The University of Adelaide
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Ecotonality, or Adapting Soundscape Ecology to Creative Practice:

Ecological Sound Art Responses to Four South Australian Ecosystems

An exegesis submitted in partial fulfilment of the requirements for the Doctorate of Philosophy

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Abstract

Ecotonality, or Adapting Soundscape Ecology to Creative Practice: Ecological Sound Art Responses to Four South Australian Ecosystems presents a practice-led research project, introducing Ecotonality, a creative framework which connects and adapts the principles, frameworks and methods of the ecological discipline, 'soundscape ecology' to ecological sound art practice. It consists of a portfolio of creative works and 30,000-word exegesis.

Drawing on the growth of research in soundscape ecology (and by extension ecoacoustics, bioacoustics and acoustic ecology), in the past decade, the Ecotonal Creative Framework considers the adaptation of soundscape ecology research, fieldwork and analysis as it relates to creative concerns of project conception, data collation, creative material preparation, compositional assemblage, artistic realisation and post-project reflection. Additionally, the framework appraises roles of human and non-human agency (via Karen Barad and Timothy Morton), and the inherent role and implications of technological mediation, as related to soundscape ecology and creative practice. Ecotonality allows a reconsideration of the macro- and micromorphological relationships of ecosystems in creative works, which engages the ethical concerns of site-specific practice and impact of creative work on ecosystems and soundscapes.

Four creative site-specific responses are subsequently discussed, each in response a different South Australian site - Mobilong Swamp (swamp ecosystem), Long Island (riparian ecosystem), Featherstone Place (urban ecosystem) and Farina (desert ecosystem) - and each employing multichannel surround sound setups and acoustic instrumentation. These creative project act as case studies of the implementation of the Ecotonal Creative Framework, creatively expressing ideas related to place, ecosystem, soundscape and identity. Through the recording, manipulation and utilisation of extant material circumstances of particular places, (i.e. their contemporary soundscape and ecosystem), the resultant creative responses provide commentary on ecological, sociocultural, political and spiritual circumstances, histories and identities.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

I give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

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Signed _____

Date _____

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May all beings have happiness and the causes of happiness.
May all beings be free from suffering and the causes of suffering.
May all beings be inseparable from the happiness that is free from suffering.
May all beings abide in equanimity, free from attachment for friends and hatred for enemies.

List of Publications

This research project has spawned a number of conference papers and articles, presented here chronologically as citations:

Budel, J. (2016). Creative Responses To Soundscape Ecology: Innovative Frameworks and Case Study. Presented at Sonic Environments 2016, Brisbane.

Budel, J. (2016). An Overview of Australian Ecoacoustic Composition: Exploring The Country's Environmental Music and Sound Art in the 20th and 21st Centuries. Presented at Musicological Society of Australia National Conference 2016. Adelaide.

Budel, J. (2018). Steve Reich's 'Music For 18 Musicians' as a Soundscape Composition. Directions of New Music (2).

Budel, J. (2018). Sonic Ruptures In Featherstone Place: Ecological Sound Art Response to Urban Environments. Presented at the International Ecoacoustic Congress 2018, Brisbane.

Budel, J. (2018). Southern Soundscapes: Ecological Sound Art Responses to Two South Australian Ecosystems. eContact!: Online Journal for Electroacoustic Practices. 20 (2).

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1 - Introduction

> *…out in this far country of dreams he imagines there is music —music that can only be heard here, music that belongs to this land like the plants and the birds, music that resonates with all this space and silence, cold and stone, wind and fire and ice.*
>
> *He resolves to follow this music wherever it may lead him.*

from 'On The Glacier', *The Singing of Thrushes*, John Luther Adams (2018)

1.1 - Background

Born and raised in the regional towns of Bordertown and Murray Bridge, respectively, I have long had an affinity with the dynamic environments of my home state of South Australia. In my early years, with family spread around the state's South East and Mid North, I was frequently moving between and attuning to the state's diverse ecosystems, whether it be the riverina of the Murraylands and Riverlands, sea-faring Limestone Coast and Fleurieu Peninsula, boreal Adelaide hills, urbanised Adelaide plains, or the arid Far North.

With a youth involved in the outdoors through Scouting and family road trips, I developed a close sense of identity with the (South) Australian landscape. Through the exploration of various musical paradigms, including Spectralism, American experimentalism, and the Acoustic Ecology movement, environmental phenomena became of increasing interest in my creative practice. My engagement with Tibetan Buddhism led to the contemplation of the Madyamaka Prasangika (Middle Way Consequence) school of Mahayana Buddhism, a paradigm that understands phenomena to be fundamentally interdependent and relational, arising dependently upon causes and conditions. Such a perspective has apparent affinities with an ecological mindset in which ecosystems are understood as integrated and interconnected systems.

The confluence of these streams led me to consider questions around creative modes of engagement with place, ecosystem and soundscape. At the time of devising this research

project, a new ecology-based discipline, Soundscape Ecology, came to my attention, presenting a cohesive model for background research, fieldwork, data analysis and research outcomes. The discipline had a clear capacity for adaptation to site-specific creative endeavours, and as a result, the discipline became the focal interest of this research project.

Some preliminary observations are necessary. Throughout the exegesis, I have capitalised Acoustic Ecology, Soundscape Ecology and Ecoacoustics to denote the disciplines distinct from one another, so as to avoid confusion with alternate applications not so widely embraced (i.e. the use of soundscape ecology and ecoacoustics) as a synonym for Acoustic Ecology.

Additionally, the concept of identity is referred to throughout, as related to place, with associated ecosystems and soundscapes. Whilst the concept can mean many things (i.e. national, ethics, gender, religious, etc.) and can be the subject of philosophical discourse, my application of the idea the exegesis assumes identity of place to be conventionally (socially and culturally) constructed, differentiated from that other places through the discernment of dissimilarity with other phenomena.

1.2 - Aims, Research Questions and Methodology

With interest in combining Soundscape Ecology within site-specific creative practice, several key project aims emerged.

As an initial goal, identifying the principles, framework and methods of Soundscape Ecology would be paramount, providing the foundational concepts with which to work. These concepts would need then be adapted to creative process, interdisciplinarily connecting scientific and artistic modes of engagement with place, and thereby developing a new creative framework.

As a point of testing and refining this framework, several site-specific creative projects would be undertaken, to develop compelling creative responses to place, and associated ecosystems, soundscape and identity. Such a framework would cover the multiple stages

of the creative process, from initial conception and field work to compositional development and realisation.

While predominantly interested in demonstrating the functionality of the creative framework, the site-specific works also aim to raise awareness of themes of South Australian place, soundscape, ecosystems and identity. As such, the works would represent new sound-based perspectives on the state's history, environments, ecosystem, culture and spirituality.

From these aims, the following research questions emerge:

1. What are the principles, frameworks and methodologies of Soundscape Ecology, and how might they be adapted to creative practice?

2. How can a creative practitioner effectively represent, respond to and reflect upon specific places, and associated ecosystems, soundscapes and identities?

3. What South Australian sites might be suitable to creatively convey the state's diverse places, ecosystems, soundscapes and identities?

Methodologically, this research project follows a practice-led research approach, informed by reflective creative practice. It is concentrated predominantly on the development of a creative framework and complemented by the development of a portfolio of work implementing this framework.

A preliminary literature review investigates Soundscape Ecology research and practice, existing Acoustic Ecology literature, and a variety of creative practices espoused by international and Australian composers and sound artists working with environmental themes. Subsequent autoethnographic identification of the stages extrapolated from my creative process to date provides a skeletal framework onto which Soundscape Ecology principles, frameworks and methods could be mapped, resulting in a creative framework appropriate for site-specific implementation. This creative framework, 'Ecotonality' was

then ‘acid-tested’ through its implementation in the development of four contrasting, site-specific works responding to South Australian locations of diverse ecosystem types.

Resulting from these works are reflective insights that have informed the progressive refinement of the Ecotonal creative framework, as well as new understandings and perspectives of place, ecosystem, soundscape and identity at each site.

1.3 - Exegesis Overview

The Exegesis can be broken down into two distinct parts.

The first part, comprised of Chapters 1 through 3, outlines the theoretical foundations of the project. Chapter 1, *Introduction*, outlines the project background, aims, research questions, methodology, and exegesis overview. A literature review follows in the next couple of chapters. Chapter 2, *Soundscape Ecology*, reviews the discipline's historical background, conceptual frameworks, methodologies and research outcomes, as well as offering critiques from within the discipline, from Acoustic Ecology, and via Karen Barad's agential realism. Chapter 3, *Creative Approaches to Soundscape*, reviews historical activities in this area, discussing soundscape composition, ecological sound art and Timothy Morton's philosophy of Dark Ecology. Additionally, a variety of international, Australian and South Australian ecological sound artists are profiled to contextualise this research project.

The second part, comprising Chapters 4-6, focuses on the creative process and outcomes resulting from the practice-led research. Chapter 4, *Ecotonality*, presents the Ecotonal Creative Framework, which adapts Soundscape Ecology research and practice to creative process through identifying methodological similarities and mapping these to a six-stage process of Conception, Collation, Preparation, Composition, Realisation and Reflection. Chapter 5, *Portfolio*, presents four site-specific works for acoustic instrumentation and electroacoustic media, each work related to a different South Australian ecosystem, and presented through collaboration with various performance bodies. *Mobilong*, for string ensemble and octophonic array, replicates a real-time sound walk experience at Mobilong, Murray Bridge, drawing attention to the site-specific conditions resulting from irrigation practices and the impact of drought. *Long Island*, for piano (four-hands), strings and stereophonic, presents contrasting terrestrial and aquatic soundscapes at the eponymous island bisecting the Murray River at Murray Bridge and considers the impact of anthropogenic motorboat activity in these waterways. *Featherstone Place*, a 24/7 quadraphonic urban sound installation, responds to the diurnal changes of the Adelaide CBD soundscape and ecosystem, with emergent activity driven by live environmental data

sources. Its complementary fixed duration work, *A Day In An Alleyway*, for string quartet and electroacoustic track, encapsulates this diurnal cycle in a concert setting. *Farina*, for community percussion orchestra and octophonic array, considers the developments in soundscape activity throughout the ghost town's 140-year European history, considering changes in fauna, weather and technology. The conclusory Chapter 6 considers the milieu in which the research project has developed, its contribution to the discipline through responses to each research questions above, and future directions of investigation as related to collaborative endeavours and technological developments.

Volume 2, *Creative Materials*, is presented on DVD and draws together the various artefacts resulting from the creative projects on a work-by-work basis. As most works employ both emergent behaviours (i.e. each realisation is a unique iteration) and spatialised sound, it is necessary to understand these artefacts as partial and perspectival representations of the creative work, conveying particular information of the work's underlying processes, behaviours and site-specific contexts. *Mobilong's* artefacts feature a modular performance score and iterative recordings in both binaural and ambisonic formats. *Long Island's* artefacts include modular performance scores and an iterative stereo recording of the work. *Featherstone Place's* artefacts comprise of representative 5-minute recordings taken at each hour of the day. Its complementary work, *A Day In An Alleyway*, features both a modular score for string quartet and performance recording. *Farina's* artefacts include text-based performance scores for community percussion orchestra and iterative recordings in both binaural and ambisonic formats.

2 - Soundscape Ecology

Ecoacoustics is like listening to the heart beat of nature.

Stuart Gage

Underpinning my practice-based research and the resultant 'Ecotonal' creative framework is the emerging discipline of Soundscape Ecology. This chapter will provide a contextual overview of Soundscape Ecology, discussing the background of soundscape terminology, the historical developments, intellectual frameworks and methodologies, outcomes of research, and critiques of the discipline.

2.1 - Terminology

First used by Southworth in an urban planning context (1969), and popularised by R Murray Schafer in his 1976 book, *The Tuning of the World* (later republished as *The Soundscape (1993))*, the term 'soundscape' has been employed in numerous contexts in the ensuing decades. The International Standards Organisation defines 'soundscape' as an "acoustic environment as perceived or experienced and/or understood by a person or people, in context", and that it is a perceptual construct, related to physical phenomena (ISO 2014). This standard bears resemblance to other definitions:

- "[A soundscape is] an environment of sound (or sonic environment) with emphasis on the way it is perceived and understood by the individual, or by a society. It thus depends on the relationship between the individual and any such environment" (Truax 1999).
- "Soundscapes are the totality of all sounds within a location with an emphasis in the relationship between [individuals'] or society's perception of, understanding of and interaction with the sonic environment" (Payne, Davies & Adams 2009, p. 2).

In its early years of use, the term 'soundscape' was employed in various contexts, particularly in connection to the World Soundscape Project (WSP) at Simon Fraser University, Vancouver. The term could refer to a real-life acoustic environment, or a

virtual acoustic environment, especially in artistic contexts. This latter understanding is seen in the categorical descriptor, 'soundscape composition', referring to creative works utilising soundscape phenomena and experience as particular foci, as heard in the works of WSP associates Barry Truax and Hildegard Westerkamp. Additionally, the term 'soundscape ecology' was used interchangeably with 'acoustic ecology', as per the definition found in the *Handbook for Acoustic Ecology* (Truax 1999)).

In the past decade, this term has come to refer to an emerging ecological discipline. At its core, Soundscape Ecology is the study of the relationship between landscape and soundscape, or topographic and acoustic patterns. It "[describes] complex phenomena at community, ecosystem and landscape scales within natural and human dominated systems" (Farina 2014b), with an initial working definition as follows:

> Soundscape ecology… can be described by our working definition as all sounds…emanating from a given landscape to create unique acoustical patterns across a variety of spatial and temporal scales… These include the assignment of a soundscape to a geographic context, the identification of anthropogenic and biological processes and spectral and temporal patterns in the soundscape, how disturbance alters patterns and processes across scales, the emphasis on interactions between biological and anthropogenic factors, how organisms perceive spatial configuration in landscapes, and the need to develop tools to quantify patterns (Pijanowski, Villanueva-Rivera, et al. 2011, 3).

Despite its application in various contexts, the term 'soundscape' has been the subject of critique. In *Against Soundscape*, Tim Ingold states "a landscape may be audible, but to be aural it would have to have been first rendered by a technique of sound art or recording such that it can be played back". Sound, for Ingold, is

> neither mental nor material, but a phenomenon of experience - that is, of our immersion in, and commingling with, the world in which we find ourselves. Such immersion… is an existential precondition for the isolation both of minds to perceive and of things in the world to be perceived… if this is so, then neither sound nor light, strictly speaking, can be an object of our perception. Sound is not what we hear, any more than light is what we see…. listening to our surroundings, we do not hear a soundscape. For sound, I would argue, is not the object but the medium of our perception (2007).

Whilst the "semantic paradox" of shaping and encapsulating the acoustic environment as 'sound + scape' is recognised in Soundscape Ecology, the term continues to be used, referring to "the distribution of sounds across a landscape when the landscape is considered a geographic entity" (Farina 2014a, p. 3).

2.2 - Historical Background

Scientific investigations of environmental sound have developed in tandem with technological advances. The invention of the phonograph by Edison and successive recording technologies facilitated the practice of field recording of environmental sound. Such practices were pioneered by the likes of Ludwig Koch, Karl Reich, Max Nicholson, Peter Paul Kellogg and Albert Brand in their early 20th-century recording of bird song toward ornithological ends (Parmar 2016). Research into attributes of acoustic environment (Aylor 1972; Embleton 1963; Eyring 1946; Ingard 1953; Johnson, Verest & Young 1947; all in Farina 2018) and relations between biological sounds and environment (Armstrong 1963; Chappuis 1971; Davis 1964; Morton, ES 1970; all in Farina 2018)) furthered this interest in the ecological sciences.

In aquatic acoustic research, early technological developments can be seen in the work of Ernest Rutherford, who helped to develop piezoelectric hydrophones for sonar detection of U-Boats during World Wars I and II. Later studies in oceanic ambient noise (Knudsen, Alford & Emling 1948; Wenz 1962) and marine bioacoustics (Tavolga 1964) further enriched the field, reaching a broader audience through marine biologist Rachel Carson's 'The Sea Around Us' (1951).

Carson's more widely recognised *Silent Spring* (1963) marked a radical shift in understandings on ecological science, drawing connections between anthropogenic activity and environmental degradation and encouraging a compelling notion that acoustic environments would become quieter without conservationist approaches to environmental regulation and management. Subsequently, research into the relationship between sound and environment has grown in various disciplinary settings. Canadian composer and educator, Raymond Murray Schafer, developed a conceptual framework for

'soundscape studies' in his early classroom workbooks (1986), the seminal Acoustic Ecology book 'The Tuning of the World' (1977) and collaborative activities on the World Soundscape Project at Simon Fraser University in the 1970s. This work provided the basis for what would later become the World Forum for Acoustic Ecology (WFAE), established at the 1993 inaugural WFAE conference in Banff, which continues to comprise of numerous international affiliate organisations and individuals conducting interdisciplinary research into acoustic environments.

In the environmental sciences, specific niche fields of research that form the disciplinary foundations of Soundscape Ecology began to flourish. 'Bioacoustics', the study of biologically-produced sound and communication, has been significantly influenced in recent decades through cheaper access to high-fidelity digital audio equipment, and the advancement of analytical software and data storage technology (Dooling & Dent 2018; Popper & Dooling 2002). Similarly, 'landscape' or 'spatial ecology', which investigates ecological processes and behaviours as related to various spatiotemporal scales in the landscape, underwent substantial conceptual and methodological changes through the introduction of civilian access to and related increasing in fidelity of geographic information systems (GIS) in the 1990s and 2000s (Farina 2006; Truax & Barrett 2011).

These confluences provided fertile ground for researchers to interrelate and investigate acoustic activities in conjunction with environmental science research (Truax & Barrett 2011). Farina establishes that the origin of Soundscape Ecology "has been the result of the intention of small and isolated groups of landscape ecologists who had recognised the necessity to investigate the patterns and processes created by sounds at all levels of biological and ecological complexity" (2014a, p. 5). Early research efforts can be identified in Krause's 'Anatomy of the Soundscape' (Krause 2008), and discussions in IT infrastructure circles of developing an acoustic environmental observatory (Mason et al. 2008). In 2009, a symposium entitled "Soundscape Ecology: Merging Bioacoustics and Landscapes' was held at the 2009 US-IALE (International Association of Landscape Ecology) conference in Utah, presented by landscape ecologists Almo Farina and Bryan Pijanowski. As interest further developed in the field, several prominent ecologists, field recordists and bioacousticians collaborated on a seminal *BioScience* article (Pijanowski,

Villanueva-Rivera, et al. 2011), followed by a special edition of *Landscape Ecology* comprising several essays on emerging soundscape ecology research (Pijanowski & Farina 2011).

In 2014, an inaugural congress was held in Paris, at which point Soundscape Ecology was formalised as a discipline, and the term 'Ecoacoustics' adopted as the term describing an umbrella field incorporating various disciplines focused on environmental sound research[1]. Here, Soundscape Ecology was positioned as a sub-discipline of Ecoacoustics, oriented towards large-scale, landscape-centred acoustic activities over more localised, specific environmental acoustic phenomena as in bioacoustics (Sueur & Farina 2015). Subsequently, interest in and support of the discipline has continued to grow. The International Society of Ecoacoustics (ISE), established in the aftermath of the inaugural conference, provides an international platform for Ecoacoustic and Soundscape Ecology research. Further proliferation of academic literature and interest from the public has also ensued (Farina & Gage 2017b) with international congresses held every two years: 2014 in Paris, 2016 in Lansing Michigan and 2018 in Brisbane. To this end, it has been suggested that Ecoacoustics has transitioned from an emerging to an established discipline (Towsey 2018).

2.3 - Frameworks

As an interdisciplinary field of research, Soundscape Ecology draws on an array of intellectual frameworks. This section discusses the discipline's taxonomy, analytical and methodological concerns, epistemological bases and research outcomes.

2.3.1 - Taxonomy

The basis for sound categorisation in Soundscape Ecology lies in the work of field recordist Bernie Krause, who proposed a taxonomy that attributes sounds with their sources:

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[1] The term ecoacoustics was previously suggested by Gary Ferrington within the Acoustic Ecology community, defining as "a field within environmental studies that investigates the role of sound in the ecology of the planet" (Ferrington 2001).

- biophony: is the collection of sounds produced by all organisms at a location over a specified time
- geophony: is the collection of sounds originating from the geophysical environment, which includes wind, water, thunder, movement of the earth, etc.
- anthropophony (also anthrophony[2] / technophony): denotes human-produced sounds, created by stationary and moving human-made objects (Krause 2002), (Pijanowski, Farina, et al. 2011, p. 1214)

The balance of sonic activity from each of these sources is correlated to environment type. Natural soundscapes are understood to feature prominent biophonic and geophonic activity alongside minimal or occasional anthropophony, whereas urban soundscapes are dominated by anthropophonic activities, and reduced geophony and minimal biophony (Mullet, Farina & Gage 2017, p. 324).

Within recent models of Ecoacoustics objectives (Sueur & Farina 2015), Soundscape Ecology is positioned at the highest spatiotemporal order of investigation, concerned primarily with landscape-level sonic activities over that of specific biological communities or populations, as in bioacoustics.

2.3.2 - Analysis

Soundscape Ecology analysis investigates patterns and behaviours emerging from an acoustic environment and how natural dynamics and human impacts affect them (Pijanowski, Farina, et al. 2011, pp. 1219-1225). By considering sound as a physical phenomenon, these observations are analysed based on acoustic parameters.

Frequency patterns observe how the soundscape, particularly the biophony, organises and behaves across the frequency spectrum. Organisms produce a broad spectrum of sounds,

[2] The term 'anthropophony' is has been used here as the most current term for human technologically-based sound activity, rather than the previously used 'anthrophony', which has been recognised as incorrectly using the prefix, 'anthro-' (referring to caves) (Krause 2015, pp. 153-154).

and their individual and collective communication systems have several suspected ecological causes. Bioacoustics hypotheses are utilised here to help better explain how interspecific vocalisations have arisen with respect to evolution and performance strategies in soundscapes. Key amongst them are the Acoustic Niche Hypothesis (Krause 1993), which proposes that organisms structure their vocalisations' particular frequency (and temporal) niches to avoid acoustic interference with other species, and the Acoustic Adaptation Hypothesis, which proposes that organisms adapt the frequencies and structure of their vocalisations for maximum communication efficacy within their respective environment.

Many *temporal patterns and cycles* are identified in soundscape activity and are assumed to be measured chronometrically. At the relative microlevel, dawn and dusk choruses of birds, amphibians, insects and other organisms correlate with diurnal and nocturnal cycles, often motivated by feeding or mating activity. Seasonal cycles impact many organisms' activities each year, including breeding, migration and hibernation, which affect a soundscape at the meso-level. Most broadly at the macro-level, climatic patterns (rainfall, temperature) impact ecosystem activities and the resultant soundscape.

Spatial dimensions are articulated through adapting the landscape ecology concepts of ecotope (a landscape patch with coincidental geotopes and biotopes) and ecotones (the boundary between ecotopes) to the sonotope, soundtope and sonotone. A sonotope "is a distinct sonic unit or sonic patch produced by the overlap of geophonies, biophonies and anthrophonies", resulting from each sound's different spatial and temporal extension (Farina 2014a, p. 17). A soundtope is a subdivision of a sonotope specifically related to biophony, that inspects the "active and passive exchange of information among collaborative members of a community" (ibid., p. 19). A sonotone is the boundary between adjacent sonotopes.

Related to a soundscape's spatial dimensions are gradients, which are the gradual changes in abiotic factors in an ecosystem. Through their dynamism, they impact elements of an ecosystem and its soundscape, and include altitude (elevation, air pressure, wind, precipitation), flow (rain and stream flows), habitat interior-edge (species distribution,

changed weather dynamics such as wind speed, turbulence and vorticity), latitude (annual climate patterns, temperature and solar radiation) and human disturbance (land use and transformation).

Sonic interactions are the relationships between biophony, geophony and anthropophony, and the way each aspect responds to the other through agency (by adapting call amplitude, frequency, or timing in animals, or modifying activities in humans) or abiotic process.

2.4 - Methodology

The methods of Soundscape Ecology occupy a "broad range of field and laboratory approaches from bioacoustics to psychoacoustics and truly heterogenous methods to collect, process, and interpret sonic data" (Farina 2014a, p. 221). Rooted in landscape ecology methodologies, Soundscape Ecology employs various field and analytical techniques, approaches and tools to develop a comprehensive understanding of a landscape and its acoustic environment.

Key amongst these are spatial analysis tools, which have allowed landscape ecology to flourish, such as geographic information systems (GIS), spatial metric software, and remote sensing technology. Each of these is useful in providing spatial information associated with a particular acoustic environment, collecting geographic, topological and meteorological data to associate with a soundscape, or utilising environmental phenomena or remote inputs as triggers for data collection events (i.e. beginning or ending a recording).

With sound as its primary concern, Soundscape Ecology also employs specific sound-based technologies to record, measure and analyse acoustic environments:

2.4.1 - Digital sound recording and storage

With significant shifts in the accessibility, affordability, efficiency and fidelity of contemporary recording equipment, high-quality sound recordings of acoustic

environments are easily achievable, resulting in rich sonic data for analysis and interpretation. In practice, the type and quantity of microphones, locus and direction of the equipment, and initiation and duration of a recording are decided by the researcher appropriate to the location, environmental conditions, and research objectives.

For Soundscape Ecology, passive acoustic monitoring (PAM) is the typical method employed, in which recorders are left in the field for long durations, capturing acoustic data across many days, months or years (Deichmann et al. 2018). Such recorders may be networked, providing acoustic data from multiple points in a landscape, and may also be automated, permitting recording at specified times and durations without constant human attendance. Predominantly, recording setups use omnidirectional microphones, which "give the most comprehensive spatial coverage per channel, and flat frequency responses aim to maintain 'fidelity' (i.e. the accuracy of representation) of the recorded signal to the actual sound in the environment… the acoustic indices to be calculated are monophonic, and so stereo recording for example would be redundant" (Barclay & Gifford 2017).

There are a number of challenges that remain, related to big data issues (i.e. file sizes and storage mechanisms, especially in systems with multiple recordings of extended duration), equipment maintenance for recording networks (replacing data storage cards and batteries in each recorder) and, until recently, equipment cost, which is now increasingly diminishing (Krause 2002; Monacchi 2011). Though there are numerous portable recorders available on the market, particular examples used by Soundscape Ecology practitioners include the Bioacoustic Audio Recorder by Frontier Labs and the SongMeter recorders by Wildlife Acoustics.

2.4.2 - Measurements, indices and analytical software

Soundscape Ecology's heterogeneous methods involve measurements of acoustic and non-acoustic phenomena in environmental contexts.
Sound can be measured in many ways and, in Soundscape Ecology, the main goal is "to process data to extract the emerging patterns in terms of complexity/information of the sonic environment" (Farina 2014a, p. 239). Primarily concerned with identifying patterns

in sound recordings, acoustic measurements related to frequency, duration, amplitude and space (where multichannel or ambisonic recording is possible) are made. Though particular instruments can measure discrete parameters (for example, sound pressure level with a decibel meter), this information is typically captured in the form of gestalt audio recordings and parsed during subsequent analysis.
Additionally, other non-acoustic measurements are made simultaneously to correlate and contextualise acoustic activity with non-acoustic environmental activity. These measurements can include (but is not limited to) localised barometric and topological data, animal behaviours, and geographic information obtained by GIS infrastructure.

Measurement data is subsequently subjected to multiple points of analysis. Spectrograms, already used by acousticians for several decades, are utilised to visually represent long-duration audio recordings, displaying parameters of frequency, amplitude and time on different graphical axes (Towsey, Truskinger & Roe 2016). Additional GIS and barometric metadata permits association of geospatial and meteorological information with the acoustic data.

Indices have been developed as a method of rapid biodiversity assessment, evaluating recordings and comparing aspects of ecological function between different sites, or different periods or conditions at a specific site. Many acoustic diversity indices have been correlated with traditional diversity indices. Whilst numerous indices predate the introduction of Soundscape Ecology (e.g. the Bioacoustics Index (Boelman et al. 2007), the maturation of Soundscape Ecology literature has seen the introduction of additional indices employing statistical algorithms to compare recordings, including the Acoustic Complexity Index (Pieretti, Farina & Morri 2011), the Acoustic Diversity Index (Villanueva-Rivera et al. 2011), the Acoustic Evenness Index (Villanueva-Rivera et al. 2011) and the Normalized Difference Soundscape Index (Kasten et al. 2012). Additionally, the Ecoacoustic Event Detection and Identification (EEDI) has been developed by Farina et al. (2016), allowing for automatic detection and identification of acoustic phenomena and events in recordings.

Numerous Ecoacoustics software packages have been developed that facilitate the precise identification, measurement, analysis, and manipulation of sound samples, and calculation of acoustic indices. Notable examples include Raven (Cornell University, 2014); the R-based packages SEEWAVE (Sueur, Aubin & Simonis 2008) and Soundecology (Villanueva-Rivera et al. 2011), the SoundscapeMeter 2.0 (Farina & Salutari 2016), and the Acoustic Workbench (Towsey et al. 2018).

2.5 - Epistemology

As a transdisciplinary field, Soundscape Ecology draws on a variety of disciplines to inform its principles and methods. An initial theoretical framework posits spatial ecology, psychoacoustics, bioacoustics and Acoustic Ecology as principal informants, representing perspectives from ecology, psychology, ethology and the humanities respectively. Through drawing on the multitude of perspectives offered by each discipline, Soundscape Ecology can form a coherent understanding of a soundscape and its component sounds, processes and relationships.

