Leaf Blowers – Proposed Restrictions in the Town of Oakville

by Ted Mitchell MD, BEng

Presented at Open Forum on Leaf Blowers at the Town of Oakville December 2, 2015

Dr. Ted Mitchell is a Hamilton, Ontario resident, emergency physician and sometimes agitator who recently completed a BEng at McMaster University. He is fascinated by aspects of our culture that are harmful, but avoid serious public discussions.

This article investigates some of the known and potential harms arising from the use of leaf blowers and their impact on quality of life in city neighbourhoods.

I am writing this paper because I believe that physicians have an obligation to promote community health as well as personal health. Community health is strongly influenced by the social environment, mainly how citizens treat each other. Personal health and well being is influenced by how well we maintain common goods in our cities such as air quality and the acoustic environment.

Perhaps because our economy puts a zero price on external costs like noise, we pretend that it does no harm. Nothing could be further from the truth.

These things should be obvious, and should be defended by our Public Health professionals. Unfortunately, for the most part they steer clear of any health issues that have political consequences. Thus it falls to concerned citizens and "activist" physicians such as myself to take over where Public Health fears to tread.

The Golden Rule

For thousands of years, the golden rule has been the foundation of religion and civilized society.

"*Do unto others as you would have others do unto you*".

This can be taken too literally, because with any difference in religion, culture, or personal preference, it can easily result in causing harm or offence to others. People have differing values, which makes our country more rich and diverse. A more appropriate version for multicultural Canada in 2015 would be:

"*Do unto others as they would have done unto them*".

The difference is critical; it requires that you understand your neighbour's likes and dislikes and ensures that everyone is responsible for the consequences of their own actions. Responsibility is the tool with which we implement the golden rule.

I think that most people would agree that in the last half century, Canada has shifted from a cohesive, community minded country where neighbours talked to and looked out for one another, to a more self-centred, materialistic, and money obsessed culture. Many of us lament the change and would be much healthier and happier if our communities worked together towards common goals and were simply civil and respectful towards each other.

Pulling the trigger on a leaf blower is not compatible with the golden rule. It inflicts far too much noise and air pollution on too many people for a small, individual, and for many people's values, an unnecessary benefit.

Why do people react so strongly against leaf blowers?

Leaf blowers have strong tonality, meaning sharp peaks in the frequency spectrum which happen to coincide with the sensitive range of the human ear. Not coincidentally, this is also the sensitive range of the auditory cortex, the part of the brain which decodes speech. In effect, the blower is mimicking human speech frequencies and tonality but it contains no information, just noise. It is exceedingly difficult to ignore this acoustic signature, **because human brains have been source of noise, and the perceived utility of that source. ???????**

Leaf blowers might be the target of so many noise complaints because of these two factors.

The person using a blower controls the outdoor sonic environment for dozens to even hundreds of surrounding properties. Simultaneously, air pollution downwind of a two stroke blower can affect dozens of neighbours. These neighbours have no control over the sounds they hear or the air they breathe and no legal recourse to protect themselves.

It may be fine to value a perfect, indoor appearance of your outdoor lawn. Others may not share those values and do not appreciate the noise and air pollution that comes with imposing these possibly vain and inconsid-

erate values on the neighbourhood. The perceived utility of leaf blowers for the latter group is astonishingly low.

Neighbours who value things like enjoying opening their windows for fresh air, or spending time in their yard or on their deck cannot do so in reasonable peace while there is a leaf blower within earshot.

This is really a discussion about the nature of freedom: should exercising freedom for one person result in denying freedom to many others?

