



# Potential for reducing noise by trees and cultivation



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# Outline

Ground effect

Effects of ploughing

Data and predictions for trees

Periodic array effects

Conclusions

# A short history of ground effect

William Derham (1657 – 1735), the rector of a small church near London, observed the difference in the sound of church bells at the same distance over newly fallen snow and over a hard frozen surface.

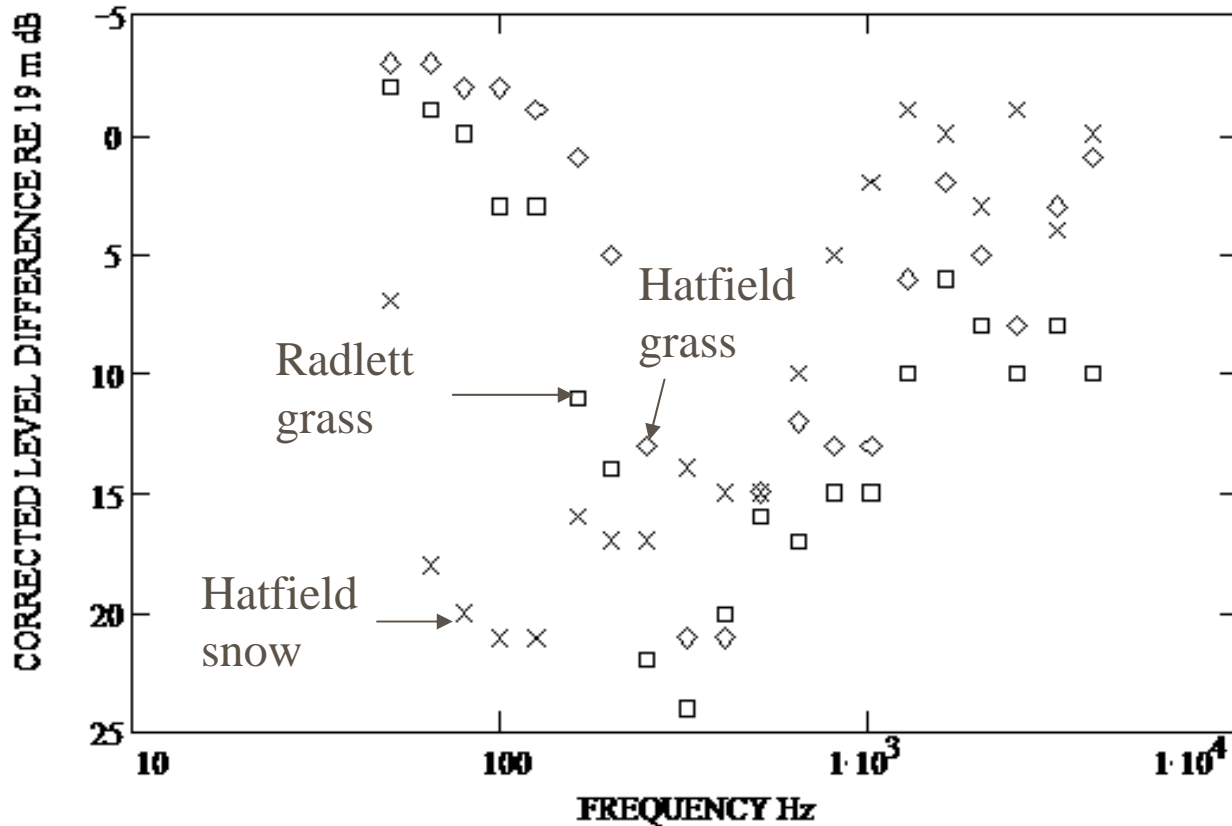
More than 300 years later..... 1965 trials at Radlett and Hatfield  
In his Rayleigh Medal lecture 1970, Peter Parkin stated :

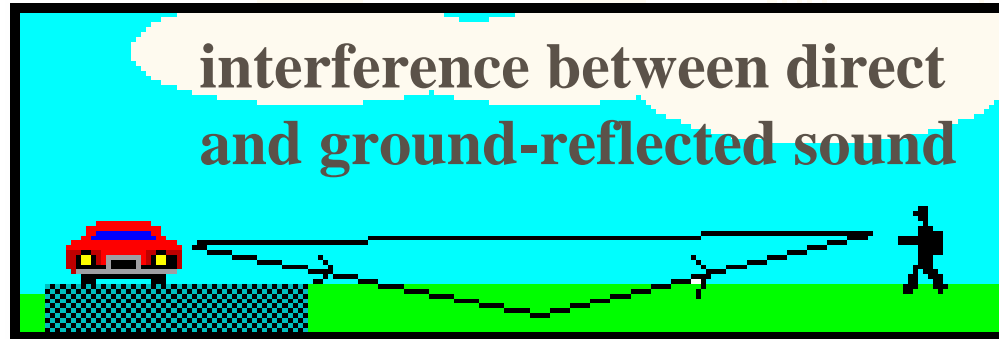
*" These horizontal propagation trials showed up the ground effect, which at first we did not believe, thinking there was something wrong with the measurements. But by listening to the jet noise at a distance, one could clearly hear the gap in the spectrum."*



Parkin & Scholes  
JSV 1971

# Ground Effect and Excess Attenuation





Ground effect is 'lost' close to a 'thin' noise barrier but not necessarily over a hill or earth berm

Excess attenuation is the attenuation exceeding the geometrical effect due to distance alone.

Ground effect and excess attenuation depend on frequency.

