Can You Hear Me Now?

Frog Call Transmission in an Open Field and in a Vernal Pond to Forest Environment at UNDERC

BIOS 569: Practicum in Field Biology
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Introduction

Whenever an effort is made to make a connection with another member of your own species by means of acoustic communication it is important that you are able to be heard and even more importantly understood. The range over which acoustic communication can travel before attenuating to a point that it can't be heard or recorded, also known as 'active space' (Miller 2006), depends largely upon the sound intensity of the source and the environmental conditions through which the sound must travel.

Sound intensity is the sound per unit of area or SPL measured in decibels (Berg and Stork 2005). The Eastern Gray Treefrog *Hyla versicolor*, has been measured as having an advertisement call with a peak decibel range of 108.5 from 50 centimeters away during their mating season May to June on vernal ponds (Gerhardt 1975). Hyla versicolor has an advertisement call commonly referred to as a "trill" (Bogert 2002) which has dominant frequencies at 1100 Hz and 2100 Hz (Gerhardt and Doherty 1988). Since lower frequencies are less likely to be absorbed than higher frequencies they will most likely travel farther due to the greater size of lower frequency wavelengths compared to higher frequency wavelengths they are also more likely to be diffracted over greater distances and lose their integrity and thus their ability to be understood by listening members of the same species may be lost. In terms of higher frequencies, even though they travel a shorter distance they are easily recognized above the other ambient noise and because of their smaller size they are less likely to be diffracted allowing maintenance of integrity over greater distances (Bosch and De la Riva 2004; Kime et al 2000).

Sound may however be reflected or absorbed by various environmental factors such as water, vegetation or the air (Rossing et al 2002; Penna and Solis 1998). For environments with open water sound could be expected to travel farther since sound absorption in water is reduced (Miller 2006). Additionally, the height at which the sound is being projected has been shown to have an influence on sound transmission primarily as a result of barriers at the given heights being tested. More active space would be expected to be present at a higher height than at ground level laden with grasses, downed logs, and other barriers to sound transmission (Kime et al 2000).

In ideal systems where there is no barrier to sound transmission sound attenuation, or the decrease in decibel level as distance from the source increases, follows the formula $\left[I = 10 \log \frac{I}{I_o} \right]$ where "I" is sound intensity and "I_o" is 10^{-12}. In the ideal system it can be expected that there will be an attenuation of 11 dB from the source to the first meter and then an additional 6 dB every time the distance from the source doubles. However outside the laboratory environmental factors such as humidity can influence sound transmission in the absence of other barriers to sound transmission (Rossing et al 2002).

Only a few studies have investigated the relationship between environment variables and acoustic transmission in regards to anuran advertisement call transmission. One investigated differences in bogs and marshes at frog distances but did not investigate height or any significant distance from the source or attenuation of the call intensity within the environment (Penna and Solis 1998). The other similar study involved most characteristics of the study including height, open field and forest in the study of the transmission of the advertisement calls of 22 species of Central American frogs (Kime et al 2000) but it did not account for the movement of the sound from a vernal pond to a forest environment as is important in a *Hyla versicolor* mating season (Gerhardt and Doherty 1988).

The first of my hypotheses is that vernal pond terrain will influence the distance that sound travels. Secondly, higher frequencies will not travel as far as lower frequencies. Thirdly, sounds projected from a greater height will travel farther than sounds projected from ground level. Lastly, sound transmission distance will be less in the vernal pond than in the open field.

Methods

Study Sites

My control site UTM coordinates (6T 0305417, 5122266), from here on referred to as the Frisbee field, was a large flat open field that is kept habitually mowed. This was ideal as it allowed for a minimum of obstruction to sound transmission even at ground level. My experimental site UTM coordinates (16T 0305948, 5124789), from here on referred to as vernal pond , contained a large vernal pond of approximately 19 x 19 meters surrounded primarily by mixed sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis*) forest with a light to moderately dense under story. Both sites are within the University of Notre Dame Environmental Research Center property located in Northern

Wisconsin/Upper Peninsula Michigan. Study was conducted during June and July of 2007.

