Section 2

Methodology and Results

"Valuation is a human process in which foresight enters. Coming events cast their shadows before. Our valuations are always anticipations"

Irving Fisher. The Theory of Interest. 1930.

CHAPTER 7
METHODOLOGY

7.1 Introduction

The methodology for this research project has four components:

1. Establishing a surrogate capital market, from which will be derived the shadow prices for ecosystem goods and services provided by public and other land in the Wet Tropics Bioregion of Queensland.
2. A systematic analysis, namely a multiple criteria analysis, using twenty identified ecosystem attributes and three models with six different criteria for each model, in order to establish the non-pecuniary weightings and sensitivities for the attributes.
3. A philosophical inquiry, namely a Delphi Inquiry, to establish expert opinion as to the need for the research, and the relative rankings of the attributes for each model. This section includes the statistical analytical technique selected as the most appropriate to deal with the data.
4. Development of a valuation table to appraise the value of ecosystem goods and services provided by individual landholdings, and development of a conceptual model to appraise the value of ecosystem goods and services on a landscape scale.

7.2 The Surrogate Market

The surrogate market is the broader property market in the bioregion selected for study. Individuals in the community constantly reveal their preferences to purchase property for a multitude of uses. The pecuniary measures of these preferences are used as comparable sales by state agencies charged with the responsibility of valuing property and determining unimproved values as a basis for levying rates and taxes. The collective values thus underpin the costs of administration and provision of infrastructure in the bioregion (Lambert 1932; Herps 1942; Murray 1954; Blackwell 1994). Unimproved values are assessed on the principle of the highest and best legal use, yet assume that improvements do not and have never existed. Reference is made to the literature and legal precedents in Chapter 4 with respect to the valuation principles associated with 'unimproved value' 'comparable sales' and 'highest and best use'.

The local government areas (LGAs) that are contained wholly within or that administer parts of the Wet Tropics Bioregion were ascertained from public records and maps (Figure 1.2). They are Cairns City Council; the predominantly coastal Shires of Thuringowa, Hinchinbrook, Cardwell, Johnstone, Douglas and Cook; and the Atherton and Evelyn Tableland Shires of Mareeba, Atherton, Eacham and Herberton. These local governments were consulted as to the total rateable value of alienated land within their jurisdiction, and the total area of that land. A dollar value per hectare was calculated for each LGA (total rateable value/total area). Statistical analysis was performed on the resulting set of dollar values for the LGAs, and the range, mean, median, mode, standard deviation and skewness were calculated. Owing to the variability in the data (range), due to varying degrees of urbanisation, development, use, distance from services, and average parcel size, the data set was expected to have a high degree of positive skewness. The measure of central tendency most commonly accepted for this type of skewed data set is the 'median' (Zar 1996; Hicks 1999). In further support of this measure being adopted, the Real Estate Institute of Australia regularly publish the 'median' house value for all capital cities and regional cities in Australia (REIA 2003). The skewness (higher values) attributable to a high degree of development (disturbance) is also indicative of smaller lot sizes, which are least conducive to the provision of a suite of ecosystem goods and services. Hence, the median unimproved value (*MUV*) is the measure that will provide the fairest approximation of all of the uses to which land is put in the bioregion on a *broadacre* basis and will take into account all of the various principles and factors that affect the value of land.

The median unimproved value per hectare of the alienated (rateable) land in the bioregion was then used as a surrogate for the median unimproved value per hectare of the un-alienated (public or unrateable land). This is consistent with valuation practice (*use of comparable sales is a fundamental activity*) and the Public Sector Accounting Standards Board requirement that public sector land be recognised as an asset in municipal financial statements (Accounting Standard *AAS 27*). AAS 27 specifically refers to land under roads, however by implication the requirement is transferable to other public land, eg. land under railways, transmission lines, public utilities, dams, impoundments, parks and reserves. Every use of land has an opportunity cost, that being the existing use or other uses to which the land could be put (the use foregone) (Edwards 1987; McNeeley 1988; Frank 1991). Marginal opportunity cost can be expressed in terms of the annual net revenue foregone, in which case it would be capitalised, resulting in a land value in restricted and unrestricted use (McNeeley 1988). This concept clearly links the natural production function of land with land valuation procedures. As ecosystem services are the production function of land in its natural state (the *Usus Fructus per annum*), and as some if not all of them are essential for planetary life support (Ke Chung and Weaver 1994), it could be argued that the provision of ecosystem services are the ‘highest and best use’ of land. It was therefore reasonable to assume that the other (unrateable) land in each LGA was worth at least as much for the ecosystem goods and services it provides as the rateable land put to its ‘highest and best’ use. However adoption of the median unimproved value as a surrogate value implies that the value is for the ‘median’ use in the region and not the single ‘highest and best’ use. It is thus a conservative estimate, allowing that other uses of land can co-exist with the provision of ecosystems services.

Sir William Petty, Valuer General for Ireland and one of the founders of the Royal Society in 1662, was well aware of the valuation theory to do with the differential element in rent when he enunciated it, although it was later attributed to Ricardo (Murray 1954). However Roll (1961) in his *History of Economic Thought* pointed out that it was Petty, and not Ricardo, who evolved the theory. Murray (1954:40) puts the theory succinctly:

“…the value of land could be ascertained by the capitalisation of the ‘Usus Fructus per annum”, and added that it is “…*a process which is known today as the productivity method of valuation”* Murray 1954:40)*.*

Petty was also well aware that capitalisation rates varied with risk, stating in 1661 that lands in Ireland were worth ‘but seven years purchase’ (indicating a capitalisation rate of about 14.3%), without elaborating on the reason for the heightened risk (Murray 1954:40). The theory is both applicable to derivation of land value from rent and to derivation of rent, or the *"Usus Fructus per annum",* by the use of comparable sales data for land. Earlier, Petty was uncertain as to how to determine the rate of return from land and came up with an ingenious solution. Petty determined that the rights to the *Usufruct* of land of three generations of humans would be a reasonable estimate, and computed the value of land at twenty one year's purchase of its annual rent, or in money-capital terms 4.76% (Roll 1961).

An appropriate capitalisation rate which was derived from a study of the market was applied to the median capital unimproved value (*MUV*) per hectare, producing a value for the flow of ecosystem benefits from land (the *Usus Fructus per annum).* Care was taken that the capitalisation rate chosen was low enough to satisfy 'Hotelling's rule' without being too low to ensure that the 'Hotelling rent' (also known as 'Ricardian rent' or 'scarcity rent') generated a flow of benefits of a value undiminished into the future (Hackett 2001). The 'Hartwick rule' also requires that to achieve the status of full intergenerational equity, each generation must reinvest the economic rent (in situ value) of an exhaustible resource. (Hartwick 1977). The *Usus Fructus per annum (UFpa)* was thus represented by the equation:

$$UFpa(\$/ha) = MUV(\$/ha) \; x \; cr(\%).$$

(Equation 7.1)

Where *cr* is the capitalisation rate (the rate at which total capital invested is recouped over a predetermined number of years, otherwise known as 'years purchase', eg. a capitalisation rate of 6.5% is equivalent to 15.4 'years purchase').

As both alienated and un-alienated land provide ecosystem services it is important to be able to estimate the extent to which the land contributes to the overall contribution. Depending on the level of disturbance, other human activities on the land can co-exist with the provision of ecosystem services. Therefore on a landscape scale, total value of a whole ecosystem *(TVw)* is represented by the equation:

$$TVw = UFpa \times \text{area(ha)} \times esi(\%).$$

(Equation 7.2)

Where *esi* is the extent to which ecosystem services are intact.

Methodology to estimate the contribution of individual holdings and landscapes is explained in sub-section 7.5. In order to distinguish between the value of individual ecosystem services that may or may not be present in a given situation, or that may be present but only to a limited extent, and to be able to account for them separately, weightings for the individual ecosystem attributes need to be derived. Then the total value of an individual ecosystem attribute *(TVi)* is represented by the equation:

$$TVi = UFpa \times \text{area(ha)} \times esi(\%) \times wt.$$

(Equation 7.3).

Where *wt* is the final weighting of the attribute, expressed as a decimal.

The methodology employed to assign weightings to the individual ecosystem attributes is explained in sub-sections 7.3 and 7.4.

7.3 The Systematic Analysis

A three-model Multiple Criteria Analysis (MCA) of ecosystem attributes was designed in conjunction with the philosophical inquiry using a broad-based panel of about 50 experts to assign appropriate weightings and sensitivities to the attributes. MCA has broad application as a multi-attribute decision making method (MADM), which was evaluated for this research project, along with the analytical hierarchical process (AHP), rank-order centroid method and the fuzzy method. The Department for Transport, Local Government and the Regions (DTLR 2002) used MCA to appraise all transport projects, including proposals for all road schemes in the United Kingdom, and the National Audit Office in the UK did likewise to analyse the cost effectiveness of the Department of Trade’s Overseas Trade Services export services (DTLR 2002). Noh and Lee (2003) used criteria of time, area, irreversibility and scientific uncertainty to evaluate eight alternative impact categories, namely:

- abiotic resources depletion;
- global warming;
- ozone layer depletion;

- euthrophication;
- acidification;
- photochemical oxidant creation;
- ecotoxicity; and,
- human toxicity.

MCA has the ability to incorporate information about alternatives from a variety of sources, convert it to standard units of measure, weight the data according to magnitude and significance, test for sensitivity, and rank alternative options. Environmental, social and cultural trade-offs become more explicit and can be considered in the process (Rivett 2000). Rivett (2000) used MCA to decide between four alternate options for the Kuranda Range Road upgrade in Far North Queensland. Using environmental sustainability, transport efficiency, social/amenity, and cost as criteria, weightings were applied through community and expert consultation for attributes including:

- important area for plants;
- ecological processes;
- construction issues;
- accommodate freight efficient vehicles;
- closures, delays;
- important areas for scenic amenity;
- noise environment; and,
- net present cost on a whole-of-project basis. (Rivett 2000)

The decision-maker faces certain choice problems, the alternatives for which can be evaluated by means of a certain set of objectives, which can be operationally defined. (Blalock and Blalock 1968; Rietveld 1980; Dick 1990; More *et al.,* 1996; Hicks 1999; KPMG 2000; Rivett 2000). The weightings for the individual attributes and aggregate values were derived from this analysis. The models were in Microsoft Excel© format and each consisted of the 20 commonly accepted ecosystem attributes (Costanza *et al.,* 1997a; and Cork and Shelton 2000) (Table 7.1) with six criteria and suggested maximum weightings (Tables 7.2, 7.3 and 7.4), generating a matrix of 120 cells for each model.

The mode of inquiry more closely resembled a Kantian perspective, where truth is a synthesis of theory and complementary empirical data, and the multiple models provide synergism (Linstone 1984). The MCA designed for this research requires a choice among the criteria in order to assign weights, rather than a choice among options in the case of MCA being used to decide between projects or proposals (for example: the decision between four options for the Kuranda range road in North Queensland).

