Towards the design of spatial decision support for stakeholder-driven collaborative land valuation in non-urban areas

by

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ABSTRACT

This thesis explores the design of a stakeholder-driven collaborative spatial decision support system (CSDSS) to facilitate relative and absolute valuation of the worth of relatively large areas of land for activities traditionally difficult to quantify in monetary terms. A possible solution is offered by taking advantage of the development of Geographic Information Systems (GIS) towards Spatial Decision Support Systems (SDSS), and subsequently to Collaborative Spatial Decision Support Systems (CSDSS).

It reports on the development of a methodology to aid in the valuing of land use activities difficult to quantify. The thesis explores an alternative to planner-driven land valuation, placing the valuation responsibility instead on stakeholders.

Three experiments are carried out. The first employs tourism experts as subjects. They conduct a gestalt based land valuation on a topographic map of the area surrounding Penticton, British Columbia. A second experiment examines the same area, but with a larger sample of subjects. The final experiment explores system developments with stakeholders from Galiano Island, BC.

The thesis justifies and explains its use of a gestalt methodology. It introduces different types of decision support information products that can be derived to facilitate consensus building. It summarises experience gained when evaluating the proposed methodological procedure using the three experiments.

It concludes that computing technology has advanced to make it reasonably straight-forward to collect information about individual stakeholders' land valuations,

and that the resultant information can be packaged effectively in a collaborative spatial decision support system (CSDSS) to facilitate consensus building.

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LIST OF ACRONYMS

CLI	Canada Land Inventory
CGI	Common Gateway Interface
CSDSS	Collaborative Spatial Decision Support Systems
CVM	Contingent Valuation Method
DSS	Decision Support Systems
GIS	Geographic Information Systems
HTML	HyperText Markup Language
SDSS	Spatial Decision Support Systems
WTC	Willingness to accept compensation
WTP	Willingness to pay

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DEDICATION

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1. INTRODUCTION

1.1 Problem Statement

This thesis explores the design of a stakeholder-driven collaborative spatial decision support system (CSDSS) to facilitate relative and absolute valuation of the worth of relatively large areas of land for activities traditionally difficult to quantify in monetary terms. Economic methodologies exist to express in monetary terms the value of land for real estate sales. These methodologies build on market value and have underlying them the theory of supply and demand. There also exist objective and scientifically supported methodologies to value land in monetary terms for production and yield oriented land-use activities, such as forestry, agriculture and mining.

Calculating value becomes more problematic when the land is not available for sale, or when land-use activities are difficult to quantify in monetary terms. Some examples include attempts to determine spiritual value of land, aesthetic appeal, or value for activities such as outdoor recreation or tourism. Methodologies have been proposed to derive value for these difficult to quantify land purposes or activities. Their validity, however, usually can be challenged since they invariably involve subjective judgments and/or violation of fundamental mathematical assumptions.

Therefore a need exists to advance efforts to derive value of land for purposes or activities difficult or impossible to quantify objectively in monetary terms. A possible solution is offered by taking advantage of the development of Geographic Information Systems (GIS) towards Spatial Decision Support Systems (SDSS), and subsequently to Collaborative Spatial Decision Support Systems (CSDSS).

1.2 GIS, SDSS and CSDSS

Geographical Information Systems (GIS) and the subsequent development of GIS into Spatial Decision Support Systems (SDSS) and Collaborative Spatial Decision Support Systems (CSDSS) form powerful information management tools that enable a complex ill-structured problem such as land valuation to be addressed in a more efficient and effective manner.

1.2.1 The advent of GIS

Foresman (1998) argues that the theoretical, epistemological and historical development of Geographic Information Systems may be traced to Ptolemy and Immanuel Kant, as well as many 19th Century endeavours. The more familiar use of the term "geographic information systems" or "GIS", however, is just over 30 years old, and is closely linked to the advent and progression of computer automation in cartography.

Today there exist many different definitions for GIS, including eleven definitions summarized by Maguire (1991). Pickles (1995) notes most definitions offered are based on a combination of what people think a GIS is as well as what it is used for, and that definitions change through time. Two general definitions are presented here. Firstly the United Kingdom's Department of the Environment (1987: 132) defines a GIS as "a system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the Earth" Secondly, Burrough's (1986: 6) definition of GIS is "a set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes."

GIS have been proclaimed as decision support technology almost since their inception (Jankowski, 1995; Mumby et al., 1995; Eastman et al., 1993). Some note that there has been a progressive evolution of GIS from an inventory-based information system (storage, display and query) towards a decision support tool (Atkinson, 2000; Heywood et al., 1998; Eastman et al., 1993; Parent and Church, 1987). Part of this progression has been periodically to attempt to invent new names and to give new acronyms to evolving geographic information technology products.

GIS clearly have a useful role to play in data collection, storage, query, analysis and display. However, it is recognized that GIS continue to lack advanced spatial analysis functions (Openshaw, 1989, 1991), most notably multiple criteria analysis (MCA), spatial autocorrelation analysis, and multivariate spatial statistical analysis (including spatial regression) that would be required to make it a truly useful decision support tool (Canessa, 1997). As the technology progresses these limitations are being addressed. It is acknowledged here that in order to be an integral part of decision support development, GIS needs to integrate human values, culture, perceptions and language (Durazo, 1995). GIS by themselves do not offer elegant solutions to facilitating an inclusive and collaborative process that allows for expert information input. GIS, by themselves, therefore are not sufficient to address the information technology needs underlying the land valuation problem addressed in this thesis. A potential solution, however, is offered by the advancement of GIS towards Spatial Decision Support Systems (SDSS).

1.2.2 Advancement of GIS to SDSS

Canessa, (1997: 27) brings together the various definitions of SDSS concluding that SDSS

> "are computer systems which combine a database management system, spatial and non-spatial analytical models, and graphical and tabular reporting integrated with human expert knowledge within a decision-making framework accessed by a user friendly interface to provide alternative solutions to a decision problem (Carver, 1991; Densham, 1991; Honey at al., 1991)".

The main difference between SDSS and GIS therefore is the integration of advanced modelling techniques, the facilitation of inclusion of human expert knowledge, and an appropriate decision support user-interface. The most prominent area of research into SDSS has been the integration of the analytical and modelling techniques such as MCA and simulation models (Fedra. 1995; Strapp and Keller, 1996a/b; Canessa, 1997; Taylor at al., 1999).

1.2.3 Advancement of SDSS to CSDSS

GIS and SDSS focus on a single information technology user. However, decision making often is a collaborative process that requires multiple stakeholders to engage in a process of consensus building. Efforts are ongoing, therefore, to advance SDSS towards facilitating collaborative decision making processes (Armstrong, 1994; Armstrong and Densham, 1995). The resultant technologies are called Collaborative Spatial Decision Support Systems, or CSDSS. Debate continues how best to advance SDSS towards CSDSS. Some note that stakeholders and decision makers participating in consensus building should not be expected to have the time, desire, experience or know-how how to handle complex information technology. This group advocates what some term the Chauffeur driven CSDSS (Canessa, 1997) where a facilitator is present at all times to operate the information technology, working for- and with the group of collaborators assembled. Others, notably Armstrong (1994) have argued that research should be directed towards making CSDSS sufficiently intuitive and user-friendly to allow the collaborating decision makers to engage directly with the technology, primarily by replacing the GIS expert 'bottleneck' with better user-interfaces.

In summary, GIS clearly have potential to assist in the type of land valuation problem addressed in this thesis, and advancement of GIS towards SDSS and CSDSS that specialize in the analytical requirements and collaborative processes underlying the problem at hand offer a way forward explored in this thesis.

1.3 Research Goal and Objectives

1.3.1 Research Goal

The goal of the research presented in this dissertation is to explore the design of a stakeholder-driven collaborative spatial decision support system (CSDSS) to facilitate relative and absolute valuation of the worth of relatively large areas of land for activities traditionally difficult to quantify in monetary terms. The dissertation seeks ways to combine collaborative expert driven land valuation processes with advances in SDSS and CSDSS, building on pioneering research by Pereira and Duckstein (1993), and subsequently Brown et al., (1994), Jankowski (1995), Strapp and Keller (1996a/b) and Canessa (1997), Jankowski and Stasik, (1997), Hendriks, (2000), Jankowski and Nyerges (2001), and Nyerges (2001).

The conventional approach to land suitability assessment and land valuation is a top-down approach whereby planners determine value based on physical or ecological criteria argued to be representative of land capability or value for a particular economic activity (Porteous, 1996). Stakeholders are asked to react to the planners' positions, including offering commentary on the nature and relative weightings of the attributes of land considered, and the final values derived. The role of experts and stakeholders in land evaluation is recognized.

Shafer et al., (1969); Shafer and Mietz, (1970); Zube, (1976) and Dearden, (1978, 1981), amongst others, have advocated a bottom-up approach whereby stakeholders themselves identify an initial land value. This thesis builds upon their works. The initial valuation exercise is not based on numeric summation of selected attributes of land, but instead on holistic valuation based on experience and personal judgement (Fines, 1968; Dunn, 1976). The method explored is one that places the responsibility for land valuation and its explanation firmly in the stakeholders' hands, with the role of the planner becoming that of a facilitator and process guide. Such a stakeholder-driven valuation process can be used in parallel with, or instead of the traditional planner-driven land valuation process. This is not a new approach for land evaluation. Shafer and his associates were pioneering this in the 1960s (Porteous, 1996). The integration of local community groups into the planning process utilising GIS is however a relatively new development that is becoming known as the Public Participation GIS agenda (Sieber, 1997; Barndt, 1998a, 1998b; Clark, 1998; Craig and Elwood, 1998; Elwood, 1998; Elwood and Leitner, 1998; Howard, 1998; Leitner et al., 1998; Obermeyer, 1998; Shiffer, 1998; Talen, 1999; Sieber, 2000; Talen, 2000).

The research presented here uses outdoor recreation and tourism as an example of a land use activity difficult to quantify in monetary terms. Some argue that the distinction between outdoor recreation and tourism is irrelevant (Jansen-Verbeke and Dietvorst, 1987) while others have noted that recreation is a component of tourism (Hall and Page, 1999; Murphy, 1985) A definition of outdoor recreation is discussed at length by Clawson and Knetsch (1966: 10) who note that a common outdoor recreation characteristic is…

> "…their need for areas of land or water – often relatively large areas. In its use of land and water recreation competes with other uses of the same resources – forestry, agriculture, grazing, homesites, factories and other uses of land; flood control, hydroelectric power production, irrigation, water supply, and other uses of water."

The above statement emphasizes a need for the ability to value land for outdoor recreation and tourism.

1.3.2 Objectives

The research presented in this dissertation seeks to answer the following questions:

1. To what extent can local stakeholders take the lead in land valuation processes?
2. Can stakeholder and expert opinions about the value of land for purposes or activities difficult or impossible to quantify in monetary terms be combined to yield an aggregate value statement by taking advantage of advances in GIS, SDSS and CSDSS?
3. Are there significant differences in land values identified by different stakeholder groups?
4. Can a web-based interface provide sufficient interactivity for a CSDSS?

5. Is it possible to express the technical and procedural specifications necessary to enable stakeholders to reach consensus for land evaluation in a straightforward manner?

1.4 Thesis Structure

The remainder of the thesis is structured as follows: Chapter Two is a review of literature and past methodologies of land valuation and stakeholder participation. A classification of land valuation methodologies is offered. The respective role of planners and stakeholders are explored and the problem of identifying and selecting suitable stakeholders is addressed. The design of the three experiments conducted is presented.

Chapter Three provides a review of an initial project carried out with stakeholders in Kelowna, British Columbia. This initial project provided the seed for the thesis. The chapter outlines and critically evaluates what was done.

Chapter Four outlines the design and testing of an initial data capture and CSDSS land valuation system. It examines the ability of subjects to divide up a map into homogeneous regions, response amalgamation techniques, visualization techniques, and explores methods for testing consensus/divergence between groups of subjects. Chapter Five illustrates further system development and testing in a scenario employing stakeholders from Galiano Island.

Chapter Six offers a discussion of the merit of the approaches taken in the thesis. It argues the case for web-based CSDSS for land valuation and presents a list of technical and procedural specifications.

Chapter Seven presents a brief summary of the thesis, as well as outlining potential future research avenues.

2. LITERATURE REVIEW

2.1 Introduction

This chapter reviews methodologies developed and tested to measure the value of land. Methodologies have been developed primarily under two research initiatives that are difficult to separate, namely 'landscape evaluation' and 'land suitability analysis'. Section 2.2 defines and differentiates the subtleties between these two initiatives. Section 2.3 distinguishes between expert and stakeholder-driven land valuation processes. Section 2.4 introduces the nature of public participation for land valuation, drawing special notice to how that 'public' is selected. Section 2.5 presents and critically evaluates methodologies proposed to solve landscape evaluation and suitability analysis. The discussion presented in Section 2.5 draws heavily on the pioneering taxonomy of methodologies presented by Hopkins (1977), updated to include methodological advances since the 1970s, and incorporating taxonomic suggestions made by Chrisman (1997).

2.2 Terminology

Porteous (1996) points out that considerable confusion exists with respect to the use of terms in landscape research. He notes, for example, that 'environmental planning', 'landscape resource analysis' and 'landscape appraisal' are used interchangeably to stand for the same thing (1996: 200). Such confusion in terminology also applies to the use of 'landscape evaluation' and 'land suitability analysis' in the literature, two areas of research of considerable importance to this thesis.

2.2.1 Landscape Evaluation

Landscape evaluation concerns itself with the intrinsic and the aesthetic qualities of the landscape. Dearden and Sadler (1989: 4) stress the importance of landscape evaluation as a field of enquiry that is:

> "based on the premise that the aesthetic quality of natural regions, rural countryside and urban areas is a matter of some importance. It incorporates the recognition that the visual characteristics of landscape, like those of buildings and architectural sites, can be systematically analysed."

Laurie (1975) defines landscape evaluation as:

> "The comparative relationships between two or more landscapes in terms of visual qualities; in this context, assessments are the process of recording visual quality through an observer's aesthetic appreciation of intrinsic visual qualities or characteristics within the landscape" (1975:103)

Since Laurie's definition proposed in the mid 1970s, research into landscape evaluation also has recognized that landscape is appreciated and experienced with more than one's visual sense and that landscape evaluation's systematic analysis incorporates many themes from humanistic research, including concepts such as 'sense of place'.

Efforts to measure and quantify how individuals or groups evaluate landscape range from qualitative to highly quantitative. At the qualitative extreme are those who argue that landscape must be evaluated holistically and can not be quantified since it is not possible to separate or measure the different senses, emotions and value judgements that lead to overall landscape value. At the other extreme are those who argue that the evaluation process can be broken down into definable component parts and these component parts can be measured quantitatively and numerically aggregated to yield an overall value. For example, Dearden (1980) presents a statistical technique for land-use planning based upon the evaluation of visual quality of landscape. Value often ends up expressed on some numeric scale, often representing a range from "very much disliked" to "very much liked". Few landscape evaluation studies have attempted to translate evaluation results into a financial measure, for example a dollar value. Outdoor recreation planning has been a primary driving application fostering landscape evaluation research.

In summary, landscape evaluation concerns itself primarily with how much one 'likes' or 'dislikes' a landscape, with a methodological division between those practitioners of reductionist and quantitative research and those who feel that the holistic nature of landscape defies reductionist quantification (Porteous, 1989, 1996; O'Connell and Keller, 2002).

2.2.2 Land Suitability

Land suitability has been defined as "the process of predicting the use potential of land based on its attributes" (Rossiter, 1996: 165). Driven primarily by agriculture, real estate and land-use planning applications, this type of suitability research tends to be rooted firmly in Natural Science style research. Methodologies developed to measure land suitability inherently are quantitative and reductionist. They tend to break land into its component parts that can each be measured quantitatively. Thereafter, these methodologies seek meaningful rules logically and numerically to combine the components back into an aggregate value. Component parts usually focus on physical attributes of land, including type of soil, slope, aspect, topography and drainage. They may also include economic considerations such as market value of land, and occasionally seek to incorporate emotional values such as aesthetics and/or traditional and cultural variables (Strapp and Keller, 1992, 1996a/b; Haines-Young at al, 1999).

An example of a large-scale land suitability classification is the Canada Land Inventory (CLI). The CLI was developed to be a

> "systematic land-use survey....to provide for an economic classification of land according to its suitability" (http://geogratis.cgdi.gc.ca/CLI/milestones)

The project, started in 1963, involved a joint venture between the Government of Canada and the provinces, with further cooperation provided by Universities and the private sector. By 1971 over 90% of the mapping representing over 2.5 million square kilometres of land and water was completed. Over 15000 maps at the 1:50,000 and approximately 1200 at 1:250,000 were generated.

The program was official ended in 1994. There has been a concerted effort, however, to transfer the files in a variety of formats, for example for either viewing online via the Internet, or download to GIS formats. Presently the 1:250,000 files are available for download from http://geogratis.cgdi.gc.ca/CLI/database.html. The CLI attempted to produce land capability for the following resource uses: agriculture, forestry, wildlife, and recreation.

The CLI's role in mapping recreation suitability may be argued to have come from the need to manage and plan for an increasing demand for land for parks and outdoor recreation sites. The data were derived from aerial photographs, selected field visits, and soil and geology surveys (Land Capability for Recreation Summary Report 14, 1978; http://geogratis.cgdi.gc.ca/CLI/rating.html)

The rationale behind the recreation capability classification was based upon

> "the intensity of the outdoor recreation use, or the quantity of outdoor recreation which may be generated and sustained per unit area of land per annum under perfect market conditions" (Land Capability for Recreation Summary Report 14, 1978:Appendix).

It ranges from Class 1 rated as 'Very High Capability' to Class 7 rated as 'Very Low Capability'. Two clarifications need to be made about this statement Firstly, quantity is measured as visitor days, and secondly perfect market conditions infer that there is uniform demand and perfect access (http://www.lib.uwaterloo.ca/discipline/ Cartography/umd/cli/cli.html#recreation). There is a further sub-class classification, which represents features that offer the possibility for recreation. Recreation is the only capability classification in the CLI that does not offer limitation to capability. (http://www.lib.uwaterloo.ca/discipline/Cartography/umd/cli/cli.html#recreation).

The Government of Canada cites that Canada Land Inventory generated many valuable initiatives (http://geogratis.cgdi.gc.ca/CLI/spinoffs.html), including Federal Policy on Land Use and the Canadian Geographic Information System. The key success of the CLI is that it provides a large-scale baseline set of maps that may be employed for comparison. This approach has been present in the work of soil scientists (McBride and Bober, 1993) and forest research (Moores et al., 1996). Peepre and Associates (1994), argue that the CLI formed the basis of the extensive GIS land inventories that have been developed for land use planning since its introduction. They argue that it is particularly useful as a tool for enabling regional scale identification of high intensity uses.

Perhaps its most interesting strength is the role of the information provided by the CLI as being

> "...neutral, value-free as much as anything can be, and is available to all. We cannot prejudice the various ways in which jurisdictions will find it useful. We should note as well the new emphasis by the public on access to information, and its relevance to the theme of public participation." Council on Rural Development Canada (1979:10) cited on Geogratis http://geogratis.cgdi.gc.ca/CLI/council.html

Despite these advantages key limitations to this dataset exist. The manner in which water bodies were excluded from the capability methodology limits the use on present day outdoor recreation activities that employ lakes and rivers, for example boating, water skiing, kayaking. Also the constraints of equal accessibility coupled with perfect market conditions are impossible to justify in real world applications. Cressman and Hoffman, (1979: 28) maintain two further limitations

> "two characteristics of the system that affect its application should be emphasized. First, land areas are not rated for their potential to support each type of recreational activity. Instead, each land's rating designateses (*sic*) its capability to support recreation in general. Second, this capability system, at its present level of generalization, is not intended to be the basis for detailed recreational site planning within any one region."

Peepre and Associates (1994:47), suggest further limitations, arguing that

> "The CLI system is not well suited to identifying wilderness attributes or sites capable of supporting dispersed recreation activities such as mountaineering or whitewater rafting. The CLI assumes that sites with the highest use capacity are more valuable, thus underestimating the value of wilderness or scenic settings for their own sake."

Burrough and McDonnell (1998) argue that land suitability research has as its basis that any landscape may be divided into basic entities called mapping units that are separated by crisp boundaries, and that an aggregate 'suitability value' can be identified for each unique mapping unit[1]. These suitability values usually are some measure of growth potential or financial measure.

In summary, land suitability studies primarily seek quantitative measures to identify value of land for a particular economic purpose, with final measures usually being expressions of growth, yield or monetary value. An example of a national attempt at land suitability mapping (CLI) was presented.

2.2.3 Land Valuation

This thesis seeks ways of determining value of land for purposes that do not necessarily have a monetary bottom line, but where value must never-the-less eventually be expressed on some relative or absolute scale that can be translated into 'value to society'. As such, this research must combine both landscape evaluation and land suitability research methodologies. This is less problematic than it may appear since the reductionist quantitative methods applied by those seeking to evaluate landscape actually are very similar to, or the same as those quantitative reductionist methods used to measure land suitability. This finding explains, in part, why the terminologies 'landscape evaluation' and 'land suitability' so often are confused and used interchangeably in the literature.

The challenge posed in this thesis, therefore, is to seek ways to combine holistic ways of evaluating landscape with quantitative reductionist techniques. Such a combined approach to determine value is endorsed by Dearden and Sadler (1989) who

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[1] It is of interest to note that Burrough and McDonnell (1998) employ the term landscape evaluation but discuss it as land suitability analysis, further adding to the confusion inherent in the literature.

stress that so long as enquiry is of a high standard, than both traditions have a lot to offer the subject.

Presented with two terms representing diverse yet similar research agendas, namely 'landscape evaluation' and 'land suitability', the question beckoned under what label to write up the research presented here. Research presented concerns itself with both, 'landscape' and 'land', and seeks both to 'evaluate' and to 'identify suitability' (although evaluation takes on a higher importance). The final research presented has both qualitative as well as quantitative analyses and thus perhaps fits better under 'landscape evaluation'. There is a subtle difference, however, between 'evaluation' and 'valuation', with the latter seeking to take an evaluation process towards relative or absolute value statements. The term 'landscape evaluation', therefore, is less than satisfactory and it was decided to employ the term land valuation to describe the research undertaken here, a term that is argued to highlight all sides of the research agenda.

2.3 Landscape Valuation Paradigms

As already noted, a large and diverse number of techniques have been developed to evaluate landscape and to measure land suitability, ranging from the highly subjective to the strictly scientific and objective (Dearden, 1987; Porteous, 1996, Wherrett, 1996). There also exist methodological divisions based upon who does the valuations. Should the valuation be expert or planner driven, or should public participation be fully embraced? The two schools of thought represent two paradigms that may be labelled as:

- Expert Paradigm
- Psychophysical Paradigm

The next two sub-sections introduce compare and explore the latter two paradigms before moving on to a new section that introduces public participation and stakeholder selection issues.

2.3.1 Expert Paradigm

This paradigm has as its' leading tacit that skilled professionals, for example landscape architects or environmental planners, should carry out landscape evaluations and land suitability under the assumptions that they are paid to do the job, and that they are the professionals who know best. This process does not seek input from the public or the users of the land, often referred to as stakeholders (Porteous, 1996).

Experts sometimes choose to suggest value based on accumulated personal experience with little underlying measurement or quantification. They more usually opt, however, for quantitative valuation techniques comprised of a number of steps identified by Leopold (1969) as early as the 1960s to include:

- Identification and selection of factors that make up value (division of overall value into its component parts).
- Division of study area into a subset of land parcels argued to have internally consistent characteristics (definition of mapping units).
- For each mapping unit, measurement of each factor argued to make up overall value.
- Logical and/or numerical combination of measurements to yield an aggregate measure.

Experts often select to present to decision makers both the individual components and summary values for each mapping unit. Litton (1974), Dunn (1974) and Porteous (1996), amongst others, comment on this expert-driven method, questioning the assumption that experts know best which factors make up value, what defines homogenous mapping units, and how best to combine these values. They are especially sceptical in situations where societal value, culture, traditional beliefs and emotion enter into the valuation process. Litton (1974), one of the first to recognise the subjective nature underlying parts of this expert-driven approach, recognised that non-experts may have a profound role to play in the valuation agenda. Litton, while sympathetic to the preferences of the users of the landscape (the stakeholders), however did not advocate their full public participation in the valuation process.

2.3.2 Psychophysical Paradigm

A leading inference of the psychophysical paradigm is that the public (or stakeholders) have an important role to play in landscape evaluation and suitability analysis. The fact that the individuals who are being planned for should be consulted seems a truism. Two dominant approaches to gathering stakeholder information for land valuation can be identified. The first is a behaviour-observation approach; the second is through questionnaires or interviews (Porteous, 1996).

The behaviour-observation approach makes the assumption that behaviour reflects preference, a contention that Porteous (1996) argues is questionable at best. The approach operates by observing and measuring stakeholders' use, behaviour within, and interaction with land and landscape, thereafter seeking ways to translate observed behaviour into measures of value. Examples of this type of research range from the use of recent real estate transactions to determine sale value for a parcel of land to aesthetic value judgements of landscapes based on investigation of holiday expenditures and selection of trip destinations (Price, 1976). These type of studies can be very effective in the former case (determining a value for a parcel of real estate), but extremely time consuming and expensive in the latter. Of course, both examples rely on a theoretical assumption that overt behaviour represents preference (Gold, 1980).

The second approach, relying on interviewing or otherwise surveying stakeholders, is based on the pioneering work of Shafer et al. (1969). Much of the work carried out in this vein is based on the use of landscape surrogates, for example photographs (Dunn, 1976) or colour slides. Stakeholders are asked to view and judge surrogate images of different landscapes or representations of 'homogenous mapping units', with researchers thereafter combining individual judgements to report measures of 'consensus' and 'divergence'. Zube et al. (1975), presents work based on what they term 'landscape-simulation techniques' that include; "line drawings, photomontages, black and white photographs, three-dimensional models and 35mm color sides" (Zube, et al., 1975:153). They argue that the use of surrogates, especially colour ones, create notable results. Evans and Wood (1980) have also claimed significant results during research on environmental aesthetics in scenic highway corridors. They employed colour slides taken at 10-second intervals along a scenic drive presented in a time delay function. Kaplan (1975) used pictures to evaluate landscape, but argued for the use of as many different landscape surrogates as possible. 25 years later, however, he continues to employ photographic surrogates to test cultural differences between American and Australian students for valuing natural areas (Herzog, et al., 2000).

The research agenda for these preference studies now encompasses technological developments by using web-based surrogates (Wherrett, 2000), as well as investigating the differences between static and dynamic displays (Heft and Nasar, 2000).

There are drawbacks to interviewing stakeholders and asking them to value judge landscape based on surrogate images. Surrogates, such as photographs or video clips, inherently contain many biases that are difficult to control for (Buhyoff et al. 1994). Firstly, somebody had to select what to include and exclude when selecting which pictures or video clips to take (Porteous, 1996). Pictures therefore contain selective bias and silence. Secondly, time of day and time of year (season) as well as weather conditions on the day will influence what the surrogates show (Dearden, 1978). Thirdly, bias can be introduced in the processing of the film medium. Finally, surrogates like photographs do not allow stakeholders to combine all their senses when judging value, excluding for example sound, smell and possible touch (Porteous, 1996). The assumption that land or landscape can be represented by a surrogate, therefore, is a contentious issue in the field of landscape research. Buhyoff et al. (1994) point out how the use of public perceptions and participation using surrogates can lead to studies that are very site specific and have limitations for wider applicability and usability.

Wherrett (1996), on the other hand, argues that the strength of the psychophysical methods is in their ability to be used in a management context. The models do provide levels of objectivity, quantitative precision and a representation of consensus among many observers rather than one expert's opinion. There are a number of examples in the literature using psychophysical models, including Carl's (1974) investigation of preferences of human-induced outdoor recreation landscapes, Buhyoff and Riesenmann (1979) forest views research and Daniel and Vining's (1983) work carried out on vistas and scaled preferences. More recently Eleftheriadis and Tsalikidis's (1990) work on coastal landscape quality also follows the psychophysical model.

2.4 Public Participation and Stakeholders

The preceding section has examined research paradigms relevant to land valuation, differentiating between expert driven processes and those engaging the public and stakeholders. This section explores issues around public participation and stakeholder involvement in more detail. Of particular relevance to this thesis are the results presented by Dearden (1981) where he critically reviews the role of public participation in landscape evaluation. In this paper he asks two fundamental questions:

1. "Is public participation desirable?" (Dearden, 1981: 4)
2. "Which public" (Dearden, 1981: 9)

There are a number of issues related to question one. The first issue is to determine whether there are differences between those who are employed to undertake landscape evaluations, for example planners, and those who the decision are made for – namely the public. Research has shown that there are differences (Gans, (1969; Lansing and Marans, 1969). Both Zube's (1973) and Penning-Rowsell (1974) have argued that planners do not represent typical cross-sections of society. Dearden (1978), however, did not find perceptual differences between planners and the general public, but did find differences between the planners and the Sierra Club (a conservation organisation). However he argues (Dearden, 1981) that, until it is proven that there are no differences present between the public and planners, public participation through public preference methods of landscape evaluation should be undertaken. He concludes that public participation should be embraced on both "philosophical and pragamatic grounds" (1981: 16).

Dearden (1978, 1981) calls for the inclusion of public input to be routine for landscape evaluation. However, Jackson (1997) notes that public participation in resource management and decision making has waxed and waned over the last twenty years, with participation encouraged in many different formats using many different processes, including 'conflict resolution' (Ness, 1992; Maser, 1996), consensus building' (BC Roundtable, 1991; Darling, 1991; Lathrop, 1992; Dorcey et al., 1994), and 'shared decision-making' with the involvement of 'stakeholders (Gunton, 1991; Gunton & Vertinsky, 1991; Abs, 1991; Mitchell, 1995). Key questions that arise when incorporating public participation include what defines stakeholders, how should stakeholders be selected, and how should their input be incorporated into management and decision making? Some of these questions are addressed below.

2.4.1 Stakeholder Definition and Selection

Dearden's (1981) 2nd question above (Which Public?) incorporates the many problems associated with stakeholder definition and selection. There exists "a mosaic of publics" (Dearden, 1981: 16) and no one satisfactory methodology for selecting a 'representative' public. Arguments may be made to select those individuals who are environmental aware as the best candidates for public participation (Tognacci et al., 1972; Tucker, 1978). In response to these are arguments are calls for the selection process to be much broader, incorporating either those who live in an area (Daniel, 1976) or even non-residents for tourism-based scenery studies (Dearden, 1981).

Yu (1999: 49) defines stakeholders as

> "any individuals or groups which have claims, interests or rights, are legally recognised, and affect or are affected by the outcome of a decision or management issue".

Grimble and Wellard (1997: 175) employ the definition of stakeholder to mean "any group of people, organised or unorganised, who share a common interest or stake in a particular issue or system." This definition is similar to the suggestion presented by Gunton and Vertinsky (1991) who note that stakeholders are those whom are significantly affected by a decision. Authors of the above definitions do not clarify what defines- or how one can measure 'affected by outcome', 'common interest' or 'significant affect', although Yu (1999) argues that a stakeholder's claims, interests or rights must be 'measurable' to qualify for consideration. The definition and selection of stakeholders to take part in a public participation process therefore is problematic at the best of times.

Harrison and Qureshi (2000) note that while much has been written on the need to take into account the interests of stakeholder groups, few insights have been offered not only into how to identify which stakeholder groups to include, but also how to select representatives to speak for each group. They suggest that stakeholder group selection often appears intuitive, but that in the process, some stakeholders may get overlooked. They suggest that stakeholder group selection should take into consideration size of the different groups, their respective relative and absolute importance, technical knowledge of each group, and each groups' degree of vulnerability to decisions made. They also suggest that alternatives to 'obvious selection' of stakeholder groups could be 'self-selection' through open invitation or a 'mandated selection' based on legal requirements. Grimble and Chan (1995) further suggest that stakeholders can be identified through reputation, focus groups or demographic analysis.

Harrison and Qureshi (2000) cite studies that present lists of stakeholder groups that should be considered in land valuation. They include representatives from all economic and industrial activities affected, all levels of government and administration, all special interest groups, the general public, the media, and community activists (Sarkissian et al., 1997; Harding, 1998). Harrison and Qureshi's (2000) paper makes it obvious that the number of potential stakeholders that should be involved in land valuation can get very large and unwieldy, and that some pragmatic strategy therefore is required to select a meaningful and manageable set of stakeholders.

In summary, the development of rigorous, formal and academically defendable methods of stakeholder group selection remains unresolved, as does the process of selecting meaningful representatives from each stakeholder group. Dearden argues in the early 1980s (1981) that whilst public participation is desirable, the choice of who participates and how remains unresolved. Almost 20 years later, Harrison and Qureshi (2000) argue the same point noting that progress still needs to be made to tighten up stakeholder selection processes. Further work is still needed to lay down guidelines that are universally acceptable and satisfactory.

2.4.2 Stakeholder as Expert

One approach to stakeholder selection is to argue that representatives at a decision making table should have 'expert' status and should bring 'expert insights' to the table. The question then comes down to "who are the experts?" and "what defines 'expert insights?'"

The Oxford English Dictionary defines as expert as "a person having special knowledge or skill." Such a definition is vague leaving ample room for interpretation. No more formal or rigorous and academically defendable definitions exist.

The managerialist approach within the public participation research literature has as its key ideology that 'the expert knows best'. Experts in this case usually are the planners and government officials given the task to solve a particular problem. Cater and Jones (1989) described these expert managers as 'gatekeepers', those who hold the power of deciding who gets what, which can result in bias and constraint. Proposed here is that the definition of "expert" be broadened to include stakeholder group representatives who have either expert local knowledge or unique thematic expert knowledge. In the case of land valuation for outdoor recreation or tourism, this may include representatives from the local tourism industry or local citizens recognized for their exceptional participation in or understanding of outdoor recreation activities.

The introduction of this type of stakeholder knowledge and expertise into the valuation process supports Murphy's (1985) call for community input into tourism management, a call that has been endorsed by Getz (1987), Haywood (1988), Inskeep (1991) and Gill and Williams (1994). Ryan and Montgomery (1994). Jamal and Getz (1997) contend that the major challenge that continues to face destination tourism and outdoor recreation planning is the need to incorporate the diverse views and expertise of the community (especially stakeholders) into the local planning process. Despite its definitional flaws and other shortcomings, the selection of stakeholders as 'experts', individuals who it may be argued can offer 'expert insights', to participate in land valuation therefore is argued to offer a step forward.

In summary, land valuation should abide by the psychophysical paradigm introduced in Section 2.3.2. It should be an inclusive and participatory process that allows for input from stakeholders bringing "expert insights" to the table.

2.5 Land Valuation Methodologies

This section introduces nine solution methodologies for land valuation commonly used in landscape evaluation and land suitability analysis. This section draws heavily on the pioneering taxonomy of methodologies presented by Hopkins (1977), updated to include methodological advances and literature published since the 1970s, and incorporating taxonomic suggestions made by Chrisman (1997).

The nine methods are summarized in Table 2.1.

a.	Gestalt
b.	Ordinal, Linear and Non-Linear Combination
c.	Factor Combination and Cluster Analysis
d.	Rules of Combination and Hierarchical Rules of Combination
e.	Outranking
f.	Fuzzy Processing
g.	Bayesian Modelling and Neural Networks
h.	Economic Valuation – Contingent Valuation Method
i.	Economic Valuation – Hedonic Price Model

Table 2.1 Solution methodologies for land valuation

When discussing each of the nine methods, attention is given to solution complexity, underlying assumptions, input data complexity, scientific repeatability and objectivity, and ability to handle data interdependence.

2.5.1 Gestalt

The Gestalt method has as its underlying assumption that landscape can not be divided into component parts, and that landscape and land ought therefore to be evaluated as a holistic entity. At the core of the Gestalt method is the determination of homogeneous regions, and their subsequent valuation directly through field observation by field survey, or through use of a surrogate such as topographic maps or aerial photographs (Hopkins, 1977). The Gestalt method therefore involves three stages (Figure 2.1).

The first stage is the division of the study area into homogeneous parcels based on some form of implicit judgement. Usually this follows some kind of landform approach, for example a division of a landscape into uplands, river valleys, etc. The second stage is a holistic examination of each homogenous parcel as a complete entity, verbally describing the potentials and problems associated with each, or ranking the perceived value for the parcel on some relative or absolute scale (for example "no value" to "maximum value"). Hopkins (1977: 387) offers the following verbal example of a parcel evaluated by the Gestalt method:

> "This region presents no construction problems, but has no amenities that would render it a pleasant place in which to live."

Information collected in step two can be summarized in a data table or in report format. The final step is to produce a map which shows the different parcels of land identified, differentiating between different values using colour, shading, numbers, descriptive paragraphs, or a combination of all the above.

The Gestalt method has a number of disadvantages. Firstly, Hopkins (1977) argues that few people have the capability to deal with land classification and interpretation in a holistic manner by means of the Gestalt method. He suggests that, if at all, experts with considerable field experience are required to carry out this type of valuation. He suggests that only very few planners have the extensive local knowledge necessary to generate Gestalt parcels. To allow planners to gain the necessary experience to conduct Gestalt style evaluation, McHarg (1969) in the 1960s advocated a planning process whereby planners should be immersed for some time in a study region to view and experience land and landscape holistically in order better to understand the geography, land and planning issues at stake.

A second disadvantage is that Gestalt method is not replicable, nor scientifically objective. The method relies on subjective value judgements where an individual cannot even guarantee that her or his judgements made one day will be the same the following day if asked to repeat the process. Finally, a disadvantage is that the data obtained from a Gestalt valuation are descriptive and usually nominal or ordinal in scale making subsequent quantification somewhat awkward.

This method also has a number of advantages. First, conceptually, the method recognizes that "the whole may be more than its component parts". Secondly, it will be demonstrated in subsequent sections that a fundamental flaw underlying many of the methodologies that break landscape into component parts is that they suffer from ultimate data interdependence, where two or more components measured to represent

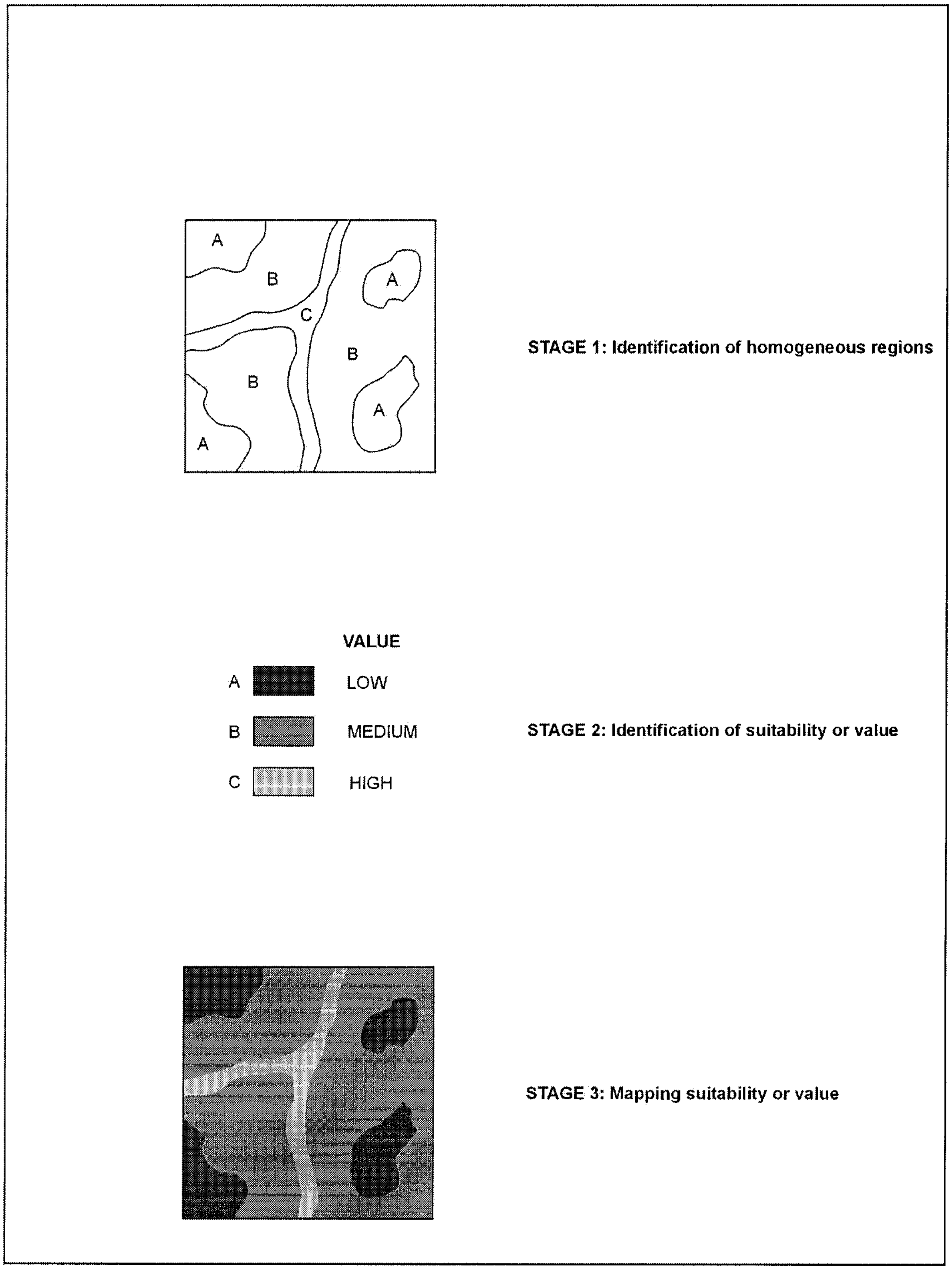


Figure 2.1 Gestalt method

value may represent or measure the same thing. Ultimate aggregation of these components back into an aggregate whole therefore runs the risk of exaggerating the importance of some components, introducing bias. The Gestalt method does not suffer from this flaw. The Gestalt method implicitly accepts non-commensurability and interdependence between individual attributes that make up value, using expert judgement intuitively to combine interdependent and/or non-commensurable data.

The literature offers examples of studies employing the Gestalt method for land valuation. Hills (1961) reports a methodology whereby Gestalts observed in the field could be grouped or partitioned to user specified levels of specificity for planning tasks. His study enabled less skilled individuals to replicate suitability by mathematical means that experts could generate by Gestalt alone. Lewis (1964) published a study which integrated wetlands, areas of steep terrain and surface water to generate environmental corridors. He then employed local citizens and generated a list of 220 icons for natural and cultural features (Niemann et al., 1998). These icons were found 90% of the time within the earlier defined corridors. Whilst not employing the actual term, the integrated nature of his corridors coupled with his arguments to employ them as entities in a planning process implicitly defines his work as part of the gestalt method. His work is still influential in the planning process of many agencies across the United States, and especially in Wisconsin (Niemann et al, 1998), where the corridors are generated employing map overlay and buffer techniques.

In summary, the real power of the Gestalt method is that it relies on expert judgement to combine complex and often interdependent and/or non-commensurable evidence to yield an overall measure of value, thereby avoiding some of the limitations underlying scientifically objective numerical analysis. The method also is relatively straight forward and allows for data collection and presentation in a relatively short time period. The disadvantages, on the other hand, are that the method requires access to experts capable of making Gestalt type judgements, and that the results are subjective and non-replicable. Hopkins (1977) notes that lack of scientific robustness and explicit scientific procedures imply that land valuations by the Gestalt method are difficult to confirm and scrutinize, thereby limiting the use of this approach in any public forum or planning process.

Lack of confidence in the subjective nature of Gestalt method therefore has encouraged the development of valuation methods that are more data-driven, and more removed from experts' value judgements.

2.5.2 Ordinal, Linear and Non-Linear Combination Methods

The perceived need to generate land suitability maps by mathematical operations that are scientifically defensible and repeatable formed the seeds for the seminal work by McHarg (1969) towards a more reductionist view of land suitability analysis using the map overlay concept that forms the basis of many contemporary GIS analyses. McHarg's methodology conceptually is extremely simplistic. It assumes that land value or land suitability comes down to a number of key factors that can be isolated, measured and stored individually as map layers, and that it is possible thereafter to combine these map layers back into an overall value by visually or numerically overlaying them, examining the resultant whole. Overall land suitability or value therefore is a simple amalgamation of those factors deemed important to the particular land use under consideration.

While conceptually elegant, McHarg's map overlay method suffers from a number of complications. It assumes that it is possible to identify exactly those attributes of land or landscape that will determine suitability or value. It assumes further that each one of these attributes may be measured in a scientifically objective manner. Next, it assumes that it is possible with simple summation to aggregate the measurements collected for each layer. Finally, it assumes that the measurements in each layer represent evidence completely independent of the evidence introduced by measures in another layer.

Through time, three simple methods developed to facilitate the combination of individual map layers to yield an aggregate suitability map, namely the ordinal combination, linear combination, and non-linear combination methods. All three methods have in common that the first step is to identify the specific themes that are to be mapped as individual layers. This requires expert insights and the need for clear statements of land suitability or land evaluation goals and objectives. All three methods also require the identification of homogeneous mapping units within each thematic layer. The three methods further have in common that each theme is measured as scientifically objective to as high a level of measurement as possible. In some cases it may not be possible to go beyond nominal measurement, that is presence or absence data (a layer of Water may show rivers and lakes present or absent; a layer of Aspect will differentiate between NE and SW). In other cases data layers may be recorded at the ordinal or cardinal levels of measurement (pH of soil, depth of soil, slope,…). Finally, the methods require that data within each layer be reduced and generalized to some very simple ordinal scale to facilitate comparison between layers (0 = no value, 1

= low value, 2 = medium value, 3 = high value). The data requirements for all three methods therefore exceed the data collection requirements for the Gestalt method. They require that detailed field inventory be carried out, that each individual data layer is divided into homogenous mapping units, and that attribution is collected and attached to each mapping unit in each layer. The three methods differ in how each data layer is introduced as evidence in the overlay process when the data layers are combined, and how the data layers are summed.

2.5.2.1 Ordinal Combination

The ordinal combination method involves the simplest of overlay summation which can take one of two forms. McHarg (1969) initially suggested that each value be translated into grey tones in such a manner that, for example, higher value mapping units appear darker than lower value mapping units. Summation of layers thereafter involves summation of grey scales - all those parts of the study area consistently shaded dark for each layer will sum to nearly black, while all those parts of the study area consistently shaded very light will sum to a light shade. The summation can be achieved by simply placing all layers on top of each other on a light table. Figure 2.2 shows this process graphically, demonstrating how the aggregate map allows for visual evaluation of relative suitability or value.

An alternative to the grey scale approach is to aggregate numbers instead of grey values as shown in Figure 2.3. Although visually not as elegant, the latter method is more efficient for subsequent quantitative analysis. The latter technique forms the basis for contemporary simple overlay analyses in GIS.

