



ASSESSING THE RELATIVE ECOLOGICAL
CARRYING CAPACITY IMPACTS OF
RESOURCE EXTRACTION

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Ottawa, Canada
August, 1994

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Preface

This report was originally published as part of the ATHENA™ project, initiated in 1990 by Forintek Canada Corp. with the support of Natural Resources Canada, under the name *Building Materials in the Context of Sustainable Development*. Work on the ATHENA™ project is now being carried forward by the ATHENA™ Sustainable Materials Institute, a not-for-profit organization dedicated to helping the building community meet the environmental challenges of the future.

The ultimate goal is to foster sustainable development by encouraging selection of the material mix that will minimize a building's life cycle environmental impact. To achieve that goal, the Institute is developing ATHENA™, a systems model for assessing the relative life cycle environmental implications of alternative building or assembly designs. Intended for use by building designers, researchers and policy analysts, ATHENA™ is a decision support tool which complements and augments other decision support tools like costing models. It provides a wealth of information to help users understand the environmental implications of different material mixes or other design changes in all or part of a building.

From the outset, the project brought to bear the combined talents of architects, economists, engineers and environmentalists in a research alliance which included the following university programs, government agencies and private firms, many of which continue to contribute to the Institute as advisory members or researchers:

- CANMET, a division of Natural Resources Canada;
- Environmental Policy Research, Trent University;
- Environmental Research Group, University of British Columbia School of Architecture;
- Forintek Canada Corp.;
- JKM Associates;
- Steltech Ltd. (formerly a subsidiary of Stelco, now part of Hatch Associates);
- The Centre for Studies in Construction, University of Western Ontario;
- Venta, Glaser & Associates; and
- Wayne B. Trusty & Associates Limited

The ATHENA™ Institute is continuing the practice of publishing all individual research reports and major progress reports to make the process as transparent as possible and to ensure the research and results are fully accessible. To ensure continuity, previously published reports such as this one are being reissued as part of the Institute series.

Institute studies and publications fall into two general categories: investigative or exploratory studies intended to further general understanding of life cycle assessment as it applies to building materials and buildings; and individual life cycle inventory studies which deal with specific industries, product groups or building life cycle stages. All studies in this latter category are firmly grounded in the principles and practices of life cycle assessment (LCA), and follow our published Research Guidelines, which define

boundary or scope conditions and ensure equal treatment of all building materials and products in terms of assumptions, research decisions, estimating methods and other aspects of the work. The integration of all inventory data is a primary function of ATHENA™ itself. ATHENA™ also generates various composite measures that can best be described as environmental impact indicators, a step toward the ultimate LCA goal of developing true measures of impacts on human and ecosystem health.

We believe this report and others in the series will be of value to people concerned with the environmental implications and sustainability of our built environment. But we caution that individual industry life cycle study reports may not be entirely stand-alone documents in the sense that they tell the whole story about an individual set of products. For example, the report on concrete notes how much steel is used for reinforcing various products, but the life cycle inventory data for those steel products is included in the reports dealing with integrated and mini-mill steel production. There are also transportation and energy production and distribution aspects that are common to many different building products and are therefore handled separately within ATHENA™.

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ACKNOWLEDGMENTS

We would like to acknowledge the valuable assistance provided by Forintek, and particularly by Jamie Meil, the Project Administrator, during the course of this project. Forintek handled all of the considerable administrative tasks associated with the survey, including the printing and distribution of questionnaires and the receipt of responses. Mr. Meil was in every sense a member of the project team, helping with development of the questionnaire, serving as a member of the test panel, and providing advice and guidance with regard to methodological issues and the analysis generally.

ASSESSING THE RELATIVE ECOLOGICAL CARRYING CAPACITY IMPACTS OF RESOURCE EXTRACTION

1.0 INTRODUCTION

This report presents the results of a survey undertaken to assess the relative ecological carrying capacity effects of extracting various resources to make wood, steel and concrete building products.

1.1 BACKGROUND

As explained in the Preface, the main objective of the Sustainable Materials Project is to develop a systems model to assess the full life cycle environmental consequences of using alternative building materials in defined applications. During Phase II of the project, quantitative estimates were developed and incorporated in the model for a range of resource inputs and waste outputs: raw materials, energy, water, solid wastes, atmospheric emissions, and liquid effluents. But we were not able, during Phase II, to develop quantitative estimates for the myriad remaining effects of resource extraction — effects that we termed ecological carrying capacity impacts.

Ecological carrying capacity can be considered as a natural resource with limits like any other resource, limits that define the point at which irreversible (or at least serious) damage would occur. Extraction activities have to be undertaken with a view to the carrying capacity of the ecosystems affected if sustainable development is to be achieved. Examples of ecological carrying capacity effects include the impacts of resource extraction on biodiversity, ground and surface water quality, soil stability and regenerative capacity, wildlife habitat, and the carbon cycle.

Deciding how to assess such impacts and develop quantitative measures has been a challenging problem from the outset of the Sustainable Materials Project. These effects are, in our view, as important as other measures such as energy use or atmospheric emissions, but are difficult to assess in a parallel manner and on a comparable basis. At the same time, we need quantitative impact estimates if ecological carrying capacity is to be incorporated in the systems model. Developing such estimates is problematic for a variety of reasons. For example:

- there are a large number of different types of impacts to be considered;
- many have not been measured, or cannot be measured, in a consistent manner;
- even where measurement is possible, the measures cannot be readily compared across impact types;
- it is particularly difficult to develop a unified measure for habitat loss because it must be measured one species at a time, and one species' loss may be another's gain;
- in several areas there is conflicting scientific evidence or lack of scientific agreement;
- in many cases an assessment of impacts involves value judgments; and
- within any single category, impact levels and implications vary depending on location, extraction methods, remedial actions and other factors.

During Phase II of the project, Dr. R. Paehlke was commissioned to document the often conflicting views about various categories of ecological capacity impacts and provide a comprehensive qualitative assessment. He was also asked to determine the feasibility of developing quantitative measures and to suggest an approach.

In his report, *Ecological Carrying Capacity Effects of Building Materials Extraction*, Dr. Paehlke concluded it would not be possible to develop quantitative measures comparable to those for energy, emissions and other more precisely defined impact categories. Quantification might be possible for specific types of impacts (e.g. effects on groundwater or wildlife habitat) associated with specific extraction activities in narrowly defined areas, but not without major on-site study efforts. Even then, the results would have limited relevance in terms of estimating impacts for other geographic areas or for extraction activities using different methods.

However, Dr. Paehlke suggested we could move towards quantification by:

- distinguishing several dimensions of the ecological impacts of extraction;
- ranking or scoring the materials regarding each of these dimensions; and
- combining the ranks or scores on each dimension in various ways.

While the results of such an approach would be highly subjective, and therefore different from the estimates developed for other types of environmental impacts, they would nevertheless make it possible to incorporate an estimate of ecological capacity effects in the Sustainable Materials Project systems model. Model users would at least have an indication of the comparable ecological capacity effects of the different building products.

Dr. Paehlke further suggested we attempt to reach some level of consensus among a large number of experts using the Delphi technique. He stated the recommendation as follows:

“An extended panel of experts could be recruited, deliberately chosen to cover some of the many aspects of and perspectives on ecological impact assessment. That panel could respond to some of the tentative conclusions drawn in this report. A Delphi technique could be utilized to refine their judgments in a series of iterations. That is, the expert responses could be summed and returned to the experts for individual responses to their collective views regarding the conclusions. In this process, scores which summarize the attributions of many analysts could be developed. This is still not a quantitative assessment of the same sort that is available regarding other impacts. But it would provide an additional step towards accuracy and objectivity that has not been taken thus far.”

We essentially accepted Dr. Paehlke's recommendations, developed a work plan, recruited a panel and completed a survey using a written questionnaire. However, we did not undertake a full Delphi survey for reasons that will be explained in a subsequent section.

1.2 STUDY FOCUS AND SCOPE

To impose some order on the information in his report, and to provide a framework for synthesis, Dr. Paehlke defined four dimensions of ecological capacity impacts:

- the intensity of impacts;
- the extent of the areas typically impacted;
- the duration of impacts; and
- the ecological significance of the areas typically impacted.

We agreed with Dr. Paehlke's suggestion that these four dimensions be used as the basis for scoring impacts in the survey. The dimensions are defined more precisely in Section 2 of this report.

The following six resource extraction activities were assessed in the survey:

- timber harvesting in the coastal area of British Columbia;
- timber harvesting in the boreal forest and the interior of British Columbia;
- iron ore mining;
- coal mining (metallurgical and thermal);
- limestone quarrying; and
- aggregates quarrying.

Although other resources are used to make some building materials, the above six extraction activities account for the predominant share of resource use in terms of volumes and mass. These are also the resource extraction activities considered in Dr. Paehlke's qualitative report.

Like other aspects of the Sustainable Materials Project, the survey was national in scope with the focus on typical resource extraction methods.

1.3 REPORT STRUCTURE

The rest of this report is organized as follows.

- Section 2** describes the study approach, including panel selection and composition, and development of the questionnaire.
- Section 3** presents the responses to the questionnaire.
- Section 4** includes a more detailed discussion of specific results and their interpretation, and explains the decision to forego a second round of questions.
- Section 5** summarizes the results and recommends a method of using and interpreting the results in the systems model .

A Cautionary Note: In the material that follows we have to use various kinds of statistical measures and presentation techniques to describe and properly characterize the results of the survey. However, the panel (i.e. sample) size was small from a statistical perspective, and our ability to use statistical techniques is limited. We have tried to be appropriately cautious in our analysis and conclusions, and we advise readers to be equally cautious.

2.0 STUDY APPROACH

This section describes our work program, including the selection and final composition of the panel, and the development and final form of the questionnaire.

2.1 WORK PROGRAM

As noted in the Introduction, Dr. Paehlke had recommended a Delphi survey of an extended panel of experts.¹ However, full Delphi surveys can take a long time if the issues are complex, and high drop-outs rates are often a problem. In view of our time and budget limitations, we therefore decided to undertake a more straight-forward survey, with the possibility of extending to a second round of questions only if absolutely necessary.

The survey also departed from the more traditional Delphi approach in other ways. For example:

- the objective was to define a current state of affairs rather than to forecast;
- expertise was defined in terms of environmental impacts generally, with different respondents having specific expertise relative to different natural resources or resource extraction activities;
- all respondents were provided a package of background materials to provide a degree of common understanding about the issues and nature of impacts; and
- respondents were asked to make judgments about relative rather than absolute impact levels.

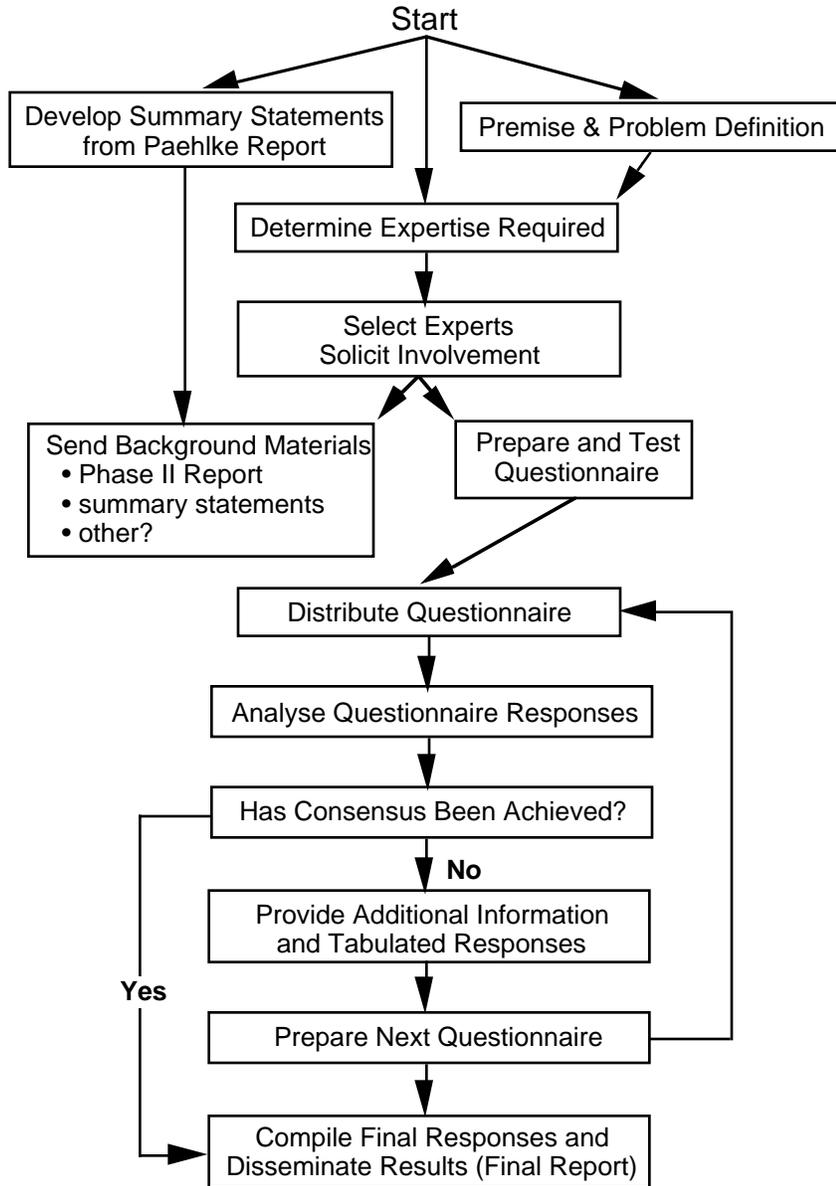
The planned study work program is shown in Figure 1.

As the figure indicates, we intended to solicit participation from a number of pre-selected environmental experts. The potential respondents were to be briefed and made fully aware of the likely time commitments to guard against unexpected drop-outs. The survey would then be conducted using a pre-tested written questionnaire and, if a second round was necessary, feedback would be provided between the first and second rounds.

As discussed below, questions were to be answered by assigning scores or ranks so that the entire process would be quantitative. As a result, it would in principle be possible to develop summary ranks or scores in terms of medians or other measures irrespective of the degree of consensus. We recognized, however, that any such measures would be suspect if the responses did not show some reasonable degree of convergence around central values. The extent of convergence would be an indicator of the degree of consensus among the panel. Without an acceptable level of consensus, the results would have little meaning and could not be used in the systems model, although such an outcome might be instructive from a more academic perspective.

¹The Delphi technique was developed primarily for forecasting applications, and involves a process of surveying experts in a field using successive rounds of questionnaires to reach a consensus on answers to specific questions. Between each round, respondents are provided information on the group position from the preceding round(s) to encourage movement toward a consensus and respondents may be asked to justify positions in an effort to sway others. The group may be told the composition of the panel at the outset, but they are not told the identity of those taking specific positions. The surveys may be conducted using written questionnaires or they may take a more interactive form using computers. Respondent participation may be solicited in advance or experts may simply be sent a questionnaire and asked to respond.

**Figure 1
PLANNED WORK PROGRAM**



Source: Adapted from Kaynak, E., Use of the Delphi Technique for the Prediction of Housing Demand in Atlantic Canada by the Year 2005, Halifax, February 1985, p.52.

As the work progressed, we slightly modified the process illustrated in Figure 1 by excluding summary statements from the materials sent to the panel in advance of the questionnaire. We developed summary statements about the qualitative nature of impacts from Dr. Paehlke's report as planned. However, we were very concerned not to lead the respondents toward any particular comparative conclusion, and failed to satisfy ourselves on that point despite several attempts at developing succinct summary statements. Since Dr. Paehlke's report already includes summary statements at the beginning of each chapter, we decided that a second set of summaries was not necessary and carried the risk of unduly influencing the panel.

The panel did receive a copy of Dr. Paehlke's full report, excluding the last chapter which again contains conclusions that could have biased panel responses. In addition, the panel was sent a summary description of the Sustainable Materials Project so they would understand the context and reasons for the survey.

2.2 PANEL SELECTION AND COMPOSITION

2.2.1 Panel Selection

Our plan was to select a panel of at least 25 people using the following criteria:

- panel members should not be currently employed by the relevant industries or industry associations;
- expertise should be broadly defined in terms of environmental issues (e.g. biodiversity, water quality, wildlife, carbon cycles, etc.) and extraction process (i.e. mining, quarrying, timber harvesting); and
- to the extent possible, the panel should be evenly balanced in terms of expertise (i.e. an equal number of members with expertise in each extraction process and coverage of as many environmental issues as possible).

Given the criteria, we expected most panel members would be drawn from government, academia and environmental organizations, although some might be experts currently working for other industries or as independent consultants.

We compiled a list of potential candidates from our own sources and from discussions with others. Officials in the State of Environment Reporting office of Environment Canada were particularly helpful. This initial list was reviewed and shortened somewhat to ensure balanced representation in terms of the different resource extraction activities and geographic regions.

People on the final list of potential candidates were then contacted by telephone, the project was explained in some detail and their cooperation was solicited. None were offered any remuneration. Thirty people agreed to participate because of the importance of the subject matter and their interest in the areas under investigation. Of those thirty, twenty-three subsequently returned completed questionnaires.

2.2.2 Panel Composition

The names, affiliations and locations of the twenty-three responding panelists are listed in Appendix A. The following table shows the basic composition in terms of regions and affiliations.

Region	No.	Affiliation	No.
British Columbia	5	Federal Government	4
Prairie Region	4	Provincial Government	6
Central Canada	12	University	10
Atlantic Canada	1	Environmental Org.	3
Other (U.S.)	1		

In the questionnaire, panelists were asked to score their own level of expertise with respect to each of the six resource extraction activities. The scores were on a scale from 1 to 5 with the following guidelines provided to assist panelists in interpreting the scale.