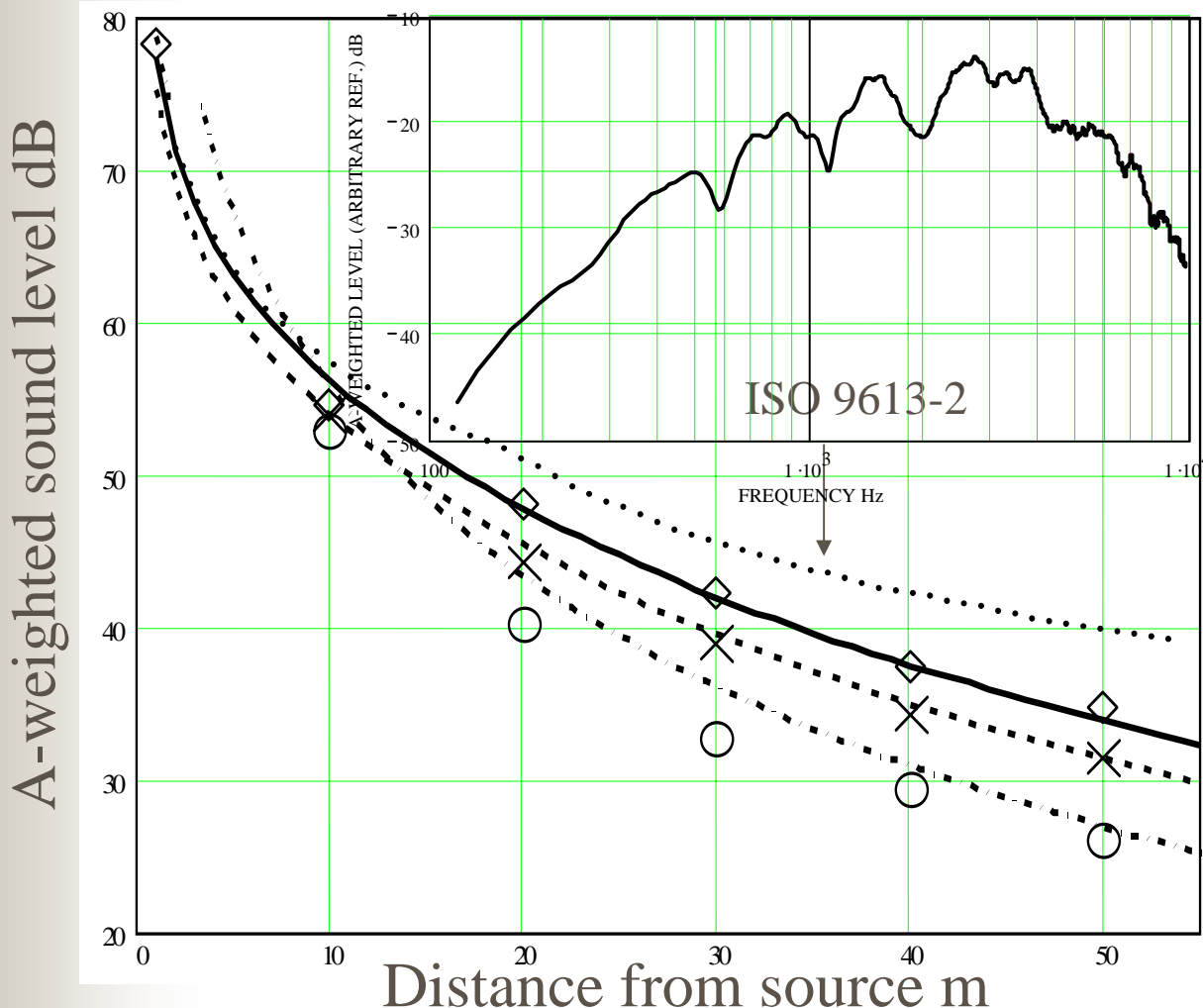
Ground effect depends on the source-receiver geometry and the acoustical properties of the ground surface

## Categories of ground surface in NORD2000 & HARMONOISE

Categories	Examples
A. Very soft	snow or moss like
B. Soft forest floor	short, dense heather-like or thick moss
C. Uncompacted, loose ground	Turf, grass, loose soil
D. Normal uncompacted ground	Forest floor, pasture field
E. Compacted field and gravel	Compacted lawns, park area
F. Compacted dense ground	Gravel road, parking lot
G. Hard surfaces	Dense asphalt, concrete, water

