Tranquility mapping for soundscape management: From concept to reality

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Introduction

The search for tranquil environments is often the chief reason people give for escaping urban settings for the 'natural' environments of Protected Natural Areas (PNA). Tranquility in natural environments is a combination of both 'natural' landscapes - *and* 'natural' soundscapes. Increasingly, enjoyment of PNAs by some visitors generates anthropogenic noise that 'consumes' natural soundscapes in a manner which subtracts from the total soundscape available to others. This conception of natural soundscapes as a Common Pool Resource (CPR) bound by time and space (Dumyahn and Pijanowski, 2011) frames the essential PNA soundscape management challenge thus: the preservation and conservation of tranquil natural environments for the long-term benefits of the public; *and* the sustainable and equitable allocation of finite natural soundscapes between different stakeholders.

The predominant source of anthropogenic noise in New Zealand's PNAs derives from the use of motorised transport, most notably the commercial operation of aircraft and jet-boats for tourism purposes. While the New Zealand Department of Conservation (DOC) has legislative jurisdiction over the land in PNAs, it has no jurisdiction over use of airspace or waterways. Therefore, prior to 2016, DOC's sole intervention for managing this anthropogenic noise relied upon controlling both the number of locations where aircraft and jet-boats could land visitors, and the number and frequency of movements to those locations. Monitoring the effectiveness of this intervention involved a purely subjective assessment of ground-based visitors' annoyance with the anthropogenic noise generated by these movements.

Over time, it became apparent to all stakeholders that both the management and monitoring mechanisms were increasingly ineffective and iniquitous in the preservation and allocation of natural soundscapes, and that a new approach was required. Following an extensive scoping study, the Tranquility Rating Prediction Tool (TRAPT) was proposed as the most appropriate solution for DOC's future soundscape management and monitoring requirements (Watts, Pearse and Donohue, 2016).

Applying Tranquility Mapping to PNAs

Developed by Watts and Pheasant (2013, 2015), TRAPT uniquely combines both objective and subjective dimensions. TRAPT includes factors for natural features, a noise metric, and a moderating factor, to produce an output called tranquility rating (TR) on a 0-10 scale (where TR >8 is 'Excellent'). However, as configured at the time TRAPT was unsuitable for the DOC application, requiring significant modification to be undertaken.

Adaptation of TRAPT

TRAPT was initially developed for stationary sound sources such as wind farms, and thus needed to be adapted to accommodate moving sound sources such as helicopters and jet-boats. Several noise prediction software packages were assessed as possible candidates for generation of contours of predicted noise levels, from which the TR could be derived. The USA Federal Aviation Administration's (FAA) Aviation Environmental Design Tool

(AEDT) was ultimately selected based on features deemed essential for PNA noise prediction purposes, particularly features directly relevant to the problem of helicopter flights in mountainous terrain. In theory, these features would enable the plotting of tranquility contours from moving sound sources onto digital topographic maps of PNAs with a high degree of fidelity. In practice, it emerged that this was the first application of AEDT to helicopter operations in uncontrolled airspace, significantly expanding the developmental challenge and timeframe.

Calibration of TRAPT

Originally calibrated for the United Kingdom population and later verified for the Hong Kong population, recalibration of TRAPT for the New Zealand population was nevertheless undertaken to maximise confidence in the predictions. Furthermore, there existed a requirement that any new management tool be able to represent additional dimensions of soundscapes at places of cultural and spiritual significance, especially to New Zealand's indigenous Māori people. Finally, while many studies have looked at population response to aircraft noise, these studies focused mainly on noise from fixed-wing aircraft, with the result that the response to helicopter noise is poorly understood.

Calibration of TRAPT ultimately involved samples of the general New Zealand and Māori populations being processed through a controlled laboratory setting according to strict protocols, using representative helicopter and jet-boat sound files and images recorded in New Zealand PNAs.

Collaboration on TRAPT

From the outset, the soundscape management initiative was based upon the premise that the department could not achieve desired outcomes through regulation, and that any solution therefore depended on collaboration with stakeholders; most crucially, the commercial tourism sector. Modelling tranquility to inform the allocation of soundscapes rather than landing rights was seen by stakeholders to offer significant advantages, including:

- Predicting noise and resultant tranquility is robust and transparent, and if repeated would give exactly the same answers. This is in contrast to the previous subjective monitoring tool where results were influenced by many variables and therefore more easily contested;
- Noise and TR predictions are able to be plotted as contours over an entire PNA. The TR plots combine both established areas of visitor concentration on the ground and typical aircraft and jet-boat tracks, to enable an easily-interpreted visualisation of acoustic 'hot spots', and assist with identifying opportunities for mitigation measures;
- Tranquility modelling allows "*what if*" mitigation scenarios to be developed, refined and agreed to by all stakeholders using a single, shared representation of a potential future state.

