GREEN NOISE:
Measuring the Value of Agricultural Noise in the Urban Fringe

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Externalities, or spill-overs, in the agricultural sector are common, particularly in the urban fringe, and flow in both directions – from households to farms, and from farms to households (Ready, Berger, and Blomquist 1997). Non-farm residents of the fringe deal with the odours and noises of agriculture and put up with slow-moving farm traffic; on the other hand, they enjoy often-picturesque views of farmland and share environmental benefits such as flood protection and wildlife habitat. Farmers have to deal with trespassing, vandalism, and nuisance complaints from neighbours, but they also enjoy additional revenue opportunities provided by nearby cities, such as farmers' markets and customers for agri-tourism operations.

These urban fringe tensions exist in many locales in Canada and beyond, where urban development is encroaching on productive farmland. They are particularly apparent in the Lower Mainland and Fraser Valley of British Columbia, which contains some of Canada's most fertile farmland and includes one of its fastest-growing metropolitan areas (Stobbe 2008). It is also Canada's chief blueberry-growing region and is second only to Michigan worldwide in production of this berry.

Agricultural sources of noise vary by crop and method of production, but few are as contentious in southern British Columbia as the sounds of propane cannons used by blueberry farmers. These propane cannons are used to scare away starlings and other small birds in an effort to prevent them from eating berries (BCMAFF 2002). Propane cannon noise is highly influenced by topography and weather but, under the right conditions, can travel for several kilometres. The propane cannon season has been lengthening as new strains of blueberries have been developed. The harvest season has now stretched to include early harvest berries (ready in June) and later varieties (ready in September). In addition to the lengthened season, more land is being converted to blueberries while other parcels of farmland have been transformed into urban uses. These

Figure 1. A triple-shot propane cannon. Photo courtesy of the BC Ministry of Agriculture.

factors have produced an increase in the number of noise complaints (BC FIRB 2012).

Both local and provincial policy-makers have been embroiled in the controversy surrounding propane cannons. Local governments have been asked to restrict their use through bylaws, and the provincial government is required to mediate disputes and complaints about them, even as it supports the farming and berry-growing sector. In this context, information about public feelings towards propane cannons (are they despised by all or just a vocal minority?) and some measure of the value people place on noise abatement are essential to sound policy-making and the functioning of civil society.

The nuisance value of noise, or the amenity value of quiet, are what economists refer to as non-market-traded (or non-market) goods. These are notoriously difficult to value because they are not traded and thus have no readily observable price. To help quantify a value for non-market goods, economists have employed the concept of contingent valuation (CV) to estimate people's willingness to pay (WTP) for them. Contingent valuation studies of environmental matters include assessments of the value attached to saving endangered species such as the spotted owl and the dis-amenity costs associated with oil spills (McCollum 2003). A few CV studies have examined noise from roadways, airports, or

railways, but this study is novel in that it employs CV techniques to quantify the value of quiet in an agricultural landscape in which the noise is seasonal and in which strong tensions exist between farmers and some homeowners.

THE ECONOMICS OF NOISE

Noise, a pervasive element of urban landscapes, has been studied a great deal, especially in relation to transportation hubs and corridors (Navrud 2002). These studies are usually policy-focused and seek to discover what compensation is required for nearby residents whose property values and life satisfaction are affected by noise, the point being to return them to their previous levels of overall utility.

Noise is most often measured by average exposure over a given period, although detectability and high threshold assessments are also used. In the detectability approach, annoyance is binary and the mere presence of noise causes discomfort regardless of its volume. In the high-threshold approach, peak events determine annoyance, not cumulative exposure (Feitelson, Hurd, and Mudge 1996). For this study, the high-threshold model is the most useful as propane cannons produce a high-volume, relatively low-frequency sound,[1] similar to airplane noise – which is considered the most offensive of all the common transportation noises (Navrud 2002).

Economists generally model noise on the logarithmic scale because this is how the human ear interprets increases in noise (Nelson 2004). This means that every ten decibel (dB) increase in noise amounts to a doubling of noise perception. Sounds under forty-five dB are considered unobtrusive, while sounds at fifty dB and above impede outdoor conversations. Sounds above sixty-five dB impede indoor conversations as well as tasks that involve an auditory component, such as watching television or reading a book, or tasks that require intellectual involvement, such as editing a paper. Sounds above eighty dB cause hearing loss when exposure is prolonged, and even brief exposure to sounds above one hundred dB can cause moderate short-term hearing loss and tinnitus (Makinen, May, and Tiitinen 2004; Mariga 2005; Hirano et al. 2006; Hensel et al. 2007).

