

## CNH-RCN: A GLOBAL SUSTAINABLE SOUNDSCAPE NETWORK

### Project Summary

#### INTELLECTUAL SCOPE AND PROPOSED ACTIVITIES

Sounds are a perpetual and dynamic property of all landscapes. The sounds of vocalizing and stridulating animals and the non-biological sounds of running water and rustling wind emanate from natural landscapes. In contrast, urban landscapes are dominated by human-produced sounds radiating from a variety of sources, such as machines, sirens, and friction generated by tires rotating over pavement. Since Rachel Carson's seminal work, *Silent Spring*, nature's sounds have been inextricably linked to environmental quality. Because sound is a fundamental property of nature and can be drastically affected by a variety of human activities, it is indeed surprising that sound has not become a more unified measure of a coupled natural-human system.

Recently, a group of ecologists (soundscape ecologists), a community of cognitive psychologists and members of a loosely formed group of scholars in the humanities called acoustic ecologists, have begun to study soundscapes from their own natural, social and creative disciplinary perspective. Work in the US, Canada and Europe is moving forward in these three camps with little to no coordination. Even within the ecological community, no formal group has been formed that allows research to be integrated and compared. As human activities increase, these soundscapes are being threatened with extinction. Our proposed Global Sustainable Soundscape Network rises to the global need to coordinate research and raise awareness that our global acoustic heritage is rapidly being lost. **Our RCN will bring together ecologists (landscape ecologists and conservation biologists), acoustic ecologists (from the creative arts) and acousticians and psychoacousticians (scientists that study sound and how people perceive sound) to coordinate studies in diverse soundscapes around the world.** The network will help to foster (1) open communication between different disciplines about the composition of soundscapes and the underlying mechanisms that control dynamics and the ways that humans experience sounds in the environment through the support of workshops (listening, conservation), sharing of tools, social networking (e.g., Jumo) and coordinated Theme Teams (standards, interdisciplinary capacity building, sustainability and conservation and engagement); (2) coordinate 4-5 soundscape monitoring sites where acoustic data are being collected long-term; (3) the development of a common vocabulary, long-term monitoring standards, and metadata standards for acoustic data for use by ecologists; (4) increase awareness of this new field among ecologists and social scientists through a variety of activities; and (5) increase public awareness of the importance of their acoustic connection to nature. The network would be lead by an interdisciplinary ecologist with assistance from a psychoacoustician.

#### BROADER IMPACTS AND TRANSFORMATIVE RESEARCH POTENTIAL

Rarely do scientists learn from those in the creative arts. We create many opportunities for this to occur. Cognitive psychologists and ecologist rarely collaborate. Integrating expertise across these natural and social sciences is a main objective of our network. Indeed, our network will bring together these very diverse communities for a common cause – to integrate how they study and perceive soundscapes and use this information to help shape a research agenda for the conservation of soundscapes. Our RCN will have high impact on education as well. Four Soundscape Fellows (PhD students) will be supported to travel to 5 different soundscapes (Alaskan Kenai, Sonoran Desert Region, Temperate Forest, Mediterranean Chaparral and Borneo Forests) to participate in Listening Workshops and two Conservation Workshops held with conservation groups and natural resource management agencies. We will support 4 Undergraduate Scholars to conduct soundscape research. Unique outcomes also include: (1) the support for a World Listening Day by the public and (2) the commissioning of a composition by an acoustic ecologist who would use recordings made by ecologists. This piece would be played at an Ecological Society of America meeting in the final year of the project. Founding Members are from two of the most prestigious HBCUs, Tuskegee University and Alabama A&M University.

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## PROJECT DESCRIPTION

### I. PROBLEM STATEMENT AND VISION

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#### A. MOTIVATION

Human domination of natural habitats has resulted in the loss of biodiversity (Vitousek et al. 1997; Chapin et al. 2000). The loss of species is so significant that some have concluded that we are experiencing the sixth extinction event (Pimm et al. 1995; Wilson 1999). With the loss of habitat and biodiversity, areas lose their natural sounds (Wrightson 2000; Pijanowski et al. in press). In addition to the world losing natural sounds, our planet is gaining in the temporal and spatial reach of human-generated sounds (Schafer 1994). Human-generated sounds can include motorized transportation, such as global air travel, sounds from industrial and domestic machines, road noise due to friction, the sounding of bells, sirens, alarms, and human voices. The contaminant loss of natural sounds from declining biodiversity and the increase in noise in landscapes beckons Rachel Carson's call of the 1950s that our ecosystems could become silenced through human actions (Pijanowski et al. in press).

The study of soundscapes by ecologists is relatively new. Historically, biologists have studied animal communication from a very species-specific perspective (Pijanowski et al. in press, accepted) and have made tremendous progress with understanding acoustics from an ecological, behavioral and evolutionary standpoint (cf Kroodsma et al. 1982; Marler and Slabbekoorn 2004). However, a macroacoustic perspective, that includes the study of all sounds --- biological, geophysical and anthropogenic -- that emanate from a landscape, has been lacking. Soundscape ecology attempts to fill this void by studying sounds from both a natural and social standpoint -- a new area of discovery that is a coupled natural human system (Pijanowski et al., accepted).

Interestingly, a field that emerged in the 1960s in the humanities, called acoustic ecology, was started by a small group of composers of electroacoustic music (e.g., Schafer, Truax and Westerkamp) interested in incorporating natural sounds into their recordings. Acoustic ecologists have become great "listeners" of nature. They understand natural sounds from a very synthetic perspective, identifying features like texture, atmosphere, balance, hierarchical structure and microtones in natural soundscapes. Ecologists have a lot to learn from acoustic ecologists and how they listen. The field of acoustic ecology grew over the ensuing decades to include not only their creative compositions but also a rich vocabulary (e.g., "soundmarks", "keynotes"), advanced techniques for listening and recording, an "ethic" that expresses the need to protect the earth's rich and varied natural sounds and an understanding of how humans relate emotionally to natural sounds and provide a sense of place (Dumyahn and Pijanowski, in review).

Parallel to these efforts in acoustic ecology has been the growing understanding of how humans perceive a variety sounds in their environments. This area of research, termed psychoacoustics, emerged from the integration of subfields of cognitive psychology, human health and audiology. This field has also grown in recent decades, with a particular focus on urban environmental acoustics, their composition and importance to providing a sense of place for urban dwellers (Augoyard and Torgue 2006; Kian, 2007; Raimbault and Dubois, 2005; Guastavino, 2006; Coyne, 2010). Some of this research is being applied to occupational noise policy development, mitigation of highway and other transportation noise, and preservation of cultural sounds (e.g., church bells, sounds of the market) that are important in urban environments. Understanding how people perceive sounds is key to increasing human enjoyment of nature and how people connect to the world around them.

#### B. OBJECTIVES

**The overarching objective of our network is to bring together ecologists (landscape ecologists and conservation biologists), acoustic ecologists (from the creative arts) and acousticians and psychoacousticians (scientists that study sound and how people perceive sound) to coordinate studies in diverse soundscapes around the world.** The network will help to foster (1) open communication between different disciplines about the composition of soundscapes and the underlying mechanisms that control dynamics and the ways that humans experience sounds in the environment through the support of workshops (listening, conservation), sharing of tools, social networking (e.g., Jumo) and coordinated Theme Teams; (2) coordinate 4-5 soundscape monitoring sites where acoustic data are being collected long-term; (3) the development of a common vocabulary, long-term monitoring standards, and metadata standards for acoustic data for use by ecologists; (4) increase awareness of this

new field among ecologists and social scientists through a variety of activities; and (5) increase public awareness of the importance of their acoustic connection to nature.