Table 7.1. Ecosystem attributes used in the multi-model multiple criteria analysis (adapted and modified after Costanza *et al.,* 1997a; and Cork and Shelton 2000).

Group	Type
Stabilisation Services	Gas regulation (atmospheric composition) Climate regulation (temperature, rainfall) Disturbance regulation (ecosystem resilience) Water regulation (hydrological cycle) Erosion control and soil/sediment retention Biological control (populations, pest/disease control) Refugia (habitats for resident and transient populations)
Regeneration Services	Soil formation Nutrient cycling and storage (incl carbon sequestration) Assimilation of waste and attenuation, detoxification Purification (clean water, air) Pollination (movement of floral gametes) Biodiversity
Production of Goods	Water supply (catchment) Food production (that sustainable portion of gross primary production~GPP) Raw materials (that sustainable portion of GPP, timber, fibre) Genetic resources (medicines, scientific and technological resources)
Life Fulfilling Services	Recreation opportunities (nature-based tourism) Aesthetic, cultural and spiritual, (existence values) Other non-use values (bequest and quasi option values)

The general approach for MCA is as follows (some steps do not apply in this case, eg. 2):

1. Identify overall desired outcomes for the project;
2. Identify alternative solutions including the no-go option;
3. Identify and measure values that may be impacted upon by the options and convert these to evaluation criteria (present in the form of packages of criteria, attributes and elements);
4. Measure the impact of the project on these values or packages of attributes by way of technical studies or preference surveys;
5. Score and weight the impacts relative to a particular characteristic of the evaluation criteria, eg. Area of native forest and relative significance of the species affected;
6. Standardise the scores (eg. -5 to +5. with –5 being the worst, and 0, no change), the sign indicating the direction of the impact, and the integer the relative magnitude of the impact;

7. Determine overall scores for each option;
8. Undertake a sensitivity analysis including weightings of each package of criteria (a positive fraction adding up to one) to test robustness;
9. Iteration in order to refine alternatives; and,
10. Results (decision-making) (Rivett 2000:4-7).

These steps were followed as much as was consistent with the evaluation of individual ecosystem services within an overall suite of ecosystem services, rather than choosing between alternate policies or proposals, as is the main application of MCA.

The criteria for Model 1 (Table 7.2: the anthropocentric perspective) were anthropocentric, economic and ecological and were generally devised from an appreciation of the literature (Section 1, Chapters 3 and 5). 'Essential' or 'desirable' for human life support were given the maximum weightings in this model, followed by the ecological criteria, and then economic, which also reflect on the anthropocentric perspective of the model, as ecosystem health is crucial for provision of ecosystem services essential for planetary life support, and maintenance of natural capital is implicitly to do with intergenerational equity.

Table 7.2. Multiple Criteria Analysis (MCA) model 1 with selected criteria and maximum weightings allocated.

Model 1 Criteria 'Anthropocentric'	**Maximum Weight**
Essential to human life	6
Essential component of ecosystem health	4
Essential for maintenance of natural capital	2
Desirable but not essential for human well-being	5
Desirable but not essential for ecosystem health	3
Desirable but not essential for maintenance of natural capital	1

In every model it was made very clear to the panel of experts that they were permitted to assign a lesser weighting for criteria than that suggested as a maximum weight for an attribute, if they so chose, but not a greater weight. In this way any subjective bias imputed by the principal researcher selecting weights was minimised (the panellist could reduce each attribute weight to parity, ie. 1, if they so desired).

Criteria for Model 2 (Table 7.3: the utilitarian perspective) were utilitarian (ie. economic), to do with intergenerational equity (bequest), and spiritual, aesthetic (existence value). These criteria are the main components of the economic approach to environmental valuation (Section 1 Chapter 2). The highest weighting was given to direct use value, with option non-use value next (the value people place on knowing that essential ecosystem services necessary for life support will be available during their lifetime). Indirect use value (for present people) is then followed by bequest non-use value (future people), option use value (can lead to increased consumption) and existence non-use value (aesthetics, spiritual), in decreasing order of importance.

Table 7.3. Multiple Criteria Analysis (MCA) model 2 with selected criteria and maximum weightings allocated.

Model 2 Criteria	'Utilitarian'	Maximum Weight
Direct use value		6
Indirect use value		4
Option use value		2
Option non-use value		5
Bequest non-use value		3
Existence non-use value		1

Model 3 (Table 7.4: balanced sensitivity) had criteria that were essentially to do with risk and uncertainty, which are important elements of this type of systematic analysis (Section 1 Chapter 2). Risk is best dealt with by a sensitivity analysis, however uncertainty is somewhat more complex. In this model the criteria of 'threats' and 'precaution' have been included to complement the other negative values or deleterious criteria in the model, which are then offset by the positive qualities of 'resistance' and 'resilience'.

Table 7.4. Multiple Criteria Analysis (MCA) model 3 with selected criteria and maximum weightings allocated.

Model 3 Criteria	'Balanced Sensitivity'	Maximum Weight
Threats		-4
Risk		-3
Uncertainty		-2
Precaution		-1
Ecosystem resistance		7.5
Ecosystem resilience		7.5

Again these criteria were selected from an appreciation of the literature (Section 1 Chapter 5). It should be noted that the net weight for each attribute, if maximum weightings for each criterion are allocated, was +5.

In the models not every attribute necessarily warrants a weight for each criteria, for example, biodiversity would not be both ‘essential to human life’ and ‘desirable but not essential for human well being’, however, it could have a weight for each of the utilitarian criteria, and most surely would have a weight for threats, risk, uncertainty, precaution and resistance and resilience. The purpose of the choice of weights was to limit outliers as is further outlined in Chapter 9 and ultimately to provide an overall weight of each of the 20 attribute as a percentage of the total basket of ecosystem goods and services. The Microsoft Excel© spreadsheets supplied to the panel for each model, with instructions as to how to complete them, are included in Appendix B. Spreadsheet entries by the panellists were checked to ascertain if they conformed to the instructions given. The results for each model were subjected to statistical analysis using Kendall’s Coefficient of Concordance (Blalock and Blalock 1968; Zar 1996; Hicks 1999). The same statistical analysis was applied to the results from the questionnaires that formed part of the philosophical inquiry, and as details of the expert panel are given in sub-section 7.4, which is pertinent to the choice of statistical analysis, a description of the technique will be included in that section.

On the proviso that there was significant concordance between the sets of weightings provided by the expert panel for the attribute/criterion in each model, the mean weighting of the panellists’ weightings for each attribute in models one and two was then normalised to a total of 100 (20 attributes multiplied by a nominal weighting of +5) (Table 7.5).

Table 7.5 Sample calculation to normalise the weightings to a nominal value of +5.

Attribute	Mean of panellists’ weightings for model 1	Normalised mean	Final mean for model 1
Gas Regulation	7.43	7.43/149.12 X 100	4.98
Raw materials	4.12	4.12/149.12 X 100	2.76
Etc etc up to 20	5.05	5.05/149.12 X 100	3.39
Total (say)	149.12	100.00	100.00

The mean results of Model 3 (sensitivity) were then ranked as continuous positive scores, with the lowest being 1, the least endangered and the most resistant/resilient, and the highest being the most endangered and the least resistant/resilient. The ranked scores were then normalised for each attribute to a decimal totalling one for all attributes. Finally, the mean of the mean result for each attribute for Models 1 and 2, was multiplied by the normalised score for Model 3, to reflect sensitivity. As the nominal weight for each attribute was 5, the total for all attributes of the product of the mean of Models 1 and 2 and the normalised score for Model 3, was also 5. Accordingly the individual weights were again normalised to a total for all attributes of 1. The final result was carried forward to the valuation table (sub-section 7.5) as the 'final weight' for each attribute. This methodology is consistent with the general approach for MCA, although it has been adapted to suit the application, ie. it requires a choice among the criteria in order to assign weights for the whole suite of ecosystem services (ie. adding up to 100%), rather than a choice among options in the case of MCA being used to decide between projects or proposals.

7.4 The Philosophical Inquiry

The method of philosophical inquiry selected for this study was the Delphi Technique. The Delphi Technique was first used by the Rand Corporation in the USA in the early 1950s as a futures forecasting tool (Cunliffe 2002), and has since then been extensively used by researchers, where it is, as described by Kaynak and Macauley (1984):

"a unique method of eliciting and refining group judgement based on the rationale that a group of experts is better than one expert when exact knowledge is not available".

Miller (2001) used a Delphi survey to develop indicators for sustainable tourism, and Cunliffe (2002) used the technique to forecast risks in the tourism industry. A set of statements/questions that pretend to describe some alleged truth need to be validated by one of the philosophical systems/modes also called an Inquiring System (IS), ie. the statement/question must embody the major philosophical criterion to be met. There are many philosophical positions and approaches to validity, although the Leibnizian, Lockean, Kantian, Hegelian (Dialectical) and Singerian are the most significant modes from which others can be constructed. Starting with an assumed ‘event’ or ‘raw data set’ in the ‘external world’, a ‘conceptualisation’, without which we cannot begin to describe ‘the world’ or our ‘knowledge’ of ‘it’, presumes a Lockean IS beginning (Mitroff and Turoff 1975). This raw data set is then transformed or filtered and modelled to produce output information, which is again filtered to transform it into the right form so that a decision-maker can act on it. The various IS can then be fundamentally differentiated from one another with respect to:

1. the priority (importance) assigned to the various systems components;
2. the degree of interdependence to the various systems components by each IS (Mitroff and Turoff 1975).

These inquiries are not about knowing something with perfect certainty, but about what we can know, and how we can justify it, which is the issue and the utility upon which Delphi depends. Some situations where Delphi is useful, features of Delphi and the phases of the Inquiry are shown in Table 7.6. Some characteristics and the essence of the most significant modes of IS are given in Table 7.7.

Table 7.6 Situations where a Delphi Inquiry is useful, features and phases of Delphi. Source: (Linstone and Turoff 1975; Helmer 1975; Mitroff and Turoff 1975; Scheele 1975; Dick 1990; Miller 2001; Cunliffe 2002).

Where Delphi is useful	Features of Delphi	Four distinct phases
The problem does not lend itself to precise analytical techniques but can benefit from subjective judgements on a collective basis	Some feedback of individual contributions of information and knowledge	Exploration of the subject under discussion, each member of the panel contributes additional information pertinent to the issue
More individuals are needed than can effectively and cost-efficiently interact face to face	Some assessment of the group judgement or view	Process of reaching an understanding as to how the group views the issue, including agreement or not and meaning of any relative terms (ie. significance)
Refereeing and anonymity ensure minimal bias	Some opportunity for individuals to revise views	Address any disagreement, underlying reasons, evaluate them
Heterogeneity of the participants is preserved to avoid the bandwagon effect	Some degree of anonymity for the individual responses	Final phase. All previous information analysed and feedback has taken place

Table 7.7 Characteristics and applications of the most significant modes of Philosophical Inquiry Systems (Source: Mitroff and Turoff 1975:20-35).