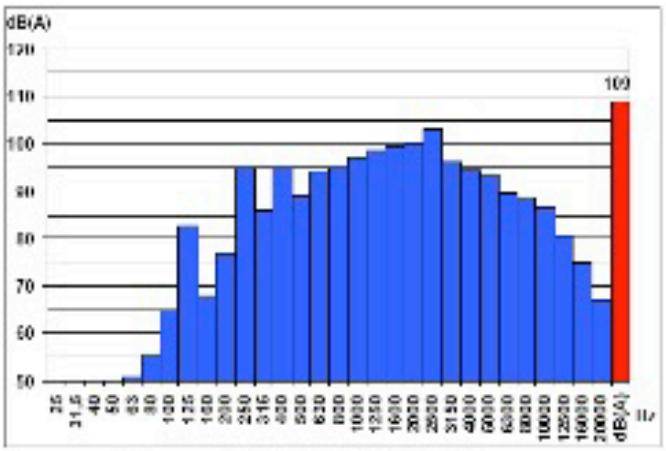


Figure 4. Echo 6000 leaf blower

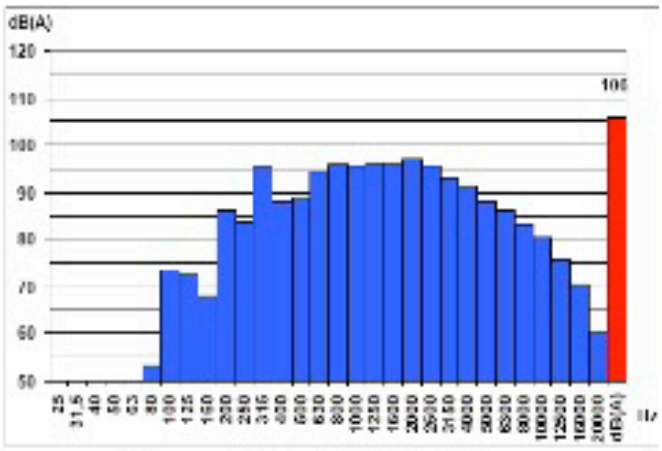


Figure 5. Echo 4600 leaf blower

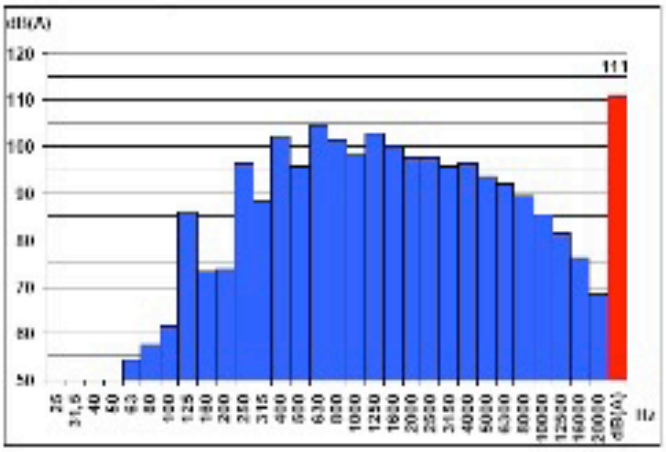


Figure 6. Husqvarna 155 B leaf blower

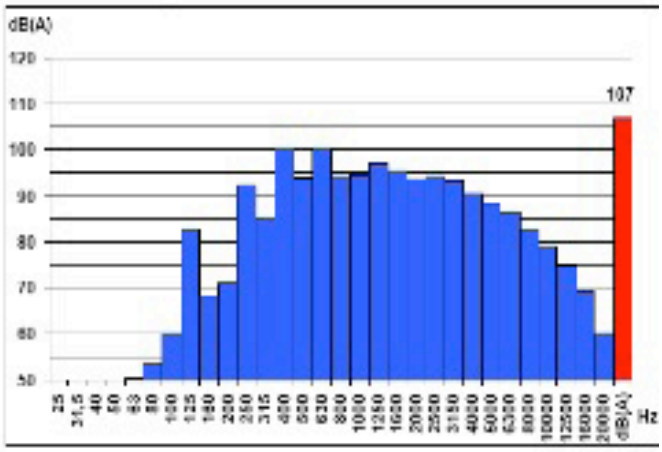


Figure 7. Husqvarna 141 B leaf blower

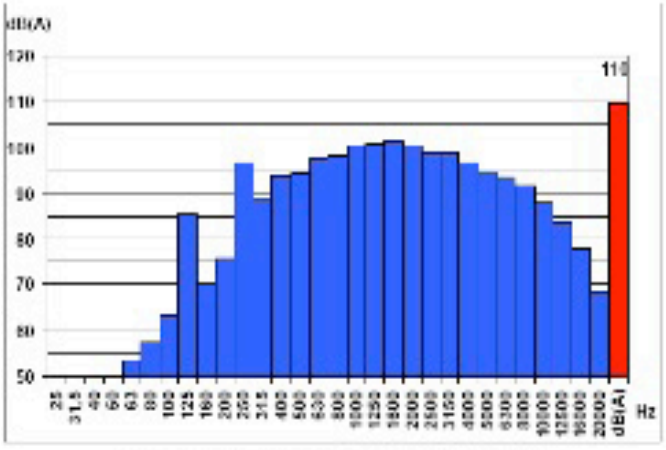


Figure 8. Stihl BR 420 leaf blower

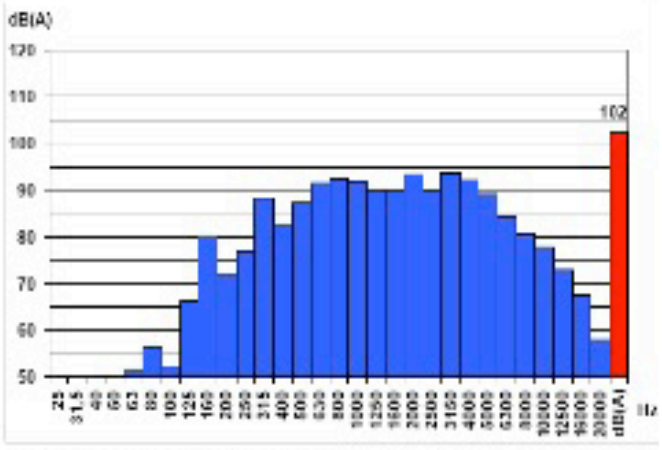


Figure 9. Husqvarna 225 BV leaf blower / vacuum

Noise Spectra of several leaf blowers showing characteristic low frequency tonal peaks in human speech frequencies. **Ted: can you explain better in a caption here? What do the red bars mean?**

Noise is not about Decibels

If there is one key concept to understand about noise, it is the inability to be quantified by decibels.

A decibel is a unit of loudness that represents sound power. It is primarily useful for deciding whether hearing protection is necessary with a given duration of exposure. Secondarily it can be used to predict intelligibility of speech given a background noise level, this is the signal-to-noise concept.