[1] According to provincial regulations in 2009, farmers could only use cannons between 6:30 AM and 8:30 PM, with a break between noon and 3:00 PM, and fire them no more than eleven times per hour. Farmers also need to ensure that cannons are at least two hundred metres from any neighbouring residence.

Perceptions of noise differ. Noise that interrupts sleep is considered the most obnoxious, and noise measurement scales typically weight or "punish" nighttime noise. The Noise Exposure Forecast (NEF) weighs nighttime noise 16.67 times more heavily than daytime noise (Gillen 2003), and the Day Night Sound Level (DNL) gives a ten dB penalty for nighttime noise events (Nelson 2004). Constant noise tends to elicit less annoyance than intermittent noise of the same magnitude. And noise is generally less distressing to hearers when they feel that they have some control over their exposure to it (Jonsson 1964; Blechman and Dannemiller 1976; Smith and Stansfeld 1986; Staples, Cornelius, and Gibbs 1999; Saremi et al. 2008).

Because some people are more sensitive to noise than others, it is difficult to establish permissible levels of noise. Although most people are not disturbed by fifty to sixty dB outdoors, it is widely agreed that roughly 10 percent of the population will find this dB level highly disturbing (Vallet and Mouret 1984; Staples, Cornelius, and Gibbs 1999). Most noise studies in the psychology and physiology literature indicate that differences in exposure to noise account for only about one-fifth of the variation in annoyance. In other words, 80 percent of the variation in the annoyance people attribute to noise is accounted for by personal sensitivity, exposure to noise in multiple venues such as home and work, and a more critical or analytical perception of one's personal environment (Smith and Stansfeld 1986). Simply put, much of the annoyance people experience is dependent on their own characteristics rather than on the variations in the absolute level of noise. Because of this sensitivity difference, the economics of noise is not straightforward. According to van Praag and Baarsma (2005), "imperturbable" individuals are likely to place a lower value on quiet than are "perturbable" individuals. This might lead "imperturbable" people to draw benefit from the lower housing costs generally found in high-noise locations. So surveying individuals near long-term noisy locations may not give an accurate perception of how noise affects the broader population.

HEDONIC PRICING MODELS OF NOISE

Hedonic pricing is the most widely used technique for valuing noise in dollar terms. Typically, such studies place a value on the amenity or dis-amenity of a location by considering its effect on the housing market. Using statistical regression models, hedonic pricing studies can parse out the effect of any aspect of the housing market, such as the increased value from having an additional bedroom, the premium people pay for a

view, or the discount they demand for living near a noise source like an airport. Most attempts to price noise develop an NDI (Noise Depreciation Index) – a measure of the percentage rate of depreciation in housing price per rising dB of noise. But NDIs vary widely, depending on the country and circumstances under consideration. Van Praag and Baarsma (2005), who examine housing around the Amsterdam airport, found an NDI of approximately 0.6 percent. Navrud's (2002) extensive survey of the hedonic pricing literature includes studies that place the NDI between 0.29 to 0.64 percent for road noise and 0.25 to 2.3 percent for aircraft noise. In a meta-analysis, Nelson (2004) finds that NDI worldwide is 0.58 percent (with a 95 percent confidence interval from 0.5 to 0.64 percent) but finds Canada's NDI to be higher, at 0.8 to 0.9 percent.