Inquiry System	Characteristics	Applications
Lockean	Truth is experiential, ie. truth content is associated entirely with empirical content. Truth of a model does not rest on any theoretical considerations or assumptions. Data are prior to and justify theory.	The epitome of experiential consensual systems, developing networks of factual propositions from a set of elementary empirical judgements, ie they are empirically inductively derived. An empirical communication is judged 'objective', 'true' or 'factual' if there is sufficient widespread agreement on it by a group of 'experts'. The validity of the resulting judgement of the entire group is typically measured in terms of the explicit degree of consensus among the experts". .
Leibnizian	Truth is analytic. Truth content is associated entirely with formal content. Models provide theoretical explanations of phenomena under the formally stated conditions which attach to them. Truth does not rest on any external considerations. Finite empirical date is seen to be an inherently risky base upon which to found universal conclusions about any general proposition.	The epitome of formal, symbolic systems, developing networks of ever expanding, increasingly more general formal propositional truths from a set of elementary primitive formal truths, ie they are deductively derived. The formal model is regarded as separate and prior to the data input component. Liebnizian 'proof' for a derived theorem or proposition is the specification of what constitutes proof, and notions of internal consistency, completeness and comprehensiveness.
Kantian	Truth is synthetic, ie. truth content is located in both empirical and theoretical components of the system. Neither data collection nor the theoretical background have priority, yet theories are dependent on data, and there is a presumption that data is collected by virtue of an underlying theory of data collection.	The epitome of multi-model synthetic systems. Kantian IS presuppose the existence of at least two alternate partly Lockean and partly Leibnizian scientific theories, if complimentary, the system is Kantian, if antithetical, it is Hegelian. A Kantian IS presupposes at least two alternate scientific theories (Liebnizian component) from which empirical investigation proceeds (Lockean component), ie a Kantian IS is concerned with getting from a present state to a future state defined by particular needs, objectives and goals.
Hegelian	Truth is conflictual, ie. Truth content is postulated on the basis of two strongly divergent and opposing conceptions of the system, requiring strong debate over the 'true' nature of the system. The result is hoped to be a synthesis of the two diametrically opposed views. Data collection is relevant to both plan and counter-plan, but meaningless without them, and there is an interpretation of the data consistent with both. Division of opinion on important issues is expected to be intense.	The strongly opposing models are Leibnizian, which are then applied to the same Lockean data set, showing that the data are relevant to both theoretical models, however presenting a dialectical confrontation to the decision maker, as interpretation of the data set will be different. Considering the diverse views that arise from political, sociological, psychological and ethical perspectives, experts may be better used as just one component of a Hegelian inquiry.
Singerian	Truth is pragmatic, ie. Truth content is explicitly telelogical, relative to the overall goals and objectives that are articulated initially and throughout the inquiry, which is non-terminating in the sense that it continually seeks to define new goals. Singerian IS is the most holistic of IS, continually adding and defining new variables, which explicitly include the system designer. Singerian IS are the epitome of synthetic multi-model, interdisciplinary systems, and they include all the other IS as sub-models in their design.	Peculiar to Singerian IS are commands that instruct the analyst to take certain hypotheses as true (even though they are only approximations) in order that they be used for experiments and theoretical predictions. The result can evidence that behind every technical-scientific system is a set of ethical presuppositions. Singerian IS can also broaden their perspective to include all of mankind, the present and the future, thus giving a unique insight not only into the problem being investigated, but to the participant's and designer's knowledge of themselves.

Delphi may be characterised as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. Delphi is better suited to setting up a communication structure among an already ‘informed’ group that possesses the same core of knowledge. A Kantian, or ‘contributory’ Delphi, attempts to design a structure that brings different ‘informed’ perspectives to the central issue under study, and allows many ‘informed’ individuals in different disciplines or specialties to contribute information or judgements to a problem area that is much broader in scope than the knowledge that any one of the individuals possesses. Delphi therefore capitalises on the collective human intelligence capability which contributes to the process of human motivation and action (Linstone and Turoff 1975).

A group of about fifty 'experts' were selected from the disciplines of neo-classical economics; environmental economics; ecological economics; geography; natural resource management; ecology, and environmental science. The Delphi Inquiry was conducted over a six-month period ending October 2002, using a purpose-designed web site, that required the panellist to log-in with user-name and password, and which preserved individual anonymity. The Delphi comprised of four rounds where the panellists were required to contribute, followed by feedback immediately after each round was closed, or included in the preamble to the next round. Two further rounds followed where there was no requirement to contribute and results were presented to the panellists as fulfilment of the commitment to them for their participation. In addition to a series of both open-ended and closed-ended questions /statements to do with the topic, the panellists were presented with the three MCA models outlined in Chapter sub-section 7.3 above. The questions or statements generally came from the literature, and either required a true or false response, or a written response. The web-page by way of introduction for round 1 and the questionnaire, is included as Appendix C. The web pages for later rounds contain feedback, and so will be introduced in Chapter 8.

The panellists' responses were tested for the level of consensus by way of a non-parametric test, namely Kendall's Coefficient of Concordance (Kendall's *W*) (Blalock and Blalock 1968; Zar 1996; Hicks 1999). The coefficient *W* permits the evaluation of the extent of concordance or agreement between three or more sets of data. It has the value 1.0 if the groups agree perfectly and 0.0 if they disagree maximally. A more common use of Kendall's Coefficient of Concordance is to express the intensity of agreement among several rankings or as a measure of the agreement of rankings within blocks. The value of *W* may range from 0 (when the sum of ranks are equal and the sum of squares of the sum of ranks is 0, when there is no association), to 1 (when there is complete agreement among the ranking of all groups). To determine if a calculated sample *W* is significant, ie. if it represents an association different from zero in concordance, the relationship between the Kendall Coefficient of Concordance (*W*) and the Friedman Chi-square χ_r^2 is used:

$$\chi_r^2 = M(n\text{-}1)W \qquad \text{(Equation 7.4)}$$

where *M* = the number of variables, *n* = the size of the sample, and employing the table of critical values for χ_r^2 (Zar 1996).

For the questionnaires, the panellists were grouped into their nominated disciplinary category, ie. neoclassical economist, environmental economist, ecological economist, geographer, natural resource manager, ecologist and environmental scientist etc., and frequencies of 'true' responses for each set of questions for each panellist and for each disciplinary category were calculated. Using SPSS for Windows (SPSS Version 11, 2001), the coefficient of concordance and the significance or intensity of agreement within and between these 'blocks' was measured. For the models, each panellists' set of total weightings for each of the 20 attributes in each model was statistically analysed for the Kendall's *W* with every other panellists' set of weightings. The groups or 'blocks' were:

- all disciplines
- neoclassical economists
- environmental economists

- ecological economists
- all economists
- geographers
- natural resource managers
- ecologists
- environmental scientists
- all natural scientists

For Models 1 and 2, where all values were positive, the coefficient of variance of the mean values of all panellists' weightings was also calculated. Finally, each discipline's set of responses was also tested with every other discipline's set of responses, eg. neoclassical economists with environmental economists; geographers with ecologists etc., using the Wilcoxon Signed Ranks test to show the highest significance of extent of agreement between the disciplines.

7.5 The Conceptual Model and Valuation Table for Ecosystem Services

Indicators for ecological integrity at the most obvious level are the naturalness of the environment, ie. spatial and temporal distance from disturbance and the health of vegetation. At the less obvious level, indicators such as feeding guilds or functional groups of saproxylic insects may have relevance to understanding the relationship between ecosystem function and biodiversity (Grove 2000). For example, the emerging pattern from studies is that in general logged forests support less species-rich assemblages, with fewer individuals overall, and also a different species composition compared to old growth forest. Another general principle that has been put forward is that the abundance distributions of organisms in disturbed or successional ecosystems (logged or regrowth forest) differ from those of more mature ecosystems. Moreover studies on non-saproxylic insects conclude that disturbance of mature ecosystems tends to homogenise assemblage composition (Grove 2000), ie. disturbance tends to reduce diversity.

The purpose of this research is to develop a new or modified approach to valuing the environment that will have wide application and can be readily implemented when it is necessary to consider the value of intangibles in systematic analyses to do with development, for example in CBA. The time frame for this type of analysis, depending on the scale of development is usually measured in weeks to months. It would thus be counterproductive to suggest that the less obvious indicators of ecosystem integrity, such as saproxylic beetle assemblages, be used. In most cases this type of study requires a dedicated researcher and assistants for an extended period of about 3-4 years. The development of the valuation table and conceptual models in this section are postulated on this assumption, and that of Lugo (1988), and the work of Holdridge (1967) and Holdridge *et al.,* (1971) and Lugo's work with Brown (Brown and Lugo 1982):

"Statistically significant relationships suggest that life zone conditions relate to characteristic numbers of tree species, biomass and rate of primary productivity, and capacity to resist and recover from disturbance". (Lugo 1988:61).

A valuation table was developed to determine the level to which ecosystem services are intact, for use with both individual landholdings, ie. rateable land and smaller public situations, and landscapes. The former was based upon observation, historical records and empirical evidence from the proprietor or management agency; and the latter (landscapes) requiring a conceptual model based partly upon the literature as to what the defining parameters were. The valuation table is included as Table 7.8. It should be noted that it is the valuer's responsibility to determine, using all means available to him/her, the appropriate and best available input to the columns within an acceptable margin (Chapter 4). From observation and consultation the valuer determines if the individual ecosystem attribute is present or not present. If it is not present, whether the absence is temporary or permanent, and the type of disturbance, and if it is present, the degree (upper limit and lower limit %) to which it is intact or productive in the sense of provision of ecosystem goods and services (*esi* in equation 7.2 and 7.3). There are strict parameters to meet in making this assessment and these are outlined in the conceptual model for landscapes. The remainder of the columns have input from earlier sections of this methodology, namely the *Usus Fructus per annum* (*UFpa* in equation

7.1), and final weight (*wt* in equation 7.3). Thus to complete the table a valuer would proceed as follows:

1. determine the *MUV* for the bioregion
2. determine the *UFpa* from the equation
3. decide if the ecosystem attribute is present
4. determine the upper limits and lower limits from the conceptual models or by observation or other evidence
5. enter the final weights of the ecosystem attributes
6. the total value range of each ecosystem attribute is determined from *UFPA* x *wt* x % intact
7. the total value of each attribute in the region is *UFpa* x *wt* x % intact x area (ha)
8. the total range of values of the whole ecosystem is the total of the relevant columns.

