6 Noise Abatement and Dwellings

Consideration of noise and sound elements in urban open space is absolutely important today in the daily life of citizens. The design of a comfortable environment must pay attention to the "*soundscape*", as defined by the Canadian musician Murray Schafre at the end of 1960s, which should complete the "*landscape*" design, which refers to a visual scenario of the environment. In soundscape, the sounds produced by human beings, different kind of traffic noise, birds, animals, waterfalls or streams, bells for traditional events, broadcasting, background music and other natural, artificial or social sounds, etc., should be integrated into one united sound environment, related to the different personal feelings of humans in various circumstances. The meanings of soundscape are social, historical, cultural and environmental (Ge and Hokao 2004). The concept of soundscape was promoted by international organizations and congresses (Inter-Noise) and has been applied to practice (sound maps) for urban planning, environmental, architectural and equipment design. Urban parks are typical subjects in which functions, such as sports, relaxation, cultural and social events, sightseeing, etc., are considered as environmental elements. Recording the soundscape components helps to catch the main sound components and their structure on a scale in terms of "preference" or "congruence" and to serve as a base for future improvements. A positive impression on the urban soundscape is produced by large vegetation areas, belts of trees, public gardens and parks.

6.1 Urban Area

The interest of acousticians for noise abatement in urban areas with vegetation, shrubs or a belt of trees is quite old (Embelton 1963; Aylor 1972a, b; Cook and van Haverbeke 1971, 1972, 1977; Haupt 1973, 1974; Herrington 1974; Kellomäki et al. 1976; Reethof and Heisler 1976; Ishii 1994). The significance of height, density, width and length of tree belts for noise reduction was underlined. Recent studies (Fang and Ling 2003) included a new parameter, namely the visibility (see Chap. 2).

Figure 6.1a, b suggests a possible disposition of trees around a house for maximum noise reduction all year round, together with an improvement in aesthetics and air quality, in a residential urban area.