There is no decibel level that makes any sense of why Julie Kavner (Marge Simpson) has an annoying voice, or why Morgan Freeman has a pleasant one.

An analogy with vision would be using the number of lux reflecting off of a Picasso artwork to determine whether the painting was beautiful or ugly. That is equally ridiculous as describing noise with numbers.

Leaf blowers have the almost unique quality of being annoying down to the level of audibility. Their noise never fades into the background like broad spectrum sources such as lawnmowers and traffic. Blowers, like air raid sirens and fire truck horns, to which they are similar in the physical generation of sound, remain annoying until the sound becomes almost inaudible.

What are the components of blower noise?

There are at least three main sources of noise from blowers: exhaust noise, blower vane noise, and tube vortex resonances.

Two stroke engines produce an exhaust note in Hertz equal to rpm/60. For a 7200 rpm blower this translates to 120 Hz fundamental frequency. Harmonics, or overtones, are very strong because the rapid, sharp exhaust gas release from a very small muffler results in a jagged wave pattern. Jagged waves like square and triangular waves are universally perceived as louder and more annoying than smooth sine waves of the same amplitude.

Four stroke models have half the fundamental frequency, and slightly smoother exhaust release. This places the fundamental at about 60 Hz, which can potentially penetrate buildings better than the two stroke sonic signature, although harmonics are less aggressive.

Multiple harmonics gradually fade out with higher frequency. Above 1 kHz, blower vane/blade noise takes over. Like the exhaust, the sharp escaping air produces a jagged waveform with multiple harmonics. If the above blower had 10 vanes the frequency would be 10 x 7200 / 60 = 1200 Hz fundamental frequency and harmonics at higher multiples e.g. 2400 Hz, 3600 Hz.

Electric leaf blower vanes showing sharp edge in air escape vent

Electric blowers are dominated by vane noise. They operate at a lower rpm, so the fundamental frequency is given by (number of vanes) x rpm / 60. Typically this would be 13 vanes at 1800 rpm = 390 Hz.

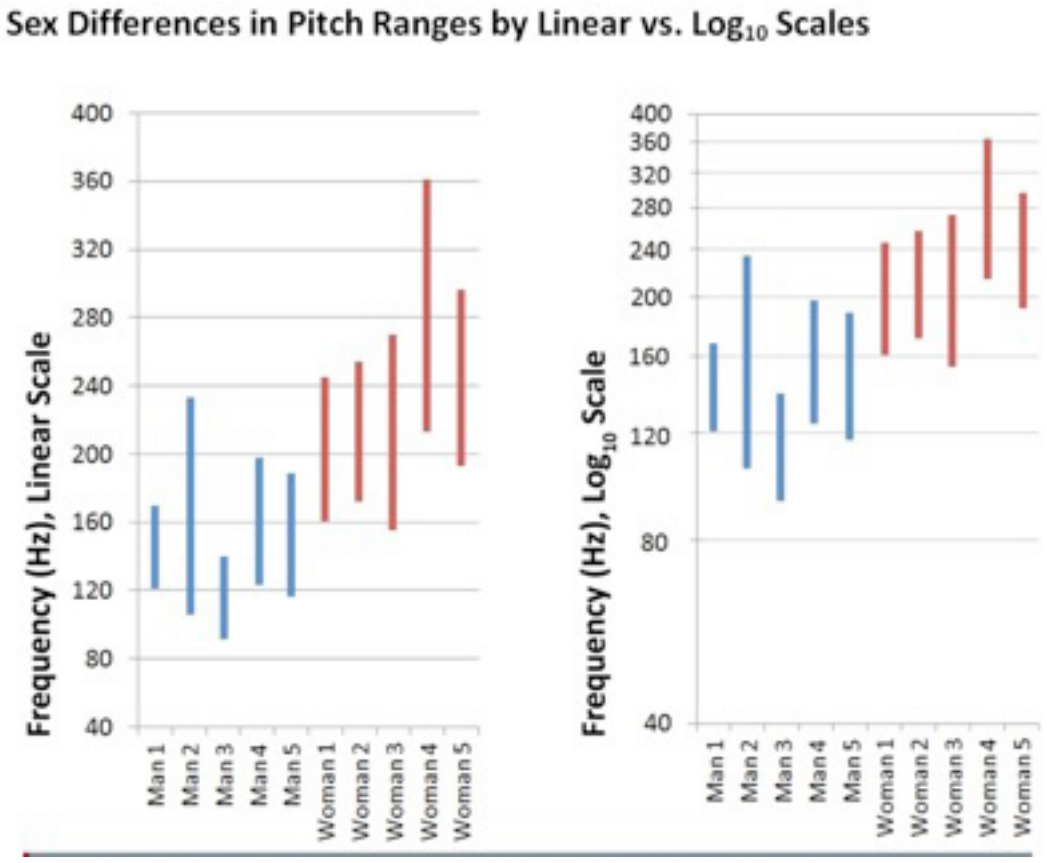
Therefore the sound spectrum of a leaf blower is complex and strongly tonal because of the exhaust and blower vanes, the latter taking over at higher frequency where the former left off.