Table 7.8 Valuation table for individual landholdings and landscapes.

TENURE CATEGORY OR PROPERTY DESCRIPTION: ~

The median unimproved value of all rateable land in the bioregion: $ per hectare

Group and Type of Ecosystem Service	Not Present Temporary	Not Present Permanent	Type of Disturbance	Present	*UFpa* %	% Intact	% Intact	Weighting	Value per ha % intact	Value per ha % intact	TOTAL VALUE Lower Limit	TOTAL VALUE Upper Limit
Stabilisation Services												
Gas regulation												
Climate regulation												
Disturbance regulation												
Water regulation												
Erosion control												
Biological control												
Refugia												
Regeneration Services												
Soil formation												
Nutrient cycling and storage												
Assimilation of waste												
Purification												
Pollination												
Biodiversity												
Production of Goods												
Water supply (catchment)												
Food production												
Raw materials												
Genetic resources												
Life Fulfilling Services												
Recreation opportunities												
Aesthetic, cultural and spiritual												
Other non-use values												

7.5.1 Landscape Valuation

The conceptual model for the level of provision of ecosystem services on a landscape scale was developed using species richness, vegetation cover, and/or either the level of protection (LOP model: national park, conservation covenant etc., Figure 7.1), or the land use characteristic (LUC model: open forest, rangelands etc., Figure 7.2), as measures of how productive or intact the ecosystem services are on a landscape scale (Holdridge 1967; Holdridge *et al.,* 1971; Lugo 1988; Mooney 1988; WTMA 2001). Focussing on general properties of ecosystems such as species richness, common scales that allow comparison between ecosystem integrity in different ecosystems do exist (Chapter 5). This methodology is thus consistent with the theory of island biogeography (MacArthur and Wilson 1967; Dreschler and Watzold 2001), although it adds another important dimension, that being human intervention. Reference is made to the Chapter 5 of the literature review, where techniques to assess ecological integrity relative to land area are discussed, ie. spatial scales have important implications for conservation (Meffe and Carroll 1997).

The model is an isosceles triangulation model with species richness on one side, canopy/vegetation cover on the other side, and either level of protection or land use characteristic along the base. The apex represents 100% (of species richness and vegetation cover) and the basal apices, 0%. The level of protection decreases towards each basal apex, as the level of disturbance increases towards each basal apex. In order to reflect the economic concept of scarcity, capitalisation rates (*cr* in equation 7.1 as a mathematical derivation for *UFpa*) were increased as the level of protection decreased and the level of disturbance increased from the centre of the base outwards to the basal apices (Figures 7.1 and 7.2). The defining parameters for both the individual model and the landscape model are:

1. The highest vegetation cover (closed canopy forest) and hence species richness, *ceteris paribus*, is in tropical rainforest (99% in the example shown in Figure 7.1).
2. As the canopy cover decreases, so also does species richness, with the exception only of Mediterranean zone ecosystems. The following approximate relationships apply (in comparison to tropical rainforests):
    - moist tropical forest ~ species richness:60-80%
    - dry tropical forest ~ species richness:30-50%

- temperate zone ~ species richness:20-40%
- Mediterranean zone ~ 40-60%

3. The ratio of species richness to vegetation cover is generally 2:3, with the exception of Mediterranean zones, where it is generally 1:1
4. The lowest level of provision of ecosystem services on a landscape scale is 39%, which includes urban landscapes and deserts

(Mooney 1988).

The alternate conceptual model, the LUC model, should yield similar results to the LOP model, however it allows wider application with choices of land use characteristic along the base of the triangle from the centre towards the basal apices, due to either human-induced or climate-induced modification, as follows (Figure 7.2):

- tropical rainforest, temperate rainforest
- wet sclerophyll, dry sclerophyll
- open forest
- rangelands, grasslands
- croplands, desert

A full set of examples of each level of protection and each land use characteristic is included in Appendix D.

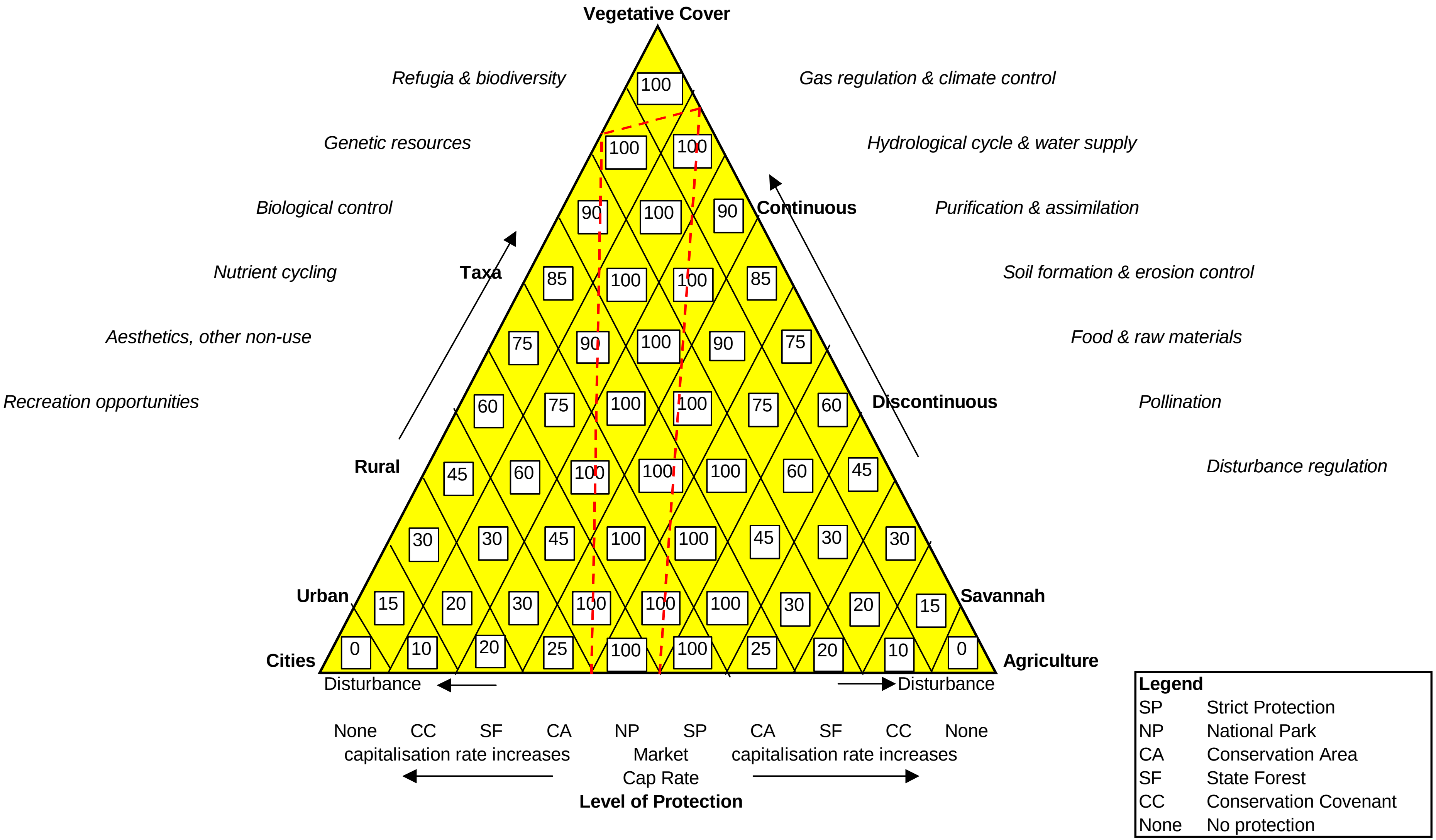
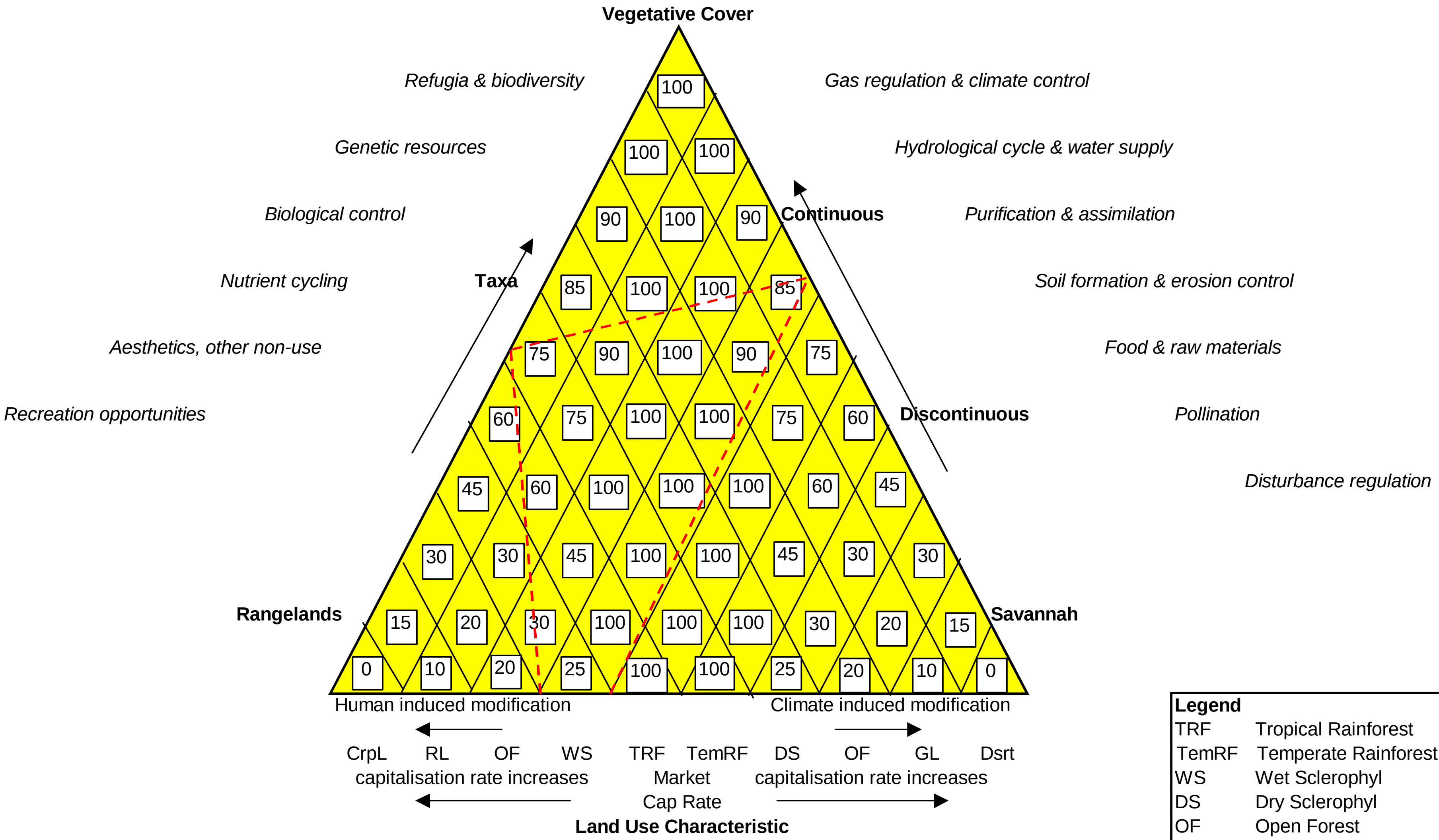