- Level 1 — very little knowledge about the extraction activity
- Level 2 — some prior exposure and knowledge (e.g. through popular press and/or non-technical literature)
- Level 3 — fairly knowledgeable based on technical literature and/or prior experience
- Level 4 — good working knowledge (e.g. through extensive familiarity with technical literature and/or intensive prior experience)
- Level 5 — expert or specialist

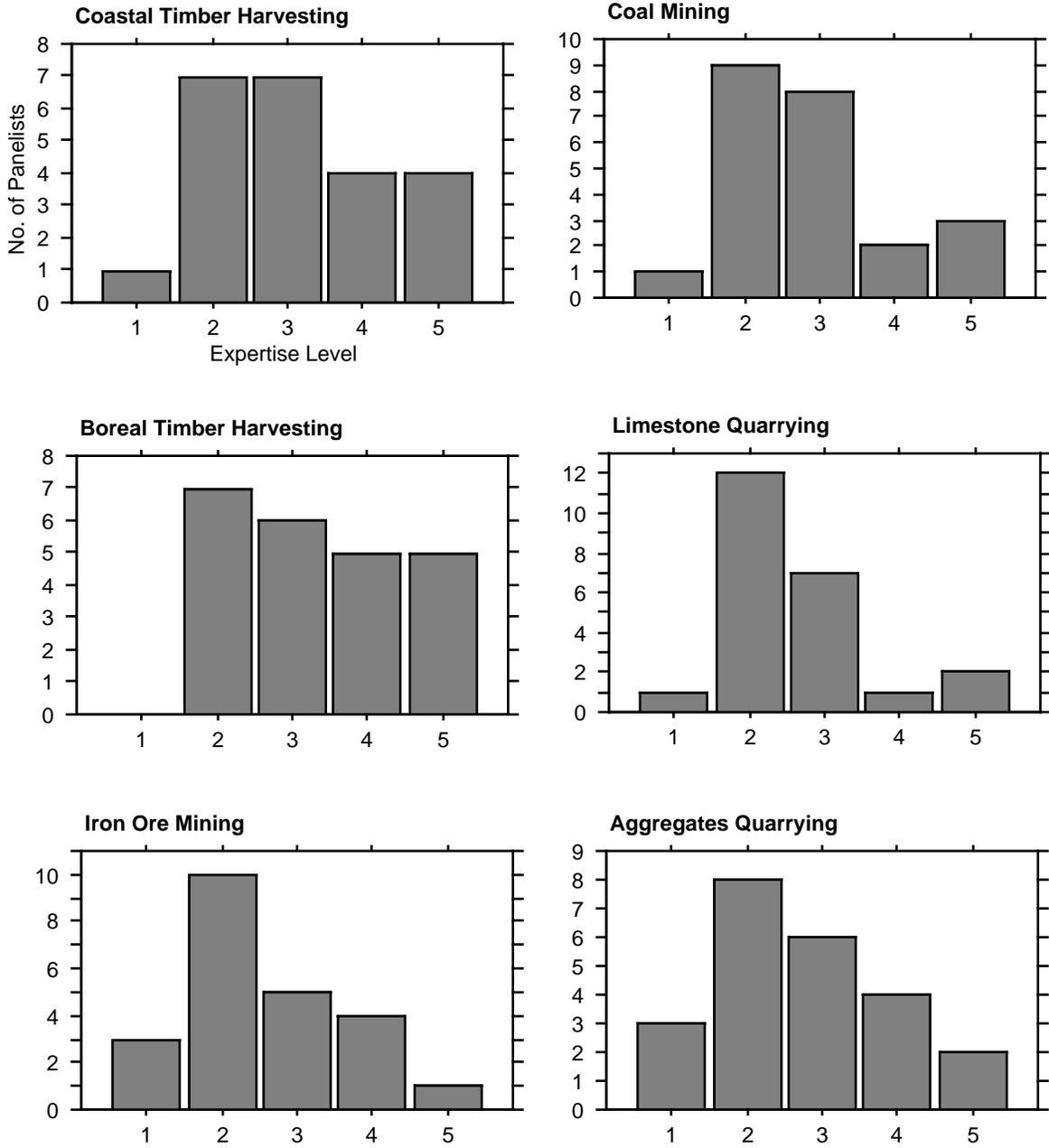
The histograms in Figure 2 shows the composition of the panel in terms of these self-attributed expertise levels.

The vertical scale in each histogram shows the number of panelists who scored themselves at each of the five expertise levels shown on the horizontal scale. For example, only one respondent indicated very little knowledge (level 1) with regard to coastal timber harvesting, while fourteen respondents ranked themselves at either level 2 or 3. The remaining eight panelists were evenly split between those who considered themselves to have a good knowledge of, or to be experts or specialists in, coastal timber harvesting (levels 4 and 5).

In general, all of the panelists had expertise levels with regard to all of the extraction activities and most indicated at least level 2 expertise with regard to all activities. It is notable, however, that expertise levels with regard to timber harvesting in the coastal and boreal forest were higher overall than for any other extraction activity, with the majority of respondents indicating timber harvesting expertise at level 3 or better. The panel was also fairly knowledgeable about aggregates quarrying, with half indicating level 3 expertise or better and six scoring themselves at the 'good knowledge' or specialist levels. Expertise levels were generally lower when it comes to iron ore mining, coal mining and limestone quarrying, with five or less indicating good or expert knowledge levels.

There is an interesting parallel between the expertise levels shown in Figure 2 and the observation in Dr. Paehlke's report that literature on the environmental implications of timber harvesting far outweighs literature on other resource extraction activities. In fact, it is hard to work in the environmental field without being exposed to books, articles and news reports about timber harvesting. Aggregates quarrying has also received considerable attention, particularly in the news media, because of the proximity of aggregates quarries to urban centres and the consequent land use implications. We will be discussing these parallels again in a subsequent section when we examine the survey results.

Figure 2
PANEL EXPERTISE LEVELS BY EXTRACTION ACTIVITY



Respondents were also asked to classify the nature of their expertise in terms of a list of environmental issues or fields of study. The following table indicates the numbers indicating expertise with regard to each item in the list. Most had expertise with regard to more than one issue or field, and the total therefore exceeds 23.

Environmental Issue or Field of Study	No. of Mentions
Atmospheric emissions	4
Biodiversity	11
Carbon cycle	4
Environmental Impact Assessment	15
Environmental Policy	14
Environmental Regulation	11
Genetics	2
Soils	7
Water pollution	7
Wildlife habitat	7
Other	10

Respondents checking the ‘Other’ category indicated a range of related subjects: forest practices and management; mining land use and land reclamation; mineral resource management; revegetation of impacted soils; environmental toxicology; economic ecology; ecological surveys; ecosystem studies; and sustainable economic development.

The relatively large numbers citing environmental impact assessment, policy and regulation are not surprising given the number of respondents working on environmental matters within government. But most also had expertise in more specific areas and we were pleased to find that the panel as a whole covered all of the pre-specified areas of interest.

2.3 THE QUESTIONNAIRE

The panel was sent a written questionnaire as well as a questionnaire guide intended to help them interpret and respond to the questions. A copy of the guide and of the final questionnaire are provided in Appendix B.

2.3.1 Questionnaire Development

Before finalizing the guide and questionnaire, draft versions were given to a small test panel to ensure both conveyed the necessary information and that the questions were easy to understand and answer. Test panelists were asked to complete the questionnaire, keeping track of the time required, and to provide comments on the structure and wording of both the questionnaire and the guide. We subsequently made a number of revisions to the questionnaire based on the information provided by the test panel. We also used the test panel results to develop an analysis framework.

Several of the eight test panelists had prior exposure to the Sustainable Materials Project, while the others had little prior knowledge of the project. None of the test panelists participated in the final survey.

2.3.2 Structure of the Questionnaire

Panelists were told in the guide that the objective of all questions was to quantify the relative effects of the six resource extraction activities compared only to each other. We explained that we were not concerned about the absolute effects, nor did we want to make even implicit comparisons to other types of industrial activities or environmental problems. We also asked the panelists to assume all the relevant resources would continue to be extracted and used.

As noted in Section 1.2, we wanted to develop impact measures by asking panelists to score the relative impacts of the six extraction activities in terms of the following four impact dimensions:

- the intensity of impacts;
- the extent of the areas typically impacted;
- the duration of impacts; and
- the ecological significance of the areas typically impacted.

The questionnaire was divided into 3 parts. Part I dealt with the relative importance of the four dimensions themselves. Part II dealt with the impacts of the six resource extraction activities in terms of the dimensions, and Part III requested information about panelist expertise.

Most of the questions were structured and worded in an exactly parallel fashion, with respondents having only to check appropriate boxes to register their judgements about impacts. Space was also provided for adding comments, explanations or general observations at the respondent's discretion.

Part I

In Part I, respondents were first asked to rank the four dimensions in order of importance from an environmental perspective. They were then asked to provide an indication of the relative differences between the assigned ranks or levels of importance on a scale from 1 to 10. To ensure a relative scoring process, at least one dimension was to be scored at the 1 level.

The final question in this part asked how important respondents thought the overall range of ecological capacity effects was compared to more measurable impacts such as energy use, atmospheric emissions, liquid effluents and solid wastes.

The questionnaire guide contained the explanations of the four dimensions shown in the box on the next page.

The reason for this part of the questionnaire was to determine whether panelists considered the four dimensions to be equally important, or whether they thought some to be significantly more important than others. In the concluding section of Dr. Paehlke's report, for example, he argued that extensiveness and site significance might be considered twice as important as intensity and impact duration.

We therefore wanted to get the panel to provide their judgments about the relative importance of the four dimensions in order to determine if the scores developed in Part II of the questionnaire should be weighted. If panelists thought them to be different in

DIMENSION DEFINITIONS AND EXPLANATIONS FROM QUESTIONNAIRE GUIDE

The Intensity of Impacts

The intensity dimension refers to the degree of overall environmental disruption associated with a resource extraction activity.

The focus of this dimension is on how much of the ecology of an area is disrupted, whether temporarily or permanently. Disruption might be assessed in terms of the removal, destruction or disturbance of flora and fauna, the removal or degree of disturbance of topsoils and subsoils, hydrological effects, and the degree of alteration to the landscape generally.

The Extent of the Areas Typically Impacted

The extent dimension refers to the extent or size of the geographic areas typically impacted, either directly or indirectly, by a resource extraction activity.

You can think of this dimension in terms of the extent of the area impacted per unit of resource — for example, per tonne of timber versus per tonne of iron ore or aggregates. Please do not think in terms of the extent of the areas impacted relative to all potential extraction sites, nor in terms of the estimated quantities of the resources potentially available.

Indirect impacts could include such effects or activities as severe dust, noise pollution and the construction and use of access or haul roads. In other words, extensiveness is not necessarily restricted to just the immediate extraction sites.

The Duration of Impacts

The duration dimension refers to the average length of time before typically impacted areas return to ecological productivity and balance, even though this seldom represents a return to the exact conditions prevailing before the extraction activities.

In considering this dimension, you should take account of the regeneration or restoration practices typically followed by the relevant extraction industries.

The Significance of the Areas Typically Impacted

The significance dimension refers to such considerations as the uniqueness, from a national or wider perspective, of areas typically impacted, the ecological richness of areas, and even their beauty or aesthetic value.

Significance might be judged in terms of such factors as:

- the number or extent of other areas with similar characteristics;
- the ability of other areas to support similar flora and fauna;
- the diversity of flora and fauna present in areas typically impacted;
- the importance of flora and fauna uniquely supported by areas typically impacted; and
- the importance of such areas for recreation or as a support for broadly held social values.

importance and reached a reasonable consensus about the relative scoring of the four dimensions, we intended to use the scores as weights attached to the resource extraction impact scores from Part II of the questionnaire. Otherwise, the scores developed through the questions in Part II would stand on their own.

Part II

There were four questions in this section of the questionnaire. The four questions followed exactly the same pattern, the only difference being that each dealt with a different impact dimension.

For each dimension, panelists were asked to judge the relative ecological capacity effects of extracting the six resources — timber from the B. C. coastal area, timber from the boreal forest and B. C. interior, iron ore, coal, limestone, and aggregates.² Respondents were asked to make their judgements assuming the relevant extraction industries follow average, or typical, practices in terms of:

- extraction methods and processes;
- the adoption of mitigating measures to minimize environmental effects;
- the restoration of extraction sites or areas; and
- other relevant activities.

Scoring of the relative impacts of the six resource extraction activities was on a scale from 1 to 10 for each dimension, where 1 denoted the least level of relative impact and 10 denoted the greatest level of relative impact. Respondents were required to score at least one activity at the 1 level in order to force them to consider scores for the six extraction activities in relative terms without regard to any other kinds of activities that respondents might consider even worse or better. As noted earlier, we were less concerned with absolute scores and more with the dispersion of scores and the consequent implicit ranking of the six activities within each dimension.

The question for the intensity dimension is shown in the box on the next page. Questions for the other three dimensions followed exactly the same pattern.

Part III

The final component of the questionnaire asked respondents to classify their expertise in terms of the resource extraction activities and in terms of environmental issues or subject areas. Information from this part of the questionnaire was used to describe the panel composition in Section 2.2.2.

²We did not ask respondents to distinguish underground coal mining from open pit mining even though a large proportion of coal used by the Canadian integrated steel industry is from underground mines in the United States. Our approach in this regard is consistent with the Sustainable Materials Project Research Guidelines which specify that all materials and products will be assumed to be produced by Canadian-equivalent methods and technologies. Only transportation distances reflect the true origins of materials. Western Canadian coal that would otherwise be used by the major Canadian integrated steel plants is typically extracted using open pit methods. The fact much of that coal is exported while user's in central Canada import their requirements is a function of economics, and we have to be cautious that these trade patterns not confuse the environmental issues. In addition, while underground mining may result in lower environmental impacts with regard to some measures, it can result in higher impacts with regard to other measures (e.g. wildlife habitat vs. groundwater impacts).

EXAMPLE QUESTION FROM PART II OF THE QUESTIONNAIRE

THE INTENSITY DIMENSION

For a definition of INTENSITY please see page 4 of the questionnaire guide.

Question II.1 (a)

Do you think all six resource extraction activities are approximately the same in terms of the *INTENSITY* of impacts when the industries follow average, or typical, extraction practices?

Yes No

If you answered yes, please proceed to question II.2 (a). If you answered no, please answer question II.1 (b), below.

Question II.1 (b)

Please score the relative *INTENSITY* of extraction impacts for the six resource extraction activities listed below, assuming average extraction practices. Indicate your scoring by checking one box on the scale provided for each resource activity. A score of **1** denotes the **lowest** level of relative intensity, while a score of 10 would denote an intensity level ten times as high.

Note: Because we are only concerned about relative impact levels, your completed scores should have at least one activity checked at the 1 level and you need not necessarily check any activity as high as the 10 level.

Resource Extraction Activities	 Scale of Increasing Intensity									
	1	2	3	4	5	6	7	8	9	10
Timber harvesting in the B. C. coastal region	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Timber harvesting in the boreal forest and B. C. interior	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Iron ore mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Coal mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Limestone quarrying	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aggregate extraction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

COMMENTS

Please type or print any comments you have about this question or your responses.

2.4 PLANNED USE OF THE SURVEY RESULTS

We wanted the survey to provide the following information.

1. A set of subjective scores showing the relative impacts of each resource extraction activity by impact dimension;
2. Possibly a distinct ranking of the four dimensions in order of importance; and
3. Data to weight the dimensions in the event they were distinctly ranked.

Assuming the panel reached a reasonable consensus on the set of impact scores, we then intended to fill in the following table.

	Impact intensity	Extent of the area impacted	Impact duration	Significance of the area impacted	Total Impact
B. C. coastal timber harvesting					
Boreal timber harvesting					
Iron ore mining					
Coal mining					
Limestone quarrying					
Aggregate quarrying					

Each cell under the dimension headings would contain the median impact score for the relevant activity multiplied by the dimension weight, assuming the panel distinctly ranked and scored the dimensions. The total impact for each resource extraction activity would then be the sum of the weighted scores across each row.

The final impact scores could then be used as weights to adjust the resource requirements for each building product to reflect the ecological carrying capacity effects of extracting those resources. For this purpose, we anticipated measuring resource requirements in volumetric rather than mass terms because it is the total volume of material extracted that determines the area impacted and the nature of impacts. For the same reason, we would include the total volume of extracted material before beneficiation or separation. The resulting ecologically weighted, or adjusted, resource estimates would then provide a comparative measure of this critical component for different products and building designs.

3.0 SURVEY RESPONSES

This section presents panel responses to questions in Parts I and II of the questionnaire. The responses are presented graphically and are discussed in terms of basic statistics, distribution shapes and the degree of convergence (central tendency) evident in the distributions. The emphasis here is on a description of the results, with more detailed analysis and discussion of specific results reserved for Section 4.0.

3.1 INTERPRETATION OF RESPONSES

The following two factors should be borne in mind when reviewing and considering the results:

1. with only 23 respondents, the sample size is small and we are therefore limited in our choice of descriptive statistics, and in terms of our ability to apply statistical techniques such as significance tests; and
2. we would not necessarily expect, nor do we find, the responses to specific questions tending toward normal distributions — in fact, most of the response distributions are skewed to one end or the other of the 1 to 10 scale.

Given the small sample size and the subjective nature of the responses, we believe the median of distributions best represents the panel score for relevant questions. Arithmetic means are the more common statistic of choice, but means can be heavily influenced by outlying responses, particularly with a small sample size. Other commonly used descriptive statistics and significance tests are suspect with a small sample size and generally assume a normal distribution.

One problem with the use of medians as the measure of central location for skewed distributions is that there are few related statistics for judging central tendency (convergence). As will be apparent in the next subsection, we have a set of distributions showing the patterns of responses (scores) for various questions. We can use the median of each distribution as a measure of the panel score, but are left with the problem of deciding whether there is sufficient convergence around the median to assume an acceptable level of panel consensus about a particular score. To put it simply, the problem is deciding how much convergence is enough.

