The Impact of Visual Air Quality on Tourism Revenues in Greater Vancouver and the Lower Fraser Valley

by

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Abstract

The objective of this study is to estimate the impact of poor visibility episodes on tourist revenue in Greater Vancouver and the Lower Fraser Valley. This work involved three general stages: (1) an interactive survey with a sample group of tourists to solicit responses to changes in visibility, (2) statistical analysis of the results to develop visibility response functions, and (3) construction of a simple economic model based on the visibility response functions to predict losses in tourist revenue from selected poor visibility episodes.

During the summer of 1999, a sample group of tourists, recruited at various locations in Vancouver, viewed photographic slides from four camera locations in the Fraser Valley and Vancouver area depicting various stages of visibility degradation. The respondents rated each slide as acceptable or unacceptable based on a personal visibility standard, with unacceptable visibility defined as a level of impairment that would deter individuals from making a return visit or from recommending the area as a tourist destination to others. Statistical analysis then was used to estimate the unacceptability or violation rates for the four camera locations as a function of visibility (represented by the BSP light scattering index), cloud cover and socio-economic variables. The analysis showed that BSP had a major effect on the violation rate compared to the other explanatory variables. Cloud cover proved to be consistently significant in the estimated equations, although with much less impact than BSP. In general, the effects of socio-economic variables were small or inconsistent, although the results show some evidence that visitors from Japan and Asia are slightly more critical of poor visibility than the group average in some locations.

A simple economic model, incorporating the estimated relationships, was then developed to predict losses in future tourist revenues from poor visibility episodes. The model predicts these losses for a range of selected poor visibility scenarios, but does not predict the average annual losses since insufficient data are available to develop a frequency distribution of poor visibility episodes. For a single extreme visibility event the model predicts future tourist revenue losses of $7.45 million in the Greater Vancouver area and $1.32 million in the Fraser Valley.

The study recommends further research to obtain data on the frequency of visibility episodes, more camera locations to give a wider variety of viewpoints for assessment, and improvements to the economic model particularly to account for the effects of visibility on the long run tourist reputation of the area.

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Chapter One
Introduction

The Greater Vancouver area of British Columbia has experienced significant growth in recent years and now encompasses a population of about two million people. Given the high environmental standards of residents and the economic importance of Vancouver's international reputation as a tourist destination, the effect of this growth on air quality is a major concern. Mitigating the effects of population increases while meeting new and more stringent national and provincial ambient standards for ozone and particulates adds to the challenge of air quality management. At the same time, regional air quality agencies are searching for ways to reduce greenhouse gas emissions to help meet national reduction commitments under the Kyoto protocol. The joint challenges of maintaining the new ambient air quality standards and obtaining meaningful reductions in greenhouse gas emissions will require significant public and private investments.

The overall strategy and methods for maintaining air quality to acceptable limits is contained in a continuing and evolving series of 5 year air quality management plans published by the Greater Vancouver Regional District (GVRD). These plans incorporate both British Columbia and Federal Regulations as well as specific local measures to control air pollution. Adjustments to the plans will be necessary to conform to the new national (called Canada Wide Standards or CWS) and or provincial ambient standards for particulate and ozone levels. The target implementation date for the CWS fine particulates level ($PM_{2.5}$) is 2010 and 2015 for ozone.

Implementation of the GVRD's 1990 -2000 Air Quality Management Plan, which was approved in 1994, represents major public and private investments in the order of billions of dollars. Previous economic analysis of the plan showed that the projected benefits significantly exceeded these costs.[1] The economic analysis to date, both on a regional and national scale, has been driven primarily by human health effects of fine particulates, with little attention given to the values arising from improved visibility. Economic analysis of the benefits of visual air quality will allow for a more complete economic assessment of air quality improvements in the region, particularly with respect to new ambient standards that will add to the cost of future air quality management plans.

From 1993 to 1995, the provincial government and the Fraser-Cheam Regional District commissioned two broad programs of study, REVEAL and REVEAL II to help understand the causes of poor visibility and to establish a visibility standard for the Lower Fraser Valley.[2] This region, immediately adjacent to the heavily populated areas of

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[1] Bovar-Concorde Environmental and the ARA Consulting Group, "Economic Analysis of Air Quality Improvement in the Lower Fraser Valley", prepared for Province of British Columbia, Ministry of Environment, Lands and Parks, 1995

[2] See, S.C. Pryor, K. Stephens and D. Steyn, "Visibility Perception in the Lower Fraser Valley", Air Resources Branch, British Columbia Ministry of Environment Lands and Parks, Victoria, B.C., 1995 and

Greater Vancouver, had been experiencing common episodes of poor visibility due to mixing of urban and agricultural sources of emissions. To establish visibility standards in the region, a sample of residents were shown slides depicting various degrees of visual air quality taken at different locations in the area and asked to rate them as acceptable or unacceptable. The program included associated nephelometer readings of the light scattering index associated with each visual scenario. Using this data and a 50% acceptability criteria to the residents, the study recommended acceptable visual ranges for the specific locations including Abbotsford, Chilliwack and Matsqui. On average, a visual range of 40 km. or greater was considered acceptable.

Subsequent to the REVEAL programs, economic analysis of the GVRD Air Quality Management Plan included a small study of visibility valuation aimed at exploring different valuation methodologies and obtaining some preliminary information on values and trade-offs against visibility improvement.[3] The study used a workshop format, which included presentations and questionnaires to 13 resident participants, all of whom had some technical or policy background in air quality issues. This preliminary study, meant to set the stage for more definitive valuations of visibility, did not address the effects of visibility on the tourist industry.

Considerable work has been carried out in other locations to obtain economic information on visibility. The U.S. EPA and Industrial Economics Incorporated reviewed and compiled a data base of U.S. visibility studies compiled for the Clean Air Act section 812 Analysis[4]. Much of this work on visibility valuation was carried out in support of visibility standards for U.S. National Parks[5]. Virtually all of these previous studies dealt with the problem of assessing the value of visibility to individuals through contingent valuation techniques, and did not examine regional effects on the tourism industry.

The current study builds on the findings of the REVEAL and REVEAL II programs by adding an economic analysis of visual air quality based on potential loss of tourist revenues resulting from poor visibility episodes. It relies on the visibility data and associated photographs obtained during the 1993 field season of the REVEAL programs, with some additional slides included to assess the effect of visibility degradation in the urban areas of Greater Vancouver. Tourist responses to these slides depicting various ranges of visual air quality were obtained during the summer of 1999 through an interactive survey similar to the resident surveys used in the REVEAL programs. Statistical and economic models of the responses of tourists are then developed to predict the effects on the tourist industry of poor visibility episodes.

S.C. Pryor, "Assessing Public Perception of Visibility for Standard Setting Exercises" *Atmospheric Environment, Vol. 30, No. 15 pp. 2705-2716, 1996*

[3] Tim McDaniels and Deanna Thomas, "Visibility Value Trade-offs - A Report Presenting the Results of a GVRD Workshop". GVRD, Burnaby B.C, 1994.

[4] Industrial Economics Incorporated "Analysis of Visibility Valuation Issues for the Section 812 Study", Memo to U.S. Environmental Agency, September 30, 1993

[5] See National Research Council "Protecting Visibility in National Park and Wilderness Areas." National Academy Press, Washington D.C., 1993 and the National Parks Service Website on Visibility - http://www2.nature.nps.gov/ard/vis/vishp.html

Study Objectives

The specific objectives of this study are;

1. to assess the response of tourists in the Vancouver and Lower Fraser Valley Regions to visible air quality,
2. to estimate the potential losses in tourist revenues due to selected poor visibility episodes, and
3. to provide direction to future research into visibility assessments and analysis of policies to improve visibility in the region.

The study does **not** provide an in depth analysis of the frequency of visibility episodes and the mean expected annual costs to the tourist industry. This limitation was necessary since the nephelometer data and associated photographs were only available for a two month period in the summer of 1993. Instead of estimating annual costs, the economic analysis is carried out for a range of specific visibility scenarios, assessing the potential revenue loss that might occur for each occurrence of poor visibility. In other words, the study does not try to estimate a total visibility frequency curve, nor to integrate the total economic losses from such a function. Some indication of the relative frequency of poor visibility events in the short period of observation for REVEAL are possible[6], but these observations would have to be supplemented by further data before reliable frequencies of visibility estimates can be derived.

The Study Area

The Greater Vancouver and the lower Fraser areas include the broad valley of the Fraser River from extending from Hope westward to the urban centre of Vancouver (Figure 1.1). The natural geographic attractions of the area are well known, with the coastal mountains and the ocean combining to produce a setting that attracts tourists from North America and overseas. In 1999 total tourist revenues received in the Greater Vancouver region were estimated to be about $3.6 billion with an additional $720 million estimated for the eastern (Fraser Valley) region of the study area.[7]

Unfortunately, the geographical features that attract tourists to the area can contribute to episodes of poor air quality in the airshed. The Coast Mountains to the north, the Cascade Mountains to the south east and the Straight of Georgia to the west form walls that reduce dispersion of air pollution. Local weather conditions are also a factor especially in summer warm periods when onshore winds push air pollution inland during the day and outflow winds bring pollutants back over the populated areas at night.

Temperature inversions, most frequent in the early fall, can occur year round and contribute to poor ventilation in the Lower Fraser Valley resulting in a pollutant build up

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[6] See Pryor, Stephens and Steyn, op cit. The possibility also exists of using the long records of airport visibility data in conjunction with relevant meteorological as the basis for calculating visibility frequency curves. See Stuart, R.A. and Hoff, R. M. "Airport Visibility in Canada - Revisited", *Atmospheric Environment* Vol. 28, No. 5 pp. 1001-107, 1994, for a discussion of the airport visibility data and methods for developing frequency curves.

[7] See Chapter four for a discussion of how these numbers were derived.

over successive days.

Figure 1.1

Study Area and Camera Locations

Fine particulate matter in the atmosphere and its ability to scatter light is the major reason for visibility impairment. The finest particles, less than 2.5 microns in diameter ($PM_{2.5}$), are the most efficient at scattering and extinguishing light. Coincidentally, these particles are also known to have the greatest effect on human health. Sources of fine particulates include both direct sources and indirect sources that provide precursors to chemical reactions resulting in airborne particles.

Direct emissions of fine particulates come from industrial smokestacks, bulk materials handling/shipping, prescribed burning, fireplaces and wood stoves, road dust and poorly running motor vehicles emitting elemental carbon. Natural sources include sea salt, wind-blown dust, pollen and forest fires.

The indirect sources are the greatest problem in terms of visibility impairment, largely because they result in a high fraction of $PM_{2.5}$. Secondary formation results from chemical reactions in the atmosphere of NOx, VOC's, Sulphur dioxide and ammonia.[8] NOx and VOC's, which also lead to ground level ozone formation, are primarily generated in the highly populated western area of the region. Sulphur dioxide is released from industrial sources in Vancouver and south of the border with additional sulphur contributed from marine biological sources. Summer sea breezes then concentrate this air to the east, where a number of reactions occur producing fine particulates and increasing ozone. During a poor air quality episode, ozone is usually at a low level along the coast near Vancouver and Richmond, increasing to peak levels in central and eastern parts of the Lower Fraser Valley, around Mission, Abbotsford and Chilliwack. However, outflow winds or calm conditions can sometimes result in high levels over the central urban area of Vancouver. Visibility tends to follow the same distribution, with higher impairment in the eastern Fraser Valley. Local variation in visibility within the eastern Fraser Valley also occurs due to variation in composition of fine particulates.

In the western urbanized part of the study area, where the chemistry is dominated by NOx emissions, the resulting visible smog will often tend to pick up a discernible orange/brown colour. In the eastern valley, ammonia from agricultural sources plays a more important role in secondary particulate formation. Under humid conditions the ammonia combines with nitric and sulphuric acid in the atmosphere to form ammonium salts which grow to form small diameter particles that are very efficient at scattering light. This results in the characteristic 'white haze' and severe visibility impairment in the region. Early autumn tends to be the season of poorest visibility in part of the study area.

Under the Georgia Basin Ecosystem Initiative led by Environment Canada, scientific research is continuing to better understand the interactions between various emissions and

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[8] See Pryor S. and Steyn, D.(1994) "Visibility and Ambient Aerosols in Southwestern British Columbia during REVEAL - Part2". Report No. ENV 484415/03/95, Air Resources Branch, B.C. Ministry of Environment, Lands and Parks. Also CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, (1999) "National Ambient Air Quality Objectives for Particulate Matter; Part 1 Science Assessment Document". Published by Public Works and Government Services Canada for Health Canada and Environment Canada.

meteorological conditions and to predict the extent and movement of both particulate and ozone episodes.[9] This research will lead to models better able to predict the effects of changing emissions and the frequency of poor visibility occurrences in all areas of the region.

The GVRD emission inventories for CO, NOx, SOx, VOC's and PM_{10} for 1990 show that the largest category of emissions was mobile sources, accounting for about 85 per cent of the total emissions of all five pollutants with 73 per cent coming from light-duty vehicle exhaust (cars and small trucks). Controlling emissions from the private automobile becomes more difficult over time due to a spreading urban area, resulting in longer and slower commuter trips.

Technological based improvements including enhanced vehicle emission standards, new fuel standards, increased fuel combustion efficiency in boilers and heaters, and automobile inspection programs have significantly reduced fine particulate emissions and precursor chemicals for secondary particulate formation. Some improvements to agricultural practices are leading to reduced ammonia emissions, but the major changes to methods of manure spreading, storage and treatment may be required before significant results will be observed.

Population growth in the area continues at an average rate of around 2% annually. Simultaneous to population growth is the increase in length of a typical vehicle commuting trip as residential population expands in areas farther away from the urban employment centres. At the same time, growth in livestock and poultry production has lead to higher production of manure and ammonia loading in a confined area. In the long run these trends threaten the gains that have been made from the array of technological improvements in vehicle and point source emissions.

Study Overview and Structure of The Report

During the summer of 1999, a total of 159 tourists recruited at various locations in the region were shown the slides and asked to rate the visibility conditions depicted. They were specifically asked whether or not each visibility scenario violated their personal standard required to recommend the region to others or to return for additional visits. Chapter Two discusses the questionnaire, the selection of slides depicting various visibility conditions and the recruitment methodology for survey respondents.

Chapter Three contains the statistical methodology for predicting tourist responses as a function of visibility (measured by nephelometer readings) and socio-economic

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[9] Pottier, J. L.: 1997, "Application of the UAM-V modeling system for the Fraser Valley of B.C., Canada and implications to local ozone control strategies", *Air Pollution Modelling and its Application XII* - NATO, Plenum Press, New York, **22,** 79-86. Also Pottier, J. L. , Haney, .J, and Deuel, Hans P.: 1997, "Modelling the future - an application of the Variable Grid Urban Airshed Model (UAM-V) to the Fraser Valley of British Columbia, Canada", Air Pollution V, Modelling, Monitoring and Management, Computation Mech. Publications, Southampton, 465-474.

parameters such as area of origin, purpose of visit, income and length of stay. The analysis relies principally on multiple regression methods to relate perceived air quality and visually unacceptable levels from the sampled respondents to nephelometer readings of the light scattering index and socio-economic characteristics of the sample group. Both Maximum Likelihood Estimation on raw data and Generalized Least Squares on grouped data are used to estimate equations that form the basis of predicting future losses in visits and tourist revenues due to poor visibility.

Chapter Four uses the estimated equations and a simple model of tourist visitation to predict future changes in tourist revenues as the result of a range of poor visibility episodes. Each visibility scenario analysed has an associated nephelometer reading of the light scattering index. The analysis includes separate calculations for the urban area of Greater Vancouver and the Fraser Valley region to the east to account for the different tourist populations, type of visibility impairment and geographical features affecting perceived visibility.

The final chapter discusses the general validity of the results and presents some directions for future research that would result in more precise estimates and allow decision makers to analyse the benefits of policy measures intended to reduce the frequency of poor visibility in the region.

Chapter Two
Survey Methodology

Several steps were required to obtain information from a sample of tourists on their reaction to visible air pollution. These steps included selection of slides showing various levels of visibility, questionnaire design, recruitment of tourist respondents and administration of the interactive slide show and questionnaire. The interactive nature of the survey and accompanying slides presented some challenges for the research, particularly when sampling a transient population of tourists. These difficulties were for the most part overcome with the help of several public and private agencies who deal with visitors to the region. The experience and procedures developed in the previous REVEAL studies also proved to be invaluable in selecting appropriate slides and in developing and administering the survey.

