, not only for those who take part in the activity, but it can also have a positive effect on adjacent areas. Such relationship between activities and the surrounding can be considered for atmospheric effects (cf. Alexander et al., 1977).

4.3.10. Resonance and reflections

This soundscape action concerns strategic consideration for acoustics and the physical propagation of sound to enhance wanted sound sources. Examples include a resonating cavity below a wooden deck that enhances the sound of walking, or the introduction of a wall behind a water feature to reflect (enhance) the sound towards the listener. Resonance and reflections can also be used to create interesting acoustic spaces in which music can be performed.

Three proposals in the workshops corresponded to the "Resonance and reflections" soundscape action. In the first workshop, a group proposed a covered walkway in which the traffic would resonate with certain frequencies to become harmonized. Another group in the same workshop introduced a resonating cavity that would emphasize the sound of water. In the third workshop, one proposal introduced a "sound box" that would emphasize certain sounds, while at the same time creating a special acoustic character.

5. Concluding discussion

5.1. The workshop as a knowledge generator

As the results presented above demonstrate, workshopping can enlighten the research process and give useful input to the generation of new conceptual tools and practical methods. This study was based on three different workshops – all with different contexts, types of participants, and prerequisites. This broad setup proved to be an asset, as it resulted in a wide variety of proposals and ideas that could be used to formulate a set of 22 soundscape actions.

Our experiences from talking and interacting with the workshop participants indicated that many regarded the workshops as a rewarding exercise. However, in groups where participants came from different disciplines, it was reported that it was sometimes challenging for people to collaborate, as their individual focus differed. Yet, the workshop format was a good platform to practice collaborations and many interesting outcomes resulted from working across disciplines.

When comparing the three workshops, some general trends between the proposals produced in each workshop could be discerned. For instance, the first workshop involved much focus on user-site interactivity, while the second workshop tended to suggest more drastic interventions in the landscape. Our experiences indicated that even small changes in the set-up and circumstances of a workshop played an important part in the outcomes. For instance, we observed that events and discussions conducted during the initial listening exercises tended to resurface in design proposals. We also found that, in the formulation of the task, the theme words that the groups were assigned to work with, such as tranquil, activity, interactivity, and free creativity, were reiterated in the resulting proposals.

5.2. Soundscape actions as a design tool

The workshop approach allowed the generation of a tool based in practice. The notion of the soundscape action was not pre-given, but formed along the way as a result of keywording and clustering. Rather than focusing on e.g., soundscape qualities or design processes, the concept of the soundscape action emphasizes the transformative act of the landscape architect, and may therefore be useful in the design process. The 22 soundscape actions that were

identified and listed may already be helpful as concrete suggestions or solutions, while the concept might inspire further actions to be identified and described. The paradigm could be used as a source of inspiration for future projects, in practice and in teaching situations.

It should be stressed that the workshops did not include practical implementation or evaluation of the proposals. The validity of the soundscape actions can thus not be ensured, but would have to be studied in future research or tested in specific contexts. Such studies could be used to develop the concept further and additional soundscape actions might be identified, while others might need reformulation or clarification. In the present paper, we lay the ground for such future development through discussing each of the soundscape actions in relation to the present research situation.

We opted to structure the soundscape actions around three main themes: localization of functions, reduction of unwanted sounds, and introduction of wanted sounds. This division is pragmatic and indicates (but does not impose) an order in which soundscape actions may be considered. All three categories should be considered to facilitate a comprehensive approach to noise. The first category, localization of function focuses on the spatial relationship between functions. As such, this category relates to strategic thinking and overall planning. The other two categories, reduction of unwanted sounds and introduction of wanted sounds are more likely to be associated with design of outdoor space. There is, however, some overlapping between the three categories, and some of the actions, like visual masking and attract activities seemed to belong to more than one category. In future work, it would be fruitful to investigate if soundscape actions could be sorted in a different way, for instance using multiple and overlapping tags in a digital platform.

It was argued that the present approach, which involved practicing landscape architects and other professionals, would increase the applicability of soundscape actions as a tool. However, it would be interesting to evaluate more closely how it could be used in practice. For instance, it would be relevant to investigate soundscape actions in relation to other soundscape tools, and in relation to the design process as a whole. It seems pertinent to study landscape architects' preferences in terms of tools for soundscaping in different contexts and phases of working.

Conventional tools for sketching and presenting projects are based on visual media, such as perspective drawings, plans, etc., but the digital revolution has brought increased possibilities to incorporate sound in projects. This can be done through e.g., field recordings and/or speaker installations, and video simulations. Furthermore, the development of auralization provides the possibility to simulate the acoustics of outdoor environments before they have been built. What would be the potential role of soundscape actions in this development?

In future work, it would also be interesting to expand and develop the concept of soundscape actions based on contexts and situations, where sound is not considered a problem from the outset, as it was in the noise-affected environments that formed the basis of all three workshops in this study. Given the focus on noise, the workshop proposals tended not to acknowledge or make use of pre-existing qualities in the soundscape. For instance, while we identified strategies to "avoid unwanted sounds" as well as "embrace unwanted sounds", there was no corresponding soundscape action to "embrace wanted sounds". Such a strategy should be formulated in future work, as it seems fruitful, for instance to locate a café beneath an (existing) rustling tree.

5.3. Conclusion

This article was based on the outcomes of three workshops that concerned soundscape in landscape architecture. The analysis of the workshop proposals has resulted in an increased understanding for potential approaches to soundscape design. A new concept, soundscape action, was proposed as a tool for landscape architects. In our analysis of the workshop proposals, 22 soundscape actions materialized and were described based on workshop proposals and previous research. Each of these actions represents an approach in which issues with noise can be addressed using the soundscape approach. As a tool, the soundscape action stands out as it is based on a systematic analysis of a wide variety of design proposals generated in collaboration with practice. This was considered as an asset to ensure validity and usability in urban planning and design.

5.4. Future challenges

Landscape architecture is subject to changing demands from society and changing trends within the profession itself. As indicated in the present study, consideration of soundscapes is relevant in relation to several contemporary trends in the profession, such as densification of cities, changes in mobility patterns, and urban greening. These new developments will increase demand for knowledge development about several aspects, including soundscapes.

Other related changes in society, such as increased use of electrical cars and bicycles, might well strongly alter the prerequisites for dealing with soundscapes in landscape architecture in the future. It seems feasible that city densification will bring with it new challenges in the future, and that there will be a continuous need to develop knowledge on soundscapes in accordance with this. Throughout history, there have always been sounds that disturb people, but the soundscape, as well as the types of disturbances have varied. The present study was therefore not intended to demonstrate static qualities and problems relating to sound in environments, but to highlight that it is possible to take action on auditory aspects of an environment, and that these actions, like any other design action, contribute to shaping the character of the environment.

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