Epistemologically, Soundscape Ecology is an empirical, science-based discipline situated within the broad field of ecology. As per a materialist, physics-centred model of an ecosystem, the discipline assumes that environmental sound is a form of acoustic potential energy resulting from kinetic activity in an environment, thereby understanding sound as a result of its productive source (i.e. a bark indicating the presence of a dog), and/or the intervening physical media and processes in its transmission between producer and receiver (i.e. the barometric qualities of local air, or the topology of a landscape). Consequently, an acoustic environment is understood to be a representation of the associated physical environment's ecological activities and behaviour (Farina 2018).

Soundscape Ecology also recognises that many environmental sounds have biological origin, often with cognitive motivation for their production or cognitive processing involved in their reception, in turn motivating responsive activity and sound production. A soundscape, writes Farina, is "an acoustical composition that results from the voluntary or involuntary overlap of different sounds of physical or biological origin,… first

perceived and successively interpreted by organisms: this means that a cognitive element must be added or at least considered in the soundscape process" (2014a, p. 17).

The cognitive element also relates to the researcher-listener position in the soundscape experience or, in their absence, a mechanical proxy such as a sound recorder. Farina and Pieretti establish that "the soundscape approach does not simply correspond to the analysis of a collection of sounds, but also pertains to a complex system of identification of sounds and the interpretation thereof. The description of soundscape patterns is an indispensable, but not sufficient, way of studying (ecologically) this matter; a biosemiotic approach is also required to understand and interpret the uses and functions of sounds" (2012, p. 22).

This consideration of biological organisms, their agency and sonic activity, and the analytical observation of this by the researcher-listener is founded on a spatial ecology conception of landscape as "a semiotic interface between organisms and resources", comprised of what Farina and Belgrano call 'eco-fields' (2006), which are "spatial configuration carriers of meaning… used to locate specific resources" (Farina 2014a, p. 22). These resources can be material, as in food or shelter, or immaterial, as in safety or cultural heritage. Motivated by the need to procure such resources, biological organisms are considered to regulate behaviour and activity, and consequently, their sound production and reception, to successfully interact within their environment. The soundscape, as such, can be viewed from this perspective as a "collection of acoustic eco-fields that are used by species to track specific resources" (Farina & Pieretti 2012, p. 22). Examples include birds using interspecific songs or geophony to determine food sources, or humans using ambulance sirens to signal an emergency. Farina and Gage link this with von Uexküll's 'Umwelt' theory (1982), which proposes that organisms construct and continually reshape their own 'self-centered worlds' through interaction with their environment. For Soundscape Ecology, the theory is valuable because "it connects behavioral and ecological aspects of a species by recognizing the individual subjectivity of the perceived world and assures the individual–specific reaction to external stimuli", and is relevant in that "it may explain the acoustic dimension of the world that surrounds every individual, … [having] different consistency, shape, and meaning [according to physiological and social

status]" (Farina & Gage 2017a, p. 18). Consequently, the environment's observed complexity is connected with multiple subjects, "the interaction between different umwelts [producing] a semiospheric network" (ibid.).

Consequently, Soundscape Ecology not only promotes but necessitates a multidisciplinary approach to data (both quantitative and qualitative) collection and analysis, where both human and non-human agencies and their cognitive activities are considered in relation to soundscape participation, perception and interpretation.

2.6 - Outcomes

Soundscape Ecology's engagement with acoustic recordings and the resultant analytical data can "help in long term studies of environmental change, whether due to negative factors such as pollution, habitat loss, climate change, or due to positive factors such as conservation and restoration projects" (Towsey, Truskinger & Roe 2016). Various ecological phenomena and behaviours have consequently become the topic of Soundscape Ecology studies, including population census, biological diversity, habitat health, migratory species arrivals and departures, diurnal and seasonal change, frequency niche competition, trophic interactions and disturbance (Farina & Gage 2017b). Positioned in the greater context of Ecoacoustics outcomes, these inform considerations of long term acoustic monitoring in landscapes/waterscapes, biodiversity assessment, habitat health assessment, soundscape management, cultural heritage conservation, citizen science and education, environmental sound arts, and technological advancement and standardisation of methodologies (Farina 2018).

Whilst predominantly associated with academic research and audiences, the outcomes of Soundscape Ecology research are achieving broader public attention through web-based media and databases (including the Macaulay Library at Cornell Labs, and xeno-canto), community engagement, and artistic responses (Barclay & Gifford 2017; Monacchi & Krause 2017), discussed further in Chapter 3.

2.7 - Critiques

Though a promising field, Soundscape Ecology has not been without critique, whether internally or from academic counterparts. These critiques range from its philosophical and technological foundations to social challenges and interdisciplinary academic disputes.

2.7.1 - From Soundscape Ecology

Recognising the relative novelty of Soundscape Ecology, and more broadly Ecoacoustics, Farina and Gage identity various areas of the field posing challenges (2017, pp. 313-319).

Philosophically, there is a concern that the borrowing from multiple existing disciplines leaves Ecoacoustics without a core identity, which "could create a less important theoretical and applied scenario in which to further develop the field of Ecoacoustics" (ibid., p. 313). New models are called for to address this, providing an ontogenetic basis for the discipline, as well as consideration of the necessary expertise and education of researchers, and modes of interaction with other disciplines.
There is also recognition that ecologists need to work with others to better understand and contextualise their work in acoustics. These understandings may relate to data analysis enhancement and interpretation through integrating different measurements or consulting other ecological disciplines (i.e. bioacoustics, landscape ecology) to determine the implications of phenomena (including interspecific communication and spatial arrangements of land mosaics) with the greater acoustic environment. Additionally, with a lack of standardised methodology, more field tests are required to determine appropriate temporal and spatial scales of soundscape analysis in a landscape (Deichmann et al. 2018).

Technologically, there are several areas for improvement in the field. Sensor technologies, while permitting the long-term collection of acoustic data in remote locations, often lack apparatus to measure other biological and abiotic ecosystem attributes. To establish correlations between acoustic activities and other ecological attributes, the integration of appropriate real-time monitoring equipment on such recording platforms is required. The efficient transmission of large (acoustic) data sets from field recorders to remote processing

platforms also remains a logistical challenge, such that the prospect of satellite infrastructure has been considered (Gage & Farina 2017, p. 315)

Additionally, as data sets continue to grow, and metrics and analytical algorithms are introduced, advanced systems for efficient reception, storage, analysis and delivery of Ecoacoustics information will be required. A predominant constraint for Soundscape Ecology and Ecoacoustics exists in the practicalities of 'big data' collection and management. Referring to the large volumes of data created through contemporary technological mediation and interaction, big data science can be described by the 'Five Vs' - volume (size of data), variety (amount of data types, such as images, text, sound), velocity (the speed at which data can be transferred), veracity (the trustworthiness of the data), and value (the usefulness of the data) (Kaynak & Yin 2015). In the case of Soundscape Ecology projects employing multiple field recording devices, each making long-duration recordings, this necessitates large-scale database storage and complex computational systems to efficiently retrieve, manage, analyse (in batches) and report on large data sets. Such challenges can additionally lead to compromises between data volume and veracity. In the field, the storage capacity on recording devices becomes a limiting factor on the duration of recordings and the quality of the recording. Given the logistical and conservationist desire to minimise retrieval of storage technology in the field, a trade-off between duration and quality of recordings is often made, with recordists choosing to record audio at lower bit depths and sample rates to maximise recording durations. As Barclay and Gifford note, this is practicable on several fronts in that "data storage, power consumption, bandwidth requirements and processing time are all mitigated by lower sample rates and fewer channels" (2017, p. 55). However, such a compromise has implications for later analysis of recorded material. For example, trade-offs on veracity (bit rate, sample rate, compression) can impact the fidelity of the recordings, complicating algorithmic identification of soundscape phenomena, and the accuracy of metrical calculations. While technological infrastructure continues to improve, allowing larger storage capacity and more expedient processing and data transfer), consideration of the quality of acoustic recordings is necessary to ensure data veracity.

In the broader social domain, Soundscape Ecology and Ecoacoustics have several areas to address. Concerned with identifying existing ecological circumstances and forecasting ecological changes at various spatiotemporal scales through sound, Ecoacoustics provides a rich source of environmental information to share with resource managers and public decision makers that other ecological methods and modalities cannot. The value of this information, both for public officials and private citizens, is needed to be publicised further, with its capacity to inform discussions on topics such as biodiversity loss and climate change from an alternative and innovative perspective.

As transdisciplinary fields, Soundscape Ecology and Ecoacoustics also offer multiple modes for educational engagement, providing pathways into subjects such as physics, ecology, mathematics and computer science. Increased accessibility to recording devices, analytical software and data sets will additionally allow for citizen scientists to contribute to the field. Given its novelty and promising early findings, media documentation of Ecoacoustics research has taken root in recent years, both in academic circles (for example, an article on Australian research in The Conversation (Watson 2017)) and broader public audiences through popular seminar platforms such as TED (Krause 2013) and Arts-Science collaborations (Monacchi & Krause 2017).

Overall, a key concern is the need for financial investment in developing and acquiring research material resources (such as network infrastructure and accessible, low-cost acoustic sensors), to conduct further field tests (allowing for the development of a standardised methodology) and to promote Ecoacoustics to a broader audience.

2.7.2 - From Acoustic Ecology

Since its introduction as a discipline, Soundscape Ecology has engaged in critical dialogue with the field of Acoustic Ecology.

To a large extent, this has been over territorial and novelty claims, an important concern for an emerging discipline such as Soundscape Ecology. The 2011 Bioscience article on Soundscape Ecology establishes that Acoustic Ecology “is seen as complementary to

traditional ecological concepts rather than situated with them", and that it "largely emphasises human-centered inquiry rather than the larger socioecological systems approach" that Soundscape Ecology takes. Farina echoes this, saying that "[the term Ecoacoustics] stemmed from the need to avoid potential confusion with "Acoustic Ecology" which was used for "the study of sounds in relation to life and society" (Farina 2018). These sentiments have been previously levelled at Acoustic Ecology in an epistemological capacity (Karlsson 2000; Redström 1998), but here they are utilised towards political goals of legitimacy and authority.

In order to take root and thrive, fledgling academic disciplines require institutional support and funding. In the initial stages, this requires legitimisation of the research, sought through claims of valid and original contributions to knowledge. With an existing discipline, Acoustic Ecology, already laying claim to interdisciplinary research into acoustic environments, this may be a challenge. However, by positioning Acoustic Ecology as ultimately non-scientific (especially at a time where there is significant institutional support for STEM research), Ecoacoustics has been able establish as a legitimate and authoritative research field, thereby ascertaining a steady stream of publications, media attention, international conferences and research funding to continue maturing as a discipline.

Consequently, there has been concern within the Acoustic Ecology community that Soundscape Ecology and Ecoacoustics pose an intellectual threat, dismissing the broad interdisciplinary research undertaken over preceding decades by entities including the World Soundscape Project and World Forum for Acoustic Ecology, relegating the discipline's contributions in the domain of Soundscape Ecology to sociocultural terminology (as seen in Fig. 1). Contrarily, reassertions of Acoustic Ecology's claim to the field have positioned Soundscape Ecology and Ecoacoustics as branches of research within the broader interdisciplinary Acoustic Ecology project (Barclay & Gifford 2017).

Additionally, the Acoustic Ecology community has been critical of Soundscape Ecology's methods as related to sonic phenomena. As Soundscape Ecology collects, stores and analyses vast amounts of acoustic data, far beyond the feasibility of a single human being

to listen to, audio visualisation (using spectrograms) is employed as a mode of audio reduction. Towsey et al. note that "visualisation of sound is a promising approach because, of all the human senses, the visual sense has the greatest capacity to synthesise and integrate large amounts of information" (2016). However, this solution to sensory limitations may result in a research culture where *listening* is extirpated from acoustic data collection and analysis. Barclay and Gifford continue:

> A common dictum in practical data analysis is to always visually examine data prior to performing statistical calculations. Data visualisation is a field unto itself, seeking ways of representing structural aspects of data in visual form. There also exists the less well known field of auditory display, which seeks to represent data in audio format. In the cases of bio- and ecoacoustics, the data is already in audio format, and yet listening to field recordings does not rank as a core method in these disciplines. Partly this is pragmatic; ecoacoustics in particular tends to generate very large data-sets; a tendency which will likely increase as long-term large-scale acoustic monitoring programs become more feasible… Partly also this eschewing of listening reflects an epistemic stance, endemic in the sciences, that seeks to remove perception from observation (Barclay & Gifford 2017).

Listening in Acoustic Ecology is deemed a critical sensory skill in learning, understanding, analysis and engaging with acoustic environments, akin to Steven Feld's concept of 'acoustemology' (acoustic epistemology) which refers "to a sonic way of knowing and being in the world" (Rice 2018). Barclay and Gifford address the consequences of this extirpation in relation to sound recording quality:

> As a practical example of disciplinary divergence within this constellation, consider differing approaches to sound quality. In bioacoustics it is not uncommon to take field recordings in 'mono' at low sampling rates, for reasons both practical—cost, data storage, power consumption, bandwidth; and theoretical—most acoustic indices and classifier algorithms are monophonic, and operate in the frequency domain, so that the high sampling rates needed to encode complex spatial or reverberant information are redundant. In contrast, for acoustic ecologists stereo recording is the de facto standard, high sampling rates preferred, and more complex techniques such as binaural or ambisonic recording common. At root this divergence relates to the role of human perception in the process: typically bioacoustics seeks to remove subjective perception whilst acoustic ecology privileges it (Barclay & Gifford 2018).

In recent years, however, there has been a more mutually supportive dialogue, framed in part through interdisciplinary Arts-Science collaborations (Barclay & Gifford 2017; Monacchi & Krause 2017). This dialogue recognises the value of different approaches to soundscape research, the efficacy of creative work as a useful tool in science communication and appreciation, and the mutual benefit that each discipline may receive through collaborative endeavour.

2.7.3 - Via Agential Realism

Soundscape Ecology's recognition of cognitive activity in the landscape and soundscape reveal complex agential interplay when viewed through the lens of physicist-philosopher Karen Barad's concept of agential realism. In 'Meeting The Universe Halfway' (2007), Barad investigates different stances on the Copenhagen interpretation of quantum physics as espoused by Werner Heisenberg and Niels Bohr, and how they apply to scientific methodology. Rejecting Heisenberg's 'uncertainty' stance that understands an observer ultimately has no direct impact on the observed measurements of external phenomena (a continuance of the traditional Cartesian-Newtonian subject-object model), Barad embraces Bohr's 'complementarity' stance that observed phenomena are contingent on the apparatus used to measure them. Recognising that experimental phenomena and apparatus are co-constitutive in a quantum mechanics setting (they are productive of one another, with apparatus measurements determine phenomenological behaviour, and phenomena informing the apparatus employed), Barad introduces a neologism, intra-action, which signifies the "mutual constitution of entangled agencies", unlike interaction, wherein which distinct agencies precede their engagement with one another. Barad extrapolates these into a comprehensive theoretical framework known as 'agential realism', an ethico-ontoepistomological (theory of acting, being and knowing) paradigm intended to critique the 'material discursive practices' not only the sciences, but broader sociocultural and political institutions and systems. While extensive in its discourse, agential realism offers several key concepts that are useful as critical perspectives against Soundscape Ecology research and practice.

Considering the environment as laboratory, Soundscape Ecology data acquisition requires the researcher-observer or proxy (i.e. recording equipment) being in an environment to acquire acoustic data. As discussed of in the Methodology section above, it is presumed in passive acoustic monitoring practice that the use of proxies removes the potential impact that human presence may have on non-human behaviour at a particular site, as well as reducing 'observer bias' in data acquisition (Deichmann et al. 2018, p. 2). In a conventional sense, the experimental equipment (i.e. the field recording equipment) is understood as the predominant apparatus for acoustic data acquisition. However, for Barad, the definition of apparatus is extended to describe discursive practices concerning agential intra-action, such that they:

> "1) are specific material discursive practices (they are not merely laboratory setups that embody human concepts and take measurements); 2) produce differences that matter - they are boundary making practices that are formative of matter and meaning, productive of, and part of, the phenomena produced; 3) are material configurations/ dynamic reconfigurings of the world; 4) are themselves phenomena (constituted and dynamically reconstituted as part of the ongoing intra-activity of the world); 5) have no intrinsic boundaries but are open-ended practices; and 6) are not located in the world but are material configurations or reconfigurings of the world that re(con)figure spatiality and temporality as well as (the traditional notion of) dynamics (i.e., they do not exist as static structures, nor do they merely unfold or evolve in space and time)" (2007, p. 146).

The notions of the apparatus above as applied to Soundscape Ecology are recontextualised to involve not only field recording equipment, but the practices of (human and non-human) participants in acoustic (and environmental) data collection and analysis, entangling the researcher-observer within their recording environment. Consequently:

1) field recording practices are the predominant apparatuses of Soundscape Ecology, implicitly involving the researcher-observer (regardless of whether passive acoustic monitoring is employed) through the decisions made upon research design and methodology (which affects the material equipment used) as much as the spatiotemporal circumstances of the recording site.

2) field recording practices are productive of the soundscape phenomenon, both concept and object. The use of a recorder, like a human listener, implies the occupation of a distinct locus in an environment that receives sound according to its configuration and environmental surroundings, thereby engendering a perspectival bias wherein recordings are framed representations of acoustic environments. Such framing denotes boundary making practices. Responding to Ingold's *Against Soundscape*, Helmreich's draws attention to the role of technological invention and intervention in enabling the soundscape concept, which regards "sound as an aesthetic and conceptual remove. Telephony, phonography, architectural acoustics… permit sound to be apprehended as an abstraction. The soundscape is a back-formation from such technologies, an after-effect" (2011, p. 10). In both research and practice, Soundscape Ecology's continued conception of the soundscape as "the distribution of sounds across a landscape when the landscape is considered a geographic entity" (Farina 2014a, p. 3) has the potential to neglect the inherent perspectival and boundary-making practices involved in listening and field recording.

3) as noted in 2), field recording practices capture and render recorded sound as an object, dynamically (re)configuring it from a transitory acoustic phenomenon to a representational audio object. Such acts of (re)configuration may be understood as 'agential cuts', causal intra-actions (between apparatus and phenomena) in which" marks are left on bodies: bodies differentially materialise as particular patterns of the world result of the specific cuts and reconfigurings that are enacted" (Barad 2007, p. 176). Recordings are thus representative bodies of the acoustic environment resulting from cuts made in the recording process: the equipment used (microphones, recorders, storage systems), file format and compression, bit rates, sample rates, and associated decisions made by the observer including number of devices, time of recording initiation, duration of recording, location of the recorder, direction of the microphones, amongst other choices. Additionally, cuts are made through the 'transductive' process, in which "the transmutation and conversion of signals across media that, when accomplished seamlessly, can produce a sense of effortless presence" (Helmreich 2011, p. 10) seen in the transduction of acoustic (environmental sound) to kinetic to

electromagnetic energy (microphone) to analog-digital signal conversion (recorder) to audiovisual data for computer analysis and high fidelity representation.

4) field recording practice employs material recording systems and analytical hardwares and softwares themselves, reconfigured in their various aspects (microphones, recorders, storage devices, network infrastructure, analytical programs) in intra-action with human and non-human beings within research design and sociocultural, economic and political forces.

5) field recording practices are necessarily open-ended and adaptable practices which are reconfigured as appropriate to the research objectives and circumstances. Different recording equipment and settings are required for different environments and research.

6) field recording practices, as shifting and dynamic apparatuses (and phenomena) intra-acting with broader sociocultural and political perspective, have been productive of (re)conceptualisations of sound and recording (e.g. Pierre Schaffer's reduced listening, Truax's ideas on acoustic communication, Attali's commentary on sound and politics), re(con)figuring new modes and means of acoustic engagement and acoustemology with environments and their related spatiotemporal circumstances.

Agential realism additionally offers a radical reconceptualisation of agency, wherein it:

> "is a matter of intra-acting; it is an enactment, not something that someone or something has. It cannot be designated as an attribute of subjects or objects (as they do not preexist as such). It is not an attribute whatsoever. Agency is "doing" or "being" in its intra-activity. It is the enactment of iterative change to particular practices - interactive reconfiguring of topological manifolds of spacetime-matter relations - through the dynamics of intra-activity. Agency is about changing possibility of change entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices in the enactment of a causal structure" (Barad 2007, p. 178).

For Barad, agency is understood as the process of cause and effect in enactment, contingent on the intra-action of phenomena and apparatus (though not necessarily

always together). For soundscape ecology, such an understanding complements the models put forward by the eco-field hypothesis and the Umwelt model, not only for non-human biotic organisms (whose agency thus emerges through their relational engagement with their environment and ecological resources), but also to the researcher-observer, whose agency emerges through their intra-action with place, ecosystem and soundscape, and broader sociocultural and political systems underlying their research and practice.

This understanding can also be extended to non-human abiotic phenomena, in their intra-action with human and non-human biotic organisms in environment (affecting behaviour), with acoustic space and field recording equipment (affecting the acoustic qualities of the resultant recording), and through data representation ascertained via appropriate measuring equipment (for example, barometric data in a weather station). In the latter case, such data can intra-act with the researcher-observer through data analysis, extending the reach of agential enactment beyond the intra-activity of data collation to influence further decision making (agential cuts) in the research process.

Though an exhaustive discussion of agential reality's implications for Soundscape Ecology research and practice is far beyond the scope of this research project, the topics briefly covered here offer alternative understandings of the implicit role of the researcher-observer in experimental design and results, the reconceptualisation of field recording practices as apparatus, and human and non-human (biotic and abiotic) intra-active agencies as related to Soundscape Ecology research and practice. While it is possible that these perspectives may encourage new directions within the discipline, there are many opportunities for creative exploration offered, as discussed in Chapter 3.

2.8 - Summary

Over the past decade, Soundscape Ecology's growth as a discipline offers a variety of acoustic-oriented perspectives and methods in environmental research, utilising sound to garner insights into ecological behaviour and function.

Drawing on existing research in acoustic environments in Acoustic Ecology and developments from such fields as bioacoustics, landscape ecology and big data sciences,

the discipline employs a variety of methods for data collation, analysis and comparison of acoustic environments, aimed at understanding ecological activities and behaviours at various spatiotemporal scales in the landscape. Increasingly, the acoustic data and its interpretative outcomes can be presented to a broader public audience to communicate evidence of ecological change.

But, as a field-in-development, there are a variety of challenges the discipline continues to address, internally in relation to philosophical, technological and social concerns, and (to a lesser degree given interdisciplinary dialogue) from the Acoustic Ecology community in relation to disciplinary politics and the absence of listening in the practice of sound recording and analysis. Additionally, new understandings of the discipline's scientific practice are engendered by viewing the discipline through the lens of Baradian agential reality. Many of these challenges offer the potential for investigation in creative activity engaged with Soundscape Ecology, which will be discussed in more detail in Chapters 3 and 4.

3 - Creative Approaches to Soundscape

> *Today all sounds belong to a continuous field of possibilities lying within the comprehensive dominion of music. Behold the new orchestra: the sonic universe! And the musicians: anyone and anything that sounds!*
>
> Raymond Murray Schafer (1993)

This chapter discusses creative approaches to soundscape, environment and ecosystems. A brief historical background considers the lineage of environmentally-oriented sound-based work, followed by a discussion of 'Ecological Sound Art', a recently-introduced term for the field of practice in which this research project is situated, and philosopher Timothy Morton's 'Dark Ecology' project. An overview of international, Australian and South Australian practitioners follows, providing context for the creative framework and site-specific works discussed in Chapter 4 and 5.

3.1 - Historical Background

The relationship between the natural world and music has been significant throughout the development of human societies, with music-makers worldwide drawing on and responding to their local sonic environment in their cultural practices (Krause 2012, 10). Such examples include the B'Aka pygmy peoples of Central Africa (Sarno 1996); the Fore (Diamond 1993, p. 256), Bosavi (Feld 1996, p. 91) and Kaluli (Feld 2013) peoples of Papua New Guinea; the Nez Perce people of North America (Krause 1993, p. 1); and the Yawur people in Western Australia (Benterrak & Muecke 1996, p. 62).

The Western art music canon has maintained a continuing interest in engaging with environmental sound, often representing 'natural' phenomena or acoustic activity in stylised, abstracted treatments appropriate to the cultural norms of the day. Examples include Antonio Vivaldi's *La Quattro Staggioni* (1717), Ludwig van Beethoven's *6th (Pastoral) Symphony* (1808), Claude Debussy's *La Mer* (1905), and Charles Ives' *Three Places in New England* (1914).

Under the influence of industrial-era technological developments and increasing urbanisation, interest in exploring urban soundscapes developed. Most notably, Futurist Luigi Russolo's 1912 *L'Art de Rumori* (The Art of Noise), advocated for an embrace of

urban noise as potent creative material, a mantle hinted at as early as 1844 in Alkan's *Railroad Étude*, and taken up in later works such as Arthur Honneger's *Pacific 231* (1923). And George Antheil's score for *Ballet Mechanique* (1924).

Around the same time, composers also began to take advantage of technological advances in sound recording and reproduction. Composer Ottorino Resphigi was the first to use recorded natural sound, a sample of a nightingale call, in *Pini Di Roma* (1924). Others followed, with Olivier Messiaen referring to Ludwig Koch's bird call recordings for transcriptional purposes in *Catalogue d'Oiseaux* (1956-58) (Tipp 2016), and Einojuhani Rautavaara employing both recordings and instrumental transcriptions of bird song in *Cantus Arcticus* (1972). Roger Payne's iconic 'Songs of the Humpback Whale' provided inspiration and source material for Alan Hovhaness's *…And God Created Great Whales* (1970) and George Crumb's *Vox Balanae* (1971). Early examples of works incorporating broader soundscape recordings include Luc Ferrari's *Presque Rien No.1* (1970), Bernard Parmegiani's *De Natura Sonorum* (1975) and Annea Lockwood's *Soundsmaps* projects.

The advent of social activism and environmental advocacy in the 1960s and 1970s, channel through movements such Arne Naess' Deep Ecology and Greenpeace, saw increased creative interest in ecological themes and concerns. Key amongst early pioneers in environmental sound research and creative practice was Canadian composer and educator, Raymond Murray Schafer. Frustrated "with urban, technological noise… and his experience in framing the issue within the tradition of anti-noise lobbies… a negative approach which does not lead to positive action or solutions, only bureaucratic legislation and public apathy" (Truax 2012), Schafer introduced the concept of Acoustic Ecology, a creative listening-centred practice of soundscape analysis and design. As an educator and composer, Schafer promoted the musician as the most idiomatically-adept person suited for Acoustic Ecology research, rhetorically advocating for treatment of the soundscape 'as a macrocosmic musical composition' (Schafer, R Murray 1977).

The World Soundscape Project, a research project at Simon Fraser University in the early 1970s, was the manifestation of this intent, and generated many associated creative research projects including the *Vancouver Soundscape* (1973), radio series *Soundscapes of Canada* (1974), and Europe-focussed *Five Village Soundscapes* (1977). Following the Project's decline in the mid 1970s, several research assistants including Barry Truax and Hildegard

Westerkamp continued developing creative work responding to real and imagined acoustic environments, a practice that became known as soundscape composition (Truax 1996, 2008; Westerkamp 2002). Of the practice, Truax explains,

> In the soundscape composition . . . it is precisely the environmental context that is preserved, enhanced and exploited by the composer. The listener's past experience, associations, and patterns of soundscape perception are called upon by the composer and thereby integrated within the compositional strategy. Part of the composer's intent may also be to enhance the listener's awareness of environmental sound (2001, p. 237).

Examples of this are Truax's *Pacific* (1990), *Pendlerdrøm* (1997), *Island* (2000) and *Chalice Well* (2009) and Westerkamp's *Kit's Beach Soundwalk* (1989) and *Beneath the Forest Floor* (1992).

3.2 - Ecological Sound Art

In recent years, increased attention to pertinent social and environmental issues such as climate change, biodiversity loss, sustainability and urbanisation has prompted a wide variety of artistic responses, including through music and sonic art. The result of this is a diversity of creative practices, examples include 'sonic ecologies' (Barclay 2013b), ecoacoustics (Burtner 2005), eco-acoustics (Monacchi 2011), eco-structualism (Opie & Brown 2006), ecocomposition (Keller & Capasso 2006), ecomusic (Branchi 2012) and ecocentric music. Despite a proliferation of terminology, a lack of umbrella terminology for the field has been recognised, with individual practitioners suggesting terms articulating specific interests related to personal concepts and processes, rather than collective approaches.

To rectify this, musicologist Jonathan Gilmurray has proposed several terms addressing this gap, at first 'ecoacoustics' (Gilmurray 2013), drawing on the terms 'ecoacoustic' and 'eco-acoustic' used by Matthew Burtner and David Monacchi respectively, and more recently, 'ecological sound art' (Gilmurray 2017, 2018). Critical of the absence of sound art within eco-art critical discourse with its focus on visual practices, and the lack of discussion on sound art practice within the field of ecomusicology, Gilmurray defines ecological sound art as a field "engaging with contemporary environmental issues such as biodiversity loss, sustainability and climate change through their work, forming a growing

movement of environmentally concerned sound art" (2017, p. 32). Common approaches to ecological sound art practices include "enacting metaphors which facilitate a personal connection with environmental issues, …articulating the harmonious coexistence of humans, technology and the natural world, …allowing us to experience normally inaccessible aspects of the environment, … communicating environmental data through sound … [and] facilitating community engagement with ecological issues" (ibid., p. 32). Continuing from the previously suggested term of 'ecoacoustics', which sought to categorise compositional practices based on their media ('note-based' practices employing acoustic instrumentation or 'sound-based' practices employing electroacoustic media), ecological sound art practitioners utilise various media from the purely-instrumental and electroacoustic concert works to ambisonic installations and mobile technologies. Though nominally related to sound art, 'ecological sound art' thereby eschews a conservative juxtaposition of music and sound art, and encourages a flexible 'sounding art' (Cobussen, Meelberg & Truax 2016) continuum in which reproductive media are employed with sensitivity to site-specific, ecologically-derived content and contexts.