# Ploughing for Noise Control: Short Range Data

**loudspeaker source at 1.6 m height , receiver at 1.2 m height**

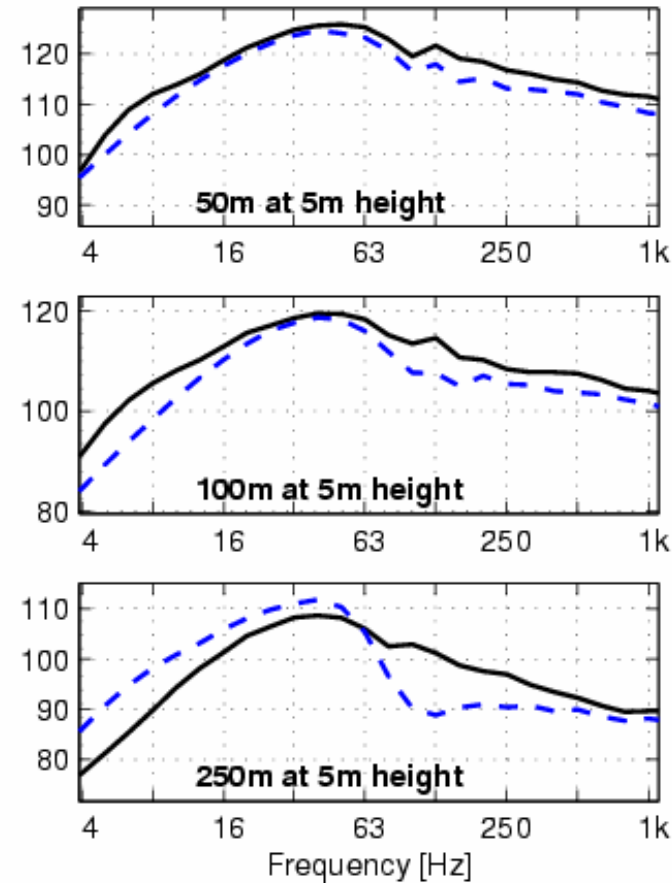
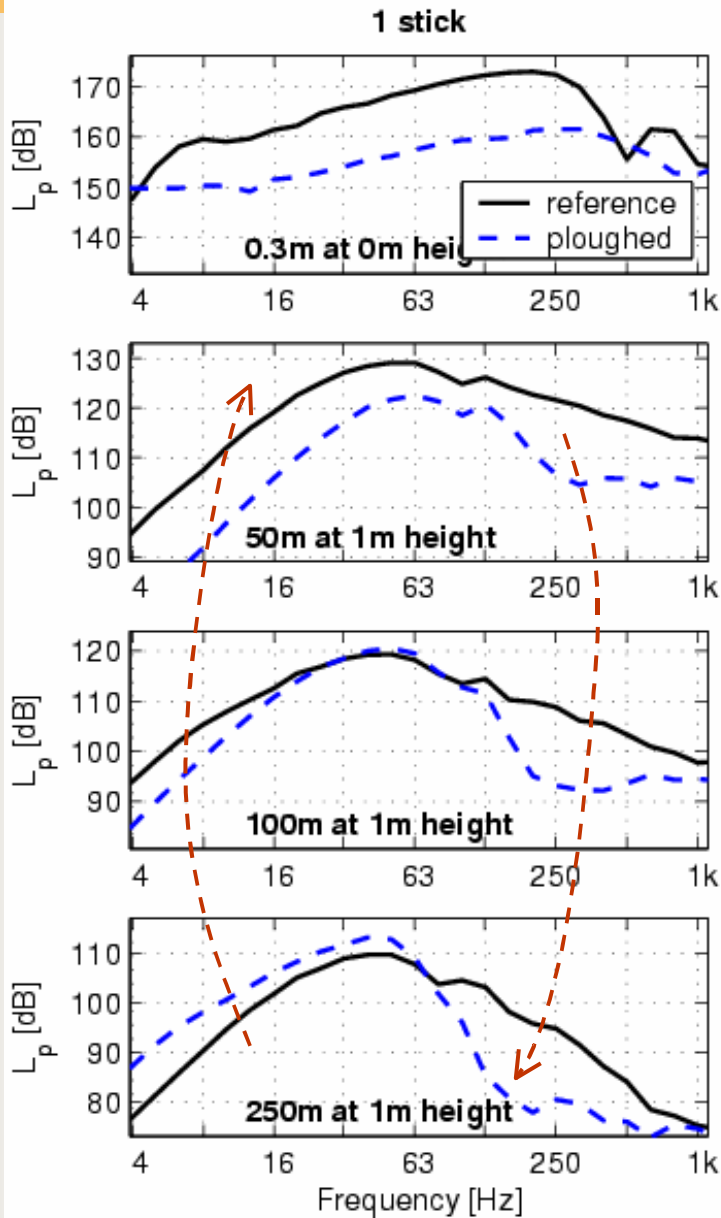


A-weighted broadband sound levels re 1 m at 1m above an oil seed rape field shortly after flowering (◊), wheat stubble (×) and ploughed ground (○). Slightly downwind conditions. Also shown are various predictions (lines).

# Ploughing and blast noise

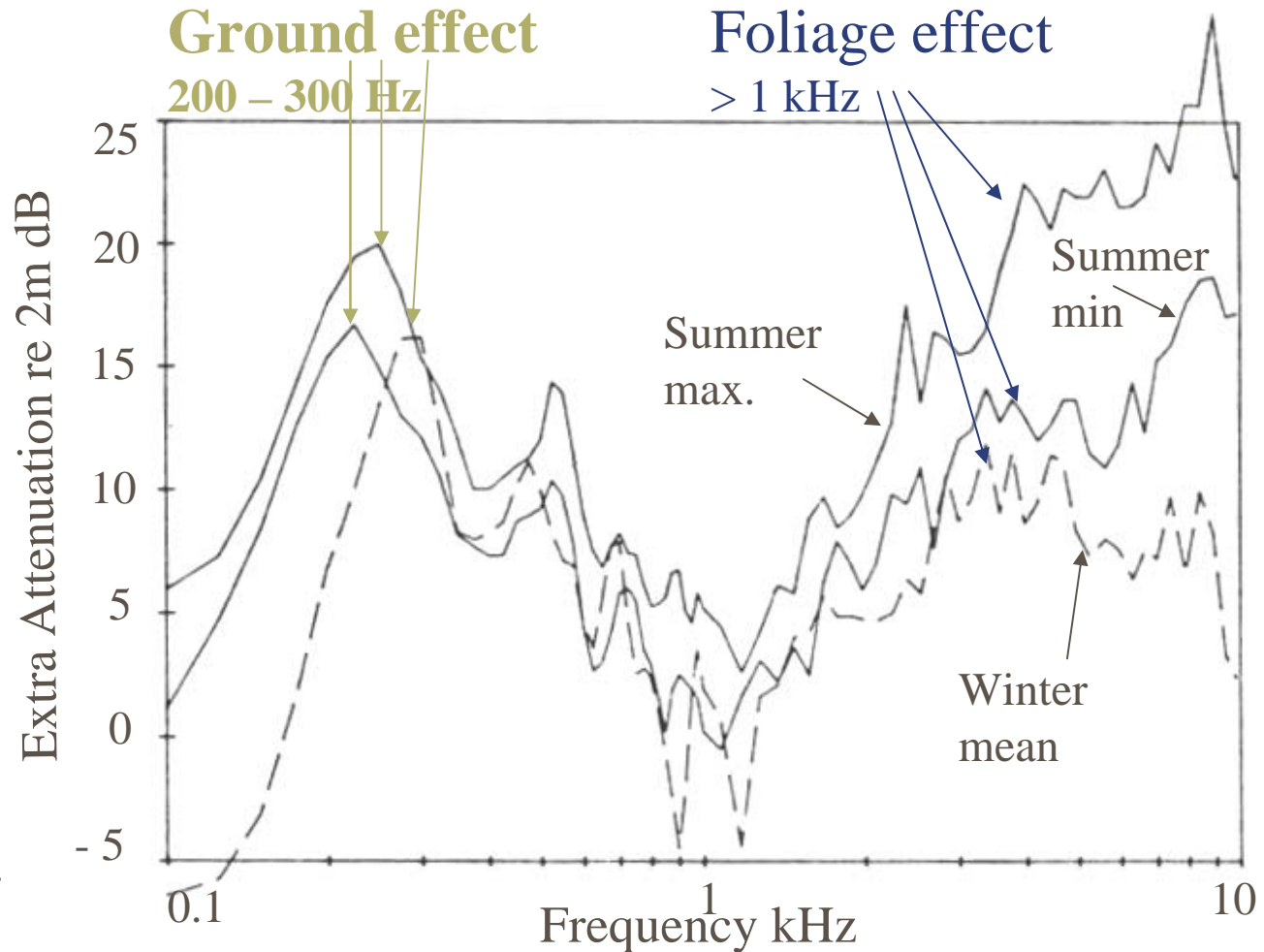


# Ploughed Ground Effects on Spectra



# Measured Attenuation Spectra in Trees

Extra Attenuation at 48m from loudspeaker source in alternate bands of Norway Spruce and Oak planted in 1946. Hawthorn, roses and Honeysuckle undergrowth. Visibility less than 24m.