Figure 7.1. Triangulation model to assess extent of ecosystem services intact under a given level of protection or no protection
Scoring: Calculate the mean of the values within the diamonds included in the selection as well as those the dotted line passes through.
This example, National Park: 99%



Legend	
TRF	Tropical Rainforest
TemRF	Temperate Rainforest
WS	Wet Sclerophyl
DS	Dry Sclerophyl
OF	Open Forest
RL	Rangelands
GL	Grasslands
CL	Croplands
Dsrt	Desert

Figure 7.2. Triangulation model to assess extent of ecosystem services intact under a given land use characteristic
Scoring: Calculate the mean of the values within the diamonds included in the selection as well as those the dotted line passes through.
This example, Wet Sclerophyll Forest: 79%

7.6 Chapter Summary

The methodology for this research project is both multi-disciplinary and interdisciplinary. The research is concerned with the various divisions or branches within economics, including applied economics in the form of valuation practice, environmental science, and ecology. The central theme of the research is the use of a surrogate market to establish shadow prices for ecosystem services. This is achieved by a systematic analysis, namely a multiple criteria analysis, and a social study, in the form of a Delphi Philosophical Inquiry. These two methods incorporate many different perspectives: namely anthropocentric, utilitarian (economic), ecological, aesthetics, equity, risk and uncertainty. The weightings provided by the panellists were non-pecuniary, and as such were not subject to any bias or odium that may have been associated with putting monetary values on nature's gifts. Finally a valuation table was devised to assess individual ecosystems on private or public land and a conceptual model devised for landscapes.

Step-wise, the methodology proceeded as follows:

1. The median unimproved value (*MUV*) of alienated land in the bioregion was determined from council records.
2. The *MUV* per hectare for all the other land in the bioregion was calculated (as at June 30th 2002).
3. Round 1 of the Delphi involved a questionnaire primarily to do with the need for the study (May 1st 2002).
4. Round 2 of the Delphi involved feedback from round 1 and a second questionnaire primarily to do with integrating economics and ecology. The first model for the multiple criteria analysis (anthropocentric) was introduced.
5. Round 3 of the Delphi involved feedback from round 2 and a third questionnaire primarily to do with global equity issues. The second model for the MCA was introduced (utilitarian).
6. Round 4 of the Delphi involved feedback from round 3 and introduced the third and final model for the MCA (balanced sensitivity).
7. The data from the MCA models were analysed and non-pecuniary weightings for the individual ecosystem attributes were determined.
8. Round 5 of the Delphi involved feedback from round 4 and some results.
9. The valuation table and conceptual model for ecosystem integrity were devised. *UFpa* was determined using a market capitalisation rate, and data entered into the valuation table included *UFpa,* the final weights for the attributes (*wt)*, and the limits to

which ecosystem services were intact in the various tenure categories in the WTWHA (*esi)*.

10. Round 6 of the Delphi presented final results to the panellists (November 1st 2002).

CHAPTER 8
RESULTS OF THE PHILOSOPHICAL INQUIRY

8.1 Introduction

The Delphi Technique features:

- some feedback of individual contributions of information and knowledge
- some assessment of the group judgement or view
- some opportunity for individuals to revise views
- some degree of anonymity for the individual responses

The disciplines and individuals selected to participate in the inquiry were considered to satisfy the requirement of a ‘Kantian’ Delphi, with ‘informed’ individuals volunteering to participate due to their interest in the topic and their own perceived ability to make a significant contribution. The Delphi rounds commenced on May 8, 2002 with 50 panellists and closed on August 23, 2002. Panellists were asked to nominate their discipline (eg. economist, ecologist etc.) in the first round and some of them nominated more than one discipline in economics or the natural sciences, or both. Panel attrition is discussed in sub-section 8.3. There was no ‘honorarium’ paid to any member of the panel, and they are acknowledged in the relevant section of this thesis.

8.2 The Questionnaires

There were three questionnaires, one in each of rounds 1, 2 and 3 of the Delphi Inquiry, totalling 60 questions in all. The web site hosting the Delphi was user-friendly, with panellists only having to log on to access the questions, and click on the true or false response, or enter a text response in the box provided. The true/false responses were downloaded to an Excel file to facilitate statistical analysis. The text answers were downloaded to a text file, which was then copied into Microsoft Word. The design of the web site enabled a quick turnaround of feedback to the panellists in order to avoid delays between the rounds. The comments of panel members relating to the open-ended questions (text response) in rounds one and three are included in their entirety in Appendices H and I, and together express the collective view.

8.2.1 Closed-ended questions/statements (eg. true/false)

In round 1 of the Delphi (Appendix C, introduced in Chapter 7), Kendall's Coefficient of Concordance (Kendall's *W*) of the frequency of 'true' answers to the questionnaire from the seven disciplines represented was highly significant, 0.814 ($P<.000$). In other words the level of agreement between the blocks was significantly different to zero, and approaching maximal agreement (ie. 1). Statements to do with past methodologies employed to value the environment had a mixed response, however an average of the responses for the 15 statements resulted in 85% of the group answering 'true', with the individual disciplines to the same order of response (82-89%). To clarify this response, more than 80% of respondents thought that there was a justifiable lack of confidence in past and current methods used to value the environment.

The group again reached consensus in round 2. Kendall's *W* of the frequencies of true responses across the disciplines was 0.747 (P<.000). The preamble to round 2 and the questionnaire are included in Appendix E. The economists and geographers had similar responses to the questions, as did the environmental scientists, ecologists and natural resource managers. Ninety four per cent of the panellists agreed that human activities are beginning to affect ecological life support systems, and 91% answered true to the next five statements to do with the merit of inclusion of ecosystem goods and services in the market system.

In round 3 Kendall's *W* of the frequencies of true responses across the disciplines was 0.868 ($P<.000$). The group again reached consensus. The preamble to the round and the questionnaire, along with the feedback from round 2 to the panellists is included as Appendix F.

Round 4 did not have a questionnaire. The preamble to the round including results from round 3 and introducing the third model for the multiple criteria analysis is included in Appendix G. Results from round 4 and a summary of the multiple criteria analysis is also included in Appendix G.

In order to clarify the points of agreement and the points of difference emanating from the Delphi Inquiry, the results are set out in a series of bar charts that merited comment. The first statement in round 1 was controversial as while some respondents agreed with the statement *per se*, that this was indeed a fair description of anthropocentrism, they expressed by separate communication that they did not agree with anthropocentrism. This resulted in a possibly misleading true/false response with the highest ‘true’ response from the ecological and environmental economists and the lowest from the neoclassical economists (Figure 8.1).

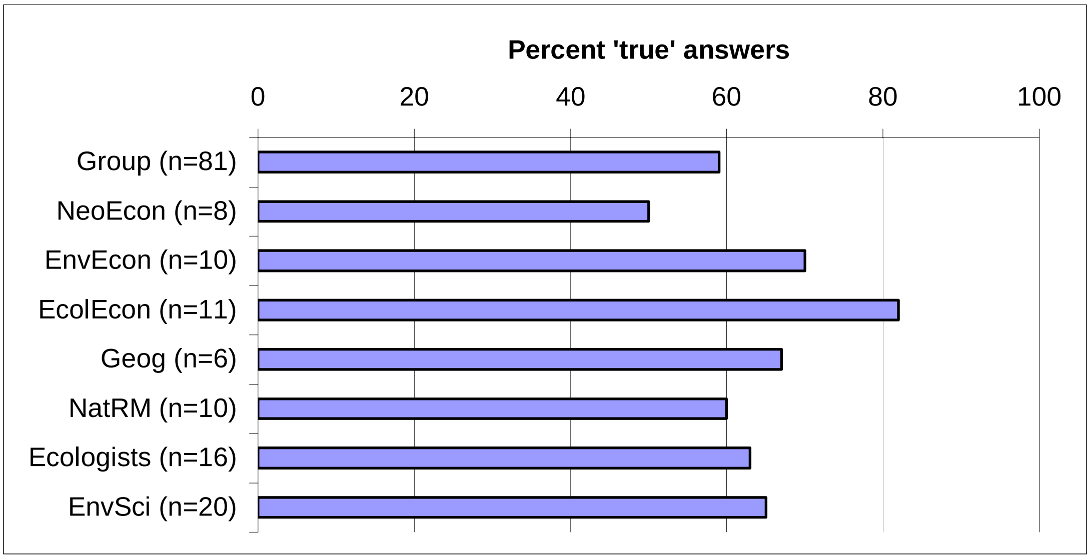


Figure 8.1 Bar chart of the responses to statement 1 “Anthropocentrism holds that only humans can have or ascribe intrinsic value, and as such all other features of the environment, whether living or non-living, can only have value through usefulness to humans”.
Note: The disciplines represented in the figures are Neoclassical Economists (NeoEcon), Environmental Economists (EnvEcon), Ecological Economists (EcolEcon), Geographers (Geog), Natural Resource Managers (NatRM), Ecologists, and Environmental Scientists (EnvSci). Some experts nominated to represent more than one discipline (hence n=81 for the group).

The next statement suffered from the same bias, and the true/false response was quite varied. All ecological economists answered true and 90% of environmental economists. Geographers had the lowest true response at 50% (Figure 8.2).