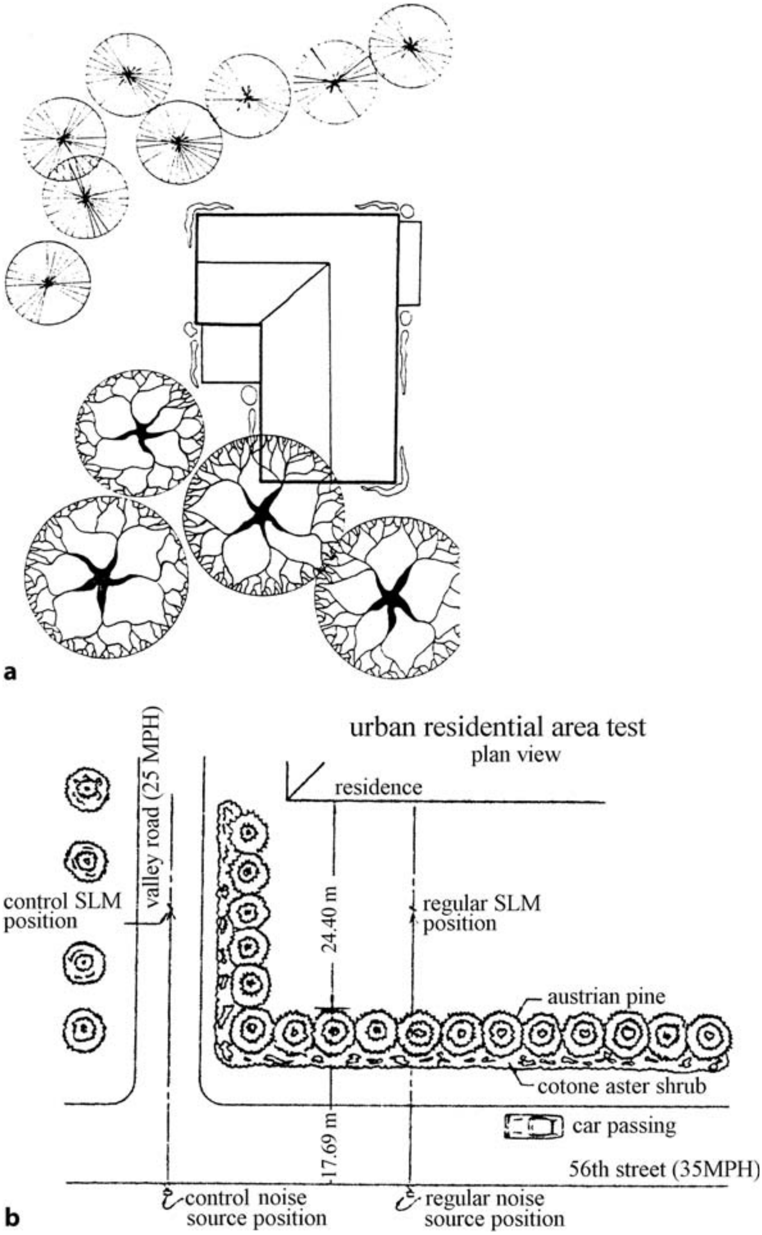

Fig. 6.1. Trees around a house for maximum noise reduction as used in urban residential area in USA: **a** all year round, with high, big coniferous and decidous trees (Heisler 1974), **b** plan view of dense trees and shrubs (Cook and van Haverbeke 1972); N.B 35 mph = 56 km/h car passing speed

A typical tree belt structure (Fig. 6.2), composed of coniferous and deciduous species, reduced the sound level produced by urban buses, autos and trucks, by about 40 dB for a distance of 150 m (Fig. 6.3).

Kellomäki et al. (1976) studied the characteristics of coniferous tree stands suitable for noise reduction in urban areas in countries of northern Europe. Attenuation and excess attenuation by coniferous stands of different ages compared to a cut area are given in Table 6.1. The early succession stage of a stand gives better attenuation than mature stands. In the case of a spruce stand,

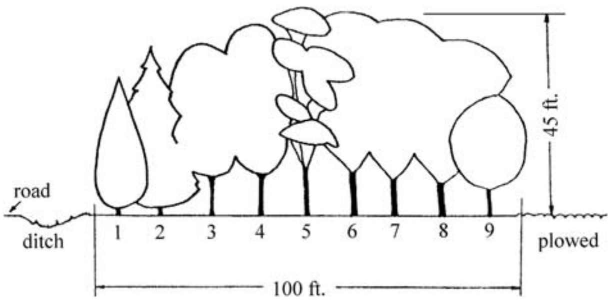

Fig. 6.2. Possible configuration of the typical structure of a tree belt in an urban area, composed of the following species: 1 eastern red cedar, 2 ponderosa pine, 3 green ash, 4 hackberry, 5 honey locust, 6 Siberian elm, 7 Siberian elm, 8 American elm, 9 mulberry (Cook and van Haverbeke 1972); 100 ft = 30.5 m; 45 ft = 13.75 m

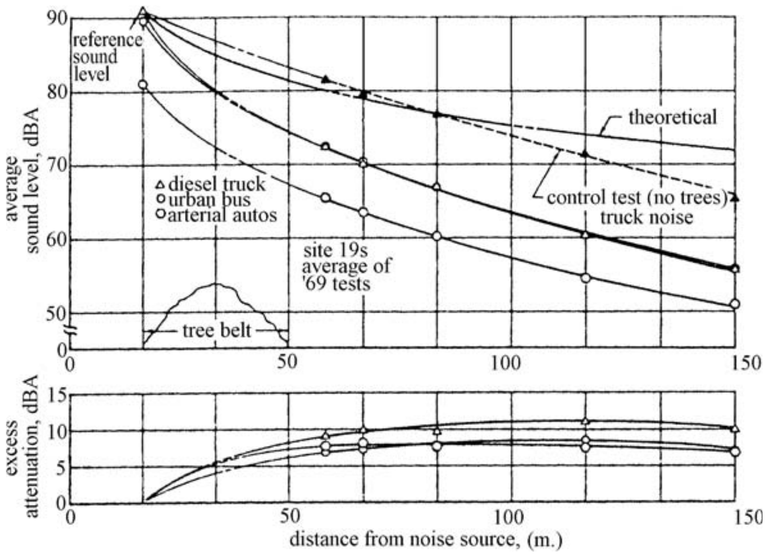

Fig. 6.3. Noise attenuation produced by a belt of trees. Relationship between sound pressure level and distance (Cook and van Haverbeke 1972)