3.2.1 - Dark Ecology and Ecological Sound Art

Whilst Gilmurray contextualises ecological sound art through various theoretical lenses - sensing the mesh of vibrating matter via Abram and Bennett; the sensation of ecological relationships through sound via Truax, Voegelin, Dyson and Von Glahn; and the possibility of new sonic worlds via Miles and Voegelin - of particular concern to this research project is the attention to the work of philosopher Timothy Morton. A proponent of the phenomenologically-based Object Oriented Ontology school, Morton presents an alternative view of environmental aesthetics that positions anthropocentrism (resulting from what he terms agrilogistics, a paradigm that begins with the advent of agriculture 12,000 years) as the dominant force behind the environmental crises faced globally today. These crises, he argues, have resulted from a fundamental misunderstanding of the way things exist, whereby humans position nonhumans (inclusive of living and non-living beings) as Other, rather than recognising the fundamental interconnections and 'enmeshment' that humans and nonhumans share in an ecological mode of being. Morton terms this perspective Dark Ecology, in which the weird and uncanny aspects of

interconnected, ecological being and knowing inform and enable us to recognise our impact with different ecological (spatiotemporal) scales and reestablish connections with non-human beings (Morton, T 2016).

Morton's concept of non-human agency also extends to non-biotic phenomena in recognition of their capacity to affect human behaviour and decisions. For Morton:

> "causality is wholly an *aesthetic* phenomenon. Aesthetic events are not limited to interactions between humans or between humans and painted canvases or between humans and sentences in dramas. They happen when a saw bites into a fresh piece of plywood.They happen when a worm oozes out of some wet soil. They happen when a massive object emits gravity waves. When you make or study art you are not exploring some kind of candy on the surface of a machine. You are making or studying causality. *The aesthetic dimension is the causal dimension*" (2013, pp. 19-20).

This affordance of affective and causal capacities to both biotic and abiotic nonhuman entities engenders a sense of solidarity between biological organisms and works of art, which Morton teases out more explicitly of ecological art in Being Ecological:

> "There is no good reason to distinguish between non-humans that are 'natural' and 'ones that are 'artificial', by which we mean made by humans. It just becomes too difficult to sustain such distinctions. Since, therefore, an artwork is itself a nonhuman being, this solidarity in the artistic realms is already solidarity with nonhumans, whether or not art is explicitly ecological. Ecologically specific art is simply art that brings this solidarity with the nonhuman to the foreground" (2018, p. 121).

Pertinent to an ecological setting, Morton's additional concept of 'hyperobjects' offers a way of conceiving and understanding as related to place, ecosystem and soundscape. Identified as large-scale objects comprised of many smaller-scale objects, hyperobjects are functional and agential in their own right, enmeshed ontologically with their constituent parts. Examples of this are the biosphere or climate, which can affect localised biodiversity or weather conditions of which they are comprised. Importantly, Morton encourages composite entities like hyperobjects to be conceived as lesser, not greater, than the sum of their parts' wholes, encouraging sensitivity to the multitudinous, complex entities and

processes that comprise a place, ecosystem and soundscape. As such, the identity of a place, an ecosystem or soundscape is not fixed, but dynamic, emergent and evolving, contingent on understanding the creative interplay (or intra-action, as per Barad) of environmental, historical, sociocultural, political and spiritual influences.

To this end, ecological art, and specifically here, ecological sound art, offers a domain of practice, research, being and doing that allows the human creative practitioner to develop modes of connection and engagement with nonhumans, at first through the aesthetic and affective experience of a creative work, and subsequently in the work's inherent connectedness to ecosystem, environment and soundscape.

3.2.2 - Ecological Sound Artists

Gilmurray's PhD thesis explains certain criteria for 'ecological sound artists'. For the purposes of establishing the genre, Gilmurray sought to identify artist whose primary output focussed on ecological-concerned work:

> "while some artists, such as Leah Barclay, Matthew Burtner and David Monacchi have made ecological issues the sole and ongoing focus of their artistic practice, for many others the ecologically-concerned works they have produced constitute just one facet of an artistic output which also explores many other subjects; thus, to characterise them as an ecological sound artist would be an inaccurate and limiting portrayal of them as an artist." (Gilmurray 2018).

As such, discussions herein of ecological sound art practitioners prioritises those whose output focuses primarily on ecological issues and interests. Some internationally recognised ecological sound artist are as follows:

Composer John Luther Adams's instrumental oeuvre is recognised for its evocation of place and soundscape-like quality, with works such as *Inuksuit* and *The Wind In High Places* influenced by his long term residence in central Alaska. Less frequently, Adams has produced emergent site-specific installations, including *The Place Where You Go To Listen*, an audiovisual work in Fairbanks, Alaska, which sonifies and visualises (through lighting)

the live meteorological, geomagnetic and tectonic activity of Alaska, and *The Wind Garden*, a sound sculpture at the University of California San Diego driven by the site's lighting and wind conditions (Adams 2009; UCSD 2017).

Walter Branchi is an electroacoustic composer whose practice is described as 'integrated' or 'eco-' music, described as "a music that goes beyond the concept of the world centred exclusively on anthropocentric values, but is based on ecocentric values; … a music interwoven into a network of interdependent relationships with the world outside… [where the audience] is not the centre of the happening, but is included" (Branchi 2012, p. 71). This is best represented in his multi-part work *Intero ('Whole')* (1979–present), comprising several works intended for site-specific outdoor performance.

Matthew Burtner is a composer and sound artist who defines his practice, Ecoacoustics, as "an approach deriving musical procedures from abstracted environ- mental processes, remapping data from the ecological into the musical domain… in the field of composition, this takes the form of musical procedures and materials that either directly or indirectly draw on environmental systems to structure music" (Burtner 2005, p. 10). Examples include his works *Snowprints* (2001), *Windprints* (2005) and *Iceprints* (2010). Burtner is also director of Ecosono, a environmental arts organisation acting as a research institution, a residency-festival sponsor and multimedia publisher, raising awareness of ecoacoustics, environmentalism and the arts (Burtner 2011, 2018).

Teresa Connors is a Canadian multimedia practitioner whose practice centres around her creative framework of Ecological Performativity. Drawing on considerations of agency through Barad and Morton, and of cybernetics through Haraway and Pickering (amongst other theoreticians) in the environmental domain, Connors develops site-responsive audiovisual installations that intra-actively emerge through practitioner engagement with site, human and nonhuman collaborators and collated materials. Examples of works include *Flight Variant*, *Undercurrent*, *Cathedral* and *Piano At The End of A Poison Stream* (Connors 2017).

Sound artist and researcher David Dunn divides his ecological sound art works into two categories, 'hybrid soundscape compositions' and 'environmental performance works' (Dunn 2009). The former approach "[aims] to represent the realities of natural environments as an antidote to the fantasies perpetuated by many soundscape works" (Gilmurray 2013, p. 8), whereas the latter are intended to be integrated into the source environment through recording, processing, performing and re-recording the material into a human/non-human (animal and machine alike) interactive ecological feedback loop. Examples include *Entrainments* 1 (1984), *Sonic Mirror* (1986-87) and *Autonomous Systems* (2003-05). Dunn's work has also had significant implications for bioacoustics, as in *The Sound of Light in Trees* (2006), which features the recordings of pine bark beetles. Not only has this drawn attention to the epidemic of tree infestation of the beetles by revealing hidden acoustic activity, but has been used as a form of pest control as a result of playing back the recordings to the beetles, which has detrimental impacts on their neural and reproductive activity.

Damián Keller is a composer whose works are developed through a process termed 'eco-composition', "a theoretical framework grounded on perceptual and cultural data; and … the subsequent development of synthesis techniques and compositional strategies coherent with this theoretical scaffolding" (Keller & Capasso 2006, p. 56). Such works emerge through compositional considerations including form emergence (the structural relationships emerging from sonic interactions between time, space and composition), heterarchy (the processes underlying changes in activity on the temporal scale), data acquisition through re-enaction (the structural coupling, attunement, and formation of the personal environment), and accumulation (use of granular synthesis to generate synthetic sound material with reference to ecological models). Examples of Keller's eco-composition work include *touch'n'go* (1999) and *Vivir sin después* (2004).

David Monnachi is an Italian composer and sound artist, best known for his body of work, *Fragments of Extinction*. Recording threatened equatorial rainforest soundscapes with spatial microphonic techniques, Monacchi presents these soundscape recordings in the 'Eco-acoustic Theatre', a periphonic audiovisual space that incorporates diffused soundscape recordings with spectrograms (Monacchi 2013). As a leading member of the

International Society for Ecoacoustics, Monacchi has been instrumental in encouraging creative collaborations between scientists and sound art practitioners (Monacchi & Krause 2017).

Andrea Polli is an environmental artist working at the intersection of art, science and technology. Her sound art works utilise sonification in compositions, installations and research projects, raising awareness of the underlying significance of meteorological and climate data as related to climate change. Projects include *Atmospherics/Weather Works* (2002) and *T2* (2006), which sonify long term weather, wind and wave data to draw attention to long-term climatic changes, creating "turbulent and evocative compositions which allowed listeners to experience geographically scaled events on a human scale and gain a deeper understanding of some of the more unpredictable complex rhythms and melodies of nature" (Gilmurray 2013, p. 9).

Douglas Quin is a sound designer, naturalist and composer whose "process of field recording and composition involves cultivating an empathetic identification with nature, with the understanding that this is an inherited basis of our humanity" (Quin undated). Notable CDs of his works include *Oropendola* (1994), *Forests: A Book of Hours* (1999) and *Caratinga* (2001).

Jana Winderen is a sound artist and former marine biologist, whose installation-based work focusses on making audible terrestrially the sound of aquatic ecosystems to raise awareness of changes in underwater ecosystem integrity (Gilmurray 2017, p. 36). Installations include *Energy Field* (2010), *Dive* (2014) and *Spring Bloom in the Marginal Ice Zone* (2017).

3.3.3 - Australian Ecological Sound Art

Australian musical and sound art practice is well recognised for its attendance to themes of environment and landscape (AMC 2016a, 2016b). As Fiona Richards notes in the introduction to *The Soundscapes of Australia,* "composers have drawn inspiration from both the landscape itself and the fauna it supports… there is an overriding sense of musicians

having an imaginative connection with the immediacy of the physical environment and a general acknowledgement that landscape has to play a part in shaping the music of the country“ (2007, p. 1).

Sound artist Ros Bandt ascribes this artistic interest with environment to the country’s identity as ‘complex interplay of site, language and technology’, catalysed through the act of listening to place:

> The land’s geography defines the acoustic shell. An ever-changing soundscape emerges from the interplay of the flora, fauna, the weather patterns and the passage of human beings. The land is the container for the sound, its past, its songs, its flora, its fauna, and its original inhabitants. How we relate to the land defines us, and thus our identity. (Bandt 2001)

Such listening of place also resonates in the dynamic and complex sociocultural implications of First Nations’ societies and cultures, European colonisation and the successive immigration of diverse cultures:

> Listening is another way of being, which inscribes and endorses silence. Not to listen in a land, which has been sung for thousands of years by many peoples, is to deny their existence, ever widening the gap of silence and endorsing the colonial imposition of terra nullius. The practice of listening has changed as the culture has changed… This is a never-ending process essential to the changing identity of Australia, a massive cultural and social experiment. The constantly changing sound environments in Australia reflect its buoyant cultural diversity. (ibid.)

Consequently, the environment can be seen as one of two areas (the other being intercultural music) that celebrating the particularities in an Australia which creatively connects sound and place, as Vanessa Tomlinson explains:

> …the most amazing and unique work in Australia has to do with soundings, improvisation, and environment. Without a doubt site-specific art has become the art of our time. The fact that place can matter in music making is really exciting… It is more about connections and extensions of the individual into the environment, and vice versa …a lot of this music is… ephemeral and temporal… I feel strongly that the soundscape of certain sites is changed by

> these works. Sonic memory of place is a really interesting concept, and one that strongly resonates with me. I think there are many sonic footprints across Australia from incredibly special musical environmental interactions (Tomlinson, in Huang 2017, pp. 109-110).

Notable Australian composers and sound artists working with environmental contexts include Peter Sculthorpe, Ross Edwards, Anne Boyd, Warren Burt, Ros Bandt, Les Gilbert, Nigel Helyer, Nigel Frayne, David Lumsdaine, Leigh Hobba, Stephen Leek, Lawrence English, Jon Drummond, Catherine Schieve, Corinna Bonshek, Mace Francis, Nic McConnaghy and Peter Mumme (Budel 2016). More specifically, numerous Australian practitioners of ecological sound art can be identified:

Leah Barclay is a composer and sound artist whose practice has focussed on emerging approaches and technologies in connection with environmental sound research and practice. Her PhD focussed on the development of the 'Sonic Ecologies' framework, which outlines a multistage creative process of engaging with site-specific subject matter, multi-platform dissemination, community education and engagement tools, interdisciplinary partnerships and collaborations, and long-term strategic visions (Barclay 2013b, p. 30). This has been implemented in numerous projects, notably the *Biosphere Soundscapes* program which brings together artists, scientists and community leaders in UNESCO Biosphere Reserves (Barclay 2014; Barclay & Gifford 2017). Additionally, Barclay has developed numerous smartphone applications that utilise mobile technologies, interactivity and listening as modes of connecting audiences to place and associated environmental circumstances (Barclay 2017).

Daniel Blinkhorn is a composer and sound artist. Under the moniker, 'frostbYte' (used either as a pseudonym and/or a reference for region-specific works), Blinkhorn produces what he terms 'biomimetic composition' by "observing ecological sensitivities, vitality and the naturally ordered continuities binding habitats of sound, place, people and space together" (Blinkhorn undated). Comprising field recordings, experimental compositions and sound/image works, examples include *Anthozoa* (2011) and *frostbYte: cHatTer* (2012).

Jordan Lacey is a sound artist and urban soundscape researcher. His 'Sonic Ruptures' framework advocates for urban sound installations aimed at positively influencing

affective relationships to urban soundscapes and spaces (Lacey 2016b). Through creative manipulation of preexisting anthropophonic sounds, Lacey's installations alter and reorient listener experiences of soundscape and place.

Timothy Opie is a composer, best known for his creative framework, 'Ecostructuralism'. Says Opie, "it is a method for composing with the situated sound samples in a manner that is designed to reveal and retain the qualities of those sounds and contexts. Sound recordings are analyzed, and the resulting data is mapped onto resynthesis processes to create new audio material, or the data is used to arrange the sound recordings" (Opie & Brown 2006, p. 11).

Garth Paine is a composer and sound artist, and director of the Acoustic Ecology Lab, Arizona State University, with musicologist Sabine Feisst. Recognised as "an innovator in the field of interactivity in experimental music and media arts", Paine has developed various ecological sound art works within the Listen^{N} Project, "an Acoustic Ecology project that focuses on field recording and community building". Specific outcomes include *EcoRift*, a "virtual reality experience of being in national parks and preserves of the American Southwest", *EcoSonic*, a "psychoacoustic environmental monitoring kit" (AEL undated), and *Future Perfect*, an IRCAM and ZKM-sponsored work employing higher-order ambisonics, wave-field synthesis, and mobile technologies (Heino 2018).

Andrew Skeoch is a field recordist who, with partner Sarah Koschak, established the Listening Earth recording label in 1993. At present, the label features 80 albums of Australian and international soundscape and wildlife recordings, "documenting the sounds of iconic landscapes and threatened ecosystems" (Skeoch 2016).

In South Australia, there are a number of people operating in the Acoustic Ecology and ecological sound art fields.

Tristan Louth-Robbins is a sound artist whose Acoustic Ecology-influenced works engage with South Australian places, particularly his native Fleurieu Peninsula and also in the Adelaide metropolitan area. He facilitates the *Fleurieu Sound Map* (since 2011), an online

repository of soundscape recording from Fleurieu Peninsula sites considered of "geographic, phenomenological, aesthetic or historical significance". Recent works include *Goyder's Line* (2014-17), which sonifies the historical and contemporary revision of Goyder's 'Line of Reliable Rainfall', and *Oblique Territories* (2018), a body of work" [encapsulating] aspects of Port Noarlunga's unique sonic environment" including a multichannel sound installation (Louth Robins 2018).

Jason Sweeney is a composer and sound artist, whose environmentally-inclined work has had a strong connection to urban spaces. Sweeney says of his home city, "Adelaide is a prototype for what a developed city in the western world could be like if it maintained levels of quiet as a way of being, as a way to think about the future" (Prato 2013). This has manifested as *Stereopublic: Crowdsourcing the Quiet*, "a participatory art project and smartphone app that maps the quietest spaces within a city" (ibid.). With an affinity for Schafer's ideas of urban soundscape listening and design, the app invites participants to record their favourite quiet spaces in cities and upload them to the Stereopublic database, documenting such acoustic environments for others to discover and explore.

Sasha Grbich is an interdisciplinary artist whose work 'explores how art performs with audience and in local environments' (Grbich 2018). Her sound-based works have focussed on soundscape phenomena and experience, such as the performance art *Very Local Radio* (2014, 2015) where the artist "navigated city streets, pushing a shopping trolley loaded with sound recording gear and an internet radio transmitter", and *Small Measures (Auckland)* (2017), a collaboration composition juxtaposing threatened ecosystem soundscapes with responsive singings of place by Auckland's Oceania Choir (Purvis 2018). Her MOD commissioned work, *Sit Down With…*, invites the audience to sit in speaker-encrusted chairs, replaying soundscape recordings of places connected with the gallery and the greater Adelaide CBD (MOD 2018).

3.3 - Summary

As seen in Chapter 2, Soundscape Ecology provides a diverse array of conceptual frameworks and methods that can be employed in creative engagements with place. As a

science-based conjunct, Soundscape Ecology offers a diverse range of concepts, frameworks and methods.

Chapter 3 subsequently reviewed an array of creative sound approaches from a historical and contemporary view point. As summarised by Opie and Brown,

> The influence of nature as a compositional stimulus has long been a feature in music making. The imitation of nature has evolved and more recent composers have created abstract works inspired by their observations of natural structures. With the advent of recording devices composers harnessed the sounds of nature and manipulated them sonically, either taking them out of context, or highlighting their sonic context through signal processing. Composers have also sought to create conceptual models of nature to explore musical ideas (2006, p. 12).

In parallel with the emergence of Soundscape Ecology and Ecoacoustics, various practitioners from the Acoustic Ecology and Ecoacoustics communities have developed creative works informed by science research and practice. David Monacchi and Bernie Krause with the Acoustic Niche Hypothesis, and conservational approach to creative field recording practice (especially through the aesthetic juxtaposition of biophonic and anthropogenic elements), and Leah Barclay with community (human) engagement with soundscape, both through interdisciplinary collaborations (Biosphere Soundscapes) and mobile technology interfaces. Damián Keller's 'eco-composition' framework applies ecological considerations to each stage of creative practice, including audiovisual material interaction, sound synthesis, sound processing, spatialisation, audience/artwork interaction and musical analysis (Keller & Capasso 2006, p. 62). Similarly, Opie's eco-structuralism undertakes a multistage development of creative works through analysis of field recordings, attribution of data, data mapping and sound generation through a strict algorithmic process. Each of these frameworks, however, predates the emergence of Soundscape Ecology as a discipline, and while dealing with ecological ideas in a compositional setting, do not specifically work with Soundscape Ecology frameworks, concepts or methods. Connors' more recent Ecological Performativity framework too considers site-specific engagement through collaborative performativity between "people, places and things moved "in a dance of agency" via Pickering that [explore] co-creative

processes to tease out … emergent paradigms of expression" (Connors 2017, p. 133). In Connors' application, Ecological Performativity is concentrated predominantly on installation rather than concert settings, which this research project incorporates in its outcomes, and is infused with generative visual components and improvisational musical contributions, creative interests with which this research project does not seek to engage.

However, such creative endeavours have typically explored specific aspects of acoustic environment, and given the recent introduction of Soundscape Ecology frameworks and methods, have not explored this discipline's approaches. As such, there remains scope to explore the possibilities of adapting Soundscape Ecology research to a framework of creative practice, as well as the opportunity to explore and refine such a framework through site-specific works. These possibilities addressed in the following chapters: Chapter 3 establishes the creative framework, 'Ecotonality', which adapts Soundscape Ecology principles, frameworks and methodologies to creative process, and Chapter 4 in its exegetical analysis of four ecological sound art works exemplifying this approach, responding to South Australian places, their ecosystems, soundscapes and identities.

4 - Ecotonality

> *Listening and hearing come in to being in a given time and place. The time and place of utterance shapes the content just like the physical features of the land shape the sound. Each site is an acoustic place with its own history, stories and groups of influences. Each story endorses an aspect of it, choosing to articulate some factors over others in a certain style… Through listening to the multiple stories of each site, we can come to hear the conscious and subconscious processes, which are constantly changing the processes of the evolution of… identity… [and as a result], more fully understood.*
>
> *Hearing Australian Identity*, Ros Bandt (2001)

This chapter expounds on Ecotonality, an ecological sound art framework which adapts Soundscape Ecology principles, frameworks and methods for site-specific creative works.

Resulting from practice-led research, Ecotonality has emerged through multiple stages of theoretical development, implementation in case studies, and post-creative project reflection, arriving at a refined six stage process which encourages the creative practitioner towards effective engagement and response to place, ecosystem, soundscape and identity.

4.1 - Background

Before launching into a discussion of Ecotonality, some preliminary considerations of Acoustic Ecology, agential realism and Dark Ecology perspectives on Soundscape Ecology are necessary.

4.1.1 - Acoustic Ecology Perspectives

First, the methodological and epistemological critiques of Soundscape Ecology by the Acoustic Ecology community are pertinent in relation to creative practice. Founded in the creative-inclined research associated with the World Soundscape Project and soundscape composition, Acoustic Ecology's consideration of audio recording fidelity and quality is of crucial importance for the creative result. Given the compromises in Soundscape Ecology recording practice noted by Barclay and Gifford (explored in Chapter 1), it is probable that

the resulting audio quality from this activity is insufficient for artistic application. As such, it is antiquated that the creative practitioner will balance the volume-veracity equation in the opposite way to the Soundscape Ecology researcher, privileging audio quality (high bit rates and sample rates, minimal compression, and spatial recording techniques) over quantity (duration). Understandably, this may necessitate extended site engagement to acquire sufficient data, as well as increase the need for sufficient storage media for longer duration recording periods.

Acoustic Ecology's concern about the absence of listening from the Soundscape Ecology process of fieldwork, analysis and presentation of research is also of fundamental importance here. Given that ecological sound art works are intended to be heard, it is thus necessary that the creative practitioner involves listening throughout the creative process, from conception and collation of data, through preparation of materials and composition of the work, to the realisation of the work for an audience and, ultimately, the reflection on the work's outcomes. Further discussion of this can be found in the work of Hildegard Westerkamp (1988) and Lawrence English (2017).

Modes of listening should be also be considered, such as those of Truax (background listening, listening-in readiness, listening-in-search) (2001), Chion (causal listening, semantic listening, reduced listening) (1994), and Burt (meditative listening, scientific listening, reduced listening, defensive listening, semiotic listening, analytic listening, deep listening, directed 'composed' listening, normal 'musical' listening, cinematic listening, ironic 'distanced' listening, purposive verbal listening, wholistic linguistic listening, paranoiac listening, internal listening, dream listening) (2009). Listening modalities contextualising the ways in which the creator, performer and audience will experience a creative work, and thus inform a compositional site-specific approach. For the composer, listening forms an integral part at all stages of the creative process, from field work and recording to composition and performance, and orients compositional methods when considering the roles of the performer (who will engage with performance material in ecologically sensitive ways) and audiences (who bring their own lived experiences and referents to their reception of the work).

It is also important to clarify the uses of temporal terminology. In Soundscape Ecology, a variety of temporal scales are investigated, ranging from individual calls and sound events (as identified through analysis of field recordings, to broader concerns of diurnal, seasonal and climatic soundscape patterns. In *Microsound* (Roads 2001), Roads presents various time scales of creative sound practice, gradated from the Infinite to Supra, Macro, Meso, Sound Object, Micro, Sample, Subsample and finally Infinitesimal. Correlating this continuum with Soundscape Ecology concerns, one can see that diurnal, seasonal and climatic soundscape patterns share temporal boundaries with Road's Supra (days, months, years) and Macro (hours, minutes) scales, and hence represent macromorphological formal concerns. Similarly, individual calls and sound events connect with the Meso (phrases) and Sound Object scales, representing micromorphological creative materials. As such, subsequent discussions of macromorphological and micromorphological will refer to these time scales articulated above, and not to smaller intervals beyond the level of the Sound Object.

4.1.2 - Agential Realist Perspectives

Similarly, the critiques of Soundscape Ecology offered by agential realism problematise assumptions of subject-object duality, apparatus, and agency in Soundscape Ecology, revealing potential avenues for exploration within creative practices.
As outlined in Chapter 1, agential realism reconfigures the subject-object duality to an understanding of the implicit involvement of the research-observer at all stages of research, whereby human and (biotic and abiotic) nonhuman entities, attendant environment, ecosystems, sociocultural and political forces intra-act with the researcher-observer. Consequently, the researcher's decisions on experimental design and choice of equipment are influenced and in turn intra-act with the influencing their decisions in experimental design and equipment throughout the research process, which in turn intra-act with the aforementioned phenomena. This has been long understood by creative field recording practitioners, cognisant of the impact that creative intent, equipment choice, field recording practices and post-recording analysis and editing have upon the resultant work (English 2014; Krause 2002; Ratcliff 2017).

The reconceptualisation of the apparatus as describing the intra-active possibilities of material-discursive practices, shifting Soundscape Ecology's apparatus from field recording equipment towards the broader field recording practices, draws attention to the inherently perspectival reconfiguration of an acoustic environment's material and spatiotemporal circumstances. Consequently, following from the discussion of the researcher-observer impact on results above, agential cuts can be recognised as an integral part of the creative process, with the creative practitioner implicitly involved in reconfiguration and representation of place, ecosystems and soundscapes towards creative ends.

Similarly, the reconceptualisation of agency, not as an attribute of an entity, but as emergent through intra-activity (of phenomena and/or apparatus) provides scope for further exploration of this at each stage of the creative process. Of particular interest is the means in which this agency can be an integrated aspect of the resultant creative outcome (through the micro- and macromorphological structures of the works, as related to acoustic instrumental performance and electroacoustic composition), and particularly the ways in which nonhuman agency, both biotic and abiotic, can be involved in creative works.

4.1.3 - Dark Ecology Perspectives

This consideration of non-human agency is vital for contemporary ecological engagement and activism, as recognised Dark Ecology. Morton urges for human reconnection with the nonhuman, and recognition of human enmeshment within ecosystems as an important means of breaking down the human/Nature divide implicit in the practice of agrilogistics. For Soundscape Ecology, this is achieved through the analysis of recordings, which represent the nonhuman through biophony and geophony (and in the form of abiotic technology, anthropophony). Consequently, for ecological (sound) art works, "art that includes its environment(s) in its very form" (Morton, T 2018, p. 52), biotic and abiotic nonhuman agency (again, as intra-active process, and not as attribute) may be expressed through micro- and macromorphological relationships, revealing to an attentive listener

the deeply entangled ecological relationships of humans and nonhumans in the environment.

Additionally, Morton's coupling of agential causality with aesthetics allows artistic works to be understood as vehicles for nonhuman advocacy, capable of influencing human behaviour and attuning creative practitioners, performers and audiences to place, ecosystem, and soundscape. Thus, for Soundscape Ecology, creative practice presents itself as an appropriate and effective means of engaging with a broad public audience, capable of fostering ecological awareness and activism.

4.2 - Ecotonality

Following the literature review of Soundscape Ecology and Ecoacoustics, Acoustic Ecology and ecological sound art approaches, I began devising the creative framework developed through this project. Initially, the stages of the creative process were identified through an autoethnographic reflection on my creative process to date. The stages are:

- Conception (of the work)
- Collation (of creative materials)
- Preparation (of materials for creative treatment)
- Composition (-al assembly of materials)
- Realisation (of the resultant work)
- Reflection (on the creative outcomes and process)

Following this, I began the process of mapping and adapting Soundscape Ecology frameworks and methods to the creative process, resulting in a creative framework-in-development.

The framework-in-development was then implemented in site-specific creative responses to four South Australian sites (discussed further in Chapter 5), from which questions, challenges and discoveries emerged through the development and presentation of each work. In the Reflective stage (which operates as a feedback loop to further refinement of

the creative process), these insights interrogated the framework-in-development, thereby cultivating more nuanced and flexible understandings of each stage of the process. Subsequently, the improved creative framework was implemented in new creative works, allowing for a further cycle(s) of the reflection and refinement process.

The outcome of this reflective practice-led research is an approach called 'Ecotonality' or the 'Ecotonal Creative Framework', a framework situated in the broader field of ecological sound art. The term, 'ecotonal' is derived from the prefix, 'eco-' (as related to ecology) and 'tonos' (tension), and has various understandings. In one sense, it is a play on the particle,' eco-' and word 'tonality', inferring ecological themes in connection with the idea of musical tonality (finding the tonality or tuning of an ecosystem). More specific to Soundscape Ecology, the term bears a resemblance to the idea of an 'ecotone', a region of transition between two (biological) communities. While applied in the ecological sense to material circumstances, its application here points at the process of transition and tensions between scientific and artistic modes of engagement with place, and associated ecosystems and soundscapes, rendered as data and creative materials.

4.2.1 - Conception

Research

Following the first crucial step in selecting a site, conceptual research can begin. In order to make informed and effective plans throughout the compositional process, it is necessary to research the multiple perspectives of the place. Multiple sources of information (i.e. documentation, maps, field recordings, artefacts, oral transmission) may be reviewed, including ecological, environmental, historical, sociocultural and spiritual sources. Collectively, this allows for contextual understandings of the site's contemporary environmental circumstances and resulting ecosystems, soundscapes and identity.

