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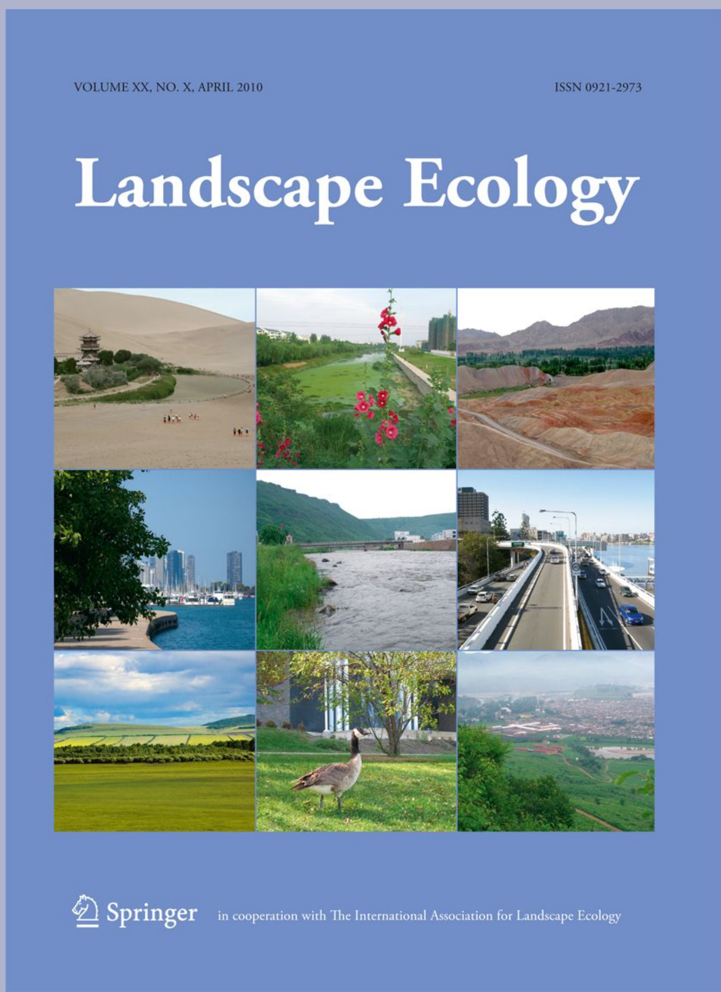
Landscape Ecology

ISSN 0921-2973
Volume 26
Number 9

Landscape Ecol (2011) 26:1201-1207
DOI 10.1007/s10980-011-9644-9



Springer

Landscape Ecol (2011) 26:1201–1207
DOI 10.1007/s10980-011-9644-9

PREFACE

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Received: 13 July 2011 / Accepted: 10 August 2011 / Published online: 17 September 2011

Abstract Soundscape ecology is being proposed as a new synthesis that leverages two important fields of study: landscape ecology and acoustic ecology. These fields have had a rich history. Running "in parallel" for over three decades now, soundscape ecology has the potential to unite these two (among other) fields in ways that provide new perspectives on the acoustics of landscapes. Each of us was involved in the "birth" of these two fields. We each reflect here on the rich history of landscape ecology and acoustic ecology and provide some thoughts on the future of soundscape ecology as a new perspective.

Keywords Soundscape ecology · Acoustic ecology · Soundscape studies · Acoustic community

Introduction

The term "landscape ecology," was first used by Carl Troll in 1939 (Troll 1939). Landscape ecology, as an evolving field of study, has a multidisciplinary background based on contributions from disciplines such as agronomy, architecture, economics, engineering, geography, vegetation science, and natural history (see Naveh 1982; Naveh and Lieberman 1984; Turner 1989; Zonneveld 1990 for an early history of landscape ecology).

Landscape ecology had its roots in Europe (see Schreiber 1990 for an early history of landscape ecology in Europe). Troll (1966) indicated that landscape ecology was not a new science, rather a special viewpoint for understanding complex natural phenomena. However, Zonneveld (1988) argued that landscape ecology is a science, rather than a mix of social activities, a state of mind, or human attitude. One of the oldest meanings of landscape, especially in fields such as landscape architecture and landscape planning, clearly contains an esthetic element (Zonneveld 1990). More recently, Barrett et al. (2009a, b) positions the aesthetic landscape as economy.