The ordinal method assumes that each layer of information contributes equally to overall analysis, and that the relative scales used to measure attribution within the individual layers are comparable. The ordinal method of combining data layers has two important limitations, namely violation of mathematical assumptions and data interdependence.

Violation of Mathematical Assumption: The addition of suitability numbers (0 = no value, 1 = low value, 2 = medium value, 3 = high value), which are on an ordinal scale, is a strict violation of the mathematical properties of addition. The relative difference between the numbers is understood, but the absolute difference is unknown. To argue that the difference between 1 and 2 is the same as that between 2 and 3 is logically and mathematically not valid. Nor is the assumption that 2 x 1 = 2 (two times 'low value' does not necessarily make a 'medium value').

Data Interdependence: An assumption underlying the overlay method presented above is that information presented by any one map layer is independent of information presented by any other layer. Especially in land suitability analysis two thematic data layers may be highly correlated with one another. For example, as part of a hypothetical study a research has data representing two layers, one measuring slope and the other soil moisture. There is good reason to argue that steep slopes imply poor soil moisture retention because of gravity while lack of slope may imply higher moisture retention. For another example, a researcher is attempting to map outdoor recreational potential where one layer represents potential for hiking trails and a second potential for horse-back trails. There is a good chance that terrain suitable for hiking trails also is suitable

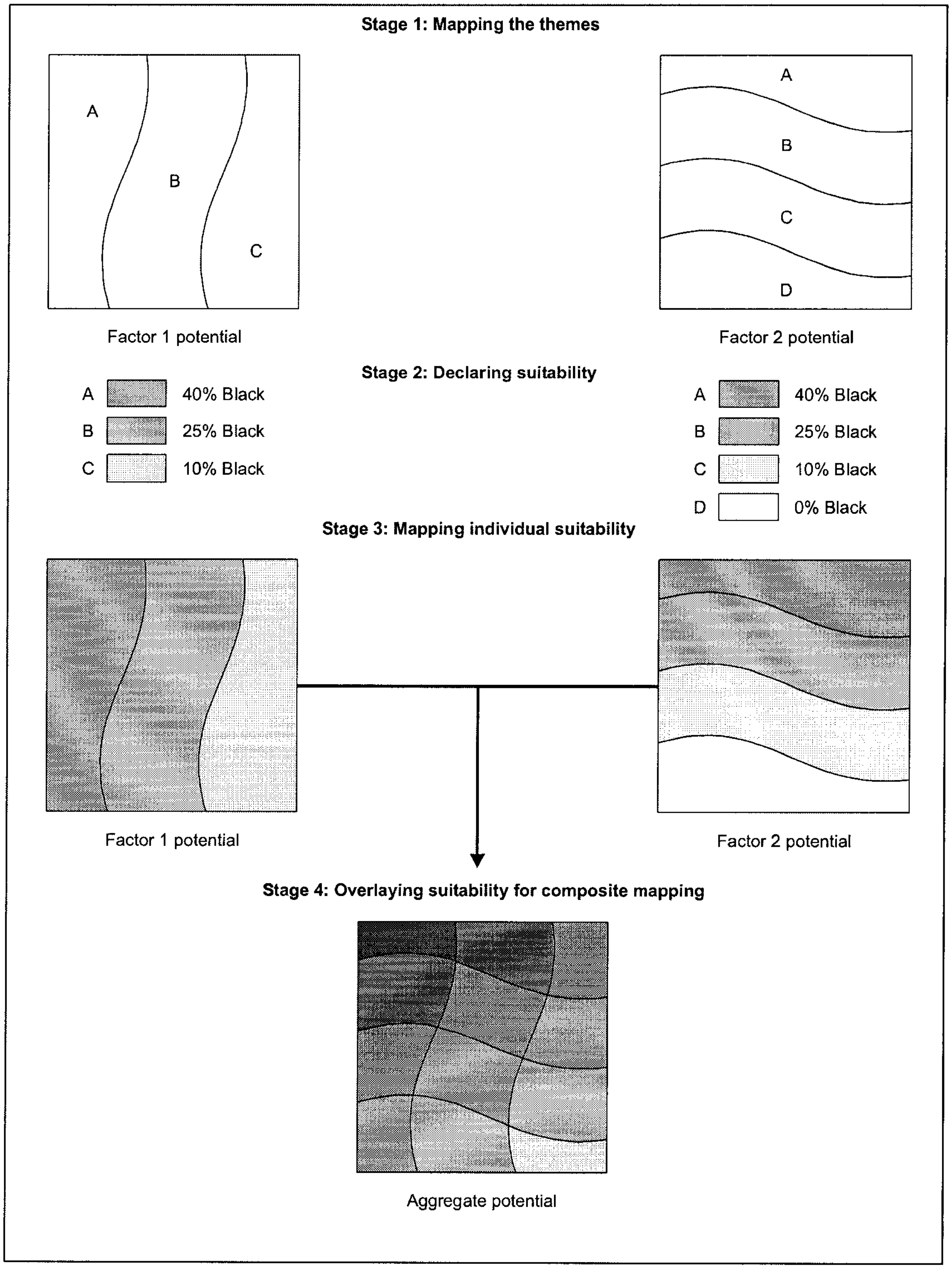


Figure 2.2 Ordinal combination mapping by grey tone (After Hopkins, 1977)

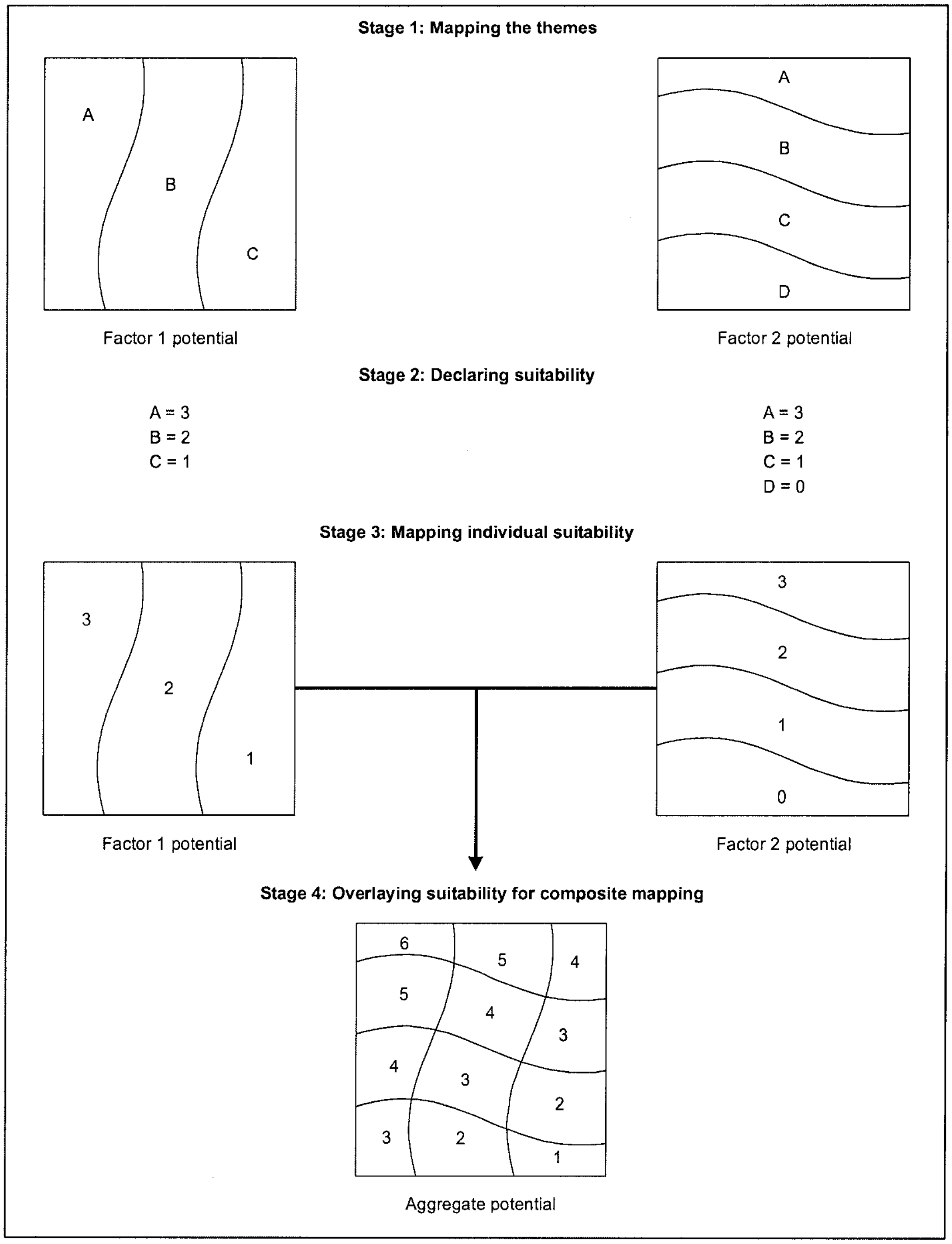


Figure 2.3 Ordinal combination mapping by numbers (After Hopkins, 1977)

for horse-back trails; in other words the two layers may measure similar things. Interdependence between data layers therefore can not always be taken for granted. Hopkins (1977) argues that deductive reasoning may solve the interdependence problem, and that a researcher can intuitively decide the apparent relationships between themes, ironically an implicit return to the Gestalt method, and negating the requirement of a robust mathematical method. The key advantage of this method is that it is very easy to understand and implement once the data have been collected.

2.5.2.2 Linear Combination

The methodology for linear combination is identical to ordinal combination, except for the inclusion of a multiplier to facilitate differentiation between how important each individual layer is to overall value. Akin to the weighted overlay approach in contemporary GIS analyses, the linear combination method allows for weights to be attached to individual layers. Figure 2.4 shows an example where Layer One was given a weight of **0.3** while Layer Two was allocated a weight of **0.7**. The implication is that Layer Two is more than twice as important to overall value than is Layer One.

A number of rating schemes are possible with this method. Ward and Grant (1971, referenced in Hopkins: 1977) placed their weighting factors on a nine-point interval scale, and then employed a standard weighted average: the sum of the products of the ratings multiplied by the respective weights for each factor, divided by the sum of the weights. In order that all the factors are on similar rating scale, a transformation may be carried out. Lyle and von Wodtke (1974) proposed a simpler scheme, suggesting

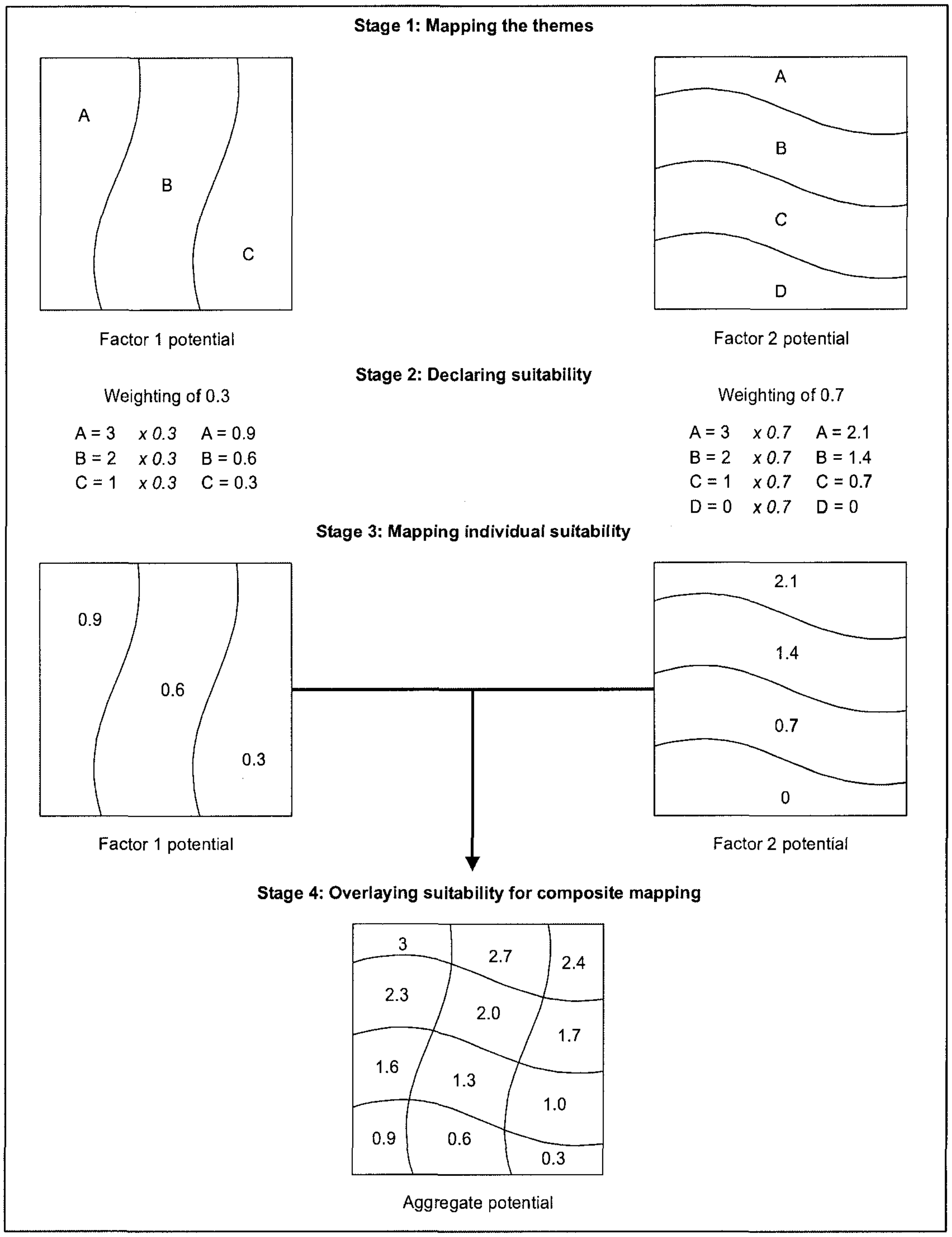


Figure 2.4 Linear combination (after Hopkins, 1977)

that weights be allocated so that their sum equals 1 or 100. They made this suggestion to facilitate computations and to encourage conceptual simplicity. Their approach has become standard practice in weighted GIS overlay analyses.

Although the linear combination method does allow the evaluator to differentiate between the relative importances of individual map layers, the technique continues to violate fundamental mathematical assumptions that ordinal data should not be summed or multiplied. Within each layer, this technique still assumes that the difference between 1 (low) and 2 (medium) is the same as the difference between 2 (medium) and 3 (high). The technique assumes further that, for example in a case where Map Layer One is weighted .2 and Map Layer Two is weighted .8, 5 times 'low' in Layer One equals 1 times 'low' in Layer Two. What sense does this make? The technique also suffers from the same potential data interdependency between layers as already outlined for the ordinal combination method. The advantage of this method is that it allows for the weighting of the relative importance of evidence introduced that are the components of value, while remaining easy to understand and implement.

2.5.2.3 Non-Linear Combination

The non-linear combination method seeks to address both, the assignment of appropriate weights as well as solving the interdependence of thematic layers in a scientifically and mathematically defendable manner. The non-linear combination method attempts to define the relationships between individual map layers in a non-linear manner based on numerical modelling, usually represented as a surface of weights in three dimensional space. It is similar to the linear combination method in that it employs weights to differentiate the importance of two contributing layers. In this case, however, the relationship between the layers is calculated in a non-linear manner, that is a unique weight is assigned, based on any given combination of attribute value found in Map Layer 1 and Map Layer Two (see graph in Figure 2.5). A hypothetical example of a non-linear combination is the potential relationship between pH of soil and its Nitrogen content.

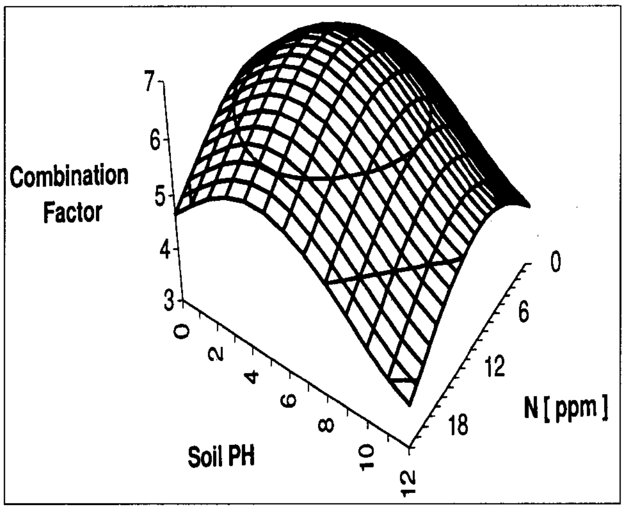


Figure 2.5 Non-linear factor combination (after Keller et al., 1996)

Both of these themes may be individually mapped by field survey. But it makes little sense to classify these themes in an ordinal manner and then add them together in a linear manner. However, it is possible to carry out experiments to study suitability for plant species for different combinations of pH and Nitrogen. The resultant relationship may be subsequently mapped on a graph. This relationship may be then employed to determine the weights for any given combination of the two layers.

The non-linear combination method resolves some of the problem of interdependence, but the derivation of this non-linear function is very time-consuming and problematic, with the relationships between layers difficult to discover and to defend scientifically. Also, any overlay technique should be easy to understand by decision makers and stakeholders. The use of a non-linear function to explain the relationships between variables, even if possible, would be extremely difficult to explain with clarity to third parties trying to comprehend how information was derived. There are examples of the use of non-linear combination method in suitability analysis present in the literature, but these studies are specific and limited in their applicability (Storie, 1933; Voelker, 1976). The limitations posed by both, the difficulty to calculate the non-linear relationships, coupled to the adverse complexity to the users, suggests that this form of combination, whilst solving the problem of interdependence, makes this a method operationally impracticable.

2.5.3 Factor Combination Method and Cluster Analysis Methods

The factor combination method starts of the same way as the previous three techniques, but differs in how data layers are combined. Again, Step 1 requires definition of what variables determine value or suitability. Again, Step 2 requires identification of homogeneous mapping units for each data layer to be mapped, and the collection of attribution for each mapping unit. This technique therefore also is very data intensive.

Once all data have been gathered, the technique moves on to identify all possible unique combinations of thematic class combinations by carrying out a logical intersection of all data classes between all layers. For example, imagine a situation where there are two layers of information where Layer One has three data classes (1, 2, 3) and Layer Two has two data classes (A, B). In this case there will be six resultant class combinations (1A, 1B, 2A, 2B, 3A, 3B). The next step is for experts to assign a suitability index (or weight) to each combination (McHarg, 1969, Hopkins, 1977, Garlick, 1999) (see also Figure 2.6).

Creating such combinatorial suitability indices solves the problem of data interdependence since it can be assumed that experts will reconcile dependency issues with implicit judgement when investigating each factorial combination separately. There are, however, serious limitations of complexity underlying this method for all but the simplest of problems. Consider a reasonably simple scenario where there are five thematic layers, with each having five classes. Using factor combination, the number of unique class combinations to be evaluated run into the order of 55, or 3,125. Imagine asking an expert to identify unique suitability values for this number of combinations! One only has to increase this to 10 themes with 5 classes to get to the order of 100,000 combinations, which makes the problem operationally unmanageable even if it can be shown that a large percentage of these class combinations can be eliminated because they cannot or will not occur in reality.

Hopkins (1977) suggests that cluster analysis techniques may offer potential to reduce the unwieldy nature of the factor combination method. Setting up and interpreting such a cluster analysis does however require considerable statistical expertise, implicit expert judgement still is required to apply relative measures of suitability to resultant clusters, and the process and results are difficult to understand and interpret by decision makers (Keller et al., 1996).

In summary, the factor combination method removes data interdependence and enables non-commensurable data to be combined by employing expert judgements to

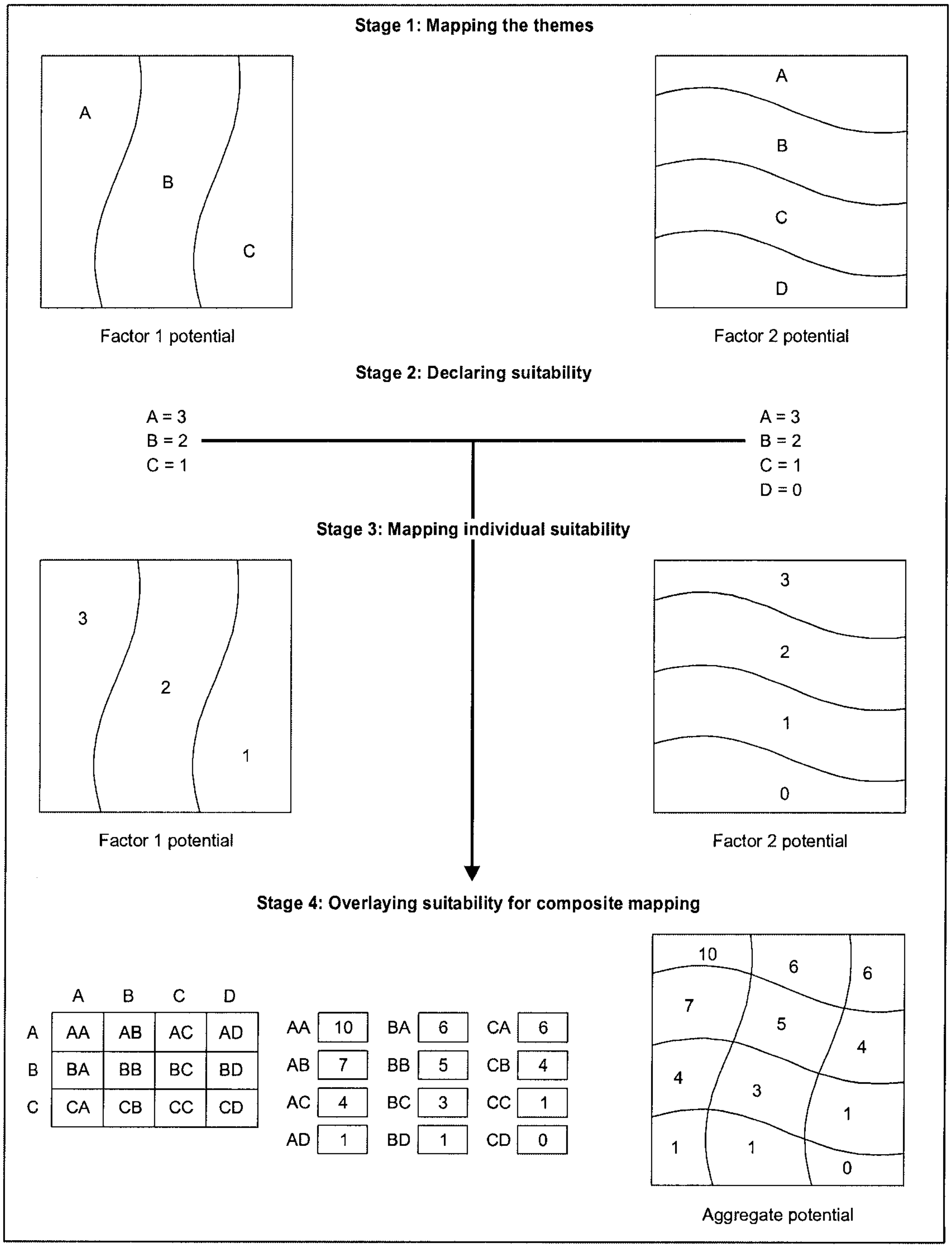


Figure 2.6 Factor combination (after Hopkins, 1977)

assign suitability weights to each combinatorial class. However, the technique becomes unwieldy even for relatively small problem sets, and efforts to reduce complexity by capitalizing on multivariate cluster analysis techniques moves this solution approach beyond most decision makers' comprehension.

2.5.4 Rules of Combination and Hierarchical Rules of Combination

The rules of combination methods offer a compromise between the non-linear combination method and the factor combination method. Again, Step 1 requires definition of what variables determine value or suitability, and Step 2 requires identification of homogeneous mapping units for each data layer to be mapped, and the collection of attribution for each mapping unit. This technique therefore also is very data intensive.

What differentiates this technique is that it requires experts to look at each data class in each layer, as well as possible combinations of data classes between layers, defining rules that determine suitability or value as they proceed. This process usually involves collaboration between experts and system designers, where the experts express rules in a structured verbal manner that are translated by the system designer into conditional statements. Examples of resultant conditional rules are:

IF "stream rating = high" THEN "suitability =high"
OR IF "access rating = low" and "safety rating = high"
THEN "suitability = 3"
OR IF "all ratings < 5" THEN "suitability = min"

Map layers thereafter can be combined by following the conditional rule set generated. Generation of the rule set often is iterative, with experts stating initial rules, examining resultant suitability maps, and thereafter generating further rules to refine the outcome. The end product of such an iterative process is usually a very large set of rule statements (Kiefer, 1965). Map algebra embedded in some commercial GIS solutions enables these rule statements to be defined and implemented in a reasonably straightforward manner by those systems supporting this functionality (Tomlin, 1990).

Hierarchical Rules of Combinations is a development upon the previously described method, based upon the work of Alexander (1964). This method implies a more structured approach to rules, where one set of rules may override or take higher priority over other rules. Imbedding a hierarchy in the rule set requires more work up-front to define the hierarchy underlying the rules, but it removes redundancies and simplifies the rule evaluation process, thereby adding efficiency (Keller et al, 1996).

Chrisman (1997) offers an advancement of the hierarchical rules of combination technique by suggesting three classes of rules to be combined in a complex hierarchy. These are: Dominance Rules, Contributory Rules and Interaction Rules. Dominance Rules imply that one attribute or variable dominates a value judgement, and that in the presence of this evidence, all other evidence becomes secondary or irrelevant. Examples of this kind of rule application may be found in FAO, 1976, Rossiter, 1996, and Burrough and McDonnell, 1998. This type of rule usually is employed as part of soil suitability research, and involves Boolean operations. Contributory Rules are straightforward expressions of how much any one attribute contributes to the final result without regard to any of the other attributes. These rules assume that individual contributions can simply be summed to yield overall contribution. The linear combination method can be argued to represent a technique based on simple contributory rules. Interaction Rules define how combinations of attributes contribute to overall value. The factor combination method introduced previous can be argued to represent a technique based on simple interaction rules. Chrisman's (1997) method therefore actually represents a clever but complex hybrid of the linear combination method, the factor combination method, and the rule of combination method, all combined as a hierarchical rule of combination technique.

Rules of combination and associated hierarchical rules of combination techniques resolve data commensurability and data interdependency issues. However, the techniques require considerable expert knowledge to set up, and the process of generating the rule sets and defining their hierarchy can be extremely complex and time consuming. Experience has shown that rules are not easy to define or justify, and Pereira and Duckstein (1993) argue that these systems have the tendency to become large and awkward. Rule structures can become excessively complex as the number of data layers and associated attribute classes increases. Incidences of duplication within the rule set are difficult to avoid as the rule set expands. Finally, situations arise where rules are contradictory causing, in the worst case, serious system failures. On a more positive note, rules and their hierarchy can easily be presented to decision makers, and are easily understood.

2.5.5 Outranking Method

Pereira and Duchstein (1993) observe that land suitability analyses usually involve many criteria and are predominantly carried out as part of a decision making process and that, as such, they lend themselves to investigation using multiple criteria decision making (MCDM) techniques, as well as being an integral part of multiple criteria analysis (MCA) This is also an important component of GIS research (Carver, 1991). A popular MCDM technique is outranking, which forms part of graph theory (Roy 1975; Jacquet-Lagreze and Siskos, 1983; Scharling, 1985).

Pioneered by Saaty (1977, 1980, 1982, 1987), this method involves the comparison and judgement of alternatives in a pair-wise manner. The technique has become known as the Analytical Hierarchy Process (AHP). An extensive literature exists on the application and discussion of AHP. The technique became popular in multivariate decision making underlying, for example, product choice, career selection or residential housing searches. (http://www.expertchoice.com/hierarchon/references/reflist.htm).

An example will help to clarify the process. In career selection, the decision variables may include salary, location, authority, security and spousal opportunity. Imagine the decision maker has three job offers. For each of the five decision variables, the decision maker will proceed by pair-wise comparing the relative priority of two job offers. Rankings usually are conducted on a scale of 1 – 9. For example: As far as spousal opportunity is concerned, how much more does the decision maker prefer offer 1 over offer 2? All possible pair-wise comparisons subsequently are combined to yield an aggregate preference outcome statement informing the decision maker which job offers ranks highest etc..

Satty's (1977) original AHP technique has attracted considerable research interest and it has been applied to land suitability assessment (Keller et al., 1996) and more recently to stakeholder preferences for forest planning (Ananda and Herath, 2003). A considerable literature has been published discussing the mathematical assumptions underlying Saaty's (1977) original Eigenvalue method to recover priorities from a preference structure, and a number of alternative methods have been explored to move from pair-wise comparison to development of a preference structures, including:

- Geometric Mean Method (Barzilai et al, 1987)
- Geometric Mean and Log least Squares Method (Crawford and Williams, 1985)
- Least Squares Method (Cogger and Yu, 1985)
- Harmonic Means (Johnson et al., 1979)
- Mean Transformation Transformation Method (Zadehi, 1986)
- Arithmetric Mean Method (Saaty, 1980)

Debate over mathematical assumptions underlying outranking techniques is ongoing (Xiang and Whitley, 1994; http://www.expertchoice.com/) It also has not been resolved whether there is a single best method to derive a preference structure although some regard Saaty's original work (1977) using Eigenvalues as the most appropriate to use since it is argued to be the only method that can recover satisfactory priorities from a preference structure with or without cardinal consistency in the pair-wise ranking matrix (Xiang and Whitley, 1994; Keller et al., 1996).

Outranking techniques require considerable input from decision makers. The process does rely on subjective pair-wise rankings, and there is no guarantee that an expert's ranking will be consistent should the exercise be repeated after some time has elapsed. The possible pairs of combinations to consider also become unwieldy for even reasonably small decision problems. This method requires the same initial data collection process as outlined for previous techniques and the numerical logic and process underlying generation of the preference structure is difficult to explain to the lay person. Finally, the technique has been criticised for violating mathematical assumptions.

On a positive note, this technique has as its advantage its ability explicitly to extract decision makers' preferences, to recover priorities, and to diagnose decision inconsistencies within the decision makers' preferences (Xiang and Whitbey, 1994; Keller et al. 1996). The technique has been proven very successful when applied to decision making, and it is used extensively by decision making consultants. The latter may come as a surprise given that the techniques scientific validity has been questioned. Perhaps a comparison can be drawn to the common practice to sum ordinal data classes.

2.5.6 Fuzzy Processing

Recognizing that landscape and features on the landscape do not conform to crisp and mutually exclusive classes and mapping units (polygons) led researchers to challenge conventional methods of measuring and representing land suitability in the late 1980s. Challenging classic set theory which fails to tolerate inherent imprecision underlying the geographical distribution of variables that define land value, researchers have started to explore application of fuzzy logic (Zadeh, 1965) and fuzzy processing (Burroughs 1986; Wang et al. 1990; Hall et al. 1992; Davidson et al, 1994; Davis and Keller 1997).

Substituting a fuzzy data model for the conventional polygonal data structure allows set membership and polygon attribution to acknowledge that there exists uncertainty in polygon classification. The abrupt attribute transition from one polygon to another underlying classic definition of mapping units is replaced by a data model that allows for smooth attribute transition.

Partitioning of landscapes into mapping units using fuzzy logic implies the need for innovative analytical techniques to derive suitability by methods incorporating fuzzy pattern recognition and Monte Carlo simulation (Keller et al., 1996).

The most important facet of this research technique is that it allows for imprecision. Research that employs precise techniques often leads to information loss and inaccuracy in analysis. Hall et al (1992) compare land suitability generated by using Boolean processing with those generated by fuzzy processing. They observe that the Boolean approach generates large suitability areas with the same rating, whereas fuzzy processing produces more variability in suitability.

Data requirements for this method also commence with definition of which variables determine value or suitability. This is followed by mapping of each theme. While it is possible to commence mapping using traditional mapping units it is possible and preferable to treat each layer as a continuously variable surface (Burrough and McDonnell, 1998). The technique also is very data intensive.

Wang et al. (1990), Hall et al. (1992), Davis and Keller (1997), and Jiang and Eastman (2000) explain details of how land suitability can be derived using fuzzy logic. Burrough and McDonnell (1998) give examples of how to manipulate both, continuous surfaces and discretely classified data layers (polygonal coverages) using fuzzy processing within GIS. In each case, they demonstrate how set membership can have an impact on the final suitability map. They note that continuous data is extremely suited to fuzzy processing, dealing as it does with data that has no crisp boundaries as part of the data structure.

The advantages of using fuzzy processing for land suitability analysis include that the underlying assumptions and data structures more closely resemble what is being modelled, as well as enabling the uncertainty with the data source and decision maker to be explicitly recognized and assessed. Woodcock and Gopal (2000) note further that the use of fuzzy sets for thematic maps allows for more flexibility in the treatment of map classes, as well as providing the ability for a wider range of queries to be explored in a GIS.

The main disadvantages, are both conceptual and computational complexity. To explain the theory and application of fuzzy logic and fuzzy processing to decision makers and stakeholders in order to allow them to understand how data have been processed is non-trivial. Fuzzy processing also usually requires Monte Carlo simulation procedures which imply running the same analysis over and over again until statistical stability has been reached. Analyses usually require access to the latest and fastest processors, and still can take days to complete. Davis and Keller (1996) therefore have argued that whilst application of fuzzy processing increases the amount of useful information, it does so at a great cost. Another disadvantage is that expert judgement is required to derive fuzzy set membership, thereby incorporating subjective judgements. Finally, output from fuzzy processing is not one, but a set of suitability maps, and the interpretation of these map sets requires sophisticated skills.

Suitability map sets derived from fuzzy processing specialize in highlighting uncertainty, and thereby may hinder instead of facilitating decision making processes that try and reach conclusions about what value to assign to land. Although intellectually and computationally elegant, fuzzy processing techniques therefore do not represent cost effective and efficient land valuation given today's knowledge.

2.5.7 Bayesian Modelling

Geoscientists have developed an approach to deriving land suitability maps that takes advantage of probability theory and weights of evidence (Bonham-Carter et al, 1988). Bayesian probability theory is an extension of classical probability theory. It enables new evidence about a hypothesis to be combined with a prior knowledge to arrive at an estimate of the likelihood that the hypothesis was true (Eastman et al, 1993). Bayesian modelling is based on the concepts of prior and posterior probability. Given an initial prior probability of the likelihood of an outcome, it is possible to keep adding information to calculate a subsequent probability based on how evidence of additional information added to the solution procedure will have supported the initial prior probability (Keller et al., 1996). Once this iterative process has been completed, weights are assigned which allow the maximum likelihood of the amalgamated factors to be shown in a map. The method is described in detail by Bonham-Carter (1994).

An example of the applied used of this technique is the calculation of mineral potential maps by geoscientists (Bonham-Carter et al, 1988; Watson et al, 1989; Agterberg, et al, 1990; Singh et al., 1993; Bonham-Carter, 1994; Agterberg, F.P and Bonham-Carter, G.F. 1999). The analysis begins with an initial prior probability generated by stream geochemistry. Further evidence, for example terrain, vegetation, etc, is added to gain further information about the initial probability.

Bayesian Modelling has a number of underlying data and information assumptions. Firstly it assumes data independence – all data layers are assumed spatially uncorrelated. Secondly, it is assumed that there exists a prior knowledge of a likely outcome given a specified combination of weights of evidence. This type of suitability analysis therefore specializes in testing hypotheses, and identifying the likelihood of occurrences (hence the application to mineral potential mapping). Its use in straight-forward land suitability analysis or landscape evaluation is less clear.

2.5.8 Neural Networks

Burrough and McDonnell (1998: 170) define a neural network as

> "a processing device, implemented as an algorithm or computer program, that is said to mimic the human brain. It comprises many simple processing elements that are connected by unidirectional communication channels carrying numeric data. The elements operate only on local data but the network as a whole organizes itself according to perceived patterns in the input data."

Wang (1994) discusses the application of neural networks for land suitability assessment. He proposes that this can be achieved by translating a land suitability assessment problem into a pattern classification problem, advocating that suitability evaluation should be based on recognition of patterns of physiographic characteristics in the landscape. Patterns are argued to be recognized as vectors of land physiographic attributes (Wang, 1994, Keller et al., 1996).

It is difficult at this stage to present the advantages of neural networks as the application of neural networks to GIS is still in the research stage, (Burrough and McDonnell, 1998, Lees, 1996). Preliminary studies suggest that neural networks will provide opportunities to deal with complex data in simple and useful ways, but that training of the networks is a complex task (Wang, 1994) that requires considerable expert input, and that is not easily explained to the lay person. Wang (1994) also points out that patterns recognized by neural network analysis must still be interpreted and value judged by experts (akin to the Gestalt method), and that no acceptable statistical method exists to test the validity of the patterns recognized.

Recognition of patterns in the landscape by neural networks to identify parcels of homogenous value in many ways resembles the Gestalt method. Advantages and disadvantages noted for the Gestalt method apply equally, perhaps with the exception that neural networks may (or may not) be able to replicate results more consistently than humans.

2.5.9 Economic Valuations

Brush and Shafer's (1975) investigation of the relationship between stated scenic preference and real estate values discovered that the two were highly correlated. They concluded that an equation could be generated that models the relationship between these two variables. This type of approach is known as economic valuation.

Inspired by Pearson's early work on correlation analysis, first attempts at land value correlations may be traced to the work of Haas (1922) and Wallace (1926) who employed regression techniques to determine the contribution that buildings, land classes, land productivity and distance to market made to land value. Brush and Shafer (1975) were amongst the first explicitly to state the correlation between market value and preference (suitability). Since the mid 1970s the understanding of this relationship has been advanced by developments in economic theory and multivariate analysis (Willis and Garrod 1991). A considerable body of theory and associated models has been developed. Two of the most commonly used economic models, the Contingent Valuation method (CVM) and the Hedonic Price Model (HPM) are introduced below.

A note of caution: Correlation between market value and preference is not unproblematic. Arthur et al. (1977), discussing the value of aesthetics, were amongst the first to point out possible drawbacks to economic valuation models, arguing that some preferences are difficult to define (and perhaps should not be defined) in absolute terms. They pointed out that using economic valuation models to place some sort of charge on for example an aesthetic resource is, at best, problematic (Arthur et al. 1977).

2.5.9.1 Contingent Valuation Model

Contingent valuation method (CVM) perhaps is the most common economic valuation technique. The technique is straight-forward. Potential consumers are asked how much they would be willing to pay for a good or service, which is argued to simulate market behaviour. In general terms the value of the good is estimated by multiplying the average value by the number of consumers. An extensive research agenda into CVM has applied and evaluated this method, giving it considerable credibility. Cummings et al. (1986) and Hoehn and Randall (1987) summarize theoretical work on CVM. A large body of research on CVM applied to environmental resources exists especially in the UK. Work includes Hanley (1989) and Hanley and Ruffell (1992) study of forest recreation, Willis and Garrod's (1991) work on estimating the value of preserving particular landscapes in the Yorkshire Dales, Hanley and Knight's (1992) study of Green Belt Land, and Edwards-Jones et al. (1995) work on ranking sites in Southern Scotland for preservation.

The data and information requirements for contingent valuation method are somewhat different to those noted for techniques discussed earlier in this Chapter. Dealing as it does with human preference, data usually are collected by means of a questionnaire. Individuals are asked how much they would be willing to pay (WTP) to access a particular site, for example a forest or a particular feature in the landscape. Value or willingness to pay is modelled based on data collected for a sample of a population, with inferences thereafter drawn for the population as a whole.

An advantage of the CVM is that it is theoretically simple to apply. Contingent valuation rates the landscape as an entity and, as such, may be seen as a logical progression from stated preferences as present in the psychophysical models as well as Gestalt valuation. Hanley and Milne (1996) argue a potential fundamental flaw with CVM. They note that respondents are asked about willingness to pay – they are not actually asked to put money on the table. There can be a considerable difference between the two, especially if survey respondents try and advance hidden agendas through their responses. Respondents may, for example, deliberately state a lower value for willingness to pay to keep a price down, or they may deliberately declare a very high willingness to pay in order artificially to boost value for accounting purposes. Hanley and Milne (1996) note that "protest" valuations also are potential issues. They stress that the ethical beliefs and behaviour of respondents should at all times be examined and considered very carefully in CVM research.

2.5.9.2 Hedonic Price Model

The hedonic pricing method (HPM) is employed primarily to estimate the value of environmental amenities on residential property values. It may be employed to estimate the influence of local environmental attributes on the market price. These attributes include air or water pollution, aesthetic views, or availability of nearby recreational sites. (http://www.ecosystemvaluation.org/hedonic_pricing.htm).

An example of the application of HPM to estimate the value of open space as it impacts on housing price would involve the following stages:

1. Collect data on residential property sales for a specified time. Data would include factors such as number of rooms, property tax, number of bathrooms, lot size, access to stores, schools
2. Collect data on the open spaces, for example either how much open space is in a set radius from the property and/or if a property is bordered by an open space.
3. Mathematically estimate the function of the collected variables to the housing prices. This is carried out usually by regression analysis. The final function enables the portion of a housing price that is generated by open space to be calculated. It is possible then to model potential increases or decreases in open space and its impact on prices.
http://www.ecosystemvaluation.org/hedonic_pricing.htm

Rosen (1974) pioneered the hedonic method of economic valuation to land value. There exist numerous studies employing this technique to value land, including Chicoine, (1981); Miranowski and Hammes, (1984); Palmquist and Danielson, (1989), Tyrväinen and Miettinen (2000) and Leggett and Bockstael (2000). A typical example is a study by Xu et al. (1993) who examine the effects of different combinations and qualities of selected site characteristics on the value of land in six substate regions in Washington State, and who presented the conclusion that land value indeed is a function of site characteristics.

The data requirements of this model, when applied to the land market, assume that a given parcel of land can be identified by a unique set of attribute levels, and that a land parcel is an aggregation of the values of its individual attributes. This method is less subjective than CVM, comparing as it does people's willingness to pay to live in particular types of landscape, represented by real estate values.

The advantage of the hedonic approach is that it uses actual market data to estimate non-market values. Also the nature of the statistical calculations enables researchers to state scientifically defendable levels of confidence for their resultant functions and equations. However, it is difficult, and computationally complex, to determine value of site characteristics associated with non-residential land since the individual components are not traded nor are they priced in explicit markets. This may be seen to be the case as well for outdoor recreation land parcels. The HPM employs systems of equations and may be associated with multiple regressions, and as with all regression analysis the resultant answers are only as good as the data input. Once again the selection of which site characteristics are to be modelled against the real estate prices will have substantial impact on the result. There is a need to select these characteristics in a meaningful way, with expert input being the most appropriate.

2.5.10 Summary

This section has introduced nine solution methodologies for land valuation most commonly used in landscape evaluation and land suitability analysis. Section 2.6 will summarize the techniques, reaching conclusions about which best suit a land valuation process that seeks to abide by the psychophysical paradigm, and that attempts to facilitate expert input from local stakeholder group representatives.

2.6 Summary

The groundbreaking work in the field of landscape evaluation and land suitability analysis is multidisciplinary. It ranges from Landscape Architecture, Environmental Studies and Geography through Psychology and Economics to Engineering, Computer Science, Mathematics and Statistics. Diverse motives exist for landscape suitability analysis and land evaluation. Techniques have been developed and refined to address disciplinary specific enquiries, to meet individual and specialized needs, or to seek to improve on limitations and weaknesses of existing techniques. No one technique has come forward as capable of outperforming all others.

It has been noted that land valuation can be conducted by experts following the expert paradigm, or in a collaborative and inclusive spirit following the psychophysical paradigm. The argument has been put forward as to why land valuation following the psychophysical paradigm is preferable. The problematic nature of stakeholder group identification, and the associated problem of finding suitable representatives to come to the table to present each stakeholder group, has been addressed. The suggestion has been put forward that it is ultimately experts with local or thematic expert insights that should come to the table, and that if carefully selected, these experts will present the various stakeholder groups.

Finally, this Chapter has identified a number of techniques that either have emerged as dominant, or that are recent developments that look promising to solve land valuation. Table 2.2 attempts to summarize the techniques discussed using three key evaluation criteria, namely what are the underlying data requirements, what are the advantages, and what are the disadvantages. Emphases have been placed on conceptual and mathematical complexity, on abilities to handle data inter-dependence and commensurability, and on ability to stand up to mathematical assumptions.

The Gestalt method stands out as unique (perhaps with the exception of neural network landscape pattern recognition) in that it seeks to evaluate landscape as a whole. The Gestalt method is one of the oldest methods and it has played a long and influential role in landscape suitability analysis.

TECHNIQUE	DATA/INFORMATION REQUIREMENT	ADVANTAGES OF TECHNIQUE	DISADVANTAGES OF TECHNIQUE
Gestalt	**Expert defined factor maps**	**Handles interdependence** **Handles Non-commensurate** **Direct Input from Decision maker**	**Finding Skilled People** **Subjectivity** **Lack of Repeatability**
Ordinal,Linear, Non-Linear Combination	Thematic Factor Maps Explicit Goals Resource Inventory	Mathematically Elegant Conceptually Simple Interdepence For Non-Linear	Violation of Ordinal Scale Interdependence
Factor Combination &Cluster Analysis	Thematic Factor Maps Explicit Goals Resource Inventory	Interdependence solved	Unwieldy number of regions How to define the similarity index
Rules of Combination and Hierarchical Rules of Combination	Thematic Factor Maps Explicit Goals Resource Inventory Expert input for rule derivation	Allow for verbal input of expert Create rules which have wider applicability	Complex iterative system Large and unwieldy system Duplication of rules (Solved for Hierarchical but at expense of more input
Outranking	Thematic Factor Maps Explicit Goals Resource Inventory	Extract Decision makers preferences Recover priorities Diagnose inconsistencies	Unwieldy with large set of alternatives Subjective interpretation of experts
Fuzzy processing	Thematic Factor Maps Explicit Goals Resource Inventory Fuzzy set memberships	Reduces crisp artificial boundaries More flexibility in the use of thematic map layers	Combination of layers complex Need for *a priori* set membership
Bayesian Modelling	Thematic Factor Maps Explicit Goals Resource Inventory *A priori* Knowledge	Testing of hypothesis	Assumes interdependence of layers
Neural Networks	Thematic Factor Maps Explicit Goals Resource Inventory A prior Knowledge	Pattern matching	No statistically accepted method to validate patterns
Contingent Valuation	Public input Socio-economic data	Conceptually elegant Mathematically simple	Non-spatial (site by site) Protest values
Hedonic Price Model	Thematic Factor Maps Real Estate Prices Resource Inventory	Econometric Statistically robust	Non-spatial Data requirements

Table 2.2 Summary of land valuation techniques

The need to identify homogeneous land parcels is at the core of most of the techniques introduced, and therefore a step that appears difficult or impossible to avoid. Evaluation by fuzzy logic does facilitate keeping layers of information as continuous surfaces, but even this technique requires definition of mapping units as a starting point from which to introduce fuzzy transition between adjacent polygons.