Sketching

Following the research, preliminary sketching draws together the multiple perspectives of place, providing creative contexts. The formal parameters of the work, including the

duration, media (whether acoustic, electroacoustic, or a combination), and performance space may be considered, though not necessarily adopted to allow the influence of engagement with place and the investigation of creative materials over the outcome of the work. As Westerkamp notes of her soundscape compositions:

> A fundamental truth about soundscape compositions is that they *emerge*, they can only be pre-planned to a limited extent. The sonic materials bring about the essential structures and sound development of the piece just as words bring about a poem. And this can happen in very subtle ways. Not only do we never know what kinds of sounds/ soundscapes we gather when we go out recording for a piece, but often we cannot anticipate what is revealed to us when we listen to the recorded sounds and when we start editing, mixing and processing them. Environmental recordings never give us sound objects, i.e. isolated, singular sounds recorded in a quiet studio environment, they give us sounds within a context of other sounds, indeed a whole soundscape. It is precisely this context that guides the composer's decisions of how to work with the available sound materials. The emergence of a piece is not unlike getting to know a soundscape itself, its rhythms and shapes, its atmosphere (Westerkamp 2002, p. 54).

Consequently, sketching may not result in a definitive structure, but rather guide as to how the site might be engaged, and with which perspectives it might be examined.

Planning

The research and sketches consequently inform planning for field work engagement with place during the Collation stage, as well as the delivery of the final creative outcomes. Much like Soundscape Ecology field work, appropriate equipment for recording, monitoring and documenting, as well as field resources, including clothing, food, accommodation and amenities, will need to be considered, with respect to the location's conditions and preliminary creative concepts. Additionally, plans should also be made for the work's presentation, liaising with relevant ensembles or organisations to present the work successfully.

4.2.2 - Collation

The plans made during the Conception stage are then practically applied during the Collation stage. This can also be understood as 'engagement with place', involving fieldwork, recording and collection of resources (materials, information and ideas) for the creative response. Particular activities may include:

Soundwalks

A predominant activity of Acoustic Ecology, sound walking on location allows the creative practitioner to become familiar with the acoustic attributes of place, informed and contextualised by the information gathered during the Conception stage (Allen 2013; Schafer, R Murray 1993). Dependent on the mode of listening, the listener may also garner insights into the place's ecological, technological, socio-political, spiritual and historical domains.

Observation and Documentation

This involves various activities, including quantitative data measurement and collation of biological, geological, meteorological and anthropogenic phenomena (in association with field recordings, discussed below), and qualitative observations of environmental and soundscape activities (for example, R. Murray Schafer's phenomenological considerations of notation, classification, perception, morphology and symbology (1993)).

Consultation

Consultation may involve liaising with people associated with the place of research (i.e. those living or working there) and reviewing documented materials often reveals more specific and intimate knowledge and perspectives (Schafer, R Murray 1993).

Field Recording

Field recording constitutes a predominant activity of the Collation stage. As pointed out in Chapter 1, many of Soundscape Ecology's concern with acoustic recording are relevant to creative field practices, including creative intent, equipment, recording setup (position and direction of microphones, temporal aspects of operation, gain settings, sample and bit rate, compression and file format (Maggs 2018)) and ethical considerations. The approaches and methods of established practitioners, including Chris Watson, Bernie Krause, Jez Riley French, Yannick Dauby, Lawrence English, Annea Lockwood, Douglas Quin and David Monacchi, may be gleaned for insights.

With long-duration recordings desired so as to capture appropriate temporal cycles, consideration should be given to appropriate recording equipment. Artistic practices advocate for higher quality microphones and recorders to ensure high fidelity recordings, but are often deployed for short-duration recordings to minimise environmental damage to equipment. By contrast, Ecoacoustic recording practices are known to employ recording setups which prioritise long-term field exposure and long-duration recordings, often with trades on audio quality (i.e. reduced sample and bit rates). Given the intersection of Acoustic Ecology and Ecoacoustics practices within Ecotonality, the interest in long-duration recordings again puts audio fidelity, audio duration and equipment durability in competition. These concerns factor into field recording equipment selection, with increased storage media offering the best solution to minimise any tradeoffs, and appropriate housing for recording equipment to prevent environmental deterioration or wildlife defilement.

Of equal consideration is the creative concept, which informs the selection of recording equipment in response to playback format. Monacchi views recording and reproduction as "interrelated processes" and "[proposes] a classification that considers the 'recording space' as integrated with the 'reproduction space'" (2011, p. 2). These are 'space-selective' techniques (employing mono or stereo directional recordings systems for monophonic or stereophonic reproduction), space-inclusive (employing omnidirectional recording systems of the spherical sound field for two-dimensional (surround) reproduction) and

space-conservative' techniques (employing binaural and ambisonic recording systems for three-dimensional reproduction). Dependent upon the conceptual plans for the work (and compositional outcomes), the practitioner will use employ appropriate recording equipment for spatial reproductive purposes.

In the field, practical and ethical concerns become equally important, with local conditions and politics impacting on the recording process. Adequate time should be allowed to determine the least impactful approach to the field recording sessions well as to test recording equipment in the field, informing decisions such as microphone positioning, times of operation (and active attendance vs. passive automated recording), appropriate gain settings and power consumption. Additionally, logistical concerns of environmental conditions and personal wellbeing also factor in, as Chris Watson discusses:

> you have to be prepared for your environment… because if you're cold, wet and uncomfortable then you're not going to record. One of the things I'm most interested in doing is getting away from the microphone, creating some space between myself and the microphone. I do very little recording where I stand there holding a microphone, because with my work, if it's wildlife, nothing comes close. I'm much more interested in getting microphones into places where you wouldn't ordinarily want to put your ears, so we're putting microphones in the middle of bushes and thorn bushes. Make sure you're comfortable with your recording environment; make sure, if you're going out 03:30 in the morning, that you can operate your equipment in the dark. Make sure you get a recorder you can operate with gloves on. Practical things, but the main thing I think is useful in achieving something different is to get away from the microphones (Ableton 2016).

Similarly, ethical sensitivity and political implications of recording endangered sounds, culturally-sensitive sounds, sound ownership should be considered, particularly as related to ecologically-compromised environments, First Nations cultures and copyrighted material. As recordist Yannick Dauby notes:

> Presenting and sharing sounds of environment, an endangered species, a threatened ecosystem or a dying cultural practice, of course have some effect on the audience, but most of the time it would require bringing the contexts of sounds, telling stories and use the

listening to engage a discussion or a reflection. In some aspects, it is a work which is not unrelated to composition (Ableton 2016).

Co-operation with local political authorities or custodians may also be necessary. For example, protected natural environments (such as the National Parks of the US or Uluru-Kata Tjuta National Park in Australia's Northern Territory) may require a permit and/or fee for sound recording, in the interest of protecting natural or cultural resources.

Further discussions of field recording in natural soundscapes can be found in Krause (2002), Isaza (2010), English (2014), Ratcliff (2017) and Ableton's article, *The Art Of Field Recording* (2016).

4.2.3 - Preparation

In the context of creative practice, the Preparation refers to the analysis and development of materials garnered in the Collation stage for creative application.

For creative activity, it necessary to relate Soundscape Ecology to musical/sound art concerns, in the interest of gleaning information on the content (the mimetic relationship between materials and source) and context (ecological relationships and processes) (Monacchi 2011; O'Callaghan 2012) offered through Soundscape Ecology analysis.

As noted in Chapter 1, Soundscape Ecology's analyses investigate parametric acoustic patterns, including frequency, temporal, amplitudinal, spatial, and interactional patterns. Similarly, music and sound art are noted for the variety of elements that constitute them. Burton proposes a flexible system capable of dealing with the diverse practices involved in contemporary creative sound practices (music and sound art alike), specifying three essential elements: sound, structure and artistic intent (2015, p. 26). Sound, he argues, can be divided into single source attributes, including:

- pitch: 'represents how the mind perceives the cycles, repetitive nature of sonic vibrations', i.e. the perception and cognitive organisation of sonic frequencies.

- duration: 'represents the onset and offset signals created by nerve responses to sounds', or rather, the perception of temporal phenomena of sound, including pulse, rhythm, sound duration and tempo.
- loudness: 'represents the totalled number of auditory nerve stimulations over short cyclic time periods'. Perceptively, this relates to amplitudinal phenomena including dynamics and articulation.
- timbre: 'represents the product of information gained from frequency transients, noisiness, unsteadiness, perceived pitch and the spread and intensity of overtones in a sound, all of which is used to identify the sound'.

Moving beyond single sound sources and considering the total sonic environment, further attributes include:

- texture: 'relates to the number of sound sources and the interaction between them'.
- spatial location: 'represents the cognitive placement of a sound in an environmental context; including the placement of a sound on both the horizontal and vertical plane, the distance to the sound source and the characteristics of the sonic environment'.

The two additional musical elements are as follows:

- structure: an inherent part of the compositional act is synthesising sonic elements into meaningful structures as, "if music is to communicate information of any form, sounds need to be structured in an understandable way." (ibid., p. 26)
- artistic intent: as music is an art form, it is reasonable to consider 'the disposition or modification of things by human skill to answer the purpose intended' (Webster 1947) as an integral element. As Burton argues: "in this context, the art of the music composer is to affect the listener by structuring or organising sound. The art of the (music) listener is to organise sound into meaningful patterns; whether the patterns are intentional, as when listening

to a symphony, or environmental, as when listening to the gentle, rhythmic tinkle of wind chimes or John Cage's *4'33".*" (ibid.) As a result, artistic intent refers to either a composer's intent in composing music or a listener's intent when listening to sounds as music.

A basic associative rubric can thus be developed, connecting Soundscape Ecology parameters with sounding art elements (Table 1):

Soundscape Ecology Parameter	Sounding Art Element(s)	Potential Applications
Frequency Patterns	Pitch, timbre	Pitch, timbre, melody, harmony, orchestration
Temporal Patterns	Duration	Pulse, rhythm, duration, tempo, patterns, cycles, structure
Amplitudinal Patterns	Loudness	Dynamics, spatialisation (distance)
Spatial Patterns (and gradients)	Spatial location	Acoustics, performance presentation (spatialiation, sound sources, staging)
Interactions	Texture	Counterpoint, orchestration, structure

Table 1: Correlation of Soundscape Ecology parameters and sounding art elements (as per Burton 2015)

Consequently, this basic framework establishes associative relationships between soundscape and musical resources, providing a means of identifying the various attributes of a recorded sound, data structure or informatics, and connecting it with modes of potential creative treatment.

Analysis

Initially, analysis of the materials is necessary to not only extract information about the content and context of each resource but also inform the transformative techniques that will adapt them to a musical context. This might be quantitative analysis, assisted by technology, to measure materials and calculate metrics; or qualitative analysis, involving

subjective evaluation of the materials, with reference to Schafer's considerations of notation, classification, perception, morphology and symbolism(1993).

Given the predominance of spectrally-oriented methodology and practice in soundscape ecology, it would be remiss not to acknowledge the existing body of creative research and work found in the technical and aesthetic insights of the eponymous 'Spectralist' movement. Emerging from the efforts of Hughes Dufourt, Gerard Grisey, Tristan Murail and others working at Institut de Recherche et Coordination Acoustique/Musique (IRCAM) in Paris in the late 1970s and early 1980s, spectralism employed computer analysis to determine acoustic properties of recorded or synthesised sound, subsequently used as compositional materials.

To this end, a spectralist-derived theoretical framework appropriate to Soundscape Ecology and ecological sound art sonic analysis is useful. One such example may be extrapolated from Hirs' analysis of Tristan Murail's *Le Lac*, which details a four-step process of analysing and processing sound and data materials as part of composition, paraphrased as follows (Hirs, p. 67):

1. "Preparatory Step: choosing sound samples and analysing them"

Here, the creative practitioner begins by listening analytically (with or without the assistance of a spectrogram) to the recordings made during the Collation stage and sampling the materials they wish to develop further.

2. "Importing Step: Importing the analysis data into a processing (audio editing) environment"

Here, the sound samples are imported into an environment appropriate to the intended analytical task, and rendered appropriately (whether graphically as a spectrogram or waveform, or as textual/numerical data).

3. “Processing Step: Selecting data, processing of the selection, showing the data or processed result in appropriate form (notation, waveform, etc.)”

Here, the creative practitioner analyses the selected samples’ acoustic attributes and applies appropriate transformative techniques for creative application. As such, the creative practitioner may analyse according to each acoustic parameter:

- Frequency Patterns, Pitch and Timbre: in an Ecotonal context, recorded material may be spectrally analysed to determine particular (ecological) behaviours of the biophony, geophony and anthropophony, and ascertain data related to their frequency and spectral profile.
- Temporal Patterns, Cycles and Duration: As noted in Chapter 1, temporal cycles and related patterns in a soundscape exist at multiple levels. Diurnal and nocturnal cycles, as expressed in dawn and dusk choruses and their intermediate periods, constitute the micro-scale. Seasonal cycles relate to the mesoscale, as climatic (and even planetary) cycles relate to macro-scale temporal activity. As such, these temporal relationships and correlated ecological activities may be ascertained through audiovisual feedback (using spectrograms) or complementary environmental and place-related data sources (meteorological information, oral/written histories).
- Amplitudinal Patterns and Loudness: Analysis of amplitudinal patterns across different temporal cycles allows the creative practitioner to determine loudness peaks and troughs in different temporal scales, and the balance between biophony, geophony and anthropophony (a concern shared with Interactions below). Additionally, amplitudinal patterns may also indicate spatial information, based on a sound’s position in the field and the qualities of its representation (attenuation, phasing) in the recording.
- Spatial Patterns and Spatial Location: analysis of spatial aspects through recordings allows the creative practitioner to determine relationships between sounds and their sources relative to the recording setup, and such information about the positioning of these sounds for creative employment. This may be further enriched

by complementary non-audio (geographic, topographic, historical) information sources.

- Interactions, Texture and Orchestration: Using combinations of the above parameters, and knowledge from other (ecological, environmental, sociocultural, political, and spiritual) perspectives, the creative practitioner may identify interactions between biophony, geophony and anthropophony, and by extension the interaction between their sources in the environment. This affords information appropriate for source-based counterpoint, orchestrational techniques (especially between acoustic instrumentation and electroacoustic media), and broader contexts in which the creative work may be placed.

Having related the above acoustic properties to sounding art aspects, the transformation of soundscape materials from recordings or information into compositional materials may take place.

Additionally, sensitivity must be employed to preserve semiotic content and environmental context. As noted by the eco-field hypothesis in Chapter 1, sounds are carriers of meaning, signifying ecological resources or activities in an environment. The identification of these acoustic signals relies upon successful transmission between sender and receiver, and as such, the retention of timbral/formant structure of the signal. Degradation of the signal by environmental or acoustic interference compromises the ability of a listening agent to interpret the information conveyed by the environment or communicated by other agents. Adapting this observation to Ecotonality, the transformation of soundscape materials necessitates retaining sufficient timbral content in order to convey the semantic information associated with a sound, for both human and nonhuman listeners alike.

Concerning soundscape composition practices, Truax establishes a continuum of compositional techniques - sonification ⇔ phonography ⇔ abstraction (Truax 2012, pp. 194-195) - that may be applied to creative materials, described as follows:

- Sonification: "involves processes that map the real world onto sound" (ibid., p. 194). Typically, data is mapped onto sonic parameters, conveyed through 'auditory display'. Alternatively, 'audification' involves literal interpretation of data as an audio waveform. Sonification has become a popular tool in communicating data structures and patterns (Grond & Hermann 2011; Kramer et al. 2010).
- Phonography: "endeavours to map the real world onto sound recordings that are usually not further manipulated other than undergoing transparent editing or mixing" (Truax 2012, p. 195).
- Abstraction: here, compositional materials begin to shift into the virtual or hyper-real, where according to Truax, "compositional manipulation is intended to invoke the implicit aspects of soundscape perception, that is, the inner world of memory, metaphor, and symbolism" (2012, p. 195). In Ecotonal treatment, abstractive techniques are best applied with consideration to ecological contexts and aim at retaining essential spectral elements necessary for successful signal transmission and conveyance of semiotic information.

These categories can be applied in both acoustic instrumentation and electroacoustic media situations. For acoustic instrumentation, this may involve:

- Sonification: as above, this involves the association of acoustic parameters to data structures, typically pitch, but potentially also duration, loudness, timbre and spatial dimensions.
- Transcription: this involves the translation of environmentally-sourced sounds into content for acoustic instrument playback, typically conveyed through a form of visual communication (whether music notation, graphic images or textual instructions). While this has historically been done aurally, computer-aided transcriptive approaches are used contemporarily, with various software packages (such as SPEAR, Open Music, Audiosculpt, and Orchideé) providing detailed spectral information or music notation (O'Callaghan 2012, 2013). O'Callaghan terms this computer-aided technique 'mimetic instrumental resynthesis', a "technical practice and an aesthetic motivation" rooted in spectralist approaches which seek to "use 'extra-musical' source materials as the [analytical] starting

point… also [attempting] to preserve aspects of the source sound through the transcriptive process to engage in a mimetic discourse" (2015, p. 235).

- Abstraction: this involves the development of abstract musical/sonic structures and activity, derived from site-specific sources, using ecological sounds, behaviours or activities as source material or points of departure for more abstracted content.

For electroacoustic media, there are comparable techniques:

- Sonification: while there is obvious potential to employ sound synthesis in the service of sonification, an Ecotonal approach may additionally use data to manipulate particular parameters of sound samples, such as pitch shifting or changes in loudness. Sonified data sets employed in an electroacoustic context maybe pre-established (drawn from existing records) or streamed from live sources (such as barometric data or traffic data) as appropriate to the work's spatiotemporal contexts.
- Sound processing: dealing here with micromorphological content, sound processing techniques may be associated with specific acoustic parameters, allowing the practitioner to infer ecological relationships and circumstances through strategic sculpting. Potential applications include:
    - Frequency shifting and filtering (equalisation)
    - Temporal warping and scaling
    - Spatial techniques including panning, sound level mixing and artificial reverberation (especially convolution)
- Abstract techniques: Although Ecotonality maintains an interest in working with materials associated with place (and a general avoidance of introducing abstracted materials into a site-specific work), there may be contexts in which abstract electroacoustic techniques may be employed. In particular, urban spaces, which feature continuous sounds emitted by modern technologies, may warrant the use of modular synthesis or granular synthesis to develop spectromorphologically-similar sounds.

Though by no means exhaustive, these techniques demonstrate how site-specific collated content may be developed to acoustic and electroacoustic compositional materials in an Ecotonal context.

4. "Exporting Step: Quantizing the musical material to discrete music notation, exporting the data to a notational program); exporting the data to a sounds synthesis platform"

Here, the creative practitioner renders the developed material into an appropriate form, whether as a textual representation for acoustic performers (music notation, graphic notation or text-based instructions) to be integrated into a score or as a rendered sound sample to be formally positioned in a software-based audio workstation.

4.2.4 - Composition

Connected with the Preparation Stage is the Composition Stage, which can be understood to focus on the larger spatiotemporal scales and contexts, or the organisation of micromorphological materials within macromorphological contexts. This stage will often relate to large scale ecological processes and behaviours, including dynamic geographical, climatic, behavioural and morphological processes.

These contextual relationships are ascertained through observations made throughout each of the previous stages of Conception, Collation and Preparation, as related to literature review and sketching, fieldwork observation and recording, and analysis and development of compositional materials. Subsequently, the creative practitioner will seek to adapt and represent these relationships within the formal, or spatiotemporal, aspects of the creative response.

Formal Aspects

Again concerning soundscape composition practices, Truax (2002) presents a continuum identifying three different perspective-based structural approaches described by their spatiotemporal qualities:

1. a fixed spatial perspective emphasising the flow of time, or a discrete series of fixed perspectives
2. a moving spatial perspective or journey emphasising a smoothly connected space/time flow
3. variable spatial perspectives emphasising a discontinuous space/time flow.

The juxtaposition of static and dynamic perspectives presented here emerges from soundscape composition electroacoustic practices, wherein the composer (often assuming a static audience listening position surround by speaker array) crafts the soundscape to suggest static or dynamic spatiotemporal perspectives. Within Ecotonal creative practice, each of these may be employed (even within a single work), dependent upon the site-specific ecological contexts and related creative concept.

While space and temporality are inherently connected in both sound-based ecological and artistic contexts, each has particular concerns as related to Ecotonal site-specific works. As described in Chapter 1, Soundscape Ecology establishes its temporal domain at larger scales, beginning with day and night cycles for micro-temporal patterns, seasonal cycles for meso-temporal patterns, and climatic cycles for macro-temporal. However, within the scope of creative practices, works are often of much shorter duration or have experiential limitations. Conventions for concert works determine limitations on work durations (typically 10 minutes to two hours) and necessitate terminal boundaries (beginnings and endings). Consequently, temporal scaling may be employed, contracting larger chronometric periods (hours, days, years) into smaller durations (seconds, minutes, hours). Alternatively, installation-based works allow for great temporal flexibility, operating potentially for much longer durations on a cyclical basis, and experientially

limited only by the listener, who may enter and exit as they please (according to the logistics of the exhibition space).

Similarly, spatial aspects related to the material circumstances of the site-environment and the agents (human and nonhuman), as well as spaces and reproductive technologies involved in creative outcome can mutually inform one another.
The foundation of the creative work's spatial relationships is the 'soundscape' component, featured as representative audio of the broader acoustic environment (in multichannel speaker arrays), and by the surrounding environment (if performed in-situ). Selection of an appropriate reproduction system may be made with reference to the reproduction and associated recording techniques offered by Monacchi (discussed earlier), including spatial-selective techniques (reproducing in in monophony or stereophony), spatial-inclusive techniques (reproducing in stereophony, quadrophony, octophony and surround formats), and spatial-conservative techniques (reproduction in binaural systems or ambisonic systems).
Like Truax's framework above, these techniques assume a fixed listening perspective, and consequently may require additional studio techniques (such as panning, filtering, reverberation and level mixing, and the introduction of new soundscape content (i.e. recordings of other environments, sounds contextually associated with different environments) to engender changes in spatial perspectives beyond that offered in the recorded materials. Additionally, basic translation of the geographic and topographic relationships (i.e. distances) in the environment may require contraction to replicate the vaster proportions within the performance space, achieved through scaling, or using cardinal directions as a means of orientation.
The selection of the specific reproductive system may inform or be informed by the performance layout, allowing the creative practitioner to determine the location of the performers, whether inside, on, or outside the boundaries of the speaker setup. Further spatial dynamics may be encouraged through the movement of performers throughout the space. These considerations are further complicated where creative works allow for audience movement within a space (especially in installation-based works), and such arrangements may influence the presentation layout and spatiotemporal elements of the work.

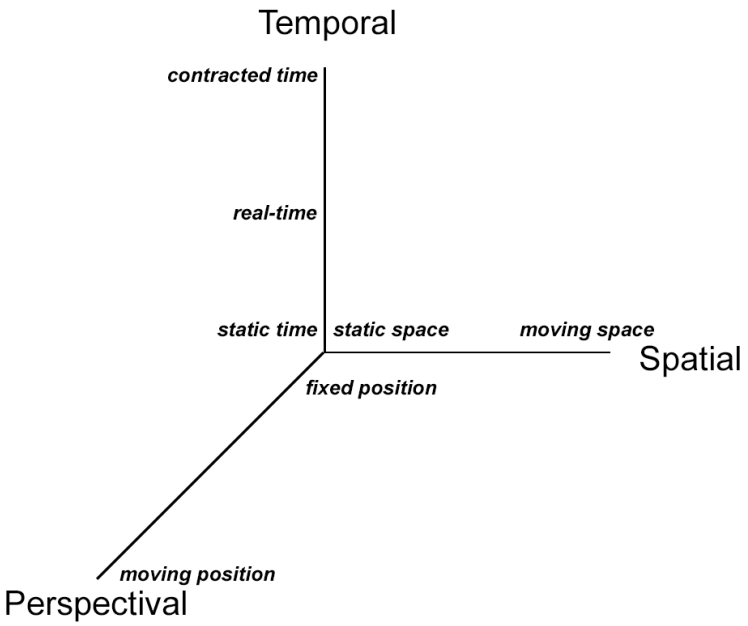

Figure 1: Macromorphological Formal Framework

From this, a basic formal framework may be devised, in which temporal, spatial and listener perspective variables inform the formal qualities of the work, positioned on three axial continua shifting between stasis and dynamism (Fig. 3). While some of these variables may be strategically combined to concentrate on particular formal aspects (i.e. static temporal relationships may draw focus to dynamic spatial relationships as would static spatial relationships draw focus to contracted temporal relationships), they are not necessarily mutually exclusive, allowing the creative practitioner to select variables most contextually appropriate.

Agency

As discussed in Chapter 1 through the eco-field hypothesis, Umwelt Theory and agential realism, and in Chapter 2 through Dark Ecology, the agentive aspects of an ecosystem and soundscape warrant inclusion in an Ecotonal compositional approach. As Soundscape Ecology, soundscapes are considered representations of ecosystems resulting from interdependent (or rather, intra-active) cognitive and material processes.

These agentive capacities may be integrated into the creative outcome through the lens of Soundscape Ecology, which infers cognitive biological activity and non-cognitive ecological activity through statistical analyses of soundscape phenomena. The patterns, structures and behaviour apprehended by such analyses may be literally or metaphorically mapped in relation to the performer domain (cognitive decision making) or electroacoustic domain (non-cognitive algorithmic, stochastic processes or data automation).

For human performance, modular scoring presents material as distinct modules, leaving their actualisation to the contextually-informed decision making of the performer. Such scoring may comprise music notation, graphic notation, or oral/text-based instructions, dependent upon the context (i.e. certain notational approach modes better convey particular acoustic parameters, and text-based instructions may be more suitable to community musicians less experienced with musical notation). Comparably, software-based algorithms articulating ecological or stochastic processes, or live data sources) may be used in electroacoustic settings to trigger sound events or automate sound processing.

Such indeterminate compositional techniques as applied to human and computer performance are attractive for Ecotonality in that they embrace the agentive aspects of the ecosystem, and deliberately move away from an deterministic level of control on the part of a composer (analogous to the exertion of anthropocentric control on the environment) towards human and non-human collaborative realisation of the work.

4.2.5 - Realisation

As has been seen above, Ecotonal creative practice and works may employ both acoustic instrumentation and electroacoustic media, with each situation involving comparable methods of realisation. For acoustic instrumentation, the conventional approach involves the delivery of compositional materials to performers, rehearsal and performance. For electroacoustic media, typical stages include installation, auditioning and presentation of

works. Consequently, a composite approach utilising combinations of these activities may be required for these creative works.

This use of acoustic instrumentation and electroacoustic media alongside indeterminate compositional techniques and processes as part of their creative concept and realisation results in various artefacts representing multiple perspectives of the work. Compositional artefacts may include scores (potentially employing music notation, graphic notation or text-based instructions), software-based materials (digital audio workstation project files) and collated data (field recordings, ecological and analytical data sets), as well as audiovisual recordings of performances and presentations.

Each resultant artefact represents different perspectives on ecological processes and behaviour, correlated with the limitations of each artefact type's descriptive or prescriptive features. In this way, singular artefacts cannot be considered as wholly representative of an Ecotonal creative work, but as complementary and mutually intra-active aspects of the ecological and aesthetic experience.

4.2.6 - Reflection

The final step of the process is reflection, where the evaluation of the work's creative development outcomes reveal perspectives and insights into creative practice. These insights subsequently refine and inform practice related to ensuing creative site-specific works, and in the context of this research project, the Ecotonal Creative Framework itself.

4.3 - Summary

This chapter has presented a creative framework, Ecotonality, which links Soundscape Ecology with creative process. Through mapping Soundscape Ecology frameworks and methods to compositional creative framework, Ecotonality connects scientific and artistic conceptual, collative and analytical practices that investigate place, ecosystem and soundscape, and further provides new perspectives of these phenomena through the composition of original creative works, public performances and presentations, and reflective review of project development to nuance and refine creative practice. This discussion continues in the following Chapter, in the implementation of Ecotonality in four site-specific works based in South Australia.

5 - Portfolio

This chapter discusses the creative portfolio of ecological sound art works developed through site-specific engagement with the Ecotonal creative framework. Each project has been developed in response to a different South Australian ecosystem: *Mobilong* (swamp ecosystem), *Long Island* (river ecosystem), *Featherstone Place* (urban ecosystem) and *Farina* (desert ecosystem).

Though developed through the creative process outlined in the Ecotonal framework, each work provided the opportunity to reflect and review the implementation and outcomes of the creative activity, in turn informing and cultivating further nuances for the Ecotonal framework.

While particular insights will be discussed concerning each work, a number are worth noting. Generally, the development of each work was not linear (as the framework might suggest), but rather a back-and-forth dialogue between various parts of the creative process. This was noticed, especially in the Preparation and Composition of each work, where various morphological relationships between sounds materials and site context were revealed and shaped by analysis and application. Similarly, in the Conception and Collation, on-site engagement had the capacity to influence the work's conceptual basis.

This is comparable to what Connors identifies though her 'Ecological Performative' framework as an 'ecosystem of practice', where the creative practitioner's engagement, analysis and creative adaptation of human and non-human entities and behaviours reveals 'complex, emergent and dynamic encounters available through situated experience and experimentation. By considering the world as a network of phenomena that are fundamentally interconnected and interdependent, the result is a performative engagement and attunement with the world that functions as an aid to the imagination' (Connors 2017).

