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CHARACTERIZATION OF THE NATURAL AMBIENT SOUND ENVIRONMENT

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1. INTRODUCTION

Silent areas can be defined as areas of at least a few square kilometers where noise levels due to human activities are neglegible. In the densely populated Netherlands, where silent areas have a legal status, a method for judging effects of human activities in such areas is needed. The audibility of manmade noise in a natural environment is affected because of masking by ambient sound. A characterization of natural ambient sound should therefore be part of a proper judging method.

Level and spectral composition of ambient sound depend on the type of area, the type of ground cover and meteorological, seasonal and diurnal variations. Little is known about this topic sofar. Ref.[1] contains a short review of relevant literature currently available. In this contribution we present ambient sound levels for two types of area and spectral distributions of ambient sound for one type of area respectively. After giving a definition of natural ambient sound (2.), we present results obtained in open agricultural grass-land during the summer (3.) and measurements carried out in deciduous forest in fall and winter (4.). A related study on sound levels in coniferous forest can be found in [2]. In the present investigations, we focus on the relation between sound level and wind velocity as the latter was expected to be the most important meteorological variable involved.

2. DEFINITION OF NATURAL AMBIENT SOUND

Natural ambient sound is defined as sound produced by natural sources as well as noise caused by human activities which cannot be recognized as such (e.g. distant traffic noise). Its level is characterized by the statistical sound level L_{95}. This choice is a logical one as it provides a true basis: noise levels of human origin, not exceeding this measure, will almost never be heard. Furthermore the L_{95} is hardly affected by distortions.

3. OPEN AGRICULTURAL GRASS-LAND [3]

Method

For this part of our investigation we used a real-time frequency analyser which simultaneously determined the sound pressure level. The L_{95} was determined for each 1/3-octave band in the frequency range from 6.3 to 20,000 Hz seperately. At the same time the total A-weighted sound pressure level was recorded. The duration of each measurement was five minutes (as wind speed variations with a frequency of 1 per five minutes are almost absent), the sampling time 0.1 second. A 1/2"-microphone covered with a 9 cm diameter foam windscreen was used. During the measurements the average wind speed was determined manually. Both the wind speed and the sound level measurements were carried out at a height of about 1.5 to 2.0 m.

Location

The measurement sites were all located in the Northern part of the Netherlands, in the provinces of Groningen and Drenthe. The actual locations were chosen in accordance with criteria formulated by the province of Drenthe for assigning silent areas. In all cases the ground was covered with grass of approximately 10 cm height, near ditches sometimes upto 50 cm height. The area is flat.

Results

We now present results based on 39 measurements. All results were obtained during daytime in August 1994. In Fig. 1 we plotted both the unweighted and A-weighted L_{95} as a function of the wind speed. The unweighted results were obtained by energetic summation of the 1/3-octave band data. Through the data points we drew regression lines, yielding

$$L_{95} = 37.9\log(v) + 42.5 \quad (1),$$
$$L_{A95} = 22.6\log(v) + 22.7 \quad (2),$$

with standard deviations w.r.t. the data of 2.4 dB and 2.0 dB(A) respectively. Assuming that L_{95} only differs from L_{eq} by a constant, it can be seen from (1) that the average sound intensity I_{av} approximately varies as v^4. It is known from literature that this agrees with a monopole source generating wind noise [4]. Relations similar to (1) and (2) for each 1/3-octave band are given in [1,3].

The frequency distribution of the L_{95} is presented in [1,3,5]. The unweighted frequency spectrum is dominated by low frequencies due to wind-generated noise. For wind speeds exceeding 3 m/s and frequencies below 100 Hz, we found the average 1/3-octave band intensity to be proportional to f^{-2}, in agreement with [6]. The A-weighted frequency spectrum is dominated by frequencies between 500 and 10,000 Hz and represents audible noise in open agricultural grass-land.

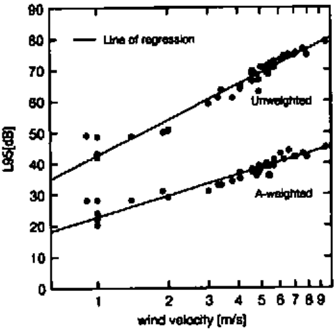

Fig. 1. L_{95} and L_{A95} as a function of wind velocity (grass-land).

4. DECIDUOUS FOREST [7]

Method

Here a measurement device was used which enables, among others, continuous monitoring of the total A-weighted sound level. For each half-hour period, the total L_{A95} was determined. The sampling time was 1 second. A 1/2"-microphone covered with rain cover, dehumidifier and windscreen was used. Averaged wind speed data were provided by the Department of Physical Geography of the University of Groningen. These were obtained at 26 m height (at tree tops) near our measurement location and were available for half-hour periods.

Location

For practical reasons, we choose our location near the site of Physical Geography, which is located in a silent area (Fochtelooërveen) in the province of Drenthe. The area is flat and primarily covered with oak and beech, although coniferous forest is present at nearby locations.

Results

Here we discuss results of the continuous monitoring of the A-weighted sound level during two 2-week periods in October '95 (autumn) and December '95/January '96 (winter). In the first period the trees still carried leaves. Similar to Fig. 1, Fig. 2 presents the determined L_{A95}-values for both periods. It is observed that in both situations the L_{A95} is almost independent of the wind velocity *v*, providing *v* does not exceed 3 to 4 m/s. This might reflect the fact that in this wind speed range wind-generated noise does not contribute to the A-weighted sound level. This result can possibly also be attributed to the relatively bad acoustical climate at the measurement site.

For higher wind speeds we determined the L_{A95} to be proportional to 50log(*v*) and 55log(*v*) for fall and winter respectively [7]. Thus the presence of leaves seems to affect the L_{A95} only slightly. At these wind speeds the detected sound is probably generated by the wind (sound generated by the airflow striking trees as well as sound due to rustling leaves etc.). Assuming L_{95} to be proportional to 50-55log(*v*) too, our results suggest that I_{av} scales with v^5-$v^{5.5}$, whereas for a dipole generating wind noise I_{av} is proportional to v^6 [4]. However, unweighted sound level data are not available and definitive conclusions can therefore not be drawn.

5. CONCLUSION

The empirical results presented here are only a first step towards a method

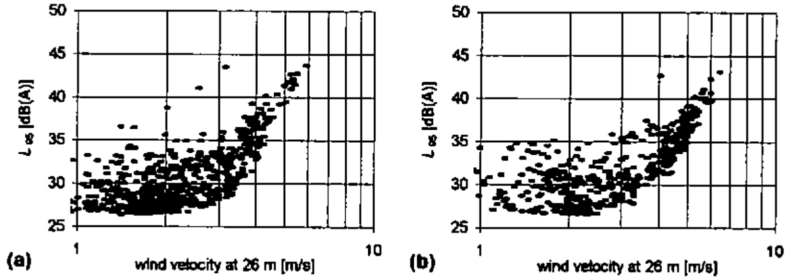

Fig. 2. L_{A95} as a function of wind velocity (deciduous forest; a. fall, b. winter).

predicting natural ambient sound under various conditions. In the future, more detailed measurements in different areas are needed. Furthermore the influence of ground absorption and meteorological parameters like the gradient of the wind velocity and temperature should be studied.

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