Spatial correlation, or data interdependence, between the spatial distributions of variables identified to make up suitability or value of land is a fundamental concern that some of the methodologies fail to acknowledge. The combinatorial methods and methods utilising rules of combination perhaps best manage to address data interdependence, although the assumption is that experts recognize inherent spatial correlations, and that they adjust for this when assigning weights or designing combination rules.

Some techniques challenge or blatantly violate mathematical or statistical assumptions. Especially the summation and multiplication of ordinal data in straight-forward and weighted overlay analyses is troubling.

Some techniques are conceptually and computationally easy to understand and perform, while others reach levels of complexity beyond most decision makers and stakeholders participating in land valuation exercises. The Gestalt method, as well as the ordinal and linear combination techniques, perhaps are the easiest to understand and implement. Factor combination and rules of combination add complexity but remain within most people's conceptual grasp. Economic valuation techniques are straight forward to follow. Outranking, fuzzy processing and Bayesian modelling introduce mathematical complexities and computational requirements that move these techniques quickly into the domain of research laboratories. Their use by public participatory land suitability and land valuation exercises should be cautioned against.

Expert knowledge and expert input are required in most if not all techniques. Those techniques identified as conceptually and computationally straight forward require less expert knowledge than those noted to be more mathematically and computationally challenging. The outset of the chapter differentiated between an expert paradigm and the psychophysical paradigm to land valuation. The former suits mathematically complex and computationally demanding techniques, including Bayesian modelling, fuzzy processing and neural network analysis. Outranking, rules of combination, factor combination, ordinal and linear combination, economic valuation and the Gestalt method can more easily facilitate the psychophysical paradigm.

The point has been argued that such a system should take advantage of the latest developments in GIS and SDSS, and that the system should facilitate stakeholder input or be stakeholder driven. Solutions must be easy to understand and interact with to allow non-computer and non-mathematically literate stakeholders opportunity to participate in the process. At the same time, solution procedures must be scientifically valid and robust. Conceptual and computational complexity rules out fuzzy processing, Bayesian modelling and neural networks.

All things considered, the Gestalt method is the technique easiest to understand and least data intensive. It easily facilitates the psychophysical paradigm. Its importance in landscape valuation therefore should not be ignored and it ought to be part of any methodology developed here. However, this method suffers from subjectivity and lack of repeatability. The Gestalt method therefore ought to be complemented by other methods that offer repeatability, robustness and scientific objectivity.

Complementary techniques should facilitate gaining insight into what key variables of land or landscape are argued to dominate suitability or value, and their relative importance. Such a step can easily be facilitated by incorporating the outranking technique.

The need to conduct elaborate field mapping or remote sensed data processing exercises to create actual data layers for variables identified to contribute to value should be avoided if at all possible given associated time, efforts and costs. Techniques that require layers of geographic data to be combined by ordinal or linear combination, factor combination or rules of combination ought therefore to be avoided. A second reason for rejecting ordinal and linear combination of layers also is that these techniques violate a key mathematical assumption (summation, and in the latter case also multiplication of ordinal data).

Willingness to pay and/or history of actual financial transactions can add considerable additional insights into any valuation exercise. Economic valuation techniques therefore should round out an overall methodology.

2.7 Experimental Research Design

This chapter has made the case for a collaborative and inclusive land valuation system that facilitates stakeholder input by a combination of the Gestalt method and economic valuation. The manner these aims were operationalised is presented in the following flow diagram (Figure 2.7). This figure illustrates the scope and development of the three experiments carried out. It is important to state that the overall experimental design was

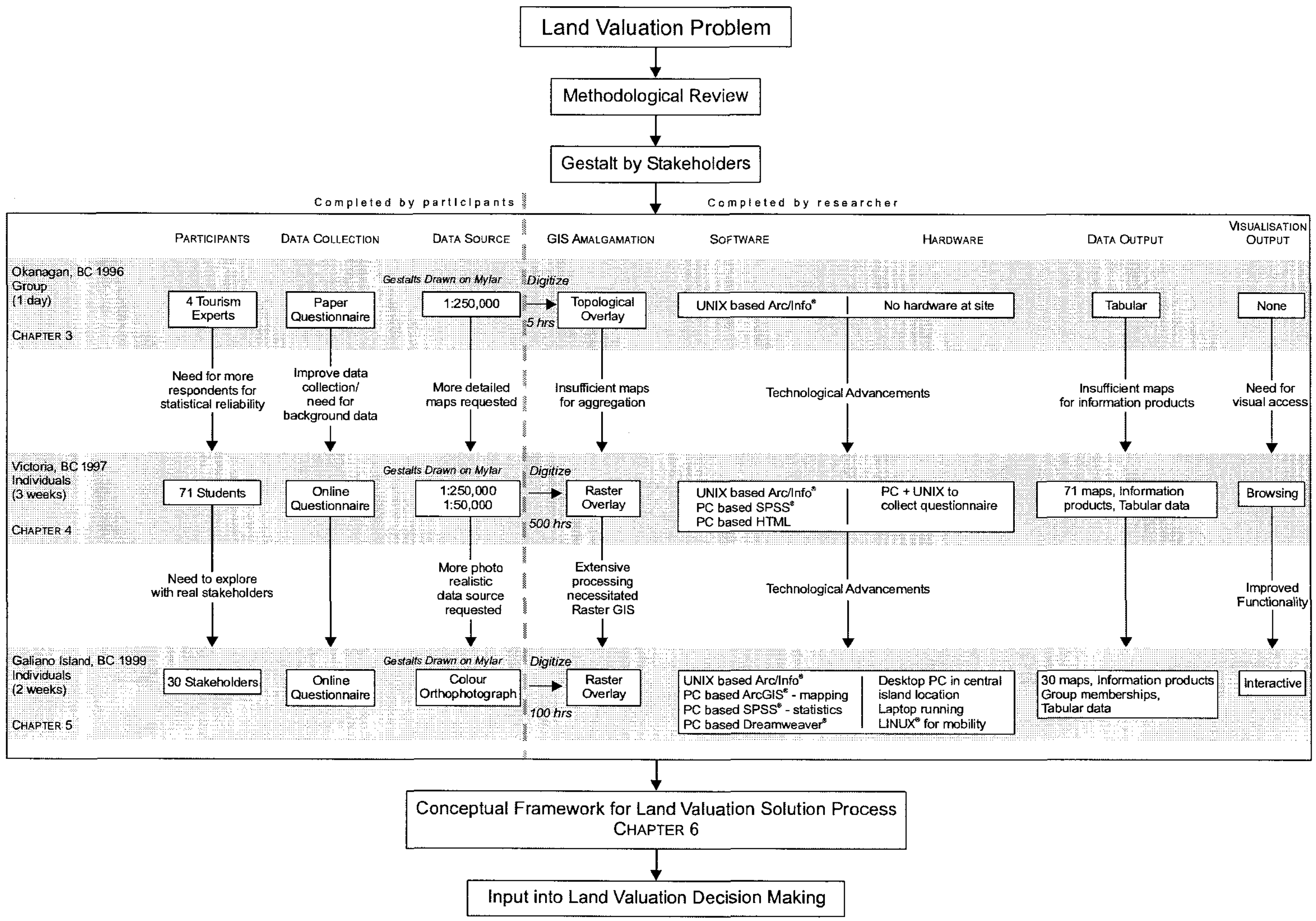


Figure 2.7 Experimental research design

exploratory in nature. Whilst the overall aims remained fixed, the manner in which it was achieved was adaptable. This flexibility took into account knowledge learnt from previous experiments, the changing technology available, and the different needs of each group of subjects. At each stage the experiments methods, achievements and limitations were examined and refined for the following one. The details of these experiments, methodological changes and approaches are examined within the following chapters. The remainder of this thesis introduces efforts undertaken towards the development and evaluation of a collaborative land valuation system taking advantage of advances in GIS, SDSS and CSDSS technologies.

3. Experiment One – Tourism Industry Experts

3.1 Introduction

An opportunity arose at short notice to carry out an experiment on land valuation and data collection for economic valuation as part of a larger collaborative project undertaken between the Department of Geography at the University of Victoria and the Inventory and Resource Planning Unit of the Province of British Columbia's then Ministry of Small Business, Tourism and Culture. The larger project dealt with data capture and evaluation for a long-term land use planning study in the Okanagan Region of South Central British Columbia. A meeting was planned in the study area between the study team and local tourism and outdoor recreation experts. Twelve experts had been invited, including representatives from the hotel industry, the outdoor recreation industry, and regional planning groups. It was agreed that part of the meeting could be used to test methodologies to be developed for the research presented in this thesis. Time did not allow for development or testing of GIS, SDSS or CSDSS capabilities. The experiment therefore was strictly a "test of concept" of a potential data collection exercise. A round-table discussion was initiated after each data collection step offering participants an opportunity to comment on what had been done. Presented in this Chapter are summaries of the undertaken procedures as well as a discussion of findings and results obtained. The Chapter concludes by summarizing lessons learned from this experiment.

3.2 Mapping Exercise

3.2.1 Experiment and Results

One part of the experiment was to test if experts could identify homogenous regions of land value from a topographic map, and if they could assign ordinal or cardinal value to these units. The larger project mentioned above concerned itself with a small scale land use planning exercise covering a large geographical region that spanned a number of 1:250,000 topographic maps. The decision was made, therefore, to run the experiment on a small scale problem covering a large area, using a single 1:250,000 map sheet. The experiment proceeded as follows:

All experts were asked about familiarity with topographic maps. All claimed to have considerable familiarity and expertise with them. The experts worked in the same room and each expert was given identical instructions. Each expert was asked to take some time to examine a copy the 1:250,000 topographic map that covers Penticton, and surrounding area (82e)(Figure 3.1). For each expert, the map was then overlaid with transparent mylar. Each participant next was asked to divide the entire topographic map area into regions of homogeneous value for the purpose of tourism and outdoor recreation. To complete this exercise, each individual was given four coloured pencils representing four different value classes (1= 'Low Value', 2= 'Medium Value', 3= 'High Value' and 4= 'Exceptional Value'). A four-class division was deemed sufficiently detailed to capture variation in value without becoming overly complex to the point of creating confusion between categories. The end-product of this exercise was a set of 5 mylar sheets showing colour coded polygons of perceived equal land value. Examples of these maps can be viewed on the research project's website at http://www.geog.uvic.ca/gestalt/gestalt.htm.

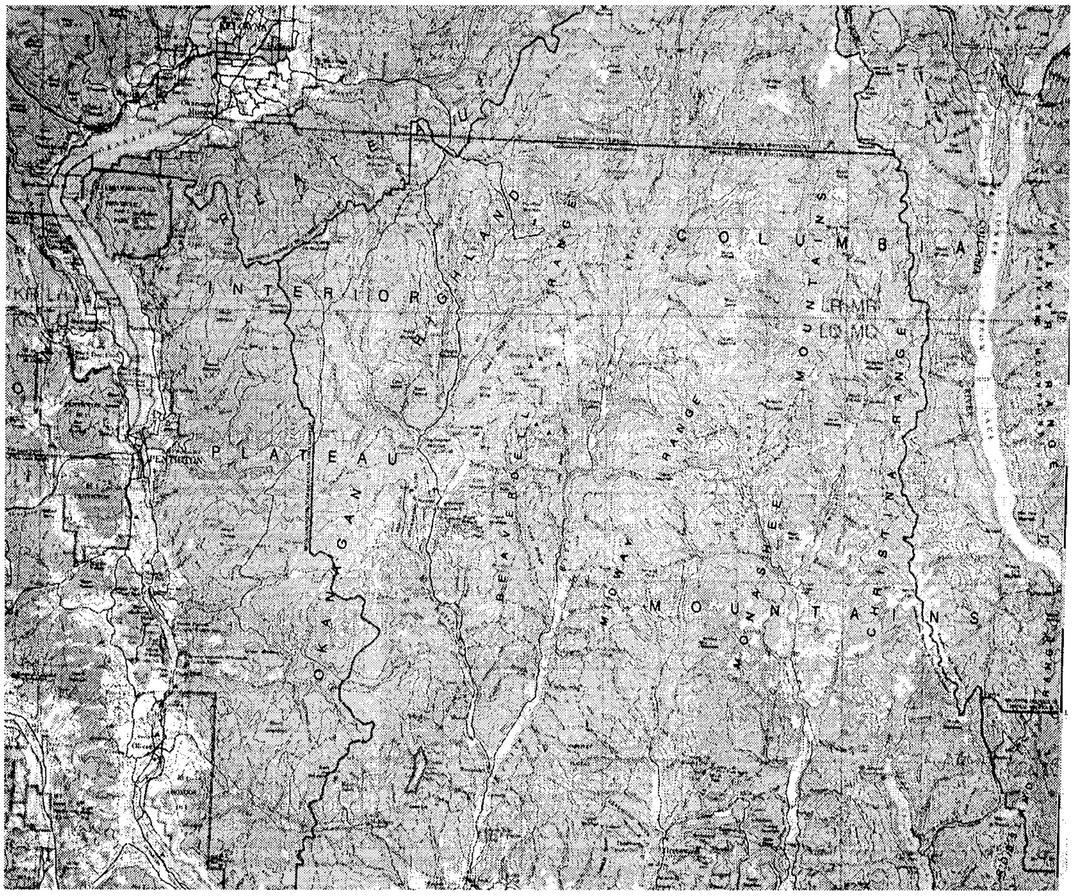


Figure 3.1 Topographic map of Penticton 82E, 1:250,000

The second component of the valuation methodology was the assignment of economic values by the experts to the different parcels. Each stakeholder was presented with a table (Table 3.1) and instructed to fill in value ranges for each category based on purchase price and lease price (per hectare) for the valuation categories they employed in the mapping exercise.

	Not Interested		**Low Value**		**Medium Value**		**High Value**		**Outstanding Value**	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
Purchase Price	$	$	$	$	$	$	$	$	$	$
Lease Price	$	$	$	$	$	$	$	$	$	$

Table 3.1 Stakeholder value form

Initial plans were to have 12 local experts participate. This number of participants would have provided a sample sufficiently large to allow for meaningful and scientifically defendable conclusions to be drawn. Unfortunately, for reasons beyond the control of this research project, only four local experts turned up to participate on the day. These local experts were all members of the local tourism industry. This is a group that may be described as broadly similar but represents only a small component of potential stakeholders. An academic tourism expert with considerable background in community tourism and some familiarity with the region was a fifth participant in the study. A total of five subjects therefore ended up participating in the exercise and discussions. However, the results from only the four local experts are reported since the fifth person had prior insights into the research design and research goals.

One variable tested was the time taken to complete the map exercise. A data capture system that takes too much time will lose participants' interest and impact upon data quality. Timing is also important in that the times taken to finish a task can illustrate to the researcher the complexity of the exercise undertaken. All of the experts were able to complete the mapping component successfully. Table 3.2 shows the times required by the four experts to complete the task. Results suggest that experts can complete this type of map exercise in a reasonable amount of time without loss of concentration or "good will". Experts did not spend their entire time on drawing parcels. Much of the work was completed within the first few minutes, with the remainder of the time spent on small details and checking their work.

	Start Time	**Finish Time**	**Time Taken**
Expert 1	1.13	1.39	26 Mins
Expert 2	1.13	1.24	11 Mins
Expert 3	1.13	1.38	25 Mins
Expert 4	1.13	1.34	21 Mins

Table 3.2 Time taken on mapping exercise

3.2.2 Experts' Discussion

Experts were observed closely as they completed the mapping exercise. The manner and sequence in which they completed the exercise yielded some interesting results. A number of patterns could be observed. All experts started drawing homogenous regions outwards from the town of Vernon, one of the larger settlements shown on the map. From there they moved outwards onto the lakes, waterways and road network. In terms of valuation categories, all experts started on "outstanding" and moved onto "high". This part of the exercise was completed relatively quickly, suggesting that these areas are the most straightforward to value. Two of the experts then worked with the lowest value. The other two worked down the value scale. Disagreement was found with respect to complete map coverage. One expert covered the entire study area with polygons. Two experts left some areas as blank. The fourth expert left a considerable part of the study area blank. The issue of areas left blank was brought up during the discussion (see below)

Explicit instructions were given to make sure that all homogenous regions were to be drawn as closed polygons. One expert, the same one who left large parts of the map as blank, struggled with this part of the instructions. This expert, who spent the least amount of time on the exercise, also was the one needing the greatest explanation about the topographic map. It may be surmised that this expert, in actual fact, had little familiarity with topographic maps.

Once the exercise was completed a round table discussion was initiated. During this discussion the experts were asked to discuss what they had just completed, bearing in mind the meaningfulness of the exercise as well as how challenging it was. They all agreed that the exercise was meaningful and important especially for regional scale planning applications. They were concerned, however, about the validity and reliability of the exercise. One expert at this stage admitted unfamiliarity with topographic maps. The main area of concern discussed was the scale at which they were asked to complete the map. All of the experts felt that 1:250,000 was too small a scale for this exercise, and that the area presented included too much land. They noted that they were unfamiliar with large tracts of land and felt that this influenced their final parcels. It was suggested that larger scale maps covering less area should be used, and that each expert should be allowed to focus in on areas they were directly familiar with.

A discussion arose over areas left blank. It was agreed that areas left blank presented areas of "no perceived interest" for tourism and outdoor recreation. One expert expressed strong opinion that all land had some tourism and outdoor recreation value while the other three were happy to leave areas on the map as "not interested".

3.3 Consensus and Divergence

The experts' divisions of the study area were analyzed in more detail back at the University of Victoria after the meeting. The mylar maps for digitized and entered into a GIS. Each mylar sheet was digitized as a separate coverage. Table 3.3 shows into how many polygons the four experts divided the study area. Once all maps had been topologically cleaned (ensuring closure of all polygons) they were overlaid to produce a single composite topological overlay map. This composite map enabled levels of consensus and divergence to be investigated. The single composite map yielded a total of 244 valuation parcels. The average area for each parcel was 6269 ha., with a range in size from 5.1 ha to 21585.2 ha..

Expert 1	22 polygons
Expert 2	21 polygons
Expert 3	28 polygons
Expert 4	21 polygons

Table 3.3 Initial number of polygons

Topological overlay retains all information from each of the source maps. The valuation categories for each of the 244 parcels therefore could be added together, assigning each parcel a relative rank (blank areas were assigned an ordinal value of '0'). The validity of this step can be questioned given that addition of ordinal data violates mathematical assumptions. However, such a procedure is common practice and was thought to yield interesting insights. Figure 3.2 shows the distribution of resultant value scores for all 244 parcels.

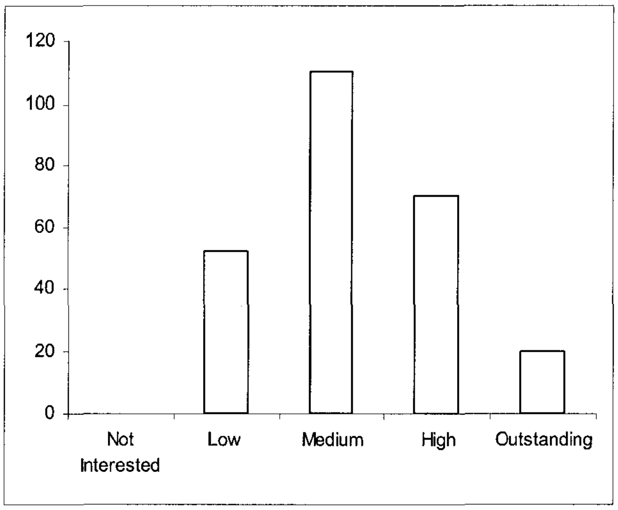


Figure 3.2 Distribution of value categories

In order to seek some measure of consensus, ordinal values assigned to each of the 244 parcels by each of the four experts thereafter were pair-wise compared for consistency. Table 3.4 shows the results. The bottom left half of the matrix shows the percentage of times two experts ranked polygons the same value. The shaded top right half of the matrix shows the percentage of times two experts ranked the same polygon within one ordinal class of each other. Examination of information for Expert 1 and Expert 2 reveals that they agreed in 26.56 % of all cases, that they were within one ordinal rank of agreement for another 60.31% of the cases. This allows one to calculate that they disagreed by more than one ordinal class rank for 13.13 % of all cases.

	Expert 1	Expert 2	Expert 3	Expert 4
Expert 1		60.31	13.82	85.54
Expert 2	26.56		63.05	68.9
Expert 3	2.23	30.38		22.28
Expert 4	72.56	28.3	3.71	

Non-shaded = Agreement of Valuation Category
Shaded cells = Agreement of Valuation Category (+/- 1)

Table 3.4 Agreement between experts' valuation categories (Percent Area)

Comparing the ranks of all four experts showed that only 0.45% of the total area of the map was ranked identical by all four experts, and that 12.98 % of all the land was ranked by all four experts within one ordinal class of difference.

Given that only four experts completed the exercise, it is difficult to draw meaningful conclusions from the above findings. The data does suggest that the four experts did not show a high degree of consensus. When pair-wise compared, Expert 2 and Expert 4 do have a reasonably high level of consensus, whilst Expert 1 and Expert 3 disagree the most. Given the small number of participants, privacy concerns preclude the reporting of why Experts 2 and 4 ranked polygons similar, and why Experts 1 and 3 may have represented unique views. It should suffice to note that there were logical reasons to help explain the differences in behaviour. However, it is recognized that the data suggest large variations to be present between the experts, bringing into question the validity of this methodology as a tool for consensus building without allowing for further interaction with the data taking advantage of SDSS or CSDSS. This point will be elaborated upon later in Chapter 4.

3.4 Economic Valuation Exercise

3.4.1 Exercise and Results

Once the mapping exercise was completed, experts were instructed to move on to the economic valuation exercise. Again, the experts were timed (Table 3.5.) Experts appeared to have no problems understanding or completing this part of the survey, completing the task in quick time. It is important to note, however, that experts were asked to keep in mind economic valuations when they were carrying out the initial mapping exercise.

	Time Taken
Expert 1	10 Minutes
Expert 2	6 Minutes
Expert 3	2 Minutes
Expert 4	9 Minutes

Table 3.5 Time taken to complete valuation exercise.

Table 3.6 represents the range of values that the experts entered for parcels identified using perceived purchase price. The table illustrates that there is little agreement on dollar amounts. Given the small sample of subjects and wide range of values quoted, it was not thought appropriate to compute summary statistics beyond a simple mean. Examination of mean value will show that, for example for "Outstanding Value", the average of $95,288 is a value that is not included in one of the experts range, and at the very top of two others.

	Not Interested	Low Value	Medium Value	High Value	Outstanding Value
Expert1	$0 - $0	$100 - $5,000	$10,000- $55,000	$ 65,000- $150,000	$200,000- $350,000
Expert2	$0 - $0	$1,000 - $5,000	$5,000 - $7,500	$7,500 - $10,000	$10,000 - $100,000
Expert3	$0 - $0	$1 - $5	$5 - $8	$9 - $1,000	$1,000 - $100,000
Expert4	$0 - $10	$11 - $50	$51 - $200	$201 - $500	$501 - $800
Mean	$1.3	$1396	$9721	$29,276	$95,288

Table 3.6 Experts' value ranges for purchase price.

Land may be leased as well as purchased. Experts therefore also were asked to suggest lease values (Table 3.7). One of the experts did not fill in this section citing that it was too problematic, an observation discussed further on. Table 3.7 still shows considerable differences between the remaining three experts, although not as great as for purchase price.

	Not Interested		Low Value		Medium Value		High Value		Outstanding Value	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Expert1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Expert2	$0	$0	$100	$250	$250	$400	$400	$500	$500	$2000
Expert3	$0	$0	$1	$2	$3	$5	$6	$500	$500	$10000
Expert4	$0	$0	$0	$5	$5	$10	$10	$20	$20	$50
Mean	$0	$0	$33.66	$85.66	$86	$138.66	$138.33	$340	$340	$4016.66

Table 3.7 Experts' value ranges for lease price.

3.4.2 Experts' Discussion

Experts saw value in this part of the survey but expressed difficulty completing the tasks. One expert got sufficiently frustrated not to complete part two of this exercise. Scale again was mentioned as problematic. A scale of 1:250,000 was thought to be too small to allow for meaningful declaration of lease or market values. Experts also had difficulty translating in their own minds between a per hectare price versus lot prices. Experts had familiarity with what properties were sold or leased for, but translating these values into value / hectare to apply to larger regions took them into uncharted terrain. Debate also arose whether the question should ask about value / hectare or value per average lot size. There was indecision as to which would be more appropriate.

Experts also noted that lease price and purchase price was something that the market decided, based upon what land was available, what had sold or leased in the past, and what the tenure characteristics were. Experts concluded that their economic valuations were at best "guesstimates".

The term 'value' also caused problems. One expert wanted to know whether it was present value, potential value or real-estate value. The example cited was that some land now is valueless for tourism activities, but that with changed behaviour patterns or technological advancement, it may become highly valuable in the future.

Finally, experts raised the issue of the sectoral component of tourism, stating that the same homogeneous parcel may have substantially differing value based upon which type of tourism activity was taking place, and that these values may occur at the same time. The example raised was "value of remote wilderness". It was noted that to some tourism and outdoor recreation sectors "remote wilderness" has no value due to the fact you can not get to it or use it. Other sectors, such as ecotourism, on the other hand, may value this land as priceless. Experts concluded that their economic valuation had little or no relevance, and that they may give widely different answers if asked to repeat the exercise another day.

3.5 Lessons Learned

Experts found the data capture methodology for the mapping exercise to be of value and useful at a regional scale. They liked the overall process. However, the suggestion was put forward that a scale of 1:50,000 or 1:20,000 would be far more appropriate. It was recognized that a map scale of 1:250,000 was useful to get a broad impression and overview of a large area efficiently, but that the added detail offered by larger scale maps was necessary to complete the mapping exercise more meaningfully. The economic valuation exercise was rejected as having little or no meaning.

Experts at the table questioned whether they really were the 'experts' that should have been consulted. Beyond a doubt, the individuals that came to the table were recognized leading authorities in tourism and outdoor recreation in the region. This was confirmed by discussion with other local groups. Having questioned their own expertise, the experts at the table were asked to comment on who they thought the 'real experts' were. They had no answer to this question and came around to recognizing that they were, indeed, the appropriate experts to consult with.

The experts that came to the table thereafter questioned whether the use of experts was the most appropriate way to proceed. They pointed out that local experts each would have their own agendas when carrying out the exercise, and that this would introduce bias. When informed that it was important to identify these biases, and to bring them to the table for discussion as part of a consensus building process, they agreed.

In the end, the conclusion was that individuals with expertise or local knowledge should be the ones consulted as part of a valuation process, and that part of the valuation exercise should be to explore biases and to negotiate agreement and differences of value at the consensus building table.

When probed about reliability and replicability of the mapping exercise, experts noted that it would be difficult for them to guarantee that they would produce a similar map at a later date, but that this was primarily because of the small scale.

Based on observations of the data collection exercises, on analysis of results obtained, and what was learned from discussion with the experts, a number of key points emerged that needed to be addressed in the next stage of developing a collaborative spatial decision support system for land valuation. They are as follows:

3.5.1 Sample size

A larger sample size would be needed to conduct more meaningful evaluation of procedures and to conduct statistical analyses of results obtained.

3.5.2 Scale

While experts were comfortable with the map as an abstraction of reality to work with, the Gestalt method needs to be evaluated using a larger mapping scale.

3.5.3 Aggregation methods

The topological overlay procedure employed for this study yielded very useful information. However, four experts already created in excess of 200 resultant polygons in the overlay process, with quite a number of these polygons so small as to be meaningless at the scale of analysis. If the exercise is to be repeated for a larger sample of subjects, a more efficient method of aggregating individual responses needs to be developed.

3.5.4 Bias and Divergence

Bias and disagreement should be recognized and information products need to be generated to highlight bias, consensus and divergence. A focus of the CSDSS should be to develop a tool that helps people recognize divergence and consensus

3.5.5 Explanation of Underlying Dimensions

The Gestalt exercise did not yield any insights into why experts valued some part of the map more than others. Whilst the importance of homogeneous regions is acknowledged, the question raised is what makes regions homogenous, and what variables or attributes lead to final value judgements. A CSDSS should seek to get at these underlying dimensions.

3.6 Summary

This chapter has outlined a experimental investigation into both the Gestalt technique for land valuation as well as an experiment with data collection for economic valuation as part of a larger collaborative project. Results from this chapter were presented and published at *GIS 97* (Whyte et al, 1997). This experiment confirmed the potential value of the Gestalt method for land valuation as well as yielding methodological insights that were employed and developed upon in the design of a second study reported in the following chapter.

4. Experiment Two: Development and Assessment

4.1 Introduction

This Chapter reports a second experiment undertaken to refine the Gestalt data collection technique as well as to develop and test decision support tools to facilitate collaborative land valuation. The Chapter commences with a critical second review of the appropriateness of the Gestalt data collection technique. It moves on to explain how a sample of university undergraduate students was used to collect a sufficient number of Gestalt evaluations to test this data capture methodology further, and to allow for development and evaluation of data visualization and data aggregation techniques designed to facilitate response comparison and collaborative land valuation to seek consensus. The next section introduces data visualization and data aggregation modules designed, testing and evaluating each one using the data collected. This is followed by a section that explores how land valuations by the response sample compares to actual attribution on the ground. This step was undertaken to seek insight into what determined individual valuation judgements, to further facilitate negotiation of consensus value. The chapter concludes with a discussion and summary of insights gained and lessons learned. The contents of this Chapter are summarized in an article by O'Connell and Keller in the Journal *Environment and Planning B* (2002).

4.2 Second Look at the Gestalt Methodology

Chapter Two introduced and justified the value of the Gestalt technique. Chapter Three reported a small experiment undertaken to evaluate whether topographic maps could be used to facilitate land valuation by this technique. The small sample of subjects was generally positive about the use of maps, but did raise questions about possible alternative sources of data for division of land into homogenous regions. The question of most suitable map scale also was raised. These findings led to the perceived need for a second critical review of suitability of topographic maps.

In an ideal situation, stakeholders should conduct fieldwork to identify and report what they perceive to be homogeneous units in the landscape. Findings from their fieldwork could be mapped. In reality, operating budgets rarely exist to support the required fieldwork. The geographical areas under consideration often are too large to be visited by all stakeholders in reasonable time, and the land may be too difficult to access and traverse.

What is required, therefore, is a model of the landscape that can be considered in a consistent manner by all stakeholders within a reasonable operating budget and within a reasonable timeframe. Different options exist: the landscape can be covered photographically or by a remote sensing technique; an analog or digital scale-reduced three dimensional model of the landscape can be build; or the topographic map can be accepted as a scale-reduced generalised abstracted model of reality.

The option of a photographic or other remote sensed coverage can be rejected for a number of reasons. Photographs taken on the ground contain considerable bias imposed by the type of film and lens used, as well as the nature of enlargement and display. Additional bias is imposed by the time of year and day, weather, as well as locations from which the photographs are taken. There are considerable costs associated with obtaining a reasonably detailed photographic coverage of an area, and considerable logistical problems would have to be overcome to present a large set of photographs in a consistent and meaningful manner to the stakeholders. An alternative is photographs or other imagery taken vertically above the ground from the air. The technology exists to produce consistent quality aerial photographic or remote sensed coverage of an area that can be rectified and turned into an orthophotomap. Such a view of the land, however, is artificial since people rarely experience landscape from a vertical vantage point, and seasonality remains problematic.

The option existed to construct an analogue or digital 3D model of the landscape. Kingston, et al. (1999) employed the construction of a 3D analogue model of the West Yorkshire Village of Slaithwaite as part of a public participation and GIS project. Landscape architects frequently use 3D analogue models to communicate their design ideas. The use of computer 3D landscape visualization has flourished more recently, particularly for visual impacts of potential changes in the landscape. Examples in forest landscape preference applications are presented by Karjalainen and Tyrväinen (2002). There also are studies involving the 3D presentation of vegetation (Muhar, 2001). Considerable advances are being made in recent years towards generation of sophisticated virtual 3D digital models of the landscape (Lim and Honjo, 2003) and the ability to simulate flights or walks through these 3D digital models (Karjalainen and Tyrväinen, 2002).

However, Bishop et al. (2001: 116) argue that "virtual environments are not yet of sufficient realism to be considered a surrogate for the real world." The design of such 3D models in either analogue or digital format continues to require considerable generalization and abstraction for which there do not exist established, consistent and easily understood rules. Lack of consistency, comparability, and bias therefore pose problems. There also are design and interpretation issues with the dynamic nature of the landscape that these models can produce (Ervin, 2001). Sheppard (2001) argues that there is a need to develop accepted and formalised procedures to use computer visualisations of the landscape. He calls for a code of ethics in order to improve "scientific validity in the use of these systems" (Sheppard, 2001: 183). To date, the necessary rules do not exist to produce such models in a consistent and unbiased manner. Imagination and tools available to the creator of the model therefore may impose biases that may determine the outcome of the exercise. At the outset of the research the use of a digital 3D model was rejected based upon the prohibitive costs, logistics, and construction time. It is interesting to note that the usefulness of these new technologies is still the matter of debate for landscape preference studies, as evidenced in the Karjalainen and Tyrväinen (2002: 15) statement:

> "the efficiency, usefulness and validity of various visualization systems in landscape preference research are inadequately known. Empirical research on human reactions to different kinds of illustrations and on the suitability of these illustrations to preference studies is limited."

This leaves the topographic map as a generalised and abstracted model of reality. The advantages of the topographic map are as follows: Firstly, topographic maps have been around for a long time. Secondly, the design and production of these maps have been formalised and they are designed and produced to rigorous and consistent standards. Thirdly, topographic maps are relatively cheap to purchase. Finally, they can be displayed with little effort and in a consistent manner. There also are disadvantages. Firstly, topographic maps are a generalised model of land communicated on a two dimensional medium, and they visualise land as seen from directly above. Secondly, it cannot be assumed that all stakeholders have the same training in and experience with topographic map reading. Thirdly, topographic maps come at fixed scales that may not be ideal for the geographical area under consideration. Finally, topographic maps are social constructions that contain considerable cultural bias and silences, and therefore are not value neutral generalisations of reality (Harley, 1990).

Weighing issues of suitability, logistics, finance and time, the topographic map again remained as the most realistic choice to use as a generalised and abstracted model of reality. This leaves the question of an appropriate scale to work with. Scale determines the trade-off between the amount of detail that can be shown and the amount of area that can be covered for an equivalent size map sheet, with large-scale maps showing more detail but less geographical coverage.

The goal is to develop a methodology to facilitate consensus building in land valuation for reasonably large geographical areas. A map scale therefore must be found capable of covering the geographical region under consideration in a reasonably efficient manner without losing too much detail. For the experiment, a map scale of 1:250,000 was ideally suited to cover the study area under consideration in one map sheet. Subjects participating in the initial experiment commented however that this scale was perhaps too small. The next available larger scale for this region is at 1:50,000. A decision was made, therefore, to ask subjects participating in a second experiment to conduct the Gestalt evaluation twice, once each for the 1:250,000 and the 1:50,000 scale coverage. For convenience sake, one scale was nested inside the other. Asking subjects to repeat the exercise using two scales was done to give them opportunity to compare experiences.

4.3 Second Experiment: Response Sample and Data Collection

Ideally, testing the revised methodology should have involved research subjects representing stakeholders with a common interest in the outcome of a real world land valuation process. Realistically, however, the primary goals of this testing of the methodology were to focus on the process of data collection and subsequent data processing steps and, given the preliminary nature of the experimentation, a real-world land valuation scenario was not thought appropriate. A decision was made, therefore, to test the methodology using undergraduate university students in a 3rd year Resource Management course. The fact that these subjects would not represent true stakeholders in a valuation exercise, nor necessarily all be directly familiar with the study area was not considered problematic. As it turns out, 89% of the students who participated had visited the study area, with 73% claiming good familiarity with the region.

Students were given a brief introduction to the research project at the end of a regular class. They were given the choice to participate in the research project in their own time outside regular class. Those wishing to participate were scheduled to complete the exercise at a time convenient to them during a two-week period. 71 students agree to participate.

The first step in the methodology was similar to the original Okanagan study reported in Chapter Three, although the instructions were changed to be more specific. Each student was asked to examine a copy each of both, the original 1:250,000 (82e) and a more detailed 1:50,000 (82e12) topographic maps. For each subject, the two maps were then overlaid with transparent mylar. Given identical instructions, each was next asked to divide the entire topographic map area into regions of homogeneous value for the purpose of outdoor recreation. To complete this exercise, subjects were supplied with four coloured pencils representing four different value classes (1= 'Low Value', 2= 'Medium Value', 3= 'High Value' and 4= 'Exceptional Value'). This time, subjects were given explicit instructions to cover the entire map sheet with polygons. Again, a four-class division was deemed sufficiently detailed to capture variation in value without becoming overly complex to the point of creating confusion between categories. The end-products of this exercise were two sets of 71 mylar sheets showing colour coded polygons of perceived equal land value. Figures 4.1a and b represent examples of these maps.

Having completed the exercise, subjects were asked to complete a short survey where they were given an opportunity to comment on what they had been asked to do. The survey also requested background information about the students, their familiarity with the study area, and their familiarity with topographic maps. A copy of the Survey can be found in Appendix 2.

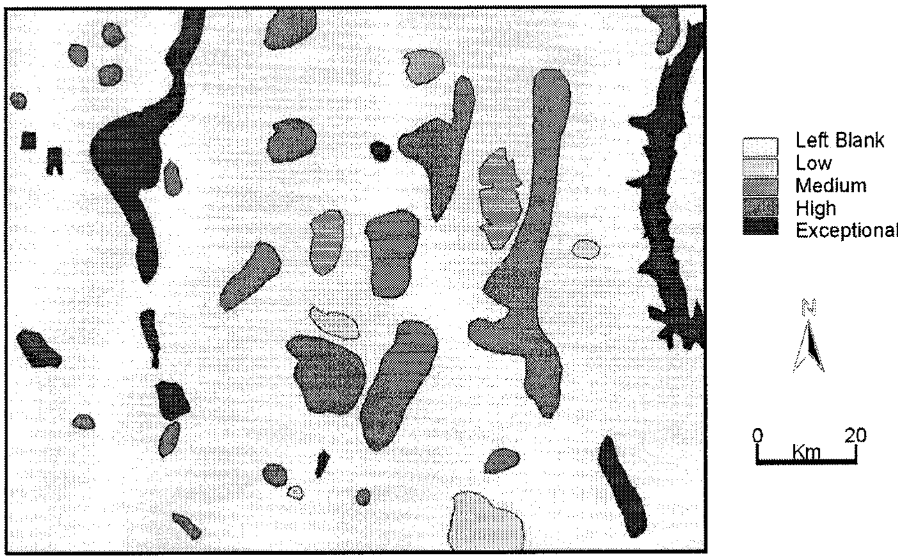


Figure 4.1a Example of colour coded polygons of perceived equal land value - 1:250,000

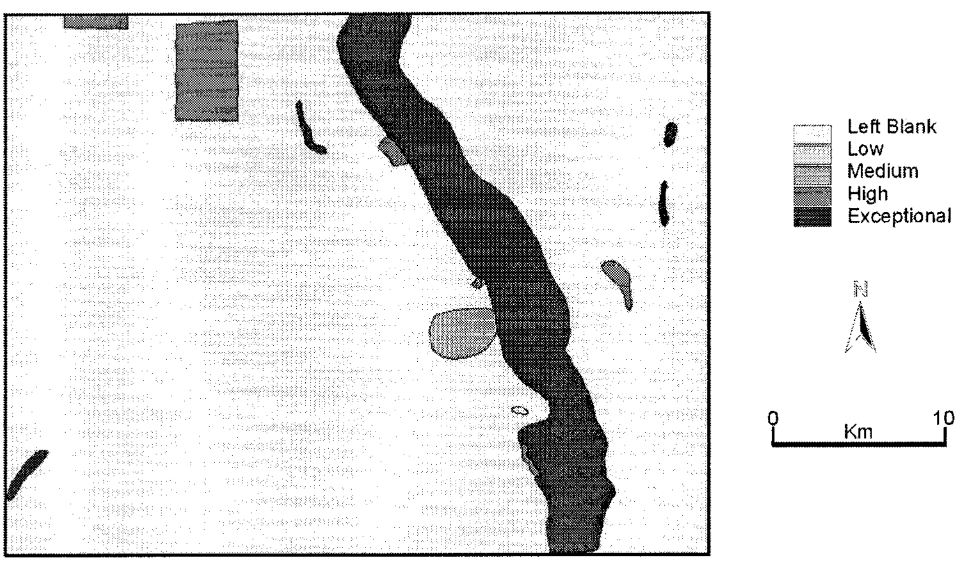


Figure 4.1b Example of colour coded polygons of perceived equal land value - 1:50,000

The subjects reported no problem understanding the exercise. Nobody commented on difficulties understanding the instructions or following procedure. All but one subject noted little difficulty using topographic maps to understand the landscape to be judged, and all were able to complete the exercise. The exercise was found to be instructive, useful and/or valuable by 43% of the students.

It is recognised that general map literacy, and topographic map literacy in specific, cannot always be assumed. The fact that none of the subjects commented on unfamiliarity with topographic maps, and that all but one felt comfortable working with this communication medium, is most likely due to the fact that students with an academic specialisation in Geography or Environmental Studies were employed as a test case. One subject did express concern about personal map literacy despite familiarity with the concept of topographic maps. It is concluded that stakeholders should be questioned about map literacy, and that those unfamiliar with topographic maps or uncomfortable with map reading skills should not be required to judge land using this medium.

Subjects were offered the opportunity to have their maps withdrawn from subsequent analysis if they felt that their value judgement was meaningless. None availed of this opportunity.

Overall, most subjects preferred working with the 1:50,000 scale (57.7%), citing additional detail shown (less generalisation) as the reason. They also commented that the 1:50,000 map provided more information about outdoor recreation activities, and showed more road detail gaining better understanding of "access". Some subjects (11.3%) expressed reservation that the 1:250,000 map was too generalised to be meaningful.

A number of subjects commented that they especially liked that some of the outdoor recreation activities were explicitly shown on the maps (i.e. ski hills, provincial parks, camping grounds) noting that this aided their valuations. This raises an interesting question, namely to what a degree does specific information presented on a topographic map bias the personal valuation process? A hypothesis worthwhile testing is that the more familiar the subject is with the study area, the less will the specific detail reported on the topographic map bias value judgements. Testing such a hypothesis was not part of this thesis but merits investigation.

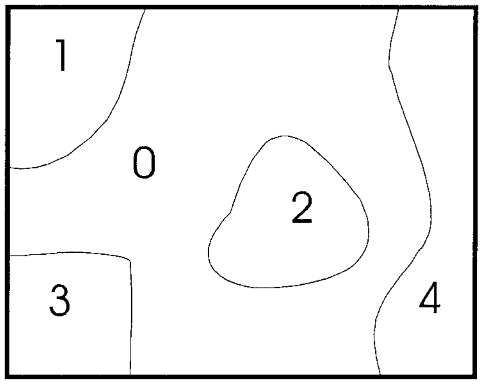
Subjects were asked to comment whether access to other information sources, for example aerial photographs or orthophotomaps, would help the land valuation exercise. They saw no harm in this additional information source, and quite a number (56.3%) suggested more visually realistic sources should have been used instead of topographic maps. Given the positive response, it is recognized that additional research should explore substitution of topographic maps with orthophotomaps. Such a substitution is presented in Chapter Five.

It can be concluded that, overall, subjects were positive and responsive to the methodology, and that they felt that this approach to data collection to obtain homogeneous parcels of land value has merit. This mirrors the original study reported in Chapter Three, with a much larger number expressing the same view.

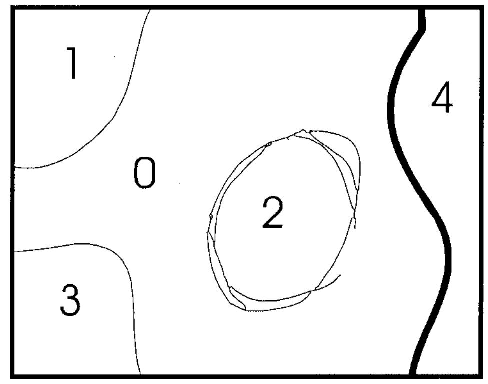
4.4 Data Processing

In order to conduct analysis of responses and to allow for generation of information products to facilitate consensus building, all 142 mylar overlays again needed to be digitized. This was undertaken by the researcher using Unix-based ARC/INFO software. A number of interesting problems had to be addressed in the process of digitizing (Figure 4.2).

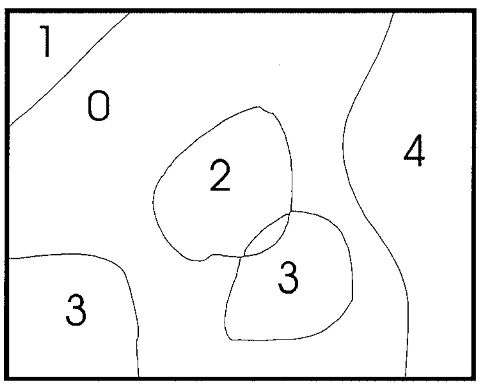
Firstly, despite the fact that subjects were asked to cover the entire map sheet with polygons, all the subjects left areas blank. This replicated what happened in the original study. Why did the subjects choose to leave areas blank despite contrary instructions? Shortage of time was not an explanation since subjects were not given a time limit to complete the exercise. The survey accompanying the map division exercise asked subjects to comment on the exercise. None of the subjects comment on the "areas left blank" issue, and none commented on "too little time". Therefore one can only speculate that subjects must have associated areas left blank in a unique manner. The most intuitive explanation is that they did not perceive these areas to have any value for outdoor recreation, or that these areas were of "no interest". For digitizing purposes areas that were left blank were coded as ordinal class '0' and recorded as "Left Blank".