Additionally, technological constraints filtered through to the creative approaches and outcomes of the work. In the early stages of the research project, higher-order ambisonic (HOA) microphones and softwares remained financially prohibitive. Additionally, the long-term field exposure required of long duration recordings led me to rely on my own equipment rather than institutional resources. As such, I employed my own Zoom H6 recorder with omnidirectional and X-Y microphone capsules. The microphone capsules and position were sensitively considered as appropriate to the situation, based on a whether a more broad or more directional recording was desired.

Subsequently, these recordings were creatively manipulated in digital audio workstations (DAWs) to render a surround sound experience, drawing on the well-established multichannel practices of soundscape composition. While not achieving the same precision as HOA microphones and reproduction, direction recordings and studio multichannel techniques, informed by the ecological spatial information garnered from soundscape ecology perspectives, may result in a favourable outcome comparable to HOA. The specific approach for each project is discussed further below.

5.1 - *Mobilong*

An English corruption of *moopolthawong* (from the Ngaralta clan, of the Ngarrindjeri nation) meaning 'haven for birds'.

5.1.1 - Background

The contemporary Mobilong is part of the Lower Murray Reclaimed Irrigation Area (LMRIA) and is situated north of and adjacent to the Rural City of Murray Bridge, South Australia. The area was originally a natural floodplain, with the water table level subject to seasonal fluctuation of the Murray River. This cycle replenished the related aquifers, with the highly saline groundwater subsequently discharging into the river basin. European settlement in the late 19th and early 20th centuries brought reclaiming of the floodplains for irrigation, and intent for the Murray to remain a constant water source (for agriculture and navigation) saw the introduction of locks, barrages and levee banks along the river channel. Drainage channels and irrigation cycles artificially replicated the natural filtration process, but multiple droughts in between 2000-2010 saw significant drops in the river level and water table, in turn impacting irrigation activities via reduced water availability. Thus, the saline groundwater rose, and the substantial clay soil profile acidified, compromising agricultural and farming activities. Since 2010, the acquisition of much of Mobilong by SA Water has seen the trial of various remedial activities. Several eucalyptus trial plantations are being trialled, and there is discussion around natural filtration through the diversion of acidic water discharge through local wetlands (EPA 2013; Sims 2013). Consequently, the environmental, ecological and sociocultural histories of this area result in its current biodiversity, and the related soundscape that arises through ecosystem function.

Figure 2: Satellite image of Mobilong Swamp, bisected by Pump Road. Toora Road and the cliffs are bottom left in the image (Image via Google Maps)

5.1.2 - Conception

As Mobilong Swamp is little more than a kilometre away from my home in Murray Bridge, I have a close connection with the area. My first creative connections with the site began back in late 2014. One evening, I was walking along Pump Road, an 880 metre stretch of unsealed road which bisects the swampland, and began to notice the dynamic and stereophonic quality of the soundscape, with stridulating crickets, chorusing birds and croaking frogs sounding either side of the road and at the riverfront. Fascinated, I resolved to respond to this site in creative work, following a real-time experience of a sound walk along Pump Road at dusk, extending from the western cliff faces (at the Pump and Toora Road intersection) to the eastern riverfront (Fig. 4). This original intention remained unchanged from the work's initial conception to fruition.

Derived from the sound walk experience of Pump Road, the overall form of the piece is an idealised procession of the observer (audience) along the road towards the river, in line with the setting sun's shadow cast by an abutting cliff face (at the foot of Pump Road, to the west).

This work follows from other ecologically-minded works inspired by swamplands, including John Luther Adams' *Night Peace,* which captures the Okefenokee Swamp in Georgia, U.S.A.

5.1.3 - Collation

Despite my engagement with the place, it was not until later 2015, involved in creative research, that I began a more thorough investigation of Mobilong and its ecosystem. This involved a variety of approaches that included reviewing published literature, discussions with numerous people connected to place, and on-site observation.

After contact with the Rural City of Murray Bridge's environmental officer, I was referred on to a local contractor, Bob Chapman (previously a dairy farmer at Mobilong, whose family had worked the land for many generations. Bob, in turn, put me in contact with numerous environmental resource managers: SA Water Land Manager, David Loveder, and Dr Luke Moseley of the Acid Sulphate Soil Centre at the Waite Institute, University of Adelaide.

Through these connections, I was able to access environmental reports on the Mobilong Swamp area from the EPA (2013) and SA Water (Sims 2013), and survey maps from the Rural City of Murray Bridge Council. Additionally, a list of local birds was sourced from a nearby bird hide at the Rocky Gully Wetlands. These information sources (human and text/visual) allowed me to develop an understanding of the ecological evolution of the space, as it related to Ngarrindjeri and European historical uses of the land, and the significant changes in the landscape (and by extension, the soundscape) in the past decade.

Subsequently, I began to visit Mobilong periodically in mid-to-late 2015, as its proximity to my home allowed for ongoing visitation and monitoring. This consisted of observation, documentation and sound recording. Recordings were made with a Zoom H6 with an X-Y microphone capsule in each distinct land patch to capture discrete sonotopes (discussed further below) between November 2015 to April 2016.

Additionally, I had the opportunity to observe a field trip at Mobilong on 30 October 2015 by Acid Sulfate Soils Centre researchers Dr Luke Moseley and Professor Rob Fitzpatrick, supported by a visiting German scientist. Collecting soil and water samples from compromised land patches and irrigation channels, the team provided explanation and insight into the ecological impact of soil and water acidification, and ongoing remediation strategies at the site (Fig. 6).

Figure 3: Pump Road at Mobilong, as seen from the western cliff. Image by the author.

Figure 4: A visiting researcher (left), Prof. Rob Fitzgerald (middle) and Dr. Luke Moseley (right) collecting samples from acidified irrigation channels at Mobilong. Image by the author.

5.1.4 - Preparation and Composition

The preparation and composition of Mobilong was an organic process in which both micromorphological and macromorphological details with addressed, mutually informing one another to arrive at the creative result.

The processes of conception and collation gave rise to perspectives and contexts that directly informed how the collated materials were creatively adapted. Of particular interest were ecological considerations, as including soil conditions, biodiversity distribution and related sonic spatial distribution, and to topographical and meteorological activity.

First, the acidification of large soil patches resulting from irrigational land use and recent droughts has directly impacted on the species of flora able to survive in the area. The most impacted areas are now populated mainly by samphire and saltbush, by comparison to more alluvial soils which support various grasses and reeds (particularly Phragmites australis). As part of ongoing land management, numerous trial plantations of eucalypts, including river box (e. largiflorens) and river red gum (e. camaldulensis), have been introduced to remediate soil conditions.
This floral distribution, combined with striated boundaries including fences, channels and transport infrastructure, has created distinct habitats, or ecotopes with associated fauna. These appear to be in four general types: grassed fields, occupied by small songbirds, birds of prey and crickets; saltbush fields, still occupied by such birds but with no crickets; plantation, populated with a greater variety of small to medium perching and songbirds; and riverfront, with a notable presence of water birds and frog species. The overlapping geophonies and biophonies of these ecotopes, in turn, creates distinct sonotopes or acoustic communities (Farina & James 2016; Mullet, Farina & Gage 2017) through which an observer can pass, experiencing subtle but dynamic changes of acoustic communities in the soundscape. In a creative context, this experience provides a natural crescendo, building from a sparse beginning to a climactic finale.

Mobilong Swamp also features an interesting relationship between its topology and diurnal activity. At particular times of the year, when the sun's azimuth is directly in line with the cliff at the junction of Pump and Toora road at dusk, a shadow is cast that gradually proceeds from the cliff face towards the water. This has important implications on the dusk soundscape: in addition to vocalising bird life and frogs, crickets in the field change their calling frequencies in response to the falling temperatures (Walker 1962), in turn affecting the collective drone of the chorus.

These observations were adapted creatively and subsequently implemented.

In order to recreate the sound walk experience in a static performance setup, I realised that the sonic materials would need to move from in front of to behind the audience, with the site's spatial relationships (road and fields) preserved by situating associated sounds to either side. Given the intended combination of acoustic instrumentation and electronics, an octophonic speaker setup was chosen with four separate groups of performers situated between each of the side speakers (Fig. 7). As such, the sonic materials progresses from front to rear, alternating between the speakers and live performers, and evolving as new sonotopes within the soundscape are encountered.

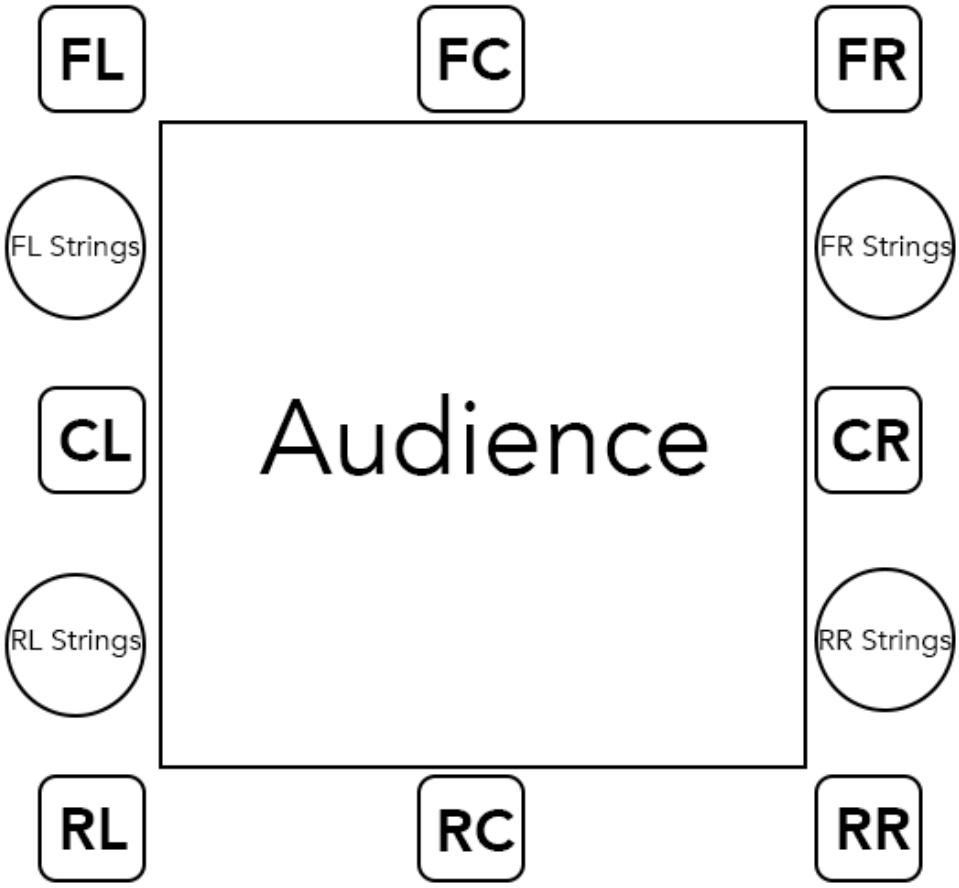

Figure 5: Performance layout for Mobilong.

To achieve this, the Council survey maps were annotated with distance measurements made with Google Maps of each distinct land patch along the road. From progressing at a virtual walking rate of 4.8kh/h (20 metres per 15 seconds), these distances were then

converted into durations (in seconds), providing specific time cues for formal transitions between sonotopes (i.e. a change from 'saltbush fields' to 'plantation' field recordings). Further, the material, played from Front Left and Right, and Rear Left and Right speakers, was conceptualised to be 60m away from the audience to create a sense of immersion and transition in the environment, and accordingly, the time cues for sonotope transitions were offset by 45 seconds in either direction.

Figure 6: Survey maps of Pump Road, with annotated distances

					Left side markers				
Location	End distance from previous marker (centre)	End distance from start (centre)	Duration (@20m per 15 seconds)	Notes	End distance from previous marker (front)	End distance from start (front)	Duration for Front Left (+60m/+0:45 to Centre)	Notes	Dis pre (ba
Base of road to bridge		15	0:15 (20m)	begin with footsteps, at 0:15, cue duck take off					
Bridge	20	35	0:30 (40m)						
Bridge descent to road base	20	55	0:45 (60m)						
Field	160	215	2:45 (220m)		0	160	2:00		
(intersection of channel)				at 2:45, brief channel sounds				at 2:00, brief channel sounds	
Saltbush/Samphire 1	75	290	3:30 (280m)		75	235	3:00 (240)		
(intersection of channel)				at 3:30, brief channel sounds				at 3:00, brief channel sounds	
Saltbush/Samphire 2	85	375	4:45 (380m)		85	320	4:00		
(intersection of channel)				at 4:45, brief channel sounds				at 4:00, brief channel sounds	
Saltbush/Samphire 3	75	450	5:30 (440m)		75	395	5:00 (400)		
intersection of channel				at 5:30, brief channel sounds				at 5:00, brief channel sounds	
Grass/Saltbush	70	520	6:30		70	465	5:45 (460)		
intersection of channel				at 6:30, brief channel sounds				at 5:45, brief channel sounds	
Plantation-grove	325	845	10:30 (840)		325	790	9:45 (780)		
(Channel)				at 10:30, introduce gums/channel				at 9:45, introduce gums/channel	
Road up to river bank	25	870	11:00 (880)		25	815	10:15 (820)		
End		fade out from 12:00	12:30			fade out from 12:00	12:30		

Figure 7: Example of distance-time conversion charts

Electronics

Utilising field recordings made in each of the identified sonotopes on site, the acoustic environment was reconstructed in Ableton Live 9 (and later adapted to Live 10), according to the temporal calculations made earlier. Field recording material situated in the front and rear speakers was attenuated relative to the centre speakers, aiming at replicating real-world distance attenuation.

Instruments

For *Mobilong*, I settled on the string ensemble as instrumentation predominantly due to the timbral versatility possible through bowing position and extended techniques. This, I felt, would sufficiently replicate the diverse biophony of bird, cricket and frog calls, as well as a selection of geophonic gestures such as bowing the body of the instrument to evoke wind rustling through reeds or tree.

Rather than attempting to identify each species through direct observation, to save time I referred to a list of birds found previously at the Rocky Gully Wetlands bird hide, and located many call recordings made by Fred Van Gess on the website Birds In Backyards (www.birdsinbackyards.net/) and Michael Dahlem (https://mdahlem.net/). With their permission, I began transcribing the calls.

In contrast to the direct notation approach of Olivier Messiaen and John Luther Adams, whose transcriptions were made listening in the field and subsequently used in *Catalogue d'Oiseaux* and *songbirdsongs…* respectively, I instead used computer-aided spectral analysis. Calls were first analysed and processed in SPEAR, viewing each call's spectral envelope and pitch content. Simpler pitched calls were transcribed by using fundamentals as the basis of the melodic trajectory, and partial density conveyed through bowing position (from fewer partials with *sul tasto* to more partials with *sul ponticello*); whereas complex and non-pitched/percussive sound materials were transcribed through appropriate extended techniques.

Similarly, the cricket chirp transcriptions were achieved via spectral analysis, with stridulation imitated by an indeterminate ricochet bowing on extremely high pitches. Considering then the topographic and barometric conditions of Mobilong at dusk, where the western cliff casts a shadow gradually proceeding towards the riverfront (between illuminated and dimmed areas in addition to the cooling of air temperature), the cricket chirp pitch content was organised to slowly and microtonally descend over the piece's duration. The sounding result of combined individual calls, reinforced in the electronic track, evokes a subtle descending high-pitched drone.

This was followed by the assemblage of the score for each string ensemble, made up of violins, violas, and cellos. Devised as a modular score where each performer plays the transcribed materials at their discretion, the content is comprised of transcriptions of bird song, cricket stridulations and geophonic activity. Like the electronic counterpart, each ensemble's content is temporally correlated with the site's habitats and associated sonotopes, using time cues to remain synchronised.

When making initial preparations towards live performance, it became apparent that significant logistical challenges with personnel and space existed. As a result, I decided to record each transcribed module individually. Recording sessions took place in November

and December 2016 with Lester Wong (violin), Hurley Baker (viola) and David Moran (cello) at the Electronic Music Unit Studios at The University of Adelaide. Each transcribed call was recorded several times and was then isolated in editing as an individual sample for use in the Ableton Live session.

To simulate the indeterminate component of the string ensembles, a Max patch 'Density' device, was developed that triggered calls in response to an assigned probability. Connected with an Ableton Drum Rack device with all samples preloaded, the device was able to limit the number of samples played (correlated with sonotopes via score-based time cues). This device was implemented on separate tracks for each of the four string ensembles (Front Left, Front Right, Rear Left, Rear Right), which were then panned to the respective speakers in the octophonic setup, allowing Mobilong to be rendered as an acousmatic multichannel work as well as a live electroacoustic work.

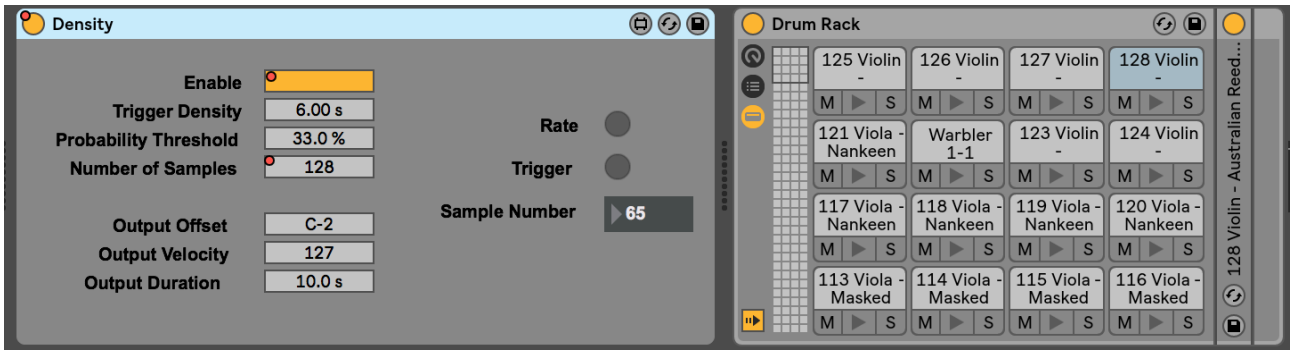

Figure 8: Presentation view of the 'Density' Patch, which triggers the transcribed string samples in the adjacent Drum Rack.

5.1.5 - Realisation

Whilst the live electroacoustic version of the work was not performed during the research project, the acousmatic version was presented as part of *Immersed: A Concert of New Surround Sound Works* at the University of Adelaide on 19 May 2018, and at the Murray Bridge Town Hall on 3 June 2018, with the support of the Elder Conservatorium EMU and a Rural City of Murray Bridge Small Wins Grant.

5.1.6 - Reflection

As the first project to implement the Ecotonal framework, *Mobilong* aims at a real-time representation of the swamp land's dusk soundscape, drawing attention to the area's current ecological circumstances emerging from historical land use. Additionally, through addressing challenges of performance logistics, approaches to representations of non-human agency (via Morton and Barad) were explored, through modular scoring (for live performance) and computer-aided stochastic activity (for acousmatic performance).

Though aiming at a real-time representation of the site's dusk soundscape experience, various abstractions emerged as a result of creative translations of Ecoacoustic phenomena and behaviours.

Concerning temporal relationships, the Mobilong swamplands are subject to meso- and macro-level temporal cycles, in the form of seasonal/climatic changes and associated dynamics such as flooding and solar activity. To fashion a broad-scale representation of place rather than of a specific period, certain environmental processes were disregarded to preserve the creative concept or heightened performance possibilities. For example, disregarded was the fact that the sun, for periods of the year, does not fall behind the cliff with its fluctuating azimuth.

Various compromises were made with bird calls. Firstly, many bird calls were included in the transcribed call collection, discounting seasonal species variance seasonal migration and mating patterns. Additionally, some calls are pitched beyond the standard range of the violins, so the associated transcribed calls were transposed an octave lower to remain playable, with occasional *(poco) sul ponticello* bowing directions intended to provide compensatory higher partials. Occasionally, calls of certain bird species were deemed too complex to transcribe for the capabilities of the available instrumentation, or too variable/improvisatory to provide meaningful instructions within the established performance methods, and were therefore not included.

Numerous human-produced sounds also featured in the real-world Mobilong soundscape, including those of the nearby meatworks, passing road vehicles, watercraft and aircraft overhead. Various pieces of infrastructure that were thought initially to produce sounds are also in situ, including wind-intoned measuring bores, aeolian harp-like powerlines, and an occasionally operated motorised irrigation pump. However, these were either absent or ineffective in the soundscape experience, or too obtrusive to warrant inclusion for this work.

Lastly, unlike a real-world sound walk, where the listener moves freely through a space, the static listener experience inherent in multichannel concert works meant that it was necessary to develop and route recorded material to specific directionally-associated tracks and speakers. Despite the stasis of listener and sound sources in performance, the shifts in content (the biophony and ambient field recordings) and distance-based amplitude attenuation give the necessary sense of transition and progression to replicate the soundwalk experience.

From preliminary research and onsite activity to creative analysis and synthesis, and finally realisation of the compositional response, *Mobilong* demonstrated to me the viability of the initial Ecotonal framework as a means of effective engagement and representation of place, and associated ecological and soundscape activities. At the same time, it encouraged further creative flexibility in the framework through identifying points of creative abstraction and investigation on specific environmental phenomena and interests, setting the stage for the next creative project at the nearby *Long Island*.

5.2 - *Long Island*

> In the Dreamtime, in search of his two wives, Ngurunderi travelled down the Murray River which at that time was only a small stream. A giant Murray cod, Pondi, swam ahead and with each swish of its mighty tail widened the stream. Ngurunderi, in pursuit, tried to spear the cod from his canoe. Lenteilin, Long Island, near Murray Bridge, represents one of the spears which missed (Bell 1998, p. 91).

5.2.1 - Background

A significant part of Ngarrindjeri culture, Long Island is a 1.8km long island bisecting the Murray River at Murray Bridge. In recent decades, the Rural City of Murray Bridge Council has placed legislative restrictions around watercraft navigation in the Island's channels. Whereas the western side is open to motorised watercraft, the eastern side prohibits this activity, preserving a waterfowl refuge (Fig. 11).

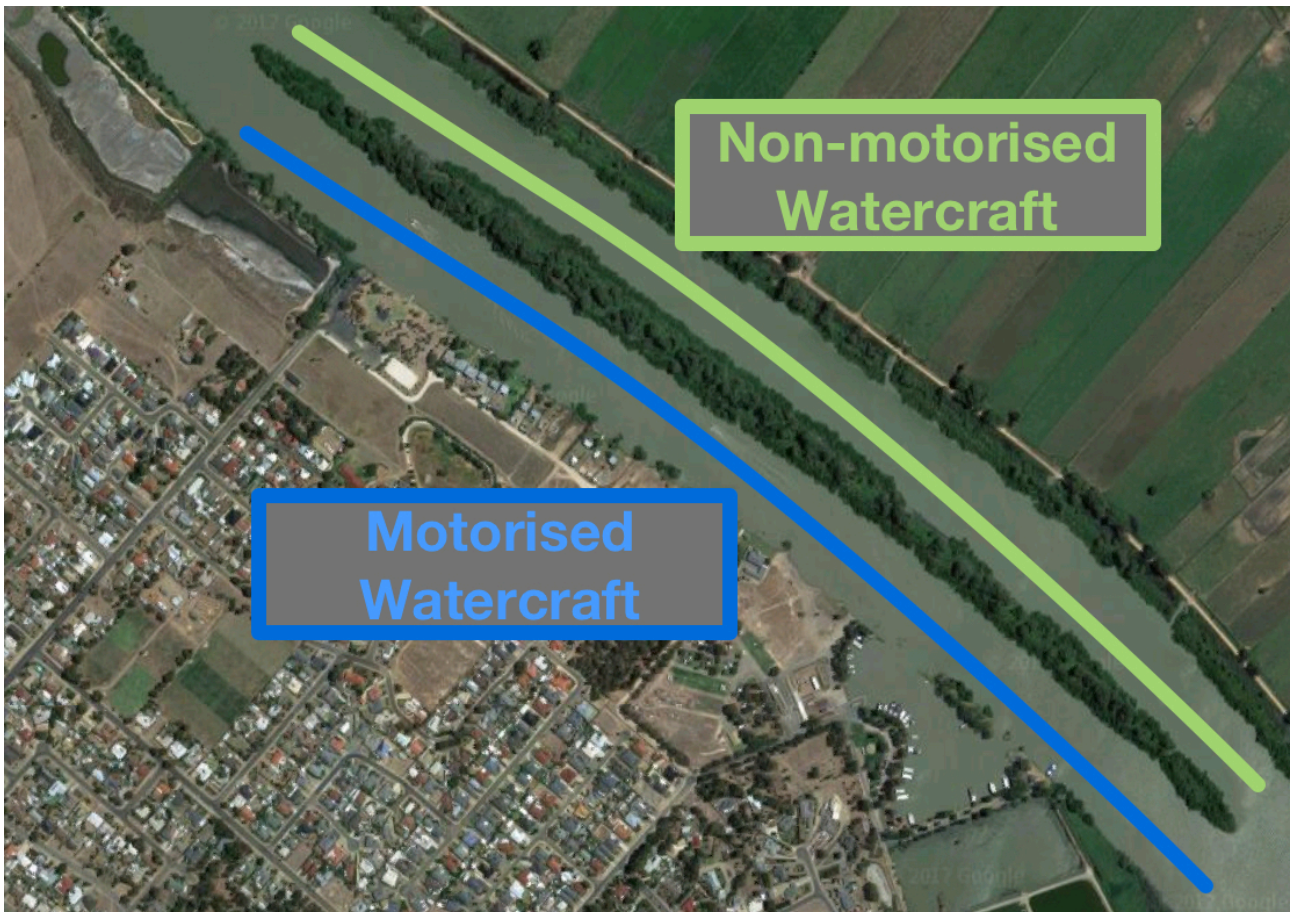

Figure 9: An aerial overview of Long Island (oriented north), with each channel's activity marked. Image via Google Maps.

5.2.2 - Conception

With the advent of Soundscape Ecology and Ecoacoustic research of aquatic soundscapes, numerous studies have identified impacts of anthropogenic boat noise on aquatic species (Chao, Xinguo & Guangxu 2015; Filiciotto & Buscaino 2017). Powered vessels occupy broadband frequency ranges and operate at very loud volumes, whereas aquatic species living in rivers and oceans (especially cetaceans) have evolved to communicate and hear in narrowband frequency ranges and can only call at volumes relative to their physiology. Because of this, these animals find it increasingly difficult to communicate effectively while being masked by loud watercraft noise and may even sustain hearing damage.

Long Island, with its existing legislative controls providing both terrestrial and aquatic soundscapes with and without motorboat activity, was an opportune site to explore these relationships. Considering the impact of motorboat noise on terrestrial and aquatic environments in a creative context, I looked to heighten audience sensitivity to non-terrestrial soundscapes, and consider less impactful alternatives to engagement with and enjoyment of these environments.
Formally, a space-by-space listening experience would progress, with the listener beginning in the non-motorised soundscapes, first above water (Terrestrial Non-Motorised), then submerging below (Aquatic Non-Motorised). With the listener still immersed, boat activity is gradually introduced and becomes overwhelming (Aquatic Motorised), after which the listener reemerges to the open air with boat activity continuing (Terrestrial Motorised) as in Figure 12.

In the early stages of development, a Pierrot ensemble (piano, flute, clarinet, violin and violoncello) was considered, and venues with vertical elements (staircases and landings) were investigated to represent the vertical spatial relationships of the river, island floor and treetop canopy. Because of potential staging difficulties, these ambitious plans were rethought, and a standard stage environment was chosen, the ensemble being scaled back to strings and piano (four-hands).

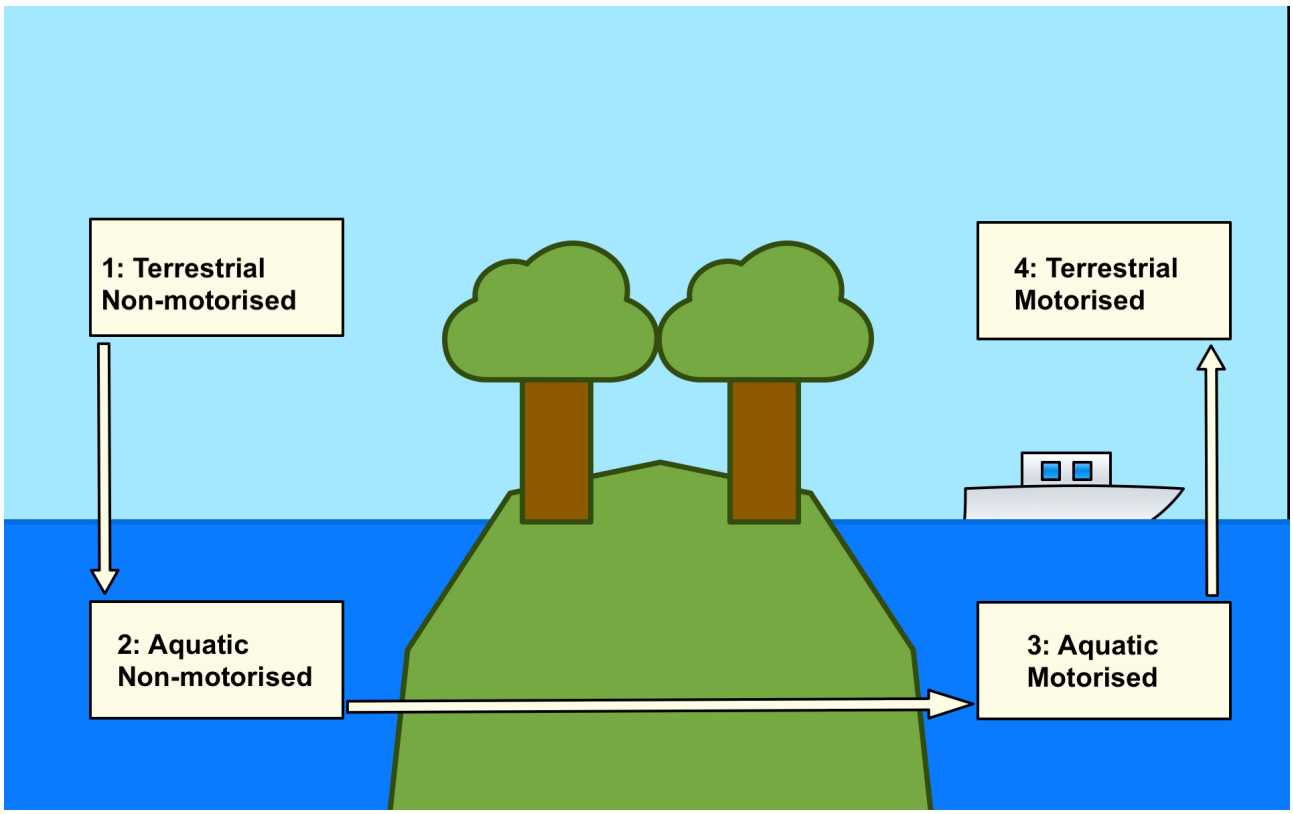

Figure 10: Formal Progression of Long Island

This work follows from a number of other works addressing river systems. Annea Lockwood's *Soundmaps* of the *Hudson, Danube* and *Housatonic* Rivers document both terrestrial and aquatic soundscapes, as does the works in Leah Barclay's *River Listening* project. Garth Paine's acousmatic work *Present In The Landscape* creatively conveys the Shoalhaven River in New South Wales, featuring local biophony and First Nations language. Other works, such as R. Murray Schafer's *North/White* includes a snowmobile in the otherwise traditional symphonic orchestration to encourage audience reflection on the impact of anthropophonic sound in natural settings.