Selection of Slides Depicting Visual Air Quality

Ideally, a complete range of visibility conditions taken at various representative views should be selected for presentation to the tourists respondents. The current study however, was limited to previous photographs taken during the REVEAL programs in the summer of 1993. These slides presented a complete range of visibility scenarios but the camera locations were limited particularly in regards to views of the downtown, western peninsula and outer harbour of Vancouver.

Four automated cameras operated during the REVEAL program (Figure 1.1) from locations near Abbotsford International Airport, Matsqui, Chilliwack and Mt. Seymour. The subsequent study by Pryor, Stephens and Steyn[10] presented only slides from the first three locations since the objective of the original analysis was develop a visibility standard for the eastern Fraser Valley.

The current study used exactly the same slides as used by Pryor, Stephens and Steyn with the addition of slides from Mt. Seymour showing a downward view of areas of Vancouver, Burnaby and the inner harbour. Including these slides provided some indication of visibility conditions that might be encountered by tourists visiting the main tourist areas of Vancouver.[11]

The researchers used a number of criteria for selecting slides in perception studies of visual air quality, as discussed by Pryor[12] and originally described by Latimer, Hugo and Daniel.[13] These criteria include:

1. Slides must be linked to instrument data that can be used to calculate the corresponding visual range,
2. Relative humidity at the time and location of the slides should not exceed 75% to ensure that visibility is not effected by rain or fog,
3. Cloud cover should either be less than 20% or greater than 90%, and respondents should be shown both of these scenarios in making their judgements,
4. Photographs should be taken at consistent times to avoid perception changes caused by sun angles. For the REVEAL studies all photographs were taken at either 12:00 (PST) or 15:00 (PST).

A total of 41 slides were selected and presented to the respondents. Because the slides for the Matsqui location were not available until part way through the field season, some respondents viewed only the 26 non-Matsqui slides. Appendix One outlines the complete list of slides used in the current study along with the associated light scattering reading (BSP), and a description of the cloud conditions at the time the photographs were taken, The appendix also presents some reproductions of the selected slides depicting various visibility scenarios at the different locations.

Questionnaire Design

The questionnaire, presented interactively with the slide show, records the tourists responses to the various visibility scenarios along with some limited demographic and economic information. The current study closely followed the basic questionnaire used

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[10] S. Pryor, K. Stephens and D. Steyn, op cit., 1995

[11] Further research on visibility planned under the Georgia Basin Ecosystem Initiative (Environment Canada) will provide photographs of different viewpoints in the region.

[12] S.C. Pryor, "Assessing Public Perception of Visibility for Standard Setting Exercises" *Atmospheric Environment, Vol. 30, No. 15 pp. 2705-2716, 1996.*

[13] D. Latimer, H. Hugo and T. Daniel "The Effects of Atmospheric Optical Conditions on Perceived Scenic Beauty" *Atmospheric Environment, Vol. 15 pp. 1875-1890, 1981*

by Pryor, Stephens and Steyn [14], in the original REVEAL studies, which in turn was based on the questionnaire originally developed by Ely et al[15]. Some modifications, made because of the different target population, are discussed in subsequent sections.

The questionnaire, along with specific verbal instructions from the facilitator and slide presentations, follows this format:

a. Introduction giving general purpose of session.
b. Instructions on grading visual air quality of slides on scale of one to seven.
c. Series of 6 to 9 warm-up slides at six second intervals for respondents to familiarize themselves with grading scale.
d. Remaining slides, shown in random order, location by location, with instructions to grade on air quality scale.
e. Introduction on grading acceptability of slides based on personal standard for visibility, whereby respondents asked to give a yes/no response for each slide whether or not it violates the visibility standard.
f. Series of 6 to 9 warm-up slides for respondents to familiarize themselves with assessing and filling out the yes/no answer on visibility standards.
g. Remaining slides, shown in random order, location by location, with instructions to respond yes/no on violation of personal visibility standard.
h. Completion of demographic/personal information such as gender, age, home location and expenditures while on vacation.

The current study made some small modifications to the questionnaire and presentation so that it would be more applicable to the tourist population being sampled, as opposed to the sample of residents surveyed in the REVEAL programs. These modifications included:

a. Tourists were asked to define their personal "unacceptable" standard for visual air quality as the level that would deter them from a return visit or recommending the area as a vacation destination to somebody else.
b. Tourists were **not** instructed to ignore possible health effects in their determination of their acceptable or unacceptable standard of visibility. The previous REVEAL questionnaires asked respondents to make their judgement based on aesthetics only and to ignore possible health effects. The current study did not make the distinction between health and aesthetics because the study is concerned with the total tourist response to visibility impairment.
c. An additional question to determine the general importance of visual air quality when visiting a vacation destination was asked in the current study. The response serves primarily as a check for internal consistency (validity) of the number of unacceptable grades of visual air quality given by each tourist.
d. Questions regarding support of various political parties and family income were dropped as they were not suitable for tourists. They were replaced with questions to

[14] Pryor, Stephens and Steyn, Op. cit., 1995
[15] Ely, D.W., Leary, J.t., Stewart, T.R. and Ross, D.M.: "The Establishment of the Denver Visibility Standard", Presented at the 84th Annual Meeting and Exhibition of the A&WMA, Vancouver, B.C. June 1991

determine the home country of the tourists, the amount spent while on vacation in the study area and the types of activities undertaken on vacation.

Appendix Two includes the full copy of the questionnaire.

Recruiting Tourists for the Questionnaire

Recruitment of the sample respondents from the tourist population presented several challenges. In general, it was necessary to make unsolicited approaches to tourists in the region, explaining the objectives of the survey, then asking them to return to a specified venue for the slide show and interactive questionnaire. Without an incentive or advance warning, this approach would naturally lead to a very low success rate. There was also the problem of obtaining adequate representation from various nationalities, a problem confounded by a lack of knowledge of English by some visitors.

To meet these challenges it was necessary to carry out several recruitment exercises at different locations in the study area and to offer an incentive (a gift pack of smoked salmon and chocolates) for tourists to assemble at pre-arranged venues to view the slides and complete the questionnaire. These recruitment exercises, all of which occurred in the late spring and summer of 1999, included:

1. International Communications Conference (ICC) - 2 days
2. Granville Island Public Market - 12 days
3. Hong Kong visitors recruited through SUCCESS - One session
4. Japanese visitors recruited through a tour group and translation service - One session

<u>1. International Communications Conference</u>

The ICC was large international business event held in early June at the Vancouver Trade and convention centre. Recruiters approached conference delegates or spouses on site, handed out brochures explaining the process, displayed the incentive gifts and asked interested individuals to assemble at a small board room at a pre-arranged time to view the slides and complete the questionnaires. One facilitator presented the slides and instructions, usually to small groups of respondents (5 - 10 individuals). In total 23 responses were received at the conference, representing a mix of business travellers and spouses. The ICC arranged conference access and use of the projection room at no charge to the study team.

<u>2. Granville Island Public Market</u>

Later in June and through much of July, recruitment moved to Granville Island Public Market, a centrally located and significant tourist destination. There were a number of advantages to using this site. First, tourists generally spend at least a few hours browsing through the public market and nearby shops on the island. This made it possible to recruit tourists and present the slide show in a single time envelope while tourists were at the site. Recruiters were also able to set up a booth displaying the incentive gifts for tourists interested in participating. The display attracted tourists who were then given a brochure explaining the survey. Interested individuals were invited back to a nearby projection room at pre-arranged times. The Canadian Mortgage and Housing Corporation, the principal administration agency of the Granville Island development provided the booth and projection room facilities for this study at no charge.

Recruitment efforts were more successful in the late afternoon and when there was a recruiter as well as a facilitator sharing the tasks. Most respondents appeared to participate because of the incentive. Some visitors participated because of their interest in the subject.

Again, the slides were mostly presented to small groups, anywhere from 3 to 12 individuals. In total 108 completed questionnaires were received at the site.

3. United Chinese Community Services (SUCCESS)

During the recruitment exercises at ICC and Granville Island, it became evident that Asian visitors were under-represented in the sample of respondents. To bolster the Asian sample, the authors contacted SUCCESS, a community based agency in Vancouver, providing a range of social services primarily to the Chinese community. Because it offers several counselling services to immigrants, SUCCESS managers have developed a broad network among the local Asian community. Through this network, SUCCESS recruited four Cantonese speaking visitors from Hong Kong and provided translation services free of charge during the slide presentation to the group.

4. Japanese Tour Group

Neither the ICC conference or Granville Island exercises were successful in recruiting visitors from Japan. Much of the problem resulted from language barriers. Moreover, the general process, involving unsolicited approaches with no third party introductions, may also have been unsuitable for recruitment of Japanese visitors. To overcome these difficulties, the study sought the cooperation of a translation service to recruit members of tour groups visiting Vancouver. A&E Communications was engaged to translate the survey questionnaire and to provide live interpretation of the instructions. The translation company also arranged through Canada Land Tours for a 23 member Japanese tour group to view the slides and respond to the questionnaire. The interpreter, under the general guidance of the facilitator, then presented the slide show and questionnaire to the group at its hotel in the region.

Survey Sessions

A single facilitator administered the slide show and questionnaire to all respondents except for the special Asian and Japanese sessions which included interpreters. The facilitator's instructions to the respondents were scripted and closely adhered to in all presentations. The process also included a fixed length of time for respondents to view each slide (6 seconds) and fill in a response. As a result, the total time for each session was consistently close to 30 minutes.

The facilitator encouraged the respondents to ask any questions of clarification to the scripted instructions. The small group size made it possible for the facilitator to respond individually to any questions or confusion with the directions. The small numbers also made it easier for respondents to ask questions when they needed clarification.

Quality Checking the Questionnaire Responses
A basic quality check should discern whether or not individual respondents followed the directions correctly, understood the concepts presented and gave consistent and valid responses. The questionnaires contained internal checks that are analysed statistically in Chapter Three. In advance of the statistical analysis it was possible to check each questionnaire to see if all questions had been answered and to assess whether the respondent had correctly understood the directions. Of a total of 159 respondents, only three questionnaires were rejected outright, all because of incomplete responses to the visibility evaluations. The low rejection rate is attributed to the small size of the groups, the consistent presentation and the quality of the questionnaire development and pre-testing in the previous REVEAL studies by Pryor et al.[16]

It was anticipated that a small percentage of respondents might unwittingly reverse their answers on violation of personal visibility standards. In the questionnaire, respondents were asked to respond with a 'YES' if a slide violated their personal visibility standard. In effect they were asked to respond with a positive answer if they experienced a negative reaction to a slide. Despite the clear and repeated instructions on this point, it was expected that a few respondents out of the 159 would still tend to respond in reverse, giving the poor visibility slides a 'NO' and the good visibility slides a 'YES'.

The researchers checked each response for the reversal phenomenon by examining the yes/no answers to slides on both extremes of the visibility scale. If respondents had indicated for all four camera locations that the slides with the best visibility violated their standard (a YES response) and also indicated that the slides with the most severely degraded visibility were acceptable (a NO response), they were deemed to have reversed the yes and no responses. From a total of 156 accepted questionnaires, four respondents were thus found to have reversed the yes/no answers. The researchers then corrected the reversals to be consistent with the rest of the respondents.

Representativeness of the Sample
The primary concern from a sampling viewpoint was that all significant countries of origin have enough representation in the sample to enable statistical comparisons between these groups. For this reason, some attempts (described earlier in this chapter) were made to increase the representation of Japanese and Asian visitors in the sample. It is less important that the total sample composition be reflective of the general tourist population in terms of area of origin since statistical differences in reactions to visible air quality can be factored into the predictive models at a later stage.

Table 2.1 presents the final composition of the overall sample based on area of origin.

Table 2.1

[16] Pryor et al. Op cit.

Area of Origin of Respondents

Area of Origin	Number of Respondents	Percentage of Sample	Percentage of Tourist Population[17]
British Columbia	4	2.6%	31.4%
Other Canadian	39	25.0	27.9
Washington and Oregon	5	3.2	7.7
Other U.S.	39	25.0	16.0
Europe	27	17.3	5.5
Japan	23	14.7	4.0
Other Asian	8	5.1	5.2
Australia, N.Zealand, S. Africa	11	7.1	1.3
All Other Nations	0	0	1.0
TOTAL	156	100%	100%

In terms of statistical comparisons between groups, the data set has low numbers for the British Columbia, Washington/Oregon and other Asian groups, making it more difficult to detect statistically significant differences. However, the grouping is somewhat arbitrary with respect to the division of Canadian and U.S. visitors into close and far areas of origin. Without this distinction between close haul and long haul visitors, the sample is adequate to consider differences in nationality between Canada and U.S. The most serious deficiency might be in the Other Asian category with only 8 respondents and statistical interpretation of any differences displayed by this group should be treated with caution.

In terms of representativeness of the general tourist population, the sample is over represented with Europeans and Japanese and under represented with British Columbia residents. This does not constitute a problem for statistical analysis, as long as the numbers from each national group are large enough to determine significant differences in responses between groups. In fact statistical estimations generally showed little or no differences between response rates for national groups at the various slide locations (see Chapter Three).

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It would also be desirable to obtain significant representation for the various categories of socio-income variables, such as age, gender and amount spent on vacation although it would be difficult to set up a sampling process that would guarantee significant representation over the range of each socio-economic variable. However, because the overall sample size was fairly large, it was found that adequate numbers and variations existed to make statistical evaluations of the effects of socio-economic variables on visibility perception.

[17] The composition of the general tourist population to the region is taken from Tourism Vancouver Surveys. See “The Overnight Visitor to Greater Vancouver - The Big Picture”, Tourism Vancouver, 1996.

In conclusion, it was felt that the sample was adequate to derive both general estimates of response rates to visibility and to determine differences between national groups and the effects of socio-economic variables. It is recognized, a priori, that detection of statistical differences in response to visibility among some of the smaller groups may be difficult. Future work would benefit from greater representation of B.C., close haul U.S. and Asian (non-Japanese) visitors.

Chapter Three
Statistical Analysis of Tourists' Response to Visibility

The primary reason for carrying out the statistical analysis is to develop predictive equations relating a measurable visibility parameter - BSP - to the personal visibility standards of visitors to the region. The statistical significance of the effect of BSP in the estimated equations will provide an assessment of the confidence that can be placed in the predicted response of tourists to degraded visibility.

Statistical analysis also allows further checking of the internal validity of the questionnaire procedure and the sample responses, which contained elements intended as checks to the consistency of each individual's responses. If individual respondents were being consistent in their responses to visible air quality, then statistical analysis should show significant correlation between the 'validity check' variables and response to visible air quality.

As a secondary objective, statistical analysis enables us to test the effect of other parameters on tourist response to visibility. These other parameters include both physical aspects of the scenes depicted in the slides and the cultural/economic characteristics of the respondents.

General Methodology

Estimation of equations relating tourist response to variation in visibility used several multiple regression methods including ordinary least squares, maximum likelihood and weighted least squares estimation.   A variety of procedures were required because of the statistical nature of the problem which included factors such as binary dependent variables, grouped data and heteroscedasticity.

Ideally a general form of an equation relating an individual's response to physical and socio-economic parameters might be estimated. This would take the form of:

Violation Rate =   f (BSP, Other Physical Variables, socio-economic Variables)   (1)

where:

Violation Rate is the probability of visibility in a particular scene not meeting an individual tourist' personal standard of acceptability. The probability will always fall between zero and one (inclusive),

BSP is the light scattering index, measured by open chambered nephelometer,

Other Physical Variables include cloud cover, existence and placement of physical landscape markers, colour and striation of pollution layers,

Socio-Economic Variables include country of origin, amount spent on vacation, air quality at home region, age and gender.

Equation (1) as a general model, can theoretically be used in any location to predict response to visibility changes if information on all the parameters is available. Estimating a general equation based on the data available to this study, however, presents some practical difficulties. The principle difficulty is developing an index of the physical landscape features in the four vistas to be used as explanatory variables in the estimated equation. Many of the physical features, such as existence of distinct geographical features (particularly mountainous skyline), degree of vegetative cover, urban/rural settings defy quantification into a numerical index. Furthermore, with only four different vistas, the variation in some features necessary for statistical estimation is not present.