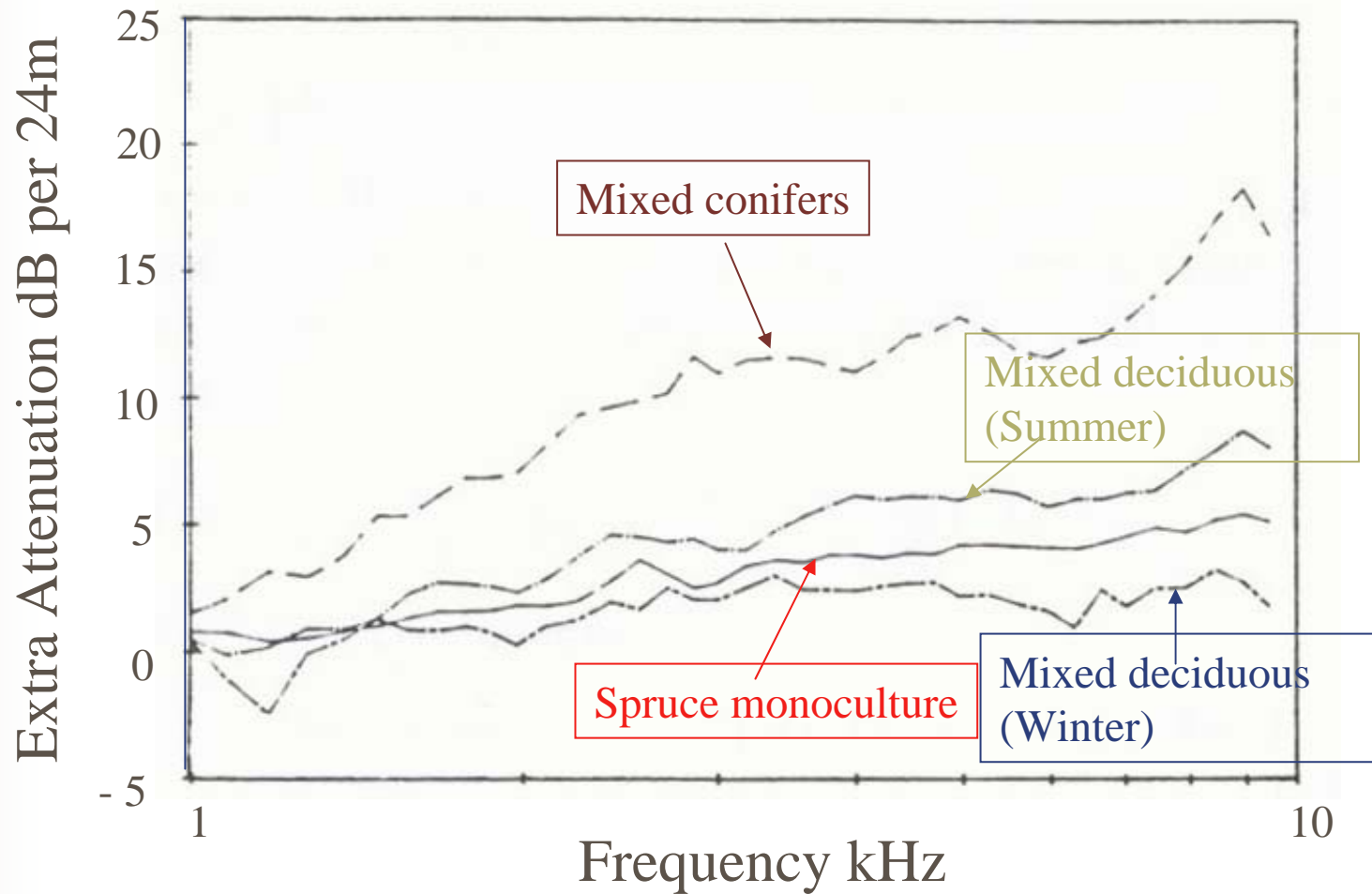


Summer:  
7/5/84  
8/8/84  
7/9/84

Winter:  
4/10/84

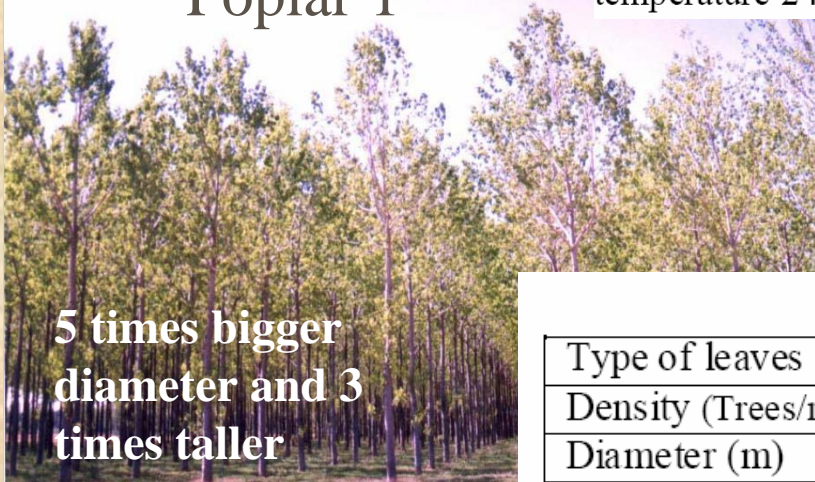
Price *et al*  
J. Acoust.  
Soc. Am.  
84(5):1836-44  
1988