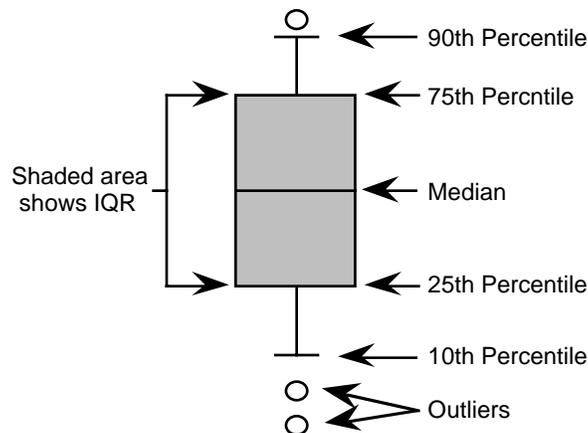
One measure that we investigated is the median absolute deviation (MAD). The MAD is the median of the set of differences between each data point and the median of the data. It is a measure of variability that incorporates all the data but does not give as much influence to outliers as the standard deviation. However, we are not aware of any statistical tests or other definitive ways of judging the acceptability of a specific MAD value when the objective is to ensure a reasonable degree of convergence in a distribution where the responses are highly subjective. Moreover, the way the MAD is calculated can result in a very low value (e.g. zero) for a distribution that is highly skewed but clearly has considerable variability.

A second measure that can be used is the interquartile range (IQR) — the spread of values calculated by subtracting the 25th percentile from the 75th percentile and containing 50% of the data. While the same problems arise in interpreting the significance of an IQR as with the MAD, differences between the IQRs from one distribution to another at least provide a consistent representation of the observed differences in the variability of the distributions.

Faced with these problems, we adopted a pragmatic approach. We dropped the MAD as a descriptive statistic and focused on the comparative IQRs. Convergence is so apparent and strong for some of the response distributions that we can use the IQRs for those distributions as control values. The control values can then be compared with the IQRs for other distributions to assess convergence. In other words, we can look at a distribution and ask whether the IQRs are close enough to the control values to assume an acceptable level of consensus.

In the next subsection, we present the distributions of responses for each of the questions with accompanying tables showing the corresponding median and IQR values. The tables also show the arithmetic means for each distribution for those interested in comparing mean and median values. Section 3.3 offers some overview observations about the results presented in Section 3.2, but more detailed analysis and discussion is deferred to Section 4.0 of the report.

With the exception of responses to Question I.4, the distributions are presented here in the form of box plots, with the corresponding histograms shown in Appendix C. Box plots are a convenient presentation summary form which captures a great deal of information. For those unfamiliar with box plots, the following is an example with interpretive labels.



3.2 RESPONSE DISTRIBUTIONS

3.2.1 Dimension Scoring - Questions I.1, I.2 and I.3

Part I of the questionnaire deals with the relative importance of the four dimensions — intensity, extent, duration and significance.

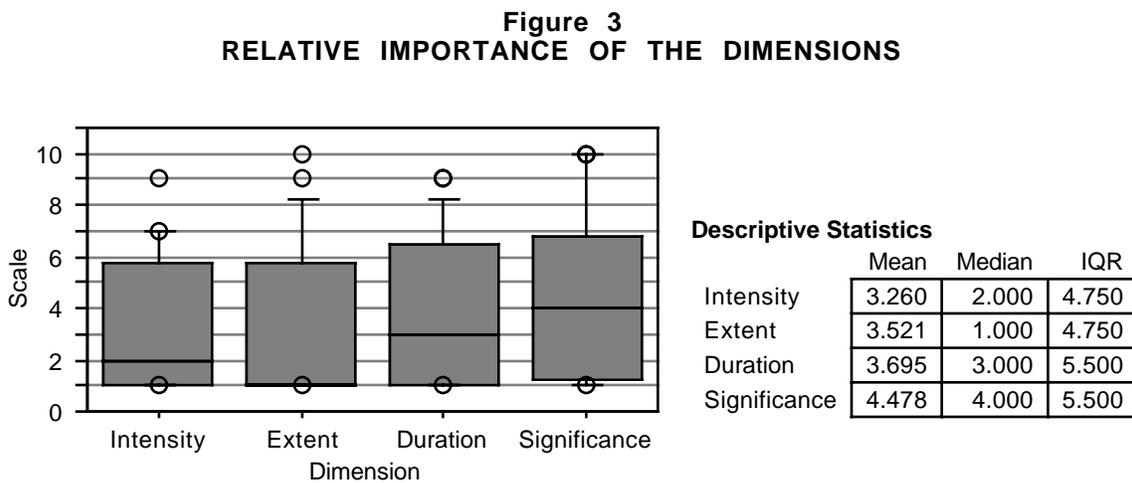
Question I.1 was a simple ‘yes’ or ‘no’ question asking respondents if they believed the four dimensions should be considered of equal importance and therefore given equal weight. If the answer was ‘no’, the respondent was asked to complete questions I.2 and I.3. If the answer was ‘yes’, the respondent was instructed to skip forward to question I.4.

Question I.2 asked respondents to simply rank the four dimensions in order of importance from least to most important.

In Question I.3 they were then asked to position the dimensions in rank order on a scale from 1 to 10 to show how much more or less important they considered each dimension relative to the others. At least one of the four dimensions had to be ranked at the 1-level, indicating least importance. In the case of respondents who answered ‘yes’ to question I.1 (i.e. all dimensions equally important) we entered a 1 for all four dimensions in the response tabulation for question I.3.

For our purposes, therefore, the distributions of responses to question I.3 capture all of the information from respondent answers to questions I.1 through I.3 — comparison of the medians shows the overall panel ranking as well as the differences in relative importance, while the IQR measures give a sense of the degree of consensus.

Figure 3 shows the box plots for the four dimensions. The horizontal axis identifies each of the dimensions and the vertical axis shows the scoring scale.



As a whole, the panel ranked extent as the least important dimension (median of 1) followed by intensity, duration and significance. For all the dimensions, the means are greater than the medians, indicating positively skewed distributions.

As shown in the histograms in Appendix C, the mode in every case is a score of 1. For the extent dimension, 12 of the 23 respondents entered that score with scores for the other 11 respondents scattered along the scale from 3 to 10. For both the intensity and duration dimensions, 10 respondents accounted for a modal value of 1. Only in the case of the significance dimension is there a marked shift toward higher scores. The mode in that case is still 1, but only 6 respondents scored at that level; another 5 scored significance at the 4-level and 3 at the 10-level.

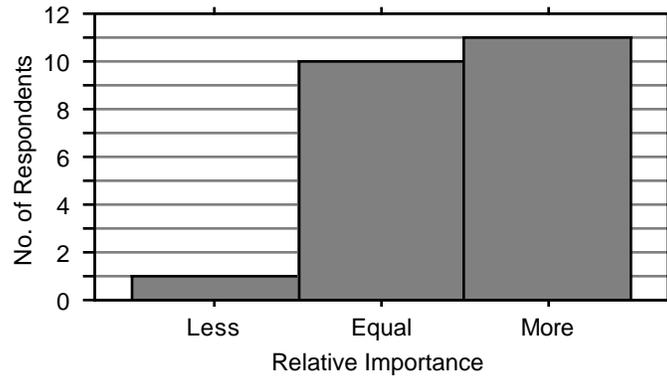
3.2.2 Importance of Ecological Carrying Capacity - Question I.4

The final question in Part I of the questionnaire asked respondents how important they considered the ecological carrying capacity effects to be in comparison to more readily measured environmental impacts such as energy use, atmospheric emissions, liquid effluents and solid wastes — less important, equally important, or more important.

As the histogram of responses in Figure 4 shows, only one respondent considered ecological carrying capacity effects to be less important than more measurable

environmental impacts, while 10 considered them equally important and 11 considered them more important. One respondent did not answer this question.

Figure 4
RELATIVE IMPORTANCE OF ECOLOGICAL CARRYING CAPACITY EFFECTS
COMPARED TO MEASURABLE ENVIRONMENTAL IMPACTS



3.2.3 Intensity Scoring - Question II.1 (a) and (b)

This first of four questions in Part II of the questionnaire asks respondents to score the six resource extraction activities in terms of the intensity dimension.

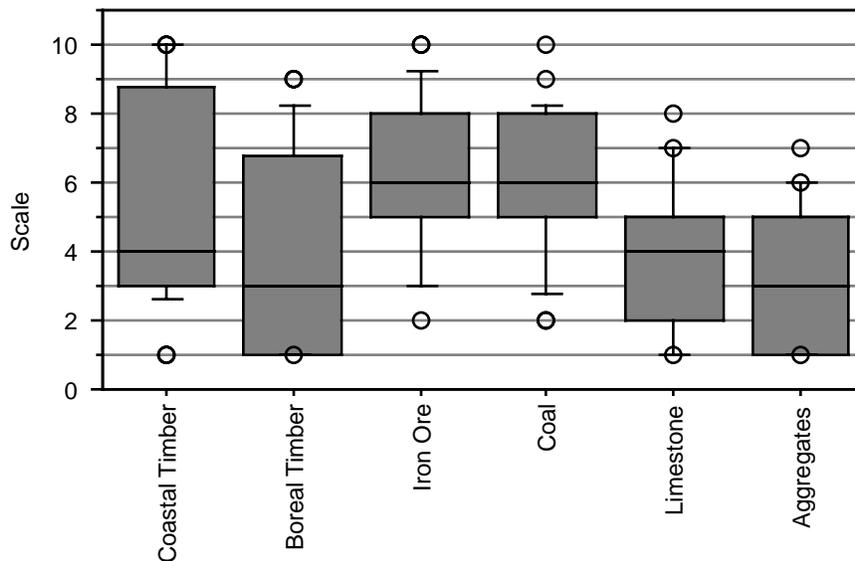
The pattern is the same in all four of the questions in Part II. In Question II.1 (a), respondents were asked if they considered all six extraction activities to be approximately the same in terms of the intensity of impact when the industries follow average or typical extraction practices, 'yes' or 'no'. If they answered 'yes', they moved on to the Question II.2 and we tabulated a score of 1 for all six extraction activities. If they answered 'no', they proceeded to part (b) of the question.

In question II.1 (b), respondents were asked to score the six resource extraction activities on a scale of increasing intensity from 1 to 10. They were instructed to score at least one activity at the 1-level and to then scale the other activities accordingly (see example in Section 2.3.2 as well as the Questionnaire Guide in Appendix B).³

The box plots in Figure 5 show the results for Question II.1. The horizontal axis identifies the box plot for each of the resource extraction activities, while the vertical axis shows the scale of increasing intensity of impacts from 1 to 10. Corresponding descriptive statistics are shown in the small table below the graphs.

³In a few cases (i.e. some questions by some respondents) respondents did not follow the instruction to score at least one activity at the 1-level. In those cases, we shifted the activity scores by taking the lowest score entered and putting it at the 1-level and then maintaining the spread of all the other scores. In other words, the entire set of scores was shifted to the left on the scoring scale.

Figure 5
THE RELATIVE INTENSITY OF
RESOURCE EXTRACTION ACTIVITIES



Descriptive Statistics

	Mean	Median	IQR
Coastal Timber	5.608	4.000	5.750
Boreal Timber	3.695	3.000	5.750
Iron Ore	6.130	6.000	3.000
Coal	5.913	6.000	3.000
Limestone	3.652	4.000	3.000
Aggregates	3.086	3.000	4.000

Based on the distribution medians, the panel ranked boreal timber harvesting and aggregates extraction as the least intensive activities, followed by coastal timber harvesting and limestone quarrying. Iron ore and coal mining were equally ranked as the most intensive activities with median scores of six.

Comparing the box plot presentation with the corresponding histograms in Appendix C shows that the modal and median values are essentially the same for coastal timber, iron ore and coal. In the case of boreal timber, limestone and aggregates, the modal values are all at the 1-level: nine respondents for boreal timber, five for limestone and 10 for aggregates.

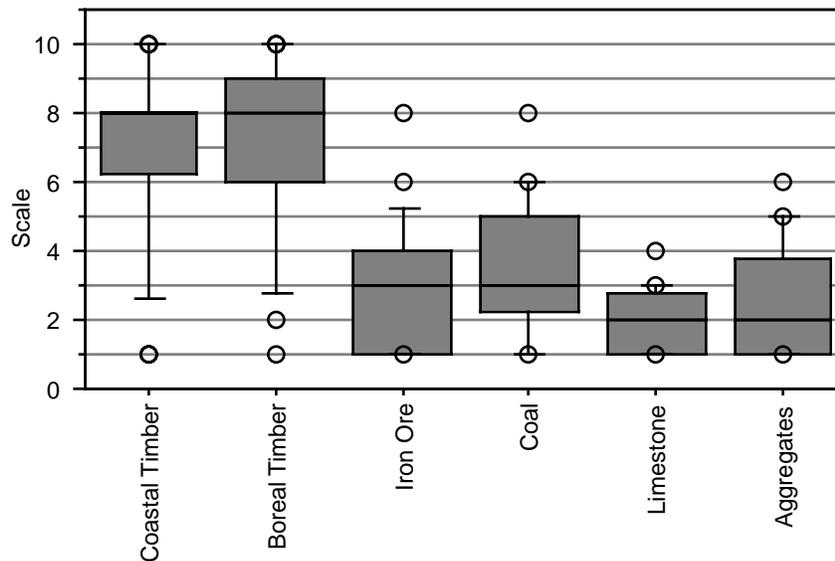
The shaded areas of the box plots and the corresponding IQRs show good convergence of the respondent scores in the case of iron ore, coal and limestone — IQRs of 3 — and reasonable convergence in the case of aggregates extraction — IQR of 4. The fact 10 respondents accounted for the mode of 1 for aggregates supports the conclusion of reasonable convergence even though the IQR is slightly higher.

The picture is quite different for both kinds of timber harvesting: the IQRs are considerably higher and the histograms show a distinct split in the distribution, with one grouping of responses at the lower end of the scale and one at the higher end. This is a pattern we see repeated in other results and will discuss in some detail in Section 4.

3.2.4 Extent Scoring - Question II.2 (a) and (b)

Figure 6 shows the box plots for respondent scoring of the relative extent of the six extraction activities. Descriptive statistics are given in the table following the graphs. As noted earlier, the structure of this and the other Part II questions is identical to the structure explained previously for Question II.1.

Figure 6
THE RELATIVE EXTENT OF
RESOURCE EXTRACTION ACTIVITIES



Descriptive Statistics

	Mean	Median	IQR
Coastal Timber	7.000	8.000	1.750
Boreal Timber	7.130	8.000	3.000
Iron Ore	2.869	3.000	3.000
Coal	3.695	3.000	2.750
Limestone	1.826	2.000	1.750
Aggregates	2.478	2.000	2.750

Coastal and boreal timber harvesting were both considered the most extensive extraction activities by the panel as a whole, with median values of 8. Iron ore and coal mining follow with medians of 3. Limestone and aggregates extraction were considered the least extensive activities with medians of 2.

None of the IQRs are greater than 3, indicating fairly good convergence in the responses for all of the extraction activities. Convergence is also evident in the Appendix C histograms.

Because log sizes are generally smaller in the boreal forest than in the B.C. coastal area, we expected the panel to score boreal timber harvesting as a more extensive activity than coastal timber harvesting (i.e. more area has to be logged to get the same output in board feet). The equal medians seem counter to that expectation. However, the box plots and histograms

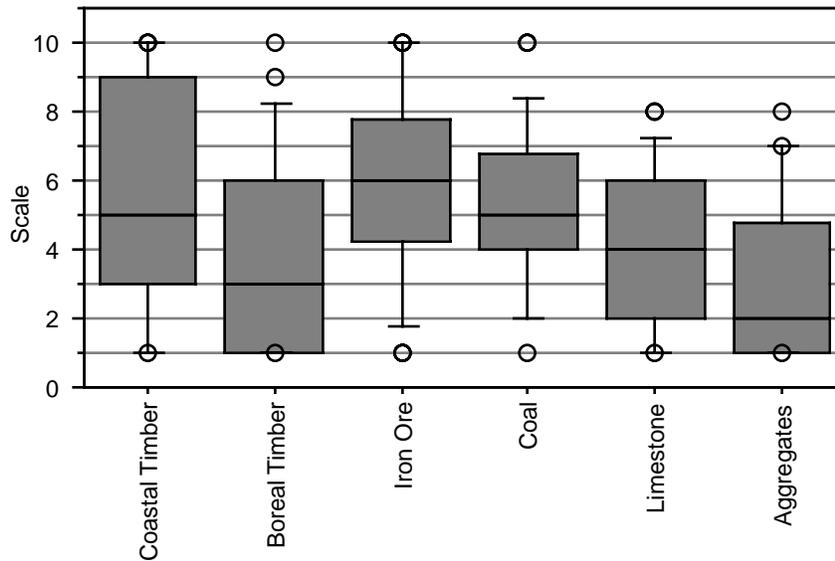
show that the distribution of responses ranged higher on the scale for boreal than for coastal harvesting. In fact, the mode for boreal harvesting is 10 compared to 8 for coastal harvesting.

It’s somewhat harder to understand why several panelists scored timber harvesting very low on the scale. For example, two respondents scored coastal timber at the 1-level and one scored it at the 3-level. Similarly, five panelist scored boreal harvesting in the 1- to 5-level range, with one respondent at each level. Our best guess is that these respondents tended to think in terms of extensiveness relative to the total area potentially available for logging, instead of in terms of extensiveness per unit of output compared to other extraction activities.

3.2.5 Duration Scoring - Question II.3 (a) and (b)

Scores for the relative duration of extraction impacts are shown in Figure 7.