### C. ABOUT THE PIs AND FOUNDING MEMBERS

**Bryan Pijanowski** (PI) is an interdisciplinary scientist that is known for his work in land-climate-people interaction modeling. He was co-PI on an NSF Biocomplexity project (2003-2009) entitled Climate-Land Interaction Project (CLIP) that examined natural-human interactions in East Africa. He has published widely in ecology and geography journals. He is the Director of the Human-Environment Modeling and Analysis Laboratory at Purdue, the Partnering for Land Use Sustainability (PLUS) project and Purdue's Ecological and Environmental Engineering GAANN Graduate Program. As co-PI of a recent NSF ULTRA-Ex grant, he also works closely with social scientists at the USDA Forest Service and ecologists at UI-Chicago and DePaul University to examine how Chicago Wilderness's Green Infrastructure Vision can be improved using ecosystem services as a framework for planning across the greater Chicago Area. Dr. Pijanowski has bridged the ecological and social sciences many times, working with human geographers and sociologists in the Midwest United States and East Africa. Dr. Pijanowski is currently the secondary member for Purdue to NSF's NEON project; he will become the primary member for Purdue in 2011. Dr. Pijanowski is lead author on a forthcoming paper in *BioScience* on soundscape ecology and is the lead Guest Editor for a special issue in *Landscape Ecology* that will appear in 2011; he is lead author on a large overview paper for the special issue.

**Catherine Guastavino** (co-PI) is an Associate Professor at McGill University in Montréal, Canada. She has been involved in soundscape research for the past 10 years. Initially trained in Music Technology and Psychoacoustics, she received post-doctoral training in cognitive psychology before joining the McGill School of Information Studies in 2005. Based on her doctoral research, she initiated a cognitive approach to soundscape in an award winning paper (European Acoustics Association award for outstanding research results for Guastavino et al. 2005). This approach relies on the psycholinguistics analysis of free-format descriptors to infer cognitive processes for everyday listening in ecologically valid situations (Guastavino 2006; 2007). She has also published extensively on the ecological validity of soundscape recording and reproduction. Her current research projects focus on methodological tools for soundscape evaluation, cross-linguistic evaluation of soundscapes, sound quality (in the context of sound reproduction, audio compression and digitization), auditory comfort, auditory similarity and categorization and multisensory integration. She established the Multimodal Interaction Laboratory in 2006 and has been directing it since then with research support from various granting agencies (e.g. Canadian Foundation for Innovation, Fonds Québécois Société et Culture, Natural Sciences and Engineering Research Council) and industry partners. She is involved in several projects on soundscape in collaboration with European institutions (e.g. European Union COST action "Soundscape of European Cities and Landscape") and a member of ISO working group 54 responsible for developing the first international standard on soundscape. From 2007 to 2009, she served as Associate Director of the Centre for Interdisciplinary Research on Music Media and Technology, a multi-institutional research center based at McGill. She has also been associated with the McGill Schulich School of Music since 2007.

Other members of the network in this proposal, that will be considered Founding Members, include scientists/naturalists that have "written the definitive textbooks" in their respective fields. These include **Almo Farina** (*Principles and Methods in Landscape Ecology and Ecology, Cognition and Landscape: Linking Natural and Social Systems*), **C. Ron Carroll** (*Principles of Conservation Biology*), **Bernie Krause** (*Wild Soundscapes: Discovering the Voice of the Natural World*) and **Mark Lomolino** (*Biogeography*). Advisory members include **F.S. "Terry" Chapin III**, one of the most frequently cited ecologists in the world and current President of the Ecological Society of America, and **Hildegard Westerkamp**, co-founder of the World Forum for Acoustic Ecology and a pioneer in the field of acoustic ecology. Membership also includes staff from several US Federal Government Agencies (United States Fish and Wildlife Service (**Morton**) and the United States Forest Service (**Landres**)) who have mandates to manage natural lands and their soundscapes. International conservation groups (e.g., Conservation International, **Ahumada**) are also members. Ecologists and acoustic ecologists hail from the United States, Canada, Latin America and Europe so its reach will be international. Finally, acoustic ecology members have international (**Westerkamp**, former President of the World Forum for Acoustic Ecology), and national (**Cummings**, founding member of the American Society of Acoustic Ecology; **Leonardson**, current President of the American Society of Acoustic Ecology) leadership responsibilities potentially

increasing the impact that the network might have on society. Our psychoacousticians (**Andringa, Guastavino, Kang, Bottledooren, and Dubois**) are global leaders in soundscape research. Members of the network are at Purdue University (**Pijanowski, Crawford**), McGill University (**Guastavino**), University of Georgia (**Carroll**), Michigan State University (**Gage**), University of New Mexico (**Polli**), SUNY-ESF (**Lomolino**), Alabama A&M University (**Tadesse**), Tuskegee University (**Kpombrekou and Smith**), Universidad Nacional (**Retamosa**), Chicago Institute of Arts (**Leonardson**), Urbino University (**Farina**) (Italy) and the Conservatory of Pesaro (**Monacchi**) (Italy), University of Groningen (**Andringa**) (The Netherlands), University of Sheffield (**Kang**) (UK) and University of Paris (**Dubois**) (France).

#### **D. TIMING AND URGENCY**

Funding of this network is timely for several reasons. First, several large soundscape research initiatives are underway with little to no coordination. This network would bring together like-minds from several disciplines. Technological advances, especially the development of low-cost acoustic sensors and availability of relatively low cost data storage are fueling considerable work on long-term monitoring. Second, many natural soundscapes are being threatened from various directions, from habitat destruction, climate change, and invasive species. Sites we intend to visit (e.g., Borneo Rainforest) may not exist in a few years. Third, this proposal is motivated by the opportunity to carry out a significant research project in collaboration with the European Network on soundscape, currently comprising 32 world-class research institutions in Europe, one in Australia and one in Canada (Guastavino). The co-applicants of this proposal are uniquely situated to contribute decisively to the development of a sustainability framework in active collaboration with this European network. Finally, federal mandates to protect natural sounds and preserve park wilderness features are in need of fresh perspectives on conservation and sustainability that also involves soundscapes. Indeed, major research initiatives in the natural and social sciences and the humanities are being conducted in complete isolation. Our novel approaches (e.g., listening workshops) to collaboration will build a unique community spirit to address a pressing societal need.

#### **E. ANTICIPATED OUTCOMES OF THE NETWORK**

Outcomes from our network will include:

- Developing a state of the art network portal where members can share tools, data, approaches, sign up for listserves and social networking sites;
- Hosting five novel listening workshops at different soundscapes around the world in order to improve listening skills of ecologists and facilitate a dialogue between diverse disciplines studying soundscapes;
- Supporting four cross-cutting Theme Teams that explore as a group core needs for furthering sustainable soundscape research;
- Hosting two conservation workshops, one domestic and one international, designed to increase the exchange of information flow between the research community and natural resource management agencies;
- Supporting 8 Soundscape Fellows so that the next generation of soundscape researchers can be trained;
- Developing a sustainability framework for soundscape protection that would be published in a high-end journal;
- Commissioning an electroacoustic work from an acoustic ecologist that incorporates field recordings made by ecologists;
- Supporting an array of broader impact activities, including an annual World Listening Day that would be promoted by the network.

## **II. BACKGROUND ON SOUNDSCAPE RESEARCH TO DATE**

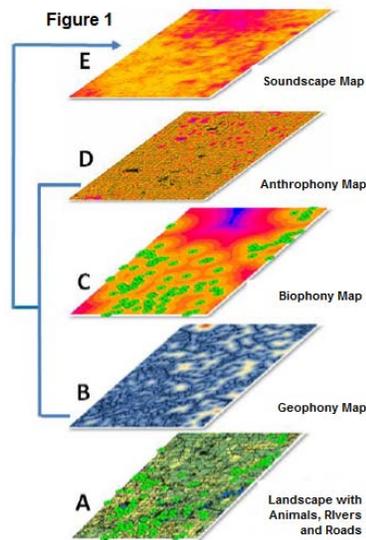
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### **A. ORIGINS**

Several disciplines have used the term “soundscape”. The etymology of the term “-scape” is reference to an “area, scene, space or view” (Zonneveld and Forman 1990). “Soundscape” is thus “sounds occurring over an area”. The first use of the term soundscape that we could find in the literature is from Southworth (1969), an urban planner who used the term to refer to the acoustic properties of cities that help people relate to certain spaces. Southworth tested how blind people used certain sounds to form a “sonic identity” of unique areas in Boston. Schafer (1977), in his seminal book “Tuning of the World”,

formalized the term “soundscape” (Coates 2005) defining soundscape as the “auditory properties of landscapes”. A musician by training, Schafer was concerned about noise pollution in natural and human dominated landscapes and the lack of awareness humans have of their acoustic surroundings. A variety of psychoacousticians (e.g., Raimbault and Dubois 2005, Dubois et al. 2006) have used “soundscapes” as a neutral term, to avoid the word noise, to describe the “structure of categorical space of sounds in cities”.