# Measured High-frequency Attenuation



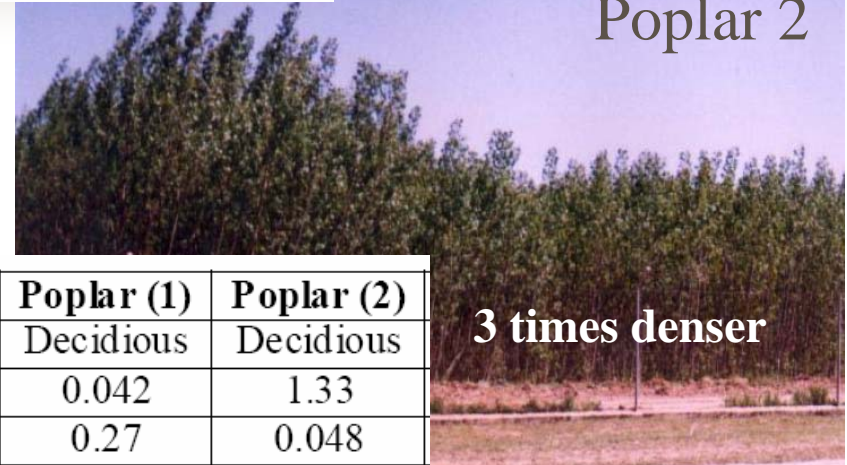
# Poplar 1

temperature 24°C, relative humidity 30 %



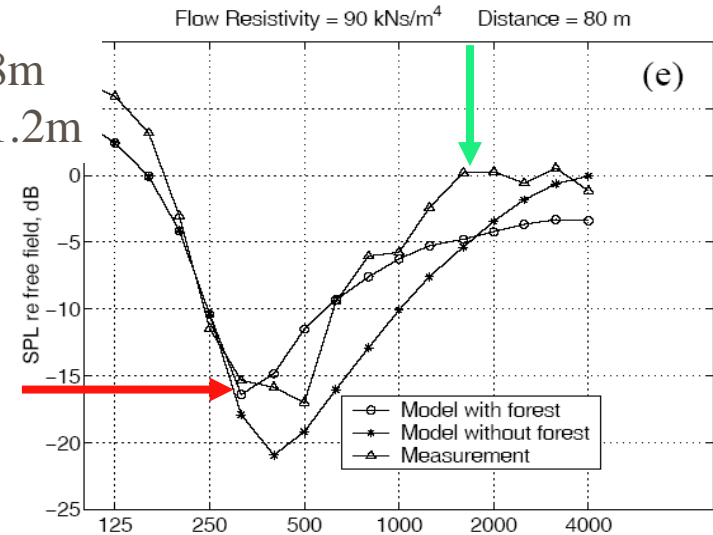
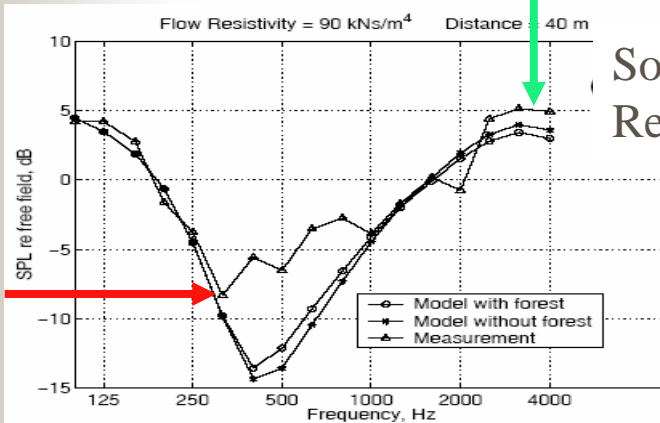
5 times bigger diameter and 3 times taller

# Poplar 2



3 times denser

	Poplar (1)	Poplar (2)
Type of leaves	Deciduous	Deciduous
Density (Trees/m <sup>2</sup> )	0.042	1.33
Diameter (m)	0.27	0.048
Height (m)	9	3



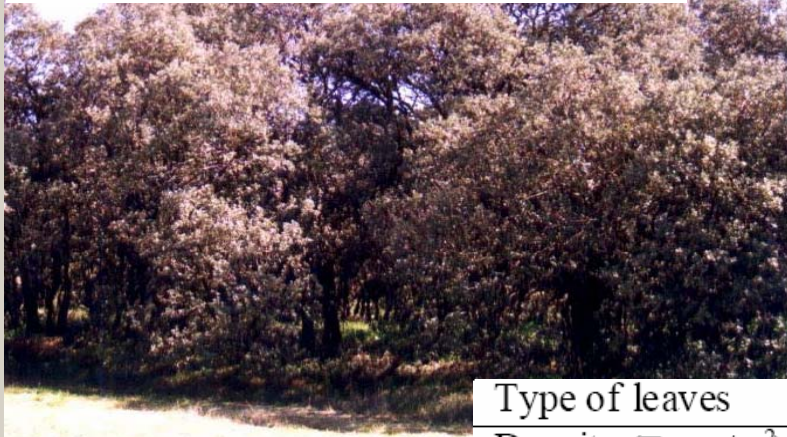
•increase of ground effect with range

From Tarrero *et al* Applied Acoustics (in press)

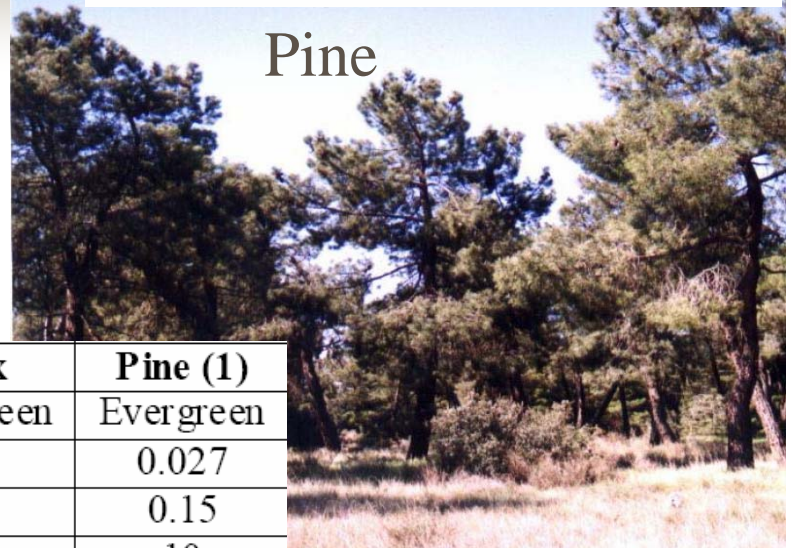
•High frequency foliage effect

temperature 24°C, relative humidity 30%.

temperature 7°C, relative humidity 60 %.