A solution to the above problem is to estimate separate equations for each of the four camera locations; Matsqui, Mt. Seymour, Chilliwack and Abbotsford. In each model, the physical geographic features would remain constant and need not be accounted for in the estimated models. The only physical variable that would retain variation at each location would be the degree of cloud cover, which lends itself more easily to quantification. The slides as originally selected in the REVEAL studies, have either very high cloud cover or very low cloud cover. This range in variation also improves the ability to analyze the statistical effect of this variable.

The analysis therefore focuses on estimating four location specific response equations:

$$\text{Violation Rate}_{\text{Matsqui}} = f\,(\text{BSP, Cloud Cover, Socio-economic Variables}) \qquad (2)$$

$$\text{Violation Rate}_{\text{Mt. Seymour}} = f\,(\text{BSP, Cloud Cover, Socio-economic Variables}) \qquad (3)$$

$$\text{Violation Rate}_{\text{Chilliwack}} = f\,(\text{BSP, Cloud Cover, Socio-economic Variables}) \qquad (4)$$

$$\text{Violation Rate}_{\text{Abbotsford}} = f\,(\text{BSP, Cloud Cover, Socio-economic Variables}) \qquad (5)$$

Logit Estimation of the Equations

The key variable in this analysis rests on each individual's response to the survey question which asked if particular slides violated personal standards for visibility. After presentation of each slide, the tourists in the sample responded with either a 'yes' if the scene violated their standard, and a 'no' if the level of visibility did not violate the standard. To translate this binary response into a violation rate, an appropriate functional form is the logistical equation, commonly referred to as the logit equation..

A logit equation takes the form:

$$P = [1 + e^{-(b_0 + b_1X_1, b_2X_2 \, . \, . \, b_nX_n)}]^{-1} \qquad (6)$$

where:
P is the probability (between 0 and 1, inclusive) of a given event occurring,
X_1 to X_n are explanatory variables,
b_0 to b_n are coefficients to be estimated

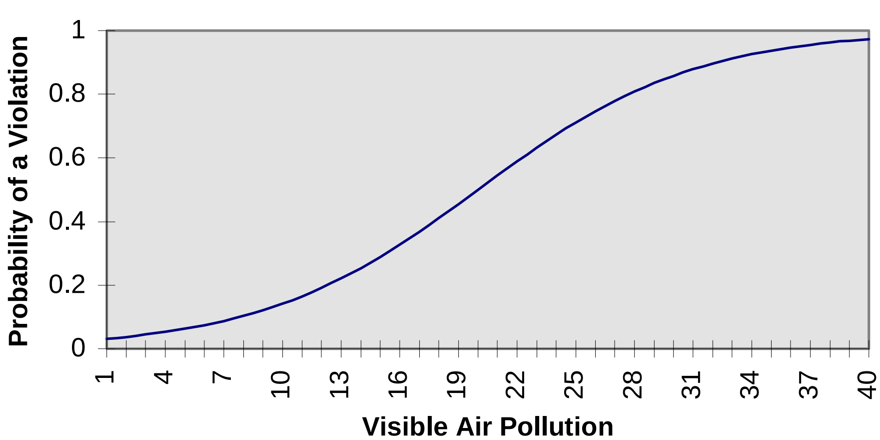
To facilitate statistical estimation, equation (6) is often transformed into equation (7), which is linear in the X_1 to X_n parameters:

$$\ln [\, P/(1 - P)] = b_0 + b_1X_1 + b_2X_2 + \ldots\ b_nX_n \qquad (7)$$

where;
ln = the natural logarithm
all other variables are as in equation (6)

Figure 3.1 shows a graph of this function with the probability plotted against a single explanatory variable representing visible air pollution.

Figure 3.1 Logit Function



Conceptually, this form is useful because of its asymptotic approach to zero as a lower bound and to one as an upper bound, which should characterize the shape of the response curve to changes in visible air quality. For example, as BSP reaches very high levels, visibility is highly degraded and virtually all of the respondents indicate a violation of their standard. If BSP increases even further, we would see only a marginal increase in the number of respondents indicating a violation - hence a flattening of the curve at the top. Likewise, when BSP is very low, virtually all of the sample will find visibility acceptable. A further decrease in BSP will decrease the violation rate only slightly, flattening the curve at the bottom.

The logit function is often used to characterize responses to yes / no questions. For statistical purposes, the responses are transformed into a binary variable with zero for a 'no' response and one for a 'yes' response. The logit response function as in the non-linear form of equation (6) can then be directly estimated with Maximum Likelihood estimation methods for fitting a logit equation with binary dependent variables.[18]

Because the maximum likelihood estimation of equations (2) to (5) allows us to use the individual respondent data, each individual's response to each slide will constitute a single observation. This results in a very large number of observations available for the estimation, ranging from 620 for Mt. Seymour to 1872 at Abbotsford. The large number of degrees of freedom greatly facilitates statistical detection of variables that will influence the response to visibility degradation.

A second approach to estimating the logit equation is to aggregate the individual response data by sub-groups of the whole sample. For example, the respondents could be grouped by socio-economic characteristics such as nation of origin or by amount spent while on vacation, and averages for each sub group of the explanatory variables calculated. A single observation then would consist of the averages of the explanatory variables and the average violation rate for the sub-group for each slide. Aggregation into sub-groups has a number of implications, both advantageous and disadvantageous for statistical estimation as discussed below.

The first advantage of aggregation into sub-groups is that the violation variable for each slide will no longer be constrained to either zero or one as it is for individual response data. By aggregating, we will obtain an average violation rate for the sub group for each slide (the number of individuals in the sub-group who recorded a violation divided by the total number in the sub-group). This gives a full range between zero and one for the violation rate variable and allows a transformation of the logit equation into the linear form shown in equation (8). The average violation rate is the equivalent of the probability P from the transformed logit equation (7).

$$\ln\ [\ AVR / (1\text{-}AVR)\ ] = b_0 + b_1X_1 + b_2X_2 + \ldots b_nX_n \qquad (8)$$

[18] For example, see White, K. J., SHAZAM User's Reference Manual Version 8.0, McGraw-Hill, 1997 pp. 281-282, for a discussion of the Maximum Likelihood Method, and the associated statistics.

where;
ln = the natural log
AVR = the average violation rate per sub-group
b_0 to b_n are coefficients to be estimated
X_1 to X_n are the average values of the explanatory variables for each sub-group

A complication arises with equation (8) when AVR equals zero. Some slides, showing virtually perfect visibility, resulted in zero violations and a zero violation rate (AVR). The term AVR / (1-AVR) then also becomes zero, meaning that we cannot derive its natural logarithm as required in equation (8). In these instances, AVR was assigned an arbitrary low number of .0001, very close to its true value of zero, so that the natural log could be calculated.

Because equation (8) is linear in the parameters X1 to Xn, it can be estimated by least squares methods, using the left hand term of ln [AVR / (1 - AVR) as the dependent variable and the sub group averages of the X values as the independent variables. However, the grouping of the response data will lead to heteroscedasticity of the estimation errors, requiring further transformation of the observations for efficient estimation. To correct for heteroscedasticity of the errors, each observation is multiplied by the following weight [19];

$$w_i = [\ N_i\ AVR_i(1\text{-}AVR_i)]^{1/2} \qquad (9)$$

where,
w_i = the weight to be applied to each grouped observation
AVR_i = the average violation rate for the sub-group
N_i = the number of individuals in each sub-group.

After the weight is applied to each observation, then Ordinary Least Squares (OLS) can be used to estimate the equation.[20]

A second possible advantage of grouping the data is to reduce the wide range of unexplained variation in individual responses to visibility. We expect, a priori, that the distribution of individuals' responses to visibility will for a large part be independent of cultural and economic characteristics of the respondents. For example Pryor, Stephens and Steyn.[21] found that most of these type of variables had little effect on their response to visibility. In a general sense, individual's importance placed on environmental quality often seems to transcend differences in income, age and cultural background. This unexplained variation or random 'noise' could possibly be large enough to reduce the

[19] See William S. Brown, Introducing Econometrics, West Publishing Co., 19 ,, page 310 and Henry Theil, "on the Relationships Involving Qualitative Variables" , American Journal of Sociology, Volume. 76, July 1970, p103-154.
[20] It is also possible to overcome the heteroscedasticity problem by use of a maximum likelihood search technique. This method was also attempted in the statistical analysis but the search for a global maximum to the likelihood function was always unsuccessful.
[21] Pryor, Stephens and Steyn, op cit. 1995,

accuracy of the estimated equations to a point where they would not give accurate predictions. By calculating the average violation response for each sub-group, a certain amount of the random unexplained variation will be averaged out, allowing for more precision in the statistical estimates.

The gains made by averaging the data into sub-groups may be offset by the loss in degrees of freedom. The total number of responses (156) will be reduced into the number of sub-groups, with a corresponding decrease in the number of total observations. This will still leave an adequate number of observations to estimate the effects of the major physical variables like BSP and cloud cover, but will reduce the detection power of statistical methods in finding influences of socio-economic variables with less impact.

The averaging process in grouping the data will also lessen the variation in the non-physical explanatory variables. The reduction in variation will again make it more difficult for statistical methods to detect the significance of socio-economic variables. However, if the individual responses are grouped by a certain common characteristic, such as area of origin, then the overall variation for this particular variable will be retained, and it may still be possible to detect its statistical significance.

Grouping by Area of Origin

In order to estimate the grouped form of the logit functions as expressed in equation (8), it was decided to group the data by area of origin. This grouping provides an adequate number of groups (eight areas of origin) as well as allowing direct comparisons of differences between visitors from the different areas of origin.

As stated earlier, grouping of data results in far fewer observations available for statistical estimation of the coefficients of equations (2) to (5). Taking the case of the Chilliwack response function as an example, 80 observations (10 slides multiplied by 8 groups) will be available for statistical analysis. In contrast, the raw Chilliwack data yields 1560 observations (10 slides times 156 respondents). However, 80 observations still constitutes a reasonable sample size for regression analysis.

As in equation (8), each observation constitutes the average group response to each slide presented. The average violation rate for each observation is the total number of violations recorded for the particular slide by the group divided by the group number. Likewise for the explanatory variables (gender, expenditure, age etc.) the recorded scores are totaled for each group and divided by the group number to give group averages.

Statistical Software

All statistical estimations using both the individual and grouped response data were estimated with the SHAZAM Econometric Package, Version Eight.[22]

Variable Definitions

[22] White, K.J., SHAZAM op cit.

Table 3.1 gives the variable definitions for all variables used in the logit estimation from the individual response data. Table 3.2 gives the definitions of the variables used in the grouped data for estimation of the logit function by generalized least squares methods. The variables for the grouped data are much the same, except that they represent sub-group averages for the eight areas of origin. Note that the physical variables, BSP and CLOUD remain unchanged by the averaging.

Table 3.1
Variable Definitions for Individual Response Data

Variable Name	Explanation
Violation	Binary dependent variable; one indicates respondent recorded a violation, zero indicates no violation recorded
VAQ	Individual's rating of the visual air quality on the slide depicted. Range 1 - 6, with 6 highest. Not used in most estimations, except to test 'validity' of responses.
BSP	Light scattering index per metre
CLOUD	Binary variable; one if cloudy, zero if clear
Area of Origin Dummy Variables;	Binary Variables
BC	one if from B.C., otherwise zero
OTHCAN	one if from other provinces, otherwise zero
NEARUS	one if from Wash. or Oregon, otherwise zero
FARUS	one if from other U.S. states, otherwise zero
EUROPE	one if from Europe, otherwise zero
ASIA	one if from Asia (excluding Japan), otherwise zero
OTHER	one if from Australia or S. Africa, otherwise zero
JAPAN	one if from Japan, otherwise zero
AGE	from 18-35 = 1 from 36-54 = 2 55 and over = 3
GENDER	Binary Variable for gender of respondent, one if female, zero if male
EXPEND	amount spent while visiting < $200 = 1 200 - 300 = 2 300 - 500 = 3 500 - 1000 = 4 > 1000 = 5
VISIMP	self rating on importance of visual air quality while visiting. Scale 1 to 4, with 4 most important
HMVAQ	A rating by the respondent of visual air quality in his/her home area.

Table 3.2
Variable Definitions for Response Data Grouped by Area of Origin

Variable Name	Explanation
AVR (average violation rate)	Total number of recorded violations for the sub-group divided by the number of individuals in the sub-group. Ranges from zero to one
VAQ.AV	Average rating over the sub-group of the visual air quality on the slide depicted. Not used in most estimations, except to test 'validity' of responses.
BSP	Light scattering index per metre
CLOUD	Binary variable; one if cloudy, zero if clear
Area of Origin Dummy Variables;	Binary Variables
BC	one if from B.C., otherwise zero
OTHCAN	one if from other provinces, otherwise zero
NEARUS	one if from Wash. or Oregon, otherwise zero
FARUS	one if from other U.S. states, otherwise zero
EUROPE	one if from Europe, otherwise zero
ASIA	one if from Asia (excluding Japan), otherwise zero
OTHER	one if from Australia or S. Africa, otherwise zero
JAPAN	one if from Japan, otherwise zero
AGE.AV	Average over the sub-group of the individual age index
GENDER.AV	Fraction of the sub-group that is female
EXPND.AV	Average over the sub-group of the index of individual amount spent while visiting base on; < $200 = 1 200 - 300 = 2 300 - 500 = 3 500 - 1000 = 4 > 1000 = 5
VISIMP.AV	Average over the sub-group of the self rating on importance of visual air quality while visiting. Scale 1 to 4, with 4 most important
HMVAQ.AV	Average over the sub-group of respondent's rating of visual air quality in his/her home area.
GRNUM	Number of individuals in each sub-group

Sample Regression Input

Tables 3.3 (individual response data) and 3.4 (grouped response data) give an example of the regression input data for a sample of 20 observations. The data was compiled in Microsoft Excel spreadsheets in data interchange format, which was readable by the Shazam econometrics program.