There are many reasons to be cautious about the values produced by hedonic pricing models. They measure housing prices alone – not the loss in utility endured by those residents who remain in situ (Feitelson et al. 1996). House-price data assume a perfect market with little to no switching costs for residents, implying that there should be no relationship between noise and happiness (van Praag and Baarsma 2005). However, many housing markets face significant switching costs in the form of property transfer taxation or loss of a rent-controlled dwelling. As Bockstael and McConnell (1999) put it: "Individuals will not change their behaviour if they cannot adjust at the margin and if their next best alternative generates less utility than their current choice, even with environmental degradation … the individual may, instead[,] suffer in (behavioural) silence." The prices used in hedonic valuation studies are also potentially influenced by modelling choices, estimation procedures, and functional form (Palmquist 1991; Navrud 2002). Other confounding factors include imperfect information about noise levels at the time of property purchase and whether marginal changes in noise can be perceived. Finally, many sources of noise are also causes of utility. For instance, Nelson (2004) notes that airports provide access to travel and employment. Similarly, in my study, agricultural noises cause annoyance, but being close to farmland provides the nearby residents with positive externalities in the form of views as well as fresh fruit.

CONTINGENT VALUATION

Contingent valuation has a long history in valuing non-market goods – an important task when it is crucial to quantify how much society appreciates them. Consider endangered species as a case in point. Most people favour policies to protect endangered species, but that knowledge

is of limited help to policy-makers who have to decide the level of protection. CV can help policy-makers decide, for example, whether there is public support for a $10 million program to restore a tract of habitat, or whether $1 million would be a more appropriate investment.

CV essentially asks those concerned how much they value a good, using dollar terms. Because people are not used to thinking this way, surveys are usually phrased in terms of how much additional tax they would be prepared to pay for the good. This is what is known in economics as a stated preference technique.

Over the last sixty years, refinements in CV methodology have addressed earlier weaknesses. Innovations in survey design and data analysis have produced a rich and deep literature (Smith 2004). Several studies have compared results from CV surveys and hedonic pricing models for the same good. These have generally shown that CV results are consistent with market-based price models (such as hedonic pricing models) to within ±50 percent (Soguel 1996; Ready, Berger, and Blomquist 1997).

The most common complaint against CV, especially in policy contexts, is the possibility of bias in the data. Because it is a stated preference method, it is usually not (or cannot be) corroborated by market transactions. Two main types of bias exist: hypothetical bias and strategic bias. Hypothetical bias usually results from respondents being unable to formulate a correct value for the good. Quantifying compensation for a loss is an unfamiliar task for most people, although they usually have extensive experience in making purchasing decisions. To combat this, respondents should be asked about their WTP for something rather than how much they would require to be compensated for its loss (Feitelson, Hurd, and Mudge 1996). Kahneman and Tversky's (1979) seminal work on risk and losses shows that people tend to place higher values on losses than they do on gains. To ask about compensation for a loss generally results in unreliably high figures due to this loss aversion effect.[2]

Strategic bias occurs because interviewees are rarely required to pay the amount they identify as the value they attach to something, so they have incentive to overstate their valuation. Free-riding behaviour is also a concern because individuals may understate the value they would be willing to pay, expecting to take advantage of the higher voluntary contributions of others (Soguel 1996). However, several researchers argue that strategic bias is not a problem, particularly with unannounced phone

[2] For readers wanting to learn more about WTP and other concepts in economic valuation, see Boyle (2003).

or interview surveys (as I conducted for this study), because people do not have time to strategize (Cummings, Brookshire, and Schultze 1986; Feitelson, Hurd, and Mudge 1996).

All of the noise-focused CV studies considered transportation noise – mostly airports and roadways. Feitelson et al. (1996) found significant effects from airport noise on both Norwegian homeowners' and renters' WTP for their dwellings, regardless of tenure, age, or income. As noise increased from fifty-five dB to seventy dB, owners wanted to pay between 2.4 to 4.1 percent less for their home and renters to pay between 1.8 and 3 percent less. Navrud (2002) reported a mean WTP per household per year of 115 Norwegian Krone (NOK) (1996 values), or $26.21 in 2011 Canadian dollars (CAD), for reducing road noise.[3] However, the sample divided into two groups: those highly annoyed and those expressing little-to-no annoyance. Their respective WTP was 335 and 101 Norwegian Krone (NOK) (1996), or $76.34 and $23.02 in 2011 CAD. Soguel (1996) found a monthly mean WTP of fifty-six Swiss francs, or $64.05 in 2011 CAD, for reducing road noise. His results identify several factors that had a significant positive effect on value: if there was a child in the household, if the respondent was male, if the respondent was especially sensitive to noise, and if the respondent belonged to an above average social stratum (proxied by education level).