Other early perspectives of landscape ecology include the chorological aspect (a conglomerate of land units used for mapping patterns of land), landscape as an ecosystem, and the total human ecosystem (Naveh 1982; Zonneveld 1990). Because the study of land requires many disciplines (see above), Naveh and Lieberman (1984) noted it was paramount to recognize landscape ecology as a "transdisciplinary" science.

With the encompassment of numerous disciplines by landscape ecology, and with rapid development of approaches in Europe, the science of landscape ecology generated considerable interest in North

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America, especially in the United States. An increase in American attendance in European meetings contributed to the establishment of the International Association for Landscape Ecology (IALE) in 1982 (see Forman 1990 regarding the early history of IALE).

Landscape ecology had its beginning in North America during the 1980s, when Gary W. Barrett, then ecology program director with the National Science Foundation (NSF), recommended funding a grant proposal, submitted by Paul G. Riser, James R. Karr, and Richard T. T. Forman, for a workshop, "Landscape Ecology: Directions and Approaches." held at Allerton Park, Piatt County, Illinois, 25–27 April 1983 (see Risser et al. 1984, for details). This workshop was the catalyst for the establishment of the United States Regional Association of the International Association for Landscape Ecology (USIALE). The first meeting of USIALE, "The Role of Landscape Heterogeneity in the Spread of Disturbance," was held at the University of Georgia, 15–17 January 1986 organized by Frank B. Golley and Monica G. Turner (Turner 1987). USIALE returned to the University of Georgia, 5–9 April 2010, for the celebratory twenty-fifth anniversary symposium, "Is What Humans Do Natural?" with Gary W. Barrett and Terry L. Barrett serving as co-program chairs and hosts.

Special symposia, organized by Bryan C. Pijanowski, were presented at the twenty-fourth annual ("Soundscape Ecology: Merging Bioacoustics and Landscapes" [with Almo Farina]) and twenty-fifth anniversary ("Soundscape Ecology: The Complexity of Acoustical Patterns in Landscapes") symposia of USIALE; the former held in Snowbird, Utah. The symposia generated interest in soundscape ecology with resulting publications in BioScience (Pijanowski et al. 2011b) and subsequent articles encompassed in this Special Issue of *Landscape Ecology,* co-edited by Bryan C. Pijanowski and Almo Farina.

Currently, wherein the evolutionary process is the science of sound in the landscape? Ecology associated with biology until the 1970s (Odum 1977; Barrett 2001); ecology as a discipline was complemented with numerous emerging fields of study in the 1980s (e.g., agroecosystem ecology, conservation biology, restoration ecology, or landscape ecology; see Barrett 1989 for listing of emerging paradigms). Landscape ecology as a transdisciplinary science has evolved into an established and a dynamic network of integrative science, landscape aesthetics, and sustainability science for example. Soundscape ecology offers yet another emerging field of study implicit within this network.

The World Soundscape Project (WSP): a novel impetus for soundscape ecology

During recent times, a number of interdisciplinary studies have emerged involving sound. Exemplary are studies in anthropology (Howes 2003, 2005), architecture (Blesser and Salter 2007), cultural studies (Bull 2000; Bull and Back 2003; Erlmann 2004), science and technology (Sterne 2003; Thompson 2004; Bijsterveld 2008), and sensory history (Corbin 1998; Smith 1999). Currently, a plethora of websites is enhancing soundscape-based perspective by reconfiguring traditional disciplinary-based avenues of scholarly communication with a synthesis of science and technologies.

One of the strongest precedents for this interest is found in the pioneering work of the World Soundscape Project (WSP) that began at the start of the 1970s at Simon Fraser University (SFU) in British Columbia, directed by noted Canadian composer R. Murray Schafer. He dubbed the work "soundscape studies" (Schafer 1969, 1977) in an effort to find a positive alternative to the negative anti-noise approach that dominated most previous efforts, including *Book of Noise* (Schafer 1970). Drawing on aural sensibilities and ethical conscience of the musician, he instead proposed a listener-based approach using techniques of "ear cleaning" and "soundwalks" to counter the types of soundscapes that produced a non-listening habituated response to the acoustic environment. His landmark book, *The Tuning of the World* (Schafer 1977), was the culmination of his humanities-based approach and prescriptions for acoustic design.