**Figure 7
THE RELATIVE DURATION OF
EXTRACTION IMPACTS**



Descriptive Statistics

	Mean	Median	IQR
Coastal Timber	5.695	5.000	6.000
Boreal Timber	3.826	3.000	5.000
Iron Ore	6.043	6.000	3.500
Coal	5.086	5.000	2.750
Limestone	3.956	4.000	4.000
Aggregates	3.130	2.000	3.750

Iron ore mining was scored the highest with a median of 6, followed by coastal timber harvesting and coal mining with medians of 5. Limestone quarrying, boreal timber harvesting and aggregates extraction follow with medians of 4, 3 and 2, respectively.

The level of convergence for this question as a whole is generally not as good as for the preceding questions, with all of the IQRs except for coal greater than 3. Only in the case of aggregates extraction and boreal timber harvesting are the modes of 1 accounted for by a reasonably large number of respondents — 9 in the case of aggregates and 8 in the case of boreal timber. Modal values for the other activities are accounted for by only 4 to 6 respondents. Low modal frequencies go hand-in-hand with higher frequencies at other points on the scoring scale.

Also, for timber harvesting we again see the pattern noted with regard to Question II.1. The IQRs are quite high with values of 6 and 5. Moreover, the histogram for coastal timber shows two distinct distributions within the full set of scores for that activity — one oriented to the low end of the scale and one to the high end.

These results are discussed in more detail in Section 4.

3.2.6 - Significance Scoring - Question II.4 (a) and (b)

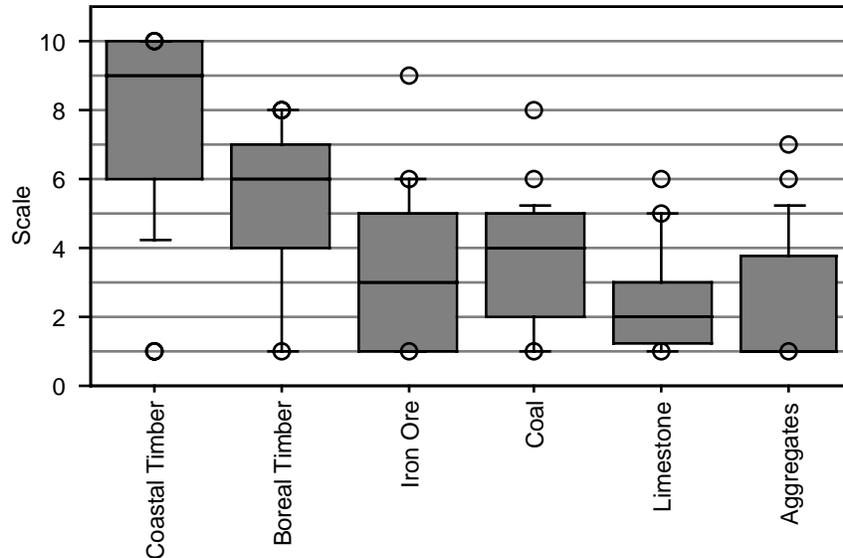
The final question in Part II dealt with the relative significance of areas typically impacted by the different resource extraction activities.

The panel gave coastal timber a high relative score for this dimension, with a median value of 9. Boreal timber harvesting and coal mining follow with medians of 6 and 4, respectively. Iron ore mining, limestone quarrying and aggregates extraction were scored lower, with medians of 3, 2 and 1, respectively.

Convergence is better for this dimension, with none of the IQRs exceeding 4. Moreover, convergence for coastal timber is somewhat better than the IQR suggests: scores for 16 of the respondents are clustered in the 8 to 9 range of the scale, with a mode of 10 (9 respondents). The reverse is true in the case of boreal timber harvesting. The distribution is bimodal, with 5 respondents scoring at the 6-level and 5 at the 8-level. Another 4 scored at the 1-level.

Convergence is particularly good for limestone quarrying and aggregates extraction. Nineteen of the 23 respondents scored limestone quarrying in the 1 to 3 range, with a mode of 2. The mode for aggregates extraction is 1, with 13 respondents scoring at that level and no more than two respondents scoring this activity at any other point on the scoring scale.

Figure 8
THE RELATIVE SIGNIFICANCE OF
AREAS TYPICALLY IMPACTED



Descriptive Statistics

	Mean	Median	IQR
Coastal Timber	7.869	9.000	4.000
Boreal Timber	5.217	6.000	3.000
Iron Ore	3.304	3.000	4.000
Coal	3.565	4.000	3.000
Limestone	2.521	2.000	1.750
Aggregates	2.347	1.000	2.750

3.3 SUMMARY

Descriptive statistics for all of the responses are summarized in Table 1, including modes. We have also added a column showing the relative ranking of the dimensions or activities for each question, based on the median values. A rank of 1 denotes the least level of importance for the dimensions or the least impact for the extraction activities (i.e. lowest median values).

In the case of the intensity dimension, for example, boreal timber harvesting and aggregates extraction are both ranked first — lowest impact — because they have equal medians of 3. Coastal timber harvesting and limestone quarrying are both ranked second, while iron ore mining and coal mining are tied for third — greatest impact.

Table 1
SUMMARY OF DESCRIPTIVE STATISTICS

Dimension Scoring	Mean	Median	IQR	Mode	Rank
Intensity	3.3	2	4.75	1	2
Extent	3.5	1	4.75	1	1
Duration	3.7	3	5.50	1	3
Significance	4.5	4	5.50	1	4
Scoring for Intensity					
Coastal Timber Harvesting	5.6	4	5.75	4	2
Boreal Timber Harvesting	3.7	3	5.75	1	1
Iron Ore Mining	6.1	6	3.00	5	3
Coal Mining	5.9	6	3.00	6	3
Limestone Quarrying	3.7	4	3.00	1	2
Aggregates Extraction	3.1	3	4.00	1	1
Scoring for Extent					
Coastal Timber Harvesting	7.0	8	1.75	8	3
Boreal Timber Harvesting	7.1	8	3.00	10	3
Iron Ore Mining	2.9	3	3.00	1	2
Coal Mining	3.7	3	2.75	3	2
Limestone Quarrying	1.8	2	1.75	1	1
Aggregates Extraction	2.5	2	2.75	1	1
Scoring for Duration					
Coastal Timber Harvesting	5.7	5	6.00	3	4
Boreal Timber Harvesting	3.8	3	5.00	1	2
Iron Ore Mining	6.0	6	3.50	6	5
Coal Mining	5.1	5	2.75	4	4
Limestone Quarrying	4.0	4	4.00	1 & 2	3
Aggregates Extraction	3.1	2	3.75	1	1
Scoring for Significance					
Coastal Timber Harvesting	7.9	9	4.00	10	6
Boreal Timber Harvesting	5.2	6	3.00	6 & 8	5
Iron Ore Mining	3.3	3	4.00	1	3
Coal Mining	3.6	4	3.00	5	4
Limestone Quarrying	2.5	2	1.75	2	2
Aggregates Extraction	2.3	1	2.75	1	1

4.0 ANALYSIS

From the outset, we recognized that our ability to use the median panel scores as measures of ecological capacity impacts in the Sustainable Materials Project systems model would be dependent on achieving a reasonable degree of consensus among the respondents. Without consensus, the exercise might be interesting in an academic sense, but would have little value in terms of building material or design comparisons. The following questions were therefore central to our analysis of results from the first round of questions.

1. How convergent are the responses around central values?
2. Is a second round of questions likely to result in improved convergence?

In Section 3 we presented the response distributions and commented on the degree of convergence around median values. This analysis section focuses in more detail on specific responses and the answers to the above two questions. We start with a look at the overall patterns of responses and then look more closely at the convergence issue in Section 4.2. Our conclusions and answers to the above questions are presented in Section 4.3.

4.1 RESPONSE CORRELATIONS

To see if there were definitive patterns in the responses that might explain the levels of convergence, we examined the relationship of every response to every other response in a correlation matrix.⁴ The correlation coefficients indicate some general tendencies or patterns in the responses. For example, the respondents tended to score:

- coastal timber and boreal timber harvesting in a similar fashion with regard to the intensity, extent and duration dimensions;
- iron ore and coal mining similarly with regard to the intensity, extent and significance dimensions; and
- limestone quarrying and aggregates extraction similarly with regard to the intensity and duration dimensions.
- the intensity of limestone quarrying and aggregates extraction in a similar pattern to the intensity of iron ore mining;
- the intensity of iron ore extraction similar to the duration of iron ore extraction; and
- the intensity of coal mining similar to the duration of coal mining.

⁴Given the sample size, we arbitrarily selected correlation coefficients of 0.6 and higher as indicative of potentially interesting relationships or scoring patterns. Most coefficients in the matrix were in the order of 0.3 or less, indicating little or no relationship between the relevant variables, and the few in the 0.5 to 0.6 range tend to reinforce the observations made in the text above. Of the 17 coefficients (out of 378) higher than 0.6, only one seemed to be inconsistent and probably spurious in that it suggested a relationship between scores for the duration of coal mining impacts and the significance of areas impacted by boreal timber harvesting.

There is an obvious logic to all of these patterns, and they reveal a level of consistency in the respondents' approach to different questions. The intensity and duration relationships between coastal and boreal timber are particularly interesting given the relatively low level of convergence for responses in those two areas, as discussed in Sections 3.2.3 and 3.2.5.

One pattern we were looking for, and did not find at all, was between respondent scoring of the dimensions themselves and their scoring of extraction activities by dimension. For example, we thought respondents who scored significance high on the scale might have a tendency to also assign high scores to the significance of specific extraction activities. This was not the case. The only relationship involving dimension scoring was a relatively high correlation coefficient of .609 between the intensity and significance dimensions and we hesitate to read anything into that result. Otherwise, the relationships between dimension scores and all other scores were quite low.

4.2 CONVERGENCE

The degree of convergence, or central tendency, in the response distributions indicates the degree of scoring consensus among panel members. As discussed in Section 3.1, we decided to focus on comparative IQRs as the primary indicator of convergence. We also decided to use the IQRs for distributions exhibiting good convergence as control values for judging the acceptability of IQRs for other distributions.

Following this general approach, we examined the box plots, descriptive statistics and histograms (Appendix C) with a view to establishing more precise guidelines. Based on that examination, we developed the following two rules for determining whether specific IQRs reflect acceptable degrees of convergence.

1. An IQR of 4 or less is acceptable if the IQR is normally distributed around the median (i.e. 50% of the responses within +/- 2 of the median).
2. An IQR of 3 or less is acceptable if the IQR is skewed (i.e. 50% of the responses are within + 3 or - 3 of the median with a highly skewed distribution or, with less skewed distributions, 50% of the responses are within -1/+2 or +1/-2 of the median).

A look at Figure 5 (Section 3.2.3), shows that the distribution for aggregates meets the criteria in rule 1, above, while the distributions for iron, coal and limestone meet the criteria in rule 2 for less skewed distributions: the IQRs are all 3 and 50% of the responses are no more than +/- 2 from the median. The distribution for aggregates in Figure 8 (Section 3.2.6) meets the criteria in rule 2 for a highly skewed distribution in that 50% of the responses are within +3 of the median.

When we apply the above rules, we find the following specific responses do not exhibit acceptable levels of convergence:

- all of the dimension scores (Figure 3 in Section 3.2.1);
- the intensity of coastal and boreal timber harvesting (Figure 5, Section 3.2.3);
- the relative duration of impacts for coastal and boreal timber harvesting and aggregates extraction (Figure 7, Section 3.2.5); and
- the relative significance of areas typically impacted by coastal timber harvesting (Figure 8, Section 3.2.6).

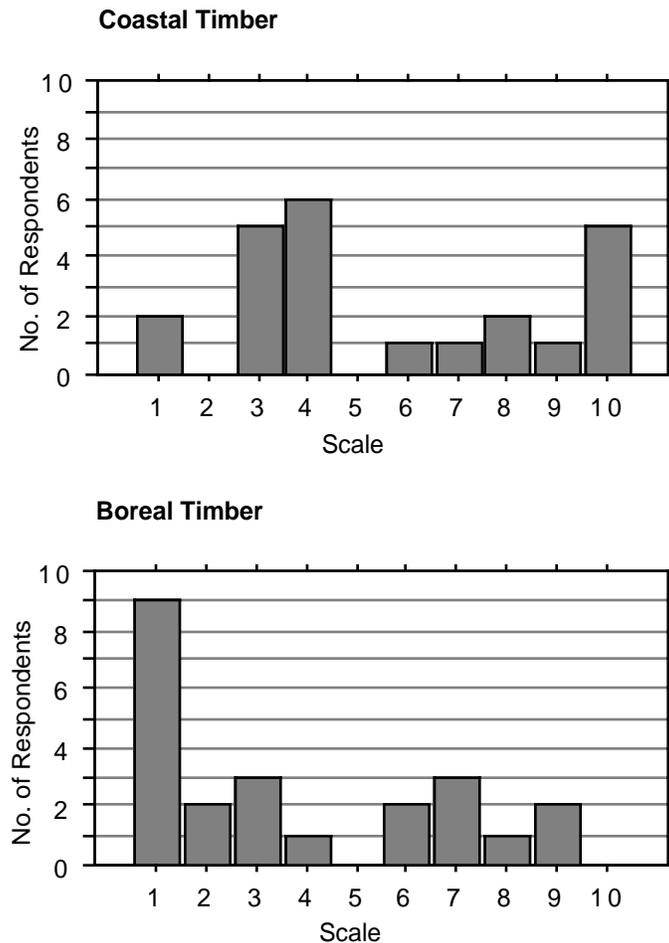
These responses are discussed in the sub-sections that follow, starting with the extraction activity scores for timber harvesting, followed by the duration scores for aggregates extraction. The dimension scores are of a different nature and are discussed last in Subsection 4.2.3.

4.2.1 Intensity, Duration and Significance for Timber Harvesting

As discussed in Section 4.1, correlation coefficients show that respondents tended to score coastal and boreal timber harvesting in a similar fashion with regard to the intensity, extent and duration dimensions. Those who scored one type of timber harvesting relatively high on the scales tended to also enter high scores for the other type of harvesting, and vice versa. In addition, in Section 3.2 we noted distinct splits in distributions for timber harvesting scores, with one grouping of responses at the lower end of the scales and one grouping at the high end.

This pattern is evident in several of the histograms in Appendix C, two of which are reproduced below in Figure 9. The horizontal axes in Figure 9 show the scoring scales for intensity, from 1 to 10. The vertical axes show the number of respondents scoring each of the timber harvesting activities at various points on the scales.

Figure 9
INTENSITY OF COASTAL AND BOREAL TIMBER HARVESTING:
FREQUENCY DISTRIBUTIONS OF RESPONDENT SCORES



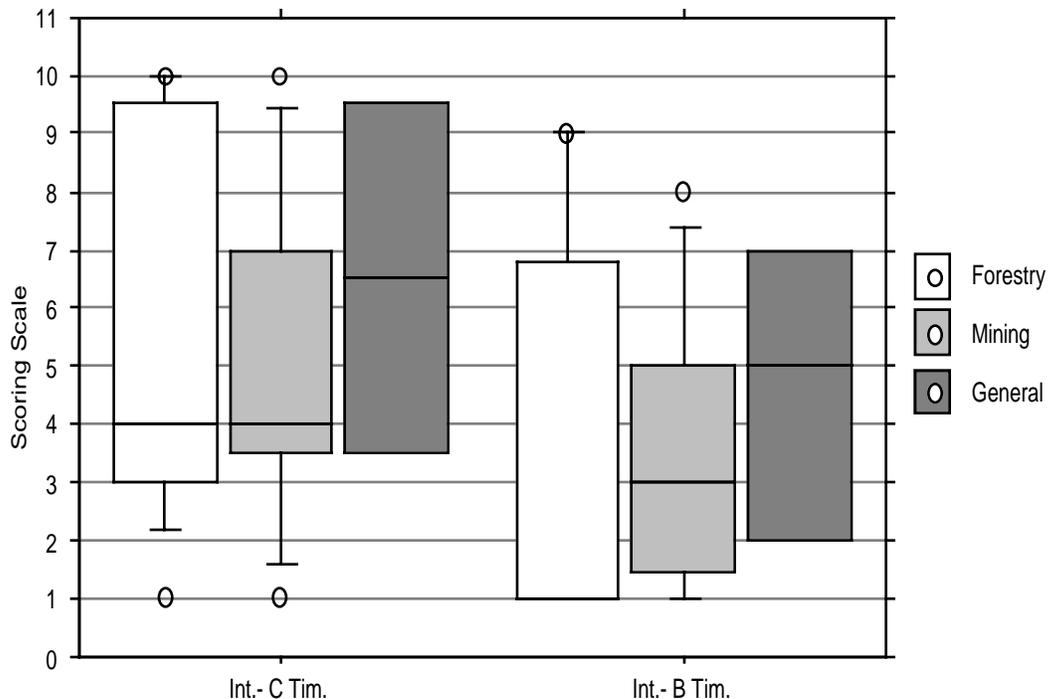
The split in the distribution is particularly marked in the coastal timber part of Figure 9, with 13 respondents scoring intensity at 4 or less and 10 scoring at 6 or more. The split is less definitive for boreal timber, with 15 scoring at 4 or less and 8 at 6 or more. The coastal timber pattern is as distinct in the Appendix C histogram for the duration dimension — 12 scoring at 5 or less and 11 at 7 or more — and is evident but less distinct for the boreal timber duration and coastal timber significance scores.

Bearing in mind the point made earlier, that the same respondents tended to score both coastal and boreal timber at either the high or low end of the scales for all but the significance dimension, it seems clear that the split distributions reflect two different schools of thought about the impacts of timber harvesting in general. But before we explore that aspect, it is useful to briefly examine the results of an analysis of scores by respondent areas of expertise.