Prior to collecting data for this study, I hypothesized that WTP would be highly variable – possibly split into two broad groups such as in Navrud's (2002) work – but would be less than has been observed in other rich countries for roadway or airport noise. This is because the agricultural noise examined here is seasonal and only occurs during the day.

STUDY LOCATION AND SURVEY METHODOLOGY

Data were collected between July and September of 2009 in the municipalities of Abbotsford, Chilliwack, and Mission in the Fraser Valley, approximately seventy kilometres outside of Vancouver, British Columbia. (Near Mission, two agricultural subareas, Hatzic and Nicomen, were the focus.) This region contains some of Canada's most fertile agricultural land but also faces a high degree of urban encroachment onto farmland. Development near farmland not only takes that land out of production

[3] Values are converted to 2011 units via the Norges Bank price calculator found at http://www.norges-bank.no/en/price-stability/inflation/price-calculator/ and the CIA World Factbook. Switzerland inflation data at http://www.indexmundi.com/switzerland/inflation_rate_(consumer_prices).html, and then converted to Canadian dollars with a conversion calculator found at http://www.xe.com/.

but also brings an increase in the rate of nuisance complaints about farm practices that generate sounds, smells, and dust. Since many ex-urbanites have moved to the Fraser Valley from Vancouver in search of lower housing costs, it is widely believed that it is the "city slickers" who are raising a fuss and causing issues for the farmers.

My study rests upon a sample of all households in the Fraser Valley Regional District (FVRD) that are located within nine hundred metres of a known noise-producing blueberry field,[4] some twenty-six hundred households in total.[5] A random sample of these households was drawn through several steps. First, twenty-two noise-producing blueberry farms were selected randomly using a GIS mapping program. The choice of twenty-two farms was pragmatic, given the budget for the study and the time resources available. They were drawn from the Abbotsford, Chilliwack, Hatzic, and Nicomen areas in rough proportion to the populations of the surrounding municipalities. Thus, Abbotsford, being the largest, had the highest number of farms selected (fifteen); Chilliwack had three farms selected; and Nicomen and Hatzic each had two farms selected. Next, households near these farms were selected randomly using a random number generator in a spreadsheet program. As the aim was to select approximately 10 percent of the surrounding households, the number of households selected for each farm depended on the population density in the area. Farms near high-density neighbourhoods had more households selected, while farms with low surrounding density had fewer households selected. Between four and twenty-four households were randomly selected for each farm, giving a total of 225 households for this study.[6]

Researchers administered the survey in person.[7] If no one was home at the first visit, at least one, though usually two, follow-up visits were

[4] According to the regulations in 2009, the minimum distance between a propane cannon and the nearest neighbour's residence is two hundred metres. The distance of nine hundred metres was selected on the recommendation of the BC Ministry of Agriculture and Lands.

[5] It should be noted that the researchers had no information about the actual position of the house on the property or of the cannons (which are mobile). Thus, a property was included as part of the population if its nearest edge was within nine hundred metres of the edge of a blueberry farm that uses propane cannons. The house may have been significantly farther from the cannons if the properties were large.

[6] Additional households that volunteered to be part of the study were politely declined so as to avoid selection bias in the data. This happened with some frequency as neighbours seemed to be very aware of visitors to a neighbouring property, and some were keen to participate in the study, presumably because they felt strongly about the use of propane cannons.

[7] The survey was pretested to ensure plausible values were elicited. This pretesting took place in the Township of Langley, the municipality adjacent to Abbotsford, which also has a high proportion of land in agricultural uses, including growing blueberries, and where the farmers also use propane cannons.

made. If no one was home on subsequent visits, a sheet was left that explained the project and invited the household to contact researchers to arrange a suitable time for another visit. Occasionally, when a researcher was unable to approach a house due to the presence of aggressive dogs or a locked gate, a sheet inviting participation was mailed to the household. In addition, researchers were trained to administer the survey in a neutral and consistent way in order to minimize interviewer bias.