Table 3.3

Example Regression Input, Individual Response Data

BSP	Violation	AGE	EXPEND	HVAQ	VISIMP	GENDER	BC	OTHCAN	NEAURUS	FARUS	EUROPE	ASIA	OTHER	JAPAN	CLOUD
0.031	1	2	4	4	3	1	0	0	0	1	0	0	0	0	1
0.031	1	2	3	1	3	0	0	0	0	0	0	0	1	0	1
0.031	0	1	3	5	3	0	0	0	0	1	0	0	0	0	1
0.031	0	3	1	3	2	1	0	0	0	0	1	0	0	0	1
0.031	0	2	4	5	2	1	0	1	0	0	0	0	0	0	1
0.031	0	1	4	5	3	0	0	0	0	0	0	0	1	0	1
0.031	0	1	4	5	2	0	0	0	0	0	0	1	0	0	1
0.031	1	3	5	3	3	1	0	0	0	1	0	0	0	0	1
0.031	1	2	5	5	4	1	0	0	0	1	0	0	0	0	1
0.031	0	2	5	7	2	1	0	0	0	1	0	0	0	0	1
0.031	0	2	5	5	3	0	0	0	0	1	0	0	0	0	1
0.031	0	3	4	6	1	0	0	0	0	1	0	0	0	0	1
0.031	1	2	5	4	4	1	0	0	0	0	1	0	0	0	1
0.031	1	3	5	5	4	1	0	0	0	0	1	0	0	0	1
0.031	1	3	3	5	3	1	0	0	0	0	1	0	0	0	1
0.031	0	3	2	7	1	1	0	0	0	1	0	0	0	0	1
0.031	1	2	4	5	3	1	0	0	0	1	0	0	0	0	1
0.031	1	2	5	4	3	0	0	0	0	1	0	0	0	0	1
0.031	1	3	4	4	2	1	0	0	0	1	0	0	0	0	1
0.031	1	2	2	5	4	0	0	0	1	0	0	0	0	0	1

Variable Definitions as in Table 3.1
Each row constitutes a single observation
Dependent Variable is “Violation”

Table 3.4

Example Regression Input, Grouped Response Data

BSP	AVR	BC	OTHCAN	LOCST	FARUS	EUROPE	ASIA	OTHER	JAPAN	CLOUD	AGE AV	GENDER AV	EXPND AV	GRNUM
0.029	0.25	1	0	0	0	0	0	0	0	0	2.1	.47	2.2	4
0.121	1.00	1	0	0	0	0	0	0	0	0	2.1	.47	2.2	4
0.082	0.75	1	0	0	0	0	0	0	0	1	2.1	.4	2.2	4
0.039	0.50	1	0	0	0	0	0	0	0	0	2.1	.47	2.2	4
0.132	1.00	1	0	0	0	0	0	0	0	0	2.1	.47	2.2	4
0.104	1.00	1	0	0	0	0	0	0	0	1	2.1	.47	2.2	4
0.024	0.00	1	0	0	0	0	0	0	0	0	2.1	.47	2.2	4
0.016	0.00	1	0	0	0	0	0	0	0	0	2.1	.47	2.2	4
0.075	0.50	1	0	0	0	0	0	0	0	0	2.1	.47	2.2	4
0.062	0.25	1	0	0	0	0	0	0	0	0	2.1	.47	2.2	4
0.145	1.00	1	0	0	0	0	0	0	0	0	2.1	.47	.2.2	4
0.031	0.50	1	0	0	0	0	0	0	0	1	2.1	.47	2.2	4
0.029	0.05	0	1	0	0	0	0	0	0	0	2.3	.56	2.9	39
0.121	0.92	0	1	0	0	0	0	0	0	0	2.3	.56	2.9	39
0.082	0.74	0	1	0	0	0	0	0	0	1	2.3	.56	2.9	39
0.039	0.51	0	1	0	0	0	0	0	0	0	2.3	.56	2.9	39
0.132	0.92	0	1	0	0	0	0	0	0	0	2.3	.56	2.9	39
0.104	0.92	0	1	0	0	0	0	0	0	1	2.3	.56	2.9	39
0.024	0.03	0	1	0	0	0	0	0	0	0	2.3	.56	2.9	39
0.016	0.05	0	1	0	0	0	0	0	0	0	2.3	.56	2.9	39

Variable Definitions as in Table 3.2
Each row constitutes a single observation
Dependent Variable is AVR -Average Violation Rate

Estimation of the Chilliwack Response Equations

As discussed in Chapter Two, respondents viewed 10 slides from a location showing part of Chilliwack in the foreground with distinct mountain ridges in the background. Cloud cover was either heavy or light, and was indexed in the analysis by means of a dummy variable. The BSP ranged from a low of .018 to a high of .126, depicting a range of visibility from unimpaired to highly degraded.

Analysis of Individual Response Data for Chilliwack

With 10 slides and 156 respondents, a total of 1560 observations were available for the analysis. Of these, 458 recorded a violation and 1102 recorded non-violation of personal visible air quality standard.

Table 3.5 shows the results of the Logit maximum likelihood estimation. Note that with this non-linear functional form estimated by a maximum likelihood search the normal 'goodness of fit' measure, the R^2 statistic, is not applicable. Several alternative measures of goodness of fit somewhat analogous to the R^2 are shown[23]. The final column, elasticity at means, is an indication of the overall impact of the explanatory variable on the violation rate. Specifically, in this case elasticity would be defined as the percentage change in violation rate divided by the percentage change in the explanatory variable, calculated at the means of both variables.

The estimated equation includes only those variables significant at the 95% level of confidence.

Table 3.5
Logit Estimation of Violation Response for Chilliwack Location
Individual Response Data

Dependent Variable - Violation Rate (binary) one = violation, zero = no violation
Number of Observations = 1560 Maximum Likelihood Estimation

Variable	Estimated Coefficient	Standard Error	T-Ratio	Elasticity At Means
BSP	30.864	2.0787	14.848	1.4859
AGE	0.34482	0.91236E-01	3.7795	0.55773
VISIMP	0.77324	0.85381E-01	9.0563	1.6842
CAN	0.67814	0.16238	4.1763	0.13122
ASIA	1.0329	0.30298	3.4092	0.40998E-01
CLOUD	0.99874	0.15785	6.3272	0.15460
CONSTANT	-6.4695	0.42949	-15.063	-5.0073

Log-Likelihood Function = -686.88
Log-Likelihood(0) = -944.32

[23] See White, K. J., SHAZAM Reference Manual p 283, for an explanation of how each of these statistics are derived

Likelihood Ratio Test = 514.882 With 6 D.F.

Maddala R-Square	0.2811					
Cragg-Uhler R-Square	0.40045					
Mcfadden R-Square	0.27262					
Adjusted For Degrees Of Freedom	0.26981					
Approximately F-Distributed	0.43726	With	6	And	7	D.F.
Chow R-Square	0.30359					

In terms of overall goodness of fit, the estimated equation explains approximately 30 to 40 percent of the variation in the violation rate (depending on the statistic used), which does not give it great predictive power for small samples of the population. Furthermore, the explanatory power is dependent to a significant degree on the VISIMP variable, which is a self assessment of importance of air quality. This type of self-assessment variable would not normally be available when making predictions of how future tourists would respond to visibility changes.

The BSP variable, which is the key to making predictions on tourists' response to visibility, is highly significant based on the T- ratio, and has the greatest impact on the equation based on the elasticity computation. The high statistical significance and the large sample size indicate that we can be fairly confident in the accuracy of the estimated coefficient, provided that we have not left out any important explanatory variables that may be correlated with BSP.

The other physical variable, cloud cover, also shows a significant effect on visibility perception. Relative to BSP its effect is quite small however, with only about 10 percent of the impact of BSP in terms of elasticity of response.

Only two out of eight area of origin variables proved to be statistically significant. Respondents from Canada (outside of B.C.) and Asia both had slightly higher violation rates than the mean of the remaining groups. However, based on the elasticity coefficients, this effect is not large in comparison to the effect of BSP, and the effects of this variable are only shifts of a few percentage points in the violation rates.

Of the other socio-economic variables, only AGE was statistically significant. Its impact is greater than any of the area of origin variables, but still substantially less than BSP.

<u>Analysis of Grouped Response Data for Chilliwack</u>

The grouped response data consist of eight sub-groups, each representing an area of origin. The average violation rate per sub-group replaces the binary violation variable. The other socio-economic variables, as defined in Table 3.2, represent sub-group averages. Because the data have been grouped by area of origin, the binary variables for area of origin retain their variation between groups.

With eight areas of origin, and 10 slides, a total of 80 observations are available for estimation. This reduction in the number of degrees of freedom along with the averaging out of much of the variation in socio-economic variables tends to make it more difficult to detect statistical significance of these variables. However, as mentioned the variation in the physical variables is retained. The averaging out of individual unexplained variation in response to visibility should tend to give the equation a better overall fit than estimated with the raw response data.

For purposes of estimation the dependent variable, AVR (average violation rate) has been transformed into the logit form as in equation (8) and the individual observations weighted as in equation (9) to account for heteroscedasticity.

Table 3.6
Logit Estimation of Violation Response for Chilliwack Location
Grouped Response Data

Dependent Variable - Logit form of Average Violation Rate; ln [AVR / (1-AVR)]
Weighted Least Squares Estimation
Number of Observations = 80

Variable Name	Estimated Coefficient	Standard Error	T-Ratio 75 Df	Elasticity At Means
BSP	26.849	3.922	6.846	-3.0560
CAN	0.31449	0.3080	1.021	-0.1091
ASIA	0.75969	0.4735	1.604	-0.0939
CLOUD	0.96127	0.3096	3.105	-0.3538
CONSTANT	-3.0510	0.3286	-9.285	4.6128

R-Square = 0.4980 R-Square Adjusted = 0.4713
Variance Of The Estimate-Sigma**2 = 1.3007
Standard Error Of The Estimate-Sigma = 1.1405
Sum Of Squared Errors-SSE= 97.551
Mean Of Dependent Variable = -0.66142
Log Of The Likelihood Function = -145.175

The overall fit of the grouped response equation is better than the equation estimated with the individual response data, although no socio-economic variables show statistical significance. This is attributed to the averaging out of the unexplained response variation between individuals when they are grouped into sub-groups.

As expected, none of the socio-economic variables show up as significant in the estimated equation using grouped response data. Even the VISIMP variable, (self-assessment of personal importance of air quality) which was very significant in the raw data analysis, is insignificant in the analysis of grouped data. The area of origin variables that were significant in the individual data analysis have been left in the regression although their statistical significance falls below the 95% confidence level in the grouped regressions. The ASIA variable is significant at the 80% level. Inclusion of the two area of origin variables does improve the adjusted R^2 of the equation, meaning that the extra explanatory power they add to the equation compensates for the loss in degrees of freedom when they are included.

The physical variables, BSP and CLOUD both remain significant in the estimated equations using the grouped data. Most importantly, the estimated coefficient for BSP of 26.85 is very close to the coefficient of 30.86 for BSP estimated from the individual response data. This robustness of the BSP coefficient over different estimation methods provides increased confidence that we have a true estimate of its effect on perception of visibility.

Estimation of the Abbotsford Response Equations

Respondents viewed 12 slides taken near the Abbotsford Airport. These slides were of a basically rural setting with forested landscapes and mountain ridges. There were less landmarks on the mountainous horizon than in the Chilliwack slides. However, a wide range of visibility was shown in the slides, and in the worst cases visibility of the nearest forest features were impaired. The BSP readings ranged from .02 to .126.

Analysis of Individual Response Data for Abbotsford

With 12 slides and 156 respondents, 1872 observations were available for the estimation. Of these 1,046 indicated a violation and 846 indicated no-violation. Maximum Likelihood estimation of the logit equation to predict the violation rate from individual data is shown in Table 3.7.

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Table 3.7
Logit Estimation of Violation Response for Abbotsford Location
Individual Response Data

Dependent Variable - Violation Rate (binary) one = violation, zero = no violation
Number of Observations = 1872 Maximum Likelihood Estimation

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	Elasticity At Means
BSP	43.174	1.9665	21.955	0.59639
AGE	0.23544	0.84497E-01	2.7863	0.11187
EXPEND	-0.24815	0.55150E-01	-4.4995	-0.20549
VISIMP	0.95266	0.82240E-01	11.584	0.61263
CLOUD	1.5731	0.15383	10.226	00.87799E-01
CONSTANT	-5.2658	0.39025	-13.494	-1.1973

Log-Likelihood Function = -752.07
Log-Likelihood(0) = -1285.2

Likelihood Ratio Test = 1066.24 With 5 D.F.

Maddala R-Square 0.4341
Cragg-Uhler R-Square 0.58147
Mcfadden R-Square 0.41482
Adjusted For Degrees Of Freedom 0.41325
Approximately F-Distributed 0.85064 With 5 And 6 D.F.
Chow R-Square 0.47949

The results for this location show some similarities to the estimated equation for Chilliwack. Again, the dominant variables are BSP and VSIMP. The AGE variable is again significant and positive, indicating a slightly higher personal visibility standard for the older respondents. The variable EXPEND (index of amount spent on vacation) also is significant in the Abbotsford estimation indicating that tourists who spend more also have a slightly lower visibility standard than the group mean. None of the area of origin variables showed any significance in this location.

The relationship of the two physical variables, BSP and CLOUD, to the violation rate also shows some consistency between the Abbotsford and Chilliwack locations. Both variables are highly significant, but BSP is dominant relative to CLOUD; with an elasticity of about seven times greater.

The overall fit of the equation is better than the Chilliwack location, with the various R-Square measures ranging from .41 to .58.

Analysis of Grouped Response Data for Abbotsford

With eight sub-groups based on area of origin and 12 slides, a total of 96 observations were used to estimate the response equation shown in Table 3.8.

Table 3.8
Logit Estimation of Violation Response for Abbotsford Location
Grouped Response Data

Dependent Variable - Logit form of Average Violation Rate; ln [AVR / (1-AVR)]
Weighted Least Squares Estimation
Number of Observations = 96

Variable Name	Estimated Coefficient	Standard Error	T-Ratio 92 Df	Elasticity At Means
BSP	35.085	2.898	12.11	6.5588
NEARUS	1.5982	0.6636	2.408	0.1241
CLOUD	1.2795	0.2502	5.114	0.9562
CONSTANT	-2.4956	0.2530	-9.865	-6.6391

R-Square = 0.6350 R-Square Adjusted = 0.6231

Variance Of The Estimate-Sigma**2 = 1.1885
Standard Error Of The Estimate-Sigma = 1.0902
Sum Of Squared Errors-Sse= 109.34
Mean Of Dependent Variable = 0.37590
Log Of The Likelihood Function = -170.968

The overall explanatory power of this equation with an R^2 of .635 is better than the equation estimated with the individual response data. BSP and CLOUD remain significant, with coefficients similar to those estimated with the individual response data.

The only area of origin that proves significant is the close U.S. states (NEARUS). Although statistically significant, its elasticity is again relatively low in comparison to the physical variables. No socio-economic variables were found to be significant.

Estimation of the Matsqui Response Equations

Respondents viewed slides taken of an integrated urban/rural setting. Although the setting did not have as many distinct landmarks on the horizon, the close landmarks were often partially obscured during episodes with higher BSP. The discolouration and blurring of forest landscapes relatively close to the camera location also increased the effect of poor air quality on visibility. The BSP readings ranged from .015 to .106.

Analysis of Individual Response Data for Matsqui

The Matsqui slides were shown to a smaller number of respondents; 53 versus 156 for the other locations[24]. With 13 slides and 156 respondents, 689 observations were available for the estimation. Of these, 218 indicated a violation and 471 indicated no-violation. Maximum Likelihood estimation of the logit equation to predict the violation rate from individual data is shown in Table 3.9.

Table 3.9
Logit Estimation of Violation Response for Matsqui Location
Individual Response Data

Dependent Variable - Violation Rate (binary) one = violation, zero = no violation
Number of Observations = 689 Maximum Likelihood Estimation

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	Elasticity At Means
BSP	62.762	5.5743	11.259	2.0416
EXPEND	-0.26910	0.11453	-2.3496	-0.70912
VISIMP	0.76037	0.13141	5.7862	1.4124
ASIA	1.0800	0.43315	2.4934	0.77757E-01
JAPAN	1.3587	0.25271	5.3764	0.44997
CLOUD	1.2165	0.21914	5.5512	0.42850
CONSTANT	-6.0198	0.68637	-8.7705	-4.5942

[24] Some of the Matsqui slides did not become available until part way through the summer field season in 1999, hence the smaller sample size.

Log-Likelihood Function = -281.54
Log-Likelihood(0) = -430.02
Likelihood Ratio Test = 296.972 With 6 D.F.
Maddala R-Square 0.3502
Cragg-Uhler R-Square 0.49110
Mcfadden R-Square 0.34530
Adjusted For Degrees Of Freedom 0.33954
Approximately F-Distributed 0.61531 With 6 And 7 D.F.
Chow R-Square 0.39035

Visitors from both Asia and Japan exhibit a statistically higher violation rate at this location than the group mean. The impact seems much higher for the Japanese according to the elasticities at the mean, although both variables have small impacts in comparison to BSP. The expenditure variable has a negative and significant impact on the violation rate, indicating that visitors who spend more are less influenced by changes in visibility.

The overall fit of the equation, with the R^2 measures ranging from .35 to .49 is somewhat higher than the Chilliwack equation and lower than the Abbotsford equation.

<u>Analysis of Grouped Response Data for Matsqui</u>
With the smaller sample size for Matsqui, two areas of origin were not represented. Thus the data are aggregated into six groups rather than eight. With thirteen slides, a total 78 observations were available for the estimation shown in Table 3.10.