Using the respondent scores of their own expertise relative to each of the harvesting activities (see Section 2.2.2), we sub-divided the panel into three broad categories: those with primary expertise in the timber harvesting field; those with primary expertise in the mining and/or quarrying field; and generalists. Of the 23 respondents, 11 were categorized as forestry experts, 8 as mining or quarrying experts, and only 4 as generalists.

We then split the box plots for the coastal and boreal timber intensity, duration and significance scores by expertise category. The results for the intensity dimension are shown in Figure 10.

Figure 10
THE INTENSITY OF COASTAL AND BOREAL TIMBER HARVESTING:
SCORES BY EXPERTISE CATEGORY



The figure shows two sets of box plots, one for coastal timber (Int.-C Tim.) and one for boreal timber (Int.-B Tim.) harvesting. Each set shows the range of scores (vertical axis)

for the forest, mining/quarrying and generalist expertise categories. Only the distributions for the forestry and mining expertise categories are useful because too few respondents were categorized as generalists to put any weight on the results for that category.

But the differences between the IQRs for the forestry and mining distributions are instructive: for both coastal and boreal timber, there was much less consensus among the respondents categorized as timber harvesting experts than among the mining/quarrying experts. Virtually the same results were found in the split box plots for the coastal timber duration scores. For the boreal timber duration and coastal timber significance scores, the forestry expertise category exhibited smaller IQRs than the mining expertise category, but even in those cases the full distribution ranges from the 10th to the 90th percentile were greater for the forestry expertise category.

In short, the respondents with the most timber harvesting expertise or experience tended to be more divided in their views about relative impacts of those activities than those with more expertise in mining or quarrying. Several factors may explain both this apparent anomaly and the distribution splits described earlier.

As discussed in some detail in Dr. Paehlke's report on ecological capacity impacts, forest harvesting is undertaken in virtually every area of the country and both harvesting techniques and environmental impacts vary widely, not just from region to region or from firm to firm, but even within the same firm operating in the same part of the country. The reasons are equally varied: techniques are a function of the nature of specific tree stands, topography, regulatory regimes, economics and a host of other factors; and environmental impacts are determined by the techniques used, topography, soil conditions, the nature of the flora and fauna in a specific area, etc. Respondents with more timber harvesting expertise would be more likely to recognize this extreme variability and to therefore find it more difficult to respond to the questions posed in the survey.

In addition, those with experience in one region could have an equally logical and valid, but very different, opinion about impacts compared to those with experience in another region. In fact, we were advised during the testing stage to consider treating timber harvesting on a regional basis. But we had to reject that advice because of the consequent requirement for a larger, regionally-oriented, panel and the associated additional survey complexity, time and cost.

Another factor related to the duration, and possibly the intensity, dimension is the issue of renewability. It can be argued on the one hand that timber is a renewable resource, that harvesting does not result in a dramatic alteration to the landscape unless serious erosion problems occur, and that proper regeneration can restore a site so that future generations might be hard-pressed to know whether the area had been logged — particularly in the boreal forest.⁵ Both duration and intensity might then be scored relatively low in comparison to activities such as iron ore mining.

On the other hand, it can be argued with equal validity that while trees are renewable, the original forest and related ecology is never renewed: an argument that has especially strong appeal with regard to the old-growth coastal forest. Since respondents had a tendency to

⁵This is obviously not the case where regeneration is with one species planted in rows or uniform patterns — a tree farm. But extensive regeneration in more northerly areas where harvesting is concentrated does not tend to follow that pattern. Moreover, most of the boreal forest has been naturally burned or destroyed by insects or disease at least once in modern history, with few stands more than 200 years old. Natural regeneration after such events may produce a new forest that appears much the same as the forest regenerated after harvesting.

score both types of timber harvesting in a similar manner, those subscribing to this argument may have applied the same reasoning to boreal timber harvesting.

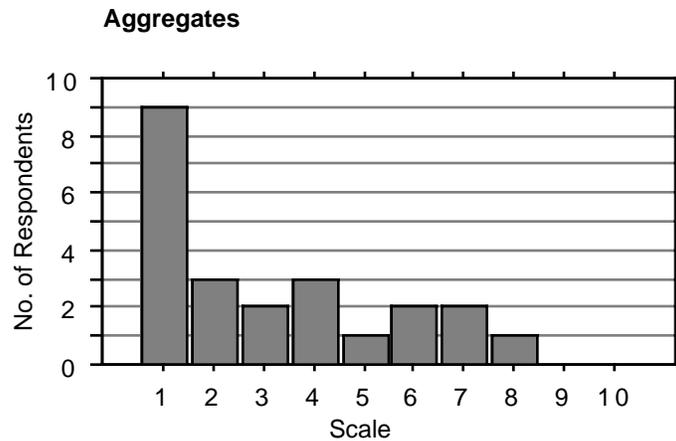
While they did not meet our guidelines for acceptable convergence, scores for the coastal timber significance dimension were not as widely distributed, nor was the distribution as distinctly split as for the intensity and duration dimensions (IQR of 4 for a slightly skewed distribution). Also, as discussed in Section 3.2.6, convergence was better than the IQR suggests with scores for 16 of the respondents clustered in the 8 to 9 range of the scale.

In this case, the median of scores for the forest experts was higher than the median for the mining experts (9 versus 7) and we suspect this results mirrors the attention in the literature given to problems associated with old growth harvesting. It is hard to work on environmental issues related to forestry without becoming acutely aware of the old growth controversies and of the significance of the areas impacted by harvesting.

4.2.2 Impact Duration for Aggregates Extraction

With an IQR of 3.75, the scores for the duration of aggregate extraction impacts almost meet our criteria for an acceptable level of convergence — the IQR is only 0.75 too high for a skewed distribution. As the histogram in Figure 11 shows, the distribution is not split but has a relatively wide range, from a modal value of 1 (9 respondents) to a high score of 8 (1 respondent).

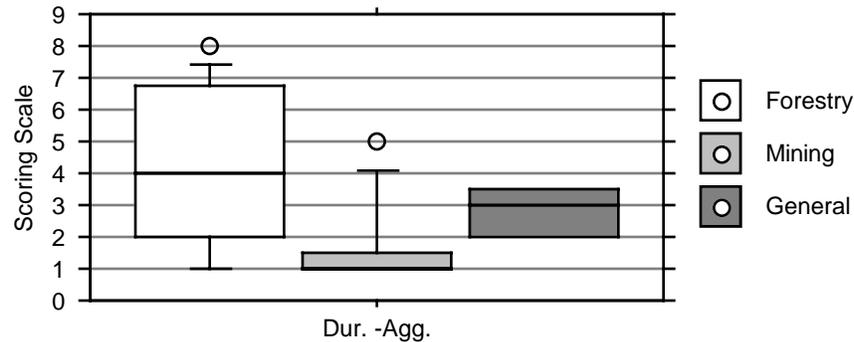
Figure 11
DURATION OF AGGREGATES EXTRACTION IMPACTS:
FREQUENCY DISTRIBUTION OF RESPONDENT SCORES



In this case, we see a distinct difference between the scores assigned by respondents with mining or quarrying expertise compared to those categorized as forestry experts. As shown in Figure 12, the IQR for the mining category is less than 1 and this group is primarily responsible for the modal value of 1 shown in Figure 11. In contrast, the IQR for the forestry category is almost 5, with a median of 4.

It is clear that those more familiar with aggregates extraction activities do not think the impacts are very lasting in comparison to other types of extraction activities — a position that fits information from other sources about the extent of restoration now carried out in the aggregates industry. Indeed, our understanding is that aggregates quarries are now

Figure 12
THE DURATION OF AGGREGATES EXTRACTION IMPACTS:
SCORE BY EXPERTISE CATEGORY



generally developed with a restoration plan in place from the outset, and that quarrying may often be the first step in developing a site for housing, golf courses or other uses.

In contrast, those less familiar with the industry may be more influenced by the fairly common sight of older operating or abandoned quarries near urban areas, and by the media attention that is sometimes given quarrying activities in general.

4.2.3 The Dimension Scores

The IQRs of distributions for the dimension scores are similar and high — two at 4.75 and two at 5.50. As the histograms in Appendix C show, the modal values for intensity, extent and duration are 1, accounted for by 10, 12 and 10 respondents, respectively. The remaining scores are fairly uniformly distributed across the scale, with no more than three respondents scoring intensity, extent or duration at any other specific level. While the modal value for significance is also 1, only six respondents scored at that level, while five scored at the 4-level and three at the 10-level.

We can offer no concrete explanations for these scoring patterns, except to note that dimension scoring is much more subjective than scoring the activities themselves.

4.3 CONCLUSIONS

Given the subjective nature of the survey and the complexity of the issues, we believe there was a remarkable degree of consensus in the panel responses. Of 28 sets of scores, 18 met the convergence criteria (see Section 4.2). Of the remaining 10, the scores for the duration of aggregates impacts and for the significance of areas impacted by coastal timber harvesting were very close to meeting the criteria — closer than the IQRs alone would suggest. That left the four sets of dimension scores and the four sets of scores for coastal and boreal timber intensity and duration as the only clearly non-convergent responses. Our focus was on those eight sets of scores when we addressed the question of whether we should proceed to a second survey round to improve convergence.

We decided against a second round for several reasons. One general reason was a concern that too few respondents would complete a second questionnaire and that we would see an already small sample shrink to an unacceptable size. The other reasons, discussed in the following two subsections, are more specific.

4.3.1 The Dimension Scores

As noted in Section 4.2.3, the dimension scores are even more subjective than scores indicating the relative impacts of the six extraction activities for each dimension. Beyond showing the panelists the distributions of first round responses, it is difficult to conceive of any other information we could provide that would cause them to adjust their scores, at least not without prejudicing the responses.

However, we did consider another approach to the use of those scores which would more explicitly recognize their subjective nature and would eliminate the need for convergence.

Our original intent was to use the median of the dimension scores as weights for the relevant extraction activity scores, assuming the medians were different and that there was reasonable convergence. The alternative was to treat each respondent's set of dimension scores as subjective individual measures and to use them to weight each respondent's set of extraction activity scores. Distributions for the individually weighted activity scores could then be compiled and analyzed in the same manner as the unweighted scores.

We followed that procedure and the resulting box plots are presented in Appendix D. Since the maximum possible score was now 100 for each extraction activity and dimension combination (i.e. a maximum score of 10 for a dimension times a maximum of 10 for an activity relative to that dimension), we proportionally adjusted the convergence criteria to an IQR of 30 for a skewed distribution and 40 for a distribution with an IQR normally distributed around the mean. In fact, all of the resulting distributions were skewed so the IQR of 30 became the relevant criterion.

Overall, there was a marked improvement in convergence when we followed this approach. A review of the box plots and accompanying tables in Appendix D shows that only three distributions failed to meet the criterion: extent for coastal timber harvesting (IQR = 32); duration for coastal timber (IQR = 34.5); and significance for coastal timber (IQR = 36). Notably, all three of these distributions deal with coastal timber and none is widely off the mark. In fact, only the extent scores show a larger proportional IQR than in the unweighted distributions discussed previously, while the degree of convergence improved for both the duration and significance scores.

However, we were surprised by what we found when we completed the final results table described in Section 2.4. Impact totals for the six extraction activities calculated using the individual weighting approach described above were virtually the same as totals calculated by weighting the medians of extraction activity scores by the medians of the dimension scores (the completed tables are presented in Section 5.0). In other words, the final impact totals that would be used in the Sustainable Materials Project systems model appear to be relatively insensitive to the weighting approach. By extension, there is a reasonable probability that an improvement in convergence of the dimension scores would be unlikely to improve the quality of the final results.

These findings added to our other concerns as a reason for not proceeding to a second survey round.

4.3.2 The Intensity and Duration of Timber Harvesting

In Section 4.2.1, we discussed what we believe are key factors underlying, or explaining, the divergence in responses regarding both the timber harvesting intensity and duration dimensions. Two factors seem particularly critical:

- the regional diversity of timber harvesting techniques and environmental impacts; and
- the fact there can be two equally logical, and probably valid, ways of viewing timber resource renewability and therefore harvesting impact duration (and, to a lesser extent, impact intensity) — a focus on the trees and the potential for regeneration or recovery of harvested areas, and a focus on forests as ecological systems that never renew in exactly the form existing prior to harvesting.

We also noted that those expert or experienced with regard to timber harvesting issues were more divergent in their views than those more expert with regard to mining or quarrying issues. Finally, the response correlations suggest that respondents viewing the harvesting issues from one perspective or the other were likely to treat all timber harvesting the same, without distinguishing the issues and impacts applying primarily to coastal forests from those applying primarily to boreal and interior B. C. forests.

In view of all these factors, we concluded a second round of questions was unlikely to result in improved convergence unless we provided specific feedback information that would probably prejudice the results. Unlike the situation for the duration of aggregates extraction impacts, we were not even in a position to point to the more expert opinions (scores) as a guideline for those less expert. There is no question this is an area that requires further exploration, but it will probably be best done in some future study with a more precise focus on regional and forest type variations.

Having reached that conclusion, we also decided that the medians of the distributions probably best represent the spirit of the responses, even if they do not reflect the desired degree of consensus. The medians give equal weight to both ends of the spectrum of responses and therefore to the scores of those subscribing to both schools of thought about timber harvesting impacts.

5.0 FINAL RESULTS AND RECOMMENDATIONS

5.1 FINAL RESULTS SUMMARY

The final survey results are summarized in Tables 2, 3 and 4 on the next page. Table 2 shows the unweighted median scores by dimension for each extraction activity. Table 3 shows the results by extraction activity when the medians of the dimension scores are used to weight the median activity scores from Table 2. Table 4 shows the median scores for each extraction activity, by dimension, when individual dimension scores are used to weight individual activity scores before calculating medians. The last column in each table shows the impact totals for each activity when the scores are added.

As we mentioned in the last section, the impact totals are surprisingly insensitive to the weighting approach used. In fact, other than a proportional across-the-board increase, the results are similar even if no weights are attached. For example, when we rank the activities from 1 to 6, where 1 is the activity with the lowest total impact score and 6 is the activity with the highest impact total, we get the following results.

	Rank in:		
	Table 2	Table 3	Table 4
Coastal timber harvesting	5	6	6
Boreal timber harvesting	4	5	5
Iron ore mining	3	3	3
Coal mining	3	4	4
Limestone quarrying	2	2	2
Aggregate quarrying	1	1	1

The rankings are unchanged from one table to the next, with the exception of a slight change for iron ore and coal mining which are tied in Table 2, and ranked 3 and 4, respectively, in Tables 3 and 4.

Another way of looking at the relative effects of the two weighting approaches is to divide the total impact scores in Tables 3 and 4 by the relevant totals in Table 2. When we do that, we get the following factors that show the amount by which scores increased going from unweighted to weighted totals.

	Increase by:	
	Table 3	Table 4
Coastal timber harvesting	2.58	2.54
Boreal timber harvesting	2.35	2.25
Iron ore mining	2.50	2.28
Coal mining	2.56	2.39
Limestone quarrying	2.50	2.25
Aggregate quarrying	2.25	2.75

For example, the total impact score for coastal timber harvesting increased by 2.58 when we weighted the extraction activity scores using the median panel dimension scores (Table 3), and by 2.54 when we individually weighted the activity scores (Table 4). Comparing all of these increase factors shows a remarkably consistent pattern of increase for all extraction activities irrespective of the weighting approach. The pattern is especially remarkable when we take into account the subjective nature of the entire scoring exercise.

**Table 2
MEDIAN EXTRACTION ACTIVITY IMPACT SCORES:
BY DIMENSION AND TOTAL**

	Impact Intensity	Extent of the Area Impacted	Impact Duration	Significance of the Area Impacted	Total Impact
Coastal timber harvesting	4	8	5	9	26
Boreal timber harvesting	3	8	3	6	20
Iron ore mining	6	3	6	3	18
Coal mining	6	3	5	4	18
Limestone quarrying	4	2	4	2	12
Aggregate quarrying	3	2	2	1	8

**Table 3
MEDIAN EXTRACTION ACTIVITY SCORES
WEIGHTED BY MEDIAN DIMENSION SCORES:
BY DIMENSION AND TOTAL**

	Impact intensity	Extent of the area impacted	Impact duration	Significance of the area impacted	Total Impact
Coastal timber harvesting	8	8	15	36	67
Boreal timber harvesting	6	8	9	24	47
Iron ore mining	12	3	18	12	45
Coal mining	12	3	15	16	46
Limestone quarrying	8	2	12	8	30
Aggregate quarrying	6	2	6	4	18

**Table 4
MEDIAN OF INDIVIDUALLY WEIGHTED EXTRACTION ACTIVITY SCORES:
BY DIMENSION AND TOTAL**

	Impact intensity	Extent of the area impacted	Impact duration	Significance of the area impacted	Total Impact
Coastal timber harvesting	10	10	10	36	66
Boreal timber harvesting	6	7	8	24	45
Iron ore mining	15	6	10	10	41
Coal mining	10	8	10	15	43
Limestone quarrying	6	3	8	10	27
Aggregate quarrying	5	4	7	6	22

Finally, it is useful to look at the absolute change in total impact scores from Table 3 to Table 4. The total decreased by 1 for coastal timber, by 2 for boreal timber, by 3 for coal and limestone, and by 4 for iron ore, and it increased by 4 for aggregates. Again, these are remarkably small absolute changes considering the scales in both weighting approaches are from 1 to 100 and the potential for variation from one approach to the other was very large.

5.2 RECOMMENDED USE OF THE RESULTS

As mentioned in Section 2.4, our starting premise was that impact scores for the different resource extraction activities could be used in the Sustainable Materials Project systems model to adjust or weight the resource requirements for each building product. Without that kind of an adjustment, model users would only know the mass or volume of resources required, and would have no indication of the environmental impacts of extracting those resources. To put it another way, tonnes or cubic metres of a resource like timber are not equivalent to tonnes or cubic metres of a resource like iron ore from an environmental perspective. But applying weights that reflect the differential ecological carrying capacity impacts of extraction is at least a step toward providing users with comparable measures of resource use.