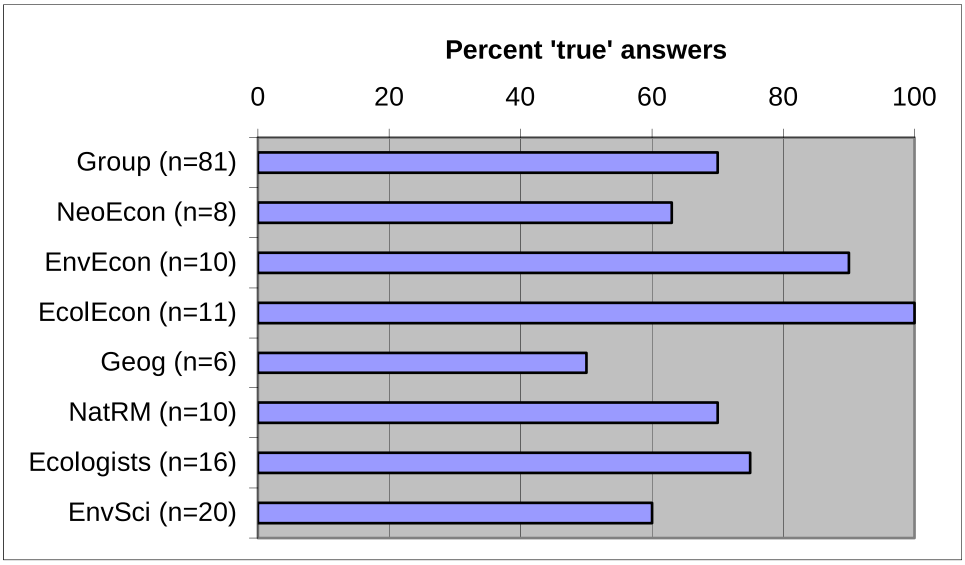


Figure 8.2 Bar chart of the responses to statement 2 "It follows that a feature of the environment or an ecosystem service must provide some utility to at least one human entity, otherwise it has no economic value".

Between 80 and 100% answered true to statement 5 (Figure 8.3), and between 90 and 100% answered true to statement 9 (Figure 8.4).

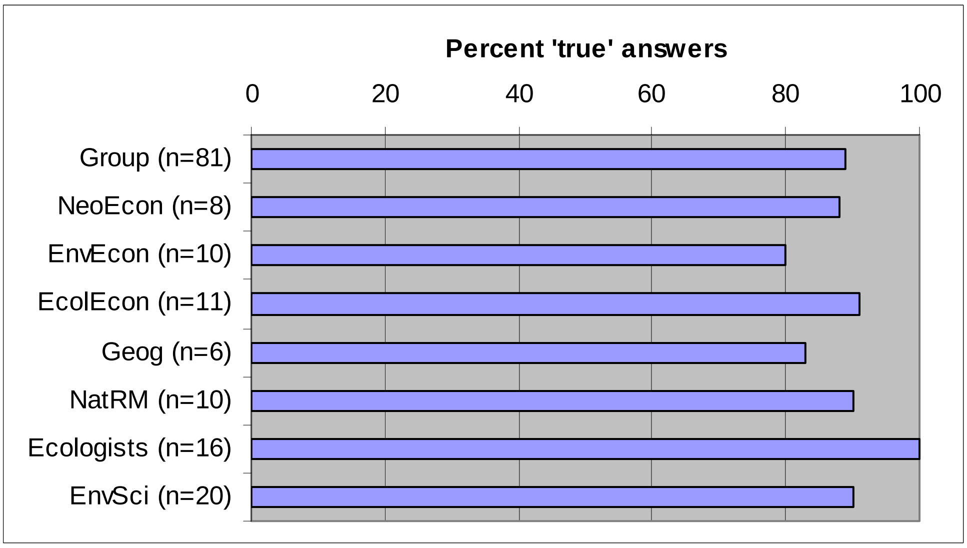


Figure 8.3 Bar chart of the true responses to the statement 5: "In the absence or failure of accepted markets, no direct mechanism exists to measure or reveal the prices of intangibles, so surrogate or shadow prices are used".

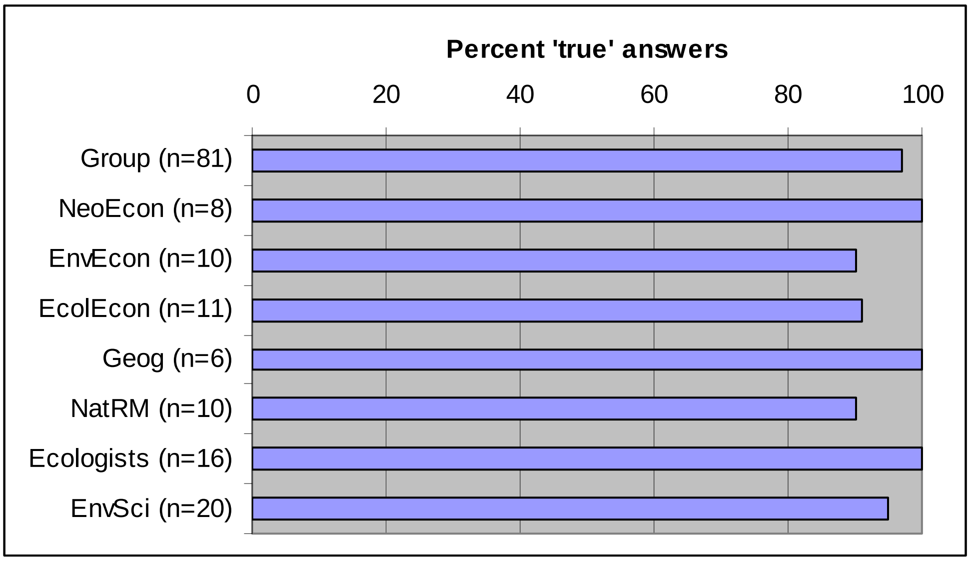


Figure 8.4 Bar chart of the true response to statement 9: “The contingency valuation method is fraught with risk where respondents have no knowledge of the resource, no experience in trading it and do not believe the market to be realistic”.

Over 80% of the group (100% of neoclassical economists) thought that the contingency valuation method was “also well known for producing frivolous responses” (Q10). Ninety five percent of the group (100% of environment economists, ecological economists, natural resource managers and ecologists) thought “conventional economics” was “totally inappropriate when dealing with environmental problems”. Clearly however the environmental and ecological economists do have a higher level of confidence than the other disciplines in ‘willingness to pay’ as a measure to value the environment, and to evaluate terrestrial ecosystems (Figure 8.5), while the other individual disciplines were not too sure. Only about 68% of the group thought that (Q16): “the many variables and feedback effects inherent in the natural world obfuscate proper modelling of environmental impacts on ecosystems” (Figure 8.6). Although the true response was much greater with the rider “the problem becomes even more difficult when links between very complex phenomena and the economy are sought” (Q17) with a group result of 97% (Figure 8.7).

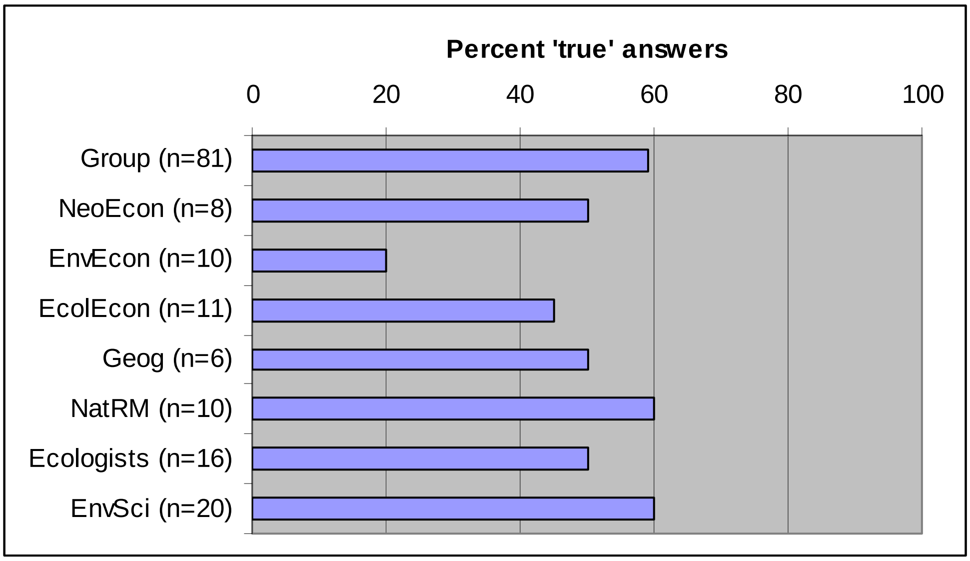


Figure 8.5 Bar chart of the true response to statement 12: "WTP is only useful in valuing a particular attribute of the environment eg. recreation, and is never areal, making it worthless to evaluate terrestrial ecosystems".

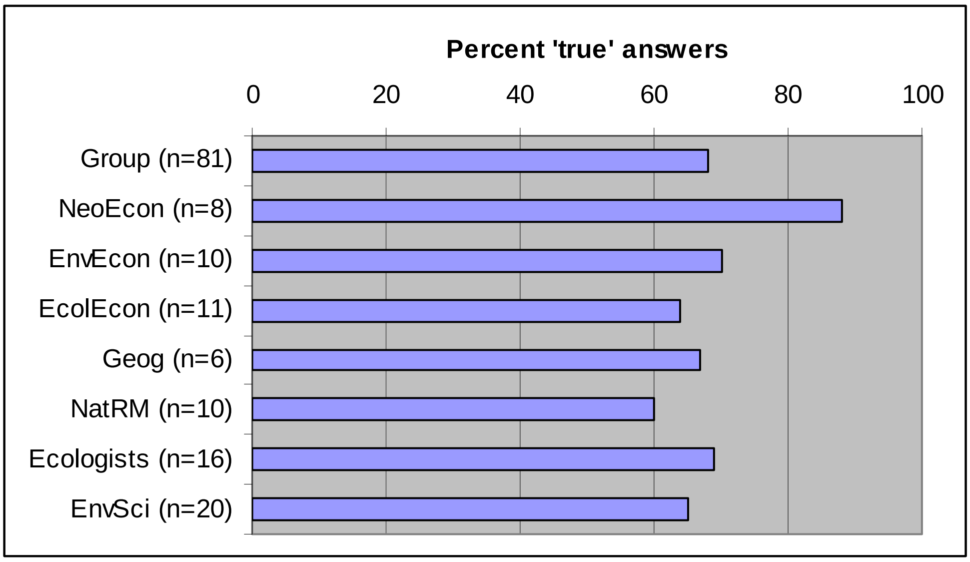


Figure 8.6 Bar chart of the true response to statement 16: "The many variables and feedback effects inherent in the natural world obfuscate proper modelling of environmental impacts on ecosystems".