It gets worse. For some blowers, tonality doesn't stop there. The blower tube may have internal irregularities that set up vortices, producing resonances like a child's whirly toy. Typically these tones "hunt" between harmonics depending on throttle modulation.

Other small two stroke engines are found in chain saws, hedge trimmers, string trimmers and some lawn mowers. All of these engines can be loud and annoying, however they are typically used at lower average rpm, also they do not have the added complex tonality from blower vanes and vortex resonances. Higher rpm results in higher decibels and faster exhaust escape meaning a more jagged waveform and stronger harmonics perceived as more annoying.

Therefore on average, leaf blowers have a more complex waveform at higher rpm than other motorized yard equipment, producing higher sound levels especially in the human ear's sensitive range.

Average speaking voice fundamental frequencies for men and women are listed in the figure below. There are complex harmonics (not shown in the figure) above these frequencies, just like in a leaf blower.

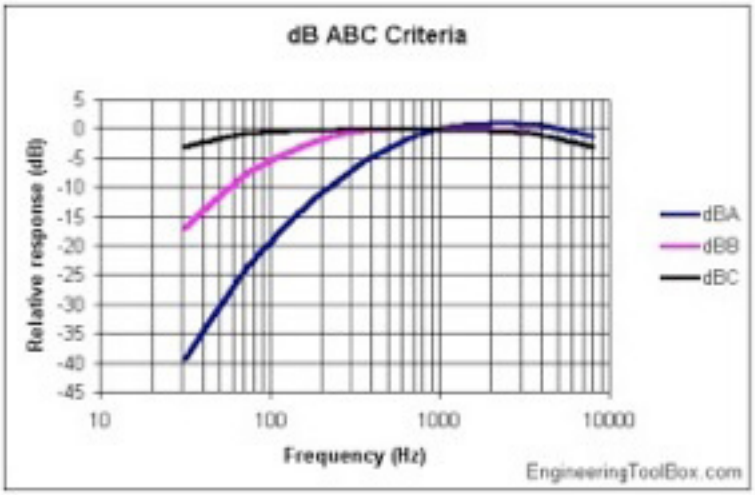


Human Voice fundamental frequencies

On a linear scale (left), vertical lines of equal length reflect equal *absolute frequency ranges:* on a logarithmic scale, which is how humans perceive pitch(right), lines of equal length reflect equal *semitone* ranges. A log 10 scale, which is more perceptually accurate, allows researches to visualize the similarity between women's and men's pitch ranges. {Data collected from women and men aged 25-37 fluent in North American English. (Herron 1989)}.

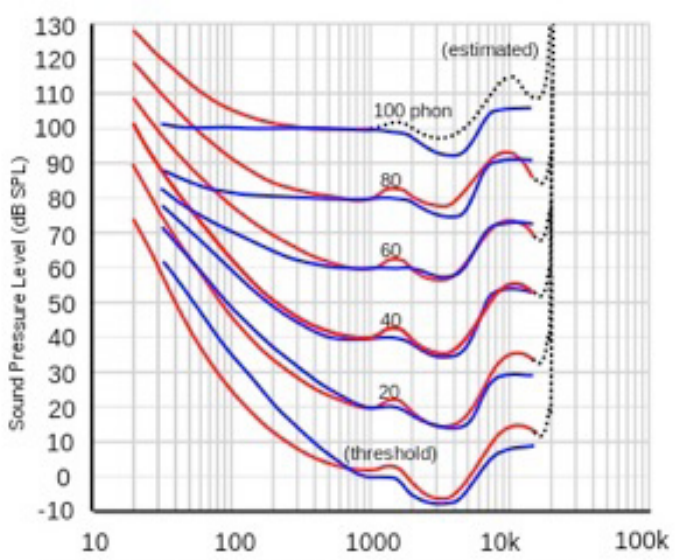
Understanding the A-weighted Decibel Scale

The A-weighted decibel scale underestimates certain frequencies of loud noise. It is based on the 40-phon Fletcher-Munson curve which is appropriate to a very quiet room and is inaccurate and underestimates loudness perception at higher decibel levels generated by leaf blowers.



dB-A curve showing low frequency rolloff

The Fletcher-Munson and modern ISO curves are generated as each frequency is subjectively calibrated to perceived equal loudness in a given decibel range. The 40-phon measurement translates as 40 dB at 1 kHz. This is the level of a whisper in a quiet room.



Equal loudness contours (red) (from ISO 226-2003 revisions)
Fletcher-Munson curves shown (blue)for comparison

Looking at the 80 or 100 phon curves, which is more typical of leaf blower sound levels, one can see the discrepancy at frequencies in the 50-300 Hz range, exactly where the lowest and strongest tonal peaks can be found. Therefore, the A-weighting rating of any leaf blower at the strongest tonal frequencies are underestimated by 10 decibels or more based simply on the inability of correction for decibel level. In short, the A-weighted measurement is artificially and significantly lower than the loudness you are perceiving in low frequency tonal peaks.

Therefore, any use restrictions which reference decibel levels are misguided for three reasons: because applying A-weighting to a loud environment results in underestimating loudness; strongly tonal noise is perceived as more annoying, and tonal peaks in the speech frequencies are even more annoying, and the inability to correlate the complex auditory experience of "noise" with a single number.