The contingent valuation questions were preceded by several questions that asked the respondents to think about and compare different noises they might customarily hear in their neighbourhood. Such noises include lawn mowers, dogs barking, trains, and wildlife sounds (birds, frogs, etc.). The CV question that followed was open-ended, merely asking respondents to state the amount of money they would be willing to pay to halt all propane cannon noise. By way of explanation, respondents were told that a (hypothetical) policy that completely banned propane cannons was proposed and that, in order to fund it, citizens were required to pay an annual fee (which would be added to their property taxes). The question asked was: "What is the highest dollar value you would be willing to pay annually to fund the policy?" Besides the CV and noise comparison questions, the survey also asked about demographics (such as age and education level) and lifestyle (such as hours spent at home each day and length of residence at that address).

DATA AND DESCRIPTIVE STATISTICS

The response rate for the survey was good. Of the 225 households selected, 60 percent completed the survey, 29.8 percent were not at home (and did not respond to the letter left inviting them to contact the researchers), and 10.2 percent refused to participate. Of the 135 surveys that were completed, 52.6 percent of the respondents were male and 47.4 percent were female. Most were homeowners (89.6 percent), but fourteen people (10.4 percent) identified themselves as renters. The average age of respondents was 50.7 years old. The average number of years that respondents have lived at the address was 14.85 years (with a median of eleven years due to significant skewing in the distribution). The number of people living in each household ranged from one to eight; the average household size was 3.17 members.

Education levels in the sample were slightly higher than those in the population as a whole, with 61.94 percent of respondents having been educated beyond high school. Statistics Canada census data reveal that 60 percent of the BC population aged twenty-five to seventy-four

attained this level, but in 2005 only 51 percent in Abbotsford had done so (Statistics Canada 2006).

Respondents reported an average of 17.73 hours per day at home, both inside and outside. Since forty-one of the properties have (self-reported) farm-class status and many are commercial farms, this number is likely influenced by the presence of farmers in the sample (who leave the property for fewer hours per day than commuters). From GIS mapping we know that 60 percent of the completed surveys came from residences that are located within the Agricultural Land Reserve (ALR) and 40 percent were from non-ALR land.[8] The ALR-status of a property is a proxy for whether that property could be classified as "rural" or "suburban." Thus, the sample is quite balanced in sampling both of these types of properties.

In all, 106 respondents (78.52 percent) said they hear cannons firing during cannon season, but only fifty-five respondents (40.74 percent) said "yes" to the question: "In general, do the sounds of propane cannons bother you?" In other words, only half (48.11 percent) of those who actually hear cannons are bothered by them.

Further questioning focused on what types of activities are being performed when cannons are heard. Slightly more than one-third (36 percent) hear them when sleeping, 56 percent hear them when working indoors for income or doing chores, 95 percent hear them when working outdoors (farming, gardening, or chores), 53 percent hear them when relaxing indoors, and 56 percent hear them when hosting social functions. Focusing on those who reported hearing cannons, questions were asked regarding their feelings about cannons during the different activities. As Figure 2 shows, feelings about hearing cannons are much weaker when people are working (indoors or outdoors) and are stronger when people are relaxing or hosting social functions. Feelings are most strongly negative when people are sleeping.

ANALYTICAL RESULTS

The contingent valuation question appeared to be understood well by participants and generated thoughtful, though varied, responses. Only seventeen responses were classified as protest votes, and their data were excluded from this analysis (Boyle 2003).[9] The average WTP for quiet was

[8] The ALR is a zoning system that prohibits subdivision, development, and non-agricultural uses on farmland. For more information on the ALR, see Stobbe et al. (2011).

[9] Protest votes were generally identified by the interviewers at the time of surveying through comments made by the participants. For instance, one man (who became agitated when

