Landscape and Urban Planning 149 (2016) 65–74

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Review article

Soundscape descriptors and a conceptual framework for developing predictive soundscape models

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HIGHLIGHTS

- The main soundscape descriptors provided in literature are reviewed.
- A distinction between 'soundscape descriptor' and 'soundscape indicator' is made.
- A conceptual framework for the development of new soundscape descriptors and indicators is established.

ARTICLE INFO

Article history:
Received 12 December 2014
Received in revised form
10 December 2015
Accepted 1 February 2016

Keywords:
Soundscape descriptor
Soundscape indicator
Sound perception
Environmental sound quality

ABSTRACT

Soundscape exists through human perception of the acoustic environment. This paper investigates how soundscape currently is assessed and measured. It reviews and analyzes the main soundscape descriptors in the soundscape literature, and provides a conceptual framework for developing predictive models in soundscape studies. A predictive soundscape model provides a means of predicting the value of a soundscape descriptor, and the blueprint for how to design soundscape. It is the key for implementing the soundscape approach in urban planning and design. The challenge is to select the appropriate soundscape descriptor and to identify its predictors. The majority of available soundscape descriptors are converging towards a 2-dimensional soundscape model of perceived affective quality (e.g., Pleasantness–Eventfulness, or Calmness–Vibrancy). A third potential dimension is the appropriateness of a soundscape to a place. This dimensions provides complementary information beyond the perceived affective quality. However, it depends largely on context, and because a soundscape may be appropriate to a place although it is poor, this descriptor must probably not be used on its own. With regards to predictors, or soundscape indicators, perceived properties of the acoustic environment (e.g., perceived sound sources) are winning over established acoustic and psychoacoustic metrics. To move this area forward it is necessary that the international soundscape community comes together and agrees on relevant soundscape descriptors. This includes to agree on numerical scales and assessment procedures, as well as to standardize them.

Contents

1. Introduction 66
2. Soundscape descriptors 66
   2.1. Noise annoyance 66
   2.2. Pleasantness 67
   2.3. Quietness or tranquillity 67
   2.4. Music-likeness 67
   2.5. Perceived affective quality 67

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http://dx.doi.org/10.1016/j.landurbplan.2016.02.001
0169-2046/

2.6. Restorativeness 68
2.7. Soundscape quality 68
2.8. Appropriateness 68
3. A conceptual framework for the development of predictive models in soundscape studies 68
3.1. Collecting soundscape data 68
3.1.1. Soundwalks 69
3.1.2. Laboratory experiments 69
3.1.3. Narrative interviews 71
3.1.4. Behavioural observations 71
3.2. Characterising the acoustic environment 72
3.3. Modelling 72
4. Principles for selecting soundscape descriptors 72
5. Concluding remarks 73
Acknowledgments 73
References ..... **??**

1. Introduction

Currently, with regards to the acoustic environment, society chiefly focuses on the epidemiological aspects of 'noise'. This is reflected in the attempts to reduce high sound levels from transportation and industry below defined guideline values (World Health Organization, 1999; European Parliament and Council, 2002; World Health Organization, 2011). The increasing interest in environmental noise and its mitigation is largely a result of urbanization (World Health Organization, 2011). Early attempts of noise regulation can be observed in Roman laws, like the Lex Iulia Municipalis from 45 BC, which prevented oxcarts from transiting on the streets of Rome during daytime, in order to avoid undue noise (Hardy, 2012). This example illustrates that noise and noise abatement chiefly are urban phenomena, and that urbanization is a driving force. However, reducing the sound levels from certain sound sources may not necessarily result in an acoustic environment of high quality, because the character of the sound is equally important (e.g., Rådsten-Ekman, Axelsson, & Nilsson, 2013; Axelsson, Nilsson, Hellström, & Lundén, 2014; Yang and Kang, 2005). Environmental sounds, like the sound of road traffic, nature or people, are meaningful and provide information. Some sounds have a positive impact, whereas others have a negative meaning or character, regardless of their sound levels. To decide which acoustic environments are good, we must consider the activities they may enable (e.g., Brown and Muhar, 2004). These notions are at the core of the theoretical underpinnings of the soundscape approach.

The term 'soundscape' gained prominence in the 1970s in the study of contemporary music through the work of the Canadian composer R. M. Schafer at Simon Fraser University in Vancouver (e.g., Schafer, 1977). Schafer and his colleagues defined 'soundscape' as "[*a*]*n environment of sound (or sonic environment) with emphasis on the way it is perceived and understood by the individual, or by a society*" (Truax, 1978). Ever since this concept emerged, researchers have wondered how the acoustic environments would affect the perceived quality of cities and how sounds could be used in urban planning and design. Southworth (1969) raised the question of 'sonic identity' for cities, which in his view should be considered and designed in correlation with the 'visible' city.

Recently, the International Organization for Standardization (ISO) published Part 1 of a new International Standard, ISO 12913, on soundscape, which defines the term as "[the] *acoustic environment as perceived or experienced and/or understood by a person or people, in context*" (International Organization for Standardization, 2014). Thus, 'soundscape' is different from 'acoustic environment.' The former refers to a perceptual construct, the latter to a physical phenomenon. Most importantly, soundscape exists through human perception of the acoustic environment (e.g., Brown, Kang, & Gjestland, 2011; Brown, 2012; International Organization for Standardization, 2014).

This paper addresses the topic of 'soundscape descriptors' and 'soundscape indicators,' and their relationship. Soundscape descriptors are measures of how people perceive the acoustic environment. Soundscape indicators are measures used to predict the value of a soundscape descriptor. This topic is increasingly investigated because of an urgent need for operational tools, like predictive models, aimed at implementing the soundscape approach in urban planning and design (Kang, 2007; Payne, Davies, & Adams, 2009; Andringa et al., 2013; European Environment Agency, 2014; van Kempen, Devilee, Swart, & van Kamp, 2014). The paper offers a collection and analyzes of the main descriptors retrieved from literature. Furthermore, it provides a conceptual framework for the development of predictive models in soundscape studies, based on a review of soundscape literature.

2. Soundscape descriptors

This review of available soundscape descriptors is based on the view that the development of descriptors must precede the development of indicators. An example from the literature on psychoacoustics is the relationship between sound level (L) measured in dB, and perceived loudness (Ψ) of pure tones, obtained by magnitude estimation. This relationship is roughly described by the equation:

$$\Psi = 2^{L/10} \quad (1)$$

Eq. (1) illustrates that the perceived loudness of pure tones doubles with every 10 dB increment (Fastl and Zwicker, 1990). Thus, the sound level is an indicator of the perceived loudness, and with the aid of Eq. (1) the sound level can be used to predict its magnitude. At large, psychoacoustics relies on such stimulus-response relationships (Rasch and Plomp, 1999). Surely, from the example of Eq. (1) it is clear that it is necessary to develop descriptors before any indicator can be considered. However, while this approach has been reasonably successful in studies of relatively simple sound signals, establishing similar relationships for soundscape will require larger efforts because of the information content that soundscape is associated with.

This section reviews the main descriptors of environmental sound that have been proposed. Some of them were originally developed for environmental noise. Implementation of these descriptors in the soundscape approach is not necessarily straightforward. On the other hand, these descriptors relate to the perception of acoustic features, so they are likely relevant to soundscape assessment, in part.