Acoustic penetration of noise through buildings

Leaf blowers all have a unique tonality that distinguishes them from other loud noise sources such as chain saws, brush trimmers, wood chippers and garbage trucks.

Recognizing this, and the fact that there is much public opposition to leaf blower noise, Finnish researcher Pasanen devised an experiment to model the frequency spectra of several noise sources including leaf blowers as perceived through an average residential wall. (Pasanen et al, 2004: www.akustinenseura.fi/wp-content/uploads/2013/08/o46.pdf)

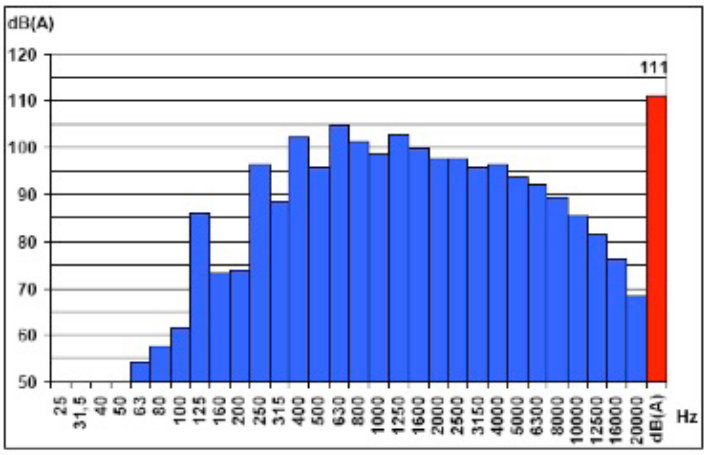


Fig.6 Husqvarna 155B Leaf Blower

Audio spectral analysis and db-A rating of a leaf blower as measured outdoors

The frequency spectra of different leaf blowers is remarkably similar in having strong tonal peaks starting at the fundamental frequency of about 120 Hz for a two stroke blower, and harmonics above this i.e. 240 Hz, 360 Hz, 480 Hz etc. The lowest, or fundamental frequency is generated in this example by exhaust airflow when the engine speed is 7200 rpm, typical of most blowers at full throttle which is their most common mode of use. This is roughly a B2 note, an octave below middle C on a piano, and it is easy to hum along with. It is also roughly the fundamental frequency of an average male voice.

Lower frequencies are longer in wavelength and better penetrate obstructions like walls and windows and trees.

Pasanen modelled a wall (see figure 3 below), and then calculated how the sound spectra of leaf blowers would be perceived inside a nearby house. The results are startling, and it is obvious that the tonal peaks stand out even more than they did from the raw measurements in the outdoors.

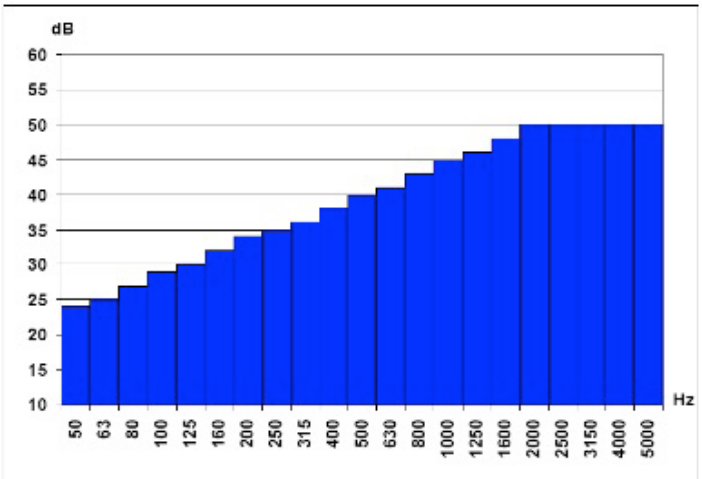


Figure 3. Estimated outer wall transmission loss in 1/3 octave bands

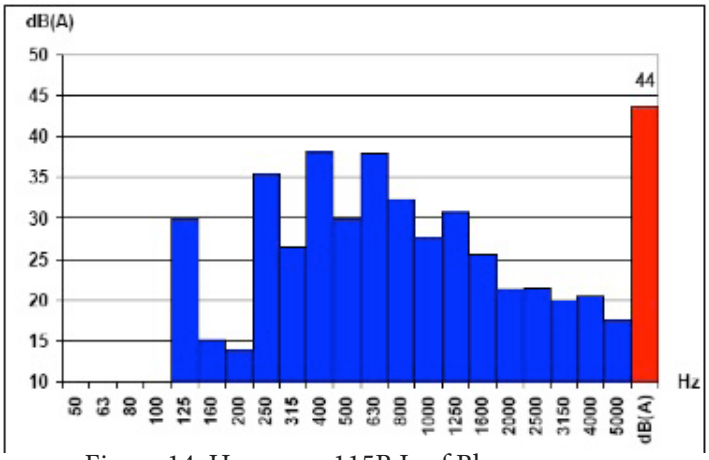


Figure 14. Husqvana 115B Leaf Blower

Leaf blower acoustic spectrum as perceived through a wall

This means that the building wall makes the sound level quieter, but the annoying character of the sound becomes more prominent. There is no escape even in your own home from leaf blowers at close range.