Our working definition of soundscapes is “the collection of biological, geophysical and anthropogenic sounds that emanate from a landscape and which vary over space and time reflecting important ecosystem processes and human activities” (Pijanowski et al. in press). We emphasize the diversity of sound



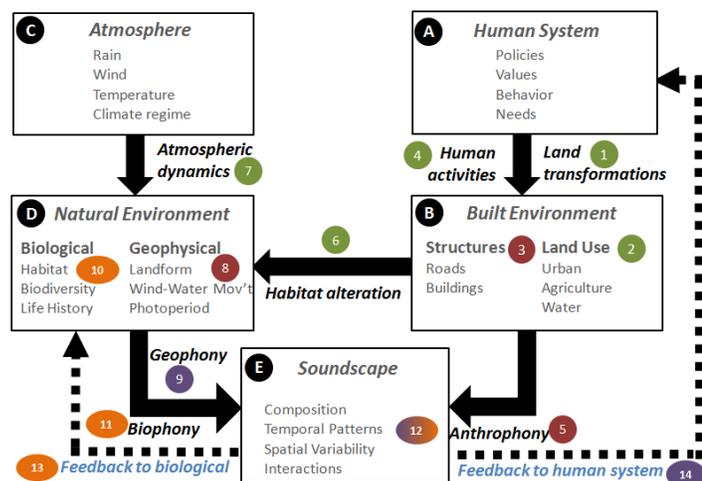
sources, those that are biological, which we call biophony, after Krause (1998), anthrophony (human produced sounds) and geophony (geophysically created sounds) that occur in a landscape. We define biophony (bio- “living”, -phony = “sound”, Merriam-Webster 2010) as the collection of sounds produced by all organisms at a location over a specified time. Geophony are those sounds originating from the geophysical environment, which includes wind, water, thunder, movement of earth, etc. Anthrophony is produced by stationary (e.g., air conditioning units) and moving (e.g., vehicles) human-made objects. We posit that landscape structure (Fig. 1A) controls the patterns of sounds produced from these three main sources (Fig. 1B-1D). Combined, they create the integrated soundscape (Fig. 1E). Sound will reflect natural *and* human activities and is thus, we believe, an excellent “universal” variable to consider in any study of a coupled natural-human system (Liu et al. 2008).

## B. SOUNDSCAPE AS A COUPLED NATURAL HUMAN SYSTEM

Landscapes are dynamic systems (Forman and Godron 1981, Urban et al. 1986, Turner et al. 1989) perturbed by natural and anthropogenic factors. A variety of these dynamics relate to sound production; here,

we present an integrative framework (Fig. 2) of soundscapes that we believe describes how natural and human driven factors influence underlying ecological and social acoustic patterns. Within the human system (Fig. 2, component A), human needs, values, policies and behaviors lead to land transformations (label #1) in the form of land use patterns (label #2). The built environment (Fig. 2, component B) is composed of artificial structures and surfaces (label #3) used for shelter (housing) and for transportation (roads) which shape human activity (label #4) patterns (e.g., traffic patterns). These human activities give rise to the spatial and temporal patterns of human generated sound – which we have labelled anthrophony (label #5). The built-environment alters natural habitat structure (label #6), and human alteration of natural areas via land use change is considered the greatest threat to biodiversity over the next century (Chapin et al. 2000). The atmosphere (Fig. 2, component C) is highly dynamic, creating rain and air movement patterns (label #7) that, upon interactions with the geophysical features (label #8) of the natural environment (Fig. 2, component D), give rise to sounds derived by water and wind (label #9). Climate patterns influence plant community structure (Gaston 2000, Parmesan 2006) which in turn influences diversity patterns of animals (label #10). Biophony (label #11) created from these biodiversity patterns (label #10) and the timing of life history events (label #10) interact with sound inputs from the geophysical (label #9) and built environment (label #5) interface to create the soundscape.

Figure 2. Underlying Processes of the Soundscape



A soundscape (Fig. 2, component E) possesses many (label #12) measurable properties: acoustic composition, temporal patterns, spatial variability, and acoustic interactions. By composition, we mean the acoustic frequency (subjectively what humans perceive as pitch) and amplitude (sound level) of all sounds occurring at the same time and location. Temporal patterns are numerous and reflect certain biological events (e.g., breeding) that occur in the landscape. Spatial variability results from the heterogeneity of the biophysical landscape. Research on auditory science analysis (e.g., Bergman 1990, McAdams) has demonstrated processes by which the human auditory system organizes sounds into perceptually meaningful events, by integrating temporal, spectral and semantic information. Some sounds will be integrate as one event (e.g., sounds coming from the same location at the same time) while others will be segregated into different sound events (or streams). The grouping principles are somewhat similar to Gestalt principles. Recent research has shown that animals (monkeys, birds, bats, frogs, fish, pinnapeds and insects also use these auditory scene analysis principles to organize sounds. Finally, a large array of natural and human-induced interactions occurs between biophony, geophony and anthrophony which create the integrated soundscape.

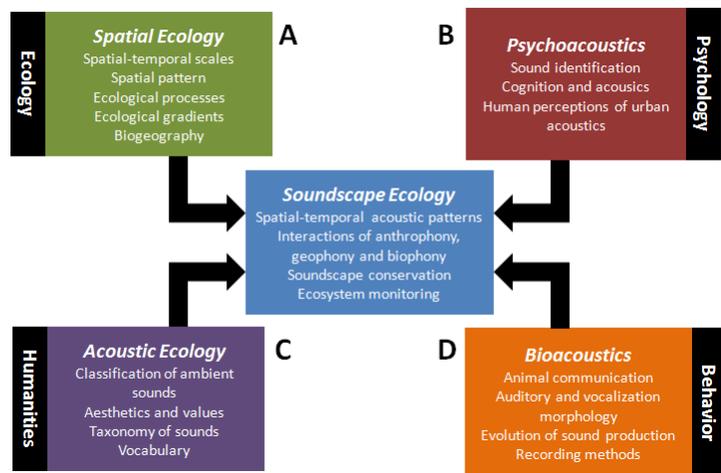
Soundscape dynamics feed back to the natural and human systems as well (Fig. 2). For example, the interactions between species and their competition for acoustic space (see Greenfield 1994) impacts mate selection and predator prey interactions (Barber et al. 2009), and thus have the potential to affect population and community dynamics (label #13). Soundscapes impact a variety of human social components (label #14) including human health (e.g., Stansfeld and Matheson 2003) and their sense of place (Dumyahn and Pijanowski, in review).

### C. INTELLECTUAL ROOTS OF SOUNDSCAPE RESEARCH

We have argued (Pijanowski et al., in press), that soundscape ecology shares many parallels with two spatial ecologies: landscape ecology and biogeography (Fig. 3A). Landscape ecology centers on the relationship between spatial pattern, or heterogeneity of landscapes and corresponding ecological processes (Forman and Godron 1983, Urban et al. 1986, Turner 1989, Wiens 1992, Turner et al. 2001). The interaction of pattern and process is generally studied at multiple spatial scales with outcomes directed toward natural resource management or decision making. Land use change (Turner 1987, Hobbs 1993, Dale et al. 1994, Pickett 1995), and more recently, climate change (Opdam and Wascher 2004, Vos et al. 2008) are frequently studied as major factors creating disturbances on the landscape. Soundscapes reflect many ecological processes and are ecological patterns in themselves. Comparison of soundscapes can also occur across large spatial scales and thus soundscape ecology could build from the knowledge generated in the field of biogeography. Biogeographers (cf. Lomolino et al. 2004), like landscape ecologists, have also long studied how species distributions and diversity patterns vary across distinct biophysical gradients, such as those found along altitudinal, latitudinal and biogeochemical gradients. Components where landscape ecology and biogeography perspectives can help support integrative soundscape ecology research are green numbered circles in Fig. 2.