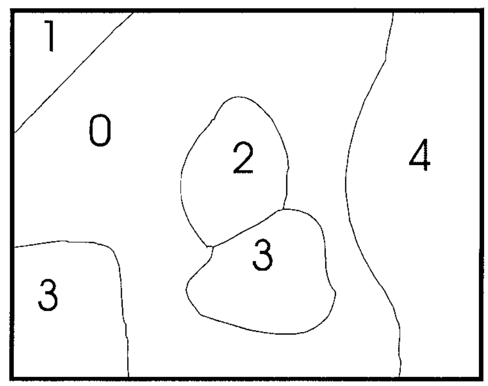
Scenario a Thin and consistent polygon boundaries



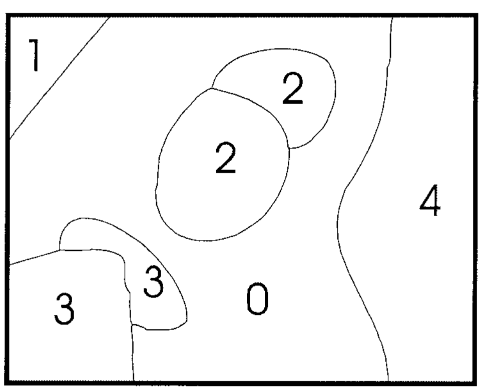
Scenario b Thick and overlapping boundaries



Scenario c Slivers



Scenario d Digitize along centre/average of disputed area



Scenario e Adjoining polygons

Legend

4 : Excellent Value
3 : High Value
2 : Medium Value
1 : Low Value
0 : Left Blank

Figure 4.2 Digitizing scenarios

Secondly, while some subjects were very careful to draw thin and consistent polygon boundaries, others sketched polygonal boundaries sometimes with thick and in some cases overlapping strokes (Figure 4.2, Scenario a, b). A number of subjects also created slivers when drawing adjacent polygons (Figure 4.2c). Efforts were made to digitize along the centre or the average of any disputed area (Figure 4.2d)

Thirdly, some subjects selected to draw adjoining polygons of the same value, violating the assumption that adjoining polygons should have differing attribute values (Figure 4.2e). A decision was made to allow adjoining polygons to have the same rank value in order not to lose information that may prove valuable later on in the research.

Initial digitising and topological cleaning resulted in two sets of 71 vector polygon map files ready for printing, digital display and comparative analysis. These maps, by themselves, are of interest. They must somehow be packaged for viewing, analysis and interpretation in order to become useful for land valuation and consensus building. The next step in the research program therefore was to build a number of information products out of the stakeholders' maps.

4.5 Individual and Aggregated Presentation of Subjects Responses

An important step in consensus building and a collaborative decision making process is to present stakeholders and decision makers with information about how individuals responded, as well as how each response compared to each other and to an average of all responses. It also is useful to show measures of variation around the average.

Showing individual stakeholders their digitised responses is a straightforward task that can be achieved on the computer screen, by wall projection, or by production of hardcopy output. Facilitating a comparison of individual responses to an average response is more challenging.

One way to facilitate comparison of a stakeholder's valuation to average valuation is to summarise into how many polygons each individual divided the study area, and their distribution by value class. Average values for these variables thereafter can be calculated. An example of this type of average reporting for the subjects' maps is shown in s4.1.

1:250,000 / 1:50,000	Min	Max	Range	Mean**	Std. Dev.	Skewness	Kurtosis
# of Polygons							
Total # of polygons	11 / 7*	106 / 87	95 / 80	34.7 /23.7**	17.8 / 12.5	1.7 / 2.4	3.9 / 8.8
Exceptional Value	2 / 1	45 / 22	43 / 21	9.2 / 5.4**	7.0 / 4.0	2.9 / 1.7	11.6 / 4.1
High Value	1 / 1	68 / 32	67 / 31	11.3 / 7.1**	9.2 / 5.0	3.6 / 2.5	20.0 / 9.3
Medium Value	1 / 1	21 / 20	20 / 19	6.5 / 5.5	4.6 / 4.1	1.1 / 1.5	0.7 / 2.6
Low Value	1 / 1	15 / 31	14 / 30	4.9 / 4.1	3.1 / 4.6	1.2 / 3.7	1.2 / 18.4
Left Blank	1 / 1	19 / 11	18 / 10	3.7 / 2.7**	3.5 / 2.1	2.5 / 1.2	7.3 / 3.8
% Area covered by							
Exceptional Value	0 / 0	45.9 / 30.8	45.9 / 0.8	9.0 / 10.9	7.6 / 7.4	2.2 / 0.3	7.5 / -0.4
High Value	0.9 / 0	51.0 / 72.5	50.1 / 72.5	14.0 / 12.9	9.3 /12.8	1.3 / 3.0	2.7 / 11.6
Medium Value	0 / 0	76.9 / 75.5	76.9 / 75.5	13.0 / 12.6	14.8 / 17.6	2.1 / 2.3	5.2 / 5.3
Low Value	0 / 0	81.6 / 45.6	81.6 / 45.6	10.0 / 8.1	12.8 / 10.3	3.0 / 2.0	13.3 / 3.6
Left Blank	0/ 0	93.4 / 87.8	93.4 / 87.8	54.1 / 55.6	25.9 / 14.6	-0.7 –0.9	0.6 / -0.1

*: 11 polygons for the 1:250,000 scale / 7 for the 1:50,000 scale

**: Denotes a statistically significant difference of the two means with a p value of < 0.01

Table 4.1 Descriptive Summary of numbers of polygons drawn (1:250,000 / 1:50,000)

Each stakeholder can be presented with a detailed summary informing her/him into how many polygons they divided the study area, the breakdown by class and total area covered by each class, etc.. Stakeholders can thereafter compare their personal response to information presented in Table 4.1. This allows stakeholders to gain insight into how they divided their study area relative to others, and the overall variations in response.

Table 4.1 reports average responses for both, the 1:250,000 and the 1:50,000 scale responses. The information presented shows, for example, that for the 71 subjects, division of the region into polygons identified close to a ten-fold variation in complexity between subjects for both map scales. Measures of mean, standard deviation, skewness and kurtosis for both map scales suggest further that average responses are skewed considerably towards more complex divisions of the maps. Examination of average polygon distribution by value class reveals that subjects choose not to value on average half of the map area, with the remaining half divided approximately evenly with ¼ allocated to each of the four value classes. Finally, the average size of polygons appears to decrease moving from "low value" polygons through to "exceptional value" polygons.

These results above are reported simply to demonstrate the type of insights that can be gained from average response analysis. Seeking meaningful interpretation for the specific results presented in Table 4.1 makes little sense given that students do not represent real stakeholders in a real valuation problem. For each individual land valuation process, stakeholders and decision-makers will have to draw their own conclusions as to what the type of information presented in Table 4.1 tells them. Of course, the specific results reported in Table 4.1 are of direct interest when comparing averages for the two map scales (more on this in Section 4.9).

Stakeholders also may wish to see average results visualised in map format in order to study the spatial distribution of average values, to draw comparisons between average response values and the location of geographical features on the ground, and to learn how their interests fare in the overall picture. One way to achieve this is to derive maps showing the spatial distributions of mean class and standard deviation.

Producing such average maps requires extensive manipulation of the original vector maps, including complex multiple overlay operations. Given the computational complexities underlying the vector overlay process, and given the alternative conceptual elegance and computational simplicity of conducting overlay in raster format using map algebra, such a step is best undertaken in the raster GIS world. All 142 vector maps therefore were rasterised using a cell resolution of 300m and 75m for the 1:250,000 and 1:50,000 scale respectively. Cell sizes were chosen to offer a balance between excessive data volumes and a meaningful minimum resolution, as well as to maintain a consistent ratio between the two map scales and their respective cell sizes. Rasterisation resulted in a total of 178,986 and 178,657 raster cells for the two maps respectively. Map algebra thereafter could be conducted in a statistical package (SPSS) by declaring each cell in the raster matrix a case, with each of the 71 maps in each set a unique variable. Map algebra allowed for calculation of modal class, mean class and standard deviation for each raster cell.

Figures 4.3a/b and 4.4a/b show the spatial distributions of mean class and standard deviation for the 1:250,000 and 1:50,000 maps respectively. It is possible to

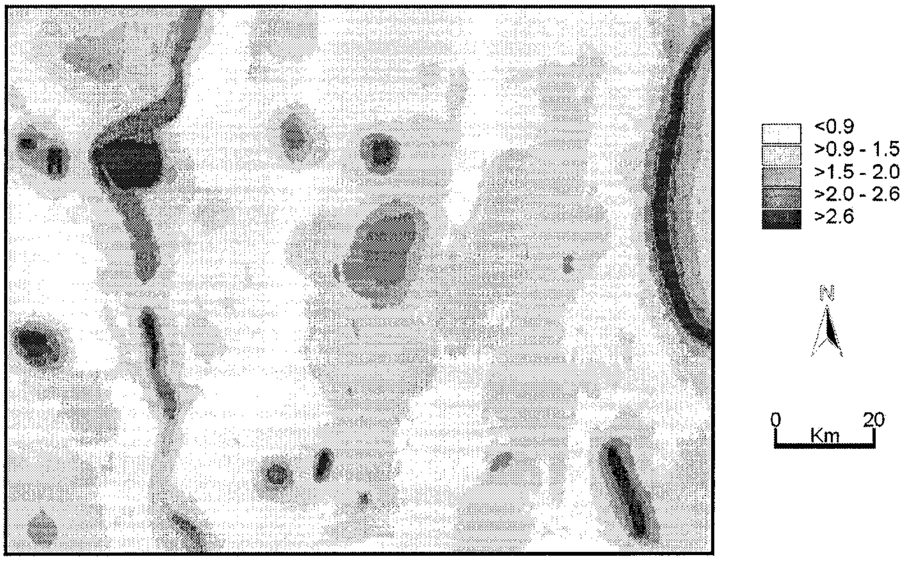


Figure 4.3a Mean class - 1:250,000 Map Sheet 82e

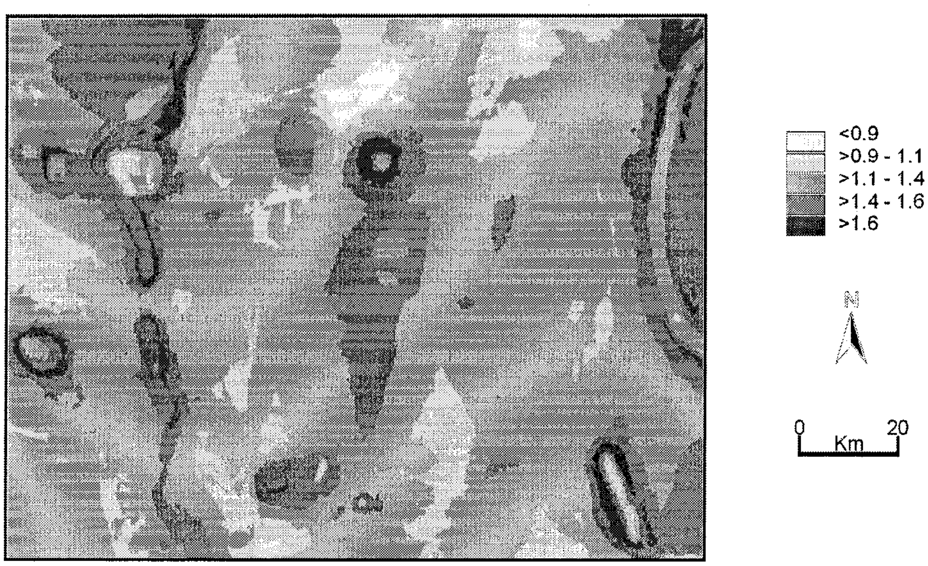


Figure 4.3b Standard deviation – 1:250,000 Map Sheet 82e

Figure 4.4a Mean class - 1:50,000 Map Sheet 82e12

Figure 4.4b Standard deviation – 1:50,000 Map Sheet 82e12

reproduce these average response maps at the same scale as the original topographic maps (and each subject's mylar overlay), thereby allowing stakeholders visually to compare these maps side-by-side, or visually to overlay them using GIS and possibly digital wall projection.

Of course, the reporting of average responses and their standard deviation for data ranked at the ordinal scale implies violation of statistical assumptions. The statistically correct procedure for reporting average response for ordinal data is to report the modal class value. An alternative step therefore should be to calculate the modal value for each cell in the grid matrix covering the two maps. This was done with results reported in Table 4.2 and Figure 4.5 a/b.

Areas "left blank" dominate the resultant modal maps. It is concluded that modal maps fail to show the same amount of information that could be gained from average response maps (Figures 4.3a and 4.4a), and that average response maps therefore were a more informative source despite the underlying statistical violations.

	1:250000		**1:50,000**	
Value Class	**Cell Frequency**	**%**	**Cell Frequency**	**%**
Exceptional Value	9319	5.2	33176	18.6
High Value	2089	1.2	3094	1.7
Medium Value	0	0	0	0
Low Value	0	0	1	0
Left Blank	167578	93.6	142386	79.7
Total	178986	100.0	178657	100.0

Table 4.2 Modal class

One way to improve the information to be gleamed from the modal class maps is to treat "left blank" pixels independent of the four value classes by producing a bi-variate map. In this case, one variable dimension is the modal class for the four value categories ignoring the "left blank" class. This variable can be visualised using variation in colour 'hue'. The second variable dimension is the percentage of times the area was actually valued. This variable can be visualised using variation in colour intensity or saturation, with increasing saturation or brightness equivalent to larger percentage of times the pixel was valued. Examples of resultant bi-variate maps are shown in Figures 4.6a/b.

A problem encountered with reporting and mapping average by modal class is the occurrence of multi-modality. Multi-modality is argued to exist where two or more data classes contain approximately equal numbers of most frequently valued data values. Table 4.3 shows that multi-modality exists for over 10.8% of the cells for the 1:250,000 and 6.3% for the 1:50,000 coverage respectively. Figures 4.5 a/b ignore multi-modality and therefore fail to show the magnitude of difference between counts in the modal class. Failure to communicate a measure of strength of the modal class can be misleading.

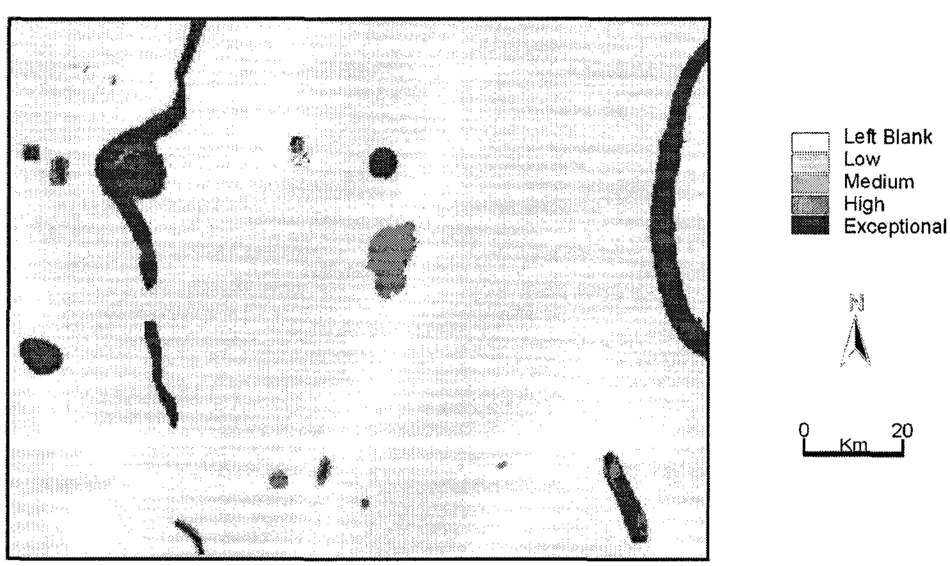


Figure 4.5a Modal class - 1:250,000 Map Sheet 82e

Figure 4.5b Modal class - 1:50,000 Map Sheet 82e12

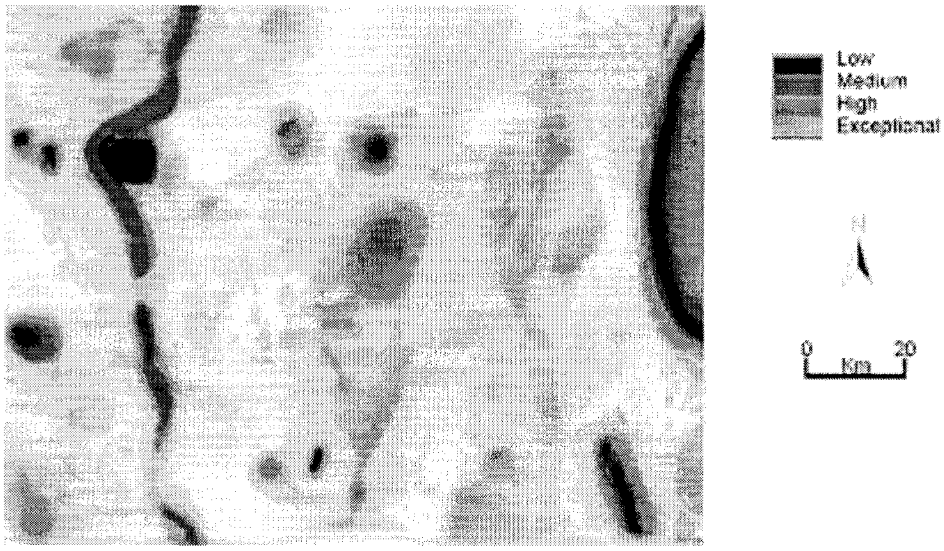


Figure 4.6a Bi-variate modal class (Excluding "Left Blank")-1:250,000 Map Sheet 82e with brightness theme of percentage of times area rated

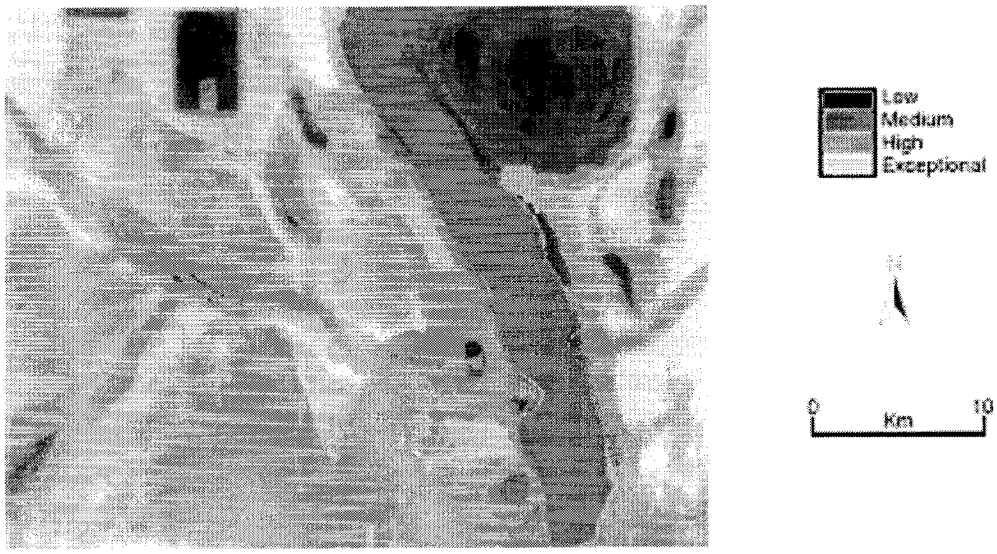


Figure 4.6b Bi-variate modal class (Excluding "Left Blank")-1:50,000 Map Sheet 82e12 with brightness theme of percentage of times area rated

	1:250,000		1:50,000	
	Frequency	%	Frequency	%
1 modal class only	159,649	89.2	167404	93.7
2 shared modal classes	17,616	9.8	10845	6.1
3 shared modal classes	1,739	1.0	403	0.2
4 shared modal classes	23	0.0	5	0.0

Table 4.3 Multi-modality for 1:250,000 and 1:50,000

A comparison between the aggregate maps and those of experiment one are not possible. The subjects in experiment one only agreed on less than 1% of the map sheet, so any aggregate map would have no statistical or pragmatic use. However, the Canada Land Inventory (CLI) has available a digital copy of the 1:250,000 82e map sheet rated for the opportunity of recreational use (Figure 4.7). It would have been preferable to do

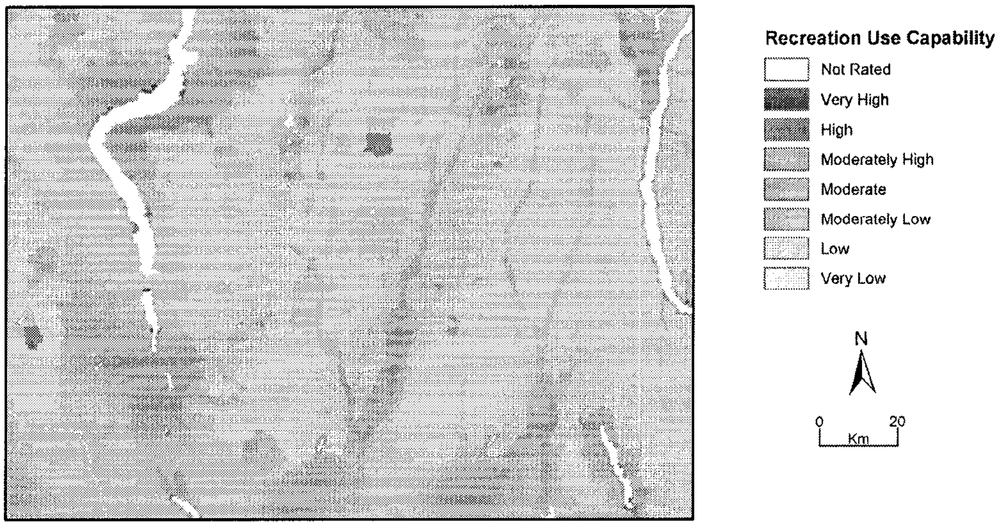


Figure 4.7 Canada Land Inventory map of 82E – 1:250,000

a quantitative comparison of the CLI map with those generated by the subjects in experiment two. This was not possible due to the different manner in which the two data sets were collected. A qualitative visual inspection is offered between the CLI map and the modal class (Figure 4.5a). The similarity with water features is the most apparent. Whilst the CLI only rated the shorelines, the subjects here rated the entire water bodies. There are also similarities based upon the central areas of the map. If the visual inspection is carried out between the mean map (Figure 4.3a) and the CLI map – then these similarities become even more apparent, especially for the areas surrounding streams and minor lakes present.

In summary, stakeholders can be presented with a descriptive tabular summary of the complexity of their own valuation, as well as a summary of the average map valuation complexity. Stakeholders and decision-makers also can be presented with two types of maps summarising their collective results. Maps showing modal class information (Figures 4.5a/b) statistically are more appropriate and correct, but maps of averages and their standard deviations (Figures 4.3a/b and 4.4a/b) were found to communicate more clearly average response behaviour. Stakeholders should determine for themselves which of the two map types offers them more information and insight. All the above results can easily be made available to participants via GIS and/or an interactive Web site.

Figures of maps shown in this Chapter are difficult to study and interpret given that the format constraint of thesis production (A4 or 11 x 8 inch format paper) does not facilitate examination of these graphics in their appropriate size (map sheet size or wall projected). It is offered for information that more appropriate size visual comparison of Figures 4.3 and 4.4 with the original topographic maps reveal considerable spatial correlation between average response patterns and the distribution of geographic features, notably lakes, other water features, parks and mountainous areas. Such a comparison will be analyzed and discussed in more detail in Section 4.8.

4.6 Reporting Stakeholders' Consensus and Divergence

Information products generated so far have presented stakeholders and decision-makers with insight into average response and variation around the average. Individual stakeholders will most likely also want an answer to the questions "How does my response compare to person X?", and "How similar were person Y and person Z's responses?" This requires pair-wise map comparison.

Pair-wise comparison of raster maps can be achieved by construction of a contingency matrix explained in Lillesand and Kiefer (1996: 612). The result will be a symmetric contingency table where all pixels encoded the same way in both maps are recorded on the trace (or the diagonal), with all non-matching pairs recorded elsewhere. A process was developed to facilitate efficient calculation of such a contingency matrix for each of the 2485 pair-wise comparisons (n=71x70/2). An example of such a contingency matrix is shown in Table 4.4.

	Exceptional	**High**	**Medium**	**Low**	**Not Valued**	**Total**
Exceptional	13115	3966	15017	19127	75522	126747
High	1618	0	312	1649	2497	6076
Medium	0	370	351	0	1325	2046
Low	578	1250	307	1311	5146	8592
Not Valued	3838	27310	0	39	3998	35185
Total	19149	32896	15987	22126	88488	178646

Table 4.4 Example of a contingency table for comparison of two 1:50,000 map responses

Large numbers of pair-wise comparison matrices are difficult to inspect and interpret. One solution therefore is to calculate a summary statistic that describes each contingency matrix. This can be achieve by calculating an index of similarity, C_{ij}, computed by dividing the number of pixels counted on the trace of the contingency matrix by total number of pixels in the study area (Equation 1).

Equation 1:

$$C_{ij} * 100 = \sum_{i=1}^{k} \sum_{i=j} n_{ij} \div \sum_{i=1}^{k} \sum_{j=1}^{k} n_{ij}$$

Where: C_{ij} = Index of similarity (expressed as a percentage
n_{ij} = number of pixels of the *ith* class on map 1 and the *jth* class on map 2
k = number of classes

Such an index will equal 100% where there is a perfect match between the two maps. In the case where no two cells correspond the index will be 0%. One of the problems with the above measure is that it does not incorporate information contained in the non-diagonal elements of the confusion matrix. An alternative measure that does explicitly consider this information is the kappa (or KHAT) statistic. This statistic is a measure of the difference between the observed distribution of data in the confusion matrix and the expected difference were the two maps drawn randomly. Details about calculating kappa can be found in Lillesand and Kiefer (1996:616) who note that this

> "statistic serves as an indicator of the extent to which the percentage correct values of an error matrix are due to 'true' agreement versus 'chance' agreement".

True agreement yields a kappa value approaching 1. A kappa value of 0 suggests that any agreement found between the two maps is due to chance. A kappa value between 0 and 1 (say .58) can be interpreted as "agreement 58% better than agreement obtained from chance". A procedure therefore has been added to calculate kappa. Table 4.5 show the summary statistics for C_{ij} and kappa.

C_{ij}	**Min**	**Max**	**Range**	**Mean***	**Std. Dev.**	**Skewness**	**Kurtosis**
1:250,000	0.91	91.33	90.43	37.18	19.25	0.107	-0.689
1:50,000	0.04	96.11	96.11	42.63	21.17	0.015	-0.852

*: The two means were statistically significantly different at p value of < 0.01

Kappa	**Min**	**Max**	**Range**	**Mean***	**Std.Dev.**	**Skewness**	**Kurtosis**
1:250,000	-0.23	0.41	0.63	0.05	0.07	0.591	1.262
1:50,000	-1.00	0.95	1.95	0.18	0.22	0.611	0.185

*: The two means were statistically significantly different at p value of < 0.01

Table 4.5 Descriptive summary statistics for C_{ij} and kappa

Allowing stakeholders to examine results for both, the index of similarity and the kappa values is thought to be important because the two measures report on different parts of the similarity matrix for each map pair. This agrees with a finding by Lillesand and Kiefer (1996:617) who note that it is

> "... not possible to give definitive advice as to when each measure should be used in any given application. Normally, it is desirable to compute and analyse both of these values".

Stakeholders may well be interested in comparing at a glance who value-judged the study area similar to themselves, and how other stakeholders compare to each other. Examining results for C_{ij} and/or kappa will meet this requirement. Having used C_{ij} and/or kappa to identify a pair-wise comparison of interest, stakeholders subsequently should be able to look up contingency tables and visually examine actual mapped responses for more specific comparative details. An efficient way to allow stakeholders and decision-makers access this type of comparative information is via an interactive Web site. Such a site should allow for specification of any pair of participants in the valuation project, requesting to view their actual mapped valuation responses as well as the associated contingency matrix, similarity index and kappa score. This type of pair-wise information can be explored for the student responses on the research program's web site http://www.geog.uvic.ca/gestalt/pilot.htm. With the advent of Web-based GIS it is not unforeseeable that, in the future, such a site also would allow the user to conduct interactive full-scale map overlay comparison of any two valuation maps as presently supported by commercial GIS products (all this is discussed further in Chapter Six).

4.7 Grouping Responses

Stakeholders and/or decision-makers may also wish to identify and to examine responses of sub-groups. Two grouping scenarios may be of interest here.

Firstly, stakeholders may be known to divide into logical groups (for example environmentalists vs. developers). In this case, it will be of interest for decision-makers to explore for consensus and variation within each group membership, and to compare average responses between groups. Repeating all analyses described above for each of the sub-populations easily performs this type of group analysis. Such an analysis was performed for the subjects' responses. It was known that students were divided between a declared major in "Geography" (n=54, 76.1%) and "Environmental Studies" (n=17, 23.9%). For each of these two sub groups it was possible, without too much further effort, to create average maps, maps of variation around the average, and modal class maps, as explained in Section 4.4. It was also possible to derive contingency tables and calculate indexes of similarity and kappa measures between the average land valuation map for all of the subjects, for "Geography" Majors, and for "Environmental Studies" Majors, as explained in Section 4.4. Table 4.6 shows summary statistics for the similarity index and kappa for the 1:250,000 map.

	All Subjects	**Geography**	**Environmental Studies**
All Subjects	-	0.98[1] / 0.88[2]	0.91 / 0.44
Geography	0.98 / 0.88	-	0.90 / 0.38
Environmental Studies	0.91 / 0.44	0.90 / 0.38	-

1: similarity index
2: kappa value

Table 4.6 Similarity indexes and kappa values for all subjects and two sub-groups

The second grouping scenario is one where statistical techniques attempt to cluster subjects or stakeholders into a number of groups in such as way as to maximise *within group* similarity while maximising *between group* differences. Multivariate statistical techniques exist to conduct this type of analysis assuming one treats each of the stakeholders as one axis in a data matrix (i.e. data column), and each pixel in the grid as the other axis (i.e. data row). However, this is problematic. This type of multivariate cluster analysis assumes statistical independence between cases. Given the inherent spatial autocorrelation underlying map data, this assumption obviously would be violated. An alternative approach therefore is to evaluate the matrix of similarity indexes or kappa values for logical clusters using a Cluster Analysis procedure. The software package COMPAH96 (http://www.es.umb.edu/edgwebp.htm# COMPAH) therefore was employed to calculate clusters and to generate a cluster diagram for both, the similarity index and kappa value matrices for the subjects' responses. Figure 4.8 shows the resultant tree type cluster diagram for the kappa index for the 1:250,000 map.

Examination of the different groupings and their associated hierarchies yields interesting insights into who responded similar, and what groups are more alike than others. Of course, group membership derived this way can thereafter be compared to background data about stakeholders, and elaborate statistical analyses can now be performed combining background data with group membership to seek an explanation for *within group* memberships and *between group* variations. There was little value to be gained conducting these analyses using the student data given that they are not real

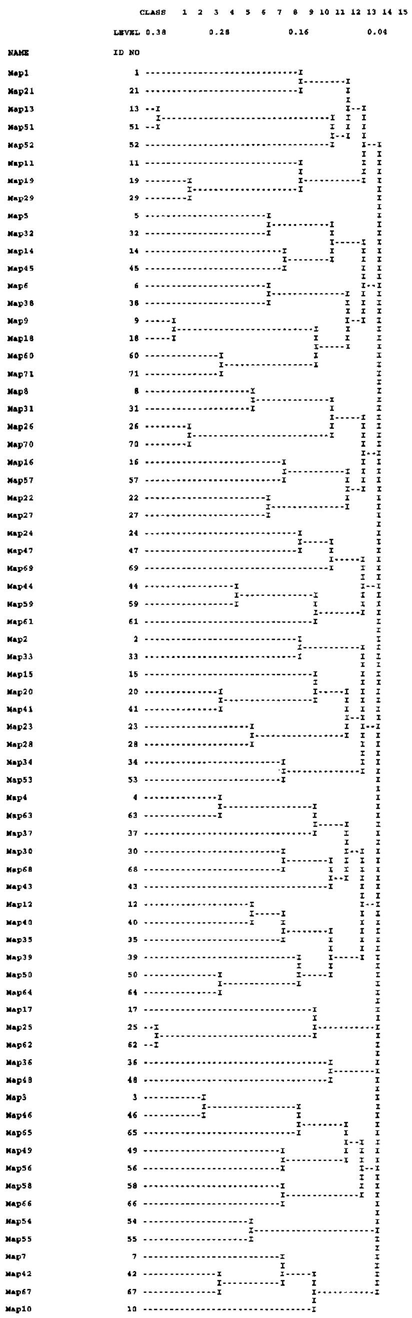


Figure 4.8 Cluster diagram of Kappa similarity indexes

* Note: It is impossible to state whether these clusters are representative. They are presented here only to demonstrate the technique.

stakeholders in the exercise they completed. In a real world valuation project, however, such analyses would offer potential to shed considerable additional insight into why stakeholders value-judge the way they do. Such an analysis is performed in a third case study reported in Chapter Five.

4.8 Comparison of Gestalt Responses to Landscape Attributes

Stakeholders and decision makers will be interested in comparing how individual and grouped Gestalt responses compare to the actual distribution of geographic features on the ground. A decision support system wishing to facilitate collaborative decision making and consensus building should offer such comparison capabilities. An easy way to conduct such comparison is by visual overlay of information products as shown in Figures 4.3 through 4.6 with the original topographic map information. This can easily be achieved through on-screen overlay or wall-projected overlays. Section 4.5, for example, concluded that appropriate size visual comparison of Figures 4.3 and 4.4 with the original topographic maps revealed considerable spatial correlation between average response patterns and the distribution of geographic features, notably lakes, other water features, parks and mountainous areas.

A CSDSS also should facilitate more quantitative overlay comparison to digital topographic baseline data where available and direct comparison should be facilitated between Gestalt valuations and valuation maps produced by quantitatively weighted overlay or rule-based techniques as advocated by the reductionist school of thought (introduced in Chapter Two).

An attempt was made to explore how reductionist valuation could be combined in CSDSS with Gestalt valuation. The following describes this effort step-by-step in some detail to allow the reader to gain insights into the difficulties that were encountered with this approach.

In order to investigate how the reductionist methodologies could be combined with the Gestalt technique, students were asked some additional questions. They were presented with a questionnaire (Appendix 2) which asked to identify the attributes they thought influenced their division of the maps into homogenous areas, and their subsequent value classifications. Each was given the option of listing up to six attributes in order of importance. In total, 366 variables were identified. A broad definition of outdoor recreation and tourism may have influenced this number. It is possible that the subjects had difficulty presenting variables that were related to the general concept of outdoor recreation. The reliability and wider applicability of these variables requires that further empirical and comparative studies. After taking account of exact matches, intuitively similar answers, as well as spelling differences, this could be reduced to 24 common variables as listed in Table 4.7. Table 4.7 sorts vertically by frequency of mention, with columns showing how often each attribute was mentioned 1^{st}, 2^{nd}, …, 6^{th}. Attaching labels to each group and explaining what each group represents proved problematic and required careful reading of subjects replies. "Water Features" for example, refers to streams, rivers, lakes, … . This category scored highest. "Topography" refers to anything related to elevation (mountains, valleys, …) This category scored second. "Accessibility" summarizes all responses referring to abilities to access an area. It scored third. "Urban" refers not to a binary variable – (presence or absence of a build-up environment) – but rather to distance away from build-up areas. "Naturalness" included observations like "undisturbed and pristine". "Aesthetics" is perhaps the most difficult to define attribute, but one mentioned sufficiently frequently by subjects to score 7th in importance. 24 variables shown in Table 4.7 still is too complex a list for reductionist modeling. Additional judgement calls therefore had to be made to collapse the list of 24 variables even further to yield the list of six variables shown in Table 4.8.

Variable name	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Variable 6	Total
Water Features	18	9	13	3	6	1	50
Topography	3	17	5	12	5	7	49
Accessibility	7	10	11	5	9	4	46
Urban Areas	4	4	7	10	5	8	38
Naturalness	11	2	7	3	4	1	28
Parks	4	6	6	5	1	6	28
Aesthetics	6	5	4	0	1	2	18
Tourism Features	4	5	0	3	3	3	18
Roads	1	1	2	5	5	2	16
Camping	1	1	2	4	3	0	11
Wildlife Habitat	2	1	0	3	3	1	10
Cost	0	1	2	2	2	1	8
Natural Features	1	1	1	1	0	3	7
Diversity of Potential Activities	0	4	1	0	1	0	6
Skiing	3	0	0	1	1	0	5
Popularity	1	1	0	0	1	2	5
Hiking	1	0	2	1	1	0	5
Vegetation	0	0	0	0	2	2	4
Infrastructure	0	0	1	3	0	0	4
Ownership	0	0	0	2	0	1	3
Pollution	0	0	1	0	0	1	2
Presence of Protection	0	0	1	0	1	0	2
Valley Bottoms	0	0	2	0	0	0	2
Forest	0	1	0	0	0	0	1

Table 4.7 Landscape attribute list

Variable name	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Variable 6	Total
Accessibility	8	11	13	10	14	6	62
Water Features	18	9	13	3	6	1	50
Topography	3	17	5	12	5	7	49
Naturalness	12	4	8	4	6	6	40
Urban Areas	4	4	7	10	5	8	38
Parks	4	6	7	5	2	6	30

Table 4.8 Collapsed attribute list

At this level of simplification, an attempt could be made to match the six remaining attributes with digital topographic data available for the study area as follows:

- Accessibility: represented by a combination of roads, back roads and trails
- Water: represented by a combination of water bodies and water courses
- Topography: represented by a terrain model
- Urban: represented by distance away from built up points or areas
- Park: represented by their boundaries

The digital representation of "Naturalness" remained problematic and had to be dropped, indicative of one of the difficulties associated with the reductionist techniques. "Water Features" and "Parks" were retained as discrete binary coverages. The remaining attributes were converted into continuous surfaces. This involved the generation of surfaces based on some "cost buffer" function based on Euclidian distance. Based on the above, five raster maps could be produced for each of the two map scales representing five layers of "evidence" or "suitability" to be combined using some reductionist aggregation technique.

For this case study, a decision was made to apply weighted overlay valuation (other techniques as introduced in Chapter Two could equally have been applied). The procedure was: Firstly, attribution in each of the five layers was standardized to a scale ranging from 0 to 1, thereby facilitating giving each layer equal starting weight. Next, weights were assigned to each class percentage proportional to frequency of times each class was mentioned by the subjects. Hence in this case:

Variable	**Number**	**Percentage**
Accessibility	62	27
Water	50	22
Topography	49	21
Urban Areas	38	16
Parks	30	13
Total	**229**	**100 %**

Table 4.9 Variable weights

The resultant weighted overlay equation is:

0.27 Accessibility + 0.22Water – 0.21*Topography – 0.16*Urban + 0.13* Parks

For each pixel, the above equation will compute a value between 0 and 1 where 0 implies maximum value and 1 no value. This explains why "Topography" and "Urban" are negative to reflect that the further the distance from urban areas the better, and the greater the topographic height the better.

The resultant valuation surface was then correlated with the mean Gestalt valuation maps at 1:250,000 and 1:50,000. Subsequent calculations of Pearson's correlation coefficients for a cell by cell comparison are difficult to interpret, despite both being statistically significant. They suggest a close match between the Gestalt valuation and the weighted overlay valuation. However, such significance can be expected given the large sample size (# of cells compared) and should be interpreted with great care.

The above section introduced the reader step-by-step to an attempt to match Gestalt valuation with stakeholder input driven valuation by one of the methods favoured by the reductionist school of thought. The purpose was both, to demonstrate that such a comparison can be achieved, and that such a comparison is full of complex value judgements and assumptions that may make any statistical comparison questionable. While it is no doubt desirable for a Land Valuation CSDSS to support comparison between Gestalt valuation and reductionist type valuation, the value of such a capability may be questionable.

4.9 1:250,000 vs. 1:50,000 Revisited

Having produced a number of information products to facilitate individual and grouped comparisons between subjects, it is possible to use the same information to draw comparisons between responses using 1:250,000 and 1:50,000 scale source maps. It is for this reason that this Chapter returns once more to the question of suitable map scale.

The 1:250,000 map covers 25 times as much geographical area as the 1:50,000 map. Let it be assumed that the nature, diversity and complexity of landscape in the larger scale map (1:50,000) repeats for the additional territory adding when going to the smaller scale map (1:250,000). In this case, to preserve the same detail of judgement used in the 1:50,000 map, subjects would have to divide the 1:250,000 map into 25 times as many value polygons. Table 4.1 reports pair-wise comparison of the mean statistics reported between the two maps using the t-test ($p = 0.01$). A statistically significant difference can be observed for total numbers of polygons, and for three of the five value classes. However, the differences in means show an increase of only approximately 50% in numbers of polygons going from 1:50,000 to 1:250,000, far from the 25 fold increase noted above. This, combined with the fact that there were no statistically significant differences in the means of two of the value classes, suggests that subjects will partition and judge landscape at the scale of the topographic map supplied as the information source, a fact that was intuitively expected.

Frequency distributions for the similarity index and kappa values were calculated for both map scales and are shown in Figures 4.9 and 4.10. The similarity index distribution for the 1:250,000 scale appears offset somewhat to the left of the 1:50,000 distribution. One conclusion that can be drawn is that similarity indices across the range are somewhat higher for the larger scale valuation process. More distinct differences can be observed when comparing the two distributions for kappa values, which take into consideration information beyond the diagonal of the similarity matrices. The 1:250,000 kappa values concentrate in the low values with a peak at the 10 < 20% level and a fall off sharply to 40%. The 1:50,000's kappa values are more evenly spread from 0 to 100%, and are more represented in the higher kappa value.

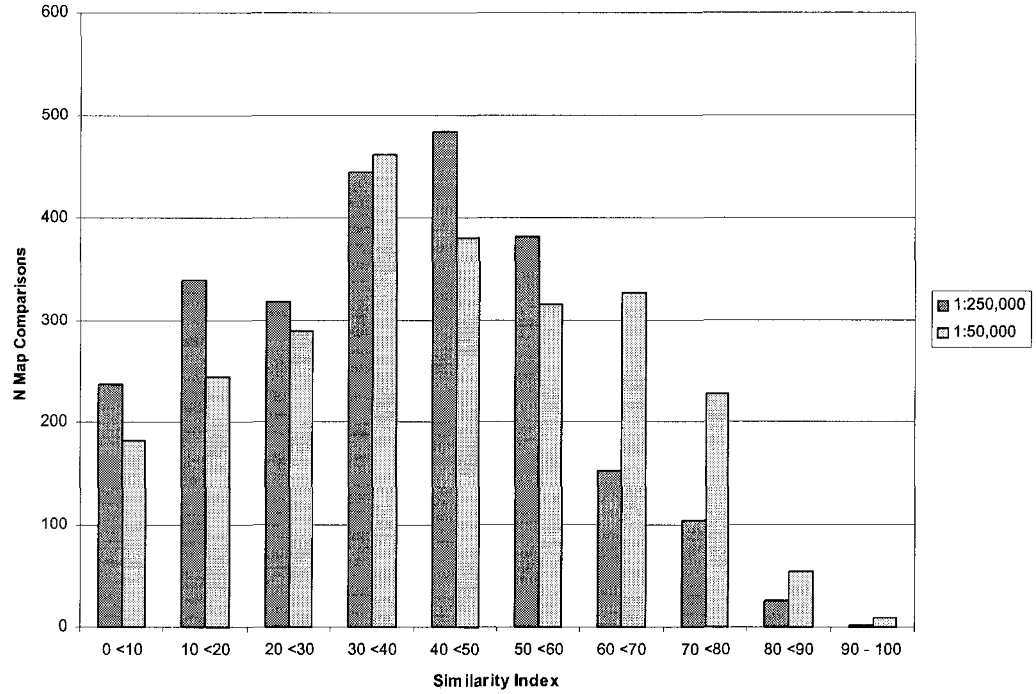


Figure 4.9 Similarity indices for 1:250,000 and 1:50,000

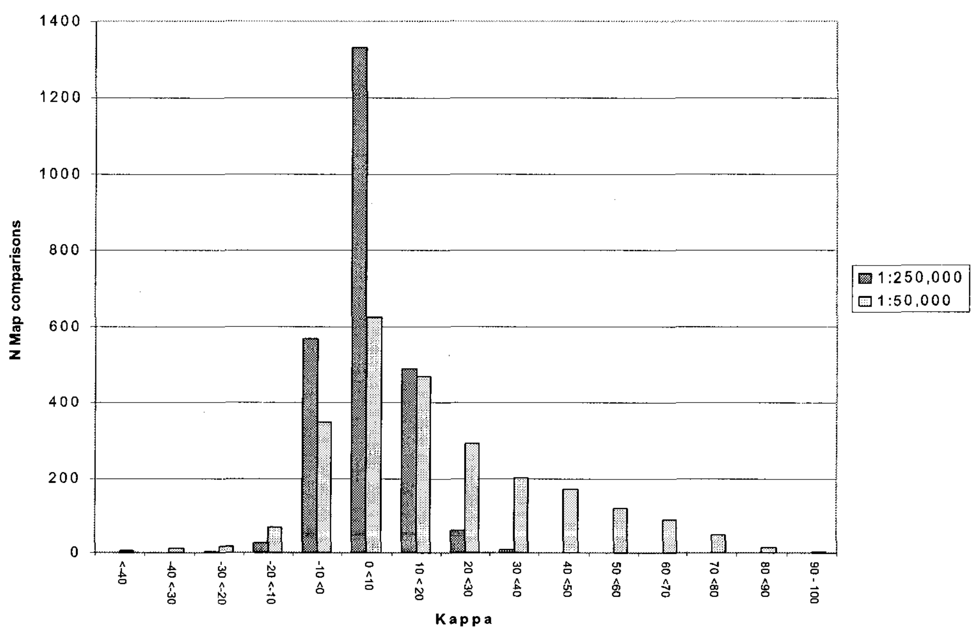


Figure 4.10 Frequency distribution Kappa values for 1:250,000 and 1:50,000

classes. One conclusion could be that the 1:250,000 scale valuation exercise yielded more inconsistencies and/or disagreement between all the value classes than the 1:50,000 exercise. The above findings suggest that subjects showed more agreement when conducting the valuation exercise at the 1:50,000 scale than the 1:250,000 scale. The temptation is to conclude that larger scale analysis yields higher consensus, and that it is more effective in capturing subjects' valuations. This conclusion agrees with the general observations offered by the students.

4.10 Discussion

This chapter has reported on a second study undertaken to refine the original experiment undertaken to conduct Gestalt valuation. A larger sample of subjects was used, two map scales were evaluated and compared, and a number of information products were designed, applied and tested to facilitate individual and grouped comparison to aid consensus building and collaborative decision making. Analytical and visual procedures have been put in place to facilitate reporting of individual stakeholder positions, the averages stakeholder positions, variations around the average, and pair-wise and grouped response comparisons. Finally, an initial attempt has been made to combine results from Gestalt valuation with reductionist techniques to further assist consensus building and decision making.

Valuations undertaken by the students show geographical patterns of consistency in value. This confirms further that the methodology can produce meaningful results. The 1:50,000 large scale source maps clearly are preferred to the 1:250,000 small scale maps. Orthophotos are suggested as a possible alternative to topographic maps. Despite their statistical shortcomings, the average maps of land value and their variation offer an interesting initial position statement. Modal maps of land value offer additional insights, especially when taking multi-modality into account. Statistical measures of consensus and divergence using the Index of Similarity or Kappa facilitate numeric pair-wise comparison as well as statistical grouping of subjects. Evaluation of consensus within and between logical groupings of subjects is argued to offer valuable insights, as is ability to group subjects statistically based on pair-wise response similarity.