Table 3.10
Logit Estimation of Violation Response for Matsqui Location
Grouped Response Data

Dependent Variable - Logit form of Average Violation Rate; ln [AVR / (1-AVR)]
Weighted Least Squares Estimation
Number of Observations = 78

Variable Name	Estimated Coefficient	Standard Error	T-Ratio 73 Df	Elasticity At Means
BSP	55.170	8.809	6.263	-3.0547
ASIA	1.7900	0.5565	3.216	-0.3342
JAPAN	1.3621	0.4138	3.292	-0.7108
CLOUD	1.3827	0.3802	3.636	-1.1149
CONSTANT	-4.6874	0.6180	-7.585	6.2145

R-Square = 0.3898 R-Square Adjusted = 0.3563
Variance Of The Estimate-Sigma**2 = 2.4329
Standard Error Of The Estimate-Sigma = 1.5598
Sum Of Squared Errors-Sse= 177.60

Mean Of Dependent Variable = -0.75427
Log Of The Likelihood Function = -173.874

BSP and CLOUD remain significant as in the individual response equations. The coefficient for BSP drops in magnitude slightly, but is still comparable to the coefficient estimated in the individual response equations. The areas of origin for JAPAN and ASIA remain significant. The overall fit of the equation is only slightly improved.

Estimation of the Mt. Seymour Response Equations

Only four slides were available at this location. In contrast to the other locations, the slides presented a view from altitude, looking down into an urban and water landscape, with coniferous forest in the foreground. The respondents could see a visible layer of pollution with some discoloration, even at relatively modest BSP readings. At higher BSP readings, visibility impairment rose dramatically, partially obscuring the forest in the foreground as well as the inner harbour and urban development. There was not sufficient variation in cloud cover within the four slides to be able to construct a cloud variable for the analysis.

The Mount Seymour location also presented some extra difficulties concerning measurements of the BSP parameter. At the times the photographs were taken, the nearest open chamber nephelometer station (Pitt Meadows) was not operating and BSP readings equivalent to those taken at the other locations were not available. However, BSP readings from a closed chamber nephelometer at Rocky Point Park (relatively close to Mt. Seymour) were available for the times the photographs were taken. Because considerable differences generally occur in the readings from closed versus open chamber instruments, an analysis was done to relate the closed chamber readings to equivalent open chamber readings. This was done by regression analysis that correlated closed chamber BSP with open chamber BSP and relative humidity for a period of record when both Rocky Point Park and Pitt Meadows stations were operating. The conversion equation had a reasonably good statistical fit and was then used to generate the open chamber BSP readings used as explanatory variables in the violation response equations for the Mt. Seymour location. Appendix Three gives the details of the statistical estimation of the conversion equation.

Once converted, the BSP readings ranged from .021 to .067.

<u>Analysis of Individual Response Data for Mt. Seymour</u>

The Seymour slides were shown to the full group of respondents. One respondent from the sample of 156 tourists was deleted for the Seymour location because of an incomplete response. With four slides a total of 620 observations were available using the individual response data. Of these, 412 indicated a violation 208 indicated no-violation. Maximum Likelihood estimation of the logit equation to predict the violation rate from individual data is shown in Table 3.11.

Table 3.11
Logit Estimation of Violation Response for Mt. Seymour Location
Individual Response Data

Dependent Variable - Violation Rate (binary) one = violation, zero = no violation
Number of Observations = 624   Maximum Likelihood Estimation

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	Elasticity At Means
BSP	78.623	6.5987	11.915	0.90459
VISIMP	0.55995	0.12408	4.5129	0.40403
AGE	0.30471	0.13386	2.2764	0.16326
ASIA	0.94221	0.49923	1.8873	0.12503E-01
CONSTANT	-4.7124	0.58915	-7.9986	-1.2116

Log-Likelihood Function = -282.61
Log-Likelihood(0) = -395.56
Likelihood Ratio Test = 225.891 WITH 4 D.F.

Maddala R-Square 0.3053
Cragg-Uhler R-Square 0.42359
Mcfadden R-Square 0.28554
Adjusted For Degrees Of Freedom 0.28089
Approximately F-Distributed 0.49956 With 4 And 5 D.F.
Chow R-Square 0.36090

The results for this equation are consistent with other areas despite the problems with the lower number of slides, lack of a cloud cover variable and with the conversion of BSP to account for the difference in closed chamber and open chamber instruments. BSP has the greatest impact and socio-economic variables are not significant with the exception of the AGE variable which has a positive effect on the violation rate.

The overall fit of this equation with R^2 values ranging from .29 to .42 is comparable to the Chilliwack and Matsqui equations but lower than the R^2 values of the Abbotsford equation.

Analysis of Grouped Response Data for Mt. Seymour

With only four slides and eight regions of origin, the number of observations is reduced to 32. Estimations are possible with this smaller sample size although the statistical confidence will be reduced because of the smaller degrees of freedom.

Table 3.12
Logit Estimation of Violation Response for Mt. Seymour Location
Grouped Response Data

Dependent Variable - Logit form of Average Violation Rate; ln [AVR / (1-AVR)]
Weighted Least Squares Estimation
Number of Observations = 32

Variable Name	Estimated Coefficient	Standard Error	T-Ratio 30 Df	Elasticity At Means
BSP	58.977	11.98	4.924	4.1540
CONSTANT	-1.8492	0.5444	-3.397	-3.1540

R-Square = 0.4470 R-Square Adjusted = 0.4285
Variance Of The Estimate-Sigma**2 = 1.6537
Standard Error Of The Estimate-Sigma = 1.2860
Sum Of Squared Errors-Sse= 49.611
Mean Of Dependent Variable = 0.58632
Log Of The Likelihood Function = -60.6342

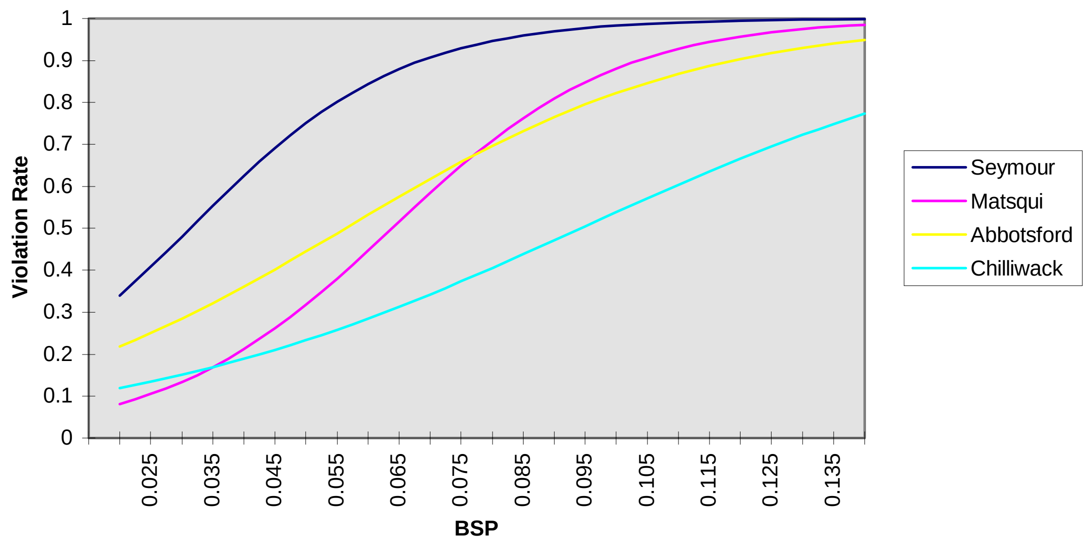
None of the area of origin variable are significant in the grouped analysis for Mt. Seymour. The overall fit of the equation is slightly improved over the individual response estimate and the effect of BSP is reduced although not a great deal smaller than estimated with the individual response data.

General Discussion of Results

Impact of Physical Variables

The impact of BSP is consistently significant and large relative to other variables. The magnitude of its effect is robust over two different estimation methods (individual response functions and grouped response functions), although its impact is slightly less in the grouped response functions. The relative effect of BSP varies depending on the location. The estimated coefficients for BSP are fairly close and relatively large for the Mt. Seymour and Matsqui locations while Abbotsford and Chilliwack have smaller coefficients, close in magnitude to each other. The size of the estimated coefficient is over 80% greater at Mt. Seymour and Matsqui than at Abbotsford and Chilliwack, meaning that an increase in BSP results in an earlier and greater change in violation rates (Figure 3.2)

Figure 3.2
Violation Response Functions



Cloud cover consistently affects the violation rate in both the individual and grouped response equations, demonstrating that respondents were more likely to record a violation under cloudy conditions. The impact of cloud cover on the violation rate varies from location to location, but is always small relative to the impact of BSP. Overall, its impact ranges from one tenth to one fifth of the impact of BSP as measured by the elasticity at means.

Impact of Area of Origin

In general, the area of origin is not a large factor in explaining differences in response to visibility. Of the eight areas of origin recorded, four showed no statistical significance in any of the estimated response functions. The remaining four areas of origin sometimes proved significant for different locations, as shown in Table 3.13. It is important to note that even for those instances in which area of origin did prove to be significant, the predicted shift in violation rates (compared to the average of all other areas of origin) was small relative to the effect of the BSP variable.

Table 3.13
Significance of Area of Origin on Violation Rate

S indicates significantly greater than mean of all other areas
ns indicates no significant difference from mean of all other areas

	Other Canadian Provinces	Asia	Japan	Near U.S.
Individual Response Data				
Chilliwack	***S***	*ns*	*ns*	*ns*
Abbotsford	*ns*	*ns*	*ns*	*ns*
Matsqui	*ns*	***S***	***S***	*ns*
Mt. Seymour	*ns*	***S***	*ns*	*ns*
Grouped Response Data				
Chilliwack	*ns*	***S***	*ns*	*ns*
Abbotsford	*ns*	*ns*	*ns*	***S***
Matsqui	*ns*	***S***	***S***	*ns*
Mt. Seymour	*ns*	*ns*	*ns*	*ns*

The variables for other Canadian Provinces and close U.S. states each proved to be significant in only one of the eight estimated response equations. In both cases, the impact was minor although statistically significant. Based on these results it is not likely that visitors from either of these locations can generally be expected to respond differently to visibility than the group average for all visitors.

The results for Asian visitors show some consistency indicating a greater response to visibility degradation. In four out of eight estimated equations, Asian visitors showed statistically significant higher violation rates than the group average. However, even when significant, the coefficients were not of great magnitude and only resulted in a five to 10 percent increase in the violation rate. The results should also be treated with caution because of the small number of Asian visitors in the sample.

Japanese visitors had statistically higher responses to visibility degradation in the Matsqui location for both the individual and grouped response equations. The relative impact of the estimated coefficient for Japanese visitors was much higher than for any other group at any location. Given the statistical significance, the size of the coefficients and the adequate sample size of Japanese visitors, we can be reasonably confident in these results.

It is not immediately evident why visitors from Japan would have a greater response to visibility degradation in the Matsqui slides than they would in other locations. The Matsqui vista does have a different appearance from the other locations in that it shows a more integrated picture of city and forest settings, where buildings and developments are surrounded or close to the forested hill that dominates the slide. Possibly Japanese visitors may have responded more to visibility degradation because of sensitivity to these visual differences.

Impact of Other Socio-Economic Variables

The remaining socio-economic variables included gender, ranking of visual air quality at home, age and amount spent on vacation. As expected, none of these variables showed significance in the grouped data response equations because much of their variation was averaged out when taking group means. Therefore, only the results of the individual data response equations were used to assess the significance of these variables.

In general the impact of socio-economic variables was insignificant or minor in the individual data response equations. Two of the variables, gender and ranking of visual air quality in home area, were not significant in any of the estimated response equations. The remaining two variables, age and amount spent on vacation, proved to be significant in more than one location as shown in Table 3.14 .

Table 3.14
Effect of Socio-Economic Variables on Violation Rate

\+ indicates statistically significant with positive impact

\- indicates statistically significant with negative impact

ns. Indicates no statistical significance

Equations estimated with individual response data

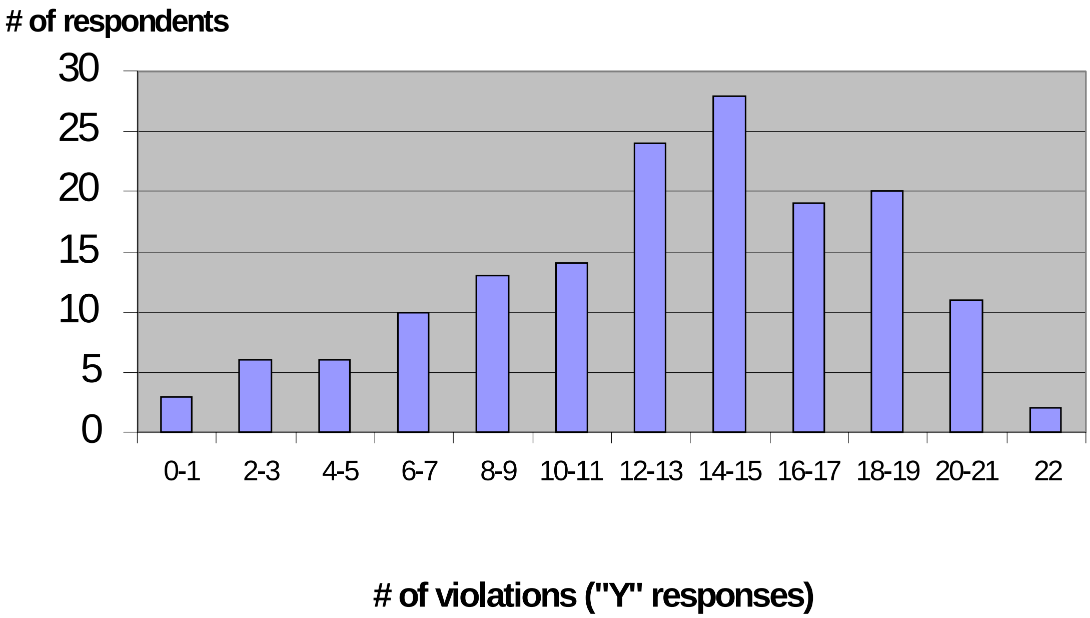
	AGE	EXPEND
Chilliwack	+	ns
Abbotsford	+	-
Matsqui	ns	-
Mt. Seymour	+	ns

In two out of the four locations the expenditure variable showed a significant negative relationship with the violation rate. As with most socio-economic variables, the size of the estimated coefficient and the overall effect on the violation rate is relatively small in comparison to the BSP variable. An explanation for this result may be that visitors who spend a great deal while on vacation in the area may be slightly less affected by visible air pollution because more of their time is spent on shopping, indoor entertainment and restaurants - activities where enjoyment is less impaired by outdoor air quality.

In three of the four locations, the age of the respondents shows a statistically positive relationship with the violation rate. Again this effect is relatively small in comparison to BSP. Older visitors thus seem slightly more sensitive to visibility degradation than younger visitors. Possibly this result could be due to higher expectations or more sensitivity to health issues in the older visitor population.

Frequency Distribution of Violation Responses
The frequency distribution of violation responses for individual respondents is shown in Figure 3.3 . This graph shows that the majority of the respondents indicated from 12 to 19 violations for the 39 slides viewed. The distribution appears somewhat normal, peaking in the middle range and tailing at the lower and higher ends of the distribution. Only a few respondents showed a zero or near zero response to poor visibility and of 156 respondents only two individuals failed to record at least one violation. The maximum number of violations recorded was 22 (by two individuals).

Figure 3.3
Violation Frequencies



Validity of Responses
The statistical analysis also included tests of the individual consistency (validity) of responses. The statistical significance of the VISIMP variable, which was a self ranking of the importance of visual air quality, represented the first test. In all four locations the impact of this variable on violation rates was highly significant in the equations estimated from individual response data . Thus, we can conclude that respondents were consistent in their self evaluations and in their responses to validity.

A second test for internal consistency relates to the respondents' ranking of the visual air quality depicted in the slides. This ranking should be significantly correlated with the violation rate if respondents were consistent in their judgment of the slides. To test this correlation, the average violation rate for the grouped responses was regressed against the average air quality score for the four locations. The R^2 values, shown in Table 3.15, ranged from .67 to .86, indicating a high degree of correlation, further evidence of the internal consistency of individuals' responses. The consistency between the rated air quality score and the violation rate was also observed in the previous REVEAL studies, which showed significant correlation between the two variables.[25]

Table 3.15
R^2 from Regression of Average Score on Violation Rates
Grouped Response Data

Location	R^2
Mt. Seymour	.83
Matsqui	.67
Abbotsford	.86
Chilliwack	.67

Comparison of Tourists to Residents

It is possible to compare the general results of this study to the previous REVEAL studies that aimed at determining a level of visibility acceptable to residents of the region. It should be re-iterated however, that the REVEAL studies did not define violation of visibility standards in the same way as the current study. The resident respondents were simply asked to rate each slide as acceptable or unacceptable based on their personal visibility standards. In contrast, the tourist respondents in this study were given a definite benchmark; an unacceptable slide was one that would deter them from a return visit or from recommending the area as a tourist destination. With these distinctions in mind, Table 3.16 shows a comparison of the violation rate between tourists and residents.