In other words, the WSP approach framed soundscape studies in a subjective, listener-centered basis, both theoretically and strategically. Examples of perceptually based categories defined by the WSP are sounds that are placed in the foreground or background of one's perception (sound signals and keynote sounds, respectively) or regarded by the community as culturally significant (soundmarks). The WSP *Handbook For Acoustic Ecology* (Truax 1999a) defines the term "soundscape" as "An environment of sound (or sonic environment) with emphasis on the way it is perceived and understood by the individual, or by a society." As of this writing (2011), the International Standards Organization (as ISO Working Group 54) is in the process of rigorously defining the term and proposing standards for evaluation strictly on the perception and interpretation of an acoustic environment. Given the casual application of "soundscape" in a variety of contexts this initiative is welcome. However, a more inclusive redefinition of "soundscape" will challenge the dominant field of acoustics and acoustical engineering, which has traditionally treated sound objectively as a quantifiable entity, including measurements of the effects of noise.

An original member of the WSP team, Barry Truax, extended the subjective concept of soundscape during the 1980s to what he termed a communicational, information-based model. In his book *Acoustic Communication* (Truax 2001), he attempted to integrate the objective approach of acoustics and subjective approach of soundscape studies. In this model, sound results in meaning based on two types of information and knowledge provided by the listener: (a) information gleaned from the properties of the sound itself—such as its spectral and temporal patterns, and (b) listener's knowledge of the environmental, social and cultural context. Furthermore, the listening process can occur at different levels of attention, ranging from a foreground, more analytical level, through to a background, distracted or habitual level. At a macro scale, sound is not merely energy and information exchange, but is capable of mediating (and even symbolizing) relationships between listeners and their environments, reflecting a dynamic system of behaviors characteristic of an ecological approach. This approach is readily adaptable to the introduction of the electroacoustic mediation of aural experience that has increasingly characterized the last century, where patterns of sound and listening become more standardized and subject to economic constraints.

In 1993, a conference was held at Banff, Alberta, to mark the sixtieth birthday of R. Murray Schafer, and suitably titled "The Tuning of the World." The conference attracted several hundred participants from around the globe, representing a variety of backgrounds and interests familiar to Schafer's seminal book. Prior to the conference, Hildegard Westerkamp edited the *Soundscape Newsletter*, as a communication vehicle for those interested in soundscape studies and practice. By the closing of the conference, the participants created an international initiative dubbed the World Forum For Acoustic Ecology (WFAE). The WFAE has since defined itself as a loose confederation of national organizations incorporating local chapters. Besides sponsoring local and national initiatives, the WFAE maintains a large website (www.wfae.net); listserv (acoustic-ecology); *Soundscape Journal*, edited by a rotating set of national groups; and occasional conferences. Even a cursory glance at the work of a group, often described as "ear-minded people," reveals a profound interdisciplinary constituency and interests.

Issues arising from soundscape ecology concepts

The excellent overview article by Guest Co-editors Bryan C. Pijanowski et al. (2011a) in this Special Issue, articulates several key concepts related to Soundscape Ecology, such as acoustic composition, temporal dynamics, spatial variability and acoustic interactions. Each of these presents particular challenges for future research. For instance, if we look at the spectral aspects of acoustic composition, such as what is commonly referred to as the Acoustic Niche Hypothesis (ANH), proposed by the bioacoustician Krause (1987), several issues arise when we define the soundscape in perceptual terms, as opposed to an objective entity. The first is simply a reminder that the human auditory system simultaneously uses both spectral and temporal analysis, and has powerful strategies for each in order to achieve rapid recognition of sound sources, particularly when heard in combination. These analytical strategies are not mutually independent but are complementary processes apparently designed to increase recognition efficiency. In some contexts such as speech, spectral recognition may be more efficient for certain elements (e.g. vowels) whereas temporal recognition may do so for others (e.g. consonants). Within spectral analysis itself, very short temporal thresholds can be found for sounds with periodicity (i.e. pitch, with extremely fine resolution [a few Hertz]), and longer thresholds for spectrum and timbre recognition, with a much broader resolution known as the critical bandwidth, which is typically a little less than a quarter of an octave (Plack 2005).