The strength of the holistic approach presented here is that it places ownership of the valuation exercise firmly in the hands of the stakeholders. A holistic valuation approach is not necessarily argued as a replacement for a reductionist technique. An initial attempt at combining a holistic valuation technique with a stakeholder driven reductionist technique revealed methodological and operational difficulties that need to be overcome if plans for a final Land Valuation CSDSS are to proceed that allows for combination of these two techniques is to succeed.

The logical next step in the research agenda therefore would be to refine the information products introduced in this chapter. The use of orthophotomaps instead of topographic maps should be explored. Finally the techniques developed should be tested in a scenario that uses stakeholders and decision-makers facing a real world valuation problem. Efforts in this direction are presented in the next two chapters.

5. EXPERIMENT THREE GALIANO ISLAND

5.1 Introduction

An opportunity arose to apply the consensus building methodology to a real-world land valuation exercise using Galiano Island as a case study. A general background to Galiano Island is offered in Section Two. Galiano Island is administered by the British Columbia Island's Trust (http://www.islandstrust.bc.ca/) and a local Council. At the time of the research, the Island Trust was interested in creating a land-value coverage for tourism and outdoor recreation as part of their GIS database to assist in ongoing land-use planning and conflict resolution over a number of controversial development issues. It was agreed, therefore, that the Island Trust would supply the researcher with existing GIS data and an orthophotomap of the island. It was agreed further that the land valuation exercise should be completed independent of the Island Trust to avoid biasing the research given the political nature of the Trust.

The plan therefore was to allow stakeholders on Galiano Island to participate in a land valuation exercise, to use the preliminary data collection to identify recognisable stakeholder groups and their positions, and thereafter to bring representatives from the various stakeholder groups to the table to use CSDSS software developed to work towards a consensus position on land valuation for outdoor recreation and tourism.

The following section introduces Galiano Island. Section Three explains how stakeholders were selected and introduces the data collection methodology. Section Four takes the stakeholders' responses and builds the necessary decision support information products to facilitate comparison of individual valuations to average valuation. An attempt to convert ordinal rankings to cardinal valuation to facilitate a more meaningful "average response" valuation is introduced. Section Five explains decision support information products developed to facilitate pair-wise comparison of responses. Section Six shows how decision support information products attempt to break the stakeholders who responded into logical groups based on univariate and multivariate analysis of background information collected about the individuals, as well as attempting to group based on valuation responses. Section Seven explains how GIS capabilities can be used to compare holistic valuations to layers of natural resource data traditionally collected, stored and used for land use planning and natural resource management. This section also demonstrates that criteria used for holistic valuation are difficult to reconcile with thematic land related data stored in GIS. Section Eight shows how land valuations can be compared with economic appraisal data taking advantage of GIS, adding economic evaluation data to land valuation decision making. Section Nine discusses findings. This chapter summarizes what happened, and why things in the end did not work out as expected.

5.2 Galiano Island

5.2.1 Introduction

Galiano Island is the most northerly of British Columbia's Gulf Islands located adjacent to Georgia Strait, situated between Vancouver and Victoria (Figure 5.1). Information about the Island can be obtained from the Internet at http:// http://tourismmall.victoria.bc.ca/galianoisland.html.

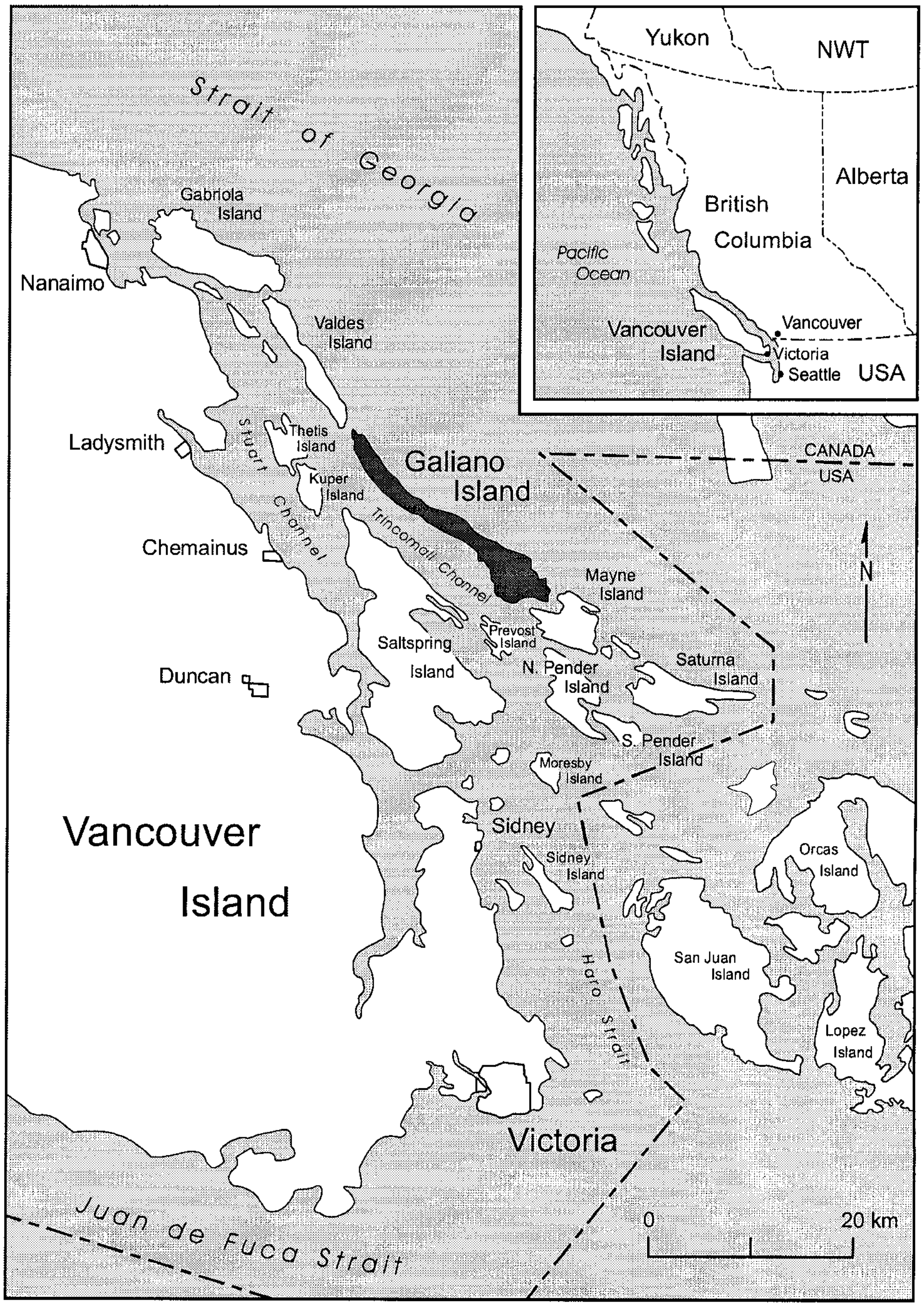


Figure 5.1 Location map of Galiano Island

Galiano Island is approximately 26km long and 4 km narrow at its widest point. It has a semi-Mediterranean climate. It is one of the driest of the Gulf Islands with an annual rainfall of 85cm, and an annual mean temperature of 23°C. The natural environment is varied, ranging from steep cliffs to meadows, including densely forested areas, and includes a complex coastline with a number of sandy beaches. The island contains a number of parks and ecological reserves.

Originally thought to have been occupied by the Coast Salish First Nations, the island was discovered by Europeans a little over 200 years ago, and is named after one of the discoverers, Dionisio Alcala Galiano. The island's original economy focussed on resource extraction, notably fishing and forestry. Today, the island's population consists of a mix of permanent residents (approx. 1,000) and vacation properties, with primary economic activities in forestry, artisans, and tourism service providers. Tourism opportunities focus on B&B, kayaking, sailing, hiking, and scuba diving. The following sub-sections provide detail on some of the key locations on Galiano Island that are referred to in this Chapter and highlighted in Figure 5.2.

The island is accessible by a ferry which docks to the south at the eastern entrance to Active Pass. The island has a basic road network with a primary road running its entire length. Population is dispersed throughout the island with some clustering around the ferry dock, a smaller community in the south, and along the coast. The island is crossed to the south by a major, and on the orthophotomap easily recognizable, powerline/utility corridor linking the mainland with Vancouver Island.

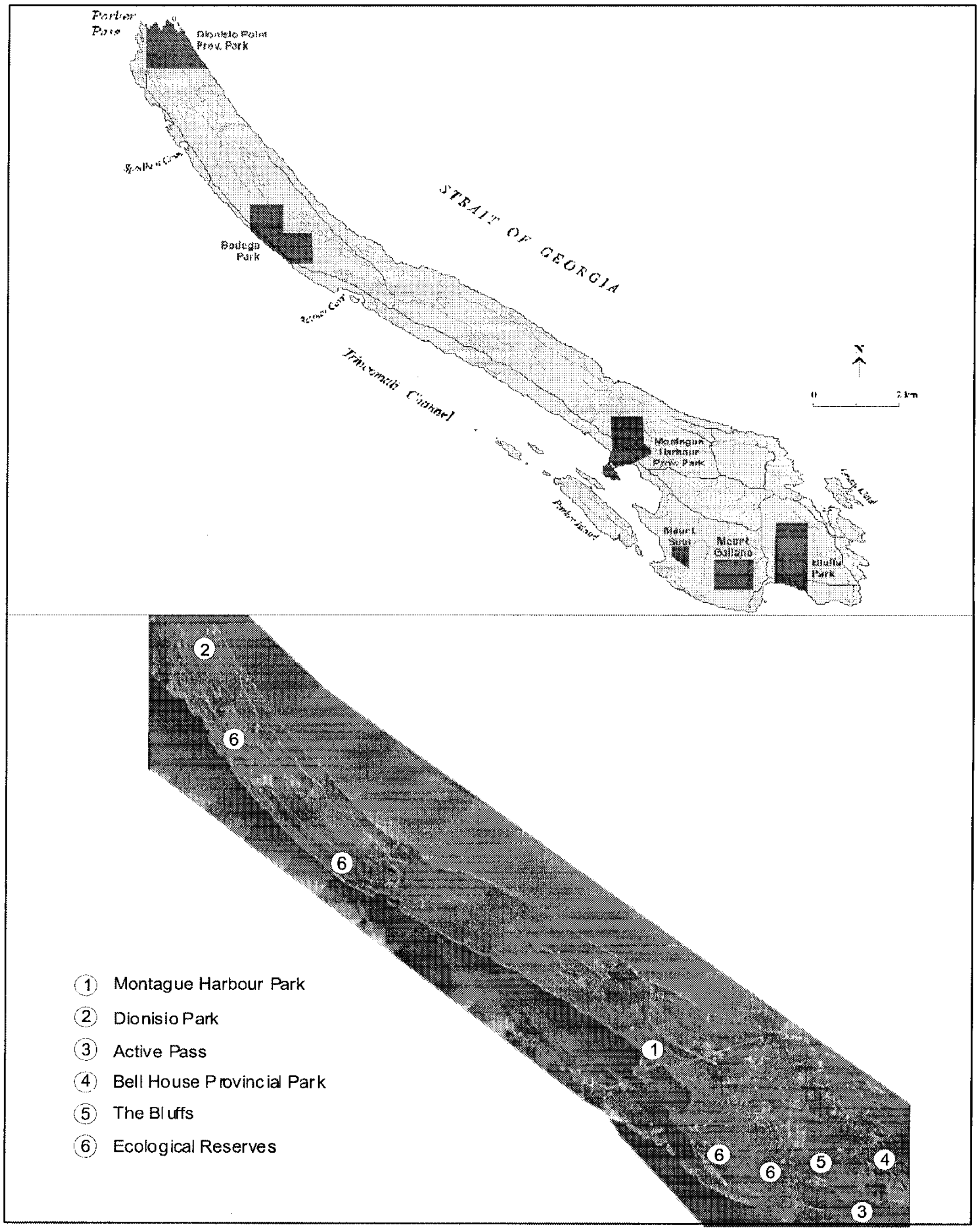


Figure 5.2 Map and Orthophotograph of Galiano Island

5.2.2 Notable Locations

5.2.2.1 Montague Harbour Park (1)

Montague Harbour Park (98 hectares) is located on the west coast of the Island. This park has white shell beaches, is highly forested, and has many hiking trails. The park contains a popular campground and the adjacent harbour / bay is a very popular anchorage for the boating community. The park also provides substantial potential for wildlife viewing.

5.2.2.2 Dionisio Point Marine Park (2)

This park (197 hectares) is at the north end of the Island, and is accessible to the public only by water. It has a tidal lagoon and sandy beaches, as well as mature forests. There are camp grounds, hiking trails, as well as a shallow bay where people do recreational diving.

5.2.2.3 Active Pass (3)

Active Pass is the channel between the southern shores of Galiano Island and Mayne Island (Figure 5.1). It is the major entrance to the Gulf Islands from the east and attracts considerable ship traffic, including all ferry traffic between Southern Vancouver Island and British Columbia's mainland. It provides spectacular opportunities for kayaking, fishing and scuba diving. It is also a significant wildlife area, with potential for viewing otters, sea lions and whales.

5.2.2.4 Bellhouse Provincial Park (4)

This is the smallest park on the island (2 hectares). Located at the entrance of Active Pass on the southern part of the island, it provides areas for wildlife viewing and picnic areas, but no camping facilities.

5.2.2.5 The Bluffs (5)

Overlooking Active Pass on the south-western part of the island is the Bluffs Park. Principle activities include wildlife viewing, especially bird watching. There are a number of hiking trails. The view from the top extends over the Gulf Islands to the Coastal mountain range of Washington State.

5.2.2.6 Ecological Reserves (6)

There are a number of ecological reserves on Galiano Island, including Mount Galiano, Mount Sutil in the southern part of the Island, and Bodega Ridge to the north. These are eco-sensitive areas that have been purchased by the Galiano community and other conservancy agencies to be maintained as forest areas not subject to harvesting. Mount Galiano has a 6 kilometer hiking trail to its summit. Bodega Ridge is a rocky bluff which provides potential for hiking with many well developed trails, and is part of the Pacific Marine Heritage Legacy of Parks Canada, established in 1995. BC Parks also has an ecological reserve on Galiano situated 2 km SE of the settlement of North Galiano. This reserve is not intended for high impact outdoor recreation use, although hiking and photography is allowed.

5.3 Stakeholder Selection and Initial Data Gathering

One of the first questions to resolve centred on selection of stakeholders/experts to be consulted to participate in the valuation exercise. Following discussions with the Island Trust and other knowledgeable people, it was decided that an obvious and clearly identifiable group of stakeholders did not exist on the Island. It became obvious that there were logical and strong divisions on the island with respect to land use planning and development, and that most everybody on the Island thought themselves to be a stakeholder and expert. A decision was taken, therefore, to make the initial land valuation exercise as transparent and open to all permanent and temporary residents on the island as possible. In other words, a public invitation would be extended to all residents on the island to give everybody a chance to participate. The initial stakeholder selection process therefore took a broad definition of stakeholder based upon the work of Grimble and Wellard (1997) whose definition includes any group of people, organised or unorganised, but making sure that a common interest or stake in a particular issue is shared between them.

Stakeholders on Galiano Island were contacted in a number of ways. An invitation (Appendix 4) was published in *The Active Page* a monthly magazine distributed to nearly all the homes on the island as well as to people who own vacation properties who can subscribe to receive the publication at their permanent address by mail Also an advertisement inviting participation was placed in the *Island Tides*, a free newspaper published and available on the ferry that connects Galiano Island to Vancouver Island and the mainland. Both *The Active Page* and *Island Tides* were thought as suitable media based on anecdotal evidence that a large number of islanders and visitors read these publications. Posters extending an invitation also were placed at the local convenience store and post office, both venues which anecdotal evidence suggests that islanders and visitors regularly frequent. Once the research was underway on the island, a list of the telephone numbers of local businesses, as published by the Local Chamber of Commerce, also was employed as a direct contact list. These businesses were given personal calls explaining the research and inviting their inputs.

Finally, anybody who showed up to complete the exercise was encouraged to inform friends or colleagues, encouraging them to participate.

Data collection was facilitated by renting a property on the Island, inviting stakeholders to visit the research property to complete the valuation exercise, or offering for the researcher to visit the stakeholder at the stakeholder's home or any other mutually agreed location. The rental property deliberately was located very accessible near the ferry dock. Data collection was over a two week period June 13th to June 26th, 1999, including weekends. Facilitating data collection over the weekends enabled visitors to the Island and recreational property owners to participate.

In the end, a total of 30 stakeholders came forward to participate, representing a broad cross-section of the Island's community and including representatives from conservation, forestry, tourism providers, tourists, and real estate developers. A higher turn-out had been anticipated. Considerable efforts were made during the three week period to solicit more responses. The individuals approached had heard about the study, but were either unwilling to participate for lack of interest, or expressed an interest in participation that never translated into turning up to complete the valuation. In hindsight, it is thought that low participation may be due to the facts that the study did not associate itself directly with a single and potentially controversial planning or development issue, choosing to identify itself instead correctly as a doctoral research project.

The data capture procedure was very similar to the previous study using University students except that the topographic map was substituted for by an orthophotograph of the island shown scale reduced in Figure 5.2. The actual orthophotomap presented to the stakeholders had dimensions of 120cm by 45cm. The substitution of an orthophotomap for a topographic map is justified as follows: Firstly, subjects participating in the previous experiment had commented that orthophotomaps may be more suitable than topographic maps to facilitate the valuation exercise, especially if topographic map literacy was thought to be an issue. Secondly, Galiano Island is approximately 26km in length by 4km in width. This implies that neither a scale of 1:250,000 nor a scale of 1:50,000 are suitable to show the Island. A larger scale map is required to facilitate valuation of an area of land the size of Galiano Island. Experimenting with an orthophotomap representing a scale approximately 1:28,500 therefore was thought to be suitable and to offer valuable insights.

Using the same mylar overlay technique already described in Chapter Four, stakeholders once again were asked to divide the study area into homogenous values using the same classes as previous. Next, participants were asked to identify what thematic variables they thought influenced their valuation. Thereafter, they were asked to pairwise rank the relative importance of these variables. The latter was asked to allow the researcher to experiment further with pairwise comparison methodologies, and to facilitate production of relative weightings for subsequent overlay analysis. Stakeholders also were asked to place relative valuations on each value class ranging from 0 for no value to 1 for maximum value in an attempt to convert ordinal to cardinal data. Additional details for this step are offered in Section 5.5. Third, stakeholders were asked to give information on demographics, familiarity with the Island, and socio-economic background. Finally, they were asked to comment on the exercise and to note whether they would be willing to participate in a follow-up exercise. A copy of the questionnaire survey presented to the participants is offered in Appendix 5.

Average time to complete the survey was 8 minutes. This is less than for the students (average 15 minutes) and the experts from the original Okanagan study (average 21 minutes). Shorter time for completion may be because the geographical size of the area to be valuated is considerably smaller, because an orthophotomap was used instead of a topographic map, and/or because the stakeholders were very familiar with the area under investigation. It would appear that time taken to complete the exercise was not a serious impediment to participation.

Without exception, all stakeholders started by valuing the exceptional areas first, thereafter working their way down the valuation scale. It became apparent that the stakeholders, once they had finished, kept returning to the exceptional valuation category. Stakeholders were given the choice to withdraw if they thought that the valuation exercise had no value or if they were uncomfortable with their answer. None of them availed of this opportunity to withdraw.

In order to minimise the impact that the "left blank" category caused in the student exercise, stakeholders were given clear instructions to value the entire island. Again the subjects ignored this instruction and left areas unassigned. Two stakeholders commented that they could not "*accurately*" (Pers Comm) do any other valuation category than exceptional, and that therefore they had to leave other areas blank. Others commented that they were finished valuing the map, and whilst some areas had remained blank, for them that was simply how it was going to be.

A simple map of the Island showing roads, coves and bays' names was made available to stakeholders as a reference point. However, all stakeholders were able to orient themselves to the orthophotograph, and were able to locate places of interest and key landmarks. All the residents looked for local landmarks and their own residences to familiarize themselves with the image. Some of the visitors to the island who participated in the survey asked for help to find key land marks they had just visited to orient themselves.

The orthophotomap solicited positive comments. The stakeholders really liked this information source. Many of them wanted to know where they could purchase such an image. When asked, all agreed that they thought the orthophotomap to be a better facsimile of the land-cover than a topographic map.

As before, the manner in which polygons were drawn on the mylar was not consistent. All stakeholders appeared to be diligent in the manner in which they completed the exercise, but lines drawn again ranged from thin and consistent to thick and sketchy. Once again, efforts had to be made when digitizing to trace along the centre line (or average) of any disputed area. This inconsistency problem appears to be an unavoidable feature of this method of data capture as instructions necessary to add consistency would detract from the real purpose of the assignment, and would make the exercise much more difficult to complete for non-cartographically trained individuals.

An unforeseen challenge arose with management of the coastline. In the previous experiments the boundary of the study area was defined by the extent of the map. Galiano Island has a natural topographical boundary – its coastline. A number of stakeholders asked how far beyond the coastline they should value, noting that tourism and outdoor recreation activities did not simply stop at the coast. The response given was to value as far as each thought appropriate, thereby avoiding giving specific guidelines. For digitizing purposes, the boundary of the coverage thereafter was the boundary of the valuation polygons drawn except in areas left blank – where the coastline was deemed to represent the boundary.

5.4 Presenting Stakeholders' 'Average Responses' and Facilitating an Individual's Comparison to Average Response

Chapter Four introduced the value in a consensus building process of allowing individual stakeholders to examine their own responses, and to compare their responses to those of others and measures of "average". One of the first steps of the Land Valuation SDSS therefore should be to facilitate this type of individual and paired review of valuations completed.

Following digitization of all responses, one of the first steps in data preparation for subsequent consensus building therefore is to compute average responses as explained in Chapter Four, thereby facilitating comparison of individual responses not only to each other, but also to an average. The complexity of how the stakeholders on Galiano Island divided the orthophotograph is presented in Table 5.1. A large range in the complexity of the stakeholders' valuation maps can be observed, with almost twenty times a difference between lowest and highest values, and a skew towards the more complex divisions of the map. The broad definition of outdoor recreation, coupled with the many outdoor recreation possibilities the island possesses may explain this broad range. It may also be inferred that the subjective nature of gestalt valuation will cause the personal idiosyncrasies of stakeholders to be more apparent in the valuation (Dearden, 1987).

One of the key features of a CSDSS is visual representation. Figures 5.3, 5.4 and 5.5 illustrate the mean, standard deviation and modal response summary of the stakeholders' valuations, produced as already explained in Chapter Four (pixel dimension = 17 x 17 m).

Orthophotograph	Min	Max	Range	Mean	Std. Dev.	Skewness	Kurtosis
# of Polygons							
Total # of polygons	4	81	77	20.3	14.9	2.6	8.9
Exceptional Value	3	32	29	10.1	1.5	1.4	1.2
High Value	1	18	17	6.9	0.9	1.0	0.2
Medium Value	1	14	13	3.7	0.7	1.8	4.1
Low Value	1	20	19	3.4	1.5	3.0	9.8
Left Blank	1	5	4	1.2	0.1	4.3	20.6
% Area covered by							
Exceptional Value	0.0	57.3	57.3	12.8	14.0	2.3	5.3
High Value	0.0	19.3	19.3	5.1	5.1	1.1	1.0
Medium Value	0.0	58.0	58.0	9.8	15.9	1.9	2.5
Low Value	0.0	40.5	40.5	2.2	7.5	5.0	25.9
Left Blank	25.4	98.3	73.0	70.1	19.7	-0.6	-0.6

Table 5.1 Descriptive summary of polygons drawn for Orthophotograph

There are no high value, medium value and low value modal classes as suggested in Table 5.2 and shown in Figure 5.5. The only modal class present is Exceptional. It appears that the number of stakeholders and the characteristics of the local geography may influence this result. Table 5.3 further reports on multimodality which appears to be negligible with only 0.8% of the area of the map shown to have multimodality, and in those cases only for two shared modal classes. A visual comparison between the maps shown in Figures 5.3, 5.4 and 5.5 and a map (Figure 5.2) showing place names suggests considerable spatial correlation between value polygons and locations such as Dionisio Point Provincial Park at the northern most tip of the island, Montague Harbour in the southwest, a number of the beaches, the main road and Bodega Ridge. It may be argued that the lack of other modal classes coupled with a strong spatial concentration impacts upon the measure of strength of the modal class being no longer an issue for this dataset.

	Galiano Island	
Value Class	Cell Frequency	%
Exceptional Value	5299	6.7
High Value	0	0
Medium Value	0	0
Low Value	0	0
Left Blank	74138	93.3
Total	79437	100.0

Table 5.2 Modal class values

	Galiano Island	
	Frequency	**%**
1 modal class only	78835	99.2
2 shared modal classes	602	0.8
3 shared modal classes	0	0.0
4 shared modal classes	0	0.0

Table 5.3 Multimodality

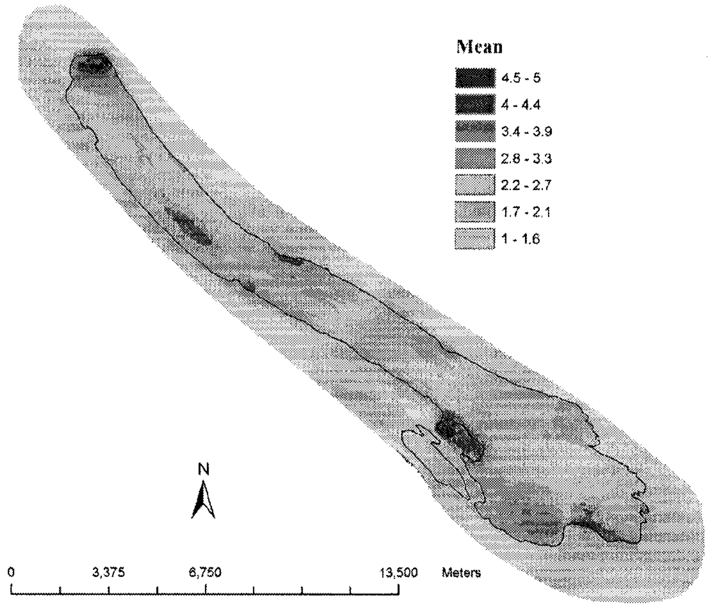


Figure 5.3 Galiano Island valuation: Mean responses

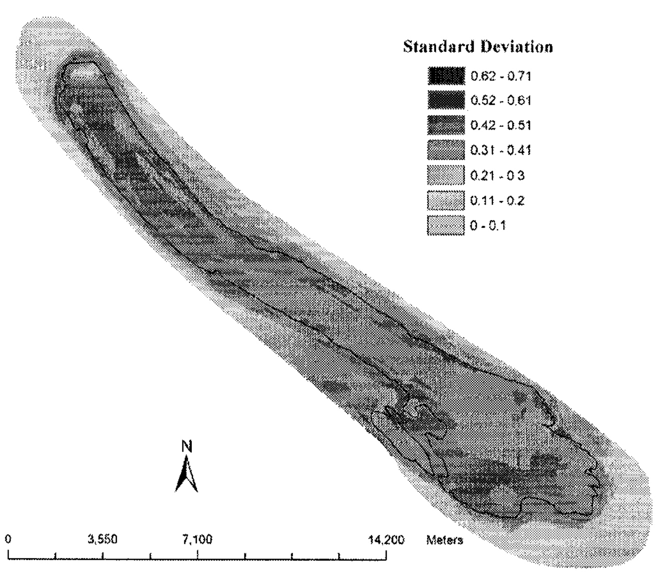


Figure 5.4 Galiano Island: Standard Deviation around Mean response

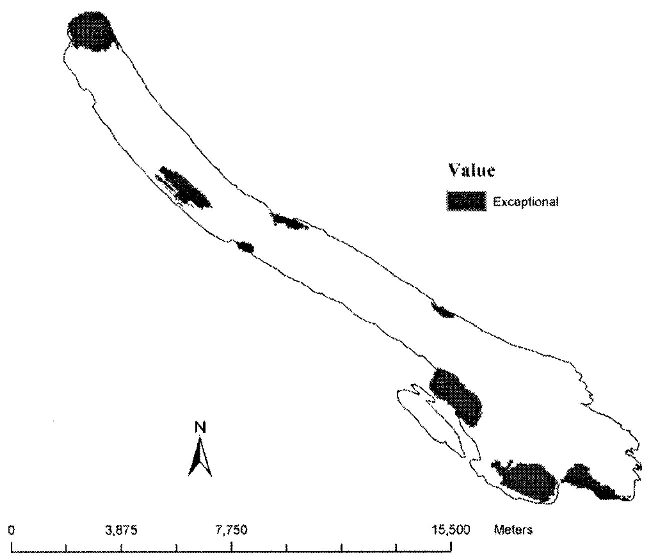


Figure 5.5 Galiano Island: Modal class – Exceptional Value

Figures 5.3 through 5.5 are based on ordinal data, as discussed in Chapter Four, and that the maps here, strictly speaking, violate statistical assumptions. An additional question was asked in the Galiano Survey to explore how ordinal valuation data could be converted to cardinal values. The additional question is shown in Figure 5.6. It seeks to get stakeholders to rank the five ordinal value classes on a cardinal scale.

A number of stakeholders (40%) asked for clarification with this question. A brief verbal explanation satisfied all but six of those who asked. The six participants who remained dissatisfied went on to refuse to answer this question, citing that they were uncomfortable with a hypothetical value and that they were unsure of what to do.

Exceptional	**$ 1.00**
High	**$**
Medium	**$**
Low	**$**
No Value	**$ 0.00**

Part (A) You have divided the landscape into up to five categories. Assuming that the Exceptional category is worth $1 per hectare, what is the value per hectare of the remaining categories. You may enter any value between $0 and $1:

Figure 5.6 Question asked to convert ordinal data to cardinal data.

Table 5.4 reports descriptive statistics summarizing responses to the question. Figure 5.7 computes responses graphically. Figure 5.7 shows, for example, that subject # 21's cardinal value assignments for the three middle classes (Low, Medium, High) are close together between 0.3 and 0.5, whilst stakeholder 1 has one of the widest spreads ranging from 0 to 0.9). It is of interest to note that two stakeholders choose to value "High" the same as "Exceptional" (Value = 1), and that 11 opted to value "Low" the same as zero while some valued "Low" as high as .5. Stakeholders who opted to value "High" equal to "Exceptional" were queried. Both replied that they were unable to split "Exceptional" and "High" on the scale presented, and that even during their individual mapping exercise they said that exceptional and high were very close.

Valuation Category	N	Minimum	Maximum	Range	Mean	Std. Deviation	Skewness	Kurtosis
High	23	.50	1.00	0.5	.8152	.10492	-.927	2.467
Medium	22	.25	.95	0.7	.6159	.17140	.084	-.339
Low	14	.00	.50	0.5	.2607	.14166	.125	.081

Table 5.4 Summary statistics for question converting ordinal to cardinal data

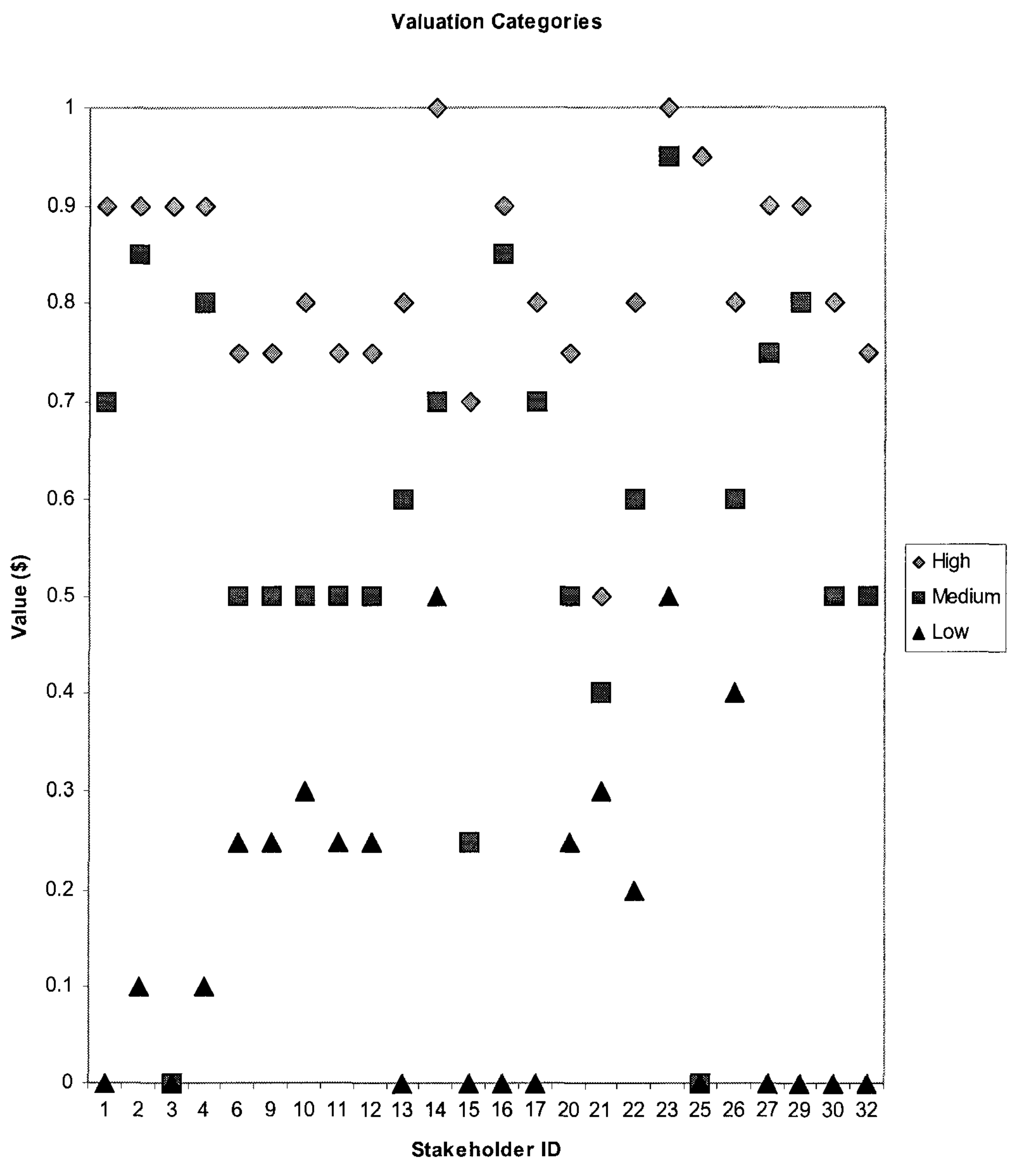


Figure 5.7 Distribution of hypothetical dollar amount for valuation classes

Data obtained from this question could be used to create three additional maps. Figure 5.8 shows a map of standardised total value for each pixel when adding the responses of all 24 stakeholders who answered this question. The procedure was as follows:

- For each subject, each pixel's ordinal value class was assigned the corresponding cardinal value.
- All 24 stakeholders' maps thereafter were added together using straight-forward map algebra. The range for data values therefore is from zero (24 x 0) to 24 (24 x 1)
- This range was converted to a scale ranging from 0 (Min) to 100 (Max).

Figure 5.9 shows the mean of all values assigned to each pixel (total value divided by 23) using the same 0-100 scale noted above. A bivariate map (Figure 5.10) may also be produced that plots the mean map in colour hue and the standard deviation map as a brightness theme. This enables the geographic features to be further investigated on a consensus level rather than merely an average portrayal.

As expected, Figures 5.8, 5.9 and 5.10 show a similar trend to Figure 5.3. These maps are offered as additional visual support to assist in decision making, and they are argued to be more meaningful than Figure 5.3 because they do not violate statistical assumptions, and because the cardinal data can be divided into as many data classes as deemed appropriate for visualization using choropleth mapping theory (Dent, 1990; Robinson et al, 1995) (in the thesis case four classes are shown).

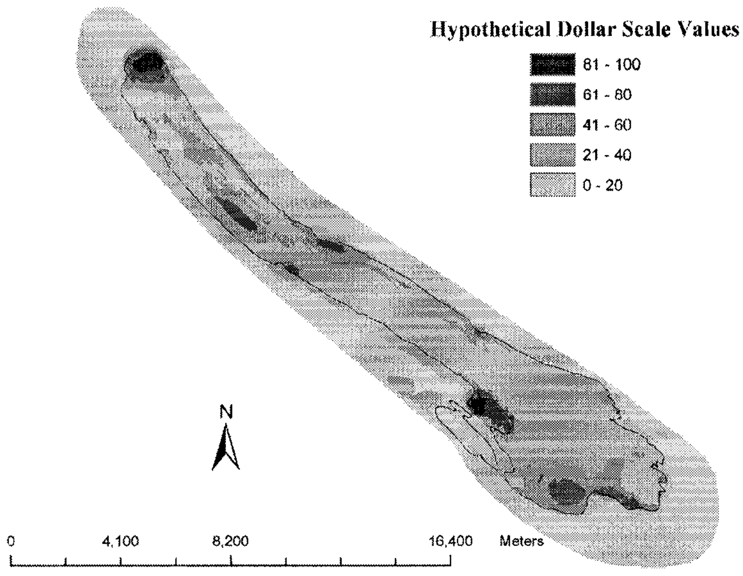


Figure 5.8 Total value based on 24 responses

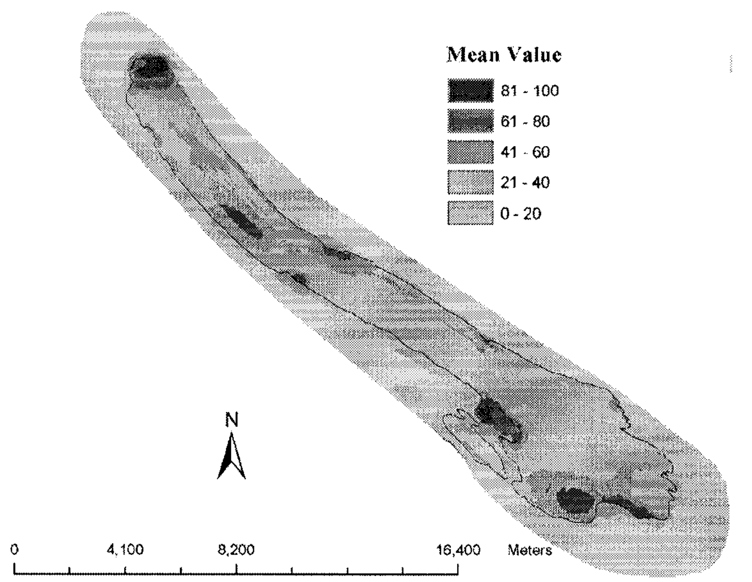


Figure 5.9 Mean value based on 24 responses

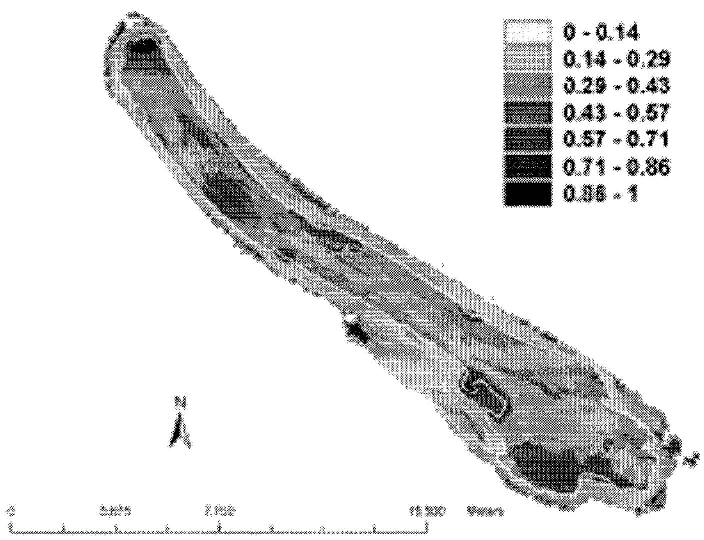


Figure 5.10 Bi-variate Mean value with brightness theme of standard deviation.

Preparation of average maps and maps showing variation around the mean allow for valuable insight into average response as well as facilitating easy comparison of how an individual stakeholders valuation compares to the average. The next step is to facilitate pairwise comparison.

5.5 Facilitating Pairwise Comparison

Chapter Four discussed how the Index of Similarity (C_{ij}) and Kappa (KHAT) measures could be used to facilitate pairwise comparison of stakeholder valuations, and why this is thought to be an important part of any land valuation SDSS.

Both measures could easily be calculated for all possible 435 (((30 x 30) -30) / 2) pairwise valuations. Table 5.5 presents summary statistics while Figure 5.11 shows the frequency distributions for all Kappa and C_{ij} values respectively.

	Min	Max	Range	Mean	Std. Dev.	Skewness	Kurtosis
C_{ij}	0.25	0.95	0.70	0.59	0.15	0.02	-0.82
Kappa	-0.09	0.84	0.93	0.13	0.11	2.03	7.69

Table 5.5 Descriptive summary statistics of C_{ij} and Kappa for Galiano Island.

Kappa and C_{ij} allow for quick and straightforward summary comparison of two stakeholders' valuations. However, neither of these aggregate measures offers detail about valuation consensus and divergence. The latter can be achieved by using map algebra to compute the differences between the valuation polygons produced by the two stakeholders, noting those areas where stakeholders agreed, and where they are one, two or three value classes apart. Examples of such map by map comparisons are shown in Figures 5.12a and b.

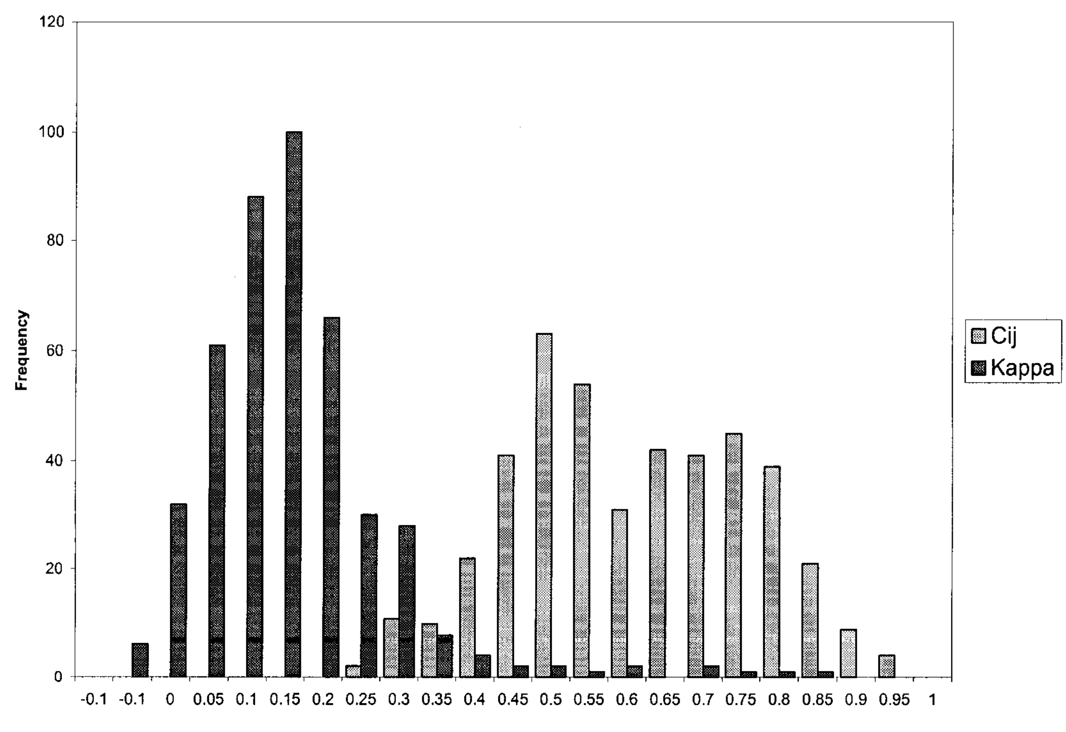


Figure 5.11 Frequency distributions for C_{ij} and Kappa for Galiano Island stakeholders

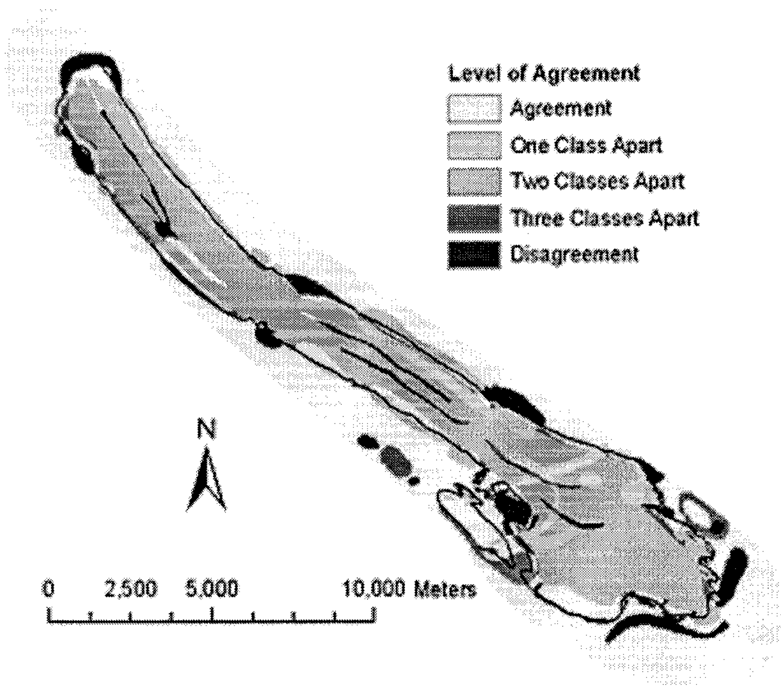


Figure 5.12a Levels of agreement between stakeholder a and stakeholder b

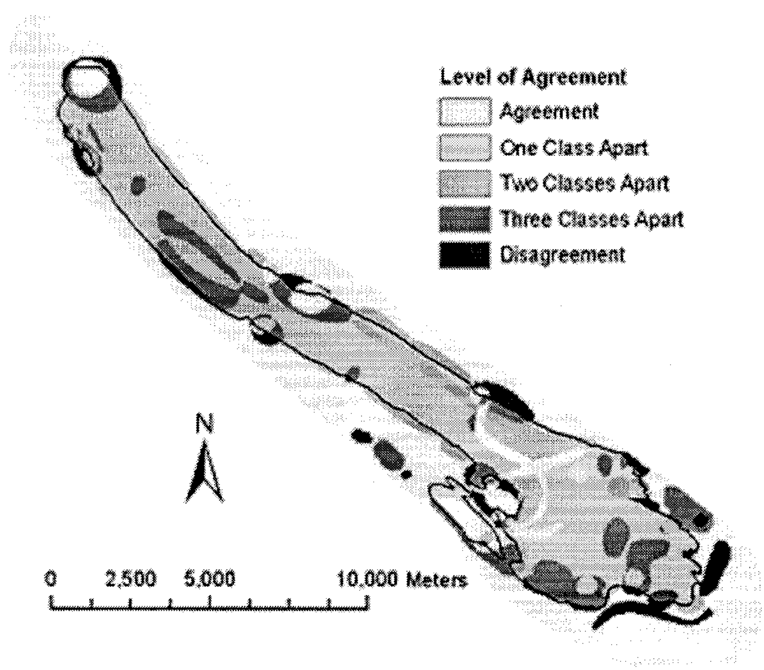


Figure 5.12b Levels of agreement between stakeholder c and stakeholder d

5.6 Grouping Responses

As already argued in Chapter Four, the logical next step when preparing information products to facilitate consensus building, is to search for logical groupings of stakeholders, or groupings of similar valuation positions (Harrison and Qureshi, 2000). One way to seek logical groupings in valuation responses is to attempt to group stakeholders by their responses to questions about socio-economic background, demographics or familiarity with the study area. At the simplest level, such a grouping attempt can be conducted at the univariate level exploring one variable at a time. The next section shows how this can be achieved.