Table 3.16
Comparison of Violation Rates of Tourists and Residents

Location	Violation Percentage*	
	residents	tourists
Matsqui	57.4	29.9
Chilliwack	44.6	35.3
Abbotsford	58.9	53.6

* Violation percentage is the total number of violations divided by the total number of observations (ungrouped data) at each location.

[25] Pryor, Stephens and Steyn, 1995 op. cit. ..

From Table 3.16 it is evident that residents have significantly higher violation rates than tourists, particularly for the Matsqui slides. The majority of the difference arises in slides where BSP is moderately high. For slides with very high BSP and extremely poor visibility, the differences in violation rates between tourists and residents are small.

The difference between tourists and residents may arise because of the different definitions of acceptability. Because tourists were asked to relate their definition of unacceptability to a definite consequence (not returning or recommending the area), they may have been more conservative in their evaluations. Another reason may be that residents live in the area year round resulting in higher standards as to what constitutes acceptable visibility.

Summary and Conclusions

The major policy variable of concern, BSP, shows statistically high significance and a large impact on the violation rate of the sample of visitors. Estimates of its coefficient in logit formulations of the response equation are fairly robust over two different estimation methods. It is concluded that the response equations estimated from the sample are good estimates and predictors of tourists' responses to visibility changes at the four locations. The other physical variable, cloud cover, also has a high degree of statistical significance and is robust in its effects on response to visibility. Its effect is, however, relatively small in comparison to BSP.

Cultural or socio-economic variables attempt to explain differences in violation rates based on differences in individuals. These 'people' variables prove to be less significant, less consistent and have far less impact than the 'physical' variables when estimating the violation response equation. From a tourist marketing viewpoint, a cautious conclusion would be that Japanese visitors exhibit some extra sensitivity to visibility degradation in certain locations that have characteristics similar to the Matsqui vista. The non-Asian visitors also indicate a slightly higher response to visible air pollution in two locations, although a larger sample of non-Japanese Asian visitors would be necessary to verify the increased sensitivity of this population to changes in visibility. Two other socio-economic variables, age and amount spent on vacation had a small influence on sensitivity to visible air quality.

Because of the relatively small importance of the socio-economic variables, it becomes difficult to estimate a violation response equation that fully characterizes the different response rates between individuals. This is evidenced by the generally low to moderate R^2 in the estimated equations. Grouping the data by area of origin results in a better fit of the equations, but it is still evident that there is a large degree of variation between individuals that can not be explained, except on the basis of basic individual priorities that are largely independent of common socio-economic and cultural classifications. Despite the limited power to explain individual variation of response to visibility degradation, it should be re-stated that the estimated equations do give robust, statistically significant and consistent estimates for BSP, which is the major policy variable in question. Given the large number of tourists visiting the region each year, the unexplained variation between individual tourists is not a major factor when predicting the aggregate response of tourists to visibility changes.

Chapter Four
Economic Implications of Poor Visibility Episodes

Based on the response functions from the sample group of tourists, it is possible to predict the response of the general tourist population to poor visibility episodes and to translate this response into losses in tourism revenues in the region. A future drop in tourist revenues will occur because a proportion of visitors who experience a poor visibility episode will not return or will not recommend the area to other potential visitors. Because word of mouth advertising and return visits are important influences on the total number of visitors, the results of a single poor visibility episode will be significant.

At the time of writing, we do not have full information on the frequency of poor visibility episodes among the various locations frequented by tourists in the area. Therefore it is not possible to estimate the total economic losses due to an expected frequency curve of poor visibility occurrences. Nor is it possible at this time to estimate the economic benefits of a policy that will reduce the frequency of poor visibility episodes. However, it is possible to provide an estimate of the tourist dollar losses for *given* levels of poor visibility expressed as BSP levels from nephelometer readings. This will demonstrate the potential economic impact and serve as a basis for further physical and economic investigation of the problem. As further information on the expected frequency curve of poor visibility becomes available, the work can be expanded to include a frequency analysis of poor visibility and to assess the impact of various policies to improve visibility.

Purpose of Economic Analysis

The purpose of this analysis is to illustrate the magnitude of future losses in tourist revenue associated with selected poor visibility episodes, where visibility is expressed as a function of BSP. These estimated changes in tourist revenues can be used in subsequent analysis to generate changes in total regional income, changes in jobs created directly and indirectly from the tourist industry and changes in government revenues. It should be noted however, that prevented losses in tourist revenues are not equivalent to the strict definition of economic ‘benefits’ and several adjustments would have to be made to the figures before they could be used in a traditional benefit-cost analysis of policy measures to improve visibility[26].

[26] Traditional benefit-cost analysis uses the sum of individual consumer and producer surplus as the basis for benefits. To convert changes in tourist revenues to producer surplus, the variable costs associated with providing the services to the tourists would have to be subtracted. Individual consumer surpluses associated with visibility changes for the B.C. or Canadian tourists would have to be added in. A foreign exchange benefit associated with the expenditures of foreign visitors would also factored in to arrive at total benefits.

Losses in tourist revenues are predicted for two sub-areas of the region - the western sub-area that includes the major population and tourist centers, and the eastern Fraser Valley region from Langley to Hope. These two areas have significant differences in the composition of the aerosols causing visibility degradation, in the coloration and striation of visible air pollution and in frequency of poor visibility episodes. The extra resolution provided by this sub-area breakdown will thus provide information more specific to future policy alternatives in these areas.

General Procedure

There are two steps to calculating the economic consequences of a given poor visibility episode:

a. use the estimated violation rate equations to predict the total number of tourists whose personal standards will be violated for given levels of BSP.
b. estimate future loses in tourism revenue based on changes in return visitation rates and on new visits generated by word of mouth advertising.

The detailed methodology and assumptions used in carrying out this analysis are described in the following sections.

Prediction of Total Violations in the Tourist Population

Although we have reasonable statistical confidence in the predictive power of the estimated equations at each of the four camera locations, the question remains as to which camera locations are most representative of what tourists will encounter while visiting the region. This question is complicated by the fact that three of the four vistas (Matsqui, Chilliwack and Abbotsford) are in the eastern Fraser Valley area while only one of the viewpoints (Mt. Seymour) represented a view of the western downtown area. However, given the variety of physical features displayed in the slides, it is possible to make some estimates of the type of scenes the tourist population as a whole would observe in the area and how they would react to visibility degradation.

<u>Variation in Response to Visibility at Different Camera Locations</u>

From figure 3.2 in the previous chapter, the Mt. Seymour vista evokes the strongest reaction to visibility degradation (expressed as BSP level), followed by Matsqui, Chilliwack and Abbotsford in order. Explaining these differences in response at the four viewpoints will help to provide understanding of how tourists will respond in other specific locations in the area.

There are a number of factors that make the Mt. Seymour view distinctly different from the other camera locations;

- it represents a downward view from a high lookout point
- a distinct layer of visibility degradation is apparent
- some visible darkening or coloration of the pollution layer is evident
- it has combined views of water and land.

The layering or striation of the pollution layer occurs because of the physiographic features of the location. Mist arising from the inner harbor or channeled through the narrows from the straight of Georgia combines with vehicle emissions to give distinct layers and pulses of visibility impairment over the water ways. These layers pick up some orange/brown colour from the nitrous oxides, providing greater distinction from the background.

In contrast visibility degradation in the eastern area most often takes the form of a ‘white haze’ which is vertically thick and with no discrete borders. It is evident that tourists respond somewhat less to the appearance of the white haze than they do to the coloured pollution ‘clouds’ that appear in the western regions. However, even within the white haze regions of the Fraser Valley, there are differences in response to visibility as evidenced by the high violation response in the Matsqui location (only slightly less than the response at Mt. Seymour) in comparison to the lower responses at Abbotsford and Chilliwack.

Differences in the response rates are most likely due to different visual clues in the vistas. In the Matsqui slides, the large hillside in the midrange was a visual marker that was often partially obscured when BSP was at moderate levels. The other Fraser Valley locations lacked a mid range marker to amplify the effects of a moderate reduction in visibility. Also as noted the Matsqui slides depicted an integrated urban/green wilderness area that might have evoked a stronger response from the sample group.

<u>Determining Representative Locations</u>
For the Fraser Valley sub-area the three camera locations in this region capture most of the physical features and typical views where visitors could perceive visibility degradation as it occurs. To predict the violation response of the tourist population the analysis therefore uses a simple average of the predicted response from Matsqui, Chilliwack and Abbotsford.

The Mt. Seymour location, by itself, may over-estimate the response of the general tourist population visiting the western area of the study region. The type of air pollution and degraded visibility that is readily apparent from Mt. Seymour is quite noticeable from many locations in the north and downtown areas, but may not be so striking when viewed from the southern areas of Richmond and Delta. Views of English Bay and the outer harbor often clearly depict coloured layers of air pollution, but these same layers may be less apparent looking northward over the inner harbor because the north shore mountains are close enough to be visible despite the effects of visual air pollution.

It is known that the large majority of tourists take part in a variety of activities while in the area, resulting in local travel to several different locations while staying in the region. Thus, during the course of a bad visibility day, tourists would likely encounter several different views in and around the city depicting poor visibility.

Without a greater range of camera viewpoints in the western area, it was decided to rely on an average predicted response of the Seymour and Matsqui locations as being representative of the general visibility picture in the western sub-area. The Seymour location is representative of the effects of poor visibility pulses over the water and inlets while the Matsqui location may be representative of vistas that combine urban and natural features. The averaging of the two areas results in a higher response rate for a given level of BSP than predicted in the Fraser Valley area and in a lower rate than would be predicted using the Mt. Seymour location alone.

Table 4.1 gives the predicted violation rates for Vancouver and the Fraser Valley at various levels of BSP.

Table 4.1
Violation Rates for Vancouver and Fraser Valley

BSP	Violation Rate Fraser Valley	Violation Rate Vancouver	BSP	Violation Rate Fraser Valley	Violation Rate Vancouver
0.035	0.219850	0.361476	0.09	0.681781	0.889254
0.04	0.253674	0.418292	0.095	0.715989	0.912583
0.045	0.291151	0.47623	0.1	0.746931	0.931578
0.05	0.332005	0.534134	0.105	0.774766	0.946817
0.055	0.375692	0.590969	0.11	0.799721	0.958895
0.06	0.421406	0.645776	0.115	0.822052	0.968373
0.065	0.468136	0.697642	0.12	0.842015	0.975752
0.07	0.514771	0.745711	0.125	0.859853	0.981461
0.075	0.560239	0.789262	0.13	0.875786	0.985856
0.08	0.603629	0.827796	0.135	0.890011	0.989227
0.085	0.644276	0.8611	0.14	0.902705	0.991805

An Economic Model of Tourists' Response to Poor Visibility

When an individual tourist's visibility standard, as defined in the questionnaire, has been violated, a future reduction in tourist visits will result. This reduction comes from two sources; (1) the decision not to return for a future visit by the same tourist and (2) decisions not to come to the region by others influenced by the word of mouth recommendations by the same tourist. Based on these two sources of future reductions it is possible to construct a simple model that predicts the magnitude of future losses in tourist revenues due to selected episodes of poor visibility.

The key data in constructing this model are the relative importance of return visits as a source of visitor generation and the importance of word of mouth recommendations in influencing potential visitors to come to the region. Fortunately these factors can be derived from extensive survey research carried out by the Vancouver Coast and Mountains Tourism Region (VCMTR) of Tourism British Columbia. The ongoing conversion research by VCMTR surveys visitors who have previously made inquiries to the region concerning tourist services. The 1998 analysis[27] carried out a mail-out survey of over 25,000 tourists who had made inquiries during the year, achieving a 25% response rate. The inquiries themselves were derived from a variety of magazine advertisements and other sources. The large sample was taken to be fairly representative of the tourist population as a whole.

Based on this survey the recruitment of new tourists in a given year is shown in Table 4.2.

Table 4.2
Recruitment of Visitors to the Region

Source	Percentage of Annual Visitors
Return Visits	37.3
Word of Mouth	9.8
Other	52.9

Given a single visibility event that results in a 100% violation rate, then the potential future visitor loss would be 47.1% of the tourists visiting during the event (9.8% word of mouth visits plus 37.3% return visits). This first order effect is expressed in equation (4.1). It assumes, conservatively, that return visitors only return once.

(4.1) First order losses in future visits = (Number of Visitors) x (Violation Rate) x 47.1% .

In addition to the first order effect there would also be an echo effect in future time periods. This echo effect occurs because the first order drop in visits results in less newly recruited tourists to continue word of mouth advertising in future periods. Equation 4.2 shows the echo effect in a subsequent period.

(4.2) echo loss = (First order losses) x 9.8%.

For a given event that causes a 100% violation rate, the first order loss is equal to 47.1% of the number of visitors viewing the event. The second order loss is equal to 9.8 % times the first order loss of 47.1 % resulting in an additional 4.6% loss in visits. The echo loss continues into the future although it declines very quickly because its value in each time period is only 9.8% of the previous period's losses. Essentially by the third time period it is very close to zero. For practical purposes the total future losses equal 51.7% (47.1% + 4.6%) of the visitors viewing the event. In general the total losses equal:

(4.3) Total losses = first order losses + echo losses.

[27] Tourism British Columbia, 1998, "Vancouver, Coast and Mountains Tourism Region - 1998 Conversion Research Summary"

To calculate the total losses in visits for a given visibility event, equations 4.1, 4.2 and 4.3 can be applied to the total visits during the event, using the violation rates calculated in Table 4.1. Equations 4.1 to 4.3 can also be used to calculate future revenue losses in the tourist industry by expressing visits in terms of expenditure per visit.

Seasonal and Daily Distribution of Tourists

In order to assess the impact of a one day bad visibility event, an estimate of the daily number of tourists or expenditures is required during the periods where extreme visibility events are likely to occur. In general extreme events usually happen during the summer months coincidental with peak tourist attendance. The following sections outline the sources and calculations used to obtain daily peak tourist expenditures.

<u>Greater Vancouver Area</u>

In 1999 Tourism Vancouver estimated the total tourist expenditures for the year as $3.6 billion.[28] The B.C. Visitor Study in 1995-96 reports information on the season of travel for visitors from various regions.[29] Using these data it was calculated that 39.5% of visitors of B.C. origin and 67% of visitors from outside of B.C. visit during the peak period of June to September. These peak season percentages were then weighted by the relative expenditures of B.C. resident visitors and non-resident visitors, also taken from the B.C Visitor Study.[30] Non resident visitors spent almost exactly twice the amount of resident visitors. Based on these weights it was determined that 49.5% of all tourist expenditures occur during the peak period.

The peak period, June to September, has 122 days. The daily tourist expenditure during this period for the Vancouver region is thus;

49.5% ($3.6 billion)/122 = $14.6 million.

<u>Fraser Valley Area</u>

Estimates of expenditures in the area of the Fraser Valley, from Hope in the east to Langley in the west, are not given in the literature. However, the B.C. Visitor Study reports that 20.2% of the visitors to the Vancouver, Coast and Mountains region visited locations in the Fraser Valley while in the region. It is possible that a good proportion of the expenditures of the Fraser Valley visitors took place in Greater Vancouver with less expended in the valley region. It is worth noting however, that there are some important primary tourist areas in the Fraser Valley such as Harrison Hot Springs and Cultus Lake. Furthermore, the Fraser Valley is the sole drive-through area for people approaching Greater Vancouver from the east and the communities on route provide significant services for the passer through. For the purposes of this study it was therefore estimated

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[28] Tourism Vancouver, "1999 Economic Impact Highlights - Greater Vancouver" reported on http://www.tourism-vancouver.org/docs/visit/about_vancouver

[29] Tourism British Columbia, "B.C. Visitor Study, - Report on Travel in British Columbia; The Report on Visitors to Vancouver Coast and Mountains Tourism Region. 1996, page 14.