Table 6.1. Attenuation of stands compared to clear area (Kellomäki et al. 1976)

Species	Attenuation of stands compared to clear area			
	Seedling stand	Middle-aged stand	Mature stand	Mean value
Pine	0.740	0.583	0.825	0.716
Spruce	0.307	0.346	0.510	0.388
Mixed	0.340	0.290	0.518	0.383
Mean value	0.462	0.406	0.617	0.495

Table 6.2. Physical and acoustic characteristics of stands (Kellomäki et al. 1976)

Stand	Tree density Number/ha	Mean height (m)	Volume (m^3)	Dominant tree (%)	Self-pruned tree (%)
Pine					
Seedling	500	16	128	14	55
Middle-aged	700	15	134	8	40
Mature	1,000	15	108	10	38
Spruce					
Seedling	1,633	5	11	9	6
Middle-aged	900	19	208	3	22
Mature	600	18	287	2	24
Mixed					
Seedling	2,433	8	71	4	13
Middle-aged	1,133	10	195	1	19
Mature	600	22	227	1	36

60% attenuation was reported. The amount of needles and branches seems to be the most important factor in noise attenuation. Table 6.2 gives more detailed information about the attenuation coefficient of white noise (octave bands 20–100 Hz) situated at 12 m from the edge of the studied stand. Pure stands composed of Scots pines have higher attenuation coefficients than mixed stands composed mainly of Norway spruce and about 20% deciduous species with birch predominance.

6.2 Suburban Area

One of the main sources of discomfort in residential suburban areas is the traffic noise produced by the continuous expansion of the highway systems. The reduction of this traffic noise can be achieved in two ways:

- First, by lowering the speed limit of the vehicles and improving engine muffling. (A large truck exceeds 100 dB.) This approach is very limited.

– Second, by creating trees belts and shrubs and solid barriers between the noise sources and dwellings. The barriers can be walls up to 2 m in wood, masonry, earth dikes or small natural hills.

In general, it can be said that the amount of noise reduction measured at the receiver is dependent on the in situ configuration and is mainly determined by the level at the noise source and by personal sensitivity. An acceptable level is 70 dB for daytime activity and 50 dB for evening time. A reduction of 10 dB produces a sensation of noise cut by about half.

In what follows we propose an analysis of practical situations, as presented by Cook for the effect of a noise source produced by traffic at 35 mph (56 km/h) on a highway (automobiles and trucks) at three sites noted A, B and C. Site A has low, dense cotoneaster shrubs backed by tall ponderosa pines. Site B has medium-height planting, a woven board fence and a downward sloping ground profile from the street to the residence. Site C has a tall evergreen hedge, a brick wall and an upward sloping ground profile from the street to the residence. A schematic presentation of the experimental configuration for noise level measurement is shown in Fig. 6.4. The average sound level and the relative attenuation function of the distance from the source are shown in Figs. 6.5, 6.6, 6.7. A noise reduction ranging from 45 dB to 10 dB was measured. Figure 6.8 gives a comparison of the noise reduction produced by the trees, the wall and the tree–wall combination. As expected, the highest reduction was obtained by the tree–wall combination, for a wall 1.8 m in height. Figure 6.9 shows the effect of wall placement between the source and the receiver. The maximum attenuation seems to be obtained at 10 m distance from the wall.