Site Set-up and Recording

For both the Frisbee field and the vernal pond a center of the site was determined. For the vernal pond this center was the middle of the pond itself, while at the Frisbee field the center was determined based upon the largest available space available in all directions from that point. From the center points at each site I ran transects in two opposite compass directions and placed a flag moving away from the center point for 49 meters (vernal pond) and 33 meters for the Frisbee field (Figure 1).

Since *Hyla versicolor* advertisement calls are characterized by 2100 Hz and 1100 Hz call components (Gerhardt and Doherty 1988). I uploaded an 1100Hz and a 2100 Hz pure tone derived from NCH Pure Tone Generator and a *Hyla versicolor* advertisement call (Bogert 1998) onto a digital recorder (Olympus WS-100 Digital Voice Recorder Center Valley, Pennsylvania). I then connected the digital recorder to an amplifier (40-Watt PA Amplifier #32-2054 Radio Shack Fort Worth Texas) connected to an omni directional speaker (GS-3 Omni Speaker® TIC Corporation City of Industry, California). At the Frisbee field the speaker set up was placed at the furthest extreme of the transect (Figure 2), while at the vernal pond it was placed on the edge of the pond (Figure 3). To power the speaker set-up a series of 16 gauge extension cords were run from a 200 volt power inverter connected to the cigarette lighter in my research vehicle.

After placing the speaker I determined the decibels being projected by the speaker for each of the pure tone frequency and for the Hyla call using an SPL meter (Digital- Display Sound Level Meter 33-2055 Radio Shack Fort Worth, Texas) standing 1 meter from the speaker and adjusted the volume until the meter read 90 decibels (Kime et al 2000) or the volume could not be increased any further. If the volume had been increased to its furthest extent without the SPL meter reading 90 decibels the highest decibel reading for that sound was taken for standard instead of 90.

Sound was both measured and projected from ground level and half a meter (50 cm) (Kime et al 2000). I then used a digital recorder (M-Audio Microtrack 24/96 M-Audio USA Irwindale California) and a microphone (line/gradient shotgun condenser microphone AT815B Audio Technica, U.S. Inc Stow, Ohio) to record 8-12 seconds of sound at each meter moving away from the speaker. I continued to collect a sound file at each meter along that transect until I had reached the end or until it could no longer be heard.

My partner remained by the speaker restarting the recording when it stopped and wore silencer headphones to prevent hearing damage due to the high decibels for sustained periods. This process was repeated for both sites, both transects, both heights, and for all three sound types. There were 6 runs per transect (3 runs per height), 2 transects per site = 12 runs per site = 24 total sound runs.

Data Analysis

I will use Raven 1.2.1 to analyze the sound files I collect to measure the decibels at each meter at 1100 Hz and 2100 Hz for both pure tones and with the

Hyla call. For statistical analysis I will use the statistical program R to run a Bayesian information criterion and stepwise regression (R Foundation 2007).

Results

Bayesian information criterion and stepwise regressions (Figure 4) resulted in model with Log Distance (LD) (B= -31.3935, SE = 0.6897, p<0.001) + LD x Height (50 cm) (B= 3.1923, SE = 0.5180, p<0.001) + LD x frequency (2100 Hz) (B= -2.1202, SE = 0.8496, p<0.01) + LD x Height (50 cm) x Frequency (2100 Hz) (B= 4.1293 SE = 0.9709, p<0.001) + LD x Frequency (2100) x Type (Hyla) (B= -5.2822, SE = 0.9971, p<0.001). Bayesian information criterion and stepwise regressions (Figure 5) resulted in model with LD of forest in the eastern direction (B= -21.475, SE= 2.153, p<0.01) + LD x direction (west) (B= -11.074, SE= 4.294, p<0.01) + (B= 8.979, SE= 3.436, p<0.01). The third Bayesian information criterion and stepwise regression (Figure 6) resulted in model with LD (B= -32.832, SE = 3.864, p<0.01) + LD x Forest (B= 7.879, SE = 2.567, p< 0.01) + LD x direction (B = -23.447, SE = 5.696, p<0.001), + LD x direction (B= 17.479, SE 4.562, p<0.001). Differences between frequencies within the hyla call were not significant. Sound transmission in the Frisbee field is significantly different than in the vernal pond (R2 = 0.5793, p<0.001, DF = 1246).