We argue that a more comprehensive study of soundscapes should also build from several other disciplines such as the fields of urban environmental acoustics, bioacoustics and acoustic ecology – which are not mutually exclusive (Fig. 3). Urban environmental acoustics (Fig. 3B) (e.g. Hartmann 1997) is the study of “the aggregate of sounds that are interwoven with the built environment” and that “emerge naturally due to the typical activities that take place in the public area” (Botteldooren et al. 2004). Because the acoustic properties of urban areas affect the quality of life of its residents, urban soundscape research has often been extended to include urban planning (Carles et al. 1999, Raimbault and Dubois

Figure 3. Intellectual Foundations of Soundscape Ecology



2005, Adams et al. 2006, Raimbault 2006, Guastavino 2006). Modelling of sound propagation from noisy human-made objects (e.g., vehicles) and the development of noise mitigation techniques (e.g., De Coensel et al. 2005, De Coensel and Botteldooren 2006, De Coensel and Botteldooren 2007) has been the focus of considerable research by transportation experts who study urban sounds. Urban environmental acoustic studies also include subjective assessments of different urban sounds, determining how humans perceive and value common urban sounds (e.g., Yang and Kang 2005, Lavandier and Defreville 2006, Dubois et al. 2006, Jeon et al. 2010). Further research on the role of the built-environment, the patterns of anthropophony, the physics of sound propagation in the environment as well as the role that sound plays in shaping human perceptions of cities (maroon numbered circles in Fig. 2) will be necessary as we attempt to understand the role that humans have on soundscape composition.

Bioacoustics (Fig. 3C) has a rich history (for excellent summaries, see Kroodsma et al. 1982, Bradbury et al. 1998, Marler and Slabbekoorn 2004, or Fletcher 2007). Its interdisciplinary focus integrates animal behaviour (Marten and Marler 1997, Marten et al. 1977, Grafe 1996, Wollerman 1999, Kroodsma and Haver 2005, Barber and Conner 2007), mechanisms of sound production by animals (e.g., Walker 1962, Armstrong 1963, Stein 1968, Walker 1975), evolutionary foundations (e.g., Morton 1975, Greenfield 1994, Mitani and Stuht 1998), communication and habitat features (e.g., Ryan and Brenowitz 1985, Boncoraglio and Saino 2007, Barker 2008), animal physiology and anatomy (e.g., Greenewalt 1968, Walker 1969, Webster et al. 1992), and timing of vocalizations (Allen 1913, Saunders 1937, Saunders 1938, Kacelink and Krebs 1982, Cuthill and MacDonald 1990, Hutchinson 2002, Berg et al. 2006, Hardouin et al. 2008), among others. Limited research has been conducted in freshwater systems (Amoser and Ladich 2005, Wysocki et al. 2007, Qi et al. 2008). Considerable research, however, has been conducted in ocean systems, especially in the area of marine mammal communication and human noise production (e.g., Payne and Webb 1971, Croll et al. 2001, Charif et al. 2001, Vasconcelos et al. 2007, Amoser and Ladich 2010). In general however, bioacoustics has focused primarily on individual species. Our view of soundscape ecology proposes a more integrative view of all sounds occurring across a landscape. Nevertheless, bioacoustics will certainly form a main foundation (orange numbered components in Fig. 2) for further studies of the ecological significance of all sounds in landscapes.

Finally, we argue that the field of acoustic ecology (Fig. 3D), as envisioned by Schafer (1977) and Truax (1978), provides several important perspectives useful to soundscape ecologists. Schafer emphasized the need to allow nature to create its natural sounds, posing the question “is the soundscape of the world an indeterminate composition over which we have no control, or are we its composers and performers, responsible for giving it form and beauty?”. Schafer (1977) and Truax

(1978, 1984), and later Guastavino (2007), also introduced useful terms and taxonomies to describe various types of sounds and soundscapes. Schafer used the terms “keynotes”, “soundmarks” and “sound signals” to describe background sounds, location specific sounds and foreground sounds, respectively, of landscapes. The keynote of a natural soundscape is often wind, whereas in cities it is dominated by traffic. Soundscapes that contain a large degree of acoustic frequency diversity are referred to as “hi-fi”; these sounds can be heard clearly and are not masked or crowded. Hi-fi soundscapes differ from “lo-fi” soundscapes where one frequency spectrum (often low frequencies such as in urban environments) dominates, and distant sounds cannot be discerned. Wrightson (2000) describes hi-fi soundscapes as those possessing “acoustic colorization”, meaning that audible sounds bounce, are absorbed, and echo off of the natural features of a landscape (trees, rock outcrops) so that acoustic size (i.e., sound intensity) and distance from the sound emitter can be interpreted by the listener. Several initiatives have arisen out of the field of acoustic ecology, including the World Forum for Acoustic Ecology which organized the World Soundscapes Project ([www.wfae.org](http://www.wfae.org)). The role of human perceptions, the need to participate in

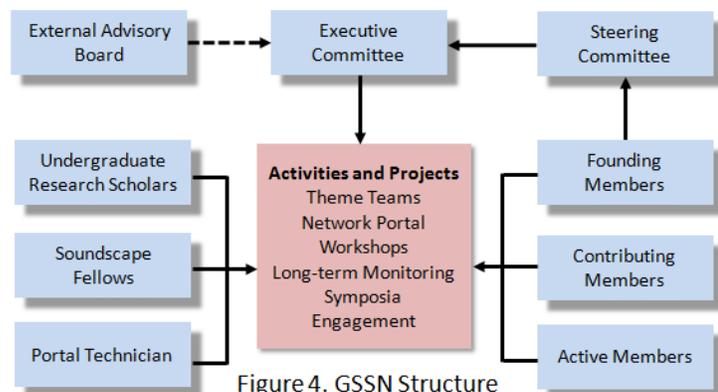


Figure 4. GSSN Structure

“soundwalks” and be “earwitnesses”, will be critical (purple numbered circles in Fig. 2) to preserving natural soundscapes and increasing the awareness of our acoustic surroundings.

### III. MEMBERSHIP AND NETWORK STRUCTURE

#### A. GOALS

The objectives of our Global Sustainable Soundscape Network are to coordinate research being conducted by ecologists and social scientists (e.g., cognitive psychologists) on soundscapes and to develop a research agenda for study of sustainable soundscapes.

#### B. MEMBERSHIP AND NETWORK STRUCTURE

We propose to create three levels of membership in our network (Figure 4). The first will be composed of the Founding Members; these will be those individuals and institutions listed in this proposal as members of the Steering Committee for the network. The second level of membership will be Contributing Members. These will be individuals and/or institutions that contribute data, tools and other resources to the network and that are recruited after the project is funded. Applications to be Contributing Members will be reviewed by the Steering Committee. Students (undergraduate, graduate and post-doctoral) could also apply to be Contributing Members. Founding and Contributing Members can exploit the travel resources provided by the network to participate in any of the proposed workshops. The third level of membership will be Active Member. These will be individuals and groups that sign-up through the network web site and participate by learning and benefiting from the online resources of the network. Founding, Contributing and Active Members will be added to the GSSN listserv. The listserv will facilitate communication across all members so that they learn about new tools, databases, papers, concerts, conferences, symposia, and research projects that are occurring.