In view of the findings discussed in the preceding subsection, we recommend the unweighted impact totals from Table 2 be used in the systems model. There is too little variation in the pattern of increase in the survey results when dimension scores are used as weights to justify using the impact totals from Tables 3 and 4: one weighting approach is essentially the same as the other, and neither changes the basic conclusions in terms of the ranking of activities or the relative impact totals. Given the nature of the survey, the less manipulation of the results, the better.

We also recommend the impact totals from Table 2 be converted to a simple index which maintains the differentials between extraction activities. Irrespective of the weighting approach, aggregates extraction is the activity with the least environmental impact according to the survey results and we can therefore assign aggregates a score of 1 and scale all the other results on that basis (i.e. all other Table 2 totals can be divided by the total for aggregates to produce the index). The results of that procedure are as follows.

	Impact Index
Aggregates Extraction	1.00
Limestone Quarrying	1.50
Coal Mining	2.25
Iron Ore Mining	2.25
Boreal Timber Harvesting	2.50
Coastal Timber Harvesting	3.25

One merit of this index is that it parallels the scoring approach in the survey: the extraction activity with the least impact was assigned a score of 1 and other activities were scored accordingly. As in the survey, the above final impact index provides relative measures of ecological carrying capacity impacts.

One way of interpreting the index is that, from an environmental perspective, 3.25 cubic meters of coastal timber is equivalent to 1.00 cubic metre of aggregates. Alternatively, we can say that coastal timber harvesting has 3.25 times the ecological carrying capacity

impacts of aggregates extraction. Of course, either interpretation is subject to the caveat that the index is the result of a subjective survey of a relatively small panel of environmental experts.

In the model, this simple index can be used as a multiplier for the actual resource volumes required to make the specific building products. The result will be a set of ecologically weighted resource requirements for each product, building assembly, or complete structural design.

5.3 FUTURE WORK

We believe the results of this study suggest promising avenues for future research to quantify, or at least clarify, the relative impacts of different resource extraction activities in terms of ecological carrying capacity.

One obvious possibility is to carry out a similar survey to the one done for this study, but with a much larger panel. We observed a consistent pattern of improved convergence as completed questionnaires were returned, which suggests that convergence could be much better for a larger panel. In addition, a larger sample size would allow more rigorous statistical analysis and testing.

A larger sample would also facilitate a more regionally-oriented analysis. As discussed previously in this report, the regional variation in timber harvesting techniques and impacts seems to be one key reason for the relatively wide variation in responses related to timber harvesting impacts. It would therefore be useful to examine those impacts on a region-by-region basis (e.g. B.C. coastal, B.C. interior, prairie region, central Canada and Atlantic Canada). The same regional breakdown could be used for limestone quarrying and aggregates extraction.

Since both wood and concrete building materials are treated on a regional basis in the Sustainable Materials Project systems model, the results of such a regionally-oriented survey could be readily incorporated. From our perspective, a regional breakdown is less critical in the case of iron ore and coal mining because these resources are primarily used in the manufacture of steel building products in integrated steel plants located in central Canada, and come from relatively few sites. However, it might be useful to differentiate open pit and underground coal mining.

Another research avenue that deserves consideration is to assess expert opinion in terms of a set of leading impact indicators instead of the intensity, extent, duration and significance dimensions used in this survey. For example, experts could be asked to assess the relative impacts of resource extraction on biodiversity, ground and surface water quality, wildlife habitat, soil stability and regenerative capacity, the carbon cycle or other indicators. One merit of this approach is that respondents could draw on more hard data and scientific evidence for at least some of the indicators. However, a drawback is that it would be more difficult to structure a reasonably balanced panel with well-defined expertise in each of the subject areas. It would also be more difficult to formulate a fair method of aggregating results to produce the kind of index required for the systems model. Nevertheless, it is an approach that warrants further consideration.

As we said in the Introduction, deciding how to assess ecological carrying capacity effects has been a challenging problem from the outset of the Sustainable Materials Project. The approach we adopted can be criticized for various reasons, but we believe it is a step in the right direction. The survey panel was unequivocal in its view that ecological carrying

capacity effects are at least as important, if not more important, than other more readily measured environmental impacts. Such effects cannot be ignored, nor can we wait for the scientific community to resolve outstanding differences and develop more precise measures of the various impacts. Indeed, that may never happen when the overall subject matter is so complex and the impacts so diverse. Other avenues have to be investigated, and we hope this report will spark discussion and research to improve on the results reported here.

APPENDIX A
SURVEY RESPONDENTS

LIST OF RESPONDENTS

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APPENDIX B

**QUESTIONNAIRE GUIDE
AND QUESTIONNAIRE**

**THE ECOLOGICAL IMPACTS OF
RESOURCE EXTRACTION**

**MODIFIED DELPHI SURVEY
QUESTIONNAIRE GUIDE**

Note:

Please read this guide before completing the questionnaire.

March, 1994

INTRODUCTION

Thank you for participating in this survey.

As you know, we are developing a systems model to assess the relative environmental effects associated with the full life cycle of various building products made from concrete, steel and wood. The focus of this survey is on the relative environmental impacts of extracting resources to make the building products.

The resources of concern are:

- timber from the B. C. coastal area;
- timber from the boreal forest, including the B. C. interior;
- iron ore;
- coal (metallurgical and thermal);
- limestone used in cement manufacturing; and
- aggregates used in concrete products.

The material sent to you earlier includes background information about the Sustainable Materials Project, as well as extracts from Dr. Paehlke's comprehensive qualitative report on the ecological carrying capacity effects of resource extraction, prepared as part of the Sustainable Materials Project. Please draw on this background information as well as on your expert and general knowledge when completing this survey.

The rest of this guide is intended to help you interpret and respond to the questions. It contains some definitions, brief explanations of the intent of each question, and indications of how we would like you to consider the various alternatives.

SURVEY FOCUS

Estimates of the energy use, atmospheric emissions, liquid effluents and solid wastes associated with extracting the six resources have already been made as part of a series of quantitative studies. The focus of this survey is on other effects such as impacts on:

- biodiversity
- ground and surface water
- soil stability
- nutrients and regenerative capacity
- wildlife
- the carbon cycle.

We refer to these and similar impacts as ecological carrying capacity effects. These effects cannot be so readily measured, nor can they readily be compared to each other. We therefore hope to use the results of this survey to develop proxy measures of the ecological carrying capacity effects of the resource extraction activities. The measures will then be used to weight the actual quantities of each resource required to make the relevant products. The resulting weighted resource requirement estimates will be used as an input to the systems model.

APPROACH

The objective of the questions is to quantify the *relative* effects of the six resource extraction activities compared only to each other. We are not concerned about the absolute effects, nor do we want to make even implicit comparisons to other types of industrial activities or environmental problems.

As a starting point, we ask you to assume that all the resources will continue to be extracted and used. The questions deal with the combined ecological capacity effects of the extraction processes, assuming **average or typical practices** on the part of the relevant industries.

The measures will be developed by asking you to score the relative impacts of the six extraction activities in terms of the following four impact dimensions:

- the intensity of impacts;
- the extent of the areas typically impacted;
- the duration of impacts; and
- the ecological significance of the areas typically impacted.

These four dimensions are defined in the next section of these guidelines.

The questionnaire is divided into 3 parts. Part I deals with the relative importance of the four dimensions themselves. Part II deals with the impacts of the six resource extraction activities in terms of the dimensions, and Part III requests information about your areas of expertise.

PART I THE RELATIVE IMPORTANCE OF THE FOUR DIMENSIONS

In this part of the questionnaire, you will be asked to rank the four dimensions in order of importance from an environmental perspective. You will then be asked to provide an indication of the relative differences between the assigned ranks or levels of importance. The final question in this part asks how important you think the overall range of ecological capacity effects is compared to the more measurable impacts of resource extraction (i.e. energy use, atmospheric emissions, liquid effluents and solid wastes).

The following explanations of the four dimensions should make clear what each encompasses.

The Intensity of Impacts

The intensity dimension refers to the degree of overall environmental disruption associated with a resource extraction activity.

The focus of this dimension is on how much of the ecology of an area is disrupted, whether temporarily or permanently. Disruption might be assessed in terms of the removal, destruction or disturbance of flora and fauna, the removal or degree of disturbance of topsoils and subsoils, hydrological effects, and the degree of alteration to the landscape generally.

The Extent of the Areas Typically Impacted

The extent dimension refers to the extent or size of the geographic areas typically impacted, either directly or indirectly, by a resource extraction activity.

You can think of this dimension in terms of the extent of the area impacted per unit of resource — for example, per tonne of timber versus per tonne of iron ore or aggregates. Please do not think in terms of the extent of the areas impacted relative to all potential extraction sites, nor in terms of the estimated quantities of the resources potentially available.

Indirect impacts could include such effects or activities as severe dust, noise pollution and the construction and use of access or haul roads. In other words, extensiveness is not necessarily restricted to just the immediate extraction sites.

The Duration of Impacts

The duration dimension refers to the average length of time before typically impacted areas return to ecological productivity and balance, even though this seldom represents a return to the exact conditions prevailing before the extraction activities.

In considering this dimension, you should take account of the regeneration or restoration practices typically followed by the relevant extraction industries.

The Significance of the Areas Typically Impacted

The significance dimension refers to such considerations as the uniqueness, from a national or wider perspective, of areas typically impacted, the ecological richness of areas, and even their beauty or aesthetic value.

Significance might be judged in terms of such factors as:

- the number or extent of other areas with similar characteristics;
- the ability of other areas to support similar flora and fauna;
- the diversity of flora and fauna present in areas typically impacted;
- the importance of flora and fauna uniquely supported by areas typically impacted; and
- the importance of such areas for recreation or as a support for broadly held social values.

PART II THE IMPACTS OF EXTRACTION ACTIVITIES BY DIMENSION

There are four, two-part, questions in this section of the questionnaire. The four questions follow exactly the same pattern, the only difference being that each deals with a different impact dimension. For each dimension, you are asked to judge the relative ecological capacity effects of extracting the six resources listed in the Introduction.

Throughout this part of the questionnaire you are asked to make your judgements assuming the relevant extraction industries follow average, or typical, practices in terms of:

- extraction methods and processes;
- the adoption of mitigating measures to minimize environmental effects;
- the restoration of extraction sites or areas; and
- other relevant activities.

Question II.1 (a) asks if you think all six resource extraction activities are approximately the same in terms of the Intensity dimension — in other words, are they the same in terms of the overall degree of environmental disruption, without regard for the extent of areas typically disrupted, the duration of impacts or the significance of areas impacted. If you answer 'Yes' you will proceed to Question II.2. If you answer 'No' you will complete Question II.1 (b).

Question II.1 (b) presents you with a set of six intensity scales, one for each resource extraction activity. The scales are similar to the scale used to denote the

relative importance of the dimensions in Part I of the questionnaire. You simply check one box on each scale to indicate your judgements about the relative intensity of each resource extraction activity.

As illustrated in the following generalized example, the scales show a range of increasing impact from 1 to 10, where the 1-level denotes the lowest relative impact.

											
		1	2	3	4	5	6	7	8	9	10
Resource Extraction	Activity 1	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Activity 2	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Activity 3	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Activity 4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Activity 5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Activity 6	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

For the dimension in question, we are only concerned about the impacts of the six activities compared to each other, without regard to any other type of activity or to any other type of environmental effect. Therefore, at least one activity should be checked at the 1-level (Activity 2 in the example). You can then scale the other activities relative to the one (or the ones) judged to have the lowest level of relative impact. In the example, Activity 6 has been scored with twice as high an impact as Activity 2, while both Activity 1 and Activity 3 have been scored at three times as high an impact. It is your choice whether to score any activity as high as the 10-level.

Questions II.2 (a) & (b), II.3 (a) & (b) and II.4 (a) & (b) follow exactly the same pattern as Question II.1 (a) & (b) and deal with the extent, duration and significance dimensions, respectively.

As you complete each question in this part of the questionnaire, we ask that you make every effort to treat each as a discrete question, without reference to the scores assigned for the other questions. If you don't, there will be implicit double counting because the combined respondent scores for each dimension will later be weighted by the combined respondent judgements about the relative importance of the four dimensions.

We also ask that you complete all four questions, even if some deal with activities or environmental impacts with which you are less familiar.

Following each of the four questions, a space is provided for any comments you would like to make about the scores you assigned, the size of the scale provided, or any other concerns or observations about that question.

PART III RESPONDENT INFORMATION

In this final part of the questionnaire, we would like to obtain information about your level of expertise with regard to the different extraction activities and environmental effects.

This information will help us to better understand the responses, and may be used, without attribution, to classify or characterize panel responses. Information about your areas and levels of expertise could be particularly helpful in preparing a commentary for all panel members if we have to proceed to a second round of questions.

THE ECOLOGICAL IMPACTS OF RESOURCE EXTRACTION

MODIFIED DELPHI SURVEY QUESTIONNAIRE

Please read the Questionnaire Guide before completing this questionnaire.
Also, please fill in the following before returning the completed
questionnaire.

Name: _____
Please print

Telephone: _____

Fax: _____

Date: _____

Note:

The identities of individuals in relation to all specific responses will remain
confidential during the survey and in any reports.

PART I THE RELATIVE IMPORTANCE OF THE FOUR DIMENSIONS

Question I.1

Do you think the intensity, extent, duration and significance dimensions should be considered of equal importance, and therefore equally weighted?

Yes No

If you answered yes, please go to question I.4. If you answered no, please answer questions I.2, I.3 and I.4.

Question I.2

Please rank the four dimensions in order of importance from least important to most important.

Indicate your ranking by circling the letter A, B, C or D opposite each of the dimensions in the list below. The letter 'A' signifies the least important dimension and the letter 'D' the most important dimension. Circle the same letter if you consider two or three of the dimensions to be of the same importance.

***Note:** Because we are only concerned about relative rankings, the letter 'A' should be circled for at least one of the four dimensions, and the letter 'D' need not be used if two dimensions are considered of equal importance.*

Dimension	Importance Ranking			
	Least			Most
The Intensity Of Impacts	A	B	C	D
The Extent Of The Area Impacted	A	B	C	D
The Duration Of Impacts	A	B	C	D
The Significance Of The Area Impacted	A	B	C	D

Question I.3

To indicate how much more or less important you consider each of the dimensions relative to the others, please position all of the letters you assigned as ranks in the previous question on the scale provided below .

Since this is a relative scale, the letter 'A' (assigned to the dimension or dimensions you ranked as least important in question I.2) has already been positioned at the left side of the scale. If you ranked two or three of the dimensions as equally important, simply position the single letter you assigned to that set of dimensions. You need not necessarily score any dimension as high as the 10 level.

Scale of Increasing Importance 									
1	2	3	4	5	6	7	8	9	10
A									

Question I.4

How important do you consider the combined ecological carrying capacity effects to be in comparison to the following more readily measured environmental impacts: energy use, atmospheric emissions, liquid effluents and solid wastes? Please indicate your answer by checking one box to complete the following statement.

In comparison to the more measurable impacts, I think ecological carrying capacity effects are:

- Less Important
- Equally Important
- More Important

PART II
THE IMPACTS OF EXTRACTION ACTIVITIES BY DIMENSION:
ASSUMING AVERAGE OR TYPICAL EXTRACTION PRACTICES

THE INTENSITY DIMENSION

For a definition of INTENSITY please see page 4 of the questionnaire guide.

Question II.1 (a)

Do you think all six resource extraction activities are approximately the same in terms of the *INTENSITY* of impacts when the industries follow average, or typical, extraction practices?

Yes No

If you answered yes, please proceed to question II.2 (a). If you answered no, please answer question II.1 (b), below.

Question II.1 (b)

Please score the relative *INTENSITY* of extraction impacts for the six resource extraction activities listed below, assuming average extraction practices. Indicate your scoring by checking one box on the scale provided for each resource activity. A score of **1** denotes the **lowest** level of relative intensity, while a score of 10 would denote an intensity level ten times as high.

Note: Because we are only concerned about relative impact levels, your completed scores should have at least one activity checked at the 1 level and you need not necessarily check any activity as high as the 10 level.

Resource Extraction Activities	 Scale of Increasing Intensity									
	1	2	3	4	5	6	7	8	9	10
Timber harvesting in the B. C. coastal region	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Timber harvesting in the boreal forest and B. C. interior	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Iron ore mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Coal mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Limestone quarrying	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aggregate extraction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

COMMENTS

Please type or print any comments you have about this question or your responses.

THE EXTENT DIMENSION

For a definition of EXTENT please see page 4 of the questionnaire guide.

Question II.2 (a)

Do you think all six resource extraction activities are approximately the same in terms of the *EXTENT* of impacts when the industries follow average, or typical, extraction practices?

Yes No

If you answered yes, please proceed to question II.3 (a). If you answered no, please answer question II.2 (b), below.

Question II.2 (b)

Please score the relative *EXTENT* of extraction impacts for the six resource extraction activities listed below, assuming average extraction practices. Indicate your scoring by checking one box on the scale provided for each resource activity. A score of **1** denotes the **lowest** level of relative extent, while a score of 10 would denote an extent level ten times as high.

Note: Because we are only concerned about relative impact levels, your completed scores should have at least one activity checked at the 1 level and you need not necessarily check any activity as high as the 10 level.

Resource Extraction Activities	 Scale of Increasing Extent									
	1	2	3	4	5	6	7	8	9	10
Timber harvesting in the B. C. coastal region	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Timber harvesting in the boreal forest and B. C. interior	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Iron ore mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Coal mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Limestone quarrying	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aggregate extraction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

COMMENTS

Please type or print any comments you have about this question or your responses.

THE DURATION DIMENSION

For a definition of DURATION please see page 4 of the questionnaire guide.