The analysis of different configurations allows one to say that, in residential suburban areas, plant material can reduce noise levels by as much as 8 dB, when the residence is at least 25 m from the centerline of the roadway. Coniferous

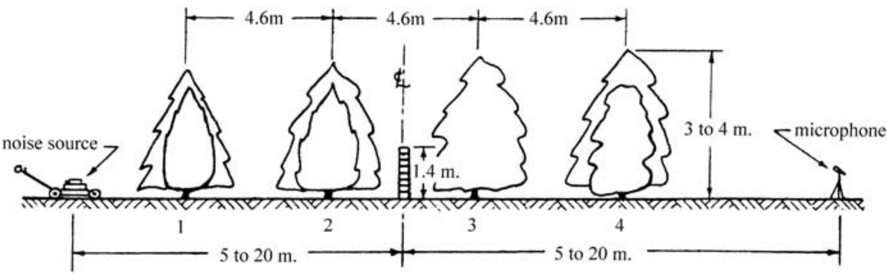

Fig. 6.4. Schematic diagram of experimental configuration for noise measurement with trees and wall. Tree spacing in all rows is 2 m (Cook and van Haverbeke 1977). *1* Austrian pine alternated with rocky mountains juniper, *2* ponderosa pine alternated with eastern red cedar, *3* Scots pine, *4* Austrian pine alternated with oriental arborvitae