A subtler issue arises when we consider the ANH across human and nonhuman soundscapes and species. Most is known about human auditory perception where the perceived spectrum can be parsed into about 32 critical bands that are more or less evenly spaced on a logarithmic scale. In passing it should be noted that most of the readily available spectral analyzers based on the FFT technique display their output on a linear frequency scale, hence producing a poor representation of human perception (see Villanueva-Rivera et al. 2011). One example of a real-time logarithmic spectral display is that produced by the Spectrafoo software. According to the ANH, when sound energy occupies non-overlapping (critical) bands, less masking will occur than, for instance, when broadband sounds dominate the soundscape (typical in industrialized soundscapes). Krause and the WSP discovered positive instances of the ANH in natural, bioacoustical soundscapes and the latter attempted to extend this model to human, social soundscapes (see also Krause et al. 2011). However, the ability of the auditory system to perform this analysis (in humans within the two and half spirals of the cochlea) is not uniform across species, with a less developed cochlea emerging only in birds and higher on the evolutionary ladder. Despite this difficulty, the concept of an "acoustic habitat," not merely a biological one, is a valuable contribution to ecology.

Perception across a number of time scales is inherent to understanding acoustic communication. Reference already has been made to its role at the lower, so-called "micro", time scale where it interacts with spectral recognition. Mid-level, or "meso" time scale recognition of pattern is clearly key to all forms of rhythmic perception and auditory stream groupings. Longer time scales, the "macro" level, interact with the role of structure in acoustic communication (clearly with music) and ultimately with our sense of the human life cycle. Beyond these are evolutionary, geological, and astronomical time scales that humans have more difficulty understanding, at least experientially. Sound recordings have given us the means to document sounds and soundscapes longitudinally, and to re-experience them, as long as we have the playback equipment to do so (not a trivial constraint). The WSP first documented its home city of Vancouver in the early 1970s, which resulted in the first extended analysis and representation of a city soundscape, namely *The Vancouver Soundscape* (WSP 1973). A second set of recordings in the 1990s, many at the same locations, allowed a double CD to be produced in 1996 with tracks and compositions from both eras. In 2010, a third set of digital recordings of the Vancouver soundscape was begun, thereby creating a 40-year span of documentation.

In 1975, the WSP studied five villages in Europe in five different countries (Germany, Italy, France, Scotland, and Sweden) and published the results as *Five Village Soundscapes* (WSP 1977). The key concept that emerged from this study was that of the "acoustic community," a soundscape as "acoustic information plays a pervasive role in the lives of the inhabitants (no matter how the commonality of such people is understood)" (Truax 2001). Although a study of small villages, the same concept was regarded as applicable to smaller units such as a home or a neighborhood, or even to electroacoustically defined "communities". The study developed criteria such as variety, complexity and balance to describe a positively functioning acoustic community. Among these original five villages, many differences were observed as to how this acoustic functioning was realized, as well as differing degrees of modernization and technological impact. In the early 2000s a group of Finnish researchers revisited all five villages and added a sixth Finnish one, and documented the changes that had occurred over the intervening 25 years, publishing their results as *Acoustic Environment In Change* (Järviluoma et al. 2009). This project provides fascinating insight into longitudinal changes of dynamic soundscapes.

In addition to spectral and temporal aspects of soundscape perception, spatial deployment and recognition clearly play an important role. However, we recognize that there is a danger in applying customary visual notions of space and ability to document it in mappings, to the experience of "acoustic space" that operates on a much different set of principles. The most dramatic difference is that acoustic space is evanescent and unstable because it depends on time. For anything to sound, there must be movement, and that movement, if it produces audible sound, interacts with the physical space and is perceived as sound that is inextricably combined with spatial information. A blind person might describe it as, if nothing happens aurally, space disappears. It might be more accurate to suggest that sound *creates* acoustic space, as well as our sense of time, rather than space and time being "containers" for sound. Or as Tim Ingold suggests, we do not hear sound, we hear "in sound" (Ingold 2007).