5.6.1 Univariate Grouping

As part of the survey, the Galiano Stakeholders were asked to complete an online questionnaire soliciting data about socio-economic status, demographics, level of familiarity with Galiano Island and level of outdoor recreation activities (Appendix 6).

5.6.1.1 Familiarity

The literature has argued that degree of familiarity with a geographical region will influence valuation (Nieman, 1980, Dearden, 1984, Williams, 1986, Porteous, 1996). The literature is less clear about the nature of the influence except to note that increased familiarity often implies more internal attachment and in-depth understanding, and consequently less consensus (Penning-Rowsell 1982). Two questions were asked to ascertain familiarity with Galiano Island. The first asked for how long stakeholders had lived there. To include the possibility of non-residents, whose long-time association with Galiano would also deem them to be familiar, a second question for non-residents was posed asking how often in a year and for how many years had they visited. There were only two stakeholders who did not live on the island, one who had been coming to the island for 10 years at least 30 times a year and the other for 2 years but only 6 or 7 times a year.

Responses to these two questions were coded into ordinal categories reflecting levels of familiarity, defined to be the length of time a stakeholder has lived or spent time on Galiano Island. Examination of the data distribution revealed that class limits should be set using the technique of "natural breaks" categorising variable into four classes (Table 5.6).

For each group, it was possible thereafter without too much effort to produce "Within Group Average Response" and "Variation Around the Average Response" maps as already described for the entire response population. Next, it is possible pairwise to compare each of the four average maps calculating Cij and Kappa (Tables 5.6 and 5.7)

Years	**Number of Stakeholders**	**Stakeholders' ID**
0 – 2	3	17,29,30
3 – 10	13	1,4,6,7,8,12,13,14,20,22,23,31,32
11 – 19	8	3,15,16,19,21,25,26,27
20 +	6	2,5,9,10,11,28

Table 5.6 Familiarity categorised on natural breaks

	All	0-2 Years	3-10 Years	11-19 Years	20+ Years
All		0.53	0.75	0.66	0.56
0 – 2 Years	0.36		0.49	0.47	0.56
3 – 10	0.66	0.28		0.57	0.51
11 – 19	0.54	0.30	0.43		0.51
20 +	0.41	0.42	0.35	0.34	

* Shaded cells represent Kappa

Table 5.7 C_{ij} and Kappa values based upon sub-groups defined by familiarity.

In this study, examination of results suggests no obvious or definitive conclusion about a relationship between "Familiarity" and consensus. However the C_{ij} results do suggest that consensus levels are at their lowest for the least and most familiar sub-groups. This result is echoed for the Kappa scores. It would have been expected that the least-familiar sub-groups would have demonstrated higher levels of consensus based upon the rationale that they have little internal connection with the land being valued and are more influenced by external stimuli (Dearden, 1987). This was not the case for the Galiano stakeholders. Penning-Rowsell (1982) and Dearden (1987) assert that there is an inverse relationship between familiarity and consensus, a result born out here by the low C_{ij} and Kappa scores for the most familiar groups.

Within group variation can be explored by calculating C_{ij} and Kappa for all map pairs within each group, thereafter compiling summary statistics (see Table 5.8). In this case, such analysis shows few obvious or insightful trends or explanations especially when considering that membership in the "0-2 Years" Group is very small at n=3.

C_{ij}	Min	Max	Range	Mean	Std. Dev.	Skewness	Kurtosis
All	0.25	0.95	0.70	0.59	0.15	0.02	-0.82
0-2	0.38	0.58	0.20	0.50	0.11	-1.62	NA
3-10	0.32	0.95	0.63	0.59	0.15	0.30	-1.09
11-19	0.43	0.91	0.48	0.62	0.13	0.43	-0.68
20+	0.26	0.78	0.52	0.54	0.18	-0.38	-1.24
Kappa							
All	-0.09	0.84	0.93	0.13	0.11	2.03	7.69
0-2	0.05	0.40	0.35	0.16	0.20	1.73	NA
3-10	-0.03	0.58	0.61	0.13	0.10	1.09	3.67
11-19	0.05	0.84	0.78	0.15	0.15	4.29	20.29
20+	-0.05	0.29	0.34	0.09	0.10	0.61	0.01

Table 5.8 Summary statistics for C_{ij} and Kappa based on Familiarity sub-groups

5.6.1.2 Outdoor Recreation Experience

Can variation is valuation response be explained by amount of participation in outdoor recreation? Six questions were posed in the questionnaire to try and elicit information pertaining to the outdoor recreation knowledge and activities undertaken by each participant:

- Outdoor recreation participation (Y/N)
- List of Activities
- Member of outdoor recreation organisation (Y/N)
- List of organisations
- Number of days spent per month on outdoor recreation
- Self rating of outdoor recreation (5 point scale)

The last question proved the most revealing. Responses to this question were grouped and evaluated as already described above for "Familiarity". Table 5.9 shows how the stakeholders divided into groups.

	Number of Stakeholders	Stakeholders' ID
I am fanatical about outdoor recreation.	3	7,27,31
I am an outdoor recreation enthusiast.	14	2,4,5,6,10,13,17,20,22,25,28,29,30,32
I enjoy outdoor recreation frequently.	11	1,3,9,11,12,14,15,16,19,23,26
I enjoy outdoor recreation occasionally.	2	8,21
I have little or no interest in outdoor recreation activities	0	N/A

Table 5.9 Stakeholders categorised by outdoor recreation activities.

Table 5.10 explores within group variation using C_{ij} and Kappa, showing summary statistics. Results do not yield any obvious findings that help gain insights.

C_{ij}	Min	Max	Range	Mean	SD.	Skewness	Kurtosis
I am fanatical about outdoor recreation	0.45	0.65	0.20	0.56	0.10	-0.60	NA
I am an outdoor recreation enthusiast	0.27	0.88	0.62	0.55	0.15	0.15	-0.78
I enjoy outdoor recreation frequently	0.32	0.91	0.59	0.62	0.14	0.01	-0.99
I enjoy outdoor recreation occasionally *	-	-	-	0.76	-	-	-
I have little or no interest in outdoor recreation activities**	-	-	-	-	-	-	-
Kappa							
I am fanatical about outdoor recreation	0.15	0.21	0.07	0.18	0.03	0.14	NA
I am an outdoor recreation enthusiast	0.03	0.59	0.56	0.15	0.11	1.71	3.73
I enjoy outdoor recreation frequently	-0.08	0.84	0.91	0.14	0.13	3.09	17.22
I enjoy outdoor recreation occasionally *	-	-	-	-0.02	-	-	-
I have little or no interest in outdoor recreation activities**	-	-	-	-	-	-	-

*One pairwise comparison carried out
**Zero responses

Table 5.10 Summary statistics for C_{ij} and Kappa based on outdoor recreation activity

To confirm visual observations statistically, a one-way analysis of variance (ANOVA) can be carried out on both, C_{ij} and Kappa scores testing the following hypothesis

H_0: There are no significant differences between the mean values for C_{ij} or Kappa.

The alternate hypothesis is:

H_1: There are significant differences.

Table 5.11 shows that the *P*-value of the *F*-test is greater than 0.05 for C_{ij} scores for sub-groups identified by outdoor recreation activity rating. In this case the null hypothesis must be accepted. In the other three cases, it is not possible to be sure that there is no significant difference between the mean values. However, variations within each group are very large making any interpretation for why the alternative hypothesis should be accepted in the latter three cases difficult.

	Source		Sum of Squares	Df	Mean Square	*F*-Ratio	*P*-Value
Outdoor Recreation Rating	C_{ij}	**Between groups**	0.189	3	0.0628	2.92	0.036
		Within groups	3.143	146	0.0215		
	Kappa	**Between groups**	0.035	3	0.0116	0.9	0.442
		Within groups	1.899	146	0.0128		
Familiarity	C_{ij}	**Between groups**	0.079	3	0.0262	01.15	0.333
		Within groups	2.740	120	0.0228		
	Kappa	**Between groups**	0.033	3	0.0110	0.85	0.471
		Within groups	1.562	120	0.0130		

Table 5.11 ANOVA for C_{ij} and Kappa by outdoor recreation rating and familiarity

The type of unviariate data exploration introduced above can easily be undertaken for any other univariate variable. For the Galiano Case Study, this type of univariate analysis did not shed easily interpretable insights into logical groupings of valuations of stakeholders. In other words, univariate analysis did not function as valuable discriminators by which to divide stakeholders into groups with similar positions. This may be the result of poor phrasing of questions when soliciting univariate responses in the questionnaire, but more likely is the result of the fact that stakeholder valuations are sufficiently complex that no single variable can explain them. The latter suggests that multivariate analysis may shed more insights.

5.6.2 Multivariate Grouping

In order to generate sub-groups that incorporate the varied characteristics of the stakeholders, a multivariate analysis can be undertaken. Choice of variables in any multivariate analysis is argued to be the key factor in the derivation of final results. For this example, seven variables were selected to represent the facets of familiarity, outdoor activity and socio-demographic characteristics of the stakeholders. The variables are:

- Years lived on island
- Number of outdoor activities
- Number of outdoor organisations a member of
- Days a month spent outdoor recreating
- Self identified outdoor recreation rank
- Age
- Income

Responses to all seven questions were translated into non-continuous ordinal scales and a hierarchical cluster analysis was carried out. The assumption is that within each cluster, stakeholders replied more similar to each other than they replied to members that belong to another cluster. The hierarchical agglomeration cluster algorithm is exploratory in its nature, and whilst clusters are statistically robust, users are warned that membership should be examined in more detail to elicit important details.

The Galiano stakeholders divided into three main clusters (represented by the three colours in Figure 5.13, page 155). Having determined cluster membership from Figure 5.13, it is possible to examine within and between cluster behaviour proceeding as already done for univariate analysis in Section 5.6.1. Summary statistics for within group behaviour for C_{ij} and Kappa measures are shown in Table 5.12.

C_{ij}	Min	Max	Range	Mean	Std. Dev.	Skewness	Kurtosis
Cluster One (Black)	0.38	0.81	0.43	0.56	0.11	0.49	-0.57
Cluster Two (Blue)	0.37	0.91	0.54	0.60	0.16	0.57	-0.84
Cluster Three (Red)	0.27	0.95	0.68	0.59	0.18	-0.12	-0.95
Kappa							
Cluster One (Black)	0.04	0.51	0.47	0.18	0.10	1.23	2.25
Cluster Two (Blue)	-0.03	0.84	0.87	0.12	0.17	2.92	11.59
Cluster Three (Red)	-0.05	0.33	0.38	0.10	0.07	0.89	2.19

Table 5.12 Summary statistics for C_{ij} and Kappa based on cluster analysis

Again, little insights can be gained from this Table. Variation within classes is considerable in all cases. To confirm visual observations statistically, a one-way analysis of variance (ANOVA) can be carried out on both, C_{ij} and Kappa scores testing the following hypothesis

H_0: There are no significant differences in land values identified by different stakeholder groups as represented by similarity measures.

The alternate hypothesis is:

H_1: There are significant differences in land values identified by different stakeholder groups as represented by similarity measures.

Table 5.13 shows that the *P*-value of the *F*-test is greater than 0.05 for C_{ij} scores. This implies that there is not a statistically significant difference between the mean C_{ij} from one cluster to another at the 95.0% confidence level – hence one may accept H_0 - the stakeholder clusters do not generate significantly different maps based upon sub-group membership. The same test conducted on Kappa statistics gives a different answer. This time, the *P*-value of the *F*-test is less than 0.05 - there is a significant difference between the mean of Kappa from one cluster to another. Hence, H_1 is accepted and it may be subsequently argued that the sub-group definitions as defined by the cluster analysis do have merit.

	Source	**Sum of Squares**	**Df**	**Mean Square**	***F*-Ratio**	***P*-Value**
C_{ij}	**Between groups**	0.025	2	0.0125	0.50	0.607
	Within groups	3.176	127	0.0250		
Kappa	**Between groups**	0.151	2	0.0757	6.64	0.002
	Within groups	1.446	127	0.0113		

Table 5.13 ANOVA for C_{ij} and Kappa by cluster membership

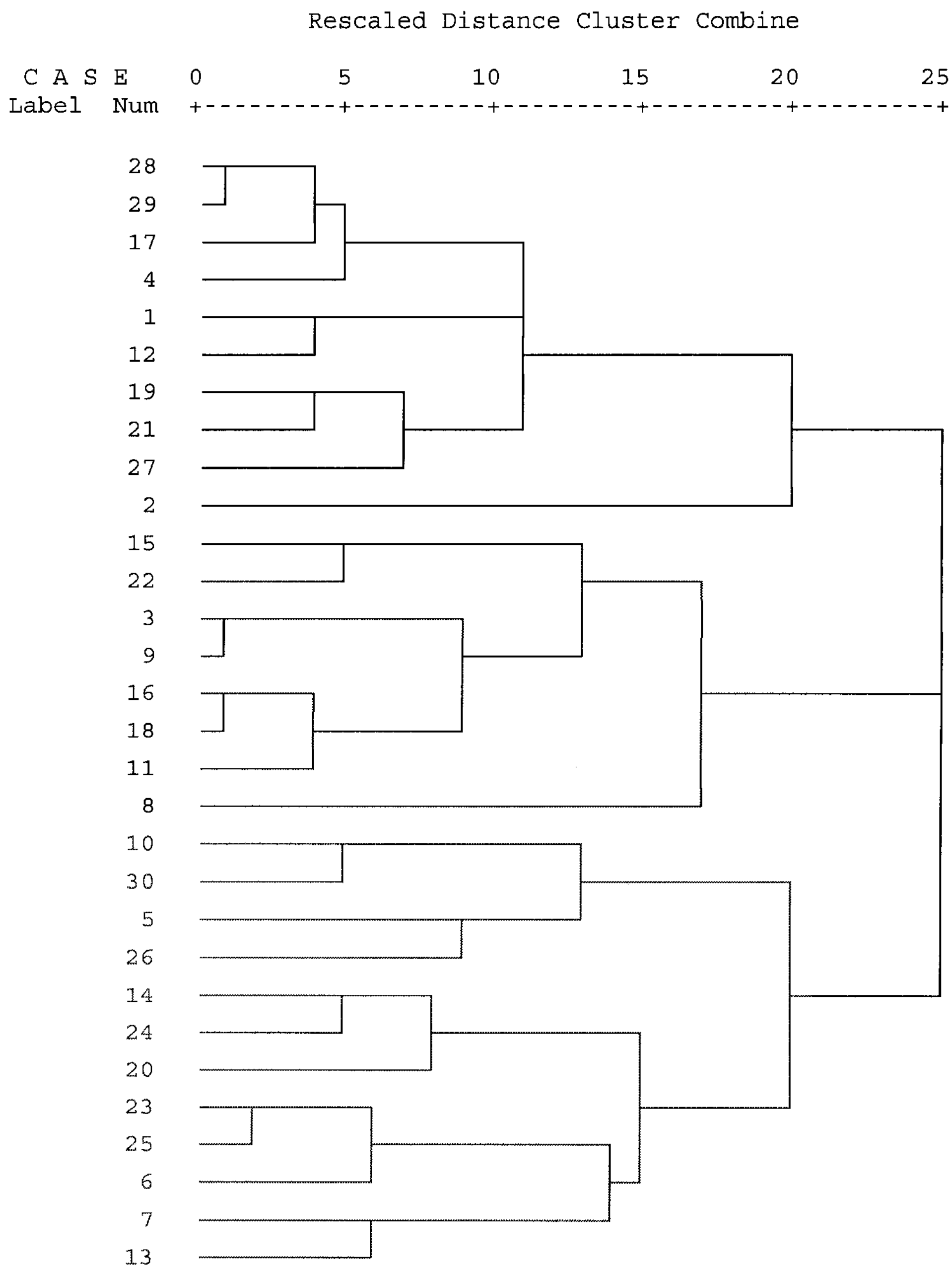


Figure 5.13 Hierarchical cluster analysis dendrogram using complete linkage.

The purpose of the information generated above is to assist stakeholders and decision makers in understanding positions, and to assist them to seek consensus. Given the contradictory nature of the above results, combined with the fact that most stakeholders will likely not be familiar with the subtleties of ANOVA analyses, it is argued that this type of information product, while of academic value, will have little practical value to add to the Galiano Case Study.

5.6.3 Grouping by Valuations

It has already been shown in Chapter Four how stakeholder valuations can be grouped by performing a Hierarchical Cluster Analysis on the matrix of all pairwsie C_{ij} or Kappa values as justified by Kaufmann and Rousseeuw (1990). The resultant dendrograms for C_{ij} and Kappa are as hown in Figures 5.14 and 5.15 respectively. How to interpret these dendrograms?

Everitt, (1983:240) notes that: "a question which is of great importance to many users is which groupings in the dendrograms gives the best fit to the data?" He further explains that researchers commence firstly by visual inspection, examining the dendrogram for obvious breaks and substantial changes in the levels. Subsequently these changes are then interpreted, albeit subjectively, as suggesting the correct number of groups. Everitt (1983) further argues that this subjective suggestion of the groups may have more to do with *a priori* assumptions than it does with correct group membership. If the dendrogram does not exhibit distinct clusters, then the choice of level for cluster membership is also subjective (Everitt, 1983).

Examination of the dendrogram for C_{ij} values suggests that there may be visual evidence for two groups, four, five or seven groups. In other words, it is difficult to decide upon an appropriate number of clusters. Table 5.14 gives the ID# for group membership for two, four, five and seven clusters respectively.

Level	Clusters	Cluster Membership
1	2	Group 1 (5,11,12,21,19,16,25,17,32) Group 2 (1,2,14,29,4,13,20,23,27,6,30,22,10,31,7,9,15,26,3,8,28)
2	4	Group 1 (32) Group 2 (5,11,12,21,19,16,25,17) Group 3 (8,28) Group 4 (1,2,14,29,4,13,20,23,27,6,30,22,10,31,7,9,15,26,3)
3	5	Group 1 (32) Group 2 (5,11,12,21,19,16,25,17) Group 3 (8,28) Group 4 (1,2,14,29,4,13,20,23,27,6,30,22,10,31,7,9,15,26) Group 5 (3)
4	7	Group 1 (32) Group 2 (17) Group 3 (5,11,12,21,19,16,25) Group 4 (8,28) Group 5 (3) Group 6 (7,9,15,26) Group 7 (1,2,14,29,4,13,20,23,27,6,30,22,10,31)

Table 5.14 Cluster membership based upon dendrogram levels for C_{ij}

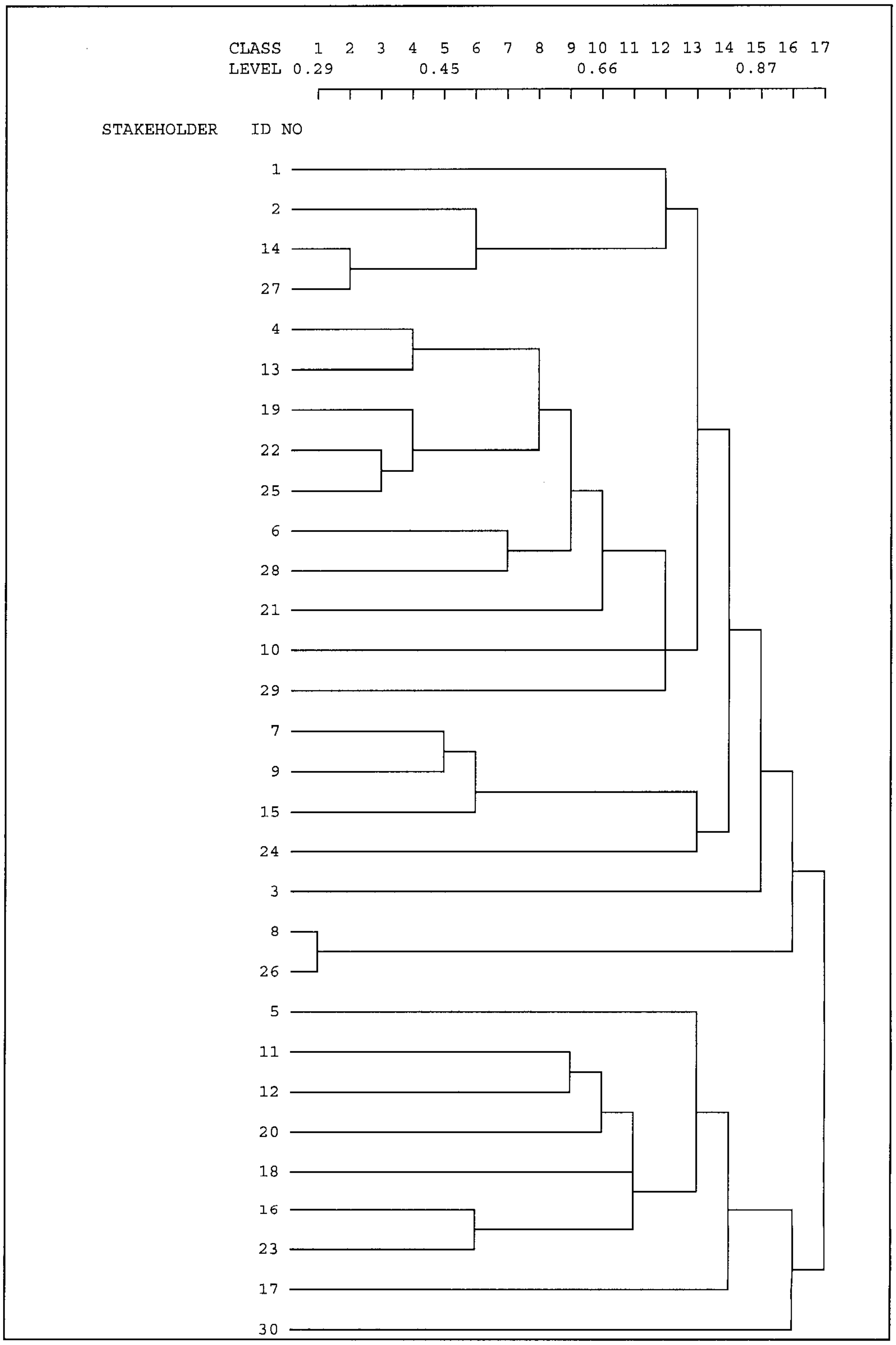


Figure 5.14 Hierarchical cluster analysis dendrogram using complete linkage for C_{ij}

Figure 5.15 is more obvious in revealing four visually intuitive clusters, although this is a somewhat subjective observation. Table 5.15 summarizes the membership for these four clusters.

Cluster One	1,6,19,29,12,26,20,2,14,4
Cluster Two	8,23,32,12,13,31,9,30
Cluster Three	5,27,15
Cluster Four	3,10,7,21,22,11,17,28,16,25

Table 5.15 Cluster membership based upon dendrogram for Kappa

What does it all mean? How would stakeholders and decision makers be able to use this type of information to help in developing positions and building consensus? For one thing, the type of clustering prepared above will allow stakeholders and decision makers to see what group of people are more likely to agree with each other. Further, the above clustering can be used to explore what underlying variables may explain the groupings. In other words, do members that form groups show similar response patterns to question asked in the survey accompanying the valuation exercise?

Out of curiosity, responses to seven questions were tested against group membership for the four, seven and nine group Kappa division. Results for Chi- square analyses comparing observed against expected are shown in Table 5.16. None of the variables show statistically significant measures of association between cluster membership and stakeholder characteristic, collaborating univariate analysis reported in Section 5.6.1.

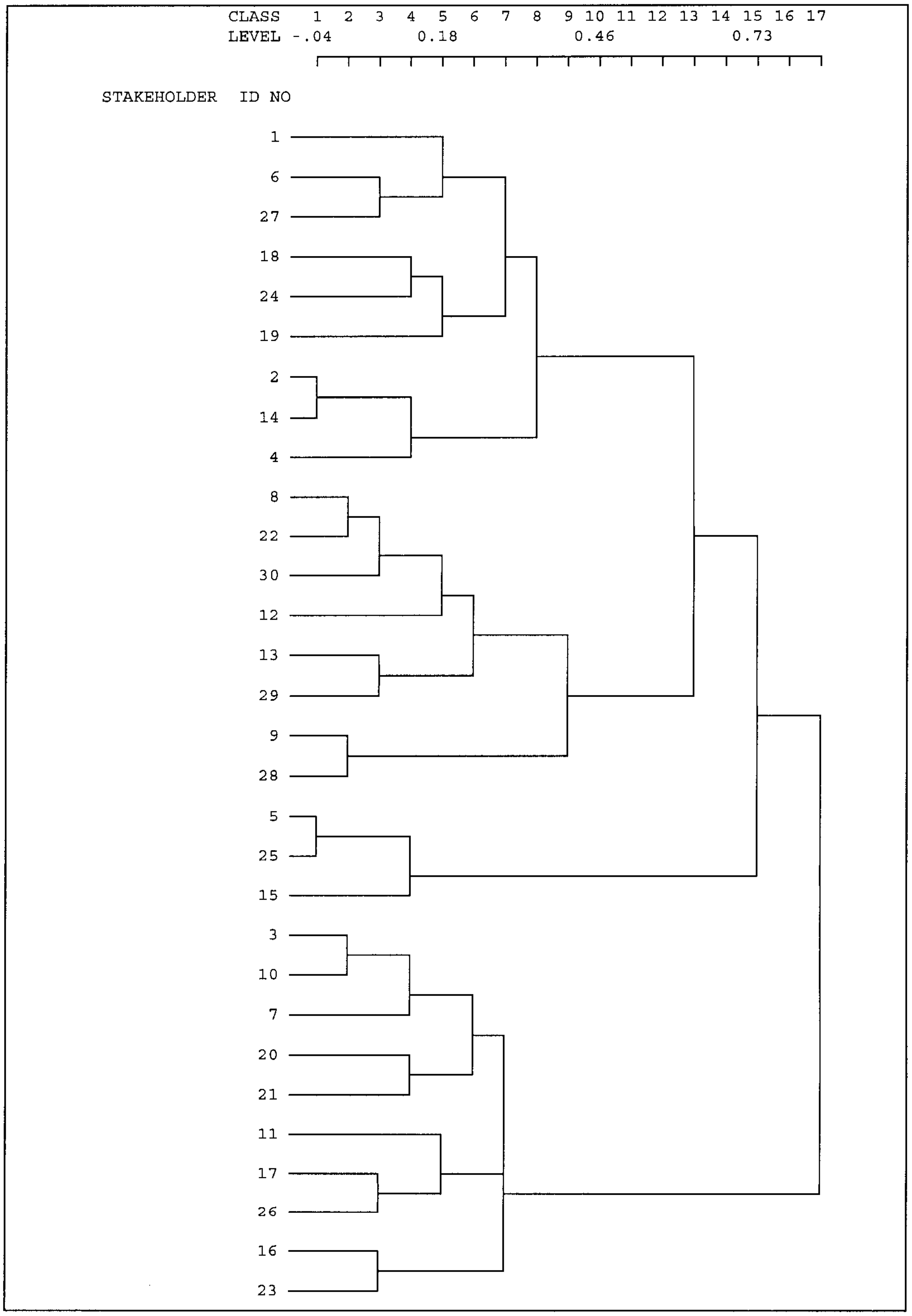


Figure 5.15 Hierarchical cluster analysis dendrogram using complete linkage for Kappa.

Cluster Variable	**Four Clusters**		**Six Clusters**		**Nine Clusters**	
	Chi	Sig	Chi	Sig	Chi	Sig
Years lived on island	11.806	0.46	16.667	0.407	35.667	0.300
Outdoor activities	26.940	0.08	20.118	0.215	36.311	0.275
Member of outdoor organisations	10.075	0.34	11.188	0.513	17.500	0.827
Days a month spent outdoor recreating	6.757	0.66	11.369	0.498	21.857	0.588
Self identified outdoor recreation rank	4.673	0.86	5.590	0.935	10.149	0.994
Age	17.837	0.12	19.286	0.254	40.167	0.152
Income	9.067	0.43	11.333	0.501	15.067	0.477

Table 5.16 Chi-squared statistic based upon multiple clusters created by Kappa

Results presented in this Section were disappointing. Attempts to break stakeholders into groups based on univariate as well as multivariate analysis did not reveal any explanatory insights. There was no evidence of a trend to suggest that stakeholders with very similar experiences, similar socio-economic backgrounds or similar familiarity with Galiano Island would have similar valuations. These results contrast with the literature. Craik (1975) found that people with similar backgrounds and personalities exhibited similar land valuations and preferences. Dearden (1984) also found differences between his subject groups, especially between the environmental group and the planners and other who were not a member of an environmental group. Van der Berg, 1999 suggests that groupings based upon socio-economic status and age are informative with respect to landscape preferences. However, Dearden (1984) found that socio-economic variables were not significant determinants. It was possible to break stakeholders into visually obvious groups based on the matrix of measures of similarity (notably for Kappa), explanation for what determined group membership remains unknown for this Case Study. Does this make the efforts to group stakeholders as reported above invalid? This Case Study does not allow this question to be answered. The methodology must be applied to other cases studies, a subject explored further in the concluding chapter.

5.7 Comparing Holistic Valuations to What is "on the Ground"

So far, the collaborative land valuation SDSS has facilitated allowing stakeholders to view their own responses, to compare their responses to other stakeholders' responses and to measures of "average response", as well as to attempt to group stakeholders based on valuations and background data in an attempt to identify logical groups or "obvious valuation positions". So far, no attempt is made to compare land valuations to what actually is found on the ground.

5.7.1 Identifying what attributes influence individual valuations

A question stakeholders and decision makers may be interested in is to find out exactly what types of land use, land cover, land characteristic or other measure of land the different valuations focus on. This can easily be achieved by facilitating digital visual overlay of individual, paired or averaged valuations with thematic map layers stored in GIS. This could be facilitated for the case study by allowing visual digital overlay of valuations with any of the data layers made accessible by the Island Trust, or available from any other source.

Of more interest and challenge would be to attempt to identify what attributes of land stakeholders thought influenced their individual valuations, whether these attributes could be mapped, and whether these attributes could be combined into a multiple weighted overlay as advocated by the reductionist school of thought introduced in Chapter Two.

Part of the questionnaire survey attached to the valuation exercise asked stakeholders to identify what variables they thought influenced their valuation, listing them in rank order. In total, the 30 stakeholders listed 125 variables. After taking into consideration spelling differences and intuitively similar categories, this list could be collapsed to 16 common variables (see Table 5.17). All stakeholders listed at least 2 variables. Over 40 percent were able to list in rank order at least five variables (see Table 5.18).

Variables	**Variable 1**	**Variable 2**	**Variable 3**	**Variable 4**	**Variable 5**		**Total**
Accessibility	1	6	1	4	4		16
Beauty	10	1	2	1	1		15
Activities		2	5	3	1		11
Views		4	5		2		11
Isolation		4	3	3	1		11
Water	4	4	2				10
Beaches	4	1	2		1		8
Aesthetics	2		2	2			6
Untampered	1	3	1	1			6
Flora/Fauna				5	1		6
Forests	2	1	1	1			5
Nature	4		1				5
Topography	1	2	1				4
Variety		2		2			4
Fun				1	2		3
Protected Areas	1	1					2

Table 5.17 Variable list by variable ranking.

Number of variables	No. Stakeholders	Percent
1	32	100
2	32	100
3	28	87.5
4	24	75
5	14	43.75

Table 5.18 Number of responses by variable

It is of interest to compare the list of variables in Table 5.17 to the same list produced by the students for the study reported in Chapter Four (Table 4.7). "Accessibility", "water features" and "aesthetics" are once again seen as important. Unlike the previous study the stakeholders this time did however manage to generate a sufficient split between those who mentioned "beauty" (15) and those who mentioned "aesthetics" (6) to keep these two apart (they were collapsed into one category in the previous study). Given that Galiano is an island, it did not come as a surprise that "water" and "beaches" were frequently mentioned as defining variables. Two variables the stakeholders list this time that were not prominent in the Okanagan studies were "views" and "isolation". "Views", of course, are difficult to identify and map on a two dimensional orthophotomap or map, and "isolation" is another variable that lacks a defensible manner in which it may be presented. Inclusion of either variable in holistic valuation as conducted here requires thorough familiarity with the Geography of the region under consideration. The general definition of outdoor recreation presented must be seen to influence the number a diversity of the variables presented by the stakeholders.

Table 5.19 identifies the thematic data layers that were made available to the study by the Island Trust, and how they *may* represent any of the sixteen variables listed in Table 5.17. Few if any of the layers supplied by the Island Trust directly match the attributes identified by the stakeholders to have guided their valuation exercise.

Variables	**Islands Trust Datasets**
Accessibility	Roads/logging roads
Beauty	?
Activities	?
Views	?
Isolation	?
Water	Water line/lakes/rivers
Beaches	Beach access
Aesthetics	?
Untampered	?
Flora/Fauna	?
Forests	forests
Nature	?
Topography	DEM/ contours
Variety	?
Fun	?
Protected Areas	Parks

Table 5.19 Stakeholder variables and potential Islands Trust datasets

Only six of the sixteen variables could meaningfully be shown using available data, namely: accessibility, beaches, water, forests, topography, and protected areas. The remaining variables all represent elements that do not translate into available geographic entities. This is a point worthwhile reflecting on since it emphasises the fundamental difference between a holistic and a reductionist way of land valuation. Given the poor match between thematic data layers available for Galiano Island and the attributes identified by stakeholders to be important when valuing land, there was little to be gained by going on to attempt a multiple weighted overlay. However, a number of interesting lessons were learned when attempting to collect data to facilitate multiple weighted overlays that are shared below.

5.7.2 Pairwise comparison of attributed to facilitate multiple overlay

Facilitating a multiple layers weighted overlay as advocated by the reductionist school of thought requires that each of the layers to be combined be assigned a weight. Information was gathered from the Galiano stakeholders in an attempt to calculate meaningful weights. Following on from the initial Okanagan study, stakeholders again were asked pairwise to compare and rank the perceived importance of all variables they identified to have contributed to their valuation. This was achieved by using a PC with the AHP software installed. The ranking scale is presented in Figure 5.16

Stakeholders on Galiano Island completing the survey struggled with this pairwise comparison exercise. Many (70%) requested additional verbal instructions in order to complete this part of the survey. They commented that this was a "difficult" part of the survey. This pairwise comparison therefore caused some difficulty.

It is recommended to conduct consistency evaluations when soliciting information by pairwise comparisons. Following two examples demonstrate the difference between a consistent and an inconsistent pairwise comparison response:

Case 1 – Consistent Pairwise Ranking	**Case 2 – Inconsistent Pairwise Rankings**
A is preferred to B	A is preferred to B
B is preferred to C	B is preferred to C
A is preferred to C	C is preferred to A

A consistency index can be created which measures the percentage of times that a subject makes an inconsistent comparison. Figure 5.17 shows the consistency scores for all 30 stakeholders. The two solid horizontal lines show the 90% and 80% consistency levels respectively. Approximately 40% of the stakeholders scored perfect consistency, with 17 stakeholders (approx. 60%) scoring 90% consistency or higher. In total 9 stakeholders scored consistencies below 80%. The outlier at the bottom left of Figure 5.17 represents an individual who only offered very few variables and scored these highly inconsistent.

The literature suggests methods for removing inconsistencies from pairwise comparisons after survey completion (Yager, 1979; Saaty, 1980, 1987). This type of removal does, however, change the response patterns and alters the data in such a way that they no longer truly reflect what was judged. Removal of inconsistencies to facilitate subsequent analysis therefore was rejected as valuable for the Collaborative Land Valuation SDSS. Instead, a decision was made simply to remove pairwise rankings supplied by all stakeholders who scored a consistency index of 80% or less. This implied that the following exercise only took into consideration responses from 21 stakeholders. The cut-off at 80% was deemed suitable given visual inspection of the distribution of the index. It is recognized that this cut-off is somewhat subjective and that the imposition of this type of arbitrary cut-off may take away from the trust and

Comparisons

1. Select the appropriate entry from the selection menus below.
2. Press the **Finished** button at the bottom to continue with the exercise.

How would you describe the **relative importance** of the following criteria / variables with respect to **Outdoor Recreation**?

VARIABLE A	COMPLETELY dominates	VARIABLE B
	DOMINATES	
	is FAR MORE important than	
	is MUCH MORE important than	
	MORE important than	
	SOMEWHAT important than	
	SLIGHTLY MORE important than	
	a LITTLE MORE important than	
	EQUALLY important than	
	a LITTLE LESS important than	
	SLIGHTLY LESS important than	
	SOMEWHAT LESS important than	
	LESS important than	
	MUCH LESS important than	
	FAR LESS important than	
	DOMINATED by	
	COMPLETELY dominated by	

Finished RESET

Figure 5.16 Example of the pairwise ranking scale.

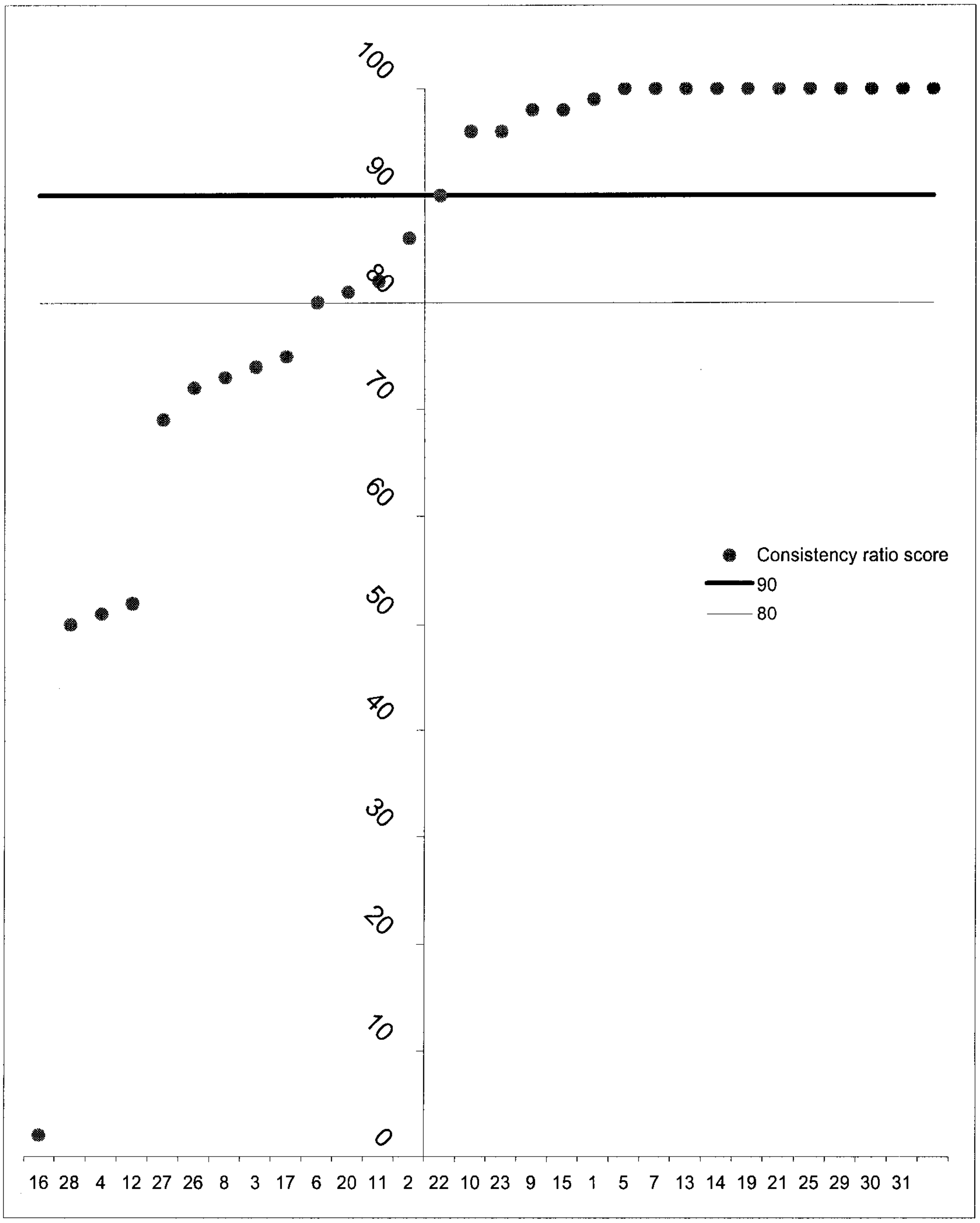


Figure 5.17 Consistency ratios for Galiano Island stakeholders

confidence that stakeholders may place in this type of SDSS. The danger exists that stakeholders dissatisfied with the final outcome of consensus building will use this type of arbitrary cut-off to argue that the process was flawed. The above observation is a consideration that merits further study.

Table 5.20 shows how pairwise comparison scores could be used to derive weights for each layer. Following steps are required:

- Step 1: Take the pairwise comparison score of the variable for each stakeholder
- Step 2: Sum the score by variable
- Step 3: Calculate each variables score by dividing the total for all variables by each independent variable. This step creates a weight for each variable.

Table 5.19 shows a hypothetical calculation of these weights. In this example variable 1 (Var1) would have a comparative weight of 38.7, whilst Var2 would be 24.7. In a map algebra environment the resultant weighted over lay would be represented by the following:

$$0.387\ (Var1) + 0.247\ (Var2) + 0.189\ (Var3) + 0.104\ (Var4) + 0.072\ (Var5)$$

Stakeholder	Var1	Var2	Var3	Var4	Var5
1	29	16	46	9	
2	29	43	13	11	2
5	50	50			
6	20	20	14	27	20
7	20	20	20	20	20
9	20	17	29	34	
10	43	17	35	5	
11	65	18	6	11	
13	50	50			
14	71	14	14		
15	43	12	35	10	
19	20	20	20	20	20
20	10	4	39	17	29
21	33	33	33		
22	11	33	19	14	23
23	68	18	14		
25	50	50			
29	24	24	24	25	3
30	24	24	24	5	24
31	75	25			
32	56	11	11	11	11
	811	519	396	219	152
Weights	**38.7%**	**24.7%**	**18.9%**	**10.4%**	**7.2%**

Table 5.20 Variable list showing comparison scores and weights.

As already noted, weights derived using the above technique ended up not being used to create a multiple weighted overlay given lack of access to suitable data to act as surrogates for attributes identified by the stakeholders to be of importance when valuing land holistically.

5.8 Comparing Holistic Valuation to Appraised Land Values

The information of potential interest to stakeholders when attempting to reach land valuation consensus, is data about actual or appraised value of land. An attempt has been made, therefore, to facilitate access to information about appraised or actual market value of land for Galiano Island. Access to this information will allow stakeholders to compare individual and averaged land valuation for outdoor recreation and tourism to land values determined by the market.

Over 80% of Galiano Island is privately held and is appraised for market value for the purposes of property taxation. Appraisals are calculated by the BC Assessment Corporation (BC Assessment, http://bcassessment.gov.bc.ca/5_system/5_his.html). Appraisals are based upon market value defined as:

> "... the price expected if a reasonable amount of time is allowed to find a purchaser and if both seller and prospective buyer are fully informed. For assessment purposes in British Columbia, market value is the most probable price that an unencumbered property would sell for on the open market on July 1"

(BCAssessment,http://bcassessment.gov.bc.ca/5_system/5_real.html)

Market value is calculated by "generally accepted appraisal principles" taking into account land variables such as location, property size, topography, fertility, use, shape, types of structures added, their replacement cost, their age, their condition, rental income, sales of comparable properties in the area, and "any other factors that might affect the property's value" http://bcassessment.gov.bc.ca/5_system/5_real.html. BC Assessment employs three main approaches to value: Direct Comparison, Cost, and Income.

Appraisal by direct comparison is based upon the assumption that a buyer would pay the same for two comparable properties. Of course, it is rare that two properties are exactly alike. Adjustments therefore are made to take into account differences based on the factors listed above.

Appraisal by cost is based primarily of the costs of building or replacing the buildings on a property; in this case a general equation is employed:

Value of Land + Cost of Improvements – Depreciation = Total Value of Property

This type of appraisal is used primarily for assessing value of new properties http://bcassessment.gov.bc.ca/3_val/3_app.html.

Appraisal by income uses income to determine value in cases where income revenue is an overriding or the most significant component determining value of a property.

It is common practice to split appraised value into value of the land, value of structures on the land, and total value combining the two. It also is common practice to differentiate between appraised values for personal use vs. value for commercial use. Appraisals do not allow separation of value for individual themes like value for outdoor recreation or tourism vs. value for agriculture vs. aesthetic value, … .

Appraised values are argued to be objective and replicable, and to represent a fair value that the market must pay to purchase land irrespective of what the land is to be used for. Land to be purchased to be set aside for outdoor recreation or tourism, therefore, must be purchased at market value, not at estimated value for purposes of outdoor recreation or tourism. The latter observation validates why information about appraised market value is important to be made accessible to stakeholders and decision makers valuing land for outdoor recreation and tourism. A further example demonstrates this point. There have been a number of initiatives to purchase lots of land on Galiano Island to turn into park land and to prevent further logging or residential development. Matthews Point is an example. It encompasses some of Galiano's most spectacular land, which includes

> "...spectacular bluffs, garry oak meadows, rare dry zone vegetation, essential eagle and migrating bird habitat, a large portion of natural forest and a quarter-mile long sand beach along Active Pass."
>
> (http://www.conservancy.bc.ca/Projects/CRD/mathews.htm).

The landowner has agreed to sell the land to the Land Conservancy of British Columbia rather than develop it. It is accepted, however, that the Land Conservancy will have to pay for the land fair appraised market value taking into consideration potential logging revenue and subdivision potential.