Discussion

Height at 50 centimeters was a factor in the distance of sound transmission for 2100 Hz (Figure 4), higher frequencies traveled farther in the Frisbee field for the pure tone and in the forest for the Hyla call. In denser forest areas decibels of the 2100 Hz frequency declined at a much accelerated rate than in less dense forest areas.

My data supports my first hypothesis that vernal pond terrain will influence the distance that sound travels although not as I thought. I thought that the terrain would influence the transmission of sound in that water would temporarily prevent attenuation by reflecting rather than absorbing the sound (Miller 2006) and the forest would abruptly hinder sound transmission. I was half correct, with a dense under story a forest does increase sound attenuation but the water in the vernal pond had no influence on the attenuation. This may be due to the large volume of floating debris and macrophytes floating on the surface of the pond as well as an increasing lack of water as the summer increased and it started to dry so the determination of "open water" is generous at best.

I failed to support my second hypothesis that higher frequencies will not travel as far as lower frequencies. In most cases in which the 1100 Hz call was not lost due to insignificance the higher frequency pure tone and hyla call characteristic traveled farther and had less attenuation. This may be due to the wavelength size and therefore higher frequencies are less likely to diffract (Kime et al 2000) upon hitting an obstacle such as leaves and are more likely to be picked up and identified accurately by the recorder and analysis software without much variability. So it is not that the 1100 Hz sound is not there but simply that it is lost in the other low frequency sound picked up by the recording device or it has diffracted beyond record ability due to its wavelength size.

Thirdly, on the frisbee field I demonstrated that height does make a difference in how far sound travels but only for 2100 Hz. For the vernal pond height comparisons for hyla calls was not significant, this may simply be due to the 1 site that I tested being located in a bowl with the forest on slight slopes on all sides. Further studies would need to be done to determine if height had any influence on sound transmission from a pond to forest system as has been demonstrated in solely forest systems in previous studies (Kime et al 2000).

Lastly, the analysis showed that the 2100 Hz frequency traveled significantly farther in the open field than in the vernal pond supporting my hypothesis that the distance the sound will travel will greater on the Frisbee field than in the vernal pond.

Unfortunately I was only able to sample one vernal pond, for only one replicate despite numerous samples. For true significant information this experiment would need to be repeated at multiple vernal ponds. It would also be interesting to pair this experiment with a male distribution experiment and create and array and use a directional speaker rather than an omni directional speaker to map how sound transmission overlaps from multiple frogs within a mating chorus the attenuation outward from the entire chorus. The study of sound transmission in anuran and hylidae is a field that offers many opportunities to explore macro and micro habitat components.