What is the sonic range of a leaf blower?

Several factors influence the distance that leaf blower noise travels: the model of blower, throttle modulation, the age of the muffler, tree cover, building type and density, topography, temperature, and wind speed and direction to name a few.

As a rule of thumb, I have measured out three distances that are relevant to most single detached neighbourhoods. I urge readers to not take my word for it but to pace out or measure with a GPS for themselves and then draw these distances around houses in their neighbourhood using Google Earth.

50 m radius in a medium density neighbourhood, reaching 28 properties

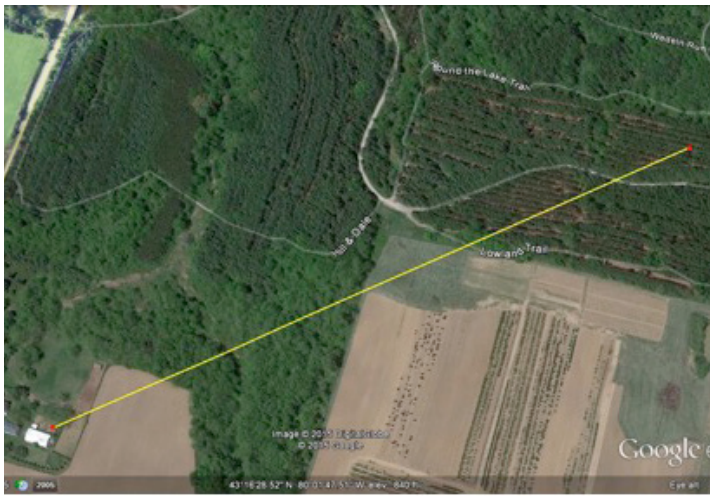
50 meters or less is the average distance at which the typical 2 stroke leaf blower penetrates every room of a house, even a concrete basement. Areas near a closed window on the side facing the blower are particularly unpleasant. Music has to be very loud to drown out the noise. Earplugs or muffs which reduce sound level by 30 dB are inadequate to escape the noise. In a medium density neighbourhood example, there are 28 houses in this radius.

150 m radius in a medium density neighbourhood, reaching 166 properties

150 meters is the average distance at which leaf blowers are perceived as annoying if outside or with open windows. There are 166 example houses within this radius.

300 meters is the average limit of audibility in a residential neighbourhood, meaning it is continuously audible above other background sounds. There are about 600 houses within this radius. I have heard some of the louder blowers easily exceed 500 m in the city.

In the countryside, these distances can be much larger, as in the example below of Christie Conservation Area outside of Hamilton, where a minimum 750 m of forest was not enough to escape the constant noise of a blower.



Leaf blower noise constantly audible at over 750m from closest possible source

Who is most at risk of noise annoyance?

Working hours, stress, fatigue, personality, creativity, age, mental illness, and hearing impairment are some of the factors that impact noise sensitivity.

Shift workers, especially those in emergency services such as nurses, doctors, police, fire fighters and ambulance attendants keep long hours and need to sleep well in daytime for half of their working career. Nightshift workers are at higher risk of early death via increased risks of cancer, heart disease, and motor vehicle crashes. It only takes a minimal amount of noise, 30 dB, to disturb sleep. This has consequences for the quality of life and mental health of these workers, and indirectly to all of us who may one day require their clear-headed expertise.

People with more introspective personalities are noise sensitive, as are creative people such as artists, musicians and scientists who maintain a "chronic wide breadth of attention" as fuel for their creative interaction with their environment.

Children are more noise sensitive, as can be easily observed on any sidewalk with kids pointing at noises that adults actively ignore. Many mental illnesses such as anxiety and depression and especially post-traumatic stress disorder are triggered or aggravated by noise. People with autism are often extremely noise sensitive.

Hearing impairment might be assumed to offer protection against noise, but even in the early stages of disease, a process called recruitment unconsciously attempts to compensate for damaged hair cells. Sounds are amplified and distorted by the feedback neurons between the ear and brain. Background noise, especially in the voice frequencies, can seriously impair speech intelligibility even if the hearing loss in decibels is minimal. Efforts to address this difficult and common problem rings up the cost of tiny hearing aides into thousands of dollars, yet the result is usually inadequate.