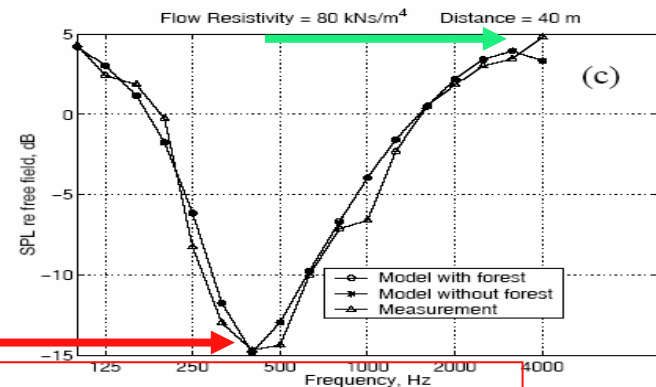
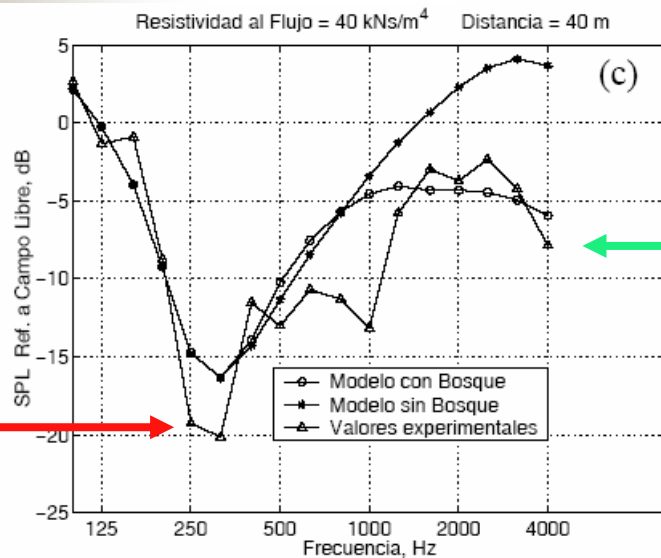
Oak



Pine

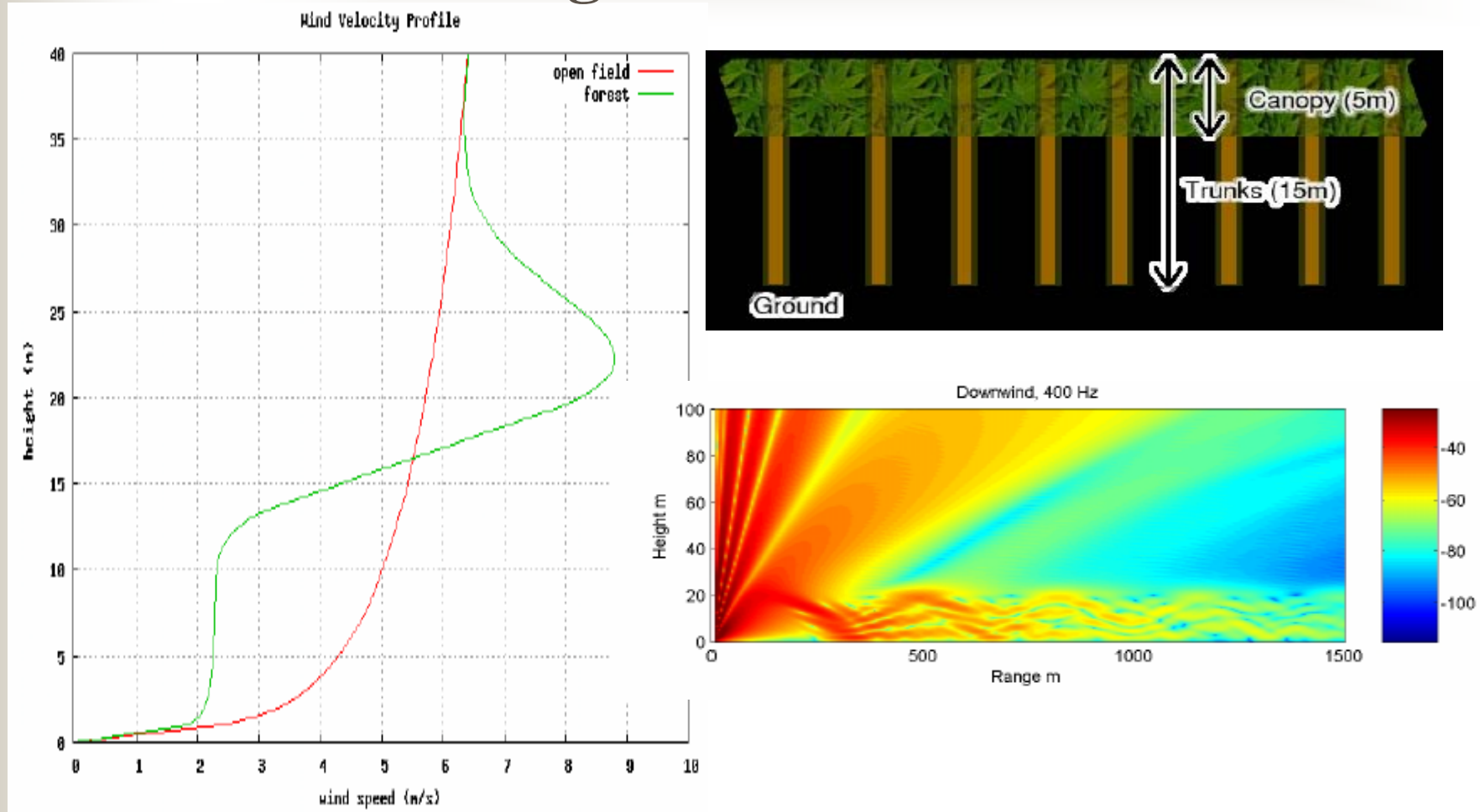
Type of leaves  
Density (Trees/m<sup>2</sup>)  
Diameter (m)  
Height (m)