Table 1. Theme Teams and Candidate Research Questions

<b>Technical Standards</b>	What recording standards (length of recording, frequency, etc.) should be adopted so we can do comparative work? What common tools/metrics should we use? What is the best archiving format? How can we share large acoustic archives?
<b>Interdisciplinary Listening and Vocabulary Building</b>	What are the best approaches to increase our listening and interpretation abilities as natural and social scientists and as creative artists? What is the necessary vocabulary for all disciplines to communicate effectively about soundscapes? What valuable disciplinary perspectives are needed to help preserve our soundscapes?
<b>Sustainability and Resilience</b>	What are the threats to soundscapes (1) in each ecosystem and (2) globally? What sustainability frameworks can be used to understand sustainable soundscapes? What are the ecosystem services provided by soundscapes? What factors are important to the conservation of soundscapes? How do these practices vary with the type of soundscape being managed?
<b>Engagement</b>	How can we increase awareness of the natural sounds of ecosystems? How can our efforts address broader issues/initiatives of Nature Deficit Disorders, No Child Left Inside and World Listening Day? How can soundscape ecology and other research on soundscape be introduced into the classroom? What are innovative techniques for accomplishing this?

Letters are attached from all Founding Members with their willingness to serve on the Steering Committee. To ensure that as much input is provided to the GSSN, all Founding Members will serve on the Steering Committee for at least one two year term. The Steering Committee will be composed of 5 members with a balanced representation across the membership demographic (area of expertise, type of organization, professional status (junior, senior)).

### IV. NETWORK TASKS AND ACTIVITIES

We propose the following activities as part of our network.

#### A. WORKSHOPS

*1. Listening Workshops.* One of the core activities of our network will be the hosting of Ecosystem Listening Workshops designed to: (1) increase listening skills of ecologists and conservation biologists in order to improve research capability on soundscapes; (2) learn more about how humans use acoustics to perceive their surroundings so that society values protecting soundscapes. Teams of

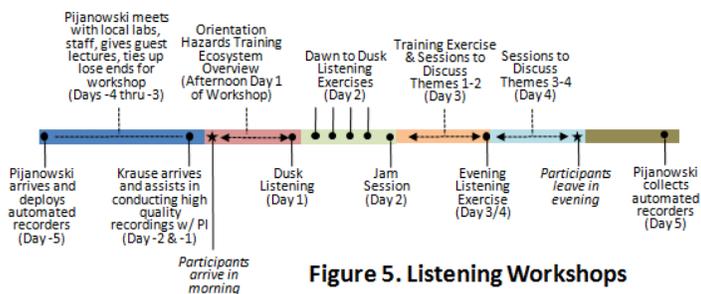


Figure 5. Listening Workshops

ecologists, acoustic ecologists, and psychoacousticians will visit five unique ecosystems over the course of the five year project. Ten network members and four Soundscape Fellows will travel to a site and join 3-6 local hosts for these listening workshops. We will attempt to select members that will attend these workshops so that there is a good balance of ecologists, social scientists, natural resource managers (generally part of the local host group) and acoustic ecologists. We also anticipate that members would travel to not more than three of these listening workshops (except PI Pijanowski who will attend all workshops). Workshops will be composed of a variety of outdoor, indoor and social events (Figure 5). These sites have been selected where long-term recording is being conducted by a Founding Member of the network:

Kenai Wildlife Refuge. (Morton lead). Ongoing soundscape studies in Kenai Wildlife Refuge will serve as the focal point for the listening workshop in the high latitudes. Kenai Wildlife Refuge is located on the Alaskan Kenai Peninsula in a heavily glaciated area 3,000 to 6,000 feet above sea level. The Kenai Lowlands contain thousands of lakes and a boreal forest covering rolling hills, ridges and muskeg. A variety of ecosystems exist here, including maritime-fjord, arctic rainforests, peat bogs, black spruce forests, and large glaciers. SP Morton, a researcher at the United States Park Service, is currently conducting long-term monitoring in the valleys. Research on what acoustically constitutes Quiet and Solitude Soundscapes is ongoing. Levels of biophony, geophony and anthrophony are being monitored with attempts to determine thresholds that classify these soundscapes as Quiet and Solitude have been recently started. Threats to these soundscapes include recreational vehicles (especially snow machines), highway traffic, and overflights. Over 1.2 million people visit the refuge each year. Listening exercises will focus on trips to various ecosystems and to places of different levels of human disturbance. The workshop will also focus on learning about the (1) ecology of the region; (2) various threats to this ecosystem; (3) review of management options being considered to protect the refuge's soundscapes.

Midwest Temperate Ecosystems. (Pijanowski lead). Midwestern landscapes are undergoing several major transformations (Pijanowski et al. in press, Pijanowski in review) of the landscape that are affecting soundscapes. These include forest fragmentation occurring as a result of increased pressures on the land for agricultural use, urbanization from manufacturing, service and residential use, and land-based renewable energy uses, especially wind farms and ethanol plants. Midwestern cities are trying to reinvent themselves as centers of recreation, finance, health industries. Chicago has been particularly successful at diversifying its economic base. Indeed, the city and its surrounding is undergoing major restoration efforts along large corridors; this work is being coordinated by Chicago Wilderness (Pijanowski is a member and belongs to the Science and Nature Committee), a non-profit organization that attempts to bring local government and environmental groups together for a common goal – improving the ecosystem services within urban areas. The Midwest Temperate Forest Listening Workshop will involve visits to Pijanowski Tippecanoe Soundscape Study Sites (old growth forests, secondary forest sites, agricultural sites, a wetland and two urban sites) to learn about sounds from these Midwestern landscapes. One day will involve travel to Chicago (2 hours away) where the workshop participants will listen to several areas where restoration (prairies, woodlands, and wetlands) are underway. Participants will also visit downtown parks and other urban centers to learn about sounds from large cities.

Sonoran Desert Region. (Cummings lead). The Sonoran Desert Region contains ecosystems with some of the greatest vegetation diversity of any desert in the world. The Sonoran Desert Region encompasses a large region, from southern California through northern New Mexico south to the Baja Peninsula of Mexico. Major threats to these ecosystems and soundscapes include expanding traffic on rural roads, rural residential development, overgrazing and climate change. The site of the indoor workshop will be either at the Acoustic Ecology Institute in Sante Fe, the campus of the University of New Mexico in Albuquerque or New Mexico State University's LTER Jornada Experimental Range site in Las Cruces. Several listening exercises will occur in desert, shrub and tropical deciduous forest ecosystems within a 2 hour drive. Candidate locations include: the Cibola National Forest, Chihuahuan Desert Rangeland Research Center, or the LTER Jornada research station. SP Cummings is currently examining the impacts of noise from wind turbines on soundscape composition and a visit to his field research areas will be made. Krause has released a CD entirely devoted to sounds of the desert.

Borneo Equatorial Rainforest. (Monacchi lead). Two of our members (Monacchi and Krause) have made numerous recordings of the Borneo Rainforests. Only a few native equatorial rainforests exist, most are located along the north and eastern portions of the island of Borneo. These forest remnants are being destroyed at an unprecedented pace and our network will attempt to visit, record and characterize these soundscapes before they are lost forever. A couple of candidate workshop locations exist – we are currently planning to hold the listening workshop at the Tabin Wildlife Reserve, located on the far eastern edge of the island. The Reserve contains places where workshop participants can stay, meet and disperse to locations to listen individually and as a group.

Mediterranean Landscapes in Tuscany. (Farina lead). SP Farina has conducted soundscape studies in a coastal to montane ecosystem gradient in the Tuscany region of Italy. Farina and his students have erected a unique microphone cabling system in a montane mixed forest that records sounds across a 0.5km by 100m landscape continuously. Habitat areas are mapped and soundscape metrics are integrated with these vegetation maps. The study also considers metropolitan areas and green areas near medium and large cities. Several invasive bird species have moved into these landscapes in recent years, representing a significant phonic invasion disrupting communication of endemic bird species (Pijanowski et al., in press). Heavy recreational use along the coasts, brought about by over 220 million visitors to this region each year, is also elevating noise levels throughout the region. Less than 10% of the native vegetation remains today. More remote regions are being threatened by human-caused forest fires, clearing for agriculture, logging and overgrazing. Desertification of the region is also occurring as a result of climate change. Coastal soundscapes are no longer dominated by biophony and geophony.