5.2.3 - Collation

My initial research involved collation of various records from different government and cultural institutions, including survey maps of Long Island from the Rural City of Murray Bridge Council, resources form the Department of Environment and Water (DEW), consultation with the local Historical Society and long-time neighbours (pertaining to historic and current uses of the island). As I learned, following European settlement of the area, the island became a popular picnic spot in the early 20th century, and acted as a

training location for US army engineers during World War II, where pontoons were temporarily built as backups for bridge access in the event that the existing (Murray) bridge was bombed). Following damage to recreational infrastructure in the famous 1956 floods, the island was abandoned. This allowed willows, first introduced as distance markers along the river in the 1800s, to spread over the island alongside well-established eucalypts, making it generally inaccessible.

This background research was followed by multiple recording trips between April 2016 - April 2017, when recordings were made on both sides of the islands with a Zoom H6 portable recorder. Above water, X-Y microphone capsules were used, recording on a small beach on the eastern side, and the jetty adjacent to the western channel's boat ramp. Below water, a pair of H1-A Aquarian Audio hydrophones provided a basic stereo image, recording on the eastern side from a kayak in the middle of the river, and on the western side from the aforementioned jetty.

Figure 11: Jesse Budel making hydrophone recordings on Long Island's eastern (non-motorised) channel, April 2017. Image by the author.

5.2.4 - Preparation and Composition

With challenges in conveying non-human experience to a human audience, I opted to use aesthetic displeasure as a mediating communication tool, positioning the ambient soundscape against introduced anthropogenic noise. By keeping the 'non-motorised' soundscape field recordings and instrumental activity dynamics at a relatively low amplitude throughout the work (akin to real-world circumstances), the intervention of loud motorboat activity creates a stark contrast by masking the ambient acoustic environment.

Electronics

With only field recordings to work with initially, the electronic component was developed first. Deciding on a stereo setup, I sampled and organised the field recordings according to the earlier formal plans in Ableton Live 9's Arrangement View, allotting each section (terrestrial non-motorised, aquatic non-motorised, aquatic motorised and terrestrial motorised) 3 minutes and 45 seconds, with a total duration of 15 minutes. For the latter 'motorised' half of the work, recordings of motorboats both under and above water were overlaid, effectively masking the background ambient activity. Simple filtering and reverberation were used to reinforce the acoustic characteristics of each medium, air and water.

Instrumentation

For the instrumentation, I focussed both transcribing the biophonic and geophonic aspects of the soundscape.

Given that the Mobilong site is only a few kilometres from Long Island, I decided to reuse the string bird call transcriptions made for Mobilong, combining them in a single score for strings, played only during the terrestrial soundscape activity.
The piano's material was generated through a multi-stage analysis and transformation of the electronic component's field recordings. Initially, the recordings were divided up into 15-second samples and analysed spectrally in SPEAR. The spectral information thus obtained was then subjected to frequency filtering (between 30Hz to 4200Hz to reduce frequency information to the keyboard range) and amplitudinal filtering (above -45dB for terrestrial, -35dB for aquatic soundscape), leaving only most prominent pitch material (Fig. 5). Exported from SPEAR in the .SDIF file format, the data was then imported into the MaxScore Environment, Macaque (Didkovsky & Hajdu 2008) and rendered as MIDI data (seen in Fig. 6), which was then transferred to Sibelius 7 to be developed into a performable score. Further editing of pitch material (rounding ¼ tones to the nearest semitone), phrasing (interpreting spectral partial trajectories as contrapuntal lines),

rhythms (quantising) and fingering (arranging for four hands, Fig. 7) sculpted the piano part into an impressionistic-cum-spectralist commentary on the soundscape. Interestingly, the rhythmic quantisation of the piano material produces a shifting relationship between the pianists and the field recordings. Guided only by time cues 15 seconds apart, the pianists play the developed material more or less *rubato* between time, such that the material and recordings made be played coincidentally (reinforcing), or before (foreshadowing) or after (echoing) one another, creating dynamic and ever-changing relationships between live performance and (pre-recorded) environment.

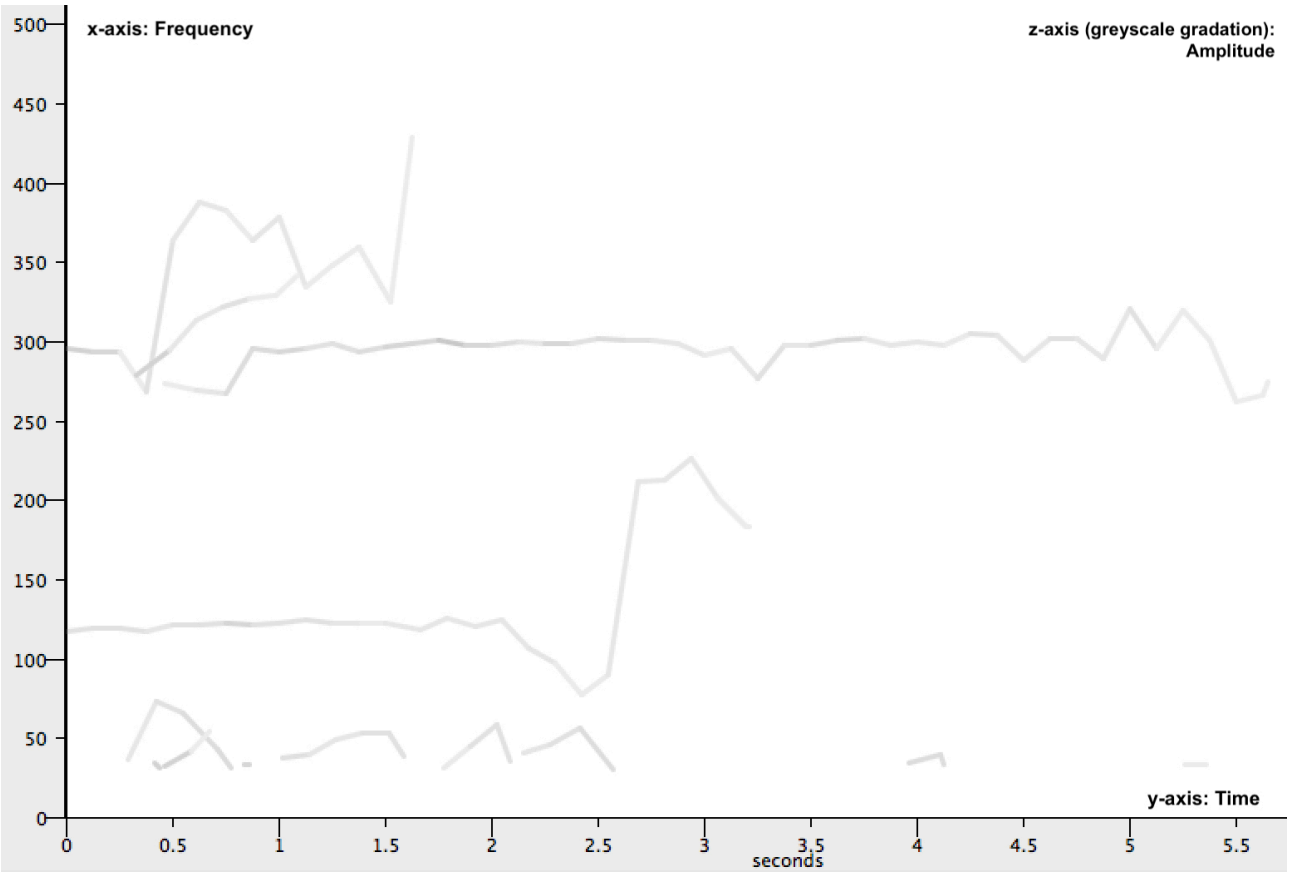

Figure 12: Spectral output of 15-second field recording sample in SPEAR. X-axis represents time, Y-axis represents frequency (in kHz) and gradation in the partials' greyscale represents amplitude

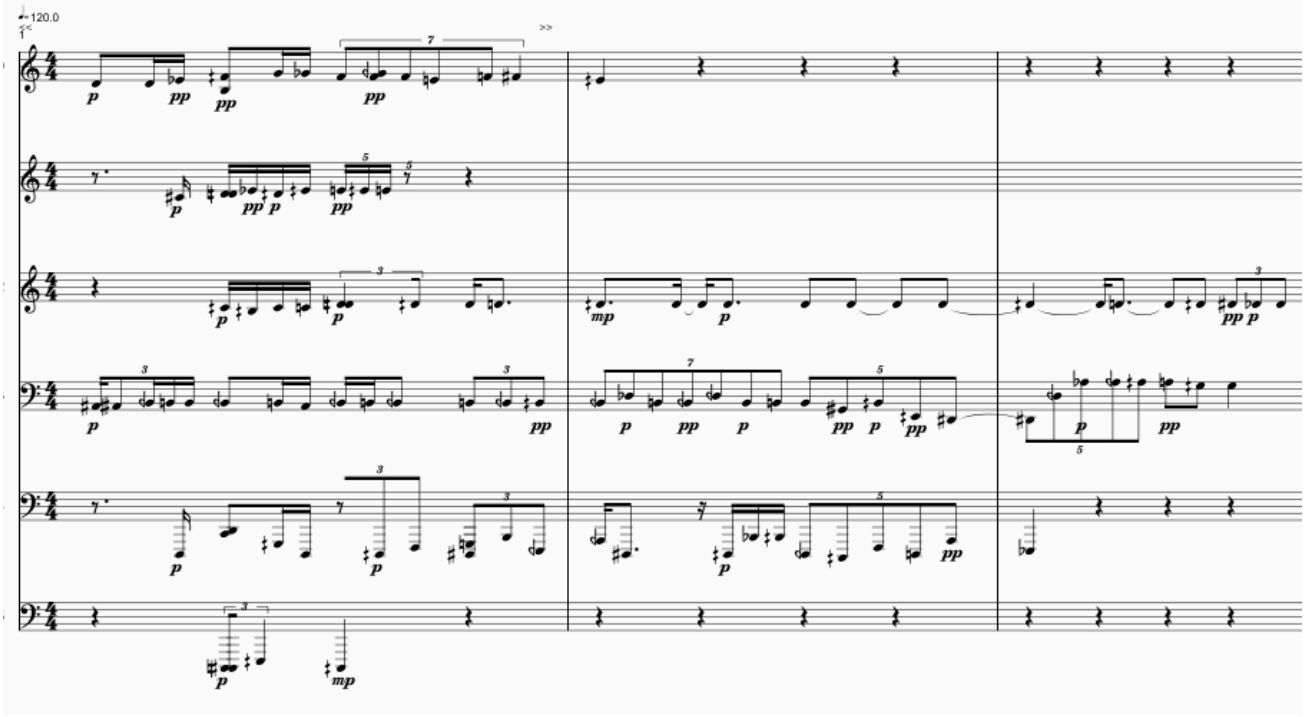

Figure 13: MIDI output of Fig. 5 spectral sample in Macaque Environment.

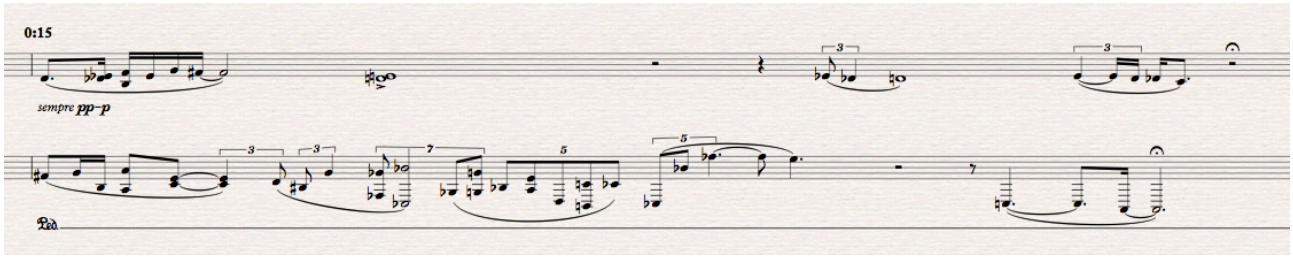

Figure 14: Sibelius 7 edit of Fig. 15 MIDI Data. Orchestration for two pianos has required quantisation of pitches, rhythms and dynamics.

Initially, it was intended that both strings and piano would be played throughout the work. However, the lack of recordings of soniferous aquatic species in the Murray River meant that the strings were chosen to play exclusively in the terrestrial soundscape sections. Then, after consultation with pianist Gabriella Smart, the piano material was scaled back only to be played in the aquatic soundscape section, as it was felt that piano throughout the entire work would become aurally taxing. This isolation of instrumental roles ended up creating clarity and more specific aural identities for the contrasting aquatic and terrestrial soundscapes.

5.2.5 - Realisation

Like *Mobilong*, *Long Island* resulted in multiple performance formats. While scored for live performers and electronics, the instrumental activity can be replicated through electronic playback, the strings using the Density Patch (as used in *Mobilong*), and the piano using MIDI playback within the Ableton session.

An alternate version of the work, for electronics and piano four-hands, was workshopped by Daniel Thorpe and Gabriella Smart at Beaumont House on February 23 2018, as part of Soundstream Collective's *Blue Touch* series (Fig. 17).

Figure 15: Daniel Thorpe, Gabriella Smart and Jesse Budel at the workshop of *Long Island*. Image courtesy of Bill Gaston.

A shortened acousmatic version of the work was developed for the Landscape Music concert at Michigan Tech University on 10 December 2017. A full duration acousmatic

version was also developed and played as part of *Immersed: A Concert of New Surround Sound Works* at the University of Adelaide on 19 May 2018 and at the Murray Bridge Town Hall on 3 June 2018.

5.2.6 - Reflection

By contrast to the real-time, surround sound approach of *Mobilong*, *Long Island* presents a temporally and spatially abstracted work. Responding to landscape topology and human impact (both cultural and sociopolitical), the work aims not an accurate spatiotemporal representation of Long Island, but rather a general cross-comparison of terrestrial and aquatic ecosystems that comments on the impact of anthropogenic noise in these environments.

Long Island extends the exploration of performative agency in *Mobilong* to the domain of the linear score. While the string part continues to use modular scoring and stochastics, the piano part encourages interaction and negotiation between the pianists as it moves between points of synchronisation and rhythmic freedom, and also with the electronically-rendered aquatic field recordings from which they are derived.

These interactions also extend to the roles that the acoustic instrumentation and electroacoustic media take, with the strings as biophony, the piano as geophony, and the electronics as anthropophony (as motorboat recordings). During the latter half of the piece, these elements are juxtaposed through the acoustic masking of the instrumental activity by the electronic boat samples. Aiming at aesthetic displeasure through deliberately obscuring instrumental activity (generally a taboo in Western orchestrational technique), this approach allows the audience to comprehend the various agencies these sound represents, and extrapolate on non-human experiences in motorboat-occupied waterways.

At first, this positioning of the 'Natural' biophony and geophony against the 'human' anthropophony may appear to apotheosise and reinforce the Romantic divide between human and non-humans, as critiqued in Morton's Dark Ecology concept. However, the creative representation of biophony and geophony through human instrumental

performance provides a mode of identifying and reconnecting with non-humans within the Long Island ecosystem, and more broadly aquatic ecosystems. In turn, this encourages listeners, performers and audience alike to consider how they relate with aquatic beings and environments in the real world.

5.3 - Interlude

Following the composition of *Mobilong* and *Long Island*, I was fortunate to undertake a four and a half month professional development tour of the US and Canada between June and October 2017, supported by a Carclew Fellowship, Helpmann Academy Grant and Rural City of Murray Bridge Small Wins Grant.

While not strictly related to this research project, this trip allowed me to cultivate skills and networks in the fields of Acoustic Ecology, Ecoacoustics and ecological sound art. Over the course of my travels, I met with Cheryl Leonard and Brenda Hutchinson in San Francisco, Barry Truax and Hildegard Westerkamp in Vancouver and Sabine Feisst in Phoenix. In addition to conducting extensive field recordings around North America, I participated in the 2017 Composing In The Wilderness Field Seminar led by Stephen Lias in Denali National Park, Alaska.

Resulting from these experiences were new perspectives on the creative possibilities offered by the Ecotonal framework. Following the development of *Mobilong* and *Long Island,* which resulted in traditional concert works limited to sonified and phonographic representations of 'real' places, ecosystems and soundscape, I felt that there were self-imposed constraints on the creative techniques and ideas employed. Meeting with the North American practitioners provided new contexts and points of departure to consider. Cheryl Leonard gave insights into using natural found objects as instruments (Leonard 2016), while Brenda Hutchinson allowed hands-on experience with her community-developed projects, where I documented a performance of her Dailybell ringing at the Chapel of the Chimes Summer Solstice event. Additionally, Barry Truax encouraged me to explore more abstract compositional techniques, in line with his continuum of soundscape composition approaches discussed in Chapter 4 (Truax 2012).

Following from these experiences, the final two projects, *Featherstone Place* and *Farina*, explore new modes of creative development, presentation and conceptual response to place, ecosystem and soundscape.

5.4 - *Featherstone Place*

> Sonic Rupture: "a sound installation that diversifies an urban environment or environments, and within which new creative human experiences can unfold." (Lacey 2016b)

5.4.1 - Background

In June 2016, I attended the joint Australian Forum for Acoustic Ecology and Australian Computer Music Association conference, *Sonic Environments*, to present on my work on the 'Ecotonal' creative framework and its application in response to Mobilong Swamp. At the same conference, Melbourne-based urban sound researcher and artist Jordan Lacey launched his book, '*Sonic Ruptures: A Practice-Led Approach to Urban Soundscape Design*' (2016b). Interested in the creative possibilities of urban soundscapes, which are characterised by monotonous, homogenous and functionalist sound palettes that offer rich materials for creative application, Lacey proposed the idea of the Sonic Rupture with the goal in improving affective experiences in urban environments for city dwellers and workers alike. Seeing the opportunity to extend this practice beyond Melbourne to Adelaide, I resolved to develop an Ecotonal Sonic Rupture.

5.4.2 - Conception

In late 2016, I was offered a mentorship with the Adelaide-based string quartet, Zephyr Quartet, as part of the New Music Network LAB program. In my application for the mentorship, I proposed to collaborate on a 24/7 evolving 'Sonic Rupture' for the Adelaide CBD. Using the urban soundscape as an acoustic background, the installation would act as an overlay, recontextualising sounds in place. Additionally, synthesising my own interest in 'spectral' music and the nearby Rundle Mall's reputation for street busking, I sought to treat the quartet as 'ghostbuskers', in which the installation would reproduce and live-process string quartet material after the quartet's performance in the space, suggesting an ethereal presence in the space.

This projects follows from many other sound art works dealing with urban sites, including Max Neuhaus' *Times Square*, Odland and Auinger's *Harmonic Bridge* and Hellström's *Sonic Space* (Lacey 2016a).

Figure 16: Zephyr Quartet and Jesse Budel soundwalking the Adelaide CBD in December 2016. Image courtesy of Zephyr Quartet.

5.4.3 - Collation

In December 2016, the Quartet and I went on a sound walk of the CBD, exploring the acoustic spaces for a potential site. Featherstone Place, a small laneway off Gawler Street, was ultimately chosen due to its relative seclusion and proximity to an eventual collaborative partner, BASEM3NT Studios, who provided technical and logistical support.

In April 2017, I was the inaugural Composer-In-Residence at the Adelaide City Library, allowing for dedicated time recording Featherstone Place, as well as public workshops and

soundwalks to discuss and promote the project. I was also commissioned to write a work for the Adelaide City Council *Soundscape* program, to be exhibited in the City Breezeway. This resulted in the development of a preliminary work, *A Day In An Alleyway,* which provided the basic formal framework for *Featherstone Place.*

Multiple day-long recordings with the Zoom H6 and omnidirectional microphone capsule were made in Featherstone Place, and short duration recordings (exclusively for *A Day In An Alleyway*) were made in the Pirie Street Breezeway. Featherstone Place's spatial dimensions were measured to assist with speaker positioning, and Bureau of Meteorology (BOM) sites information were identified as potential sources of live weather data, with the recently reopened West Terrace/ngayirdapira site ultimately selected.

5.4.4 - Preparation and Composition

Audiovisual analysis of these materials in iZotope RX5 Audio Editor identified a variety of different biophonic and anthropophonic activities occurring at different times of day, which included:

- Two prominent air conditioner drones, at 590Hz and 100Hz, that switch on and off intermittently (controlled either by timer or thermostat)
- Biophony, both as dawn/dusk choruses and individual calls, featuring house sparrows, pigeons and magpie larks
- Other intermittent sounds, including traffic (cars, motorbikes, sirens), pedestrians (footsteps, human voice), and percussive urban activity (slams, bangs, clangs)

Samples of each activity were created and processed in RX5, removing background noise through frequency filtering and noise removal tools. Occasionally, the processed samples contained spectral artefacts, emphasising partials which in turn gave a spectral, 'ghostly' quality to the sound.

Additionally, the applications for the live data provided through the West Terrace/ ngayirdapira BOM site, including temperature, humidity, air pressure, precipitation and

wind behaviour, were considered and later associated with a Soundscape Ecology gradient-oriented perspective.

A Day In An Alleyway

As the brief for *A Day In An Alleyway* was a fixed-duration loopable work, I decide to represent the diurnal urban soundscape by temporally compressing each hour the day into 30 seconds, resulting in a 12-minute piece. To achieve this, 40-second samples of representative audio were sourced from each hour of the field recording and crossfaded between one another using the five seconds either side.

Over this base, various layers of activity were placed. Inspired by Lacey, a Day Chorus of air conditioners was developed. Constrained by the existing 100Hz (G2) and 590Hz (D5) drones, a chord of stacked fourths ascending on the pitches C#3, F#3, B3, E4 and A4 provided the harmonic palette, intoned between 6 am - 6 pm (3:00 - 9:00) of the piece.

Pedestrian activity was correlated with the times of 7-9am (arrival at work), 12-2pm (lunch), and 5-7pm (departure from work), represented through assorted sounds including footsteps and keycard swipe beeps. Additionally, the nearby Victoria Tower Bells were also featured, with their chronometric quarter-hour tolls retained through playback at 12 am (0:00), 6 am (3:00), 12 pm (6:00) and 6 pm (9:00).

Featherstone Place*, and revisions of *A Day In An Alleyway

Extrapolating from the sonic materials and temporal structures of *A Day In An Alleyway*, *Featherstone Place* instead looked to embrace the indeterminate nature of soundscape activity. While continuing to use the air conditioner choruses, biophony and incidental anthropophony, more emergent processes were employed to determine each component's activity.

While considering the existing air conditioner's tones of 100Hz (approx. G2) and 590Hz (approx. D2), a harmonic connection with the Australian mains hum (beginning on 50Hz)

was noticed. As such, the 'Mains Hum' component was developed. This involved the recycling of the Density Patch, randomly intoning sine tones at 50Hz, 100Hz, 200Hz and 400Hz, and processed with the 'Metallic Rezo' audio effect in Ableton to add noise.

Redeveloping the Day Chorus, I was interested in adapting the idea of frequency partitioning described by the Acoustic Niche Hypothesis (Krause 1993). A psychoacoustic parallel was identified in the Bark Scale, a frequency scale comprised of critical bands that are perceptually equal in distance. The centre frequency of each critical band between 60Hz and 4400Hz was converted to musical pitch, then tuned to the nearest equal temperament pitch. After placing additional notes on either side of the centre frequency notes to thicken the potential harmonies, the Day Chorus chord was developed.
A modulating tuning system was then derived in reference to the Liturgy of the Hours, a traditional Western ecclesiastical system of observing the passage of time[3]. Rooting the modality in G (in harmony with the Mains Hum), Rooting the modality in G (in harmony with the Mains Hum), the Day Chorus chord tuning shifts each hour, from the darkest modal tuning, Locrian, at 6am, progressing gradually (Phrygian (7am), Aeolian (8am), Dorian (9am), Mixolydian (10am), Ionian (11am) - to the brightest mode, Lydian, at 12pm, then reversing each hour back to Locrian at 6pm. The chord was then divided into high, middle and low chordal subsets, with Individual tones of each subset are triggered by a modified version of the 'Density' patch. Active between 6 am - 6 pm, the probability of the Day Chorus patch is controlled in response to the current BOM-referenced temperature.

[3] Though not originally conceived in this way, this is appropriate as Adelaide is colloquially known as 'The City of Churches'.

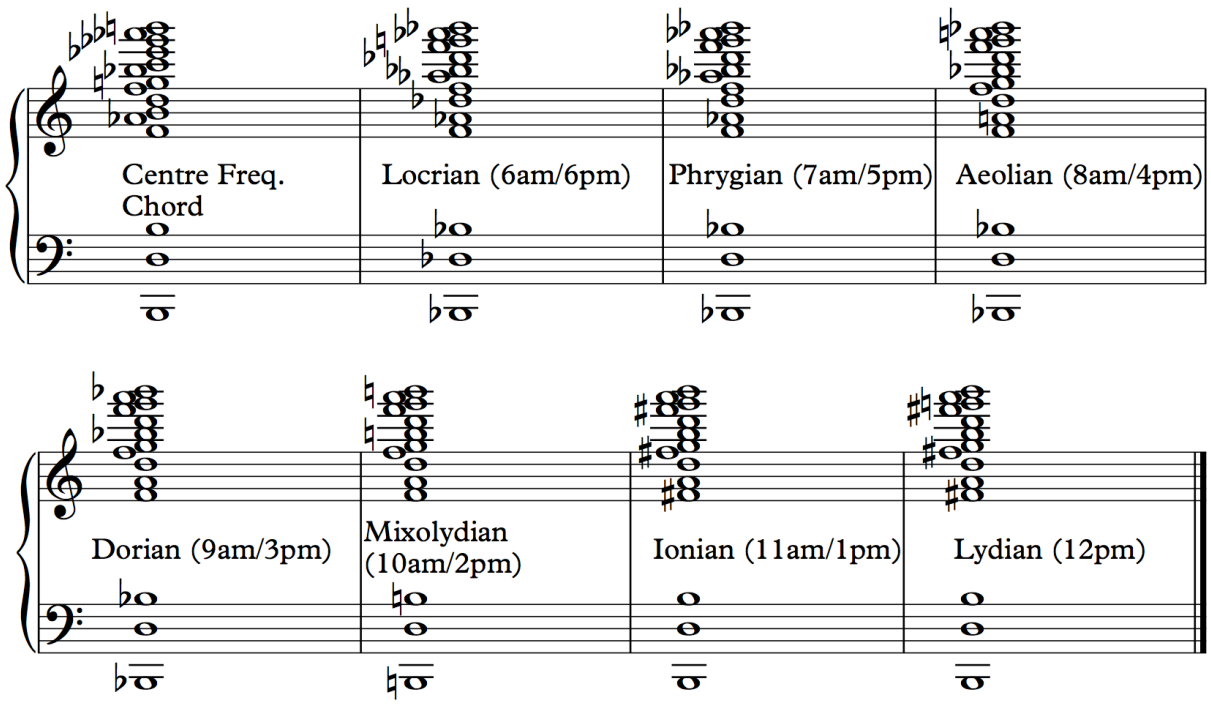

Figure 17: Day Chorus Chords. Basic Centre Frequency chord, then modal variants.