Oak	Pine (1)
Evergreen	Evergreen
0.2	0.027
0.2	0.15
4	10



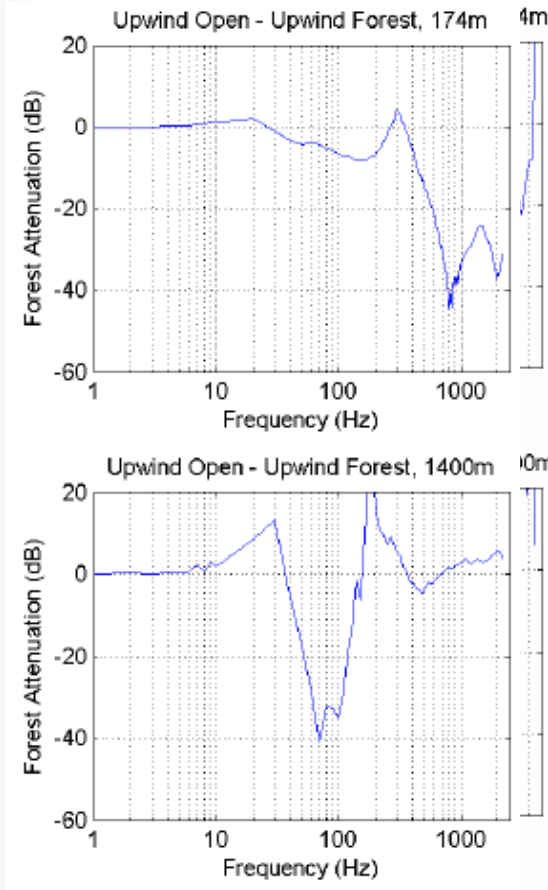
- Difference in ground effect
- High frequency foliage effect

# Meteorological Effects in Trees



From Michelle E. Swearingen and Michael J. White, Proc. 11<sup>th</sup> LRSPPS Vermont June 2004

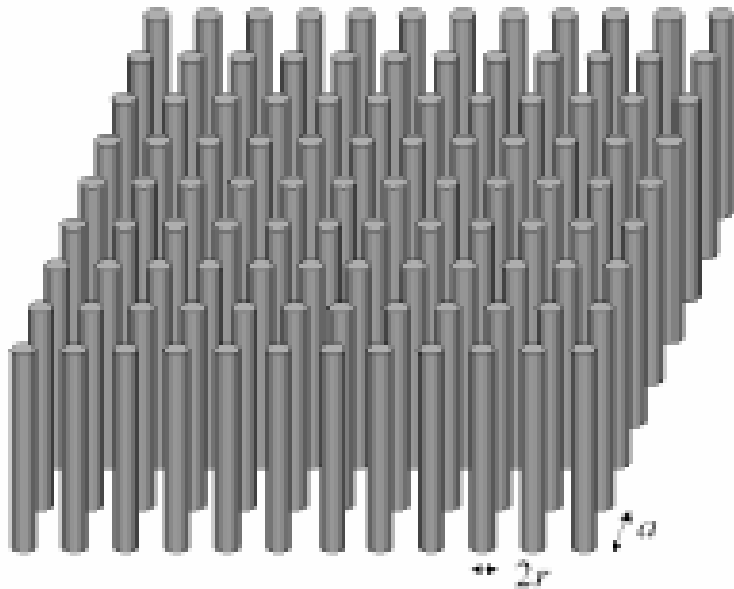
# Measured effects of trees on blast noise



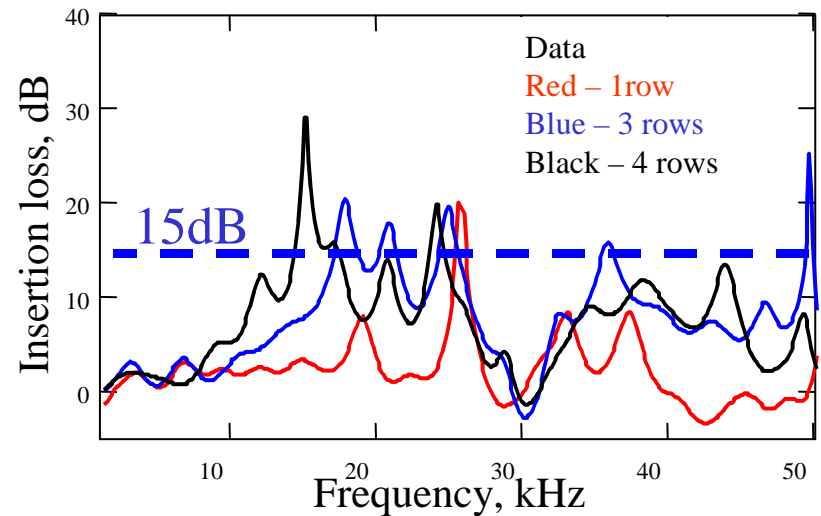
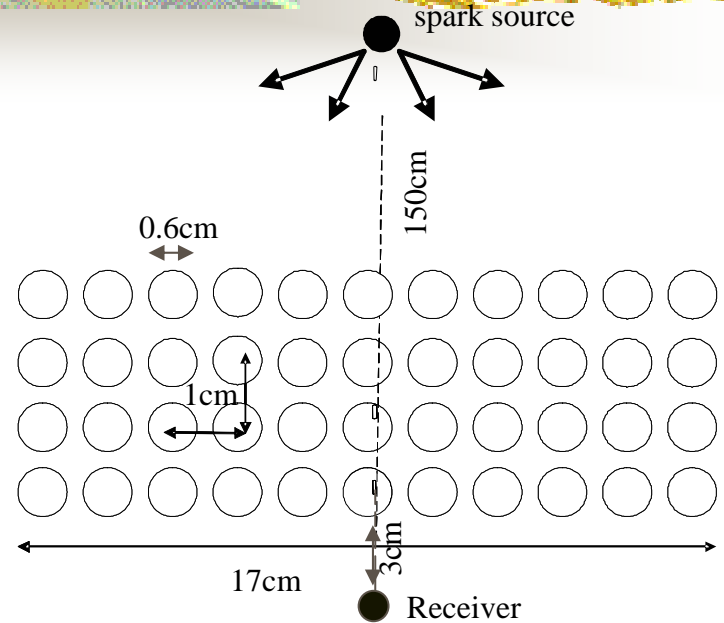
In downwind conditions, Forest is better than open field for frequencies greater than 200 Hz. No gain between 174 and 1400m.