Figures

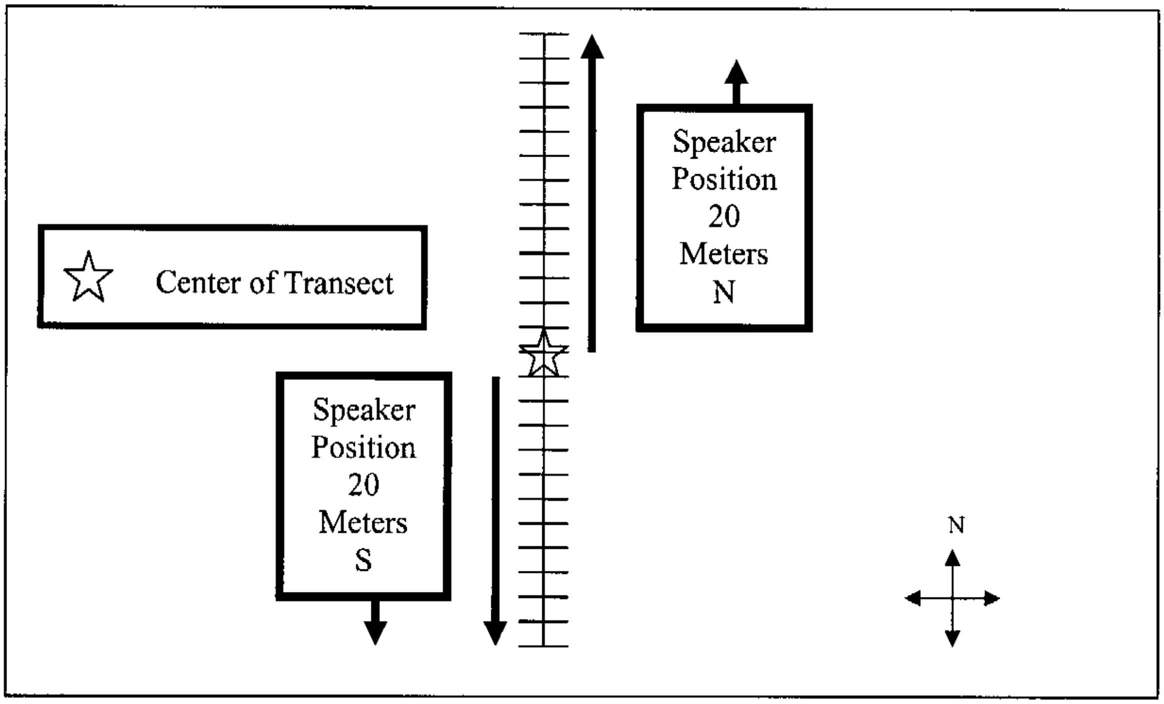

Figure 1: Frisbee field transects. Arrows denote separate transects.