The listening workshops will have the following structure:

Field Recordings. Field recordings will be made at each site by Pijanowski approximately 5 days prior to each Listening Workshop. A set of 3-5 automated Wildlife Acoustic sensors and data loggers will be placed in different microhabitats or in areas that have some human disturbance. Krause, a professional natural recording engineer, will work with Pijanowski using high-end recording gear to record various aspects of the soundscape (e.g., dawn chorus, dusk chorus, near field and far field recordings) that can be used for further scientific research and for use by the acoustic ecologist for their GSSN commissioned piece. These recordings will also be placed on our network portal for anyone to listen to, download and view soundscape metrics associated with each recording. We intend have the automated recorders deployed for about 10 days.

Hazards Training. Because several of these sites present obvious hazards that will be addressed at the beginning of each workshop prior to listening exercises, we will incorporate hazards training into the workshops. The PI will work with local groups to prepare an Emergency Guide for each site. Hazards include encounters with dangerous animals (large carnivores, venomous animals), getting lost, vehicle breakdown, etc.

Outdoor Listening Exercises. Listening teams will visit several sites in each ecosystem, those that are relatively undisturbed and some that are disturbed, during dawn, dusk chorus and at night. We will experiment with different ways we can listen as a group and individually. Acoustic ecologists have experimented with several listening exercises and we intend to try these over the course of our project. One technique employed by acoustic ecologists is the head-together-as-a-star exercise where 4-8 people lay on their backs with their heads oriented toward the center; bodies are organized like a star. This allows people to listen but whisper comments so that everyone can hear. We will also try the listen-then-comment approach where members gather in a group and listen for long periods of time without speaking, moving and writing. Participants will be asked to listen for one hour as a group without speaking or writing. Participants will also be asked to listen in solitude. The group would travel to a location and then scatter a short distance and listen in solitude. After these intense listening periods, participants will then gather back at a central point and discuss what they hear. Time will be given to take notes. Following the note taking, participants will listen again, integrating ideas and observations from other listeners. A third technique, soundwalks, will also be explored. These entail walking slowing, stopping to listen and observe. Soundwalks are useful when microhabitat structure has a great influence on local soundscape composition (e.g., low, closed canopies tend to dampen sounds). Experiences from these listening exercises will then be discussed during the conclave. How

each discipline hears the soundscape will also be documented. Descriptions of these techniques will be developed and placed on our web portal.

Technical Training. A morning will be devoted to a hands-on exercise where one of the participants, most likely a member of the host team who is conducting long-term monitoring, will use data and tools to demonstrate how they analyze soundscape data. The workshop would ideally be conducted in a room full of computers.

Jam Sessions. At least one evening during the workshop will involve a social gathering where ecologists that play musical instruments will gather with acoustic ecologists for an open “jam session”. These jam sessions are designed to create a sense of community. Open “jam sessions” are common at the Ecological Society of America meetings, Resilience Alliance Conferences (e.g., Stockholm in 2008, Tempe in 2010), etc. and have been ways in which scientists share their creative talents with each other.

Lectures and Discussions. The workshops will also be composed of indoor lectures and discussions framed around the four GSSN Themes (Table 1). Each Soundscape Fellow will be assigned a Theme which they will be responsible for gathering information on during that Theme’s discussion. Another Soundscape Fellow will be asked to facilitate (with assistance from the PI) discussions. Mini-lectures by ecologists, acoustic ecologists, and psychologists will be given that help frame the ecological understanding of ecosystem dynamics, the composition of sounds in these ecosystems and how humans perceive these sounds. The PI will work with the four Soundscape Fellows to gather the notes from the workshop, synthesize the ideas which will then be posted these on the Theme Team web pages of the Network Portal.

*2. Conservation Workshops.* Two workshops will be held in the final two years of the project. A domestic workshop will be held at the Aldo Leopold Wilderness Research Institute in Missoula Montana. An international workshop will be held at the La Selva Biological Research Station in Costa Rica where Pijanowski is assisting the Conservation International TEAM project in the use of acoustics for rapid assessment of species loss in tropical habitats. The domestic workshop will involve (1) a guest keynote lecture by a person familiar (e.g., Dr. Nick Miller of HMMI) with high-level conflicts between a variety of stakeholders (FAA, recreationists, conservation groups) occurring at National Parks; (2) presentations by natural resource agency staff on specific challenges of managing soundscapes in protected areas; (3) group discussions on soundscape sustainability issues. International workshop will focus on challenges presented in managing international locations. Faculty and students from Universidad Nacional will attend and make presentations on their work in conservation. Local conservation groups will also be invited to attend and participate in discussions. Both workshops will attempt to address how traditional conservation planning approaches (e.g., Noss and Cooperrider 1994; Soulé and Sanjayan 1998; van Jaarsveld et al. 1998; Margules and Pressey 2000; Groves et al. 2002; Groom et al. 2006; Brooks et al. 2006; Lindenmayer and Hunter 2010) can be applied to the conservation of soundscapes. Sustainability and conservation of soundscapes from different perspectives will be presented and discussed at each workshop. The PI and other participants will write these outcomes and will submit this to PNAS Sustainability Science as a special issue with a collection of papers that describes sustainability of soundscapes from different perspectives. An overview paper will lay out a research agenda as well.

## **B. INFRASTRUCTURE PROJECTS**

*1. Soundscape Web Portal.* We will develop a comprehensive web site, which we call the Soundscape Web Portal, that will contain information about network partners (e.g., WFAE, Ecological Society of America) and a calendar of activities/events, information related to joining the network and subscribing to the soundscape listserv, Theme Team project pages, soundscape data collected by researchers that belong to the network, tools created by ecologists and others to analyze soundscape data, links to recordings of soundscapes by acoustic ecologists, links to webinars and PowerPoint slides and network Sponsored Projects. A listserv will be established that helps to announce special events (e.g., World Listening Day) and conferences, papers that are produced by members of the network. Membership will be solicited from large listserves (e.g., eco-log which has over 10,000 members) and the WFAE (which has over 2,000 members). The portal will be hosted at Purdue using a 100+ TB data server located in a state of the art data center. Researchers (Steering and Contributing Members) would be allowed to upload

their data to the soundscape database. A Purdue technician (at approximately ¼ FTE) will be supported to manage the portal.

Tool Sharing. Several soundscape analysis and data management tools are being developed by many PIs and SP of this project and these will form the initial set of tools and databases. Tools include Seewave-soundscapes, a spectrogram analysis tool written in R modified from Seewave (Saeuer et al. 2008). A new GIS based tool that imports \*.wav files to a raster database for use in ArcGIS is being made available February of 2011. These python scripts allow researchers to process hundreds to thousands of sound files using spatial analysis tools; signals within the soundfile are extracted and polygons created. The size and shape of the polygon is then used in an analysis of total signal composition. Finally Pumillo is a php and mysql tool that allows researchers to store and retrieve sound files from a large archive. A major feature is that the interface is all web-based ([www.purdue.edu/soundscapes](http://www.purdue.edu/soundscapes)). We will also encourage members that develop shareware to post this on the network portal.

Theme Team Pages. The web site will also contain links to Theme Team results that are generated from the workshops. Theme Teams will also be supported by separate listserves so that exchanges between members interesting in these themes can communicate frequently.

Social Networking. We will encourage the use of LinkedIn to link all of the members professionally. We will also create a Jumo site devoted to the protection of natural soundscapes. Jumo is a social networking site, developed by the creator of Facebook, to “connect individuals and organizations working to the change the world”. The Jumo site will also be used to connect the Soundscape Preservation project to related projects, such as those related to protecting biodiversity and those promoting the arts.

*2. Annual Web Conferences.* We will host annual Adobe Connect web conferences for all Founding and Contributing Members. The first web conference will serve as the project “kickoff” meeting aimed to acquaint everyone with the project’s members, objectives and activities. These meetings will be held annually with each year focusing on (1) Listening Workshop coordination and (2) Theme Team coordination.

