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SOUND PROPAGATION THROUGH FORESTS AND TREE BELTS

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1 INTRODUCTION

The potential of forests or narrow belts of trees alongside surface transport corridors for reducing noise is often dismissed. Partly this is a consequence of conflicting experimental evidence. But also it is the result of incomplete understanding of the various attenuation mechanisms involved and, therefore, of how they could be exploited and used together in tree planting schemes. First experimental evidence supporting the use of forests or tree belts for noise abatement is presented. Subsequently the principal attenuation mechanisms and models for them are reviewed and resulting predictions are compared with data. Finally numerical simulations showing the potential for traffic noise reduction by narrow tree belts are outlined.

The United States Department of Agriculture National Agroforestry Center has published guidelines for the planting of trees and bushes for noise control based on extensive data collected in the 1970s[1,2]. Another study in the USA found a reduction of 8 dB in the A-weighted L_{eq} from road traffic due to propagation through 100 m of red pine forest compared with open grassland[3]. In this study, the edge of the forest was 10 m from the edge of the highway and the trees occupied a gradual downward slope from the roadway extending about 325 m in each direction along the highway from the measurement site. A TRRL study in the UK found an extra 6 dB reduction in A-weighted L_{10} index of traffic noise propagating through 30 m of dense spruce compared with the same depth of grassland[4]. Also this study found that the effectiveness of the vegetation was greatest closest to the road. Measurements made with broadband source 2m high and receiver height 1.5 m through 500m of coniferous woodland have shown significant extra attenuation compared with CONCAWE predictions for propagation over acoustically-soft ground particularly in 63 Hz (3.2 dB), 125 Hz (9.7 dB), 2 kHz (21.7 dB) and 4 kHz (24.7 dB) octave bands[5]. A relative reduction of 5 dB in the A-weighted L_{10} index was found after transmission through 10 m of vegetation. In an investigation of the attenuation of sound by 35 different tree belts[6], a point source was placed in front of the tree belts and sound pressure levels inside the tree belts were measured at different positions. Attenuation was found to depend on the width, height, length and density of tree belts. Large shrubs and densely populated tree belts were found to give more than 6 dBA attenuation, medium size shrubs and tree belts attenuated the sound by between 3 and 6 dBA and sparsely distributed tree belts and shrubs attenuated the sound by less than 3 dBA. The depth of vegetation was found to be the most important factor; the greater the depth, the greater the pathway of sound through the vegetation resulting in higher sound absorption and diffusion. The shrubs were considered to be the most effective in reducing noise due to scattering from dense foliage and branches at lower source-receiver heights. It was concluded that tree belts and shrubs should be planted together to provide best attenuation performance.

The propagation of sound through forests and tree belts involves 'soft' ground effect due to decaying leaf litter, reverberant scattering out of the direct source-to-receiver path by trunks and branches, absorption by tree bark, loss of coherence between ground-reflected and direct sound due to scattering, acoustically-induced vibrations of leaves and visco-thermal scattering by foliage. On the basis of calculations made in this paper and elsewhere, acoustically-induced leaf vibration and bark absorption do not contribute much to the overall attenuation whereas ground effect, the influence on ground effect of scattering by trunks and branches and attenuation by foliage appear to be relatively important. Ways of modelling these more important contributions are considered in the next section.