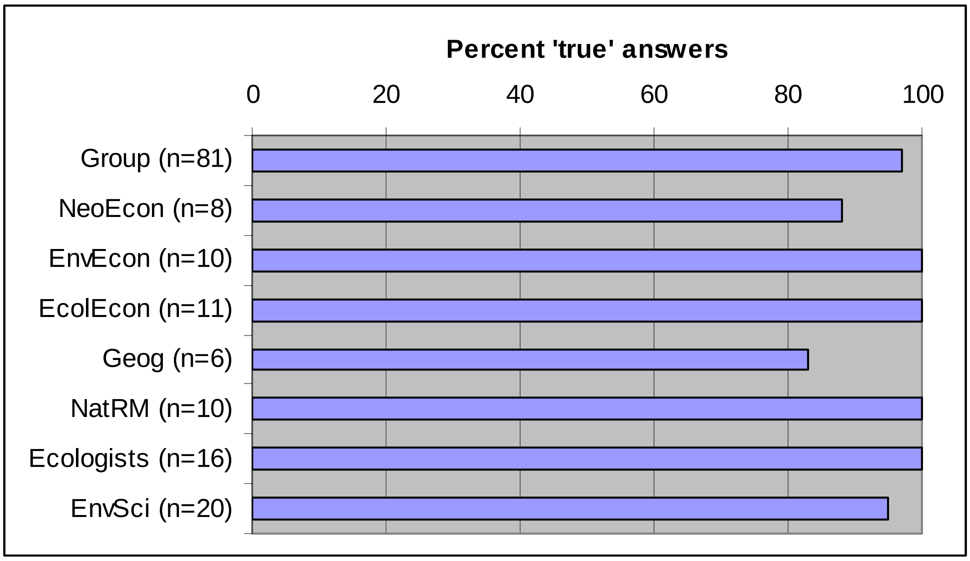


Figure 8.7 Bar chart of the true response to statement 17: "The problem becomes even more difficult when links between very complex phenomena and the economy are sought".

The question/statement "it has been called 'self-deception' and 'the deception' of others, that to 'measure the immeasurable' is absurd" (Q21) produced a median response with neoclassical economists the highest with over 70% for true and geographers the lowest, just over 30% (Figure 8.8).

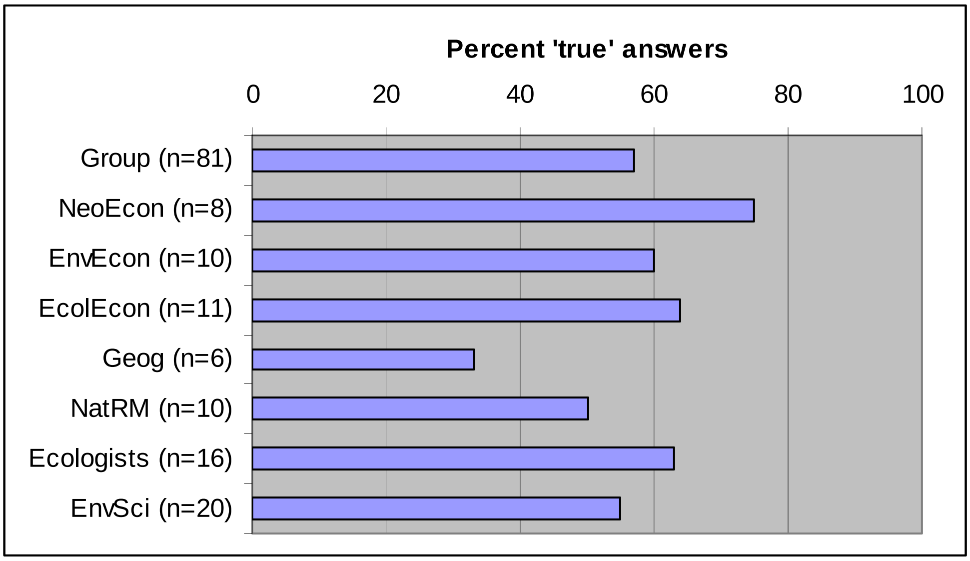


Figure 8.8 Bar chart of true responses to statement 21: "It has been called 'self-deception' and 'the deception' of others, that to 'measure the immeasurable' is absurd".

However, when suggesting that: "there is an instinctive conviction that what cannot be measured may not exist" (Q26), 72% answered false, with only environmental economists and environmental scientists having a 50% true/false response (Figure 8.9).

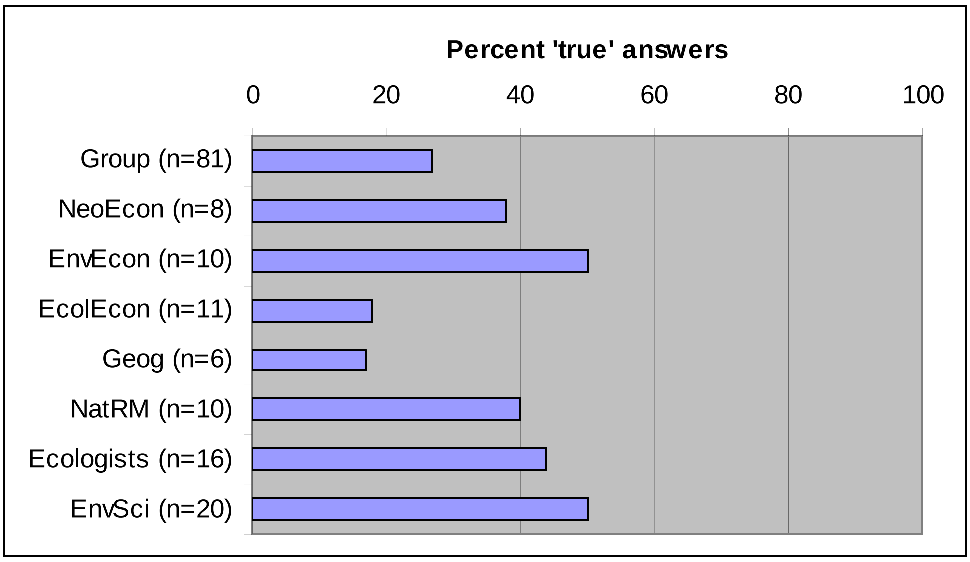


Figure 8.9 Bar chart of true responses to statement 26: "There is an instinctive conviction that what cannot be measured may not exist".

The four statements to do with money also raised some obvious consternation, with the question (Q22) producing a median overall group response, however all economists responded with between 45 and 60% true, and all natural scientists between 75 and 83% true (Figure 8.10).

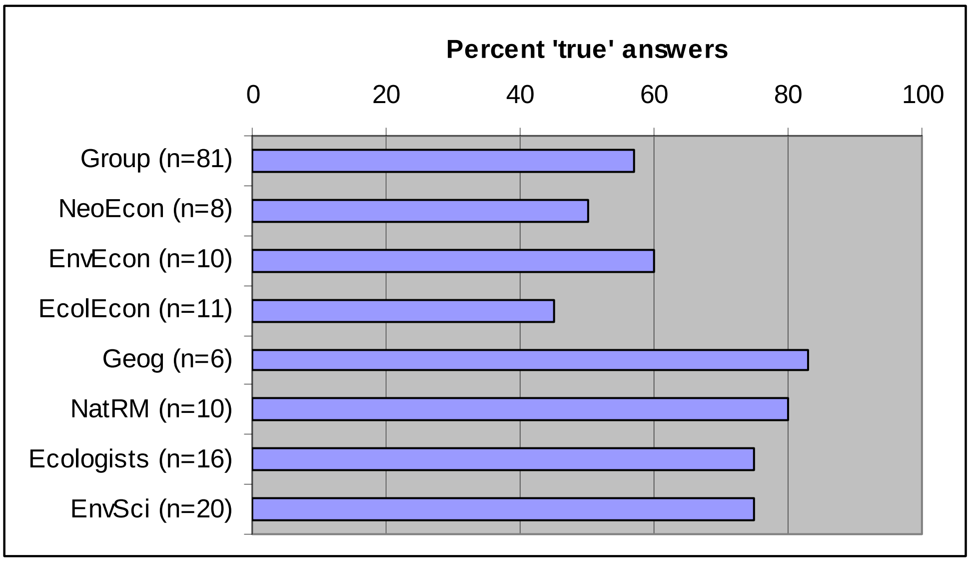


Figure 8.10 Bar chart of the true response to statement 22: "Nothing else compares to the medium of money in the marketplace, which is the context in which millions of individuals express countless preferences daily".

Ninety three per cent of the group agreed that: "people express preferences for or against goods and services by buying them or not buying them" (Q23). However, there was an almost overwhelming rejection of the statement that: "money is regarded as the store of value (in terms of income and wealth), such that to express preferences or vote, it is assumed one must possess money" (Q24) Figure 8.11. Responses to the statement (Q25): "cash is the obvious choice, having the advantage of comparison with its own investment cost on a case-wise basis" were very variable, with 51% of the group answering false, however environmental economists (80%), ecological economists (73%), ecologists (69%) and environmental scientists (60%) answered true.

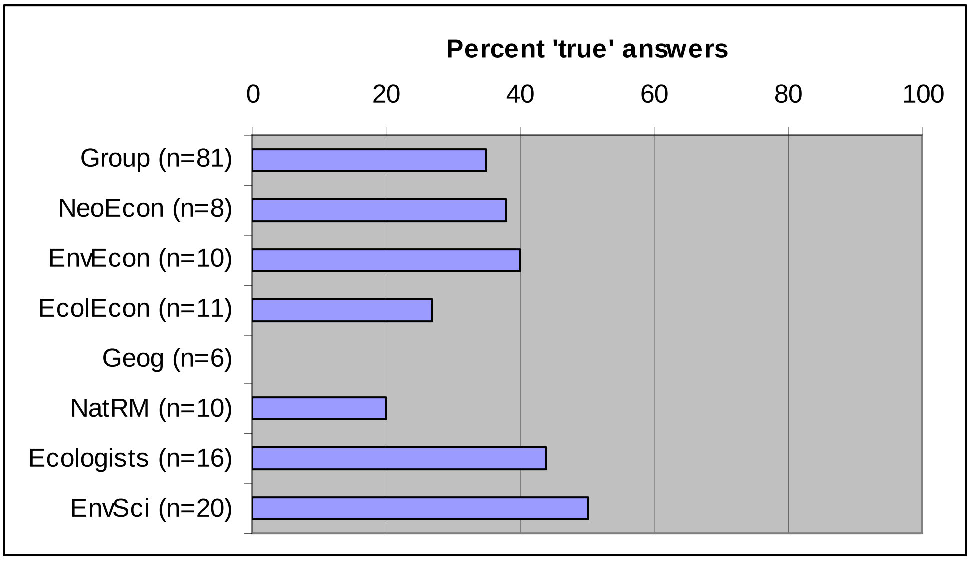


Figure 8.11 Bar chart of the true response to statement 24: "Money is regarded as the store of value (in terms of income and wealth), such that to express preferences or vote, it is assumed one must possess money".

The group response to the statement: "society can put a monetary value on a non-market good or service…under the right experimental conditions" (Q27) was over 80% true, with the highest being environmental economists (90%) and the lowest ecological economists (64%). The next statement (Q34):"By developing a method to ascribe dollar values to ecosystem goods and services and thus finance conservation by way of establishing trading markets in them, natural resource utilisation can be made sustainable", elicited a group response of 59%, with environmental scientists the highest at 75% and geographers and neoclassical economists the lowest at 50% (Figure 8.12).