*3. Center for Sustainable Soundscapes @ Purdue.* Sometime in year 1 or 2, we will launch a Center for Sustainable Soundscapes (CSS) that will be located in the PIs lab. We will use this center to help provide the network with long term permanence so that the work produced by participants can have a “home” after the funding is over.

*4. Long-term Monitoring Support.* At least 5 long-term monitoring sites will be coordinated by the network. Although funding for this work will come from sources other than this NSF grant, GSSN will offer to host a copy of the long-term data at Purdue’s CSS. Long-term monitoring at the Kenai Refuge in Alaska by the Fish and Wildlife Service is ongoing, as well as the Tippecanoe Soundscape Study (temperate forest). Funds will be used to purchase 7-10 acoustic monitoring stations for use by faculty and students at Alabama A&M University in Huntsville and another 7-10 will be provided to the Tuskegee University team. Data from Conservation International TEAM projects acoustic monitoring project at La Selva will be available to all members of the network as well.

## **C. COLLABORATIVE SUPPORT PROGRAMS**

*1. Soundscape Fellows.* PhD students from universities of Founding and Contributing Members will be eligible to become Soundscape Fellows. Soundscape Fellows will participate in the Listening and Conservation Workshops. They will either be assigned to be facilitators and/or session rapporteurs – providing these fellows with opportunities for leadership. Funding for their personal research will be the responsibility of network members. Fellows will also be paired with another senior (faculty) member of the network that is outside their discipline of study. Where possible, Soundscape Fellows will be established as pairs (e.g., ecologists paired with cognitive acoustic psychologists).

*2. Undergraduate Research Scholars.* Five grants will be disseminated to members who can mentor an undergraduate student researcher in ecology, acoustic ecology or psychoacoustics. Grants for up to \$3500 may be used to cover hourly work, equipment or travel. Proposals will be due in Spring of each year. It is anticipated that work would occur over a summer.

3. *Cross-fertilization Symposia.* We propose to sponsor 3-6 symposia at professional conferences. Pijanowski has lead two symposia at the US International Association of Landscape Ecology meetings (in 2009 and 2010); at least one more will be held in the future. We also plan to host a symposium at future Ecological Society of America meetings, Society of Conservation Biology meetings and at least two future World Forum for Acoustic Ecology meetings. The network will pay for Fellows to attend. Fellows will be required to organize and lead the session. Funds for members to travel are expected to come from other sources of funding. Social events at these conferences will also be sponsored by GSSN, where appropriate. For example, ESA often has evening “mixers” where small groups get together and socialize. We would hold one for those interested in soundscape ecology. We also plan to coordinate our efforts with the CHANS network which host social events at US IALE and AAG every year. Information about these symposia will be announced through appropriate society venues (e.g., ECO-LOG).

4. *Promotion of World Listening Day.* The originator and sponsor of this global event (member Leonardson, who oversees this as the World Listening Project) will coordinate these efforts with the GSSN. World Listening Day is held annually on the birthday (July 18<sup>th</sup>) of Canadian composer F. Murray Schafer, the originator of the term “soundscape”. The purpose of World Listening Day is to (1) celebrate the practice of listening to the environment around us; (2) raise awareness about the importance of sounds that occur in nature and (3) increase the knowledge of natural sounds in practice (e.g., planning, design) and in learning about the environment. PI Pijanowski will work with Leonardson every year to prepare press releases about this global event. Announcements of the event will be made through the GSSN listserve, our Jumo social networking site, and the WLP listserve.

5. *“Soundscapes of Ecosystems” Commission.* We will commission an acoustic ecologist to compose a composition using the field recordings gathering from the listening workshops. We will announce a competition for the work (1) at a WFAE conference, (2) in the World Soundscape Newsletter and (3) through the various listserves. Members of the Steering Committee will be selected to examine applications sent in year 3. A commission of \$5000 will be made (typical rates are \$500 per minute so this will lead to a 10 minute recording) to this individual at the start of year 4. In year 5, the work will be played at a plenary at the ESA meetings. This individual will be paid to attend this plenary, play the work, and discuss the inspirational and intellectual motivation behind the work. Commentaries by GSSN ecologists will also be made. If possible, the recording and notes by the artist and ecologists will be distributed to ESA participants on the conference disk stick that contains the conference schedule.

6. *Collaborative Scholastic Outcome.* By the end of the fifth year, we intend to submit either a paper on sustainability of soundscapes for submission to the *Proceeding of National Academy of Sciences Sustainability Series* or a proposal for a special issue, the latter would depend upon the level of success of various aspects of related work to our network (e.g., psycho-acoustic research on sense of place).

## V. PROJECT MANAGEMENT

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Management of the proposed network will be guided by several principles, be directed by a variety of committees, assessed using a variety of metrics, and have the following general schedule:

### A. Management Principles

Our guiding management principles will be:

Ensure openness. We believe a successful network will be one where participants benefit greatly where the decision making process is transparent. Members of committees will always be known, outcomes shared and the decision making process clearly articulated to all members.

Operate an easy- access network. Not only will tools, data, and information about the network be posted on the network portal, but management structure, responsibilities, contact information and network project reporting will be available online.

Make decisions by committee. A Steering Committee formed from Founding Members will make key decisions about the use of funds and selection of individuals to participate in a variety of workshops and other activities.

Diversity increases creativity and broadens impact. Our initial network is composed of a diverse set of individuals and organizations. We will strive to promote the inclusiveness and diversity of the network as its main strength and will seek to expand its diversity in the future by reaching out to groups that could benefit from its products and activities. Two HBCU institutions are Founding Members which demonstrates our commitment to reach out and include underrepresented groups.

Adaptive management ensures resilient network. We will examine several key metrics and use these to judge success of the network. Adjustments will be made if our metrics show that we are not accomplishing our goals.

Ultimate responsibility for network success rests with the PI. A majority of the work will be carried out by PI Pijanowski who is devoted to making this network a success. He will ensure that Listening Workshops have the greatest impact possible, that Soundscape Fellows grow intellectually in their capacity, that reporting is done thoroughly, with broad input and on-time, lead and facilitate useful discussions amongst members at workshops, through listserves, and at professional conferences.

## **B. Leadership Responsibilities**

PI Pijanowski will oversee the entire project on a day to day basis. His email address will be prominently posted on the main web page. He will join all listserves, listen and participate actively. He will be responsible for organizing all workshops, ensuring that the EC and SC runs smoothly. He will oversee the technician who will develop the portal. Annual web conferences will be lead and organized by him as well. The PI will communicate with Theme Team leaders about progress on these coordinating activities and will work to adjust the project based on feedback from the SC. The PI will interact frequently with the other EC members. Monthly conference calls will be made to ensure that the network is functioning well. The PI will help lead discussions at workshops, be available to Fellows for questions and potentially mentoring. The PI will also track SC duties, as these are numerous over the course of the project (e.g., selection committees). The PI will also help move the conference symposia along, encouraging members of the network to step up and provide leadership in organizing the symposia. The PI will also attempt to make sure all management practices are followed, that the network maintain inclusiveness and fairness. The PI will also lead in the expansion efforts of the network, reaching out to likeminded individuals and groups to ensure that the network has high impact. The PI will also lead annual project reporting to NSF. The PI will also seek counsel from the External AC when more independent input is needed.

As co-PI, Guastavino will co-organize the workshops with the PI and coordinate research activities with the European network of acousticians and psychoacousticians, specifically the EU-funded "COST Action" on soundscapes involving 32 experts in soundscape research. Her efforts to broaden the network will enable North-American researchers to collaborate with the best European group working on soundscape and to gain increased international recognition. She will attend a majority of the workshops and be responsible for ensuring ecologists understand the cognitive psychological aspects of listening and sound identification.