Furthermore, to model TR geospatially it was necessary to obtain representative track data to position the moving sound source in space and time. This data could only be obtained through the voluntary installation of purpose-built GNSS tracking devices in commercial aircraft and jet-boats.

Completed Tranquility Mapping Tool

The completed DOC Tranquility Mapping Tool (DOC-TMT) comprises four key components:

1. Global Navigation Satellite System (GNSS) track file – provides the spatial and temporal movement of the source noise (aircraft/jet-boat)

2. AEDT software - provides the source noise (aircraft sound file), propagation properties of that noise, and models the observed noise at ground level across the PNA in question;
3. TRAPT - provides the algorithm that calculates the TR levels;
4. GIS software - generates the graphic representation of TR contours across maps of PNAs.

Figure 1 shows the flowchart for calculating the TR from various noise inputs, and the subsequent mapping of the associated tranquility contours.

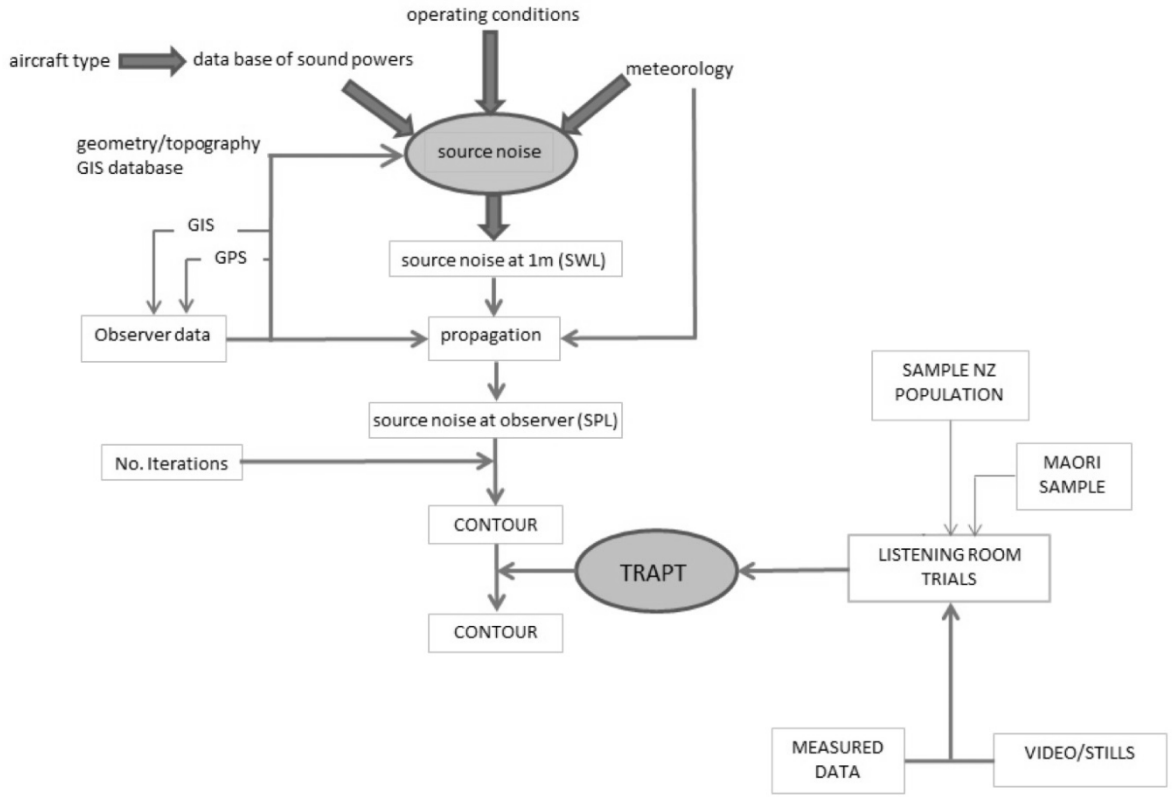

Figure1: Conceptual Schematic of DOC Tranquility Mapping Tool

DOC-TMT is now generating high-fidelity tranquility maps representing the current state of natural soundscapes in several National Parks. These maps are informing the establishment of tranquility management settings in zones across the Parks, while also providing the means by which commercial tourism operators can collaborate in the preservation and conservation of natural soundscapes through innovations in their operational practices. DOC-TMT will also enable monitoring through the periodic generation of maps based on updated track data.

AEDT 2b User Guide at: https://aedt.faa.gov/Documents/UserGuide.pdf

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