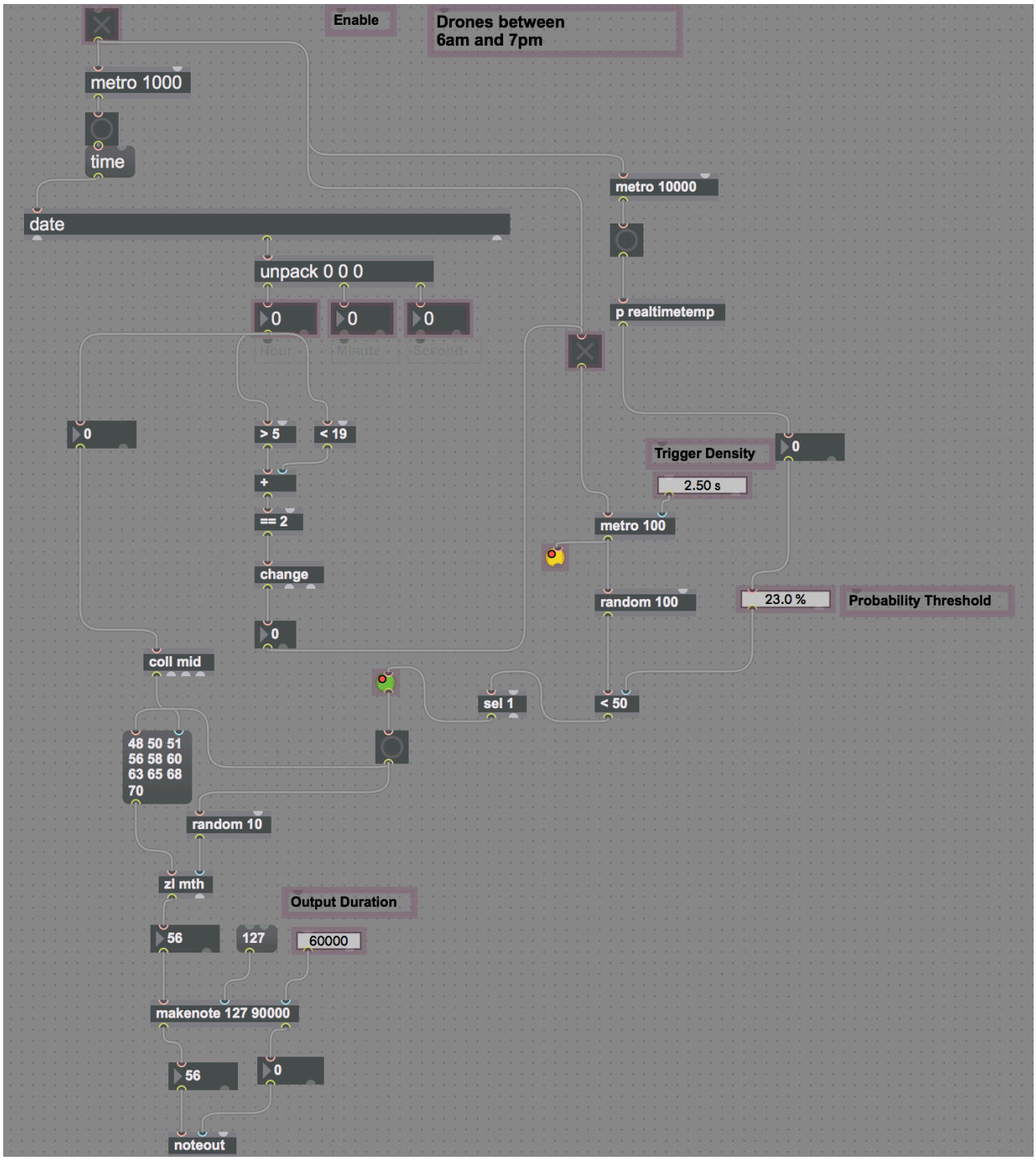

Figure 18: Example of DayDrones Max Patch

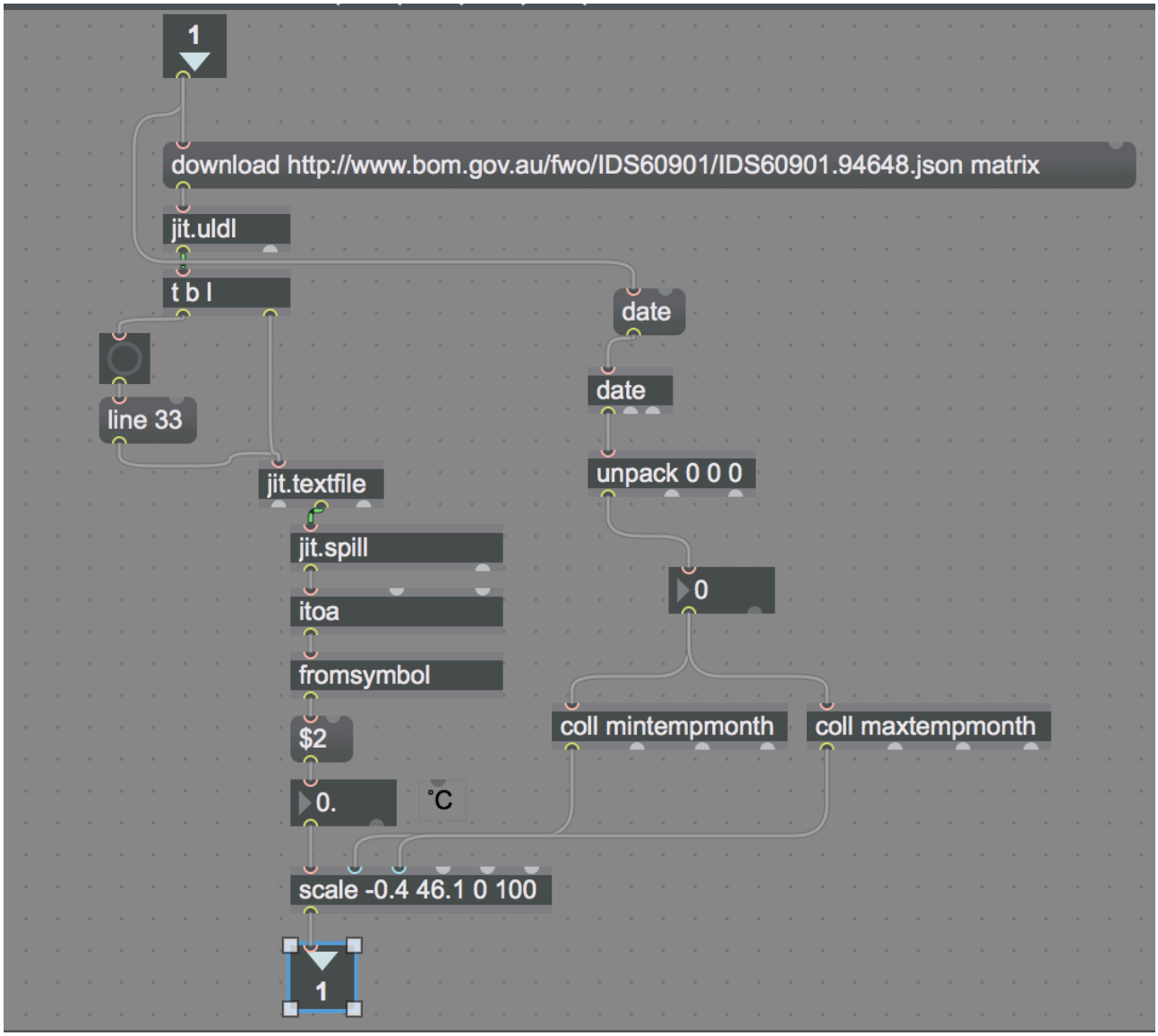

Figure 19: realtimetemp subpatch

A Night Chorus was introduced, active between 8 pm - 6 am. Reduced to the prominent 590Hz tone and its overtones (1080, 2160, 4320 Hz), the Night Chorus manifested additional pitch material by ring modulating the tones values of the Mains Hum (50, 100, 200, 400 Hz), suggesting 'spectral interference' (pun intended) in the electronics. This was achieved through the Max RingModDual patch, which widened the palette of modulating frequencies each hour from 8 pm (only 50Hz) to 11 pm (all Hz values), sustaining them until 1 am, and then narrowing them each hour back to 5 am.

Gaps between 5-6am and 7-8pm between Day Chorus and Night Chorus activity allowed for clear transitions between each component.

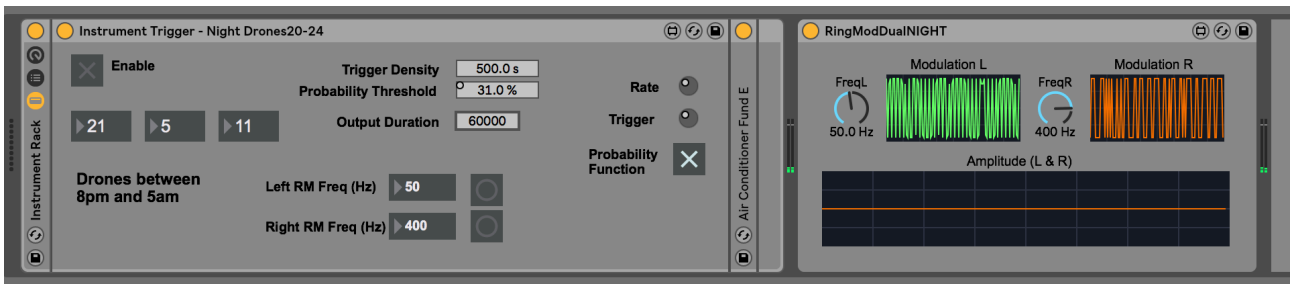

Figure 20: Night Chorus Patch with Ring Modulator

The biophonic elements were divided between choruses and individual birds. Samples of the dawn and dusk choruses taken from the long-duration field recordings were triggered by max Patches that referenced each day's official dawn and dusk times. Individual birds calls were loaded into a drum rack, and triggered with an adapted 'Density Patch'.

Anthropophonic sounds were sorted into activity-based groups. Pedestrian-based sounds such as footsteps and 'walking' traffic signals retained the temporal relationships of 'A Day In An Alleyway' with 'Density' patches triggering samples between 7-9am, 12-2pm and 5-7pm. Throughout the day, other walking samples and a 'waiting' traffic signal were randomly triggered. The 'Bells' patch triggered samples of the Victoria Tower bells at the appropriate quarter-hour interval. Other components, including vehicles, sirens, and percussive bangs, clangs and slams were triggered randomly through the day.

Interested in live-processing sound samples and distorting them slightly to suggest a spectral, ethereal presence[4], live weather data from the West Terrace/ngayirdapira weather station was sourced through a JSON file, and specific data sets were connected with Ableton Audio Effect or Max patch parameters. Examples include:

- Using temperature data to affect the density of sound events (as previously explained of the Air Conditioner Chorus)
- Using humidity data to affect the Dry/Wet ratio of the 'Metallic Rezo' effect of the 'Mains Hum' component

[4] The distortion of a sound signal is a hallmark of electronic voice projection (EVP), a field of pseudoscientific research which endeavours to record the voices of spirits (Banks 2001)

- Connecting the BOM temperature and humidity data with the Sound Particles 'Air' Plug-in, filtering frequency spectra based on air quality (Fig. 23)
- Connecting air pressure and wind speed data with the Grain Delay effect's 'Spray' and 'Time' parameters for processing of discrete samples (Fig. 24)

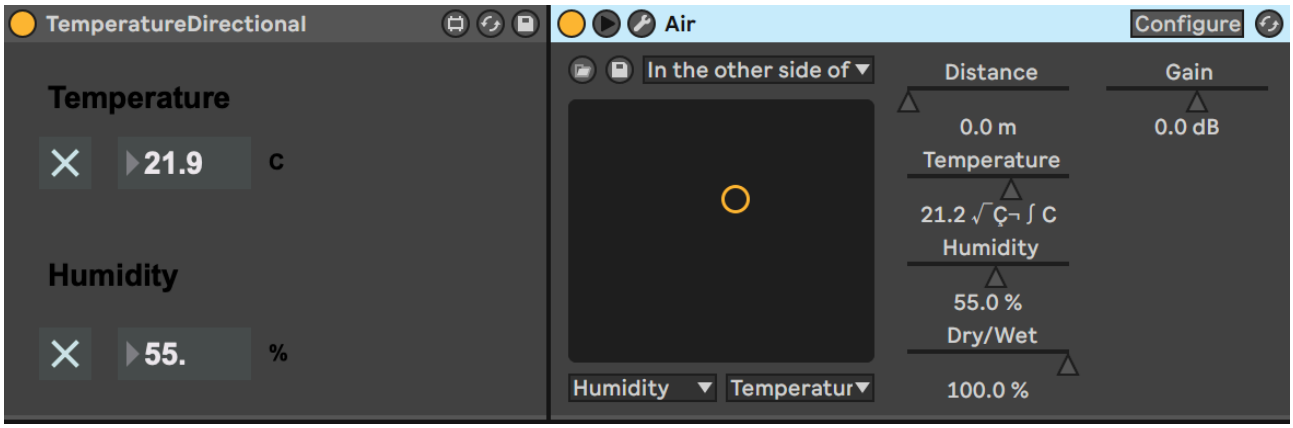

Figure 21: Temperature and Humidity data drive the Air Plugin

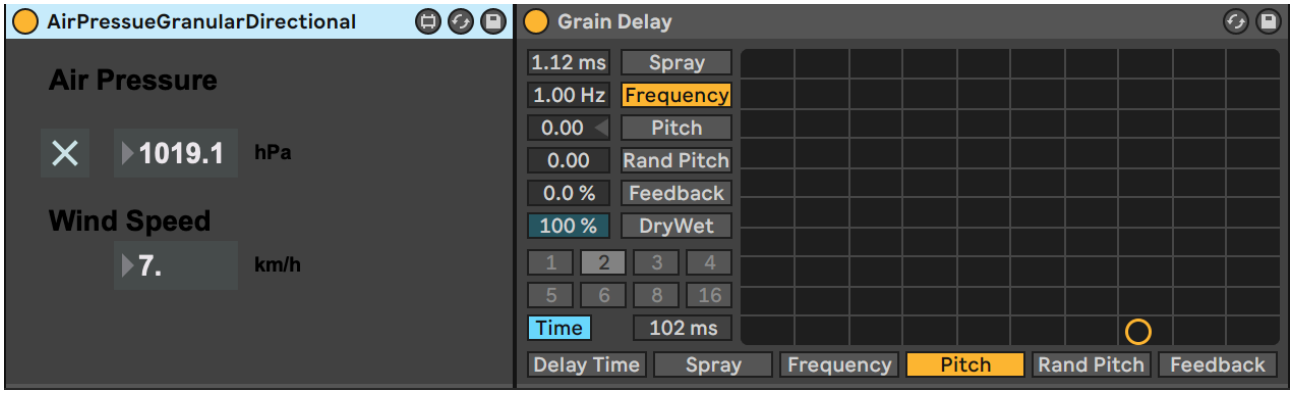

Figure 22: Air Pressure and Wind Speed Data driving Grain Delay parameters

Complementing this spectral processing, the Convolution Reverb Pro devices were use to convolve sounds with an impulse response of the space (sourced from the field recordings). Variations on the Size, Decay and Dry/Wet parameters were made to suggest a sense of other-worldliness in the resultant sound.

Figure 23: Convolution Reverb Pro with Featherstone Place impulse response

Additionally, the quadrophonic setup allowed for panning of sounds. While this was challenging in the initial stages of the project, the release of Ableton Live 10 in early 2018 introduced a Surround Panner Max patch, which allowed for easy routing of multichannel audio and automation of patch parameters. Taking advantage of this, a complimentary 'Wind Direction' Max patch was developed which converted the current BOM-referenced wind direction into Cartesian (X/Y) coordinates, which controlled the coordinates of the Surround Panner.

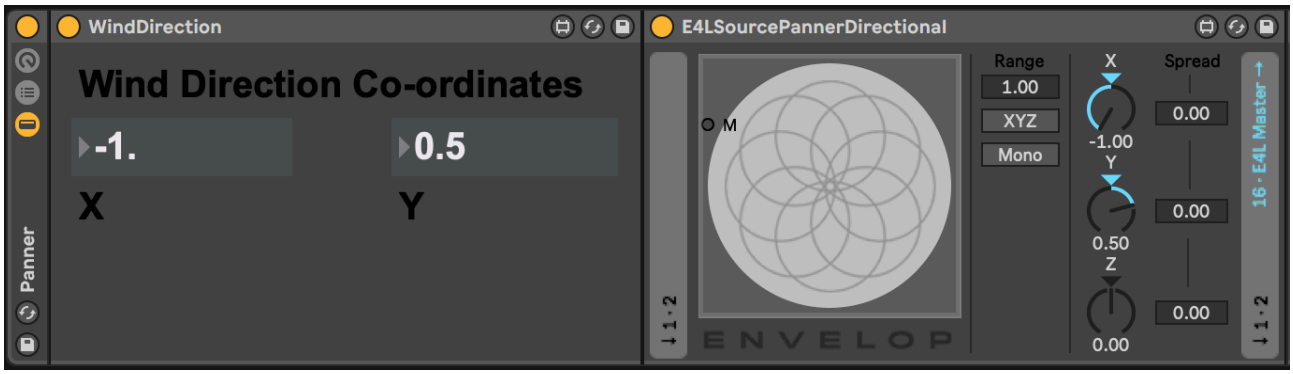

Figure 24: WindDirection patch with Envelop for Live Panner

In order to complement the new components of *Featherstone Place* and involve Zephyr Quartet as performers, *A Day In An Alleyway* was redeveloped into an electroacoustic work. This involved implementing the Mains Hum and Night Chorus components into the electronic part and devising modular transcriptions of the components for the quartet. This occurred with the Pedestrian Traffic Signal component as well, resulting in a Reichian

canonic pattern emulating the phasing relationships between multiple pedestrian traffic signals heard at intersections. The Victoria Tower Bells were also transcribed with spectral analysis and arranged for the quartet to play at the original times of the acousmatic work.

5.4.5 - Realisation

The original version of *A Day In An Alleyway*, commissioned by the Adelaide City Council as part of the *Soundscapes* program, was exhibited in the Adelaide City Council's Pirie Street Breezeway from 15 February to 8 April.

Featherstone Place was exhibited in the eponymous laneway from 20 April to 15 May 2018. This was realised in a quadraphonic speaker setup, made up of weatherproof Tropix speakers kindly provided by Krix Loudspeakers. Suspended with wires from those overhead wires supporting a vine canopy, the speakers hovered mid-air, giving the ghostly impression that they were floating. All audio cabling was routed to the installation hardware, which was housed behind the front door of BASEM3NT studios.

Within in the installation space, a performance by Zephyr Quartet on 27 April 2018 featured the string quartet and electronics version of *A Day In An Alleyway*, as well as arrangements of various pop songs from the Quartet's Cult Classics concert series, as a tie-in with the 'ghostbusker' concept mentioned earlier (Fig. 28 & 29). The installation was exhibited again at the International Ecoacoustics Congress in Brisbane, on 23 June 2018.

Figure 25: Featherstone Place with quadraphonic speaker setup installed in vine canopy. Image by Jordan Lacey.

Figure 26: Zephyr Quartet performing at the Featherstone Installation space, 27 April 2018. Image courtesy of Zephyr Quartet

Figure 27: Zephyr Quartet performing at the Featherstone Installation space, 27 April 2018. Image courtesy of Zephyr Quartet

5.4.6 - Reflection

In developing 'A Day In An Alleyway' and 'Featherstone Place', particular concerns emerged around the nature of site-specific work, namely ethics (and ethology), the sourcing of 'live' data streams, and the presentation of site-specific works in other locations.

Given the Sonic Rupture focus of promoting affective engagement with place, there is a need to consider its functional use of space, and how an installation may relate to pre-existing dynamics, whether as a passive background sonic texture, or an active foreground contributor to the sonic environment. In *Featherstone Place*, such considerations were required to adhere to constraints resulting from such legislative controls as the need to operate within regulated noise levels, and to work with inhabitants of the space such that they might embrace rather than reject the introduced sonic activity.
Working with inhabitants extended to non-humans as well, particularly where there is playback of site-specific sound samples, such as bird calls and traffic sounds. As per the Eco-field Hypothesis (Farina & Belgrano 2006) and Acoustic Habitat Hypothesis (Mullet, Farina & Gage 2017), which propose that animals identify and locate resources and appropriate habitats through sound referents, numerous studies have demonstrated avoidance of a space as habitat by particular species, resulting from audio playback of conspecific calls or urban noise in situ (Betts et al. 2008; Fletcher 2007). From this, considerations of the cognitive and behavioural impact on non-humans arise, influencing creative decision making.

With the rise of big data, many additional sources other than BOM may be utilised. In the early stages of development, urban traffic data was considered, in reference to studies indicating that urban birds alter call frequency and amplitude to overcome traffic noise (Slabbekoorn & Peet 2003). The HERE traffic API, which includes informatics such as traffic flow and congestion, was investigated as a potential data source to influence the installation's biophonic component pitch and amplitude. However, following developmental challenges, this was not implemented, something that is intended to be rectified in future iterations. Even so, such sources provided a broad scope for dynamic,

emergent and co-creative elements (via Connors 2017) to be implemented in urban sound installations.
Additionally, the question of whether it is appropriate to exhibit site-specific work at sites other than the original arose from presenting at the International Ecoacoustics Congress in Brisbane. Ecoacoustically, the sounds and relationships manifest in the creative responses to Featherstone Place and, by extension, the Adelaide CBD ecosystem and soundscape, are not directly related to those of the Brisbane Southbank area. However, as noted by Lacey (2016b), urban sound can have a homogenous and monotonous quality that is invariant between different locations. Consequently, I feel there are potential intersections between specific urban environments that emerge when locating a site-specific 'Sonic Rupture' elsewhere.

Together, *A Day In An Alleyway* and *Featherstone Place* can be considered as contrastive approaches to urban sound installation in an Ecoacoustic framework. One is a temporally-contracted fixed duration work, the other an emergent and ephemeral real-time overlay on the existing soundscape. As related to the Ecotonal creative framework, these work mark a departure from the more rigid approach to creative material development and composition evident in Mobilong and Long Island, moving towards greater flexibility and abstraction. These aspects are explored further in the creative response to the desert ghost town of Farina.

5.5 - *Farina*

> At Farina, as in other inland settlements, there was the constant battle with survival. There was little time for elegance or aesthetics as people battled merely to exist. To provide shelter and gather the necessities for a simple living was in itself an achievement and led to a sense of impermanence and uncertainty. People were continuously ill at ease with the physical environment and due to the struggle, became adept at improvisation and adaptation. Such improvising made for a unique humanscape of fascinating difference - buildings are visually stimulating for they often consist of conglomerations of wire, iron, stone and timber; they themselves are an unimaginable combination of the battered, the battler, the determined and the enduring (Olston 2009, p. 11).

5.5.1 - Background

Farina is a ghost town in the Far North of South Australia. It was founded in 1876 as an agricultural community despite advice from Surveyor General George Goyder, whose famous 'Goyder Line' denoted areas of reliable rainfall in the then colony, with Farina falling far outside of this boundary (Sheldrick 2013). Following multiple seasons of crop failure and the introduction of the Ghan railway venturing further north, the town became a service centre in Central Australia in the early to the mid 20th century, the population gradually declining in tandem with new technological developments. After the town's desertion in the mid-1960s, the area came under the custodianship of Farina Station, a pastoral lease station. In recent years, there has been significant restoration activity by the Farina Restoration Group, preserving Farina as a historic desert pioneer town (Olston 2009).

Like many colonial South Australian towns, Farina's survey plan borrowed from that of Adelaide, a gridded street system with border terraces in each cardinal direction. To the west, a train line ran north to south, supporting a hub of activity throughout the town's history. Many businesses and dwellings were situated in the town, with various trades represented: the ruins include those of an underground bakery, hotels, blacksmiths, general stores, stables, plus police stations, schools and churches. Surrounding the town were numerous multicultural presences including an Adnyamathanha (local First Nation) camp located to the north above the creek line, gardens established by Chinese railway

workers, and a Middle Eastern cameleer camp situated further to the west on 'Afghan Hill'.

Figure 28: An aerial overview of Farina's contemporary landscape. The modern Farina Station homestead is marked centre left. Image via Google Maps.

This projects follows from other sound art works dealing with desert ecosystems, including Garth Paine's Listen^{N} Project, an open-access desert field recording database for scientific study and creative works with compositions by Bandt, Barclay, Del Farra, Quin and Paine (2015), David Dunn's *Nexus I* and *Sky Drift*, Maggi Payne's *Airwave (realities)* and *Desertscapes* (Feisst 2016), and Richard Lerman's sound maps of the Sonoran Deserts (Britton 1997).

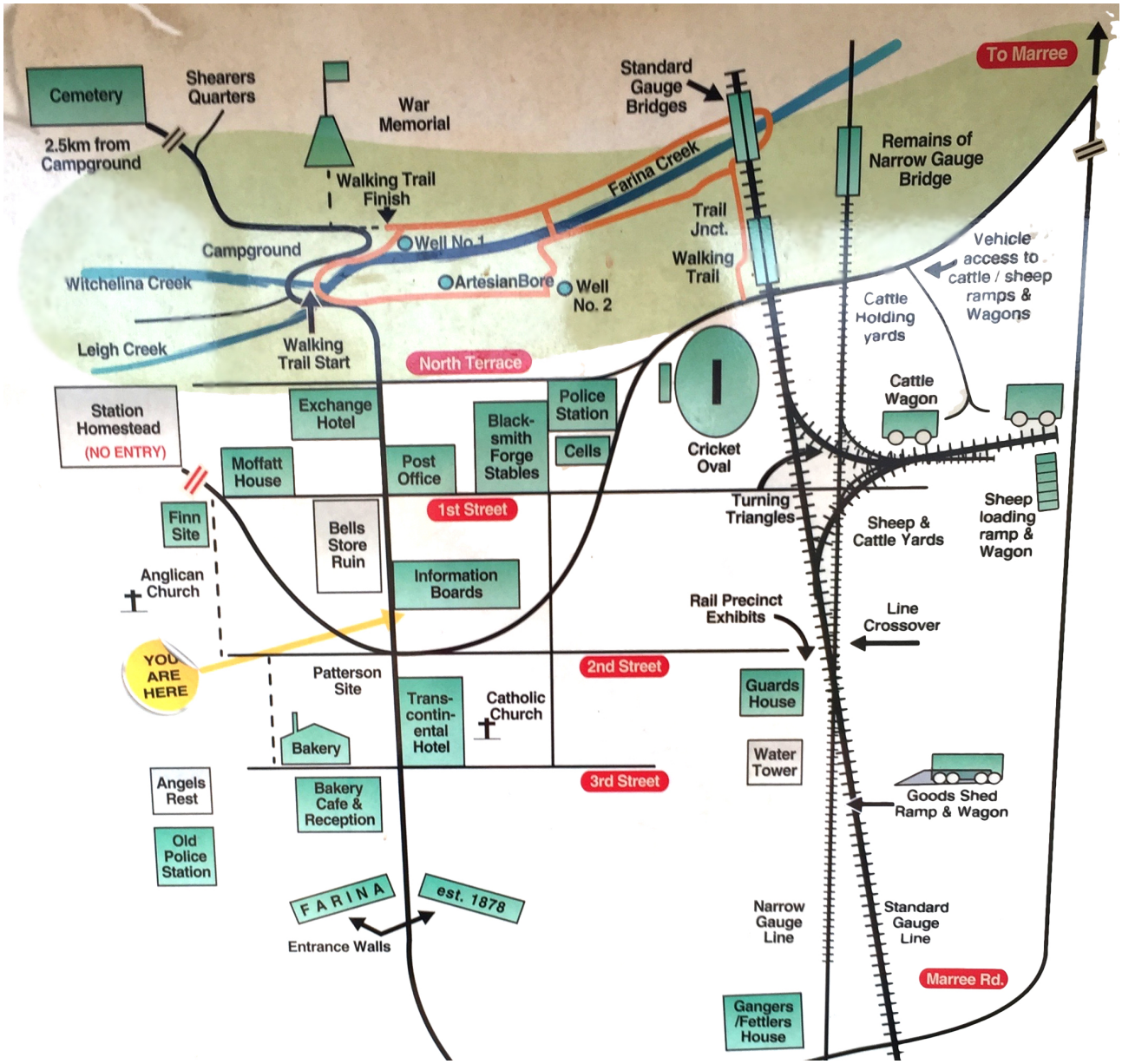

Figure 29: A detailed sign mapping Farina's ruins and current buildings. Image by the author.

5.5.2 - Conception and Collation

For my initial ideas and research, several print sources were consulted. Rob Olston's book, 'Farina - From Gibbers to Ghost Town', provides a comprehensive historical overview of the town's development, and was gleaned for references to industrial, technological and cultural dynamics that would have contributed to the evolving soundscape (2009). A subscription to the Farina Restoration Group's newsletter provided information of the redevelopment activities, and further historical records were identified through correspondence with the Group's volunteers. Additional resources from DEWNR and the

Bureau of Meteorology (BOM) were both consulted for environmental and climatological information.

From these records, I compiled a list of potential sound sources related to biophony, geophony and anthropophony. Each of these has developed throughout the town's history. The biophony was initially composed of native animal vocalisations, later diversifying and competing with introduced species. The geophony, occupying a significant omnidirectional presence, is sounded through seasonal fluctuations between drought and flood and conveyed more subtly through the dry reverberance of the open, flat landscape. The anthropophony exists at multiple levels, at the microscale with sounds related to specific industries (hotels, bakery, blacksmith) and the macroscale with changes to infrastructure (primarily transportation and the changes of transit technologies on the ground and in the air). Influenced by this information, I conceived the idea to creatively reconstruct the soundscape, mapping the town's acoustic evolution its 140-year history from settlement to the modern day.

Field work began in June 2016, in the South Australian winter. This involved recording with a Zoom H6 portable recorder in various habitats, including gibber plains, scrubland and the creek. I was also able to engage with many locals, both permanent and transitory, whose specific knowledge of environment, industry and culture in the area informed my understanding of place. Amongst them were the Farina Station owners, Kevin and Anne Dawes, the head baker and president of the Farina Restoration Society, Martin McLennan, and many others, grey nomads from around Australia. While there, I also had the opportunity to participate in an annual commemorative ceremony conducted by representatives the of the Royal Australian Air Force, acknowledging the death of Farina-born Flight Lieutenant John Bell, one of the first Australians killed in World War II.