[30] Tourism British Columbia, "B.C. Visitor Study" *op cit.*, page 6.

that daily peak expenditures in the Fraser Valley were 20% of the daily peak figures in the Greater Vancouver Area resulting in expenditures of $2.92 million per peak day in the region.

Losses Associated with Poor Visibility Events

Using the violation rates from Table 4.1, equations 4.1 to 4.3 and daily peak season tourist expenditures, we can estimate future losses in tourist revenues associated with a range of poor visibility events (as represented by BSP readings). These predictions are given in Table 4.2.

Table 4.3
Potential Losses in Tourist Revenues Associated with Poor Visibility Events

BSP	Greater Vancouver Area Revenue Losses (millions)	Fraser Valley Area Revenue Losses (millions)
.05	$4.03	0.50
.06	4.87	0.64
.07	5.63	0.78
.08	6.25	0.91
.09	6.71	1.03
.10	7.02	1.12
.11	7.24	1.20
.12	7.36	1.27
.13	7.45	1.32

For extreme visibility events revenue losses of about $7.45 million for the Vancouver area and $1.32 million for the Fraser Valley area are predicted. These projections are based on a single poor visibility event, and do not represent the annual mean tourist losses from visible air pollution. As mentioned previously, calculating the mean annual losses would require a frequency curve of poor visibility events (as measured by BSP) and sufficient data are not available at the time of writing to generate the expected frequency distribution of poor visibility events.

It is also important to note that significant losses occur at BSP readings of around .05, which, while not common, occur much more frequently than the extreme readings of over .10. While the losses are much less in individual magnitude than losses for extreme events, their cumulative impact could well be as great or greater than extreme events because of their more frequent occurrence. Again, a frequency distribution would be required to estimate the relative cumulative impacts of extreme versus moderate occurrences of poor visibility.

Chapter Five
Summary, Methodological Issues and Recommendations for Further Research

Because the study represents a new approach to quantifying the impacts of visible air pollution on tourism, it relies on some innovative but untested methods. The sensitivity of the final results to these methodological issues is worth examining, both to assess the confidence that can be placed in the results and to provide guidance for further research.

Summary and Methodological Issues

The study included three general phases;

1. Surveying a sample of tourists for their reactions to scenes of visible air pollution,
2. Statistical analysis of the survey results to predict violation of visibility standards,
3. Construction of a simple economic model to translate violation rates into losses in tourist revenues.

As each of these three phases was undertaken, a number of specific methodological issues were encountered. These issues are discussed below, with particular emphasis on how they might affect interpretation or confidence in the results.

<u>Sample Selection</u>

At the outset, the recruitment and surveying of a sample group of tourists presented the greatest challenge. Fortunately, the questionnaire design was able to draw on significant previous work carried out by Pryor, Stephens and Steyn[31] in the Fraser Valley and by Ely et al[32] in Denver, where residents were asked to determine an acceptable level of visibility based on their personal standards. The question remained however, whether a sample group of tourists would understand and respond to a similar survey (with some modifications). Recruitment of a sufficient and representative sample of tourists also posed significant logistical problems.

Very early in the survey process the researchers found that tourists were demonstrating an excellent understanding of the questions and the objectives of the survey. This was demonstrated by the internal consistency of responses, by the low overall rejection rate of returned surveys and by the nature of questions tourists posed to the facilitator. It was evident that tourists were as interested and as diligent in their responses as were residents in previous studies.

Recruitment of tourists for the survey required a flexible approach. Some of the major problems included determining an adequate sample size without prior information on the expected variance in responses, obtaining enough responses from tourists of different nationalities to determine the effect of ethnic origin on responses and obtaining a mix of

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[31] Pryor, Stephens and Steyn, 1995 op cit.

[32] Ely, D.W., Leary, J.T., Stewart, T.R. and Ross, D.M.: "The Establishment of the Denver Visibility Standard", Presented at the 84th Annual Meeting and Exhibition of the A&WMA, Vancouver, B.C. June 1991

both pleasure and business visitors. These issues could not be fully addressed until the process was started and the early responses examined. As the field season progressed, a variety of recruitment exercises, including a major international conference, a selected tour group and a booth at a major tourist destination, were carried out to ensure adequate representation. These exercises added significantly to the cost and the time involved in the survey. However, it proved possible to obtain enough responses for a statistically valid sample size, using a single facilitator and assistant in the course of one field season (spring and summer).

Possibilities of Self-Selection Bias

A possible shortcoming of any study that aims to assess the importance of environmental amenities based on sample respondents from a general population is self-selection bias. People who are more interested in environmental issues and place a higher value on environmental quality may be more inclined to respond to the survey, thus providing a biased indicator of the response of the general population. It is not possible to say to what extent this self-selection bias affected the results of the current study, although efforts were made to minimise the effect. Throughout the field season, the recruiters relied heavily on the gifts provided as a means to recruit tourists to the sample. All recruitment was carried out in the urban centres of Greater Vancouver, away from scenic and wilderness destinations that tend to attract more environmentally conscious visitors. Based on the assessment of the recruiters who interacted with the tourists, the primary reason for visitors to consent to the interactive survey was the free gifts provided. Overall, it is the authors' conclusion that self selection bias was not a significant factor and the results are not significantly affected by this effect.

Visual Reproduction Versus Live Viewing of Visibility Degradation

The question of whether or not respondents respond to projected images of air pollution in the same manner as they would to live viewing of the actual scenes is difficult to answer. Previous studies by Malm et al[33] and Middleton et al[34] compared responses to visual presentations with field survey responses to actual visibility and found high correlations. Their work provides some reassurance that the photographic slide presentation in the present study is a valid methodology for capturing responses to visibility changes. However, care should be taken when generalising results to other studies that present different perspectives, different scenes and elicit different types of information.

One of the major differences between viewing slides and between viewing actual events of poor visibility is that the slides present a number of different visibility conditions for each view shown. The respondents are therefore able form a mental baseline of what each scene should look like under unimpeded visibility, and then assess the slides with poor visibility against this baseline. Tourists viewing actual scenes during relatively

[33] Malm W., Kelley K., Molenar J. and Daniel T. (1981) "Human Perception of Visual Air Quality (Uniform Haze)", *Atmospheric Environment* **15**, 1874-1890

[34] Middleton P., Stewart.R. and Leary J. (1985) "On the Use of Human Judgement and Physical /Chemical Measurements in Visual Air Quality Management", *Journal Air Pollution Control District*, **35**, 11-18

short visits will not have the same baseline and therefore may not be aware of the extent that air pollution is affecting visibility. For mild to moderate visibility impairment they may not even attribute it to air pollution, particularly for the white haze events in the Fraser Valley. However, when distinct coloration or extreme visibility impairment exists it is much more evident that air pollution is the cause.

There are some factors in actual viewing of air pollution events that would increase tourists' sensitivity compared to viewing the same events on slide projections. The wide expanse of certain views, difficult to reproduce on a small screen, may elicit a stronger response to visible air pollution. Some individuals, through physical sensitivities to air pollution may be much more critical of visibility impairment in real situations than when assessing photographic slides.

In summary, greater confidence could be placed in the results of this analysis if site-specific studies were available comparing actual event responses to responses to photographic representation. In the absence of such studies, caution should be taken in interpreting the results, particularly for low to moderate visual impairment scenarios.

Camera Locations

Given the differences observed in the violation response functions at different camera locations, it would be useful to have a greater variety of views available in the analysis. Views are lacking from points in the southern area of Greater Vancouver in all directions. Given the sensitivity of the sample respondents to the city and water views from Mt. Seymour, the study would benefit from other locations that show views of highly frequented areas including English Bay and the outer harbour. In general, it was felt that the lack of camera from the major population centres of Greater Vancouver was a weakness in the study, and the representativeness of the locations used should be tested further when more camera locations become available.

Elicitation of Economic Information

The central question posed to the sample of tourists is much simpler than the detailed information usually solicited in studies that estimate values of environmental goods. Unlike contingent valuation studies, which aim to determine a monetary value of non-market environmental goods, the current study did not require the respondents to determine a personal monetary value or willingness to pay for changes in visible air pollution. Rather respondents were asked to determine the level of visibility degradation that would deter them from returning or recommending the location to others. This simplification of the valuation process removes much of the theoretical and operational issues that occur when hypothetical monetary values are solicited from respondents. Theoretical issues of contingent valuation include the difficulty respondents have in assessing the scope of the environmental amenity and the order in which environmental goods are presented for evaluation. Operational issues include the importance of careful definition of the environmental good, plausible policies for providing (protecting) it and a plausible payment mechanism applicable to all users. Improved statistical techniques, which have eliminated many of the earlier problems with this type of analysis, have however, resulted in larger sample size requirements.

Despite the above issues and debate about its reliability, a tremendous amount of applied analysis using contingent valuation techniques has been carried out and has formed the basis for significant policy evaluation of environmental questions. Compared to this body of contingent valuation analysis, the present study holds up well in terms of the confidence that can be placed in the answers given by the respondents. As noted in chapter four, however, the economic numbers generated by the present study are not necessarily comparable to the economic values generated by contingent value surveys and would be more suitable for a regional economic or multiple accounts analysis rather than a benefit-cost analysis.

Statistical Methodology

The study also attempted a more detailed statistical analysis than had previously been carried out on visibility/perception studies. Previous studies primarily were concerned with determining the 50th percentile acceptable visibility standard for residents, and used statistical analysis primarily for verification of internal consistency of responses. In contrast, the current study, which estimated violation response functions, required statistical methods of greater technical complexity. Despite the greater technical complexity, statistical methods designed for econometric and sociometric research proved to be readily adaptable to the problem at hand. The methodology should generally be suitable for future studies of this kind.

The Economic Model

The study relied on an original but highly simplified economic model to predict losses in future tourist revenues in which changes in future revenues result from losses in return visits and in word of mouth advertising. This model does not claim to represent the complete dynamics of tourist recruitment to the region. A notable shortcoming is that it does not predict the time period in which reduction of future tourist visits would occur. Thus, losses in revenues generated cannot be discounted to a present value.

The economic model gives conservative predictions of future losses from poor visibility for two major reasons. First, when calculating the reduction in future return visits, the model assumes that potential repeat visitors only make a single return trip to the region. This understates the total return visits, since many repeat visitors will return on several occasions. Second, the model only includes changes among the 47% of potential visitors who come because of word of mouth advertising or on return visits. The model assumes that the remaining 53% in each year represent a stable visitor population, unaffected by poor visibility events because they are independently recruited to the area through business affairs, pre-packaged tours and media advertising. Yet much of the convention and packaged tour industry depends on the general reputation of the area among trade professionals, convention/event organisers and the international media. This general reputation, which helps generate over half of the potential annual visitors, is also dependent on the natural amenities of the area including visual air quality. While it is difficult to quantify the effect of a single bad visibility episode on the general reputation of the area, it is certainly obvious that persistent poor visibility would, over the long run, erode the national and international status of the region as a tourist destination.

Recommendations for Further Research

Further research will be useful both in improving the estimates of losses in the current study and in estimating expected annual losses based on frequency evaluation of poor visibility events. Finally, an improved economic model incorporating greater knowledge of how and why tourist visits are generated would add confidence to the results.

<u>Improving the Estimates of Losses due to Specific Visibility Events</u>

The most important area for new research would be in obtaining and analysing responses from more camera locations in the area. As mentioned the analysis would benefit from additional camera viewpoints of the main populated area and adjacent waters. This would represent a significant expense and research effort since it requires integrated nephelometer and automated camera shots over a period long enough to experience some bad visibility events. However, such work is already scheduled under the Georgia Basin Ecosystem Initiative lead by Environment Canada, and the results will be used in future economic studies.

<u>Developing BSP Frequency Curves</u>

A BSP frequency curve would show the expected annual probability for a range of one day BSP events. Ideally these curves would be developed on a sub-regional basis, as probabilities are likely to vary substantially within the airshed. The frequency curves can then be integrated and multiplied by the economic losses at each level of BSP to give an annual estimate of tourist revenue lost due to poor visibility.

In order to carry the analysis a step further and assess the economic benefits and costs of policies that improve visibility, it is necessary to establish the relationship between emission reductions from various sources and the BSP frequency curves. For example, if a policy is introduced to reduce vehicular emissions by 20 percent, this reduction in emissions will generate a new frequency curve for BSP. The economic benefits due to improved visibility would be the difference in the annual losses between the old and new BSP frequency curves. Ongoing work on air quality chemistry along with better monitoring of pollutants and visibility should eventually provide enough data to quantify the relationships between emissions and frequency of poor visibility events.

<u>Improving the Economic Model</u>

The economic model would be improved by incorporating knowledge of the number and timing of repeat visits, the number and timing of visits generated by direct word of mouth, and by the importance of the general environmental reputation of the region. While such information may be expensive to generate, industry agencies do undertake major periodic surveys and questions could be added to these surveys to help generate data required to model growth and changes in the tourist industry. Given the importance of tourism to the region the extra effort would be justified.

Appendix One

Slide Descriptions and Illustrations

The following tables give the basic data for each of the slides presented during the interactive survey. All photographs and data were obtained during the 1993 REVEAL field season. The final column of the tables, which is 'Cloud Cover', contains either a zero indicating no cloud or a one indicating significant cloud cover. The bsp readings were taken with open chamber nephelometers at the Chilliwack, Matsqui and Abbotsford locations. The bsp reading for Mt. Seymour, was originally obtained from a closed chamber nephelometer and converted based on the statistical equation estimated in Appendix Three.

The illustrations of the slides in Figure A1, illustrate examples of good, moderate and poor visibility at each location.

Chilliwack Slide Data

SLIDE #	b_{sp}	b_{ext}	est. visual range$^{\Psi}$	# of violations	mean VAQ score	Cloud cover
	($10^{-3}m^{-1}$)	($10^{-3}m^{-1}$)	(km)	N=156	(scale from 1 to 7)	
A	0.126	0.199	19.65	66	2.9	0
B	0.027	0.055	71.09	8	5.1	0
C	0.02	0.036	108.61	71	3.1	0
1	0.063	0.105	37.24	40	3.5	0
2	0.067	0.112	34.91	60	3.1	1
3	0.086	0.128	30.55	86	3.2	0
4	0.119	0.185	21.14	126	2.3	1
5	0.018	0.037	105.68	4	5.6	0
7	0.045	0.07	55.86	13	4.8	1
8	0.051	0.096	40.73	54	4.0	**1**

$^{\Psi}$ Visual range estimate = $3.91/b_{ext}$. Where 3.91 = 2% threshold value for distinction of an object from the background. See Pryor 1996.

Abbotsford Slide Data

SLIDE	b_{sp}	b_{ext}	est. visual range[λ]	# of violations	mean VAQ score	Cloud cover
#	$(10^{-3}m^{-1})$	$(10^{-3}m^{-1})$	(km)	N=156	(scale from 1 to 7)	
D	0.029	*0.058*	*67.41*	11	4.8	0
E	0.121	*0.242*	*16.16*	142	1.9	0
F	0.132	*0.264*	*14.81*	47	3.6	0
11	0.082	*0.164*	*23.84*	116	2.8	1
12	0.039	*0.078*	*50.13*	72	3.4	0
14	0.104	*0.208*	*18.80*	149	1.3	1
15	0.024	*0.048*	*81.46*	3	5.8	0
16	0.016	*0.032*	*122.19*	5	5.1	0
17	0.075	*0.15*	*26.07*	80	3.5	0
18	0.062	*0.124*	*31.53*	99	2.9	0
19	0.145	*0.29*	*13.48*	138	1.9	0
20	0.031	*0.062*	*63.06*	91	2.5	1

Mt. Seymour Slide Data

SLIDE #	b_{sp}[℘]	b_{ext}	est. visual range[ℵ]	# of violations	mean VAQ score	Cloud Cover
			(km)	N=156	(scale from 1 to 7)	0
21	*.032*	.064	61	109	2.5	0
22	*.021*	.042	93	25	4.0	0
23	*.067*	.134	29	126	2.3	0
24	*.059*	.108	36	152	1.2	0

[λ] Visual range estimate = $3.91/b_{ext}$. Where 3.91 = 2% threshold value for distinction of an object from the background. And where b_{sp} = 50% of b_{ext} for an urban areas as per White.
See Pryor 1996.