The human auditory system has a remarkable ability to separate simultaneous combined vibrations into the perception of separate auditory streams (Bregman 1990). The effects of spatial coloration of sounds assist in that process, at least with balanced soundscapes (in other words, the Acoustic Niche Hypothesis (ANH) is not only a spectral space but also an acoustic representation of physical space). The most common example is called "cocktail party effect," which describes the ability of the healthy auditory system to focus on one (correlated) source vibration in the presence of others (an ability that drops off rapidly with hearing impairment). Likewise the auditory system can distinguish between the correlated early-arriving vibrations from the later-arriving uncorrelated ones created by reflections in the environment (though the latter can overpower the former when precedence effect breaks down) (Truax 1999b). Hence at the primary level of psychoacoustic perception, feature extraction of sound sources is a complex set of abilities involving spectral and temporal cues imbedded in spatial information, all of which, interpreted by the contextual knowledge and ability of the listener to interact with the world, allows the listener to form an embodied relationship with that world.

As stated in the previous sentence, soundscape perception is complemented by soundscape interaction—listening is intertwined with soundmaking. Just as we cannot speak clearly without hearing ourselves through auditory feedback, so too, our movements and actions, along with the sounds they produce, are part of what creates our relationship to the landscape and the soundscape. A simple example is the soundwalk that emphasizes listening, but also the dynamics of bodily movement through a space. Given this system of interaction as the basis of Soundscape Ecology, how do we integrate disembodied electroacoustic sound into the process of communication? Sounds are now detached from original sources (and reattached to loudspeakers). Recorded sounds come from an ambiguous past, amplified sounds have an arbitrarily large (or small) volume, synthesized sounds can have no apparent physical source, and all can be packaged in arbitrary combinations.

While the introduction of such audio elements into the soundscape has a clear potential for disruption and sound pollution, as well as reflecting powerful economic interests beyond our control, more positive aspects can also be identified with respect to Soundscape Ecology. For instance, the electroacoustic community need not be physically bounded and can create mass or niche communities (and markets). Listeners fairly readily learn to decode contradictory elements of the soundscape (elements that are "in" but not "of" the landscape), and hence can hone new interpretative skills. Despite having electroacoustic sound frequently imposed on oneself, one can also learn to regain control by embedding one sonic environment within another, whether through portable personal stereos or other media (Bull 2000).

Lastly, among the many creative options in the use of audio technology, the one that may contribute most to Soundscape Ecology is the soundscape composition (Truax 1996, 2002, 2008). In North America it grew out of the work of the WSP that originally used soundscape recordings in a documentary, or "phonographic" mode. Early examples from Europe include the work of Luc Ferrari and that of various radiophonic sound artists and composers. Today the genre covers a wide range of approaches from phonographic to abstracted, assisted most spectacularly by multichannel reproduction that is speakers are deployed around the audience on one or more vertical levels to create an immersive sonic experience. Source recordings can be stereo or multi-miked. David Monacchi has supplemented his Amazon soundscape recordings with wall-sized projections of their spectrograms using Spectrafoo in a clear demonstration of the ANH. The intent is usually some combination of pedagogic and artistic, and the possible formats include concert, sound installation and digital media. Given the environmental issues that are of concern to global citizens as never before, and that all such compositions put a priority on listener recognition of the sounds used, these works have the ability to engage audiences with environmental representation at many levels. They can evoke soundscape experiences in the real world as well as transport the listener to imaginary worlds of potent symbolism.

Concluding remarks

Soundscape ecology is an emerging paradigm in the field of landscape ecology. Soundscape ecology as an emerging transdiscipline is challenged to resolve that: (a) soundscape boundaries be established delineating ecological systems and landscape elements in order to quantify such parameters as biotic diversity, species competition, and mutualistic behavior based on sounds within changing environments (Hansen and DiCastri 1992); (b) science of sound in the landscape contribute to problem-solving approaches focused on ecological resource management (Barrett 1985), and as an emerging component of sustainability science (Wu 2008; Barrett et al. 2009a); (c) funding be provided (private and public) to analyze and integrate the collection of sounds across temporal-spatial scales to configure ecosystem/landscape patterns and processes; and (d) contextualize sound as acoustic process within a transdisciplinary science of soundscape ecology.

Acknowledgments We thank Co-editors Bryan C. Pijanowski and Almo Farina for their invitation to contribute to this Special Issue of Landscape Ecology; and Editor-In-Chief Jianguo Wu for insightful recognition and publication of an emerging field of knowledge, education, research, and service.

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