Question II.3 (a)

Do you think all six resource extraction activities are approximately the same in terms of the *DURATION* of impacts when the industries follow average, or typical, extraction and reclamation or regeneration practices?

Yes No

If you answered yes, please proceed to question II.4 (a). If you answered no, please answer question II.3 (b), below.

Question II.3 (b)

Please score the relative *DURATION* of impacts for the six resource extraction activities listed below, assuming average extraction practices. Indicate your scoring by checking one box on the scale provided for each resource activity. A score of **1** denotes the **lowest** level of relative duration, while a score of 10 would denote ten times as high a duration level.

Note: Because we are only concerned about relative impact levels, your completed scores should have at least one activity checked at the 1 level and you need not necessarily check any activity as high as the 10 level.

Resource Extraction Activities	 Scale of Increasing Duration									
	1	2	3	4	5	6	7	8	9	10
Timber harvesting in the B. C. coastal region	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Timber harvesting in the boreal forest and B. C. interior	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Iron ore mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Coal mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Limestone quarrying	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aggregate extraction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

COMMENTS

Please type or print any comments you have about this question or your responses.

THE SIGNIFICANCE DIMENSION

For a definition of SIGNIFICANCE please see page 5 of the questionnaire guide.

Question II.4 (a)

Do you think all six resource extraction activities are approximately the same in terms of the *SIGNIFICANCE* of the geographic areas typically impacted when the industries follow average, or typical, extraction practices?

Yes No

If you answered yes, please proceed to Part III of the questionnaire. If you answered no, please answer question II.4 (b), below.

Question II.4 (b)

Please score the relative *SIGNIFICANCE* of areas typically impacted by the six resource extraction activities listed below, assuming average extraction practices. Indicate your scoring by checking one box on the scale provided for each resource activity. A score of **1** denotes the **lowest** level of relative significance, while a score of 10 would denote a significance level ten times as high.

Note: Because we are only concerned about relative impact levels, your completed scores should have at least one activity checked at the 1 level and you need not necessarily check any activity as high as the 10 level.

Resource Extraction Activities	Scale of Increasing Significance 									
	1	2	3	4	5	6	7	8	9	10
Timber harvesting in the B. C. coastal region	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Timber harvesting in the boreal forest and B. C. interior	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Iron ore mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Coal mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Limestone quarrying	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aggregate extraction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

COMMENTS

Please type or print any comments you have about this question or your responses.

PART III RESPONDENT INFORMATION

Question III.1

Please rate your level of expertise with respect to the six resource extraction activities listed below by checking one box on the scale provided for each activity.

The scale can be interpreted as follows:

- Level 1 — *very little knowledge* about the extraction activity
- Level 2 — *some prior exposure and knowledge* (e.g. through popular press and/or non-technical literature)
- Level 3 — *fairly knowledgeable* based on technical literature and/or prior experience
- Level 4 — *good working knowledge* (e.g. through extensive familiarity with technical literature and/or intensive prior experience)
- Level 5 — *expert or specialist*

Resource Extraction Activities	 Scale of Increasing Expertise				
	1	2	3	4	5
Timber harvesting in the B. C. coastal region	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Timber harvesting in the boreal forest and B. C. interior	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Iron ore mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Coal mining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Limestone quarrying	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aggregate extraction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Question III.2

Please indicate your primary areas of activity or expertise with regard to environmental matters by checking any applicable items in the list below.

- Atmospheric emissions
- Biodiversity
- Carbon cycle
- Environmental Impact Assessment
- Environmental Policy
- Environmental Regulation
- Genetics
- Soils
- Water pollution
- Wildlife habitat
- Other

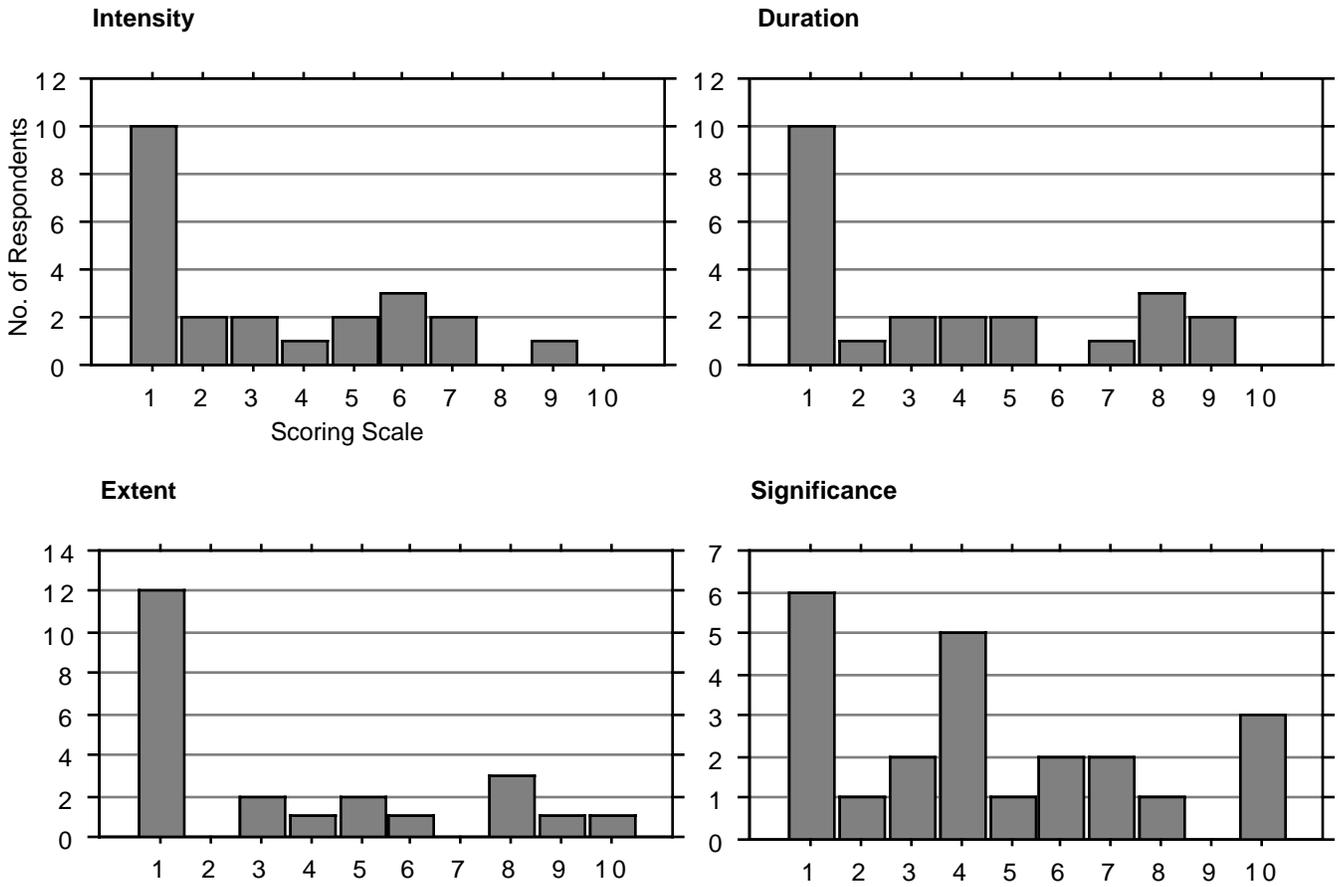
Please describe

APPENDIX C

**FREQUENCY DISTRIBUTIONS FOR
RESPONSES TO QUESTIONS IN
PARTS I AND II**

APPENDIX C FREQUENCY DISTRIBUTIONS FOR RESPONSES TO QUESTIONS IN PART I AND II

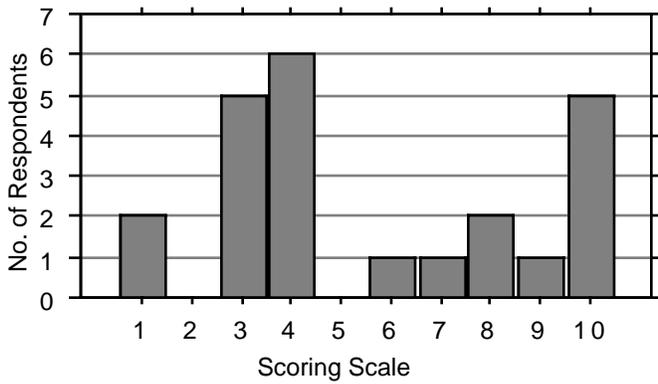
DIMENSION SCORING Question I.3



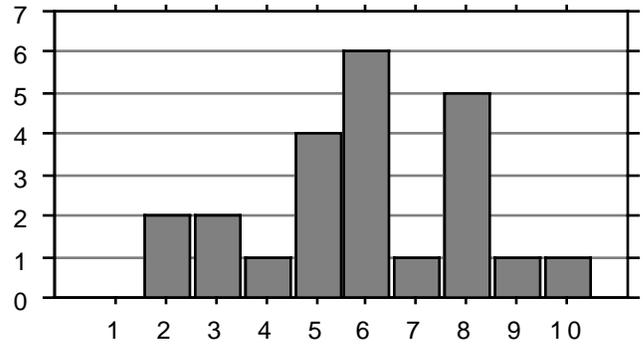
Note
Vertical scales are not the same for all histograms in this appendix.