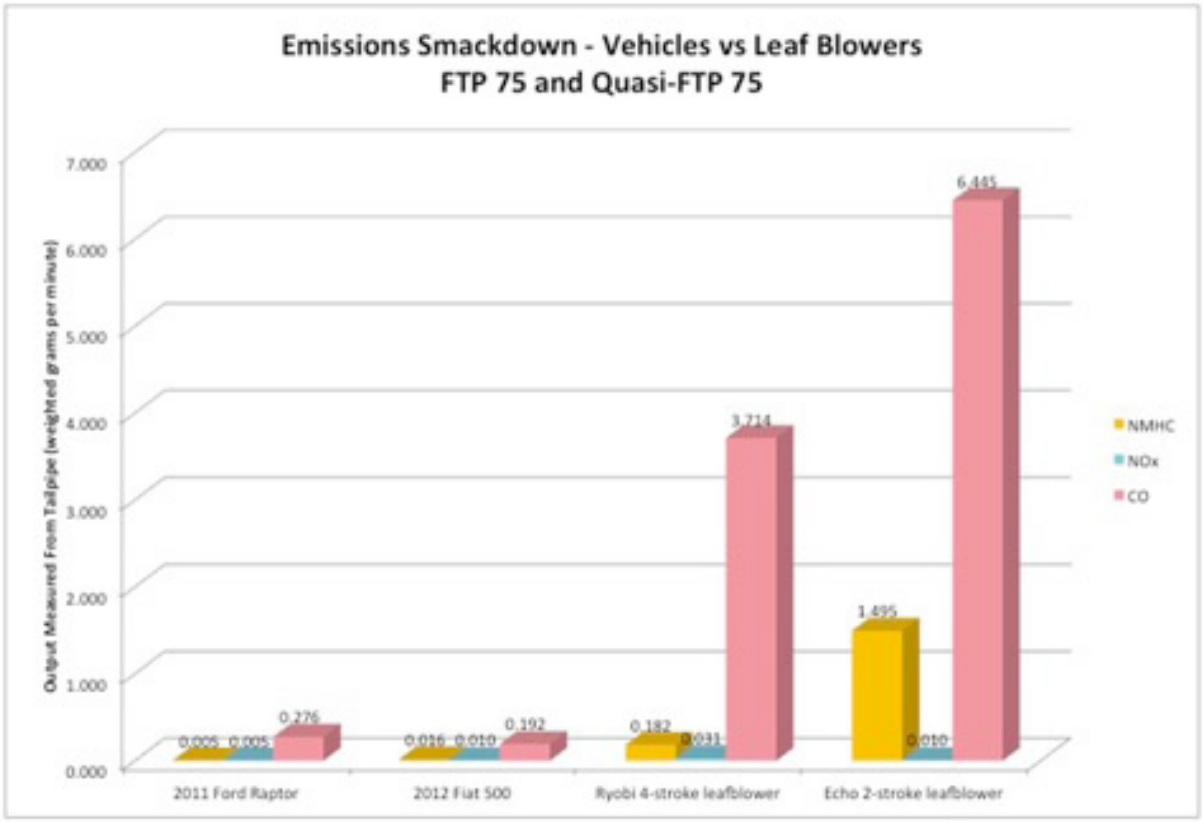
What are the emissions of leaf blowers?

Very little scientific study has gone into possible health effects of leaf blowers, but this should not be surprising. For example, EMS workers are almost surely at higher risk of suicide, but no studies have looked into that either. You can't study everything, and "absence of evidence is not evidence of absence". Also, following the money, there are powerful corporations that have a vested interest in not doing such studies.

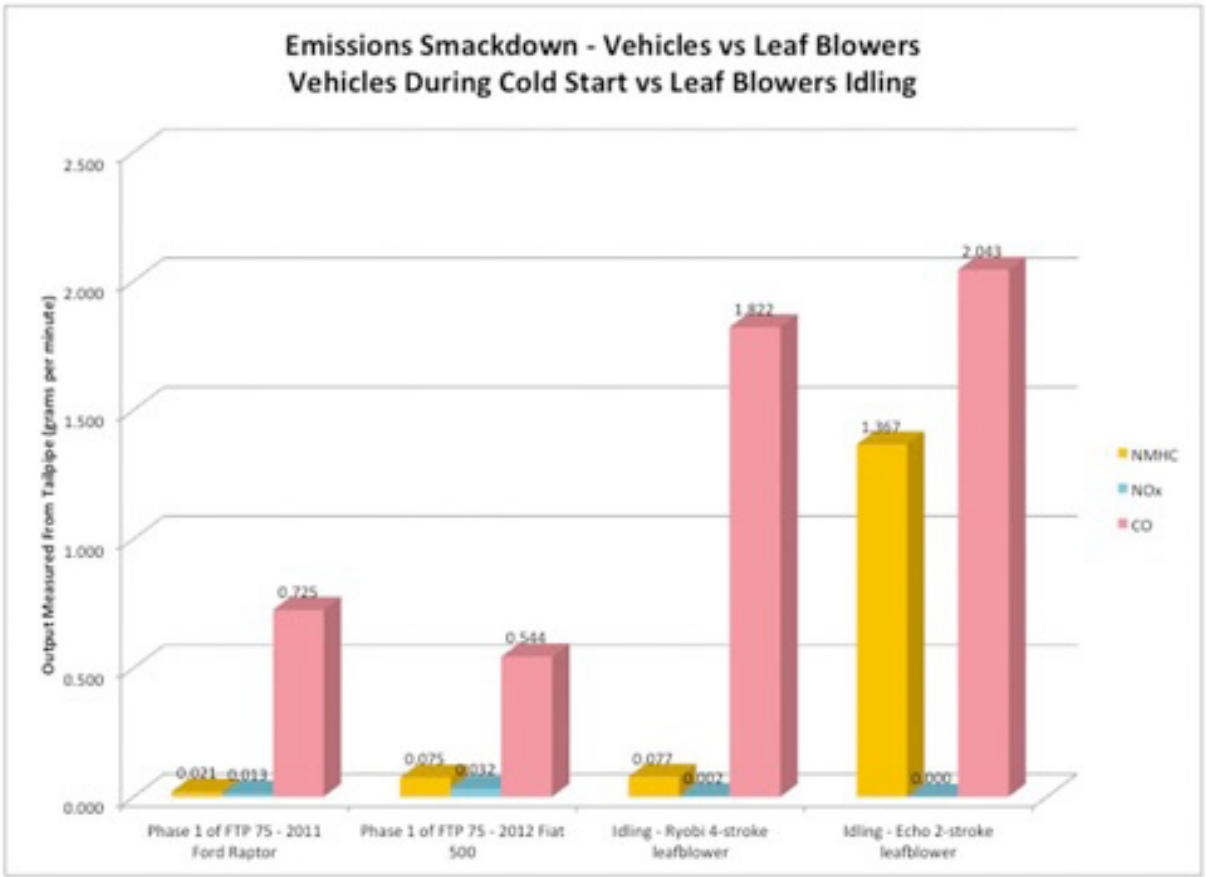
Lawns are not typically exposed to hurricane force winds like those generated by blowers. This liberates mold spores and pollen, animal fecal matter, and soil organisms that normally stay safely at ground level. Anyone concerned about their health should be concerned about this potential risk.