FIGURE 2

Opinions on hearing cannons during various activities

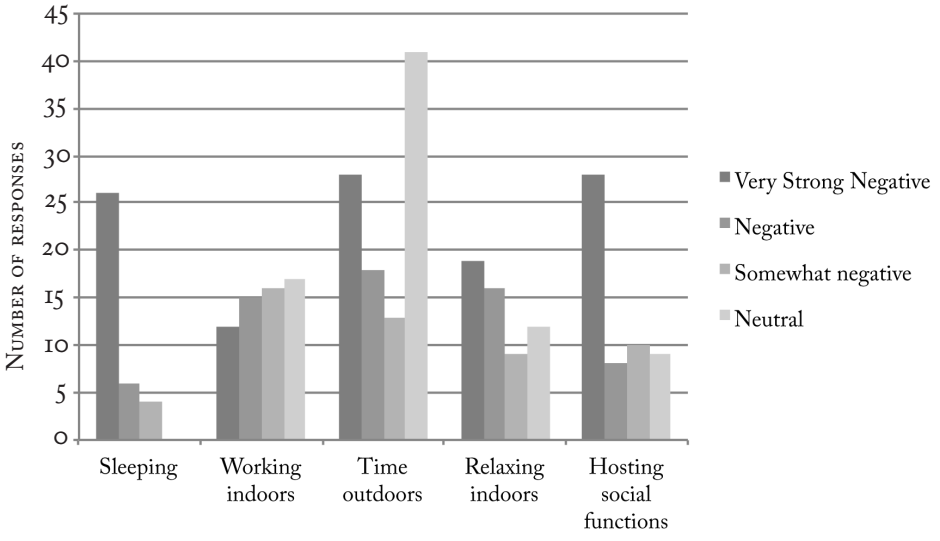
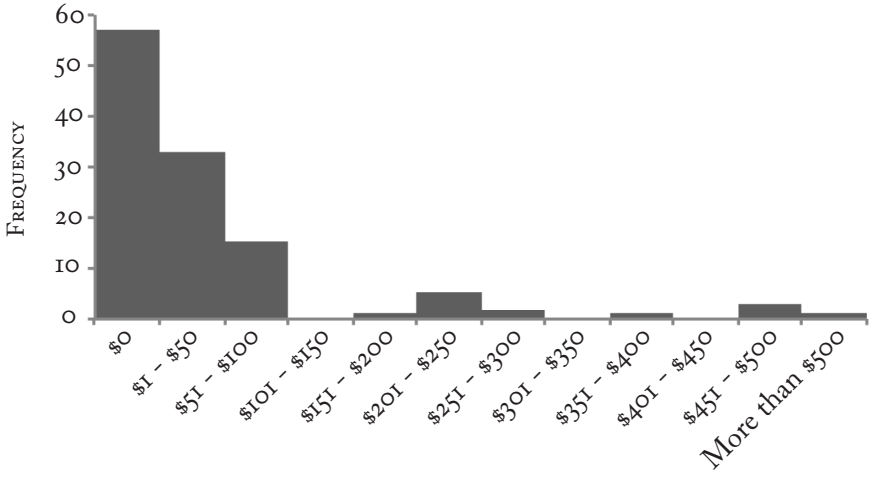


FIGURE 3

Histogram of WTP to halt all cannon noise



$70.97, but the distribution was quite skewed (see Figure 3), with fifty-seven of the 118 responses being zero dollars. This resulted in a median WTP of just five dollars. The zero responses are used as they represent true valuations of the good being considered (Feitelson et al. 1996). (See below for more discussion of the outliers in the WTP variable.)

In order to aggregate the results up to the population level, one must decide what the relevant population should be. If you count all households in the FVRD within nine hundred metres of a *noise-producing* blueberry field, the exact population size is 2,613 households and the total WTP is $185,445 (with a 95 percent confidence interval of $86,671 to $284,242). If the population is considered to be all households within nine hundred metres of *any* blueberry field, the population size would be 8,207, giving an aggregate annual WTP of $582,451 (with a 95 percent confidence interval of $272,219 to $892,758). Since there is no difference (statistically) in the WTP of people who hear cannons and those who do not (p-value of 0.17), the latter population should perhaps be used by policy-makers.[10] One explanation for this lack of difference in valuation may be that the group that does not hear cannons is concerned it will do so in the future if cannon use expands.

DIFFERENCE TESTS

Gender does not seem to affect WTP as men and women assigned similar values on average (p-value of 0.523). Respondents who had complained about the cannons expressed a significantly higher WTP for quiet ($345 for complainers versus $45.51 for non-complainers; p-value

discussing propane cannons) claimed he would pay $1 million per year. Several others were indignant at the idea of paying higher taxes and claimed that their WTP was zero, but they did express strong preference for quiet and willingness to pay in other ways (such as through higher berry prices). The current approach of using voluntary comments to identify which responses should be considered protest votes and which reflect true valuations for the good is similar to Hoevenagel and van der Linden (1993) and Milon (1989). Lindsey (1994) categorizes a high proportion of his sample as protest responses (42 percent), while Desvousges et al. (1993), who argue for very conservative criteria for defining what constitutes a protest vote, found 8 percent and 12 percent, respectively, in two of their CV studies. This is in line with the current study's finding of 12.6 percent being protest votes. For more on this issue, see Boyle (2003) or Jorgensen et al. (1999).