INTENSITY SCORING Question II.1

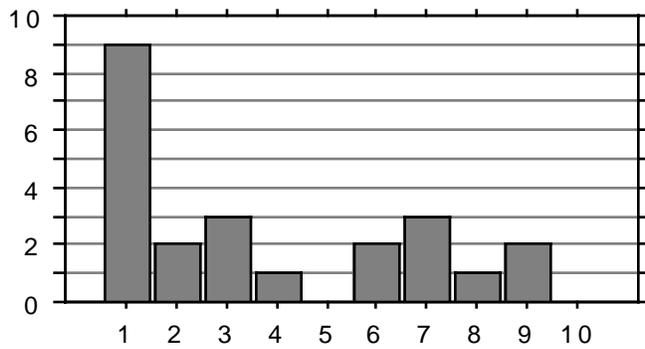
Coastal Timber



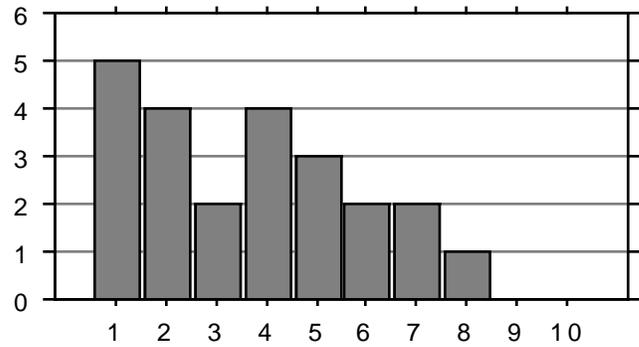
Coal



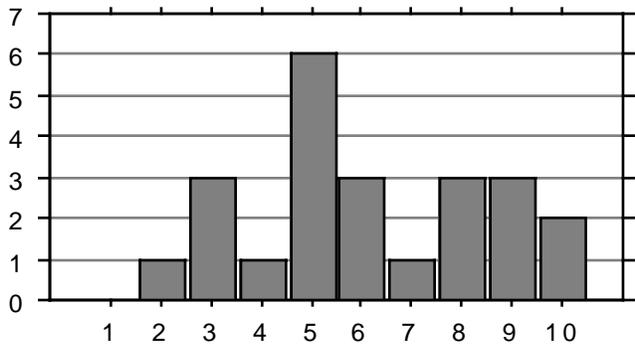
Boreal Timber



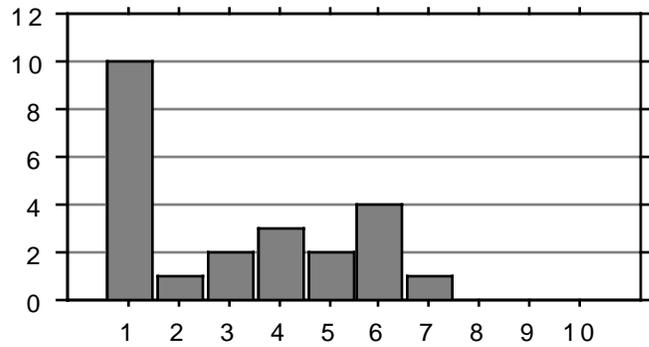
Limestone



Iron Ore

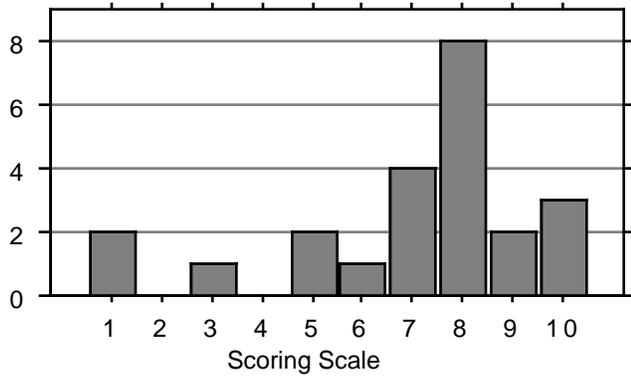


Aggregates

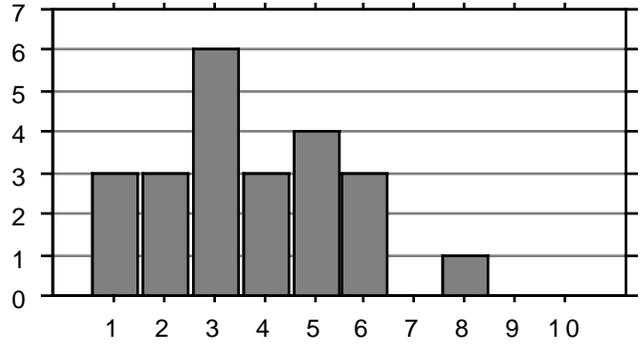


EXTENT SCORING Question II.2

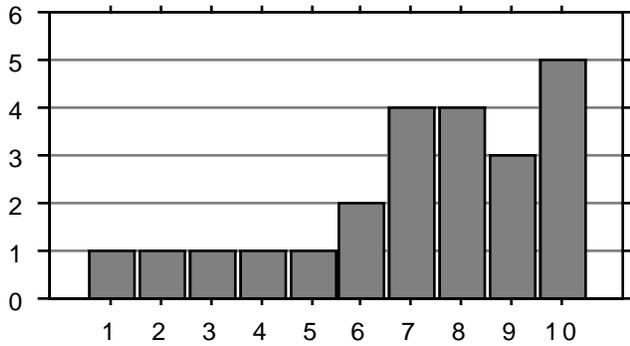
Coastal Timber



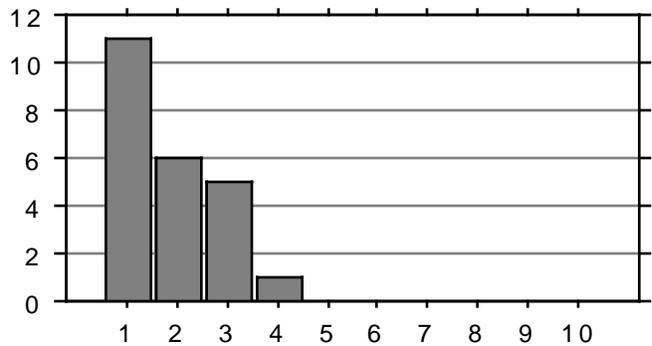
Coal



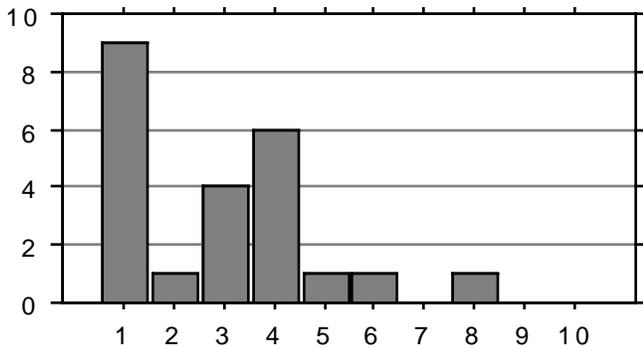
Boreal Timber



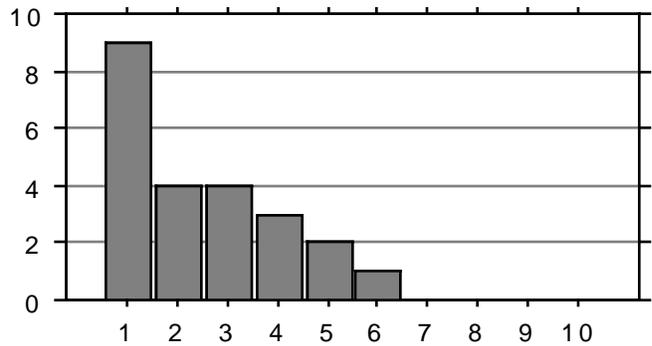
Limestone



Iron Ore

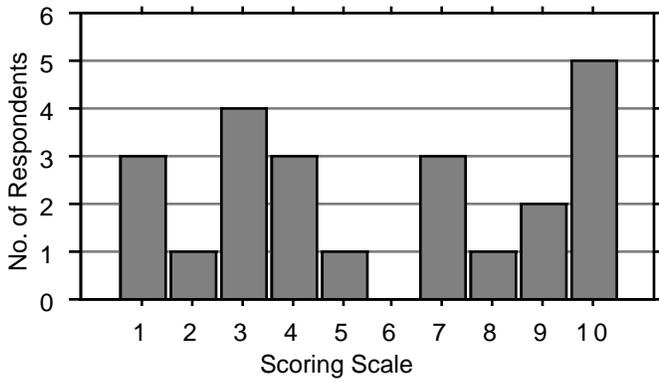


Aggregates

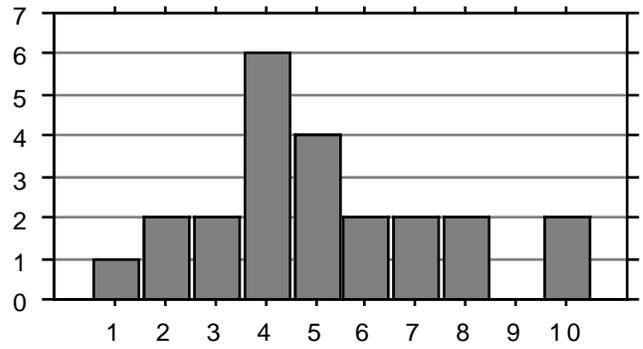


DURATION SCORING Question II.3

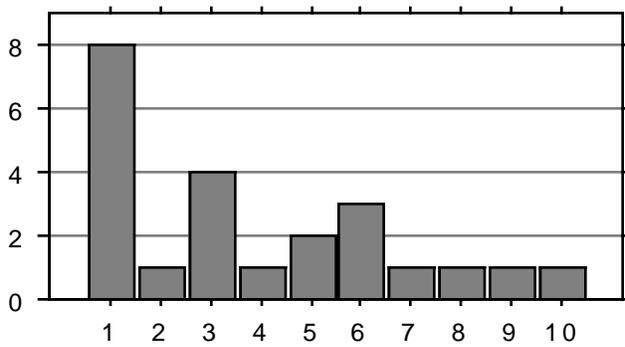
Coastal Timber



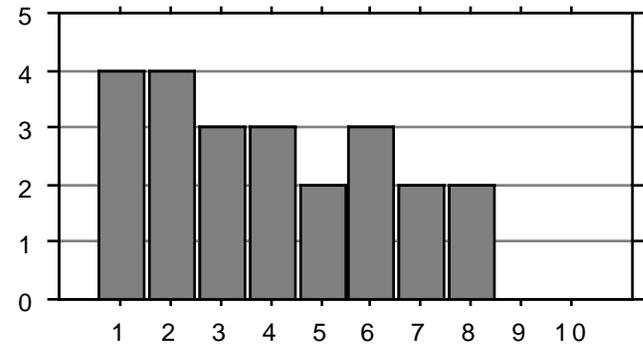
Coal



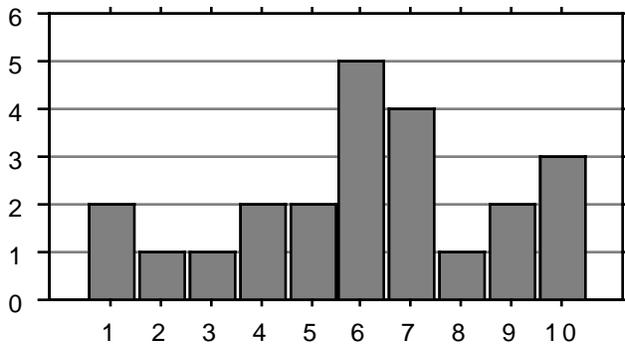
Boreal Timber



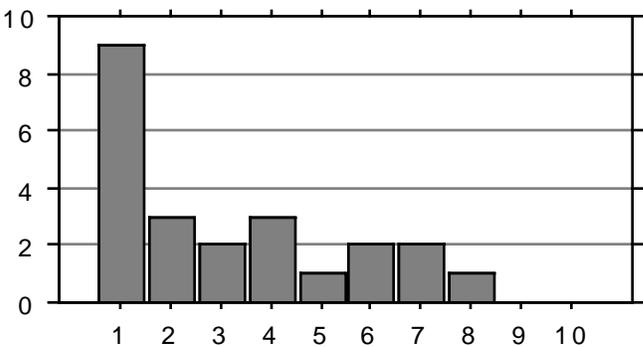
Limestone



Iron Ore

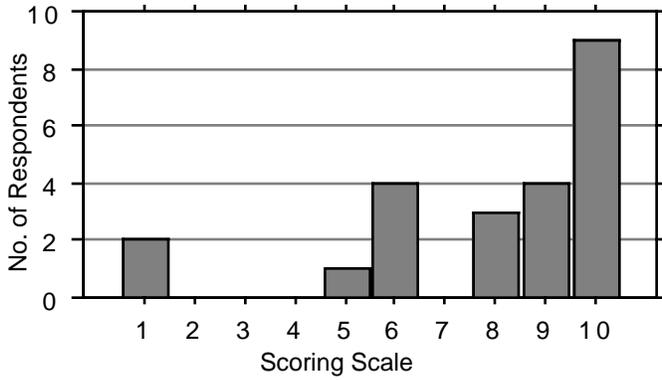


Aggregates

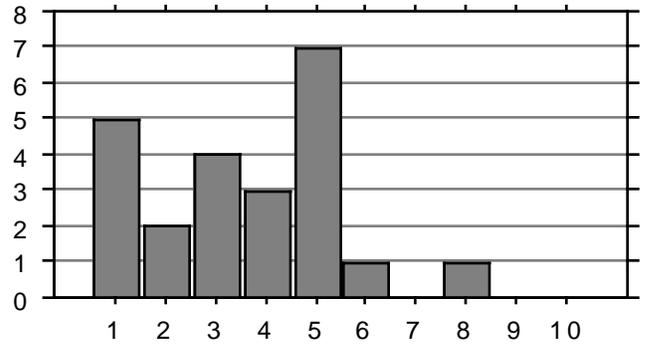


SIGNIFICANCE SCORING Question II.4

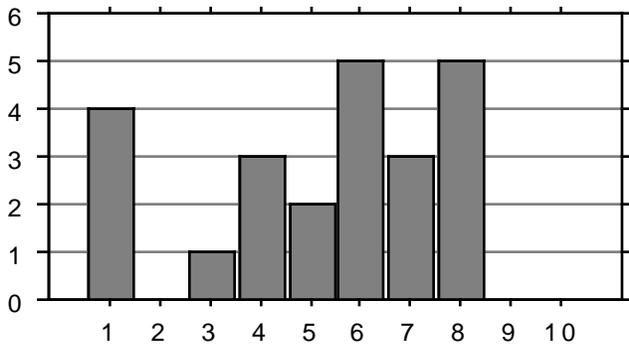
Coastal Timber



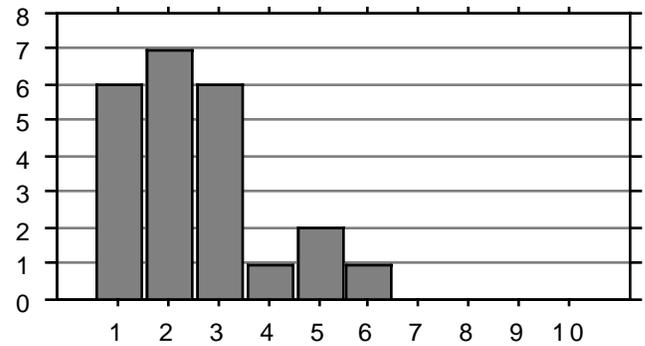
Coal



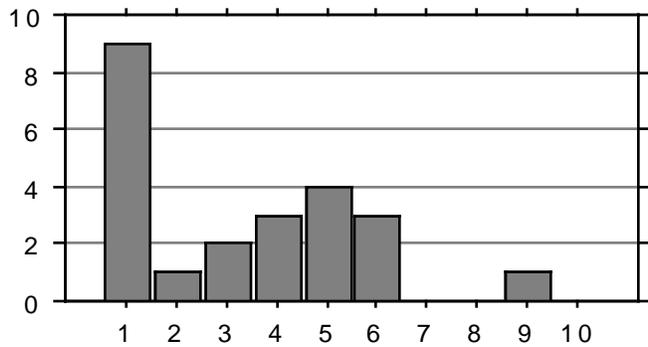
Boreal Timber



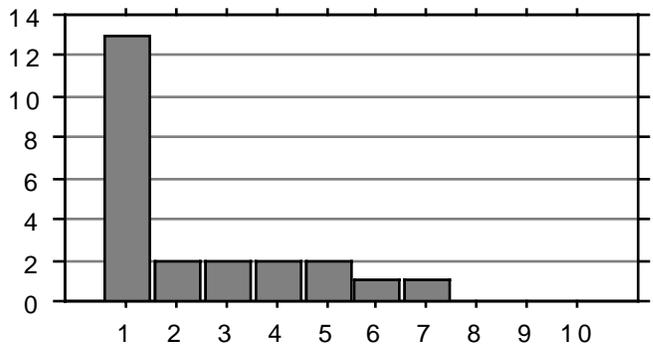
Limestone



Iron Ore



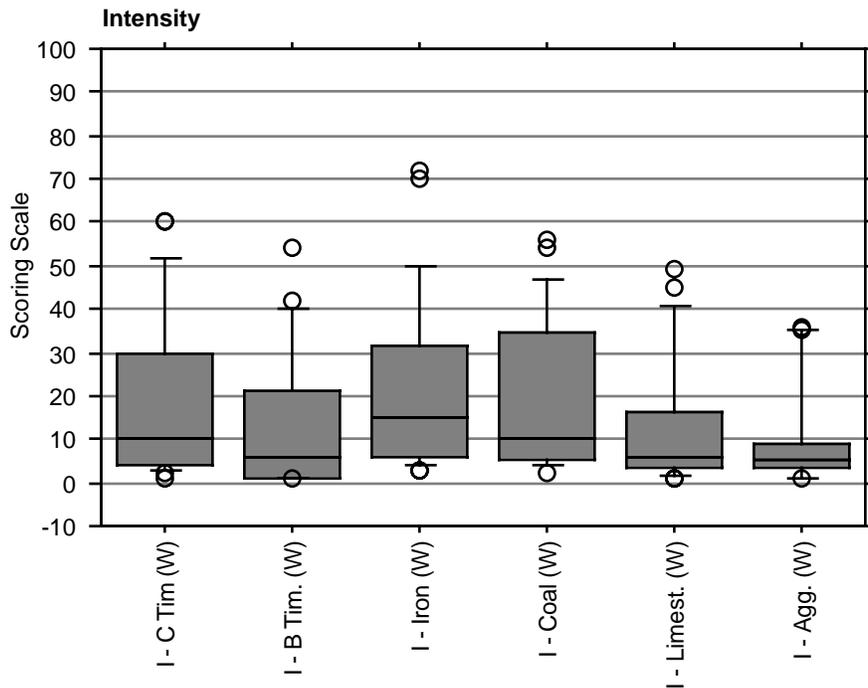
Aggregates



APPENDIX D

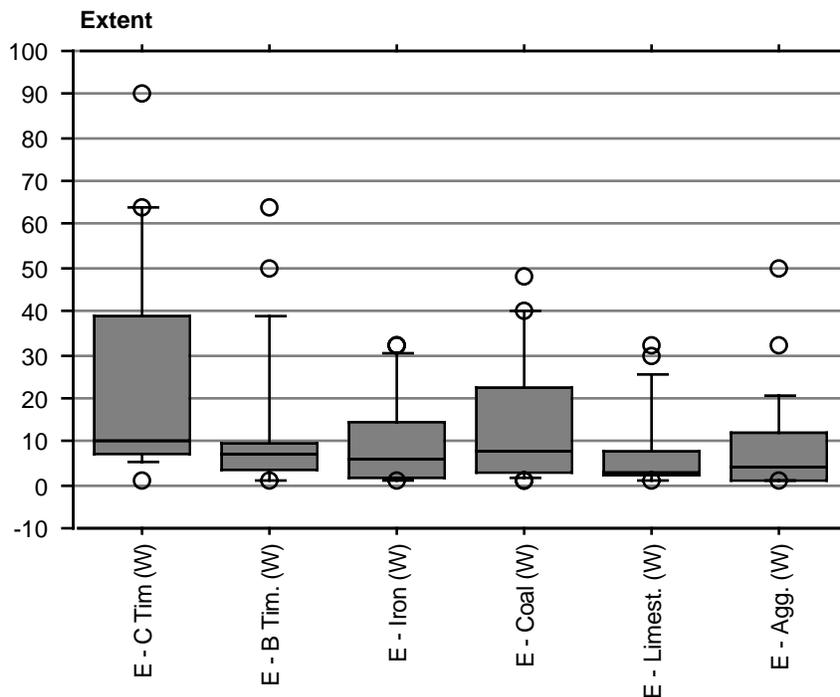
**BOX PLOTS FOR INDIVIDUALLY
WEIGHTED RESPONSE
DISTRIBUTIONS**

APPENDIX D BOX PLOTS FOR INDIVIDUALLY WEIGHTED RESPONSE DISTRIBUTIONS



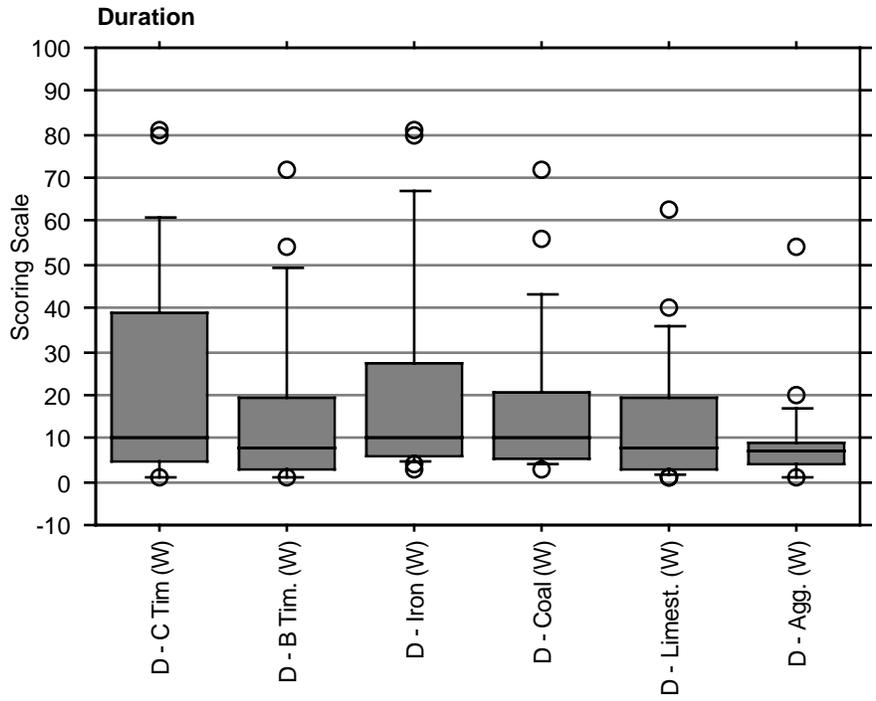
Descriptive Statistics

	Median	IQR
I - C Tim (W)	10.0	25.5
I - B Tim. (W)	6.0	19.7
I - Iron (W)	15.0	25.2
I - Coal (W)	10.0	29.2
I - Limest. (W)	6.0	13.2
I - Agg. (W)	5.0	5.7



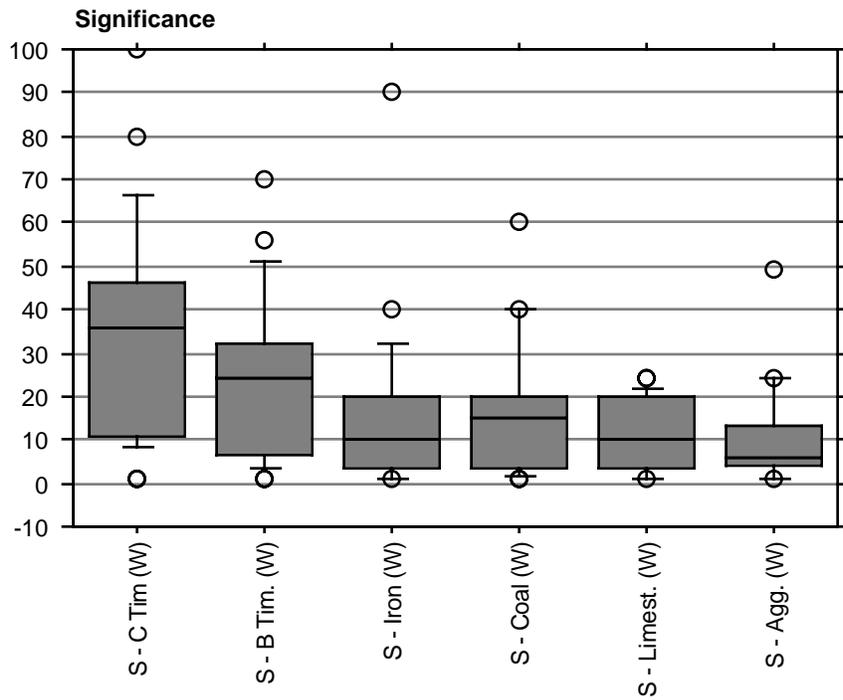
Descriptive Statistics

	Median	IQR
E - C Tim (W)	10.0	32.0
E - B Tim. (W)	7.0	6.5
E - Iron (W)	6.0	13.0
E - Coal (W)	8.0	19.5
E - Limest. (W)	3.0	5.5
E - Agg. (W)	4.0	10.7



Descriptive Statistics

	Median	IQR
D - C Tim (W)	10.0	34.5
D - B Tim. (W)	8.0	16.5
D - Iron (W)	10.0	21.5
D - Coal (W)	10.0	15.5
D - Limest. (W)	8.0	16.5
D - Agg. (W)	7.0	4.7



Descriptive Statistics

	Median	IQR
S - C Tim (W)	36.0	36.0
S - B Tim. (W)	24.0	25.5
S - Iron (W)	10.0	16.7
S - Coal (W)	15.0	16.7
S - Limest. (W)	10.0	16.7
S - Agg. (W)	6.0	9.0