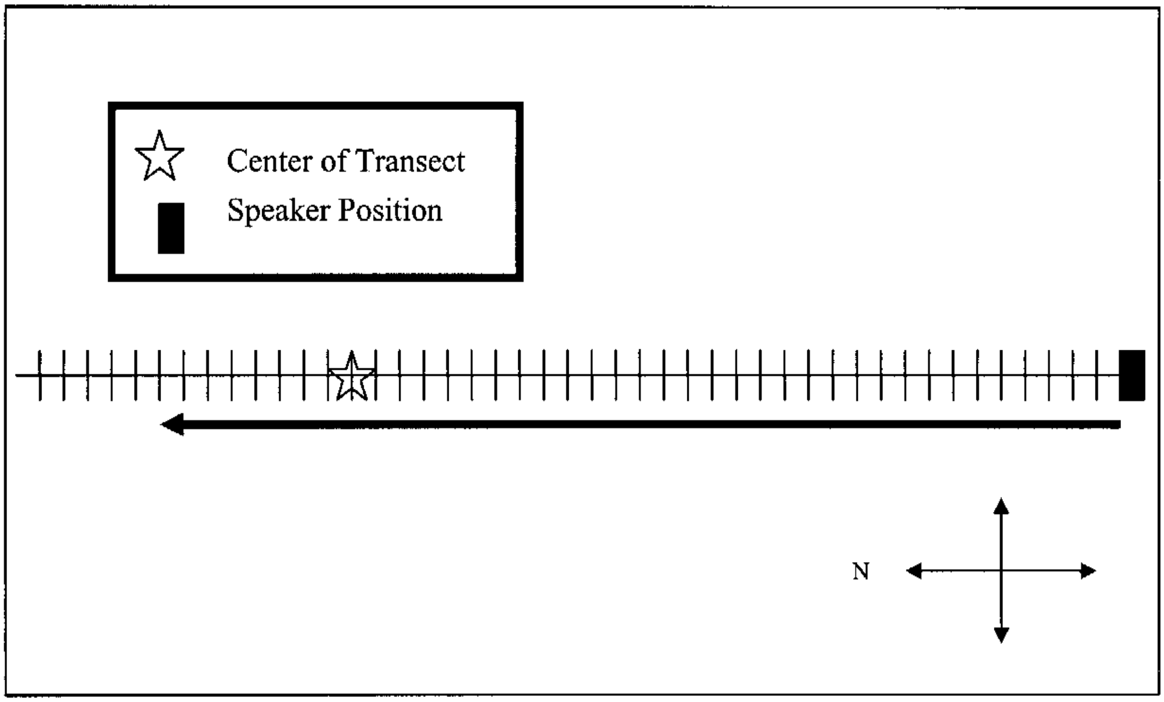

Figure 2: Frisbee field speaker position along the transect from a south to north direction.

Arrow denotes direction of sound sampling

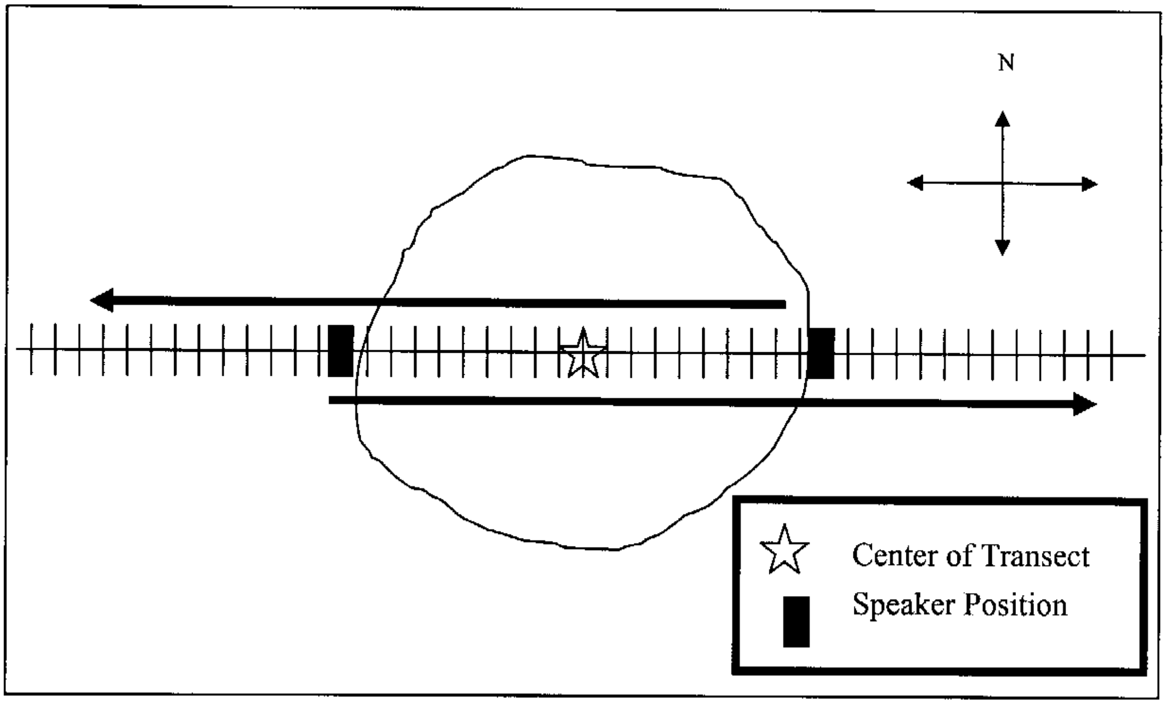

Figure 3: Vernal pond speaker set-up. Arrow denotes direction of sound sampling.