[10] The average WTP of people who reported hearing cannons is eighty dollars, whereas the average WTP of people who reported not hearing cannons is $35.63. This difference, though, is not statistically significant (p-value of 0.17) – which means we are not convinced that it is a true difference between these groups and that it did not just happen by chance. We would never expect two randomly selected groups to have the exact same WTP; for us to conclude the groups actually have different preferences, the gap between them needs to be sufficiently large.

of 0.0719).[11] Just over 30 percent of the sample had (self-reported) farm class status but collectively showed no statistically significant difference in WTP (p-value of 0.9094). Tests for location show that the WTP for respondents in Abbotsford ($83.33) is significantly higher than the WTP for respondents in Chilliwack ($18.75) (p-value of 0.078). One possible explanation for this result is a simple income effect – in 2005, median household income before taxes was $54,535 in Abbotsford and $49,342 in Chilliwack (Statistics Canada 2006). However, it seems unlikely that all the difference is attributable to an income effect, and so this question is left to future research.

REGRESSION MODELS

OLS regression models calculated using STATA 10 show that being bothered by cannons and having made a complaint about cannons were significant or marginally significant factors in explaining WTP (see Table 1). Those who say they are bothered by cannons are willing to pay $56.18 more than those not bothered, controlling for all other factors. Those who have made a complaint are willing to pay $256.89 more than those who have not complained, controlling for all other factors. Working full time for income is, predictably, not only significant but also a large value ($104.28 more than other categories). One variable that does not appear in this model to explain WTP is distance to the closest noise-making berry farm; it was found to be insignificant. There may be two reasons for this. Either people's sensitivity to noise is not affected by how close they are to the noise source (within a one-kilometre range, roughly) or else the topography of the different farm landscapes means that volume (and presumably annoyance) is not related to distance in a simple way.

Because being bothered by cannons seems to be important, the data were separated into two groups: those bothered by cannons and those not bothered by cannons (see Table 2). Among those not bothered, several variables proved to be insignificant and were eliminated.[12] This model

[11] In total, there were eleven complaining households included in the sample of 135 (8.1 percent). In terms of spatial location, Abbotsford had six complaints (6.4 percent), Chilliwack had one (5.3 percent), and Mission had four (18.2 percent). Although Mission's rate appears to be higher, because of the smaller sample size from Mission (at just twenty-two households), this was not a statistically significantly higher rate than was found in other areas (p-value of 0.1685). Complaining households were located at 529.3 metres from the nearest blueberry field on average, which is not significantly different from non-complaining households at 461.5 metres (p-value of 0.4300). Farm class status was not significantly related to complaining (p-value of 0.2563). As noted in the literature review, sensitivity to noise seems to be a highly personal attribute and not related to the other variables included in this study.

[12] One interesting and perhaps surprising result is that WTP is significantly affected ($245.03) by having made a complaint, even for those who say they are not bothered by cannons. This

TABLE 1

Linear Regression mModel (WTP [$] as dependent variable); n = 118

Variable	Coefficient	P-value
Bothered by cannons	56.1800	0.136
Made a complaint	256.8945	0.000
Living in Abbotsford	63.9271	0.101
Years at address	2.8134	0.030
Hours at home	8.4585	0.074
Work full time for income	104.2769	0.014
Constant term	-267.8984	0.009
Adjusted R^2	0.2347	0.000

TABLE 2

Segmented Regression Models (WTP [$] as dependent variable)

	Bothered by cannons (n = 44)		Not bothered by cannons (n = 74)	
Variable	Coefficient	P-value	Coefficient	P-value
Made a complaint	263.253	0.020	245.0297	0.001
Living in Abbotsford	174.1781	0.119	30.2873	0.103
Years at address	5.8190	0.043	0.9474	0.166
Hours at home	16.8658	0.098	-	
Work full time for income	226.2329	0.023	-	
Constant term	-567.9691	0.098	-12.0831	0.519
Adjusted R^2	0.2210		0.1312	
Mean WTP	$147.95		$25.20	

reinforces the previous model (in Table 1), which indicates that higher WTP is observed in people – particularly those bothered by cannons – who live in Abbotsford, work full time for income, have lived at the address longer, and spend more time at home than those in other groups.

result, though curious, should be used with caution as the sample size is extremely small. Only one complaint came from a household whose members claimed that cannons did not bother them.