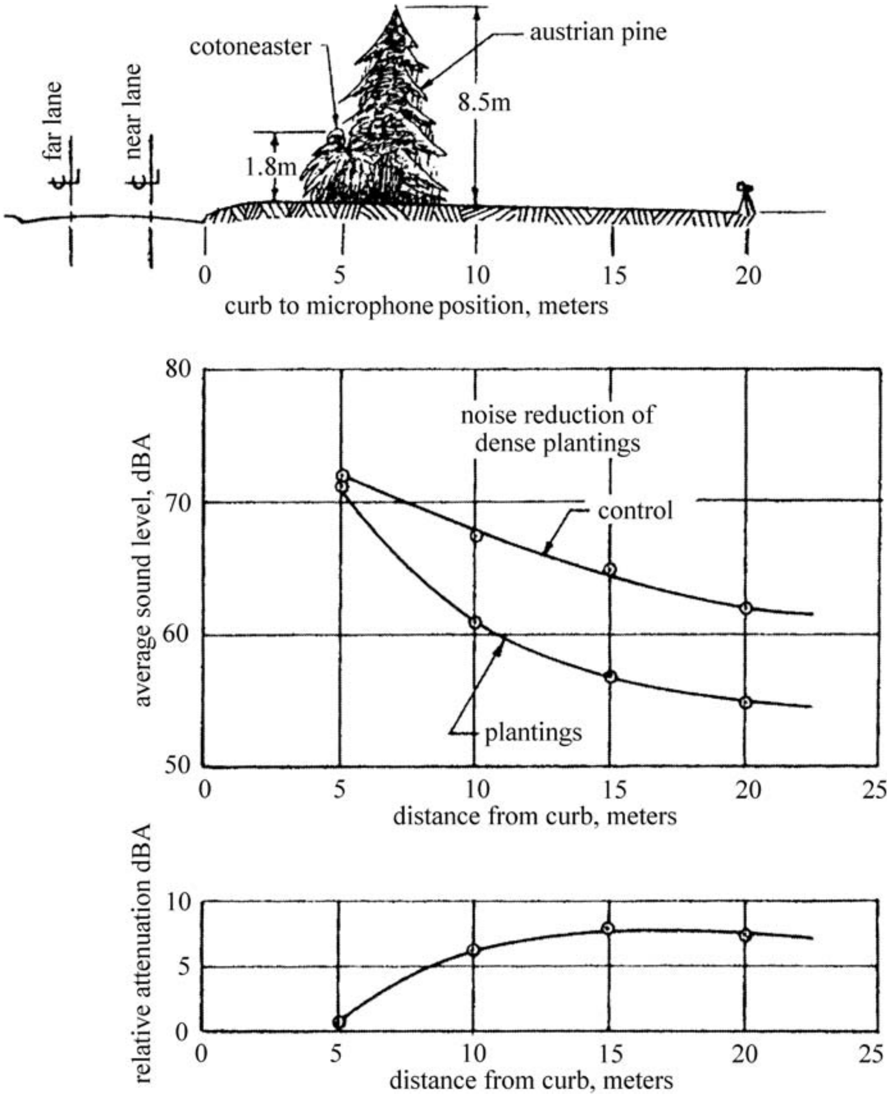

Fig. 6.5. Site A has low, dense cotoneaster shrubs backed by tall ponderosa pine (Cook and van Haverbeke 1972)

species or evergreen shrubs provide year-round protection. For residences at less than 20 m from the centerline of the roadway, trees and solid barriers are required.

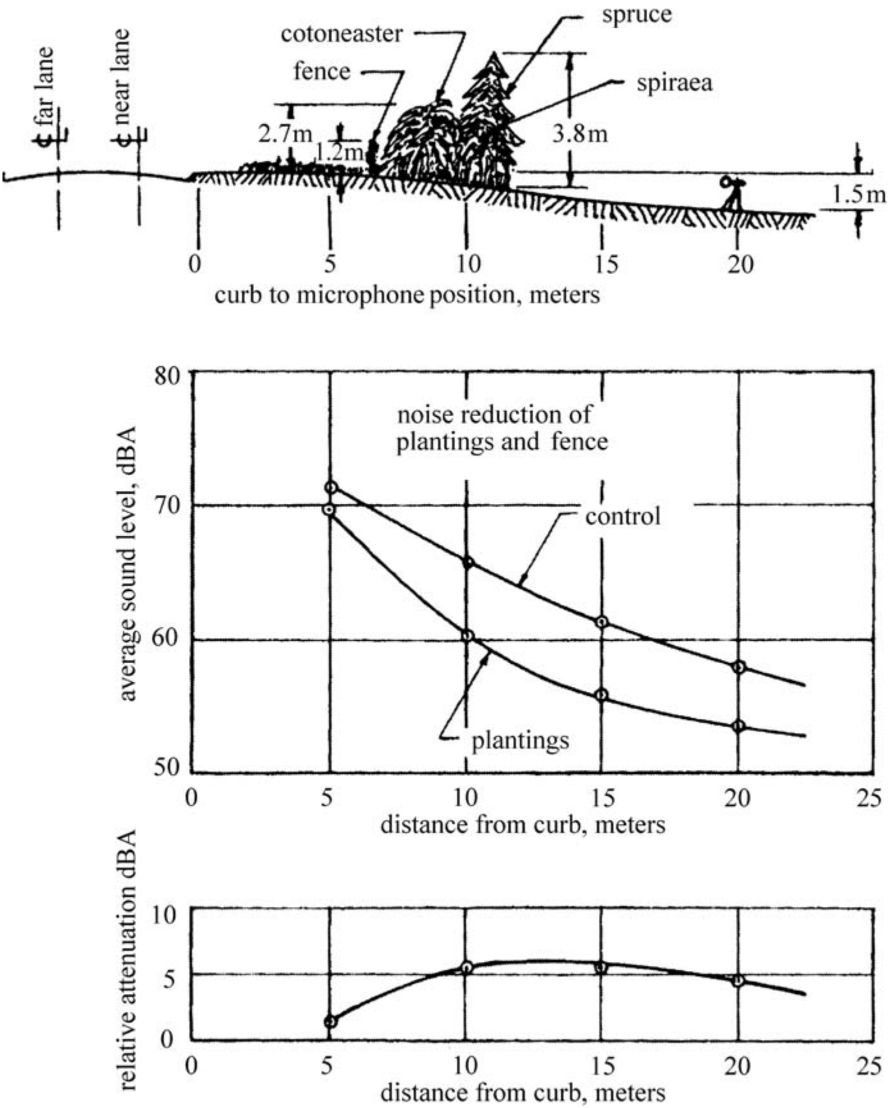

Fig. 6.6. Site B has medium-height planting, a woven board fence and a downward sloping ground profile from the street to the residence (Cook and van Haverbeke 1972)