Figure 5.18 shows property boundaries for Galiano Island. Figures 5.19 and 5.20 show total appraised value and appraised value for land only (not including structures) respectively. Table 5.21 reports descriptive summary statistics. Figure 5.21 illustrates the frequency distribution of the appraisal data.

	Minimum	**Maximum**	**Range**	**Mean**	**Std Dev**	**Skewness**	**Kurtosis**
Total	0	1948600	1948600	248480.8	195466.2	3.09	16.54
Total Land	0	1620000	1620000	179843.3	154246.3	3.78	23.48

Table 5.21 Descriptive summary statistics for total land value and land only value

Figures 5.18 and 5.19 can easily by visually or topologically overlaid on any individual or averaged valuation maps introduced earlier on. Cursory visual inspection of such overlays suggests spatial correlation between appraised land value and land valuation for outdoor recreation. For example, highest value tends to concentrate at the northern most tip of the island, near Dionisio Point provincial park, as well as the south eastern end, close to the Mount Galiano and Active Pass.

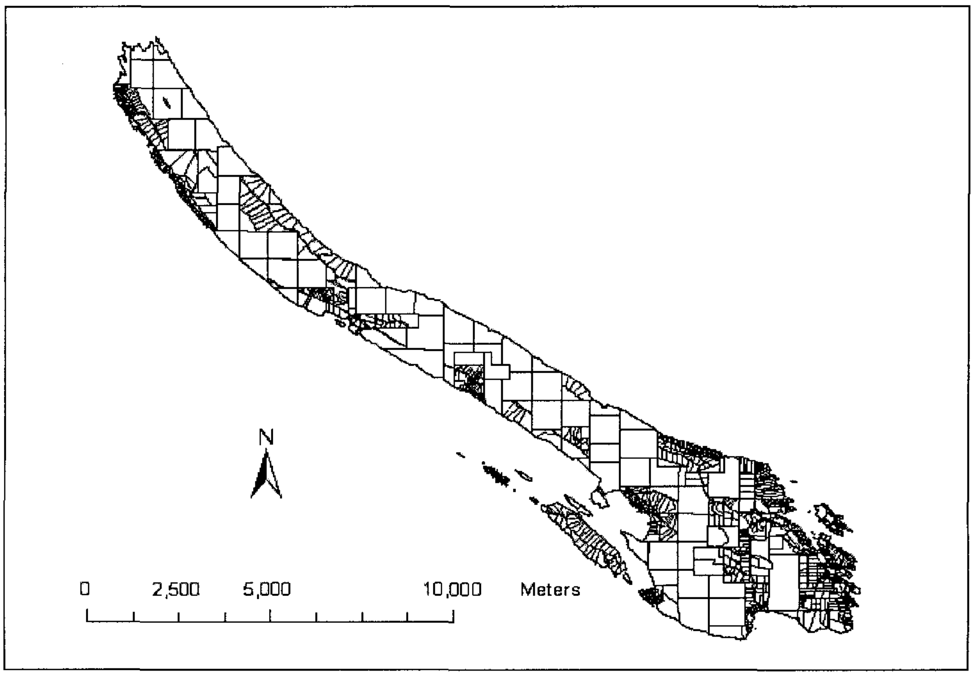


Figure 5.18 Lot boundaries of Galiano Island

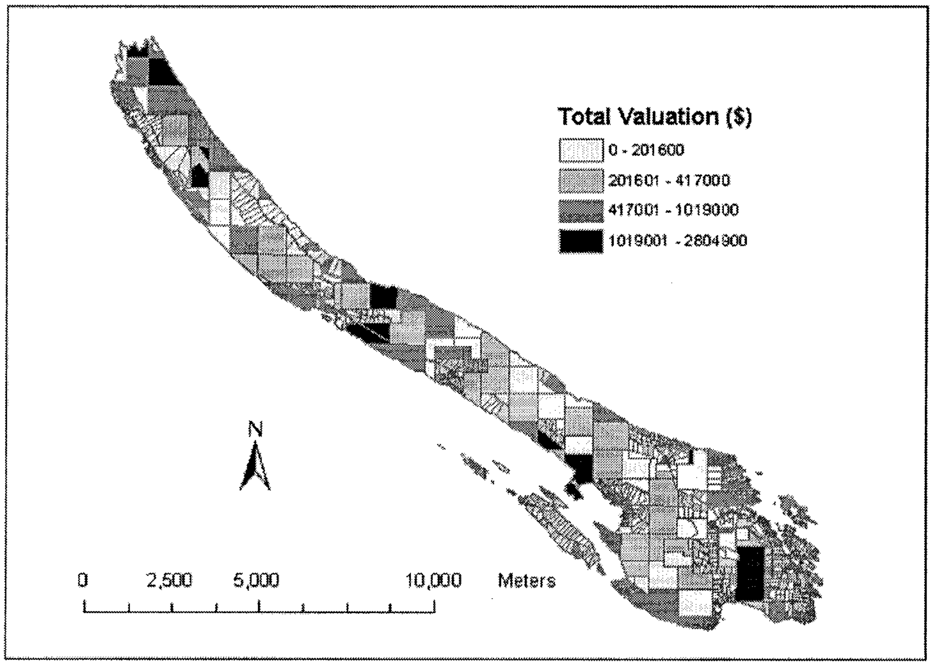


Figure 5.19 Total valuation by lot for Galiano Island

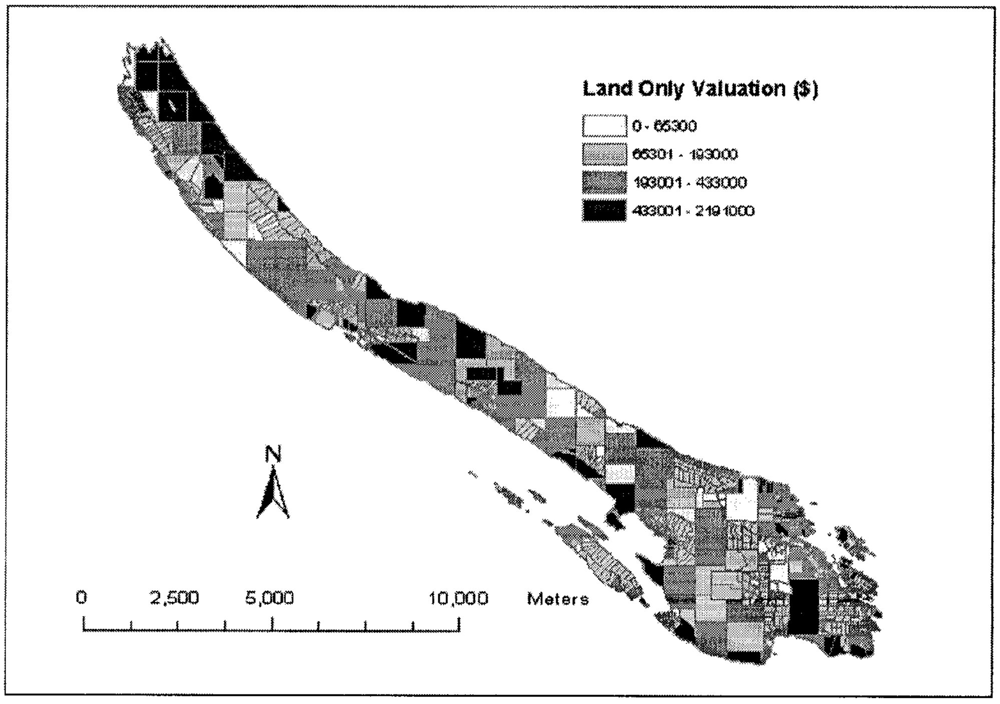


Figure 5.20 Land only component of valuation by lot for Galiano Island

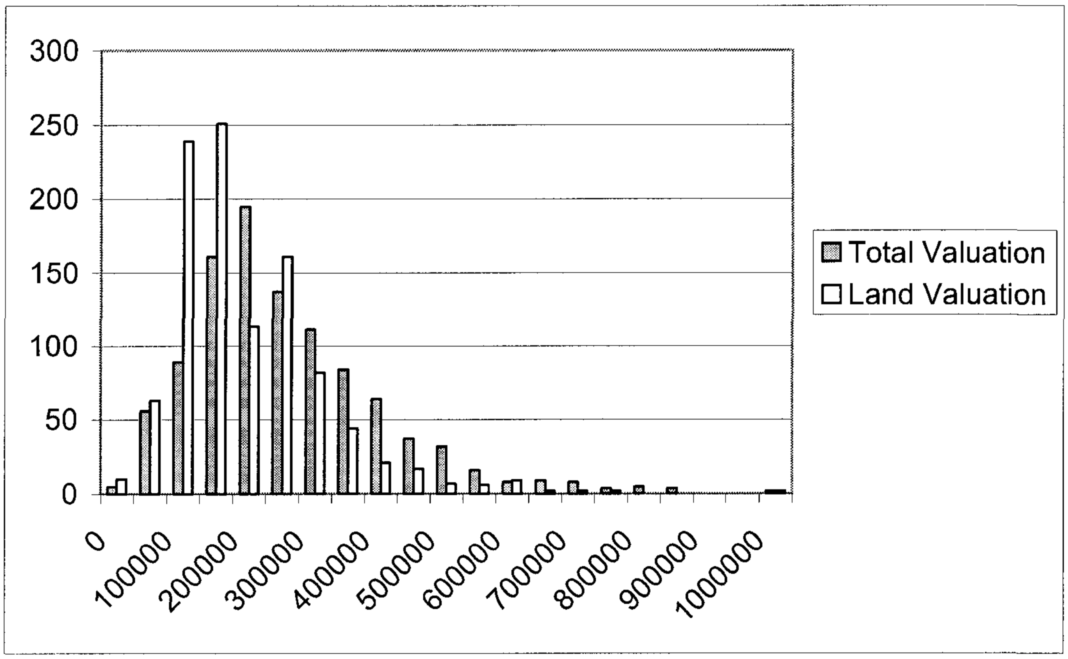


Figure 5.21 Frequency distribution of total and land only valuation.

Such visual comparison, whilst valuable as a first step, of course does not allow meaningful and scientifically defendable comments to be made. The latter can be achieved by a statistical comparison through topological overlay. Pixel by pixel comparison reported on a scatterplot as well as subsequent reporting of a simple Pearson's r provides easily understandable statistic, which can explain the level of association between the maps. Such a scatterplot comparing the stakeholder mean value map (Figure 5.3) with the total appraisal map (Figure 5.19) is shown in Figure 5.22. The associated Pearson's $r = 0.11$ is a statistically significant at the 95% significance level (note that a low value of r that still is statistically significant is expected given the large number of cases compared [n-35,000]).

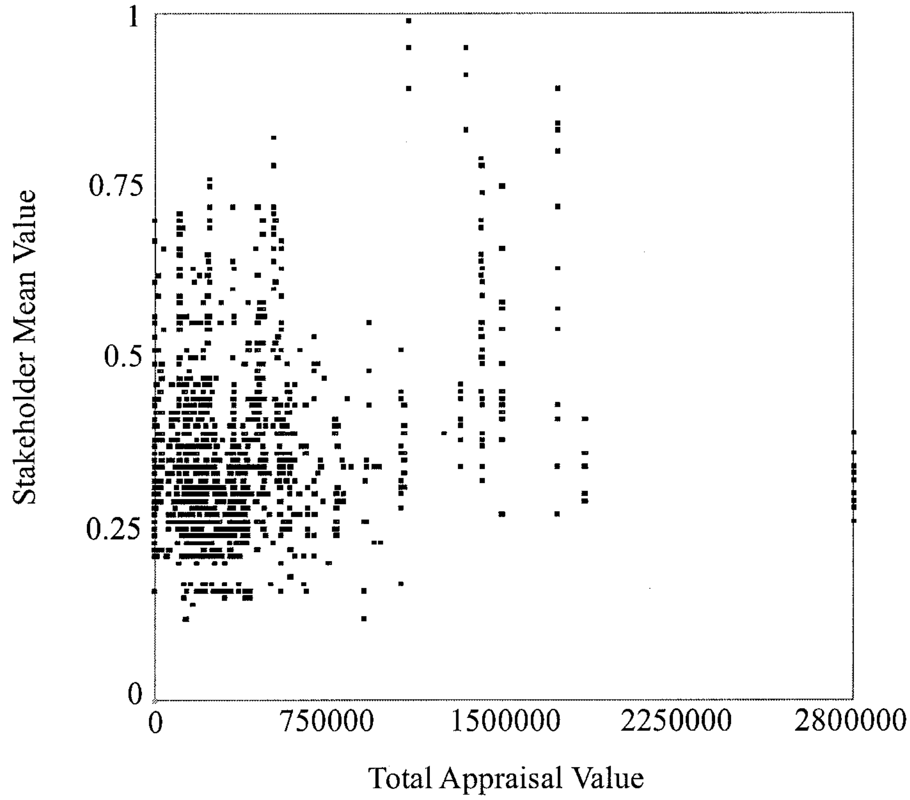


Figure 5.22 Scatterplot of total appraised value by stakeholder Mean value.

Of course, Pearson's *r* assumes that each case is statistically independent from any other case, a condition that is violated given spatial autocorrelation inherent in any geographical data. Spatial autocorrelation using Moran's statistics reports a value of 0.91 for total valuation and 0.98 for the stakeholders' mean map suggesting considerable spatial autocorrelation (Goodchild, 1986). The real value of calculating and reporting a Pearson's *r* therefore is questionable. Anyhow, reporting spatial correlation and autocorrelation statistically is complex and requires considerable numerical literacy and statistical training. It is perhaps unreasonable to assume that stakeholders and decision makers will have the necessary statistical background or patience to gain familiarity with the intricacies of these measures and it should be anticipated, therefore, that visual overlay for specific areas of interest, as well as inspection of scatterplots as shown in Figure 5.22, will be the primary information pieces used in this part of the collaborative land valuation SDSS. The conclusion is that it is valuable for the Collaborative Land Valuation SDSS to facilitate stakeholders and decision makers to call up maps of appraised land valuations, and to facilitate their visual comparison against maps of holistic land valuation, but that elaborate reporting of spatial statistics measuring strengths of correlation and association is not worthwhile.

5.9 Discussion

This Chapter has reported the application of the holistic land valuation using Galiano Island as a case study. The original plan was to commence with stakeholder identification, to collect stakeholder valuations, to package the valuations and associated information products reported in Sections 5.3 through 5.8 in a Collaborative Land Valuation SDSS, to identify logical grouped stakeholder positions, and thereafter to bring the stakeholders to the table to use the CSDSS to build a single consensus map of land valuation for outdoor recreation and tourism for Galiano Island. The latter was though to be important to test the validity of the CSDSS and its associated information products in a real-world consensus building scenario.

Things did not work out as expected. It proved more difficult than anticipated to get stakeholders to participate in the original survey. Thirty stakeholders did come forward and participated willingly and enthusiastically. However, it became clear that while they were interested in participating to learn and contribute, they did not perceive there to be a real planning issue or controversy. In other words, they were "stakeholders with little at stake". As well, no logical stakeholder groupings or clearly identifiable and opposing valuation positions emerged around which to build a consensus process. In other words, there was no issue that had to be resolved; there was no case that needed consensus building. There therefore was no valid reason to request the original thirty stakeholders to come back to the table to use the CSDSS to reach a consensus.

Did this imply failure? While it did not allow for the CSDSS to be tested, it did facilitate further evaluation of holistic land valuation, it did facilitate evaluation of the orthophotomap as a surrogate for the real land, and it did allow for production and evaluation of considerable number of information products to be used by stakeholders and decision makers in consensus building.

Recognizing that it would be ideal to have opportunity to test the CSDSS in a real world controversial case study that would require genuine building of consensus amongst stakeholders, the researchers searched for a suitable case study to proceed. None availed and real world testing of the consensus building component of the CSDSS remains for another day.

A number of observations and conclusions could however be drawn from the Galiano case study. They are reported below.

5.9.1 Orthophotomaps vs. Topographic Maps

Chapter Four and O'Connell and Keller (2002) suggested the use of orthophotomaps instead of topographic maps as generalised and abstracted models of reality to be used in holistic land valuation. All the Galiano stakeholders found the orthophotomap clear and easy to use and understand. As already noted earlier in the chapter and reported by Keller and O'Connell (2000), the orthophotomap provides the answer to requests by students in the previous experiment for a more visually appealing and less abstract geographic representation of the area under investigation.

Cartwright (1996) noted industry disappointment with orthophotomaps commenting that orthophotomaps

> "...either did not practically provide the products promised or were not accepted by map users, leading to their eventual dismissal as technological gimmicks or something that was seen to be inferior to existing paper products. "

The findings disagree. The Galiano stakeholders unanimously found the orthophotograph to be a straightforward representation of their island. They commented that they found the orthophotograph to be interesting and intuitive to use, demonstrating the points raised by Nale (1995). The key benefit of an orthophotomap appears to be that it actually shows what is on the ground without cartographic symbolization, abstraction and omissions. In other words, it allows one to see what is actually on the ground rather than "an interpretation of what someone else thinks you want to know" (Fowler, 1999), and one that is more intuitive (Strand, 1999). Based on findings from the Galiano study, Keller and O'Connell (2000) have gone as far as to challenge that the orthophotomap should be considered as a future substitute for topographic maps in many other applications. Such a discussion is beyond the realms of this thesis.

There are drawbacks to using orthophotomaps that must also be recognized. Notable are that they do not show place names, and that many orthophotomaps are poorly produced clearly showing mosaic lines. In addition, while a considerable body of research has investigated how users employ and interact with topographic maps (DeLucia and Hiller, 1982; Woodward 1982; Castner, 1983; Kumler and Buttonfield, 1999), little is known about how users employ, interpret and process orthophotomap information. Considerable further empirical research is needed in this area.

5.9.2 Stakeholder vs. Planner Driven Land Valuation

In Chapter One the following research question was introduced:

> *To what extent can local stakeholders take the lead in land valuation processes?*

Research presented in this Chapter demonstrates that stakeholders and users of the land are comfortable with and perfectly capable of producing land valuation maps, and that their results are reasonably consistent and based on sound judgement. Stakeholders were able to identify what criteria they used to value land. It is of interest to note that these criteria are not the same criteria that make up thematic data layers traditionally collected to determine value of land for land use planning and natural resource management purposes. Stakeholders' valuation criteria were more vague yet inclusive, including criteria like "aesthetics", "beauty", "scenic views", "wilderness" and "access". In other words, all stakeholders in the Galiano Case Study had issues with producing a list of valuation criteria that could readily be modelled in a traditional layered GIS approach – an approach employed for over 30 years in planning.

A number of stakeholders in the Galiano study had participated in previous planner driven studies. These individuals made a point of noting that layered GIS the manner in which the planners presented evidence to them was confusing, and that they saw great value in the holistic approach introduced. This questions whether it is the natural resource data available in GIS or stakeholders' values should drive a land valuation process. The research presented here does not argue that stakeholders' values should be used in a vacuum, but rather that they have at least equal value, and that they should be employed in conjunction with evidence used and presented by traditional reductionist land evaluation means. The conclusion drawn therefore is that stakeholders can take the lead in a bottom-up land valuation process, and that it does provide a possible complement to planner led initiatives. This position concurs with Dearden's pragmatic and philosophical stance on the need to carry out public preference studies (1978, 1981) as well as answering in a positive manner his question (1981) on public participation desirability.

5.9.3 The role of GIS, SDSS and CSDSS

In Chapter One the following additional question was introduced:

> *Can stakeholder and expert opinions about the value of land for purposes or activities difficult or impossible to quantify in monetary terms be combined to yield an aggregate value statement by taking advantage of advances in GIS, SDSS and CSDSS?*

Evidence presented in this Chapter as well as Chapter Four clearly leads to the conclusion that this question may be answered in a positive manner. The ability to amalgamate individual valuations into average and aggregate valuations using GIS and integrated into SDSS has been demonstrated successfully on many levels. Whilst a number of statistical limitations underlying some of the aggregation techniques have been identified, the study on Galiano Island offered a number of techniques side-stepping these statistical limitations. Numeric and visual aggregate value statements have been produced employing averages and distribution around the averages.

Statistical methods have been demonstrated to offer insights into levels of consensus and divergence.

5.9.4 Stakeholder vs. Planner Driven Land Valuation

A third question introduced in Chapter One noted that:

> *Are there significant differences in land values identified by different stakeholder groups?*

The answer to this question remains inconclusive based upon the results presented in Chapter Five. A number of techniques were presented to identify logical stakeholder groups based on their individual valuations as well as background data volunteered. It did prove possible to divide valuations into clusters especially when performing cluster analysis on Kappa values. However, interpretation of these clusters proved problematic for the Galiano study, and no logical groupings emerged when exploring univariate and multivariate clustering of background data.

Appropriate selection of stakeholders in any land valuation or land management scenario is a recognized problem that still provides an active research interest (Yu, 1999; Harrison and Quershi, 2000). The research into stakeholder involvement in planning and decision making has a long tradition going back over 30 years (Jackson, 1997) It is recognized and viewed as an intrinsic part of the planning milieu (Gunton, 1991; Gunton & Vertinsky, 1991; Abs, 1991; Grimble and Wellard, 1997). But how to identify, define and bound stakeholder groups, and how representatives from the various stakeholder grouped should be identified for participation, remains illusive (Dearden, 1978, 1981; Yu, 1999; Harrison and Quershi, 2000).

An opportunistic approach was used to identify stakeholders for the Galiano study. In the end, it had to be concluded that there was "little at stake" for the stakeholders who participated in the Galiano study, and that it remains unknown whether those who participated really were representatives of all stakeholder groups with an interest in land valuation for outdoor recreation.

The primary conclusion reached is that this Chapter clearly has demonstrated that it is possible to use statistical techniques to identify recognisable differences in land valuation positions where they exist.

5.10 Summary

This chapter has explored the ability of GIS driven capabilities to capture, analyse and visualise stakeholders' valuation positions. A multitude of decision support information products have been developed and evaluated. A logical sequence of their presentation, staring with visualization and evaluation of individual valuations and their comparison to average valuations, moving on to pairwise comparison of valuations, followed by logical grouping of valuations and their interpretation, and finally facilitation of comparison of valuations to traditional GIS natural resource databases and economic appraisal data has been suggested.

While it was not possible to test how all these decision support information products would be used by stakeholders in a real-world consensus building exercise, it was possible to use findings to answer three of the five research questions introduced in Chapter One. The remaining two questions will be investigated in the next chapter.

6. Design and Implementation Specifications

6.1 Introduction

The preceding three chapters have focused on presenting research efforts attempting to gather and integrate diverse sources of land valuation information data for consensus building and decision making. This chapter commences by discussing generic principles that ought to be considered when building a Collaborative Land Valuation SDSS. Twelve guiding design and implementation specifications are offered. A Section introducing what has been built today, and how it can be modified in the future to address the requirements of the these guiding specifications as technology advances and/or the need for application arises follows this.

6.2 A conceptual framework for the implementation and design of a web-based land evaluation process

6.2.1 Introduction

This section introduces a framework for the packaging and implementation of a Collaborative Land Valuation SDSS. The purpose of the CSDSS is to collect initial stakeholder valuation positions, to inform about these positions, and to facilitate consensus building by exploring modification to initial positions. Discussion focuses on both, design specifications and implementation procedures. Discussion is divided into three topic areas as follows:

- Implementation Milieu
- Data Collection
- Functionality, decision support and analyses

Figure 6.1 presents an overview of a conceptual framework for the material presented below, introducing some of the decisions that will have to be made in system design. The reader will find it useful to keep referring back to this Figure as they work their way through the twelve specifications that follow.

The bottom third of Figure 6.1 deals with the implementation milieu. Section 6.2.2 offers four design specifications to be considered here. The middle third of Figure 6.1 addresses data collection, discussed in detail in Section 6.2.3, where four additional specifications and one observation are offered. The top third of Figure 6.1 is discussed in Section 6.2.4, dealing with decision support and consensus building functionality of the CSDSS. Four specifications are suggested here.

The three experiments conducted during the research differently influenced the design of the conceptual framework. The original experimental design flow diagram is presented in Figure 2.7. It illustrates the development and goals of each experiment. The following is a brief summary of what was achieved by each experiment and how these achievements shaped the conceptual framework in Figure 6.1. Detailed results have already been summarised within the relevant chapters.

6.2.1.1 Implementation Milieu

The researcher was retained as the role of facilitator for all of the experiments. There were issues of representation, based upon both the size (four subjects) and composition of the sample size (all tourism experts). Experiment Two built upon this, by increasing the sample size to 71 but not addressing the representation issue. The final Experiment attempted to be implemented in a manner to address a 'real-world' land valuation problem, but none was available. It employed stakeholders with a selection process that took the broadest definition of stakeholder (Grimble and Wellard, 1997) with an open invitation to all to participate. The results raised issues about stakeholder selection, privacy concerns, and increased participation possibilities via new technologies.

6.2.1.2 Data Collection

The data collection source for the first two experiments involved the use of a topographic map. These maps were then manually digitized. The final experiment employed an orthophotograph, based upon the requests for a more photo-realistic representation of the land being valued. Experiment One employed a traditional paper-based questionnaire. The remaining two experiments employed a web-based survey in order to improve data collection time. These two also investigated variables that could be employed in a traditional map overlay process.

6.2.1.3 Functionality, Decision Support and Analyses

Experiment One provided little opportunity for detailed analysis or functionality to be explored based upon the limited number of subjects. Experiment Two enabled many analyses to be conducted, in particular the development of information products, indices of similarity, and group membership explorations. The thematic layer approach was investigated using subject identified variables and weighted overlay. The potential for decision support tools was examined by employing the Analytical Hierarchy Process. Visualization concerns were addressed, as was GIS functionality. Experiment Three built upon these information products. The stakeholders were able to use an orthophotograph as an acceptable surrogate for the landscape. Similar information products were developed. The final products were compiled into an interactive web site that enabled stakeholders to both examine and compare their own and others' maps. The final stages of the implementation were to include consensus-building and final input of the map within the planning milieu. This remains an unrealized aim of the final experiment.

6.2.1 Implementation Milieu

Specification 1 *Public participation is key to a successful planning process of land valuation and stakeholder selections should be based upon the premise that those who feel they are involved in the impacts of decision are the stakeholders.*

The need for community involvement in any planning exercise is an intuitively obvious truism to this researcher. Moves to integrate GIS with community involvement in planning presents an active research area often conducted under the labels of community mapping (Craig and Elwood, 1998; Elwood, 1998; Talen, 1999), PPGIS (Public Participation in GIS) (Barndt, 1998a, 1998b; Clark, 1998; Howard, 1998; Obermeyer, 1998; Shiffer, 1998; see also *Cartography and Geographic Systems* 1998, Vol. 24, No 2 and NCGIA Specialist Meeting of the Project Varenius - http://www.ncgia.ucsb.edu/varenius/varenius.html), Bottom-UP GIS (BUGIS) (Talen, 2000) and "Grassroots – GIS" (Elwood and Leitner, 1998; Leitner et al, 1998; Sieber, 1997, 2000). Many of the case studies presented under these labels are still primarily representative of top-down planning, where planners make available planning data for comments in community or "town hall" style meetings, and/or where planners solicit information or opinions from the public in "town hall" style meetings to be taken into consideration in the final decision making stages.

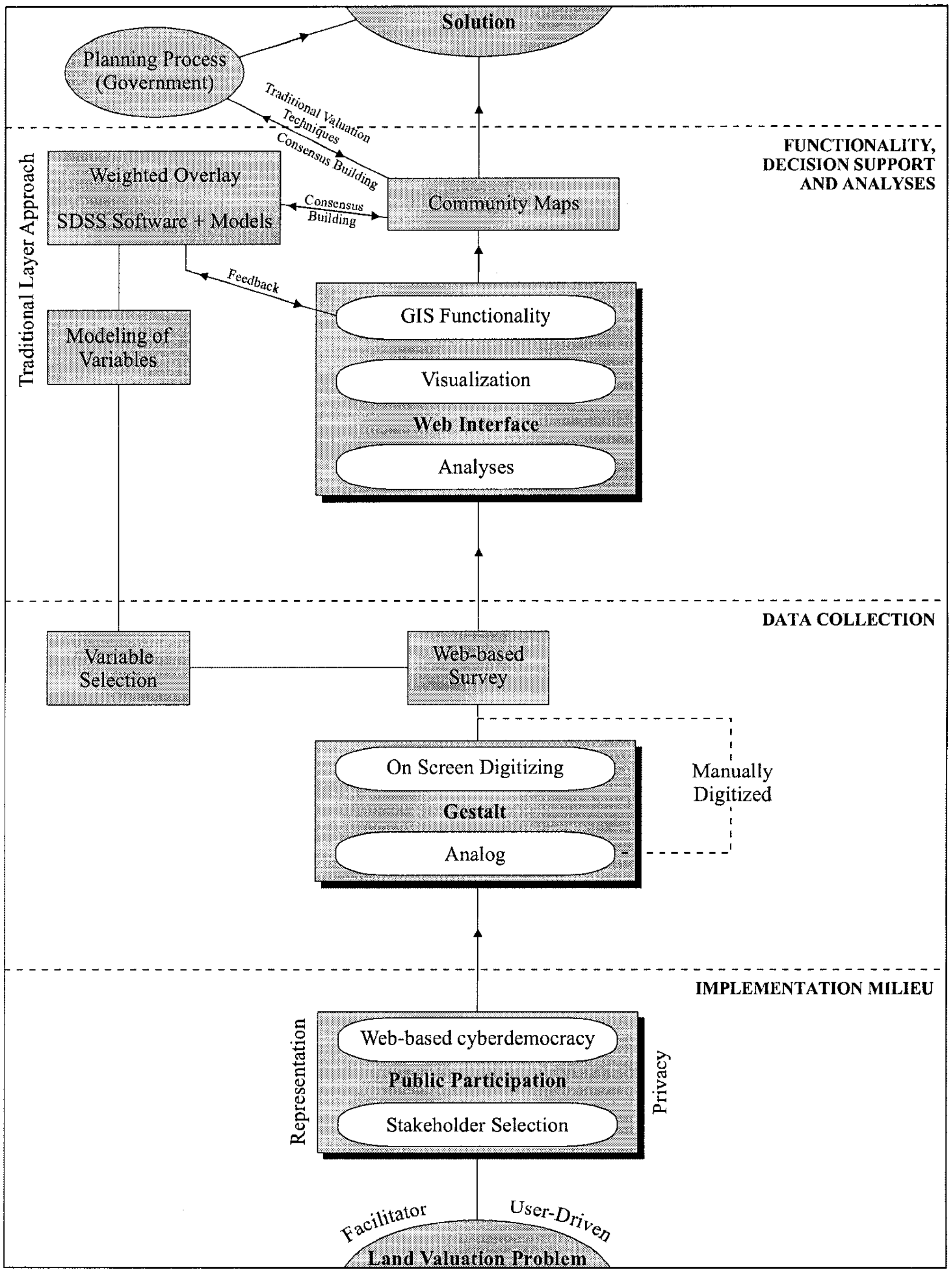


Figure 6.1 Conceptual framework for the implementation and design of a Web-based land valuation solution process.

A key assumption underlying the CSDSS proposed in this thesis is that land valuation should be a community and stakeholder driven process, and not an elitist planner driven exercise. The process therefore assumes some form of "public participation" that avoids a "top-down" approach. There exist different levels of public participation. Arnstein's (1969) seminal work on the ladder of public participation identifies the different levels (Figure 6.2). Her ladder makes the point that there are gradations of citizen participation ranging from non-participation to full empowerment. Arnstein (1969:217) concedes that her ladder is a gross simplification, but it provides a framework that enables the value of participation to be placed within a socio-political context.

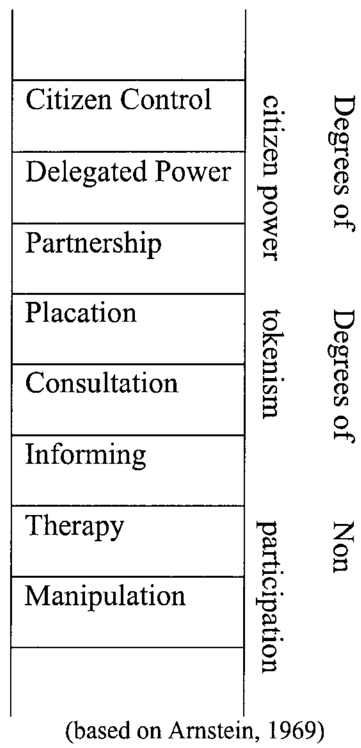


Figure 6.2 Ladder of citizen participation (Arnstein, 1969)

The aim of the CSDSS proposed here is to place participation as high as possible on the ladder, at the partnership level. The partnership rung was defined by Arnstein (1969: 221) as:

> "At this rung of the ladder, power is in fact redistributed through negotiation between citizens and powerholders. They agree to share planning and decision-making responsibilities through such structures as joint policy boards, planning committees and mechanisms for resolving impasses"

Land valuation tends to be issue based and initiated by some planning or conflict resolution process. In most cases, a valuation exercise will be planner initiated. The Partnership rung of the ladder acknowledges this, but argues that stakeholders should be equal partners in determining outcomes. Placing the participation at the next rung up, "Delegating Power", may be too high since it removes the planners from the decision making process, while moving a rung or two down to "Placation" or "Consultation" removes the stakeholders from true participation since they no longer have control over any outcome. They can suggest, but their suggestions may not be acted upon.

In summary, a Land Valuation CSDSS should be designed to facilitate an equal partnership between planners and stakeholders where the end-result is a consensus position based on exchange of initial positions, identification of averaged position, dialogue and subsequent adjustment of average position to consensus based final position.

The next logical step in the land valuation process is to identify the stakeholders that should be invited to the table to participate. Harrison and Quershi (2000: 13) argue that Governments "often have sound processes in place for identifying stakeholders". For example a local authority may approach a residents association, plus an environmental concern group and perhaps the local chamber of commerce to gather feedback and to identify an individual to come to the table representing each group. These individuals, then, may be argued to be representative of those who have an interest in the issue as well as, by default, the community as a whole. Selection of what interest groups should be invited to the table, and selection of an appropriate individual to represent each group is problematic and will inherently imply bias. The usual assumption is that every interest group can reach consensus on a position, and that a single representative will present and defend that unique position at the table.

The academic literature extensively presents the idea that everybody who believes they have a legitimate interest are a stakeholder and must be approached as such (Sewell and Coppock, 1977; Freeman, 1984; Grimble and Wellard 1997, Yu, 1999) and that participation should be based on self-selection without any *a priori* decision made about inclusion or exclusion (Dearden, 1981)

The process whereby a government agency initiates the stakeholder selection is argued to be the prevalent mode of selection since it has as its base the business model of stakeholder (Mitchell et al., 1997; Agle et al., 1999), and since most western democracies are representative democracies whereby the population vote for someone and then enable him or her without further consultation to make decisions based upon their best interests. However, the above justifications do not apply in the case of community level planning where broad and public participation is actively encouraged.

Community level planning and consensus building argues for the second approach to stakeholder selection, encouraging input from anyone who feels they are stakeholders. Proposed therefore is that the work discussed in this thesis use Freeman's

(1984:46) definition of stakeholders identified as "any group or individual who can affect or is affected by …", and that the proposed CSDSS therefore facilitate access through a process of stakeholder self-selection via widespread public announcements using various media.

Specification 2 *Limits imposed by the technological skills of stakeholders need to be appraised and minimised*

Design of any SDSS must take into consideration the technological skills and familiarities of the people who will be using the system. SDSS tend to be designed on top of GIS solutions since GIS excel in storage, manipulation, analysis and display of geographic data. However, a key argument advanced against the use of GIS in any planning milieu is that it is elitist (Pickles, 1995) because of its conceptual and user complexities. Some (Aitken and Michel, 1995) have gone perhaps a little too far by stating that the complexities of GIS are the reason that a top-down rationalistic and technicist approach to planning is maintained. Their position belittles the many genuine attempts made to integrate scientific and objective information technology into participatory planning processes. The dominance of GIS as a tool in planning practices does however raise a number of important theoretical issues with respect to its use by the public (Talen, 2000). Some note that GIS are used in planning to separate facts from values (Lake, 1993). Others take the diametrically opposed view, noting that GIS can combine facts with value (Heywood, 1990). The recommendation here is that GIS be used as a component of a larger CSDSS to facilitate the latter. In other words, the Collaborative Land Valuation SDSS should be an agent to allow value and facts to come together.

The main barriers to widespread use of GIS by communities, and what makes GIS elitist, are the technological skills necessary to use GIS as well as the outrageous pricing of the software and necessary hardware. However, both these limiting factors are changing. GIS has developed from command line driven software using cryptic syntax that was available only on expensive UNIX based operating systems to "click and drag" structured software using standardized syntax, able to run on common operating systems and average desktop/laptop computers. Price for software, unfortunately, continues to remain high.

Software improvements have brought with them the potential for more widespread and better use of GIS. However, even with increased user-friendliness, the assumption can not be made that all public participants in a land valuation exercise are (or wish to be) sufficiently computer literate to manipulate GIS based SDSS software. Carver et al. (2001) argue that computer skills still are not equal amongst social groups, and that having to manipulate software as part of a decision making or consensus building process can distract from the very process that the software is intended to facilitate.

The question beckons whether the CSDSS to be designed here should be "chauffeur driven" or "end-user" driven. An end-user driven approach implies that the public participants must complete all interactions with the CSDSS by themselves. They must enter their own data, quality control their own entries, build all information products, and perform all their own data manipulation steps to explore positions and to evaluate alternative solutions. It is highly unlikely that all participants in a land valuation process will have the necessary skills or the will to do this. In the foreseeable future, it is anticipated that there will always be participants in the valuation process who will actively seek to minimize their hands-on computer time. True spirit of participation requires that these individuals need to be catered for, and the CSDSS therefore ought to be sufficiently "chauffeur driven" to minimize participants' time spent doing routine computing tasks. In other words, computing technology should be taken advantage of to create powerful information products and to facilitate interactivity while minimizing the need for stakeholders to interact with it. Any routine computing tasks or background data processing is best done by those professionally familiar with the computing environment – the chauffeurs. This observation agrees with others who have researched how stakeholders should interact with SDSS (Canessa, 1997; Ceccato and Snickars, 2000). The recommendation, therefore, is that data entry and creation of resultant information products should be handled by professional systems people, and that interaction of stakeholders with resultant information products could be either "end-user" or "chauffeur" driven.

Specification 3 *Access to the CSDSS must be facilitated to the greatest number of stakeholders possible.*

A Collaborative SDSS, to be truly collaborative, must be as widely and easily accessible as possible. This may sound contradictory to the argument put forward under the previous specification where it was noted that the CSDSS should be at least in part chauffeur driven, which implies more limited access. The following discussion will try and explain how these two specifications may be reconciled.

It was noted when discussing the first design specification that most efforts at public participation in GIS take advantage of community or "town hall' style meetings

(Evans et al., 1999). However, they argue that public meetings are many times dominated by small and concerned interest groups who are able to express their views in a dominate and vocal manner. Healey et al. (1988) cited in Evans et al. (1999) argue that many individuals are hesitant in expressing their views in such public meetings and that they, therefore, do not become a part of the input and consensus building processes. To make a land valuation tool truly participatory and public, access to the methodology ideally should be to all members of the public in a manner that allows the quiet and timid to express their views as forcefully and equally as those comfortable arguing their point of view in public. Making parts of the CSDSS web-based is argued significantly to aid this step.

It is becoming more and more apparent that the technological skill sets of the public at large are increasing, and that the public (at least in the Western and Asian World) is embracing the Internet as part of everyday life. As long as the speed of acceptance and 'mainstreaming' of the Internet continues on its present course, web access know-how can soon be assumed as much as numeric and written literacy. One way to make the CSDSS under discussion as widely available as possible therefore is to take advantage of the web.

The integration of GIS with web-based technologies is an active research area. Web-based GIS did not exist at the outset of the research summarized in this thesis, yet it can be assumed with some certainty that, in a few years time, web-based GIS solutions will be the norm.

Taking advantage of the web for CSDSS access is not without concern. At present, access to the web is via computer by phone line or cable (with wireless access soon to be added). Spatial databases are large and require considerable computing power and bandwidth access for efficient web download and retrieval. This will penalize members of the public with low-end computers and those without access to cable Internet connection. There remains the risk, therefore, of continuing an elitist trend levied against GIS if the CSDSS is to be web-based. The only way to get around this is to assume that, through time, the playing field will level with even remote rural areas gaining high speed – broad bandwidth access to data transmission, and by assuming that computing power will eventually platform with most households having access to a computing environment of sufficient capacity to handle the demands of spatial data.

Another concern is the physical limitation of the average display monitor. Spatial data traditionally have been viewed through maps. Maps generally are large in order to show sufficient detail. Computer monitors come in set sizes – usually a fraction of the dimensions of a map typically used for land use planning and natural resource management. How can the same information traditionally displayed on large maps be communicated as efficiently and effectively on small monitors? Today's solutions lie in viewing an entire map coverage severely scale reduced, or viewing partial coverage by selective zooming and panning. These solutions represent a compromise. It may well be the case that tomorrow's home computer solutions will allow direct and low-budget wall projection instead of monitors, thereby facilitating display of map information much larger than for traditional maps.

Specification 4 *Privacy concerns must be addressed in an open and transparent manner, with stakeholders concerns to the fore.*

An interesting lesson learned from the Galiano case study was that many of the stakeholders raised the issue of privacy and confidentiality when participating in the land valuation exercise. Fear was expressed that opinions provided honestly and in good faith would end up being employed in a manner that it was not originally collected for, and that it might indeed be used against individuals in the future. Participants requested assurance of "privacy".

Privacy is difficult to define, encompassing as it does many subjective and personal connotations. However, in Canada it is recognised by the Supreme Court as important :

> "society has come to realize that privacy is at the heart of liberty in a modern state ... Grounded in man's physical and moral autonomy, privacy is essential for the well-being of the individual" (R. v. Dyment (1988), 55 D.L.R. (4th) 503 at 513 (S.C.C.). quoted in Information and Privacy Commissioner/Ontario report on Geographic Information Systems http://www.ipc.on.ca/english/pubpres/papers/gis.htm)

Fear publicly to express opinions and make value statements in case of future repercussions furthers the argument for web-based CSDSS since it is relatively straight-forward to implement procedures to ensure that no personal information identifying individuals is broadcast. However, the demand for privacy raises some interesting questions.

One of the assumptions underlying the CSDSS proposed here is that stakeholders be able, pairwise, to view and compare each other's opinions, be they textural or graphical and that valuation responses be combined into groups with identifiable membership. The assumption is that Individual X would be interested in knowing how similar or different her/his position is from Individual Y. This necessitates the need for stakeholders to allow their names to be attached to their valuation. Guaranteed anonymity therefore may be a barrier to better information.

On a more philosophical note, if a stakeholder is unwilling to take public ownership of their information, how important is their input? What is it that they have to hide? Are they playing games or do they have "hidden agendas". Should a consensus building process not be based on transparency? Answers to these questions are beyond this thesis.

What must be addressed, however, is how participants in a land valuation exercise can be ensured of an open and up-front information handling process that keeps them informed of their rights and obligations at all times. Participants must be able to understand in a transparent and open manner how their data are to be used, as well as having the choice to have that data removed or corrected at any point should this be requested.

Privacy issues should not provide a barrier to the collection and dissemination of data and information. However, stakeholders should be given opportunity to give informed consent as to how their information is to be used. Proposed is that the CSDSS contain an explicit section addressing privacy and confidentiality as well as outlining every step of the CSDSS process in a simple and straightforward language. Thereafter, protocols and guidelines need to be put in place to ensure that stated procedures and policies are adhered to in a consistent manner throughout all stages of the collaborative consensus building process.

6.2.3 Data Collection

Specification 5 *Data collection should be based upon a medium that the stakeholders understand and are comfortable with.*

Research reported in Chapters 3, 4 and 5 investigated two principle data collection media to solicit valuations; the topographic map at different scales and an orthophotograph. It was learned that participants preferred larger scale to smaller scale topographic maps, and that some were critical of the use of topographic maps, while all participants using the orthophotomaps had little problems and no complaints using this medium. No experimentation was undertaken to give stakeholders an opportunity to directly compare scale equivalent topographic and orthophotomaps. Future research should investigate such comparison.

Land valuation based upon a standard topographic map must take into account map-reading and geographic literacy of participants, and the fact that topographic maps are abstractions and generalizations of reality that contain inherent biases and silences.

The stakeholders of Galiano Island found the orthophotograph to be both an exciting and engaging medium. They found that it was straightforward and simple to use, commenting that it represents a near 'realistic' representation of the land under investigation and as such does not exhibit any substantial biases or silences.

Proposed therefore is that, wherever possible and available, orthophotomaps be used in preference to topographic maps, and that where topographic maps have to be used, information be gathered to verify participants familiarity and comfort level with this medium.

Specification 6 *The Gestalt data collection should be streamlined and automated as much as possible.*

The original Gestalt method of data collection presented in this research used analog topographic maps and orthophotographs and required participants to draw valuations on mylar overlays. An operator was present during the valuation exercise in order to facilitate the process, as well as to explain and guide the stakeholders as they drew their valuation regions. An operator thereafter had to go and digitize each of the mylar overlays to facilitate subsequent building of information products.

Reliance on an operator to hand out the tools necessary to conduct the valuations and to be present to explain the process implies limited access to the valuation exercise, a fact that contradicts earlier specifications. Participants and the operator have to make mutually satisfactory arrangements when and where to meet to conduct the exercise, and in situations where the number of participants gets large, the valuation data collection process will become very time and labour intensive.

Considerable time also is required by the operator to digitize each participant's valuations. Using this analog approach therefore implies, by necessity, that there will be a substantial gap in time between the initial valuation exercise and any subsequent ability to interact with the resultant information products presented in the CSDSS. Ceccato and Snickars (2000) have noted that this type of interruption in the process could prove undesirable.

In theory, it should be possible to automate the Gestalt data collection process through some form of on-screen digitizing of valuation polygon boundaries on top of a digital facsimile of the topographic map or orthophotograph. Using such an automated approach makes a number of assumptions. Firstly, it assumes that this technology is widely available and accessible today. The technology does exist, but it is not widespread. Secondly, it assumes that on-screen digitizing is as simple and straight-forward as drawing with coloured pencils on mylar overlays. Anybody who has ever tablet or screen digitized will know that software and hardware technology have a long way to go before a steep learning curve required to digitize can be eliminated. Finally, on-screen digitizing suffers from the same average monitor size limitation already referred to earlier in the thesis. The average computer monitor cannot facilitate the same type of display of map information offered by the paper map, and future technological advances will have to be waited for to overcome this major hurdle.

On–screen digitizing is an active area of research (Al-Kodmany, 1999, 2000, 2001a, 2001b) and, despite the negative points raised above, it is anticipated that in a few years time, the Gestalt valuation exercise will be able to be conducted in digital format using web-based technology and average household computing hardware and software. Once this is achieved, the requirements of Specification 3 noted earlier will be met.