Figure 30: Modern day Farina, with heritage buildings and tourist information centre. Image by the author.

Figure 31: Examples of Farina ruins on the expansive landscape, involving various building materials. Image by the author.

In February 2018, I returned to Farina for further fieldwork. In the midst of summer, where each day exceeded 40ºC, I made field recordings in each direction surrounding the town - in the north and west by the creek beds, in the east close to the railway ruins and the south amongst a plain of gibbers. Also, I spoke further with Kevin and Anne Dawes, who allowed me access to the various scrap materials around the site for further investigation off-site.

Figure 32: Examples of glass, metals and wood scrap. Image by the author.

Figure 33: Remnant animal pen, made from scrap metal. Image by the author.

5.5.3 - Preparation and Composition

Assembling the work began by devising a schema for the temporal contraction of the 140-year history to a concert work duration. Each year (1876-2018) was attributed ten seconds, with an additional set of 20 seconds at the beginning to establish the soundscape before European colonisation. This gives a total duration of 24 minutes.

Then, drawing on the multiple sources of textual information including Rob Olston's book and the interpretative signage at Farina, a spreadsheet was made compiling textual references related to animal, weather and human-orientated activities at Farina in chronological sequence. From this, the various sources of biophony, geophony and anthropophony and their related periods of activity were deduced.

Electronics

The electronic component was designed around an octophonic speaker array, which was correlated directly with the cardinal and intercardinal directions of the town's design. This permitted the representation of Farina's spatial dynamics, particularly of the creek's water flow in the north (flowing NE to NW), the transportation thoroughfares to the east (flowing interchangeably between NE to SE), and the omnidirectionality of weather patterns (Fig. 36). In Ableton Live 10, the ambient soundscape was first developed, using interwoven samples of the 2018 field recordings made in each direction.

Initially, panning was achieved with the 'Surround Panner' Max for Live patch. However, during development, a suite of ambisonic Max patches, 'Envelop for Live', were released, featuring an encoder, a decoder, and multiple spatial effects. Given the versatility of ambisonics and the effects within the Envelop suite, the switch to Envelop was made.

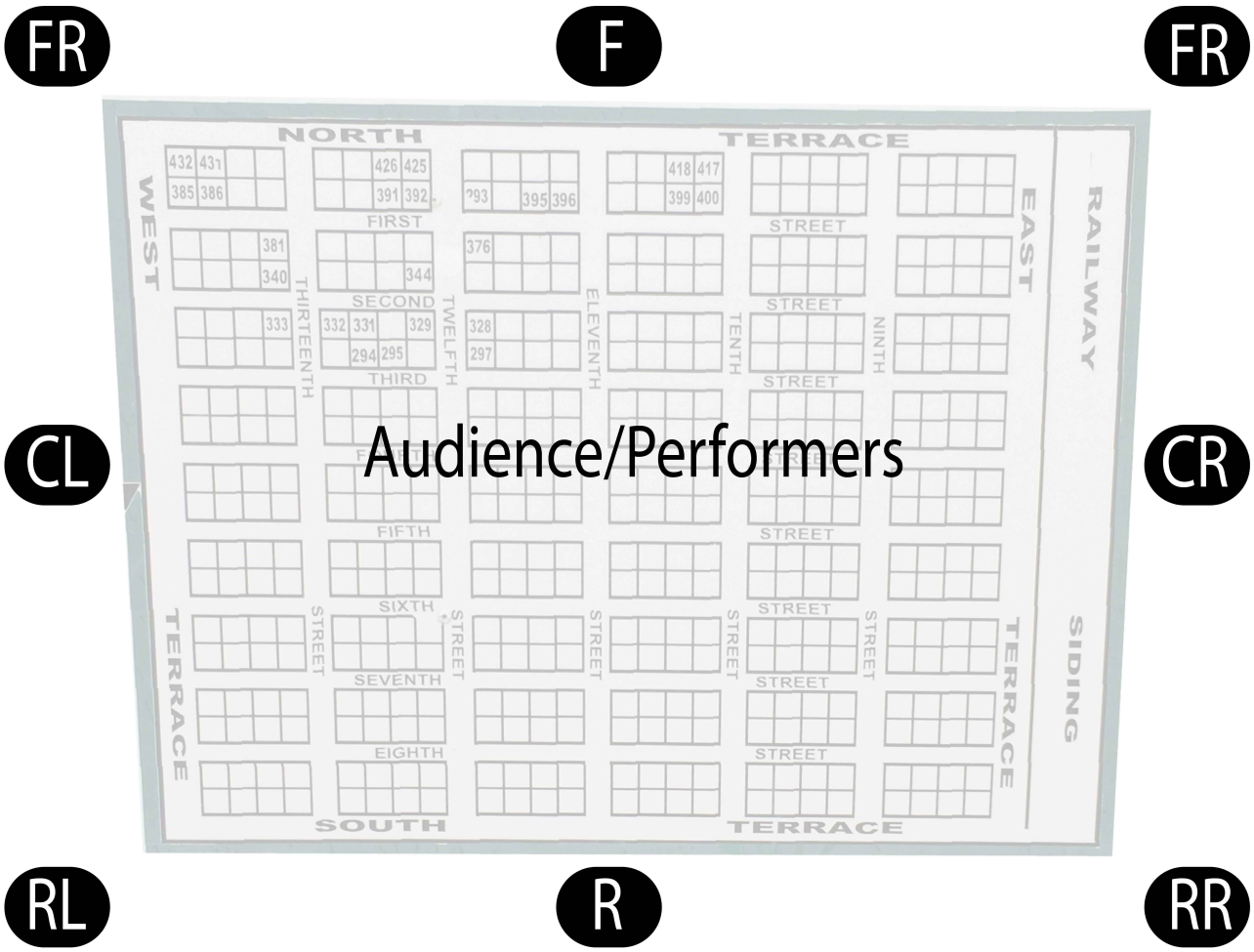

Figure 34: Performance setup, superimposed over a Farina survey map (printed on a sign at the site).

Separately, components for the geophony, biophony and anthropophony were developed. The Geophony featured two tracks entitled 'Storm' and 'Thunder', developed from a 2016 field recording made at the flooded Wilpeanna Creek, and peaking wind noise in the 2018 Farina recordings respectively. The amplitude of these tracks was automated in response to rainfall records at Farina, with the minimum and maximum values mapped to a range of -30dB to 0dB in the 'Rainfall' Max patch.

Relying on the direction field recordings to represent the native wildlife, the biophonic components featured exotic animals primarily associated with the town's pastoral and transportation activities. These included cattle, sheep, pigs, goats, dogs, horses, donkeys and camels. Many samples of each animal were collated, and, using the Sound Particles software, which allows the creation of sonic particle systems, unique group arrangements of the samples were made. These were then arranged in the Ableton according to

appropriate times and spatial locations. While some animals occupied particular locations (i.e. cattle and sheep in the NW at the stockyards), others moved more freely, and for these samples, the Envelop Spinner patch was used to randomise spatial position in playback.

The Anthropophonic components featured transportation and infrastructural sounds. Like the Biophony, samples of trains, planes and cars were sourced from historic foley recordings and positioned with respect to appropriate times and spatial locations.

Basic filtering was done through Sound Particle's 'Air' plugin, with the Temperature control automated by temperature records from Farina (from 1908 to 1939) and Marree (from 1938 to 2015), with missing years filled from sets of the available data. The automation of the plugin's Humidity control (devised from the rainfall data) was also tested but removed due to awkward filter sweeps resulting from irregular rainfall patterns.

Instrumentation

Drawing on my insightful experiences with Cheryl Leonard in mid-2017, and her practice of using found natural objects as instruments, I was attracted to the idea of using found objects as percussion instruments for *Farina*. During my fieldwork, I came across many objects lying on the ground, including wood, corrugated iron, scrap metal, glass bottles, and bone. Linking the intended performers of the Farina Restoration Group to the inhabitants of old, I had the idea that these materials could be associated with their related trades, wood and metal for construction, glass bottles for hotels, bells for churches and schools, and so on.

Knowing that any onsite performance would have to take place in winter, I planned to engage the Restoration Group volunteers as a community percussion orchestra, as a means of engaging the current community with the area's soundscape, and sociocultural and historical identities. As such, the work was envisaged to provide both learning and (re)connection through active participation of volunteers in as performers, rather than passive observation.

Text scores, recognised for their ability to articulate sonic ideas and information outside of traditional Western musical concerns (Hope 2017), were chosen as the most effective and accessible means of conveying instructions to performers. Information was restricted to instrumentation, time cues, relative dynamics, and spatial location. Like the octophonic speaker array, the performers were assigned particular directional locations from which to play, related to the direction of the industry they were representing.

5.5.4 - Realisation

On 19 - 22 June 2018, I travelled with percussionists Vanessa Tomlinson and Josh Baldwin to Farina to realise the work. This trip was supported by funding from the Outback Community Authority and the Farina Restoration Group.

Two workshops took place. On Wednesday 20th June, Tomlinson, Baldwin and the community members explored sound-making with found objects collected that day. On Thursday 21st June, the sound explorations were integrated into the full work, and rehearsals with the electronic track took place.
Also on that day, I realised that the multichannel snake cord necessary for the 8-channel playback was missing. Fortunately, two cords were sourced from the nearby community of Leigh Creek and Copley to allow for stereo playback, and as such, the Envelop ambisonic decoder was rerouted to 'stereo'.

As described by Leonie Kerley, who documented the Restoration Group's activities that week:

> Wednesday night practice was fun. Blowing into bottles to make them sing, whistle or hum was interesting; surprisingly difficult for some. The 'found objects' included horse shoes, an old stock pot, a hub cap, an old wood stove, bottles, dog spikes, corrugated iron, old metal and a fork. Thursday night dress rehearsal indicates we have a hit on our hands (Kerley 2018).

On Friday 22nd June, *Farina* was performed outside Tom's Shed at dusk, attended by approximately 60 people.

> 5pm and complete silence at Tom's shed. The audience is keen to be involved and walk or stand silently within the square. The sound, pre-recorded by Jesse commences and the percussion by the 'musicians' begins. 24 minutes of goose bumps from the eerie sounds of wind howling, train, planes and birds and the sounds of the found objects being tapped, hit, banged and stroked, reaching a crescendo and then ebbing to peacefulness and it was all over, coinciding with the setting of the sun (Kerley 2018).

Figure 35: Drone image of Farina landscape, with performance layout outside Tom's Shed. Image courtesy of John Toogood.

Fig. 36: Rehearsing bottle blowing outside Tom's Shed. Image courtesy of Leonie Kerley.

Figure 37: Vanessa Tomlinson and Jesse Budel rehearsing *Farina*. Image courtesy of Leonie Kerley.

Figure 38: Drone image of the performance of *Farina*, 22 June 2018. Image courtesy of John Toogood.

Figure 39: A performer playing bottles in *Farina*. Image courtesy of Leonie Kerley.

Figure 40: Jenny Rainbow playing with wooden materials in *Farina*. Image courtesy of Leonie Kerley.

Figure 41: The Farina community percussion orchestra after the performance. Image courtesy of Leonie Kerley.

5.5.5 - Reflection

The final work of the portfolio, *Farina* aims at creating a record of the broad-scale ecological, sociocultural and technological changes over the area's 140 colonised history. This is achieved through temporal and spatial compression and gestural representation of soundscape activity using industrially-associated found objects and automated sound processing driven by barometric statistics.

Here, Soundscape Ecology's principles and methods moved beyond basic ecological representation and commentary to develop new modes of access in experiencing the place's multilayered ecological, sociocultural, political, technological and spiritual identity. It provides a means of reconnecting contemporary custodians, descendants and visitors of Farina with the landscape and soundscape of the town and greater Arid South Australia.

Additional, the work can be seen to engage in archeoacoustic endeavours, using extant material realities and documentation towards reconstructing the historical soundscape. An

example of combining archeoacoustics with ecoacoustics as discussed by Farina and Gage (2017a, pp. 22-24), *Farina'* employs soundscape ecology understandings of the impacts of gradients (abiotic factors) upon soundscape activity. In lieu of recorded acoustic data, historic environmental records (weather data, diaries, survey maps) were consulted identify elements influencing the biophony, geophony and anthropophony of the historical soundscape, in turn informing the creative approach and result.

There is scope for further developments of the work. Presented acousmatically in an ambisonic format, Farina has the capacity to develop into a VR/AR work, coupled with 360 panoramic images, in a similar vain to Garth Paine's *Ecorift* VR work in the Sonoran Desert as part of the Listen^{N} project. Not only would this allow for greater accessibility to the work (moving beyond the complex logistics necessary in a multichannel and multi-person setup), but it would also act as a cultural artefact that could be experienced by visitors to Farina on-site (as part of the Restoration Group's Visitor Centre) or further afield by means of a stand-alone iOS/Android app. Given advances in mobile technologies and the capacity for community engagement (Barclay 2017), a virtual or augmented version of Farina allows for further exploration of the material's potential.

Through the VR/AR medium, there is also the capacity to involve oral histories of place, and Farina's diverse, multicultural identity would necessarily warrant the inclusion of Adnyamathanha and Afghan perspectives of place and history. Including these voices would not only provide a means of representing and reconnecting with their associated cultural histories but educate contemporary South Australians about cultural history through the foregrounding of non-European perspectives.
In early concepts of *Farina*, it was intended that oral histories would be included in the concert work (Budel 2018) through collaboration with Farina's local First Nations peoples and descendants. However, due to time and geographic constraints in contacting potential contributors, I came to feel that efforts toward this would result in tokenistic inclusions of culturally and spiritually-sensitive materials in the electronic component of the work. This, I felt, could potentially replicate the questionable ethical approaches and mishandling of sensitive materials by Australian art music composers (as discussed in Paget 2013), and decided to omit such content. However, with opportunity to revisit the work as a virtual/

augmented reality experience, and with examples of appropriate methods of intercultural collaboration in Acoustic Ecology (e.g. Biosphere Soundscapes (Barclay 2014)) and Ecoacoustics (Ritts et al. 2016), the capacity for collaboration with current-day custodians, descendants and adherents of faith in a new multimedia version is envisaged, in which communal research, contribution and commentary on our complex and interwoven histories can be fostered.

6 - Conclusion

" 'Neath the gumtrees by the roadway,
As the sun goes down outback
I lay at rest in peaceful reverie,
Then I thought of all the songs I'd sung
About the outback track,
And that is how this vision came to me."

Along The Road of Song, Slim Dusty (1962)

Before discussing the contribution to knowledge that this research project makes, I feel it necessary to reflect on the milieu in which it has taken place. Since the beginning of the project in early 2015, the conversations and ideas of Soundscape Ecology have been refined and re-contextualised within the broader research and practice of Ecoacoustics. My research and practice began on the periphery of this community and its discussions, and over the past four years, has engaged more closely with those interested in and contributing to its development.

In June 2016, I first presented early findings of this research at the Brisbane-based Sonic Environments Conference, a joint effort of the Australian Forum for Acoustic Ecology (AFAE) and the Australian Computer Music Association, wherein in I connected with key members of the AFAE. Later, I joined the AFAE as a board member and am currently serving as its Secretary. I also met composer and sound artist Teresa Connors, whose own investigations of Barad and Morton in her Ecological Performativity framework became influential in my research. Our paths were to cross later at the Toronto International Electroacoustic Symposium, where I presented internationally on the Ecotonal Creative Framework as applied in *Long Island* and *Farina*.

In mid-2017, my professional development tour of the US and Canada (though not strictly related to this research project) allowed me to connect with Barry Truax and Hildegard Westerkamp at a time of substantial change in Acoustic Ecology. Not least of these developments was the 2017 special edition of *Organised Sound* (co-edited by Truax)

codifying 'context-based composition', featuring a piece positioning soundscape composition within this framework and Gilmurray's article introducing 'ecological sound art', a field in which the Ecotonal Framework can be situated.
Most recently, I was fortunate to attend the International Ecoacoustics Congress in Brisbane in June 2018, at which my paper on Ecotonality and its implementation in *Featherstone Place* gained recognition as the best student paper in the Congress' Creative stream.

These changes in the scope of Soundscape Ecology and its connections to the broader conversations in Ecoacoustics and Acoustic Ecology have come to inform and influence my site-specific creative practice, consequently manifesting as the Ecotonal Creative Framework.

6.1 - Contribution

In understanding the contribution made by this research project, I return to the research questions presented in the Introduction.

1. What are the principles, frameworks and methodologies of Soundscape Ecology, and how might they be adapted to creative practice?

To answer the first part of this question, Chapter 2 presents a literature review of Soundscape Ecology frameworks, methods, principles took place, identifying the discipline's key concepts and ideas as related to historical development, taxonomy, field practices, analytical methods and epistemological bases, supplemented by critical perspectives of the discipline, both internally and externally by those in other fields.

Relating to the latter part, Chapter 4 identifies systematic similarities between Soundscape Ecology research and sounding art practices and subsequently maps Soundscape Ecology frameworks, methods and principles across to creative process to result in the Ecotonal framework.

2. How can a creative practitioner effectively respond to, represent, and reflect upon specific places, and associated ecosystems and soundscapes?

This question is initially answered using the literature review of creative practices connected with soundscape, environment and ecology. The result of this appears in Chapter 3, which provides a background overview of historical developments, the Acoustic Ecology movement and soundscape composition, and the recently introduced field of 'ecological sound art', before discussing numerous ecological sound art practitioners internationally, in Australia, and more specifically in South Australia.

Chapter 4 subsequently present the Ecotonal Creative Framework, which presents a multistage creative process of creative conception, materials collation, preparation and analysis of materials, composition and realisation of the work, and post-creative activity reflection. The framework provides strategies for the identification and manipulation of micromorphological relationships between sounds and their sources (i.e. biophony, geophony, anthropophony), and importantly in a Soundscape Ecology context, their macromorphological representation according to spatiotemporal relationships, and broader sociocultural, historical, political and spiritual contexts.

Consequently, creative responses, representations and reflections are the result of the creative practitioner's conceptive, collative, preparatory and analytical, compositional, realising and reflective intra-actions with human and non-human entities.

As suggested by Barad's paradigm of agential reality, the aspiration to represent soundscapes and ecosystems through creative work necessitates recognition that any attempt at exact reproduction is fundamentally compromised. As identified in Chapter 2, the practice of field recording in collating materials involves many decisions that increasingly abstract materials from their source environment where content (sound and related sources) is situated in an environmentally-meaningful context (ecosystem and soundscape). Such an understanding is equally important for the Soundscape Ecology researcher-observer, whose conceptual and methodological research design, recording practices, associated monitoring devices, and analytical activities are likewise productive

of their research outcomes, regardless of the use of long-term passive acoustic recorders in the field. For creative practice, the inherence of abstraction of sounds from its source necessitates transformation as part of the creative act. This allows the creative practitioner to work within a flexible and responsive continuum of transformative practices in developing ecologically-sensitive site-specific responses, both at the micromorphological (sonification ⇔ phonography ⇔ abstraction) and macromorphological scale (variable spatiotemporal and perspectival scales) .

The Ecotonal Framework additionally endeavours to embrace the non-human (as related to the work of Barad and Morton), both as living biotic beings in place (biophony), and abiotic phenomena represented either as sound (geophony and anthropophony) or through data. This is achieved metaphorically through involving performer decision making (through modular scoring as an interface for agential intra-action with transduced representations of sound) and through employing stochastic event triggers and environmental data-automated processing. As a result, the creative works, while in part a manifestation of the creative practitioner's intentions and activities, may only be realised through the participation of entities and processes outside of the creative practitioner's direct control, and thus situates them within creative ecosystems of infinitely unique outcomes.

Ecotonality can also be understood to offer new modes of creative engagement with acoustic environments that move beyond the categorical limitations codified in musical and sound art theory to operate on a sounding art continuum. Extending from Chapter 3's positioning of ecological sound art as a field of sounding art practice, Ecotonality explore the context and site-responsive adaptation of ecologically-sourced materials to creative circumstances. Through connecting Soundscape Ecology analytical parameters with acoustic parameters, these materials were adapted for instrumental representation or electroacoustic treatment appropriate to the ecological context and creative resources available for realisation. In turn, this allowed for flexibility in creative concepts and outcomes, including traditional concert works to installations and potential VR/AR works, all featuring emergent elements which render each presentation ephemeral. Consequently, Ecotonality engenders a flexible methodology of creative engagement with

place, resulting in multiple potentialities that highlight the dynamism of associated ecosystems and soundscapes.

3. Which South Australian sites might be suitable to creatively convey the state's diverse places, ecosystems, soundscapes and identities?

With an area close to one million square kilometres, South Australia offers many places with different ecosystems and biomes for site-specific creative response. As the creative projects were intended as acid tests of the Ecotonal framework, the selected sites emerged in part through attempting to work in different biome types, and through professional opportunities, logistical circumstances and personal connection and access to places.

Mobilong represents a real-time, spatially-dynamic sound walk of Pump Road at Mobilong Swamp, Murray Bridge, where the associated soundscape and ecosystem are the result of historical activities including early settler irrigation practices, land striation, drought and remedial activities.

Long Island presents a temporally-static, spatially-dynamic cross-comparison of terrestrial and aquatic soundscapes impacted by motorboat activity in the Murray River, revealing the impacts of human recreational and commercial activities, political controls and environmental management.

Featherstone Place is a real-time, spatially-static overlay to the existing Adelaide CBD acoustic environment, driven by site-specific conditions and attuning the mobile listener to the city's diurnal and seasonal soundscape patterns. Complementing this, *A Day In An Alleyway* provides a temporally-contracted rendition of the emergent and evolving installation.

Farina is a temporally-contracted, spatially-static capsule of the ghost town's 140-year history, bringing to light its sociocultural and ecological elements through community engagement and participation.

Following from brief discussions of identity earlier in the exegesis (as related to Barad and Morton), two works from this research project are discussed in Camille Roulière's doctoral thesis, 'Visions of Waters in Lower Murray Country', which critically investigates sociocultural engagement with the Lower Murray River. Roulière draws attention to the aesthetic influence of place upon the creative practitioner (especially the ecological sound artist), and the compositional processes and outcomes that follow:

> In recent years, there has been an amplification of relational and mimetic compositional processes: beyond the desire to make histories audible, stands the desire to (de) or (re)compose waters—that is, to thwart compositional perspectivism and use multivocality to remove hierarchies, and to destabilise the fixity and compartmentalisation of environmental concepts. Performatively constituted and geo-temporally located, these processes of composition are physical; they are suffused with polyrhythms (p. 268).

Rouliere goes on to discuss how this is demonstrated in *Mobilong* and *Long Island*, both site-specific works situated on the Lower Murray River. In *Mobilong,* the sonic material is recognised as representing material circumstances and histories of place, "a story of waters that is about regeneration rather than simply depletion and destruction" (p. 269). Suggesting narrative structure via the passage of the listener through interconnected habitats and acoustic environments, *Mobilong* operates "as an ear-opening journey: the monocrop-based enclosure of land fades away in parallel with the monological colonial imaginary of the auditory mind. Polyphonies are (re)discovered" (ibid., p. 270).

By comparison, *Long Island* "plays with the unsightliness of noise, usually left out of traditional scores and charts… instead of blocking or removing noise (boat engines), Budel incorporates it prominently in his work in order to make a statement: human-produced sounds strongly impact ecosystems. As the piece unfolds, the listeners become aware of their detrimental impact on the sonic equilibrium of Long Island" (ibid., p. 272).

These acoustemological observations that recognise connections between place, ecosystem, soundscape and identity were also made anecdotally. In addition to Leonie Kerley's commentary on *Farina* (as seen in Chapter 5), Melanie Sjoburg writes:

> [Jesse Budel] … has spent many months around Farina, working with the volunteers and investigating its history and to compose a score redolent of the life in the town. At sundown music and sounds from various rusted tins and scrap, stones, bark and old bottles created an intriguing effect harking back to a life lived around a rail line, dusty streets, pubs and contrasting quiet of the outback.

Extrapolating from Rouliere's critique of *Mobilong* and *Long Island*, this body of work "provides ground for the (electroacoustic) mimicking or (re)creation of multi-species collaborations through artistic sonic collations". It embodies:

> a 'sonic symbiocene'- … an era characterised by the affirmation of the interconnectedness of all entities… - between environmental and instrumental sounds… In site-specific compositions, these entities are interconnected in the sense that they are sonically combined for sonic mutual benefit, either by the composer, the performers or through a randomised process. Through these different combinations, they acquire a greater impact and reinforce one another. Beneficial associations for artistic purposes structure sound and organise sonic units to generate meaning through patterns, volumes, pitches, ranges and so on (2018, p. 270).

Consequently, in the adaptation of site-specific micromorphological content and macromorphological structures to sound-based creative works, the Ecotonal Creative Framework facilitates engagement with and attunement to the multifaceted identities of the chosen South Australian places, their ecosystems and soundscapes. On a personal level, I recognise my own deeper connections to these places that this creative research has cultivated, and identify my creative works to be potentially useful resources for communicating diverse perspectives on South Australian identity, ecology, biodiversity, history, society, culture and spirituality.

6.2 - Future Directions

As I look beyond this research project towards my next steps, I feel there are areas where I would like to extend my investigations and practices in connection with Ecotonality further.

In one of these, I would like to broaden the creative outcomes of this research outside of South Australia. Having produced four site-specific creative works in locations that are familiar to me, I feel that the Ecotonal framework is sufficiently prepared for employment interstate and internationally, where it may be an effective tool for creative engagement with unfamiliar locations and site-specific circumstances.

For these new projects, I would like to connect more directly with First Nations custodians of place and engage with ecological, sociocultural and spiritual perspectives connected to the relevant ecosystems and soundscape. Australian First Nations peoples represent the oldest living cultures in the world, and their extensive lineage of cultural knowledge practices encapsulate sophisticated understandings of ecological function and environmental management. Also within the past decade, numerous Ecoacoustics and Acoustic Ecology practitioners have sought to collaborate with Indigenous communities in soundscape research, in recognition of the intimate connections and understandings that these communities have with their local (acoustic) environments and the acoustic properties of specific sites (Barclay 2013a; Farina & Gage 2017a, pp. 22-24; Ritts et al. 2016). Whilst there was a keen interest in collaborating with the Ngarrindjeri community for *Mobilong* and *Long Island,* and the Adnyamathanha community for *Farina*, the evolution of this research project (from a smaller Masters to a larger PhD, additionally interrupted by the travels to the US and Canada) made it logistically challenging to organise periods of meaningful collaboration with these communities, and as such remains an aspect of creative process deserving further enquiry.

Given the scientific underpinnings of the Ecotonal Framework, I am additionally interested in closer involvement and collaboration with Ecoacoustics researchers, with creative projects integrated more directly with scientific research and outcomes. Given the relatively recent burgeoning of the field, a community of South Australian-based researchers had not developed during the course of my research. As such a local community develops, and as my creative practice moves beyond the confines of South Australia, I anticipate that such collaborative partnerships will emerge more readily. Along with this, I am also keen to involve acoustic indices as creative material or devices. As with other less-explored areas concerning challenges which emerged from the project's

logistical constraints, acoustic indices for the sites were not developed or implemented. This was due to either the requirements of long term data collection, which was not feasible due to field trip durations and equipment constraints or that the employment of acoustic indices was not appropriate to the creative conceptual design. Given the growing libraries of recorded sounds for particular sites and associated acoustic index data, I anticipate that future creative projects will recognise the information that these indices convey, and utilise them in creative contexts.

During this research project, various technological advances have indicated future pathways for creative exploration, which I am keen to explore.
Within the realm of spatial audio practices, ambisonics is one such route. Though existing as a theoretical framework since the 1970s, computational power for live decoding has remained a challenging factor until the present day, with improved hardware capabilities enabling efficient processing for ambisonics. Inexpensive commercial ambisonic microphones (for example, the RØDE NT-SF1 and Sennheiser AMBEO VR microphones) allow more accessible means of full spherical soundscape recordings, which may be adapted to a broad range of surround sound playback through commercial and open-source software packages, and used in tandem with other reproduction approaches (including wave-field synthesis and mobile arrays). For example, Envelop for Live, an open-source ambisonic Max for Live patch suite used in this research project, is available for spatial audio design and applications in concert and installation settings.
Complementing ambisonics, binaural systems are increasingly used to deliver immersive audio experiences to an individual listening with mobile technologies, and represent another route in which soundscape recordings and creative works may be complemented by interactive digital interfaces, ecological information and social media networking.
Lastly, the implementation of remote recording networks (especially those powered by renewable energy sources) will allow for the live streaming of site-specific audio, presenting an additional route of exploration in Ecotonal creative projects by employing live audio and processing.

Paraphrasing the conclusory rhetorical question posed in my talk at the International Ecoacoustics Congress, I ask: Can site-responsive ecological sound art works be considered as Ecoacoustics research?

As the field of Art-Science collaboration indicates, and as this research project has demonstrated, it is possible to engage creative practices with science-based disciplines. Ecotonality, as presented here, draws analogous connections between creative practice and Soundscape Ecology principles, frameworks and methods, identifying parallels in research and practice approaches to allow complementary yet alternative perspectives on place, ecosystem and soundscape. Through investigation of a site's current spatiotemporal circumstances, as sculpted by environmental, sociocultural, political, historical and spiritual agencies, Ecotonality enables the development of site-specific creative works that directly employ associated ecological activities and processes. Representing the micro- and macromorphological activities of a site in cohesive yet flexible compositional structures or, as discussed by Morton, the causal domain through the aesthetic, the resultant creative works allow for new insights and appreciations of place, ecosystem, soundscape and identity. To this end, I am convinced that as Ecoacoustics continues to proliferate, artistic inquiry will become a necessary and integral partner to scientific research of acoustic environments, not only as an effective means of communicating new scientific knowledge, but - all too pertinent in this time of ecological crisis - a conduit for complementary paradigms on shared human and non-human interdependent ecosystems and acoustic environments.

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