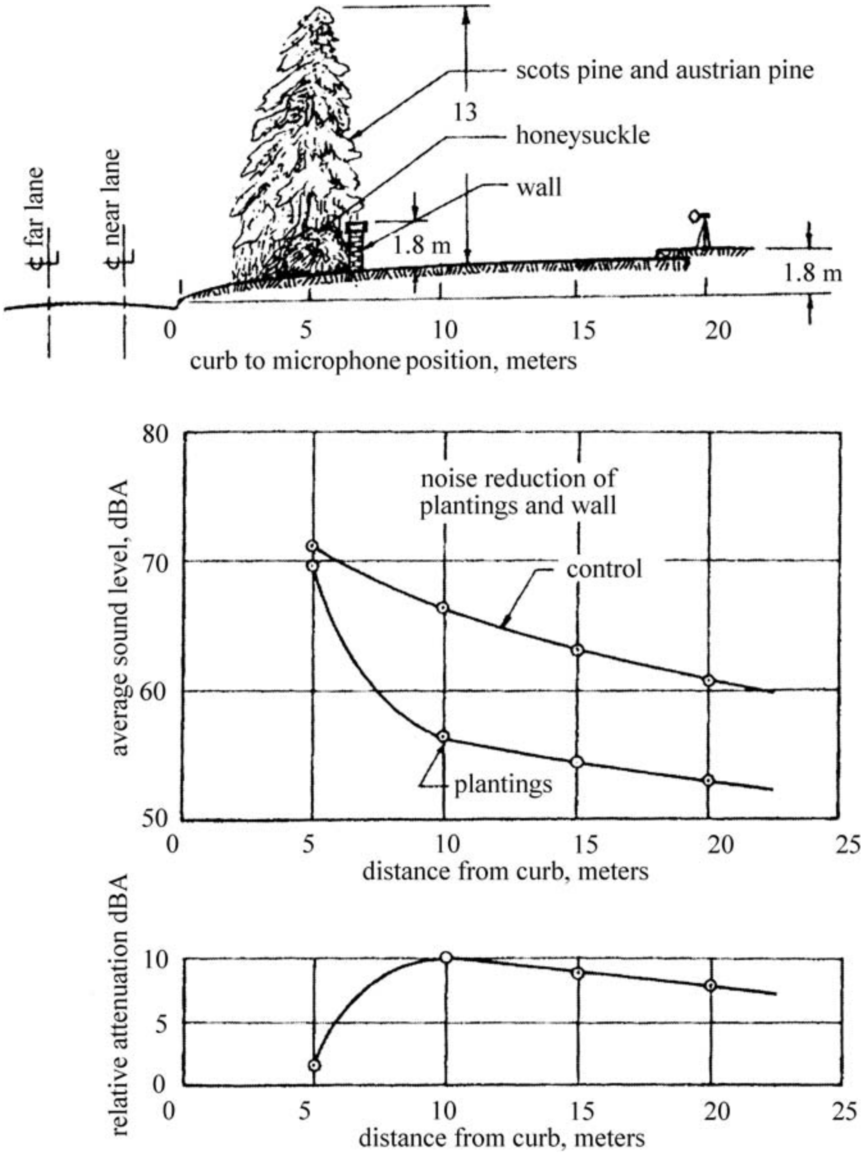

Fig. 6.7. Site C has a tall evergreen hedge, brick wall and an upward sloping ground profile from the street to the residence (Cook and van Haverbeke 1972)