In upwind conditions, at 174m forest gives less attenuation than open field above 100 Hz and at 1400m, forest gives less attenuation between 50 and 200 Hz.

# Sonic Crystals

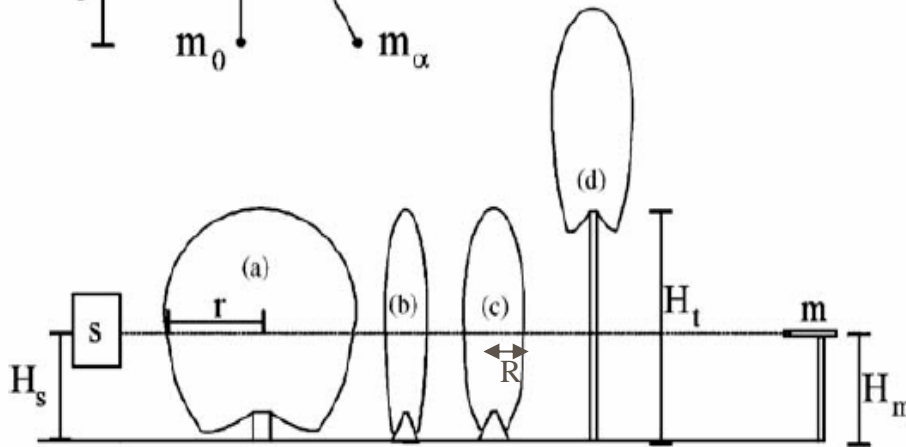
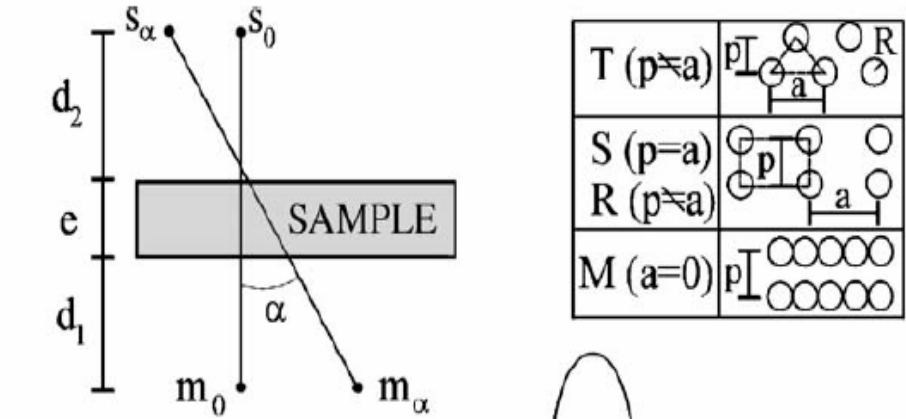


First 'band gap' in transmission loss where  $a \approx 2\lambda$



# Measured effects of periodic trees

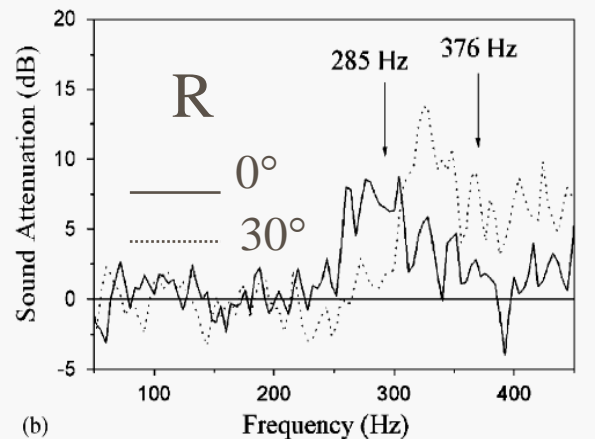
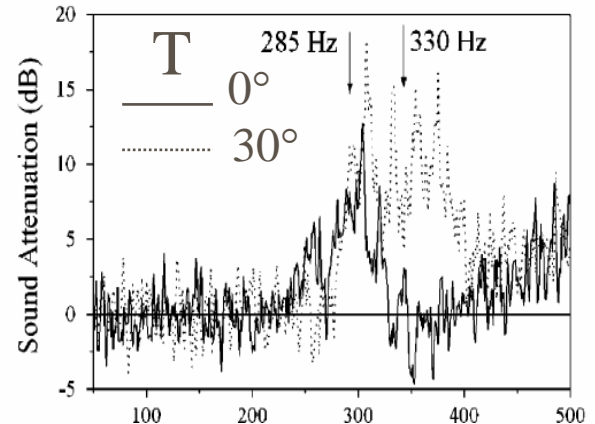
From Martinez-Sala *et al* J Sound Vib **291** 100 – 106 (2006)



Laurel (tree height 1.45m, radius 0.25m,  $H = 0.85\text{m}$ ,  $d_1 = 1.3\text{m}$ ,  $d_2 = 2.3\text{m}$ ,  $e = 2.9\text{m}$ )

5 rows of Laurel

$a = 0.7\text{m}$       $p = 0.6\text{m}$





# Conclusions

Ground effects can be altered in a useful way e.g. by cultivation

Can obtain up to 10 dB attenuation of traffic noise with 30m wide belt

Good potential for attenuation of low frequency or high frequency sources

Dense plantation with vegetation to ground level

Downwind of source and upwind of receiver

Periodic high density arrangements (willow, bamboo) might be useful as noise barriers