In the meantime, cost permitting, the proposal is to facilitate Gestalt valuation data collection by preparing a packaged set of carefully worded instructions with all the necessary analog tools to allow participants to complete the valuation exercise in their own time at their place of convenience without the presence of an operator. An operator would still need to digitize all mylar overlay submitted. Cost clearly would make access to valuation by a large membership of the public prohibitive. However, the proposal is thought to be a reasonable compromise between full web-based access and very limited access requiring operator participation.

Specification 7 *Information about the socio-demographic characteristics and other background information of the stakeholders should be gathered to test for sample bias and to enable investigation of group membership*

Specifications introduced so far call for large participation in the valuation and consensus building process. Two primary reasons are identified why this is of interest to gain insights into the backgrounds of those who participated.

Firstly, comparison of summary statistics for socio-demographic information will allow planners and decision makers to validate that a representative sample of the community has indeed participated in the valuation exercise. In cases where a lack of representation or under-representation is noted, steps can thereafter be implemented to seek to remedy such situations. Checking for and managing potential sample bias and under-representation in self-selected sampling makes for good practise and should be encouraged at all times.

Secondly, Chapters Four and Five introduced methodologies to allow participants to be grouped based on socio-demographic background data and self-declared information about "interests, familiarity and experiences" using univariate and multivariate statistics. The suggestion was made that, for each group identified, valuation responses could be evaluated for within group similarities, and that averaged between group valuations could be compared.

In order to facilitate both the above, participants need to be encouraged to complete a survey accompanying their Gestalt valuation. Proposed is that this part of the survey be web-based to facilitate efficiencies. It should be noted here that any collection, storage, manipulation, aggregation and reporting of personal information ought to meet the privacy (Onsrud, 1994) and confidentiality criteria introduced when discussing Specification 5.

Specification 8 *Appraisal and natural resource inventory data should be collected and integrated into the CSDSS*

Chapter 5 demonstrated how appraisal data for parcels of land and natural resource inventory data could be integrated into the CSDSS, and how resultant information products could facilitate visual and topological comparison of individual, paired or averaged valuation responses with these data.

Proposed is that, wherever possible and feasible, these additional data be collected, packaged and integrated to form part of the overall CSDSS. The recommendation further is that these additional data be carefully documented, and that all resultant metadata be made readily accessible to all participants.

Observation *Insights to be gained asking participants to identify and pairwise rank criteria thought to have influenced their valuation requires further research*

Chapters 2, 3 and 4 reported efforts to get participants to identify what criteria they thought they used to judge value. The Galiano participants also were asked to pairwise rank these criteria. The students did not suggest too much difficulty answering this question while Galiano stakeholders commented on the value and difficulty of this exercise, and expressed some frustration at the pairwise rankings.

Efforts to aggregate responses in order to translate them into some form of weighted overlay procedure proved questionable. Firstly, it proved difficult to combine a large list of identified criteria into a shorter summary list. Assumptions had to be made whose validity can be questioned. Secondly, a number of criteria (see Table 5.19) listed by the participants were value based – they are not easily measured and data to represent them are not readily available in natural resource inventory databases. Trying to match subject supplied "value" based criteria with scientifically measurable criteria found in natural resource inventory is guess work at best. Finally, considerable inconsistencies were found in the pairwise rankings of criteria using AHP making weights calculated from these data for use in weighted overlay analysis questionable.

This leaves the observation that, while there is intuitive value in learning what criteria people use to value landscape, how best to aggregate and represent this knowledge for the purposes of landscape valuation requires further research.

6.3.3 Functionality, Decision Support and Analyses

Sections 6.2.2 and 6.2.3 looked at stakeholder selection, process and data collection issues. The decision support component of any SDSS is that part which allows decision makers to visualize and interact with information to explore the database, evaluate alternatives, explore scenarios and conduct sensitivity analysis. A number of specifications are suggested for design of the specific SDSS under consideration here.

Specification 9 *The requirement for users to access commercial GIS directly should be minimised or avoided.*

Proprietary GIS excel in input, storage, manipulation, analysis and visualization of spatial data. However, as already discussed, they remain very expensive and awkward to use. GIS will be required to create digital versions of participants' mylar drawn valuations, and to create the different information products identified in Chapters 4 and 5. GIS also will be required to conduct any overlay analysis that wishes to go beyond simple visual overlay comparison.

How much proprietary GIS are required beyond that to support the remainder of the proposed functionality of the CSDSS is debatable. There is a tendency for planners and academics to stress the importance of commercial GIS solutions for decision support, planning, etc. The assumption usually is made that SDSS are built on top of GIS, making GIS an essential component of any SDSS (Densham 1991, Densham et al., 1995; Armstrong 1994; Nyerges 1999). The role of GIS in SDSS is assumed to be to facilitate query, analyses and visualization.

The need for GIS in all aspects of SDSS increasingly is questioned, however, and some (Kingston, 1998; Kingston et al., 2000) argue that customized web based programming offers more cost-effective and easier to use solutions (Sieber, 1997; Kellogg 1999). Proposed therefore is that while proprietary GIS should be taken advantage of to prepare data and to produce information products, subsequent browsing and interaction with these information should be web-based, and should not require the need to access licensed GIS software. This recommendation is an interim recommendation. Integration of GIS functionality with web-based technologies is a recent but now considerable research area. The advent of full fledged non-proprietary web-based GIS is just around the corner, and the obvious long-term solution to packaging the CSDSS under discussion here is to go with non-proprietary web-based GIS functionality.

Specification 10 *CSDSS functionality should include review of individual valuation, pairwise comparison of valuation, average valuation, grouped valuation, and comparison of valuation to appraisal, topographic and natural resource inventory data.*

This specification argues for functionality as introduced in Chapters 4 and 5. It is assumed that there is no need to repeat detail about this functionality here.

Specification 11 *The Collaborative Spatial Decision Support Systems should be intuitive, logical easy to use and interactive.*

To be of real value, a digital decision support system must facilitate decision making or, in this case, consensus building, without beginning to take over a decision making process or becoming a burden to decision makers. In other words, a decision support tool should be intuitively interactive and easy to use, and should facilitate instead of dominate (Carver, 1996, 1998). It should be designed in such a manner so as not to favour those more computer literate and "pro-computers". It must strive to make the computing parts as "transparent" as possible. A recommended specification therefore is that the CSDSS proposed here should allow for access to all information products with no further knowledge of computing than should be assumed for regular web access.

To facilitate consensus building, the CSDSS also must support individuals and groups to change valuations in order to reach consensus. In other words, individuals or groups must be allowed to change their valuations on the fly, and must be allowed to explore how this will change other information products, including average valuations and variation around the average. This interactive capability without accessing proprietary GIS is beyond today's readily available computing solutions. However, it will be possible to achieve this once non-proprietary web-based GIS come on-line. Today, interactive manipulation of valuations to reach consensus therefore must be via chauffeur driven access to the SDSS, and will require interruptions in the consensus building process as it will take the operator time to re-build all information products once a valuation has been modified.

Specification 12 *The Consensus Building Process must be structured sequentially, logical and fair to avoid chaos.*

The final specification focuses on the way in which initial individual, averaged or grouped valuations can be modified to reach consensus. It is beyond this thesis to suggest what consensus building sequence should be used. It is argued that this will vary from case study to case study, and that it is something that should be agreed before individual valuations are solicited. Proposed, therefore, is that the CSDSS be able to facilitate any logical and structured sequence of valuation modification agreed to, and that control mechanisms should be imbedded in the CSDSS to ensure that this logical sequential structure is adhered to. The control mechanism may be automated or facilitated through a systems operator.

6.3 A prototype web-based interface for land valuation

Kraak noted in 2001 (1) that the World Wide Web is "the most recent medium to present and disseminate geospatial data". The specifications listed in the previous section argue that the CSDSS should be packaged up to be web-accessible without requiring access to proprietary GIS. Discussion also noted that web-based technology is rapidly changing, and that the advent of web-based GIS is just around the corner.

Efforts commenced as early as the late 1990s to program components of the CSDSS proposed here to be web accessible. Efforts were made to focus on the user-friendly strength of the web while avoiding the need for users to download plug-ins or other gimmicks in order to run the system. The design therefore always has attempted to be as usable as possible, whilst not relying on technological gimmicks or superfluous web functionality. Contemporary computing technology were found to make it reasonably straightforward to design a website which allows individual stakeholders and decision makers to view their own position, to compare their position with that of others, and to compare average positions for subgroups defined by common interests, socio-demographic backgrounds, or any other justifiable grouping criterion.

The originally designed site is accessible on the web at http:// www.geog.uvic.ca/sdss (see also Appendix 6). The original site was organised hierarchically. Users enter via a home page, which presents basic information about the purpose of the site as well as providing links to all other components. Stakeholders are encouraged on this page to follow the pages in a sequential manner, as each builds upon information already presented. However, stakeholders are given the option to access individual pages as they see fit, and hence use the information in any manner they want. Sequential pages linked by the entry portal are as follows:

1. What to do – Gestalt Exercise
2. Questionnaire
3. Map Exploration

4.Ma p Analyses
5.Other Inf ormation Products
6.Conse nsus Building
7.Comments

Pages 1 and 2 are part of the data collection module of the web site. Page 1 introduces the Gestalt exercise. This data collection step, although introduced on the website, has remained an analogue exercise, awaiting advances in on-screen digitizing capabilities. Page 2 is an on-line questionnaire designed to collect socio-economic background information and to query participants about familiarity with the Gestalt input medium, the geographical area under consideration, and familiarity with the topic land is valuated for. The questionnaire lay-out is straight forward and follows a traditional paper-based survey format in order to remain user-friendly and familiar. Running in the background behind the on-line survey is simple HTML coding and a CGI script to enable answers to be automatically input into a statistical program for analyses. Checks are put in place where necessary to protect privacy.

Considerable interruption is required in going from Pages 1 and 2 to pages 3 onwards. This is because at this stage, all respondents' Gestalt valuations must be cleaned up and digitized manually as explained in Chapters 3, 4 and 5, all subsequent information process must be build by a GIS operator using proprietary GIS, and all information products thereafter must be transferred into the web site to be accessible by pages 3, 4 and 5. For the analyses presented in Chapters 4 and 5, all data was manipulated the ESRI's ARC/INFO® and ArcGIS® product lines, and notably the GRID module of ARC/INFO®. Output was converted to JPG format for web integration. The prototype site therefore does not present "on-the-fly" GIS but rather a method whereby GIS created images may be viewed. The potential of future web-based GIS to change all this has already been discussed.

Pages 3, 4 and 5 at the moment offer the following capabilities: Opening Page 3, in the top two panels, users may select their own mapping exercise or the exercise of another stakeholder, allowing them to compare valuation maps side by side. At the moment, these maps appear very small and visual comparison is not easy. Wall projection of the monitor image at the highest possible resolution improves this situation a little. Ideal here would be a multiple display environment where instructions are entered on a regular monitor, but all maps are displayed side-by-side or on top of each other on a high quality wall projection display. The technology to do this exists today.

Two panels at the bottom of the page provide the stakeholders with the opportunity to select a tabular comparison of stakeholders in a pairwise manner. A contingency table is produced in the remaining panel, along with the C_{ij} and Kappa values. The table and the similarity indices enable stakeholders to see how similar or dissimilar their position is to others on a map by map basis.

The next page presents stakeholders with information products focussing on averaged and grouped valuation analysis. The items presented or linked on the page are by no means exhaustive, but represents those information products the research has investigated. The potential exists for many more information products to be added or linked.

What is missing at the moment is page six, the consensus building page. An attempt would have been made to add a version of this page had the Galiano study led to a consensus building process. Such a page would have been difficult to construct since it would either have had to act as an input page to allow a GIS operator to conduct necessary background work to report back new information products (implying a time-delay), or since this page would have had to have been programmed to communicate directly via a client-thin or client-rich linkage to proprietary GIS software (this technology exists today, but did not exist when the research started).

The final page enables the stakeholders to make comments. These comments are important in any collaborative decision making process. It provides the potential for a two-way dialogue between stakeholders and stakeholders, and stakeholders and planners. At present these data simply are posted to a text file. It is possible to build a linkage from this page to the latest in chatline software facilitating the latest in web-based group discussion technology.

The web site presented is a prototype. It represents a proof-of-concept. Given the rapid advances in GIS and web-based technology, full-fledged programming of this type of web-site to be ready for real world use should await until a definite case study has been identified

6.4 Summary

This chapter has introduced recommendations for design specifications to take the research presented in Chapters 2 through 5 to a full-fledged CSDSS. Table 6.1 summarizes the twelve design specifications. A prototype web-based CSDSS based on readily available technology in existence around the years 2000 to 2002 that was used in the Galiano case study also has been summarized. The argument has been made that design of a full-fledged Collaborative Land Valuation SDSS should await until the last moment before real world application in order to capitalize on the latest in web-based GIS technology that is rapidly emerging.

Implementation	Public participation is key to a successful planning process of land valuation
	Limits imposed by the technological skills of stakeholders need to be appraised and reduced
	Access to the tool must be provided to the greatest number of stakeholders possible.
	Privacy concerns must be addressed in an open and transparent manner, with stakeholders concerns to the fore.
Data Collection	Data collection should be based upon a medium that the stakeholders understand and are comfortable with.
	The Gestalt data collection should be streamlined and automated as much as possible.
	Information about the socio-demographic characteristics of the stakeholders should be gathered to enable investigation of group membership
	Appraisal and natural resource inventory data should be collected and integrated into the CSDSS
Functionality, decision support and analyses	The requirement for users to access commercial GIS directly should be minimised or avoided.
	CSDSS functionality should include review of individual valuation, pairwise comparison of valuation, average valuation, grouped valuation, and comparison of valuation to appraisal, topographic and natural resource inventory data
	The Collaborative Spatial Decision Support Systems should be intuitive, logical easy to use and interactive
	The Consensus Building Process must be structured sequentially, logical and fair to avoid chaos

Table 6.1 Summary of technical and procedural specifications

7. SUMMARY AND FUTURE RESEARCH

7.1 Discussion

Research efforts presented in the thesis explored ways to advance the agenda. The research presented build on the arguments that value of land for purposes or activities difficult or impossible to quantify objectively in monetary terms should be derived by a collaborative effort of stakeholders and experts who have a direct interest in and/or experience with what is to be measured. The research therefore positioned itself in support of a bottom-up approach to land valuation where stakeholders themselves identify land value, passing their valuations up to planners and decision makers.

The problem to be solved therefore became that of identifying a process that would allow stakeholders to seek consensus on relative and ideally also absolute measure of value of land for a given land use activity or land characteristic. This consensus building problem was identified to be an example of an ill-structured spatial problem. The case was made that spatial decision support systems (SDSS) offer an approach to managing ill-structured spatial problems, and that collaborative spatial decision support systems (CSDSS) can facilitate bringing multiple players into the solution process using a strategy of consensus building.

The research presented in the previous chapters explored the design and evaluation of such a stakeholder-driven collaborative spatial decision support system (CSDSS) to facilitate relative and absolute valuation of the worth of relatively large areas of land for activities traditionally difficult to quantify in monetary terms. Given the requirement to be able to handle large pieces of land, a key challenge to solve when designing such a CSDSS was how to present stakeholders with the geography of the area under discussion. The research experimented with various facsimiles of the real landscape, notably topographic maps and orthophotomaps. A second key research challenge was to design information products that would allow stakeholders to compare their own valuation position to that of others, and to explore agreement and divergence. Examples of potential information products were developed and introduced throughout the thesis.

The research was presented in the form of a set of five questions. The questions were as follows:

1. To what extent can local stakeholders take the lead in land valuation processes?
2. Can stakeholder and expert opinions about the value of land for purposes or activities difficult or impossible to quantify in monetary terms be combined to yield an aggregate value statement by taking advantage of advances in GIS, SDSS and CSDSS?
3. Are there significant differences in land values identified by different stakeholder groups?
4. Can a web-based interface provide sufficient interactivity for a CSDSS?
5. Is it possible to express the technical and procedural specifications necessary to enable stakeholders to reach consensus for land evaluation in a straightforward manner?

The first three questions already have been discussed in Chapter Five. The conclusion reached were that there is value to a bottom-up land valuation approach, that there can be considerable differences in land valuations identified by different stakeholders, but that stakeholder positions can be combined taking advantage of CSDSS to yield aggregate value statements.

Unanswered questions do remain. While the literature and the Galiano residents support a bottom-up approach to land valuation, both also agree that there remain power imbalances between those who the valuations are done for, and those doing the valuation. Land valuation usually is part of a larger planning scenario, for example, assessing alternative land use or land development scenarios. Communities rarely conduct land valuations outside the realms of a specific planning, development or conflict resolution issue. Valuation exercises therefore invariably are politicised and have a top-down agenda associated with them. In an ideal world, land valuations should be conducted by communities for communities independent of case or scenario specific issues, thereby creating objective information layers ready for use in decision making if and when the need arises.

With respect to the second question, the research clearly has demonstrated that GIS capabilities can be combined with SDSS and CSDSS functionality to capture valuation positions, and to derive subsequent information products to facilitate comparison, averaging, grouping and search for consensus. However, the prototype designed requires considerable further work to take to a full-fledged functioning system that can be deployed in real-time in-group decision meetings. The prototype requires considerable effort and time to convert stakeholders' initial analogue valuation positions into digital format to facilitate subsequent comparison and analysis, and the system requires systems operators working in the background to function. However, technological solutions exist, or will soon exist, to automate all this functionality.

Research conducted also raised the issue that both data input medium and associated geographic scale of presentation have a possible impact upon how stakeholders partition a region into polygons of homogeneous values. Ample scope exists here for further research.

Evaluation of stakeholder responses to valuing Galiano Island revealed that there did exist differences in valuation, but these differences could not be grouped into meaningful sub-populations and/or be associated with logical socio-demographic characteristics of stakeholders. Literature on land valuation discussed in the thesis has a rich history investigating socio-demographic characteristics and their impact on land valuation and preferences. The Galiano study approached this part of the research from both, a deductive and an inductive manner. It investigated deductively whether the stakeholder grouping based upon personal characteristics generated levels of similarity. This was followed by an inductive approach whereby stakeholders were grouped based upon maps' levels of similarity. Results from both approaches yielded no obvious insights. This may be reflective of the sample of individuals who participated in the Galiano study, or the nature of Galiano's land and its value.

The fourth question asked whether a web-based interface provides sufficient interactivity for a CSDSS. This question addresses digital technology available to package a CSDSS. The question seeks to explore if the Internet can be taken advantage of to facilitate information collection and exchange. The thesis has demonstrated that web-based technology can be taken advantage of to package and present CSDSS based information sharing. However, the research was not able to test the power of mark-up language programming and the Internet on a real-world applied case. Future research is required to package all the information products introduced in this thesis in a manner suitable to facilitate an interactive consensus building process. Given computer monitor size limitations, it is likely that such efforts will need to explore digital wall display and other innovative CSDSS facilitation requirements. What this research has demonstrated is that a web-based interface does provide substantial levels of information exchange interactivity. The stakeholders are able not only to look at their own maps, but also at those of the other stakeholders, as well as exploring aggregated positions, clustered positions, and information products that demonstrate levels of consensus and divergence. In addition, the web site provides other statistical and visual information. Given emerging technologies, it is likely that in the future, stakeholders will be able to view and enter their initial land valuation and personal data by screen interaction, and that all subsequent information processing can be automated to be available in real-time.

The fifth question explores the technical and procedural specifications necessary to enable stakeholders to present their opinions about land valuation. Chapter Six set out twelve design and implementation recommendations to follow in order to design a CSDSS to facilitate land valuation. These specifications provide a conceptual framework whereby the land valuation is divided into three components, namely: data collection, information processing, and functionality. Each component has specific design specifications that are straightforward, allowing a positive answer to the question.

7.2 Future Research Opportunities

The research presented in this dissertation has raised issues that merit future research.

7.2.1 Bottom-up Participation in Planning

While this research proposes and develops a prototype CSDSS to facilitate such a bottom-up approach to planning, it leaves many procedural questions unanswered. Research must continue to build on existing literature to explore how best to achieve true bottom-up stakeholder driven land valuation and planning. Initial plans were to use this thesis to contribute to this research as well, using the prototype CSDSS developed to take a bottom-up land valuation to a completed consensus building process. The Galiano study unfortunately did not develop into a suitable case study, and no other real-world application materialized to facilitate this part of the research.

The research presented here would have benefited from being tested on a real-world problem where stakeholders truly had a stake in the data they provided. Questions of stakeholder selection, how stakeholders would participate while respecting issues of privacy and confidentiality, how to minimize potential frivolous participation, and what role systems analysis and systems operators should play in the process remain unanswered.

7.2.2 Most Suitable Facsimile to Model Landscape

It has already been noted that the role of an orthophotomap as a facsimile for landscape requires further exploration, and that the question of most suitable scale for land valuation remains poorly understood. The research presented here employed topographic maps and orthophotomaps at various scales. The use of orthophotomaps looks promising, but cartographers and geomaticians are in agreement that there remain many unresolved questions about how to design specifications to produce consistent, reliable and comparable orthophotomaps. Spatial, temporal and spectral resolutions underlying any orthophotomap will shape what the final orthophoto will look like, and there exist considerable room to use image processing techniques to manipulate any remote sensed imagery to highlight what is desirable to be shown, and to down-tone what is undesirable. Future studies are required to further our understanding of a comparison between conventional topographic maps and orthophotographs, and to allow for the development of standards and procedures underlying production of orthophotomaps of equal rigour to those underlying production of topographic maps.

In order to be able to argue definitively that orthophotographs are the preferred facsimile for landscape, comparative research needs to be undertaken between an orthophotopgraph and a topographic map at the same scale. For the wider applicability of orthophotographs for the land valuation, the seasonality of the orthophotgraph also needs to be investigated. Should different valuation maps be drawn for different seasons? Is it realistic to assume that the bird's eye view underlying both, orthophotographs and topographic maps, is comparable to the oblique perspectives by which humans usually view landscape (Robinson et al, 1995)? Finally, comparative research needs to be conducted comparing hand-drawn maps versus on-screen digitized maps. Screen digitized maps remain poorly researched, but such capabilities would considerably aid interactivity of the Land Valuation CSDSS, decreasing the downtime between initial valuation and subsequent viewing / consensus building.

7.2.3 Advancing CSDSS Information Products

This thesis has documented information products designed to facilitate exploration of stakeholder positions and subsequent consensus building. These need to be tested and evaluated using a real-world land valuation consensus building exercise.

How best to package and present these information products also requires further investigation. The web is a relatively new communication medium. Society is so busy populating the web that little attention is paid to investigating what defines web-based communication excellence. Upcoming literature by Peterson on web cartography and research as presented by Richmond (forthcoming) are attempts to gain better insights into how effectively and efficiently to communicate via the web. Considerable scope exists for further research into excellence in web cartography and more general web communication.

Research presented here has argued against the reductionist approach to land valuation, noting that the division of landscape into thematic layers is artificial. Analyses presented in Chapters Five and Six support this argument. However, the conventional traditional layered approach to land valuation and land suitability modelling should not be dismissed without considerable further research. Considerable advances have been made towards building object oriented GIS databases. A switch from layers to objects may be the logical compromise facilitating a bridge between the reductionist and the holistic schools of thought. How to define a meaningful set of objects to define landscape, and how to determine what data need to be collected to map these objects is beyond this study.

How best to produce CSDSS information products from initial land valuations requires further study. Web-based GIS capabilities offer the intuitively obvious answer. Considerable research is presently invested in advancing web-based GIS. How best to conduct web-based GIS remains unanswered. Should solution be client or server processed? Should solutions be package or applet based? What data exchange standards should be enforced. What is the most suitable mark-up language to handle spatial data? Web-based CSDSS must await answers to the above research questions before advancing beyond prototypes. At the same time, advances in bandwidth, computer speed, and software design will offer opportunities for SDSS and CSDSS hitherto only dreamed of.

Using Human Computer Interaction (HCI) methodologies two key questions must be answered. Firstly what is the exact nature of the goals that are to be achieved by interacting with a web-based SDSS product and, secondly, how successful is the eventual web-based product at achieving these goals (Keller and O'Connell, 1997).

7.3 Summary

Densham, 1991 (referenced in Malczewki, 1999, 282) notes four key functions for spatial decision support systems designed to handle ill structured spatial problems.

- Provide mechanisms for the input of spatial data
- Allow representation of the spatial relations and structures
- Include the analytical techniques of spatial analysis
- Provide output in a variety of spatial forms, including maps

This dissertation has advanced all of the four SDSS functions when exploring design of a CSDSS to facilitate land valuation for land use and activities difficult to quantify in commensurable and monetary terms. The study also has challenged the reductionist layered approach to viewing landscape, and has further advocated a bottom-up approach to planning. It led to the design and testing of a prototype. The prototype awaits further advances in web-based GIS and a suitable case study before it can be taken to full-fledged CSDSS and its application. This is but a small step in a considerable research agenda awaiting further work.

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http://www.geog.uvic.ca/sdss Galiano Spatial Decision Support System

http://www.ipc.on.ca/english/pubpres/papers/gis.htm

http://www.islandstrust.bc.ca/) Islands Trust, BC, Canada

http://www.lib.uwaterloo.ca/discipline/Cartography/umd/cli/cli.html#recreation) University of Waterloo Library, Canada – University Map and Design Library – Geospatial Data.

http://www.ncgia.ucsb.edu/varenius/varenius.html Varenius - NCGIA's Project to Advance Geographic Information Science

APPENDIX 1 – AGREEMENT TO REPRODUCE TOPOGRAPHIC MAP PRODUCTS

Natural Resources Canada | Ressources naturelles Canada
Geomatics Canada | Géomatique Canada
Mapping Services Branch | Direction des services cartographiques
615 Booth Street
Ottawa, Ontario
K1A 0E9
615, rue Booth
Ottawa (Ontario)
K1A 0E9

AGREEMENT TO REPRODUCE TOPOGRAPHIC MAP PRODUCTS

September 3, 2002

Ian O'Connell
Department of Geography
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PO BOX 3050 STN CSC
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for Pierre Rochon
Project Manager
Centre for Topographic Information
Geomatics Canada
Natural Resources Canada

Date: ______________ Per: ______________

Ian O'Connell

APPENDIX 2 – EXPERIMENT ONE QUESTIONNAIRE

Land Evaluation Exercise

Part 1 Gestalt Valuation Exercise for 1 : 250,000

The objective of this exercise is to divide the map sheet into a set of homogeneous functional regions for outdoor recreation and to rank the relative importance of the regions on the following five point scale;

Exceptional
High
Medium
Low
Not Applicable

You have been given five pencils (white, red, green, blue, black). Each colour represents a category of land value for outdoor recreation.

It is important that you value the entire area of the map sheet.

i) Draw boundaries around areas which you consider to fall into these categories using the provided colour scheme.

ii) On the map sheet please write down what value metric you are using.

Part 2 Gestalt Valuation Exercise for 1 : 50,000

Please repeat part 1 but with the 1:50,000 map sheet.

Part 3 Survey

Please answer the following questions as fully as possible.

1. **Which data source did you find the most appropriate?**

   1:250000 1:50000

Why ?

2. **Please list the criteria / variables you used for evaluating recreation:**

3. **Please rank the six most important criteria / variables:**

   1. [most important]

   2.

   3.

   4.

   5.

   6. [least important]

4. **Did you use the same critieria for each data source ?**

   Yes No

   if **No** please elaborate :

5. **What other information would you have liked to have available ?**

6. **Comments ?**

Part 4 Background Questionnaire

Enter your **exercise id-number** :

Please answer the following questions as completely and accurately as possible. Feel free to note on the survey any additional information which you feel is necessary to provide a complete answer.

Socio-Demographic Background

1. **Gender** (•) Male ( ) Female
2. **Year of Birth :** [eg. 1976]

Region Familiarity

3. **How long have you lived in British Columbia ?** [years]
4. **Have you ever lived in the Okanagan Region of British Columbia ?**
   ( ) Yes (•) No

if YES :

- When did you last live there ? [years ago]
- For how many years did you live there ? [years]

if NO :

- Have you ever visited there ?
  ( ) No (•) Yes --> How long ago ? [years ago]

5. **On the following four point scale, how familiar would you say you are with the Okanagan ?** Not familiar

Outdoor Activity

6. **On your resume, do you list any outdoor recreation activities ?**
   (•) Yes ( ) No

if **Yes** please list them :

7. **Are you a member of a club of organization with an interest in outdoor recreation ?**
   Yes No

if **Yes** please list :

8. **How many days on average do you spend on recreatonal activities each month ?**
   [days]
9. **In the last year (Nov '97 - Nov '98), how many nights have you spent camping ?**
   [nights]
10. **Where on the following five point scale would you rate yourself ?**
    I enjoy outdoor recreation occasionally.

APPENDIX 3 – GEOGRATIS USER AGREEMENT

GeoGratis : User Agreement for Digital Data

NATURAL RESOURCES CANADA
GEOMATICS CANADA, Earth Sciences Sector
Canada Centre for Remote Sensing
GeoAccess Division

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7. Canada shall not be liable in respect of any claim, demand or action, irrespective of the nature of the cause of the claim, demand or action alleging any loss, injury or damages, direct or indirect, which may result from the User's use or possession of the Data. Canada shall not be liable in any way for loss of revenue or contracts, or any other consequential loss of any kind resulting from any defect in the Data.
8. The User shall indemnify and save harmless Canada and its Ministers, officers, employees and agents from and against any claim, demand or action, irrespective of the nature of the cause of the claim, demand or action, alleging loss, costs, expenses, damages or injuries (including injuries resulting in death) arising out of the User's use or possession of the Data.
9. The parties agree that this agreement does not restrict Canada in any way from authorizing other parties to use the Data in the same kind of products or in different products.
10. This Agreement shall be interpreted in accordance with the laws in force in the Province of Ontario, Canada

APPENDIX 4 – STUDY ADVERTISEMENT

Galiano Outdoor Recreation and Tourism Evaluation Study.
(June 13 - June 26)

I am a Ph. D. student at the University of Victoria. This study examines the value of land and landscape to outdoor recreation and tourism. To complete this study I need people to come and do a small mapping exercise, and to answer a few questions. The exercise is one that I believe is valuable and fun. You will be asked to draw areas on Galiano Island for their potential and suitability for outdoor recreation and tourism. You will only have to donate about 30 minutes of your time. Total confidentiality will be observed at all times, with no identifying information whatsoever being sought. Community input is extremely valuable and important to my research and your time and help will be greatly appreciated.

I will be based at 23 Madrona Drive at Sturdies Bay (Property management door of Windermere Galiano Island Realty) and available from June 13 to June 26, 10 a.m. to 4 p.m. It would be appreciated if you could schedule a time when it is most convenient for you to come, or if these hours do not suit, I can make other arrangements.

If you have any queries I can be reached at either 1-250-[redacted] or 1-250-[redacted]. My email is IOCONNEL@UVIC.CA. You may also contact my academic supervisor (Prof. Peter Keller) at 1-250-721-7333.

I thank you in advance for your participation. I look forward to meeting as many of you as possible.

Ian O'Connell

APPENDIX 5 – GALIANO QUESTIONNAIRE

Total Confidentiality is assured. There are no questions which allow for the identification of the respondent

TIME REQUIRED for entire exercise is approximately 30 minutes.

Part 1 Gestalt Valuation Exercise for Galiano Island

The following section will take approximately 10 minutes to complete.

The first objective of this exercise is to divide the map sheet into a set of homogeneous functional regions for outdoor recreation and to rank the relative importance of the regions on the following five point scale;

Exceptional
High
Medium
Low
Not Applicable

You have been given five pencils (white, red, green, blue, black). Each colour represents a category of land value for outdoor recreation.

It is important that you value the entire area of the island.

Draw boundaries around areas which you consider to fall into these categories using the provided colour scheme.

Please rank up to five of the important criteria / variables you employed to determine the value regions

1. ______ [Most Important]
2. ______
3. ______
4. ______
5. ______ [Least Important]

Part 2 Background Questionnaire

The following section will take approximately 10 minutes to complete.

Please enter your **map number** : [ ]

Please answer the following questions as completely and accurately as possible. Feel free to note on the survey any additional information which you feel is necessary to provide a complete answer.

Region Familiarity

1. Do you presently live on Galiano Island ?

( ) Yes (•) No

if YES :

- How long have you lived here ? [ ] [years]

if NO :

- Have often do you visit ?
  [ ] [times a year]
- How many weeks per year do you spend on the island ?
  [ ] [weeks]

Outdoor Activity

2. Do you participate in outdoor recreation activities on the Island ?

(•) Yes ( ) No

if **Yes** please list them :

[ ]

3. Are you a member of an organization with an interest in outdoor recreation ?

(•) Yes ( ) No

if **Yes** please list :

4. How many days on average do you spend on recreational activities each month ?

[days]

5. Where on the following five point scale would you rate yourself ?

I enjoy outdoor recreation occasionally.

6. What percentage of tourists visiting Galiano Island do you feel participate in outdoor recreation activities ?

[%]

7. How important do you rate outdoor recreation to local economy of Galiano Island ? Somewhat unimportant.

8. In your estimation, what percentage of tourism activities on Galiano Island are outdoor recreation based?

[%]

Part 3 Hypothetical Valuation Study.

*In order to generate information on the economic value of tourism and outdoor recreation to the island, it is necessary to setup a **hypothetical** situation. The following questions are based on a purely **hypothetical** premise*

Part (A) You have divided the landscape into up to five categories. Assuming that the Exceptional category is worth $1 per hectare, what is the value per hectare of the remaining categories. You may enter any value between $0 and $1:

Exceptional	**$ 1.00**
High	**$**
Medium	**$**
Low	**$**
No Value	**$ 0.00**

Part (B) For the purposes of outdoor recreation and tourism provision it is proposed to levy an island fee for visitors. This would be levied on all visitors to the island. What do you think this fee should be ? It would not be levied on residents.

$

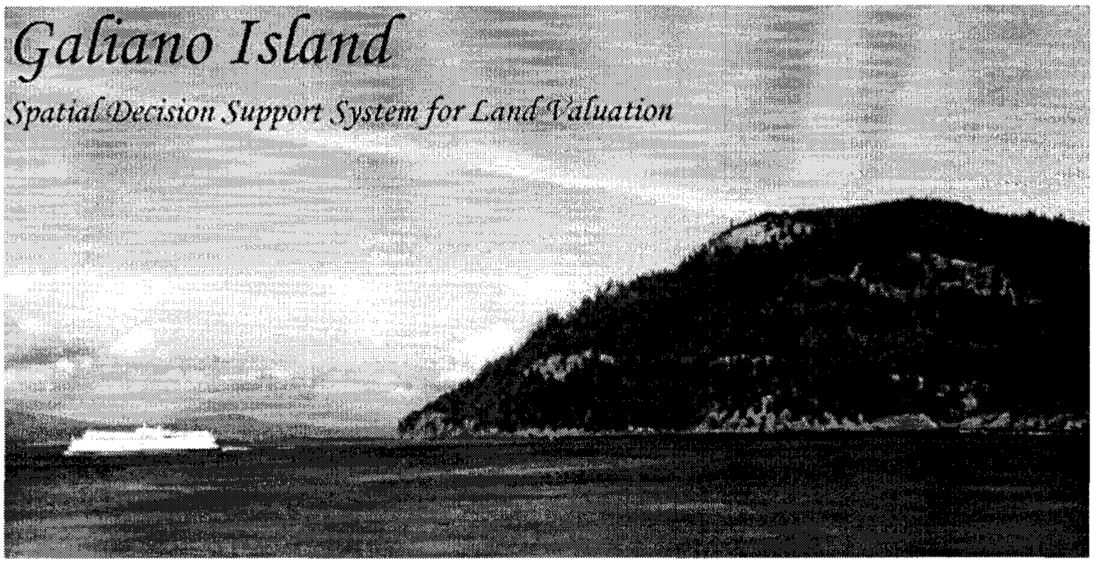
If you did not answer this question or entered $0 please explain. If you feel your answer needs further clarification please feel free to enter your comments here:

Socio-Demographic Background

1. **Gender** Male Female
2. **Year of Birth :** [eg. 1976]
3. **What is your annual household income ?** N/A

Thank you for your time and contribution.

APPENDIX 6 – WEB SITE PROTOTYPE



Welcome to the Galiano Spatial Decision Support System. This SDSS will guide you through six modules. The initial two modules are designed to gather data both spatial and numeric. Modules three and four are graphic representations of your mapping exercise where you can view your own as well as other stakeholders maps, as well as comparing them. Module 5 is presents statistical analysis of the mapping exercises. Module 6 will enable consensus to be built. Module 7 enable you the stakeholder to comment on what you have done.

Please Click on Each Module in Turn

Module 1 What to do - *Gestalt Mapping Exercise Instructions*

Module 2 Questionnaire

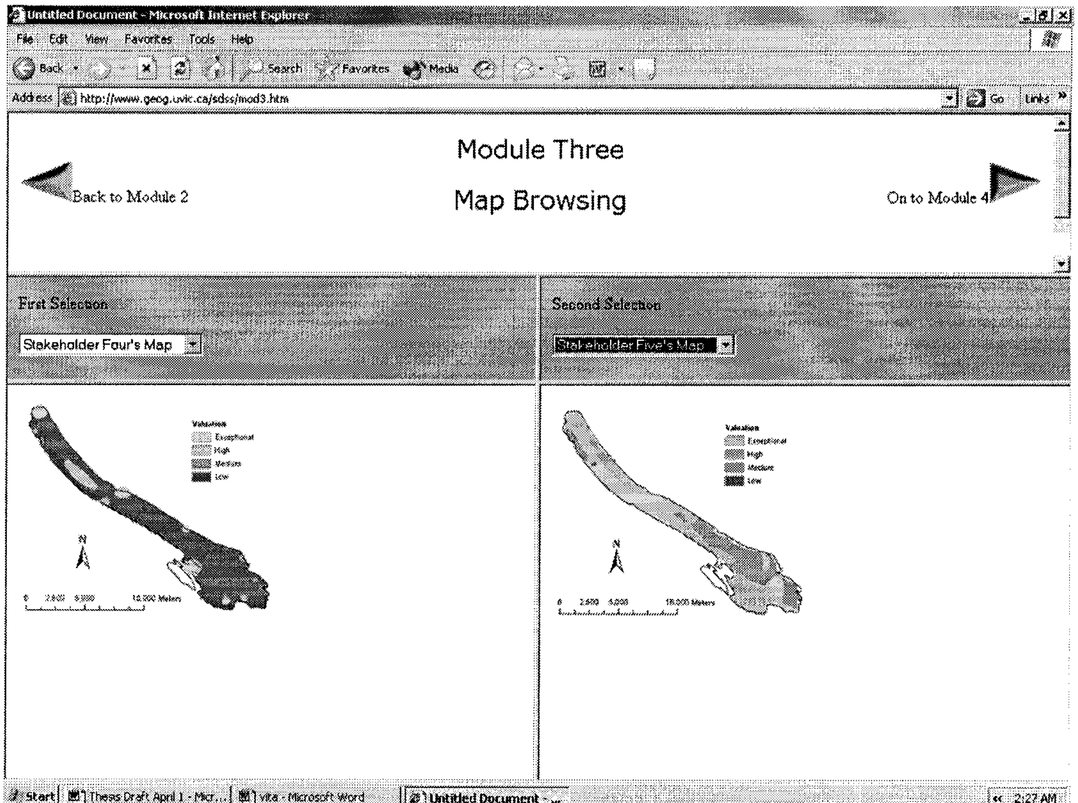
Module 3 Map Exploration

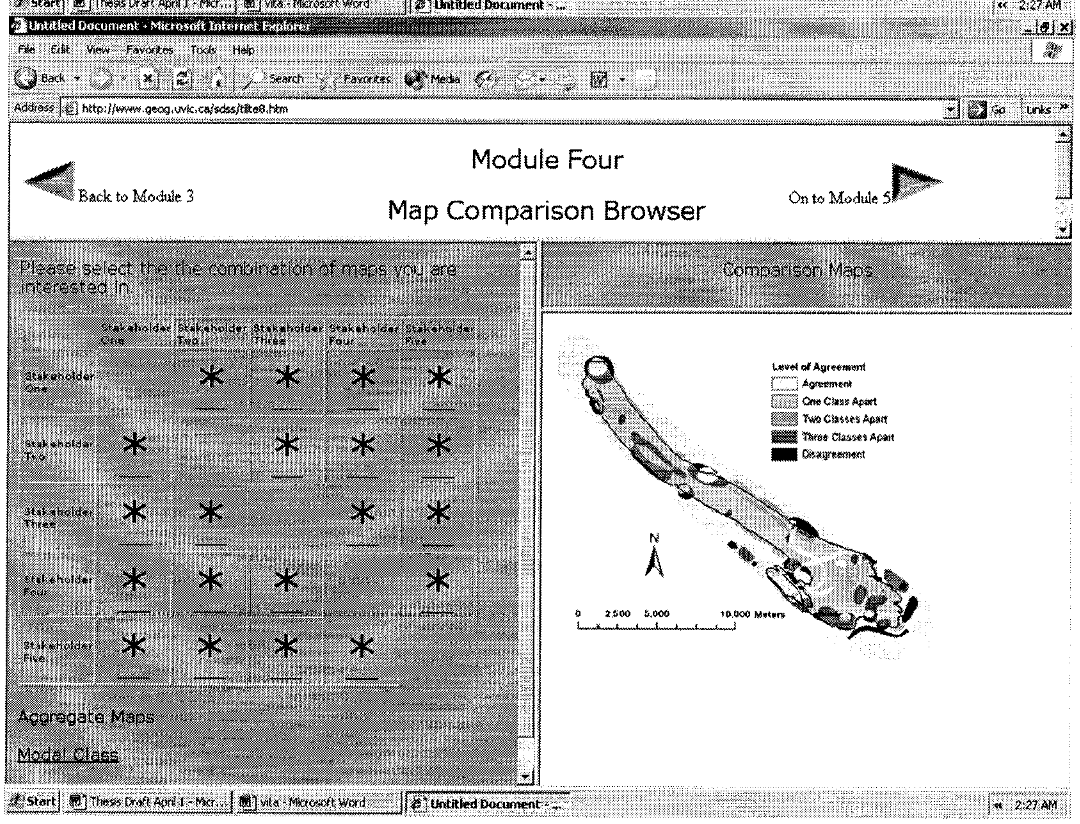
Module 4 Map Analyses

Module 5 Other Information Products

Module 6 Consensus Building (To be constructed...)

Module 7 Comments and Evaluation


Untitled Document - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://www.geog.uvic.ca/sdss/mod3.htm
Module Three
Map Browsing
Back to Module 2
On to Module 4
First Selection
Stakeholder Four's Map
Second Selection
Stakeholder Five's Map
Valuation
Exceptional
High
Medium
Low
Start
Thesis Draft April 1 - Micr...
vita - Microsoft Word
Untitled Document - ...
2:27 AM


Untitled Document - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://www.geog.uvic.ca/sdss/tilte8.htm
Module Four
Map Comparison Browser
Back to Module 3
On to Module 5
Please select the the combination of maps you are interested in
Stakeholder One
Stakeholder Two
Stakeholder Three
Stakeholder Four
Stakeholder Five
Aggregate Maps
Modal Class
Comparison Maps
Level of Agreement
Agreement
One Class Apart
Two Classes Apart
Three Classes Apart
Disagreement
0 2,500 5,000 10,000 Meters
Start
Thesis Draft April 1 - Micr...
vita - Microsoft Word
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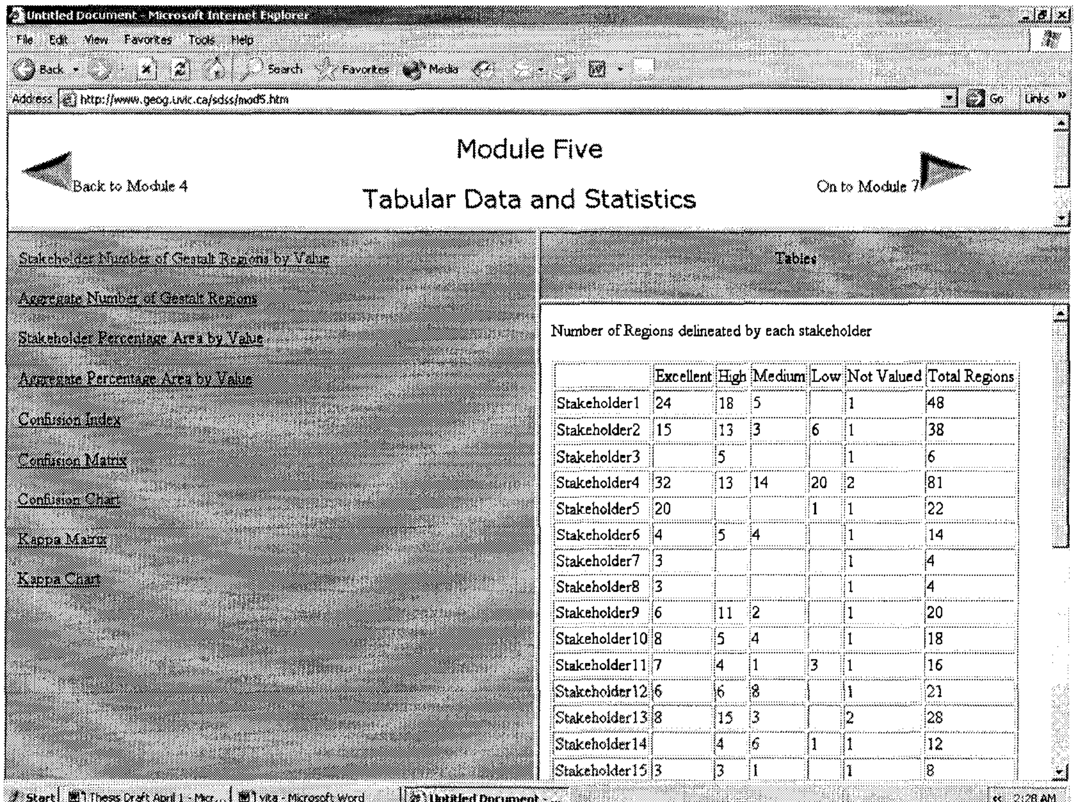

	Excellent	High	Medium	Low	Not Valued	Total Regions
Stakeholder1	24	18	5		1	48
Stakeholder2	15	13	3	6	1	38
Stakeholder3		5			1	6
Stakeholder4	32	13	14	20	2	81
Stakeholder5	20			1	1	22
Stakeholder6	4	5	4		1	14
Stakeholder7	3				1	4
Stakeholder8	3				1	4
Stakeholder9	6	11	2		1	20
Stakeholder10	8	5	4		1	18
Stakeholder11	7	4	1	3	1	16
Stakeholder12	6	6	8		1	21
Stakeholder13	8	15	3		2	28
Stakeholder14		4	6	1	1	12
Stakeholder15	3	3	1		1	8