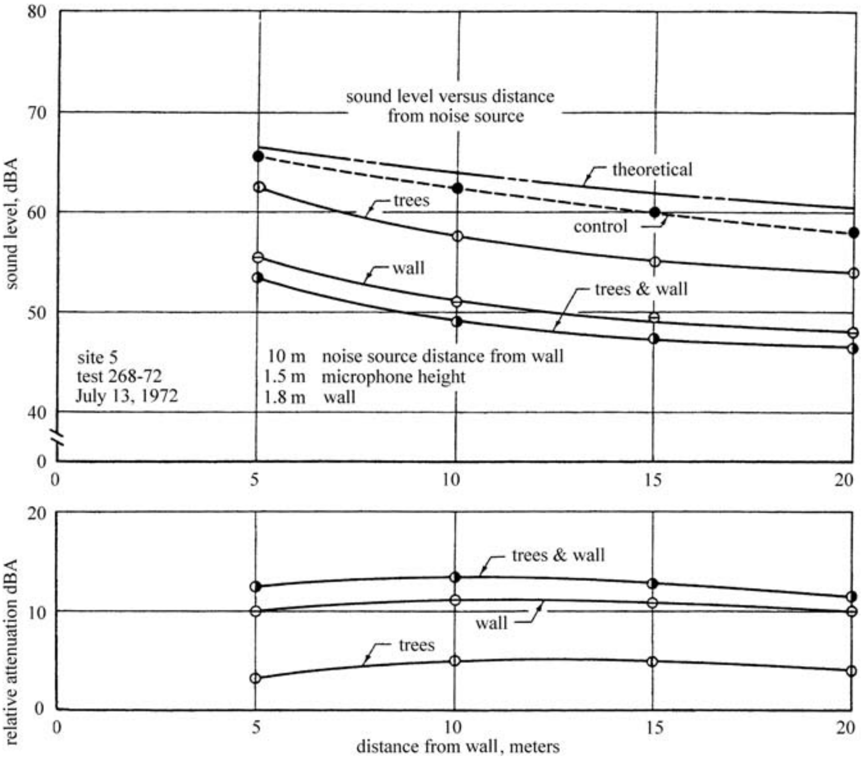

Fig. 6.8. The influence of different surfaces – wall alone, trees alone, trees and wall – on noise reduction (Cook and van Haverbeke 1972)

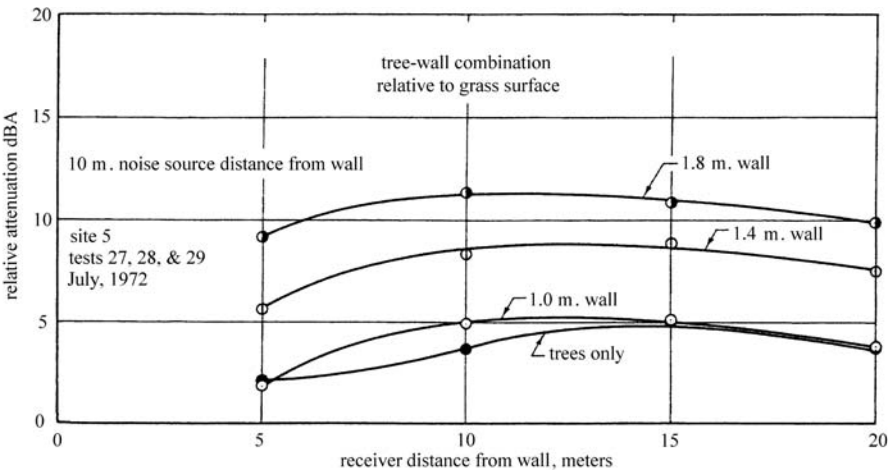

Fig. 6.9. The effect of the position of the wall between the source and the receiver (Cook and van Haverbeke 1972)

6.3 Summary

The design of a comfortable environment must pay attention to the "soundscape" which should complete the "landscape" design. The meanings of soundscape are social, historical, cultural and environmental. A positive impression on the urban soundscape is produced by large vegetation areas, belts of trees, public gardens and parks.

In urban residential areas, the disposition of trees around the houses should be made for maximum noise reduction, together with an improvement in aesthetics and air quality. In residential suburban areas, discomfort is produced by highway systems. In this case, noise reduction can be achieved by creating tree belts and noise barriers.