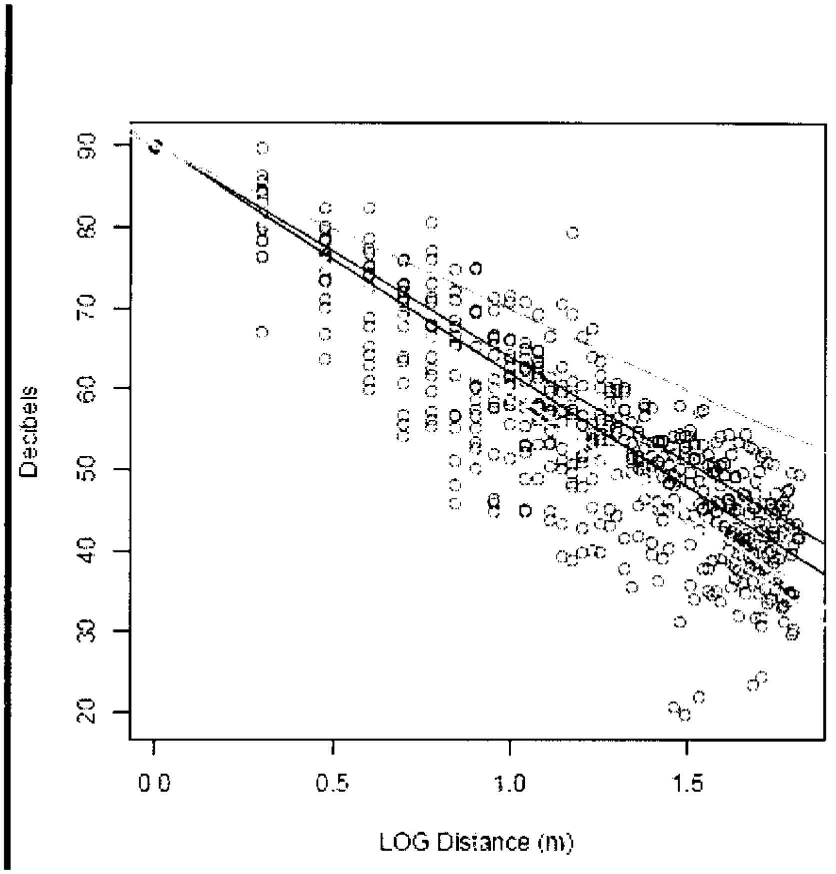

Figure 4: Best Model from Bayesian Information Criterion using Stepwise Regression analyzing (from Top to Bottom) (1) Theory Line [sound intensity over distance in an ideal

system], (2) Height at 50 cm and 2100Hz Frequency, (3) Height at 50 cm, (4) 2100 Hz Frequency, (5) Reference Line [North direction, Ground Level, 1100 Hz, Pure Tones], (6) 2100 Hz and Hyla Calls. R2 = 0.816, p-value (p<0.001), DF = 524