Of the 118 responses, thirteen identified a WTP in excess of $100 (see Figure 3). The average age of these "outliers" was 57.2 years (compared to 50.7 years for all respondents), they had lived at that address for an average of 21.4 years (compared to 14.85 years), their average distance to the noise-making farm was 390 metres (compared to 509 metres), and 62 percent were female (compared to 47 percent overall). Thus, a high WTP seems to be correlated with an older group that has lived at the address for a long time and lives relatively closer to the noise-making farm.

CHI-SQUARE TESTS

A series of chi-square tests sought to identify whether each respondent's attitude towards banning cannons is related to other factors. There is a statistically significant relationship between living in the ALR and attitude towards banning (p-value of 0.0592). Households in the ALR are significantly more likely to oppose banning.

Similarly, we can analyze whether people who hear cannons are more likely to want them banned compared to those who do not hear cannons. The result shows insufficient evidence to say that opinions differ significantly based on whether one hears them or not (p-value of 0.2702). Usually significant results are of interest, but in this case, the insignificant result is illuminating. One might think that people who hear cannons would be more disposed to wanting them banned, but we cannot conclude that based on these data. People's opinions on whether cannons should be banned or not may be based on other factors, such as their ideological views on farming and government.

Since several respondents claimed that being awoken by cannons was particularly distressing, the data were analyzed to assess whether hearing cannons increased the inclination to ban them, and this was found to be the case (p-value of 0.0091). Yet, a t-test on the WTP of people who hear and do not hear cannons while sleeping reveals that there is no significant difference in WTP between the two groups (p-value of 0.1899).

CONCLUSION

This study documents another example of conflict and tension in the urban-rural fringe that is created by the proximity of agricultural operations to residential housing. The externality studied here – noise from propane cannons – has been a very noticeable issue in the community. Similar to other studies on noise externalities, the data reveal a very diverse group, with some people placing high values (into the

thousands of dollars) on quiet and half valuing it at zero. The average value, $70.97, would translate into either (depending on which definition of the population is used) $185,445 or $582,451 of annual benefit to society if the cannons were banned. However, without doing a cost analysis of what the farmers' losses might be, it is impossible to say whether this policy would pass a cost-benefit-analysis test.

The results of this study are broadly consistent with other research conducted on the value of noise. Navrud (2002) found an annual WTP for road noise of $26.21 (2011 CAD) but also observed significant subgroups, and Soguel (1996) found a monthly mean WTP of $64.05 (2011 CAD). Given that noise level comparisons are not possible between these studies and this one, it is reasonable to postulate that the CV values on noise found in this study are within the range of others' work on the topic.

One perennial concern of CV results is the possibility of bias. By using WTP measures and by using a familiar payment vehicle, I have attempted to minimize hypothetical bias. Strategic bias is possible, however, especially since some members of this community have not accepted cannons as a part of their auditory backdrop in the same way as they have accepted trains, air traffic, or highway traffic. The fact that the survey was being conducted tells people that this noise may not be permanent, and thus their incentive is to over-state their displeasure or their WTP to try to eliminate it. Most people said that the other noise they experience does not bother them or that "you get used to it." This may be because they know the chance of changing the noise level from trains, planes, or automobiles is remote, whereas they perceive that it may be possible to eliminate cannon noise. The point of this discussion is that it would seem reasonable to view the values stated in this survey as an upper bound, particularly since it was conducted at the height of cannon season, when emotions about cannons are at their peak.

The challenge for policy-makers in this context is to navigate a path between those who feel entitled to quiet and the value of the noise to the economy. The study location is an agricultural region, and 97 percent of households reported on the survey that they knew commercial agricultural operations can produce noise, dust, and odour as part of their ongoing operations when they moved into their current house. This fact, however, does not change the acrimony that is generated between neighbours over this issue and the imperative to mitigate impacts as much as possible.

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