[℘] Based on Rocky Point open-chamber nepholometer readings.
[ℵ] Visual range estimate = $3.91/b_{ext}$. Where 3.91 = 2% threshold value for distinction of an object from the background. And where b_{sp} = 50% of b_{ext} in urban areas as per White.
See Pryor 1996.

Matsqui Slide Data

SLIDE #	b_{sp}	b_{ext}	est. visual range[ξ]	# of violations	mean VAQ score	Cloud Cover
	($10^{-3}m^{-1}$)	($10^{-3}m^{-1}$)	(km)	N=54	(scale from 1 to 7)	0
G	0.015	*0.03*	*130.33*	1	5.5	0
H	0.037	*0.074*	*52.84*	9	4.5	0
I	0.073	*0.146*	*26.78*	50	1.8	1
31	0.032	*0.064*	*61.09*	25	2.9	1
32	0.042	*0.084*	*46.55*	10	3.7	1
33	0.036	*0.072*	*54.31*	9	3.9	0
34	0.106	*0.212*	*18.44*	48	1.5	0
35	0.047	*0.094*	*41.60*	4	4.1	1
36	0.04	*0.08*	*48.88*	11	4.1	0
37	0.017	*0.034*	*115.00*	18	3.6	1
38	0.049	*0.098*	*39.90*	26	3.2	1
39	0.025	*0.05*	*78.20*	6	4.4	0
40	0.034	*0.068*	*57.50*	1	5.5	0

[ξ] Visual range estimate = $3.91/b_{ext}$. Where 3.91 = 2% threshold value for distinction of an object from the background. And where b_{sp} = 50% of b_{ext} in urban areas as per White.
See Pryor 1996.

Appendix 1

sample slides

Figure A1

Abbotsford

clear

moderate

partially impaired

severely impaired

Chilliwack

clear

moderate

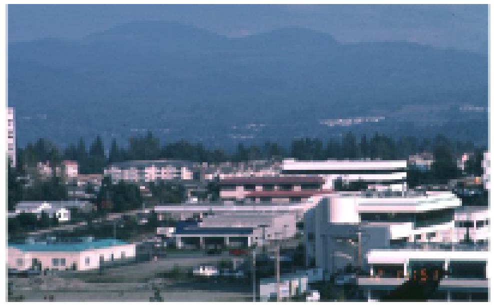
partially impaired

severely impaired

Appendix 1 **sample slides** Figure A1

Matsqui

clear



moderate

partially impaired

severely impaired

Seymour

clear

moderate

partially impaired

severely impaired

Appendix Two

Questionnaire and Facilitator’s Script

VISIBLE AIR QUALITY TOURISM SURVEY INSTRUCTIONS

Purpose of the investigation

To assess perception of visibility conditions in British Columbia's Lower Mainland. This study attempts to determine what visitors to the Lower Mainland consider acceptable visibility.

Method

You will be asked to view 28 slides of vistas in the Lower Mainland and to assess:

1) the visibility on a scale from 1 to 7 and

2) whether you feel the conditions depicted are acceptable for a vacation destination.

You are also asked to answer a few demographic related questions. This information is requested purely to help us assess how representative your sample group is of the population at large.

ALL INFORMATION IS STRICTLY CONFIDENTIAL. THE COMPLETED QUESTIONNAIRES WILL NOT BE REVIEWED BY ANYONE OTHER THAN THE INVESTIGATORS.

Your participation is strictly voluntary. A completed questionnaire will be regarded as evidence of your consent to full survey participation. To thank you for your participation, we will present you with a gift at the end of the session.

Time commitment: 30 minutes maximum.

Note: This questionnaire should have 5 pages, if it does not please advise the facilitator.

AIR QUALITY JUDGEMENT SURVEY

Session date: Observer #
(Please leave this blank)

VISUAL AIR QUALITY SCALE

1	2	3	4	5	6	7
very poor						excellent

<u>Instruction for Part 1</u>

Please indicate the visual air quality (VAQ) of the conditions depicted on each slide in the space provided below utilizing the 1-7 VAQ scale.

Warm-up slides

A. _________ D. _________
B. _________ E. _________
C. _________ F. _________

1. ________ 11. _________ 21. __________
2. ________ 12. _________ 22. __________
3. ________ 13. _________ 23. __________
4. ________ 14. _________ 24. __________
5. ________ 15. _________
6. ________ 16. _________
7. ________ 17. _________
8. ________ 18. _________
19. _________
20. _________

Instructions for Part 2

We are seeking your opinion on the level of visibility that you consider acceptable as a pleasure visitor to the Lower Mainland. For the purposes of this study, the Lower Mainland includes all of the municipalities of Greater Vancouver, as well as municipalities further east into the Fraser Valley. In Part 2, you will judge the slides again and decide whether conditions depicted represent unacceptably degraded visibility and would affect your decision to return to the Lower Mainland on vacation or to recommend the area to others.

When making your decision please consider the following:

1) Please base your answer on your expectations for this particular region as a vacation destination. Visitors come here for both the natural and urban setting.

2) Respond “Y” if you consider visual air quality to be unacceptable. Please do not merely indicate “Y” whenever any amount of scene degradation is detectable unless you believe that any amount of visibility impairment is “more than you want to see while on a trip to the Lower Mainland” and would “discourage you from returning to the Lower Mainland for a pleasure trip or recommending the area to others”.

In summary, your opinion should be based on what you feel is reasonable as a pleasure traveler to this particular area. Please indicate by circling a response whether the conditions depict an unacceptable amount of lost visibility for a pleasure trip destination in your opinion.

Part 2

Please remember the following:

1. Pleasure trip destination location
2. Visual air quality that is unacceptable. How much is too much?

Warm-up slides

A. Violate? Y N	D. Violate? Y N
B. Violate? Y N	E. Violate? Y N
Violate? Y N	F. Violate? Y N

Study slides

1. Violate? Y N	11. Violate? Y N	21. Violate? Y N
2. Violate? Y N	12. Violate? Y N	22. Violate? Y N
3. Violate? Y N	13. Violate? Y N	23. Violate? Y N
4. Violate? Y N	14. Violate? Y N	24. Violate? Y N
5. Violate? Y N	15. Violate? Y N	
6. Violate? Y N	16. Violate? Y N	
7. Violate? Y N	17. Violate? Y N	
8. Violate? Y N	18. Violate? Y N	
	19. Violate? Y N	
	20. Violate? Y N	

Demographic Information

(Reminder: This information is strictly CONFIDENTIAL)

1. Sex (circle one) M F

2. Age (circle one) 18 – 34 35 – 54 55+

1. Where are you from? (circle one)

British Columbia (other than Vancouver Island or Lower Mainland)
Other provinces
Washington or Oregon state
Other states
Europe
Asia Pacific
Other parts of the world

2. Approximately how much will you/would you spend while on vacation in the Lower Mainland? (circle one)

Under $200 CAN
$200 – 300
$300 – 500
$500 – 1000
over $1000

3. Using the same 1 – 7 scale you just used to evaluate the slides, how would you describe the air quality in your region of origin?

1
2
3
4
5
6
7

1. What do you usually do on vacation?

City/town site seeing
Visiting friends and relatives
Shopping
Art galleries/museums
Nightlife/entertainment
Casual walking
Outdoor wilderness activities
Downhill skiing/snowboarding
Hiking/backpacking

2. Having seen these slides, how important is visible air quality in your decision to visit, return or recommend a region?

Not important Somewhat important Important Very Important

Survey verbal directions for Facilitator

(Hand out questionnaires and pencils as people enter the room. When they are all seated and settled ask if anyone does not have a questionnaire or pencil).

Hello. My name is ***. I am here today to facilitate your participation in our survey regarding perception of visibility in the Lower Mainland. I want to emphasize that your participation is voluntary and you may withdraw at any time. A completed questionnaire, however, will be regarded as evidence of your consent to full survey participation. All your responses will be treated as confidential though the survey results will be released into the public domain. The purpose of this survey is to get your input on what you consider to be acceptable visibility for a region that you are visiting on vacation. Note, there are not right answers to the questions.

There are two parts to the survey: First you will judge the visual air quality (or visibility conditions) depicted on a number of slides. You will then judge these same slides and this time decide whether the conditions depicted would violate your visibility standard for a vacation destination. Please feel free to express any questions you have.

(Turn on the projector and show the **first** warm-up slide).

The slides I will show you were taken in Chilliwack, Abbotsford and Mount Seymour. The slides will be presented in fairly quick succession, you will be given 6 seconds to assess each slide.

There are 6 warm-up slides and then 22 study slides. The warm up slides were chosen to show you the range of visibility conditions and to get you familiar with the scale I will be asking you to use.

The scale during Part 1 of the survey is a 7-point visual air quality scale that you can see on page 2 of your questionnaire. The “1” is labeled “very poor” visual air quality and so corresponds to severely impaired visibility. “7” is labeled “excellent” visual air quality, and so corresponds to “excellent” visibility. So the lower numbers indicate poorer visibility and the higher numbers better visibility. As you look at each slide decide whether it should be rated 1, 2, 3, 4, 5, 6, or 7.

Please provide a response for each slide. Please don’t leave any blank. Again, there are no right answers. I should also mention that the relative humidity when each of the slides was taken was less than 75% and the slides do not depict ground-based fog.

So let's move through the warm-up slides. You will see them once and then I'll show them again and you can grade them then.

(Show the warm up slides).

I'd just like to point out that these first images are of the Fraser Valley and that it's the mountains in the distance that you can't see all that well.

Are there any questions? I want to remind you of the visual air quality scale. The higher the number, the better the visual air quality, the lower the number, the lower the visual air quality.

Just to remind you that you will be viewing 4 - 10 slides from four different locations.

(Go through the study slides using a 6-second exposure. Call out the number of each slide as it is shown. ***Halfway through the slides remind them that the higher the number the better the visual air quality conditions depicted****).*

These Mt Seymour slides are a little different. In this case, we're looking from up on the mountain down into a layer of visual impairment***.***

Reset slides to beginning

We will now do part 2 of the survey. I would like to read through the instructions with you.

(Read through instructions to part 2 while showing the first warm up slide).

Instructions for Part 2

We are seeking your opinion on the level of visibility that you consider acceptable as a pleasure visitor to the Lower Mainland. For the purposes of this study, the Lower Mainland includes all of the municipalities of Greater Vancouver, as well as municipalities further east into the Fraser Valley. In Part 2, you will judge the slides again and decide whether conditions depicted represent unacceptably degraded visibility and would affect your decision to return to the Lower Mainland on vacation or recommend the area to others.

When making your decision please consider the following:

1) Please base your answer on your expectations for this particular region as a vacation destination. Visitors come here for both the natural and urban setting.

2) Respond “Y”, for YES, if you consider visual air quality to be unacceptable. Please do not merely indicate “Y” whenever any amount of scene degradation is detectable unless you believe that any amount of visibility impairment is “more than you want to see while on a trip to the Lower Mainland” and would “discourage you from returning to the Lower Mainland for a pleasure trip”.

In summary, your opinion should be based on what you feel is reasonable and appropriate as a pleasure traveler for this area. Please indicate by circling a response whether the conditions depict an unacceptable amount of lost visibility for a pleasure trip destination in your opinion.

Are there any questions? We will run through the 6 warm up slides and then the 22 study slides that you have just seen. Remember this time you are viewing each slide so as to make a decision about whether you feel that visibility conditions depicted would fail a visibility standard you would set for the places you visit. The response is YES if you feel that the depicted conditions would violate your visibility standard and deter you from visiting a recommending a region.

(Go through warm-up slides)

You are being asked what level of visibility degradation is unacceptable to you for a leisure trip destination.

(Go through 24 study slides. Remind them that a “Y” responses indicated that those conditions violate their visibility standard for a pleasure visit destination.)

Finally, please fill out the demographic information requested. This information is strictly confidential and is requested purely to help us assess how representative the sample group is of the tourist population. Only one page.

Thank you for your participation. I hope you enjoy your stay in Vancouver.

(Ensure that all participants receive their gift on the way out).

SCREENING QUESTIONNAIRE

1. Where are you from? (screening out visitors from the Lower Mainland and Vancouver Island)

Lower Mainland or Vancouver Island	rest of B.C.
other provinces	Washington, Oregon
other states	Europe
Asia Pacific	other parts of the world

2. What is the purpose of your trip?

   a) business
   b) pleasure
   c) visiting family and friends

1. If you answered a) in question 2, would you consider returning to Vancouver for a vacation?

Appendix Three

Conversion of Dry Chamber BSP into Equivalent Open Chamber BSP

During the period that the photographs were taken from Mount Seymour the only nearby nephelometer operating was at Rocky Point Park. This was a closed chamber instrument that removed some of the water vapour before measuring the light scattering index, resulting in relatively lower readings than would have occurred with an open chamber instrument. In the other locations in the study (Abbotsford, Chilliwack and Matsqui), all BSP readings were recorded with open chamber instruments. In order to compare the results of the visibility readings at Mt. Seymour with these other locations, it was necessary to estimate an equation to convert dry chamber BSP readings to open chamber BSP.

A conversion equation was estimated by regression analysis relating open chamber BSP measurement at Pitt Meadows to the dry chamber measurement at Rocky Point and relative humidity. The relative humidity readings were based on hourly readings at Abbotsford, which was the closest weather station recording these data at the time.

Simultaneous hourly data for the three variables were available for a 25 day period during July and August of 1993. Based on the advice of S. Pryor[35] the regression analysis did not include observations where the relative humidity was greater than 80%, since BSP readings can be unreliable at high humidity. For practical purposes, all of the high humidity observations occurred during the night time, after the temperatures had dropped. Therefore the analysis relied solely on daytime observations.

The analysis used a double log form for the regressions. Untransformed, the relationship is expressed as a Cobb-Douglas function;

$$\text{BSPpm} = a_1 \text{BSPrp}^{b1} \text{RH}^{b2} \qquad \text{(A.1)}$$

where: BSPpm = BSP measured at Pitt Meadows (open chamber)
BSPrp = BSP measured at Rocky Point (closed chamber)
RH = Relative humidity measured at Abbotsford
a_1, b_1, b_2 are coefficients to be estimated

Taking the natural logarithm of each side of equation (A.1) gives a linear equation, which can be estimated by ordinary least squares regression:

$$\log(\text{BSPpm}) = \log(a_1) + b_1 \log(\text{BSPrp}) + b_2 \log(\text{RH}) \qquad \text{(A.2)}$$

The regression estimates for equation (A.2) are shown in Table A.1.

[35] Sara C. Pryor, Ph.D., Climate and Meteorology Program, Dept. of Geography, Indiana University, Personal Communication

Table A.1
Regression of Open Chamber BSP on Closed Chamber BSP and Relative Humidity

Dependent Variable - Log of BSPpm; open chamber measurement at Pitt Meadows
Ordinary Least Squares Estimation
Number of Observations = 258

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 255 DF	ELASTICITY AT MEANS
Log BSPrp	1.4561	0.5683E-01	25.62	1.6704
Log RH	0.70784	0.7882E-01	8.980	0.9175
CONSTANT	-0.78055	0.3771	-2.070	0.2472

BSPrp = Dry chamber BSP measured at Rocky Point
RH = Relative Humidity measured at Abbotsford

```
R-SQUARE =   0.7389     R-SQUARE ADJUSTED =   0.7368
 VARIANCE OF THE ESTIMATE-SIGMA**2 =  0.10568
 STANDARD ERROR OF THE ESTIMATE-SIGMA =  0.32508
 SUM OF SQUARED ERRORS-SSE=   26.948
 MEAN OF DEPENDENT VARIABLE =  -3.1581
 LOG OF THE LIKELIHOOD FUNCTION = -74.6697
```

Despite having to use three different stations for data observation, the regression shows a high degree of correlation and high significance of the estimated coefficients. The high R-Square and T-ratios indicate that the BSP measured at Rocky Point and the relative humidity are good predictors of open chamber BSP readings at Pitt Meadows over the period of observation.

The estimated coefficients from Table A1 are then entered into Equation (A1) which is then used to convert the closed BSP chamber readings at the time of the Mt. Seymour photographs to equivalent open chamber BSP readings for use in estimating the Mt. Seymour violation response equations.

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