With respect to exhaust emissions, it becomes difficult to compare blowers with vehicles as the EPA limits for pollutants are upper limits in controlled tests and do not capture real world emissions.

There was a recent study that utilized high tech calibrated emissions equipment which is instructive. Edmunds, a well known automotive review company, conducted the test. They compared a large 6.2L truck, a small import car and two leaf blowers.



Typical-use emissions of hydrocarbons, nitrous oxides and carbon monoxide.



Worst case vehicle emissions versus best case leaf blower emissions

Here is the summary from Edmunds:

"The two-stroke leaf blower was worse still, generating 23 times the CO and nearly 300 times more NMHC than the crew cab pickup. Let's put that in perspective. To equal the hydrocarbon emissions of about a half-hour of yard work with this two-stroke leaf blower, you'd have to drive a Raptor for 3,887 miles, or the distance from Northern Texas to Anchorage, Alaska."

Note that the truck's engine is more than 200 times the displacement than the 30cc leaf blower, yet the absolute emissions from the blower still completely overwhelmed the truck's emissions.

(http://www.edmunds.com/car-reviews/features/emissions-test-car-vs-truck-vs-leaf-blower.html)

A word on blatant hypocrisy. Many cities have anti-idling, and anti-smoking bylaws. They typically have no unregulated off-road engine or residential wood smoke bylaws. This is unfortunate as the latter are sometimes orders of magni btude worse than the former, as evidenced by objective testing like this, or by simply trusting the lowly human nose. The absence of medical studies proving a negative association with health is not a rationale for inaction.

Do Leaf blowers save time and effort?

It depends. If you compare moving leaves to a pile on the lawn, a two stroke leaf blower can be a bit faster. Tests have shown that rakes are faster than electric blowers.

Rakes are easy to use by people of all ages and abilities, and a healthy way to keep fit and strengthen muscle. It can be done entirely at one's own pace, and primarily uses the large efficient muscles of the back. The effort level is that of a brisk walk, considerably easier than shovelling snow, using a reel lawn mower, or even a push broom. Done properly, with frequent switching of sides, it is unlikely to cause acute or overuse injury, certainly much less than activities with repeated bending, twisting, and lifting. My 90 year old neighbour with two artificial hips still rakes both his own and his daughter's yard.

A rake used in conjunction with a tarp hits the efficiency sweet spot where leaf blowers cannot compete. Rake the leaves onto a tarp, pull back the tarp a couple of meters and repeat until the tarp is sufficiently full. Then drag the tarp to a corner of the property and dump, composting the leaves behind some bushes. Minimal bending is involved and zero bagging. In this fashion, I spend less than half the time and effort of any of my neighbours, whether they use rakes or leaf blowers, and I puzzle over why anyone would do differently if they have a large property.

What is a reasonable course of action going forward? There are many possible ways to limit the negative effects of leaf blowers on health and quality of life in our cities.

Leaf blower manufacturers, whose representatives turned out in intimidating force in the front row at a recent meeting in Oakville, obviously take any discussion of limiting leaf blower use as a serious threat. They argue that it's not as bad as a few people think, and the economic consequences for them will be dire.

On the flip side, there are economic consequences to noise. I would suggest contacting real estate agents to come up with an estimate for how ambient noise reduces property values, as in the proximity to roads, highways, airports, and industry.

Contacting the home and yard renovation contractors could also come up with an estimate as to the lost investments in outdoor decks, pools, gazebos etc, in noisy areas where people are reluctant to build something expensive that will often be too unpleasant to use.

It is important to know that all things that matter to health and quality of life cannot be quantified in dollars. But if I must be forced to put a dollar amount on it, for me personally the number is $500,000. As in, I would move my family to a city where there were no leaf blowers if I could buy a similar house in a similar neighbourhood for that extra price differential. It wouldn't be worth it just for the noise reduction, but for what it represents: a city where neighbourliness and quality of life matters and is defended by the municipality.

If the annoyance/necessity metric is utilized, there really cannot be anything worse than a loud, penetrating, inescapable tonal sound that is generated for the sole purpose of moving around tiny bits of organic matter that can't even be seen from across the street, during a beautiful summer evening.