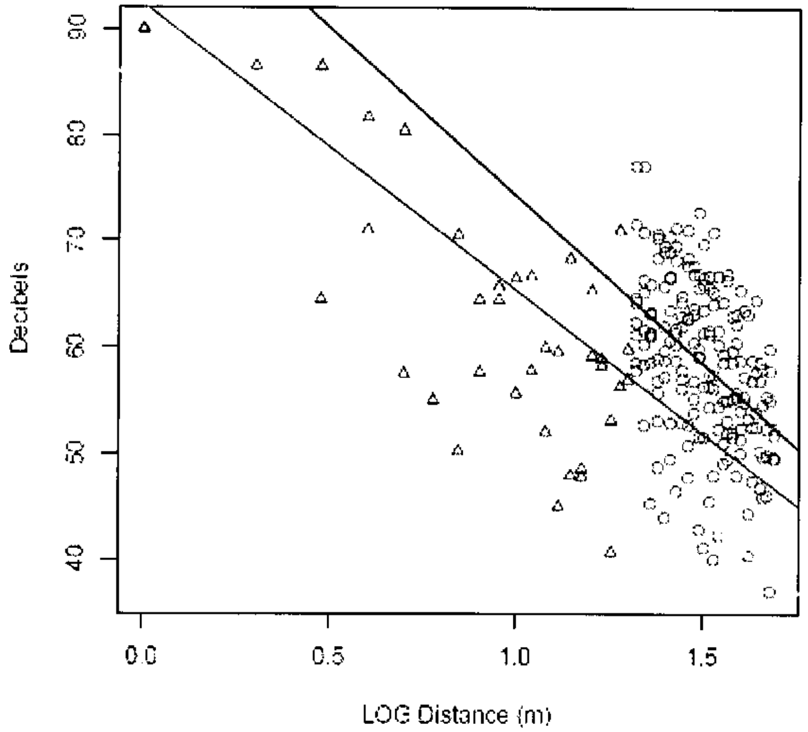

Figure 5: Best Model from Bayesian Information Criterion using Stepwise Regression analyzing (from Top to Bottom). (1) Distance (2) Shrubs + Canopy = Forest (3) Non Forest West Direction. R2 = 0.513, p-value (p<0.001), DF = 78. Circles denote shrubs and forest canopy, and triangles denote open water, mud and grass

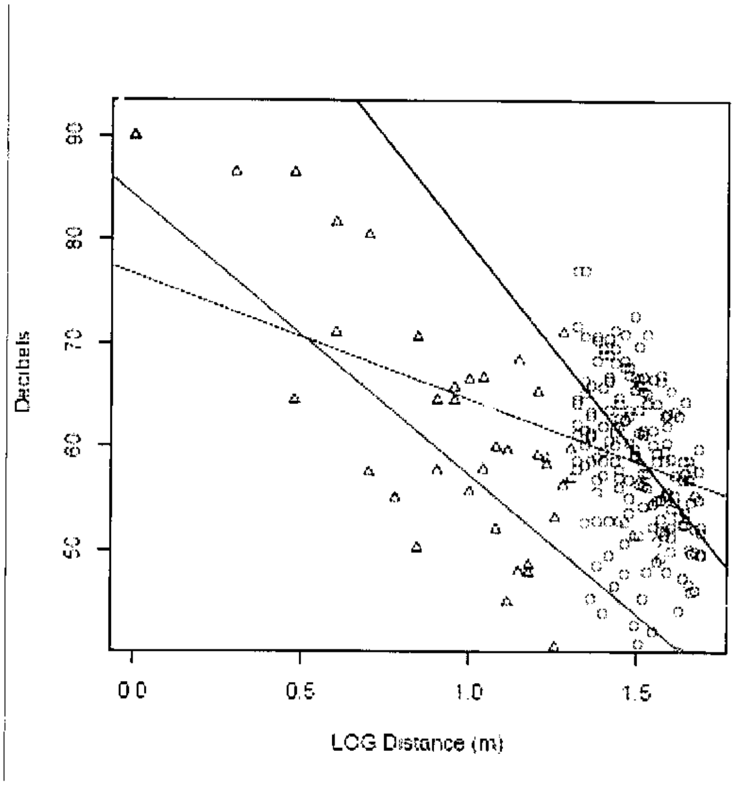

Figure 6: Best Model from Bayesian Information Criterion using Stepwise Regression analysis (from High to Low Y- Intercept). (1) Forest from a western direction (2) Non forest from an eastern direction (3) Non forest from a western direction (4) Forest from an eastern direction. R2 = 0.5971, p-value (p<0.001), DF = 79. Triangles denote open water, grass and mud, circles denote forest canopy and shrubs.

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