## **C. Committees**

Committees and their responsibilities are:

Executive Committee. The Executive Committee (EC) will be responsible for ensuring that the network has the greatest impact as possible on facilitating research in sustainable soundscapes. The initial EC will be composed of the PI (Pijanowski), co-PI (Guastavino) and SP (Cummings). These three have broad expertise, collectively span nearly all areas of interest of the network (ecology, social science, and arts) and have collaborated with all of the initial members (Table 1). The EC will also review applications for Contributing Members. The PI will chair this committee.

Steering Committee. Four members from the Founding Members and, in the future, individuals that are Contributing Members, will serve on the Steering Committee for two year terms. Note that all Founding Member letters of participation state their willingness to serve on the SC. The SC will perform the following: (1) select individuals to participate in Listening Workshops; (2) select Soundscape Fellows (in the first year, Soundscape Fellows will serve for 4 years); (3) select individuals to participate in the Conservation Workshops; (4) select the five undergraduate grants and (5) serve as Theme Team leaders. The first five SC members will be Gage (standards), Carroll

(sustainability), Leonardson (engagement), and Tadesse (interdisciplinary building). After the end of the two year term, nominations (self nominations allowed) will be made by all Executive, Founding and Contributing Members for new SC members. The EC will select the next five members from this list of candidates

Advisory Committee. The External Advisory Committee (AC) will be composed of two members: Hildegard Westerkamp and F.S. “Terry” Chapin. Both are world renown in acoustic ecology and global change ecology, respectively. The functions of the AC are to (1) help the EC increase the visibility of the network by leveraging the deep professional experiences/networks both of these individuals possess that can be used to increase awareness of the network; and (2) seek advice from these senior scholars about general directions of the network if the EC is presented with difficult/challenging issues to address.

**D. Project Assessment**

Assessment of the GSSN will entail (1) tracking the number of members and organizations represented that join the network in various capacities; (2) the number of tools posted to the network portal; (3) the number of hits at the main portal web page; (3) the number of attendees at workshops; (4) the number of TBs of acoustic data stored and provided through the portal; (5) the number of presentations made by network members at professional meetings; (6) the number of emails sent over the listserves. Other project metrics will be developed and tracked over the five year funding period. Surveys of workshop participants will be made, assessing the effectiveness of the workshop components and soliciting comments for improvement. These surveys will be used to help reshape future workshops.

**E. Expanding the Network**

All members of the network will help to promote it through their own professional network. The PI will work with the other two EC members to post notices on a variety of large professional listserves (e.g., wfae listserve, eco-log). Our efforts to expand the network will also be strategic and we will seek “low hanging fruit” partnerships. More psychoacousticians will be sought out, especially those interested in natural sounds. Connections to the European Union noise and soundscape initiatives will be explored by co-PI Guastavino. Other key areas to expand would include seeking participation from bioacousticians (e.g., Cornell Laboratory for Ornithology), researchers in other ecological networks (e.g., Phenology Network, NEON) and marine soundscapes research communities. We also intend to reach out to the National Park Service Natural Sounds Program in Ft. Collins. Their participation as a Founding Member was problematic as more long-term planning was required to include them in this proposal.

**F. Schedule**

Activity	Year 1	Year 2	Year 3	Year 4	Year 5
<b>Network Portal</b>	Create	Expand and Maintain	Expand and Maintain	Expand and Maintain	Expand and Maintain
<b>Listening Workshops</b>		Temperate Forest Mediterranean	Kenai Refuge Sonoran Desert Borneo Forests		
<b>Conservation Workshops</b>				Domestic	International
<b>Symposia</b>	US IALE	WFAE	ESA	WFAE	ESA
<b>Commission</b>			Announce	Select	Present
<b>Undergrad.Scholars</b>		Two grant	Two grants	One grant	

**VI. RESULTS FROM PRIOR NSF SUPPORT**

Pijanowski has been PI and co-PI on five NSF awards (BE/CNH #0308420, 2003-2009) Climate-Land Interaction Project (CLIP) resulted in over 30 peer-reviewed journal articles spanning areas such as

climate, land use, food security, remote sensing, coupled modeling. Pijanowski was co-author on at least 7 of these papers, a majority of which included his students as authors. Papers appeared in *International Journal of Climatology*, *Geoforum*, *Environment and Planning B*, *Agricultural Systems*, and *Earth Interactions*. Adaptation workshops were held in 2007 in Kenya, Tanzania and Uganda where co-PIs presented their work to high level natural resource managers in national and international organizations. Local feedback workshops were also held where the team (Pijanowski participated) presented results of work to farmers and village chiefs and elders of local scale analysis. Pijanowski's lab led one of the largest team papers (Washington-Ottombre et al., 2010) of the project that included five African scientists. An NSF Water Cycle Research (WCR #0233648, 2002-2008) led to 8 papers in peer-reviewed journals including *Environmental Management (2)*, *Hydrobiologia*, *Landscape and Urban Planning (2)*, *Journal of Land Use Science (2)*, *Ecology and Society*. Work was featured at the American Museum of Natural History. A current NSF project (III-CXT #0705836, 2007-2011) focuses on using remote sensing and land use models to address environmental problems in novel ways. Journal articles from Pijanowski's lab from this project have appeared in *Landscape and Urban Planning*, *International Journal of Environmental Research*, *Land Use Policy*, *BioScience* and *Landscape Ecology*. The Land Use Policy paper was showcased by the Christian Science Monitor, US Today and Texas Public Radio. Data from all projects are used in Pijanowski's Spatial Ecology and GIS course at Purdue. The model developed from the Water Cycle Research project is provided free to researchers along with all of the data used to build and validate the model. An online GIS interface to the model output has also been developed, some of which has been incorporated into a Local Decision Maker tool used by planners across the state of Indiana. An ULTRA-Ex award was just funded (#0948958). A DDRI grant to a PhD student was used to support this student's work in the Mt. Kenya area. She successfully defended her PhD in summer of 2010 and is currently an Assistant Professor at Oberlin College.

## **VII. DIVERSITY**

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We have recruited faculty from two of the top HBCUs into our network. Pijanowski has worked with faculty (SP Tadesse among others) at Alabama A&M University (AAMU) for the last 7 years developing proposals and coordinating field research. PI Pijanowski is currently serving on the graduate committees of two PhD students at AAMU. PI Pijanowski is a colleague of the new President of Tuskegee University (Dr. Gilbert Rochon, see letter of support attached) who was the Vice President of Research Engagement at Purdue. Dr. Rochon is a remote sensing expert. When Dr. Rochon left, he encouraged PI Pijanowski to develop collaboration with faculty in the College of Agriculture and the Environment. Funds from the network will be provided to jump-start novel soundscape research at these two universities. Several acoustic sensors will be placed in the NSF funded CREST research site in northern Alabama owned by AAMU. Research on forest management practices and impacts to wildlife and water quality have been ongoing for over 3 decades. Several additional acoustic sensors will be provided to Tuskegee University faculty interested in ecosystem dynamics. Data will be used in teaching and research. Tuskegee currently produces more graduates of agricultural and natural resources than any other HBCU in the country. The GSSN will also attempt to recruit students into new research projects through the Ecological Society of American's SEEDS Program, and through SACNAS (PI Pijanowski is a member; Purdue was selected as Best Chapter in 2009). Including students from the Universidad Nacionale in San Jose Costa Rica will also broaden participation as many graduate students from Mesoamerica (including Puerto Rica). Students from Tuskegee and AAMU will be recruited to fill the Soundscape Fellows positions.

## **VIII. BROADER IMPACTS**

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This network will help move a very young field forward, coalesce several research activities occurring in disciplinary isolation and potentially lead to new ideas that could help protect natural soundscapes. Founding members of our network will include faculty and students from two HBCUs. Four Soundscape Fellows will be exposed to novel collaboration techniques and get to work across large disciplinary divides. Four undergraduate scholars will conduct research with network faculty. We will also support high impact and novel outreach activities through the World Listening Day Project. Finally, data generated from ecological recordings will be used in a composition by an acoustic ecologist that will acoustically "define" the ecosystems that will be visited during the listening workshops. Our Jumo site could spur many efforts by the public to help preserve our natural and cultural soundscapes and raise awareness of this global problem.

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