Patterns emerging from the individual disciplines' responses will be discussed later in this Chapter.

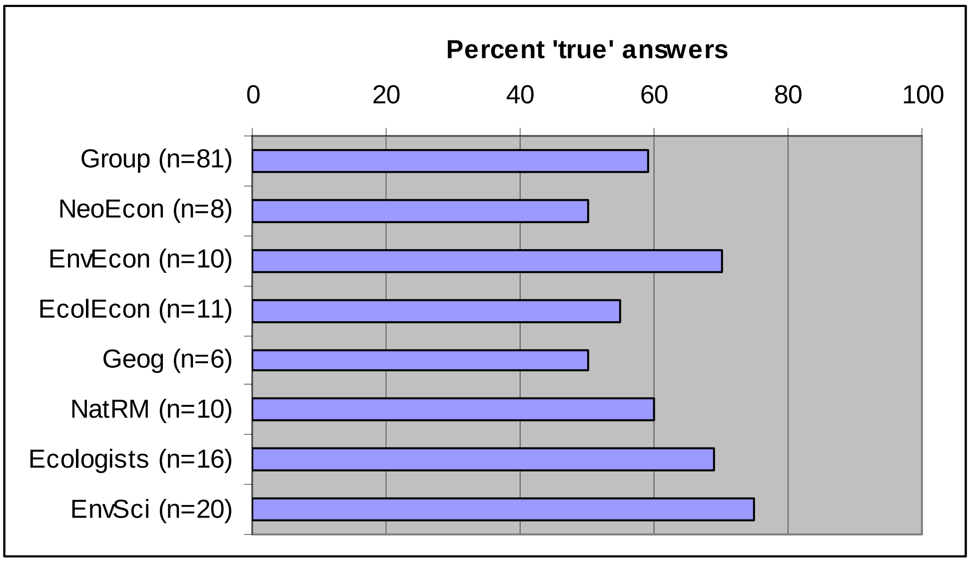


Figure 8.12 Bar chart of the true response to statement 34: "By developing a method to ascribe dollar values to ecosystem goods and services and thus finance conservation by way of establishing trading markets in them, natural resource utilisation can be made sustainable".

The next nine questions/statements were in round 2 (Appendix E), and were partly economic and partly ecological, with the first (Q42): "Human activities have grown so large and pervasive that they are beginning to affect the ecological life-support system itself", having a 94% true group response, with the only values less than 100%, the natural resource managers, ecologists and environmental scientists. Statement 43: "Costs and benefits not included (when they should be) in market prices (ie. externalities) affects how people interrelate with their environment", dropped from 94% true to 91% true group response, but elicited an almost identical response from all disciplines, with ecologists and environmental scientists dropping from 94% true to 88% true. Again, Q44: "Biodiversity is not adequately protected because it is not included in market signals that guide economic decisions of producers and consumers, and in turn the whole economic system, ie. market failure", elicited a group true response of 91%, with neoclassical economists, environmental economists, geographers and ecologists registering 100% true and the others, 88-89% true. And yet again, Q45: ”Ecosystems are being lost because they don’t have prices acting as negative feedback to keep use in equilibrium with availability”, had an almost identical response with only ecologists slipping back from 100% true to 94% true (Figure 8.13).

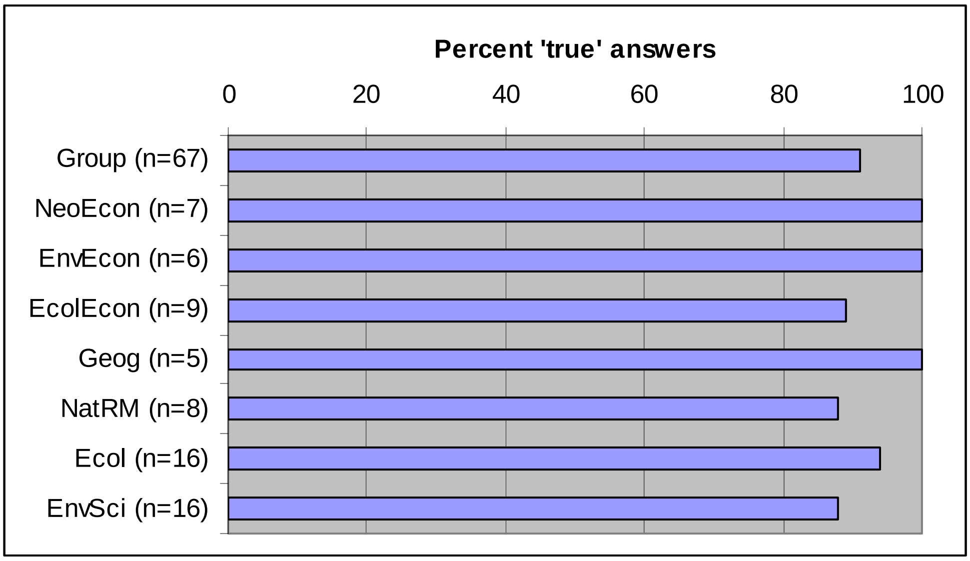


Figure 8.13 Bar chart of the true responses to statement 45: ”Ecosystems are being lost because they do not have prices acting as negative feedback to keep use in equilibrium with availability”.

The true response to statement 46: “Biologists say that if the true value of species or biodiversity were understood, it would be conserved. If they were included in the market system, the markets themselves would assist in conservation”, was again almost identical with the same group response of 91% true. Statement 47 was almost identical to statement 45, with the only change that *the argument was being put by economists* (emphasis added): “Economists argue that ecosystems are being lost because they don’t have prices acting as a negative feedback to keep use in equilibrium with availability”, with the overall group response for true slipping to 84% and only ecological economists and environmental scientists not resiling from their previous view. Neoclassical economists and environmental economists slipped by 14% and 17% respectively, geographers by 20%, natural resource managers by 13%, and ecologists by 12% (Figure 8.14).

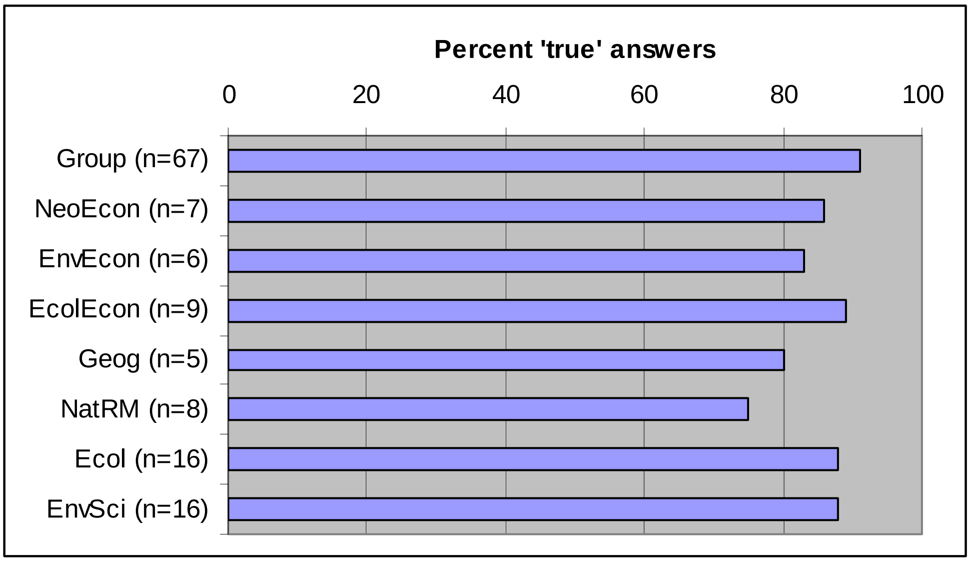


Figure 8.14 Bar chart of true responses to statement 47: "Economists argue that ecosystems are being lost because they don't have prices acting as a negative feedback to keep use in equilibrium with availability".

Statement 48: "Efforts to protect the environment can be accomplished in ways that internalise the full costs and bring out real benefits, thus creating necessary support for their implementation", elicited a 79% group true response with neoclassical economists, environmental economists and geographers voting 100% true, and ecologists least sure on 69% true. Statement 49: "Biodiversity supports the natural ecosystems on which life depends, enriching the soil, purifying the water, and creating the very air we breathe. The greater the biodiversity of species in an ecosystem, the more productive and stable it is", had a very surprising relatively low response for true across all disciplines. The group response was 65% true, with the highest the neoclassical economists at 71%, and the lowest, geographers on 40% (Figure 8.15).

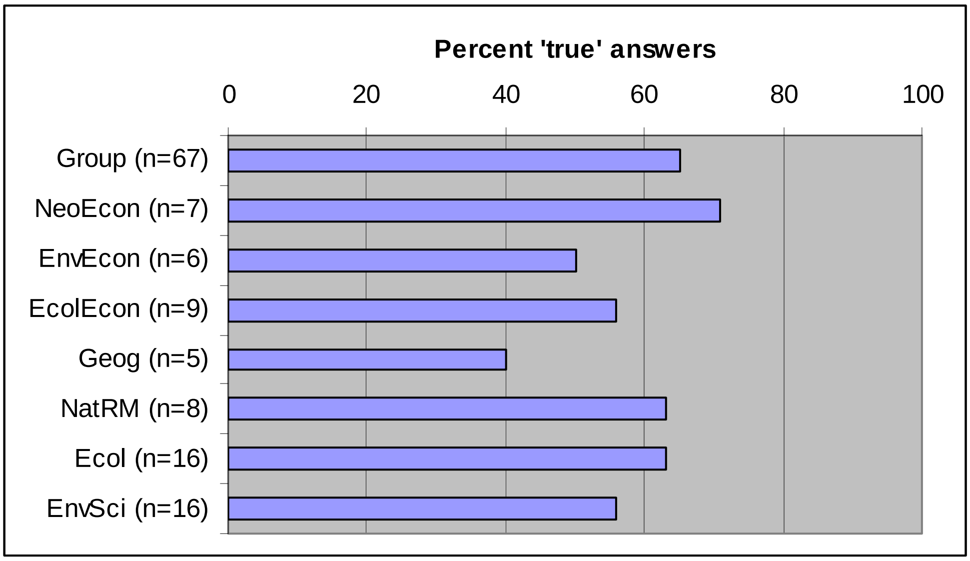


Figure 8.15 Bar chart of true responses to statement 49: "Biodiversity supports the natural ecosystems on which life depends, enriching the soil, purifying the water, and creating the very air we breathe. The greater the biodiversity of species in an ecosystem, the more productive and stable it is",

The final statement (Q50) in this round was attributable to Al Gore: "The single best opportunity to make sustainable development happen is to make investments in sustainable practices and technologies attractive to private business and private investment" (Figure 8.16). The group true response was 68%, six disciplines ranged from 50 to 75% true, however the geographers were totally in agreement with 100% true.

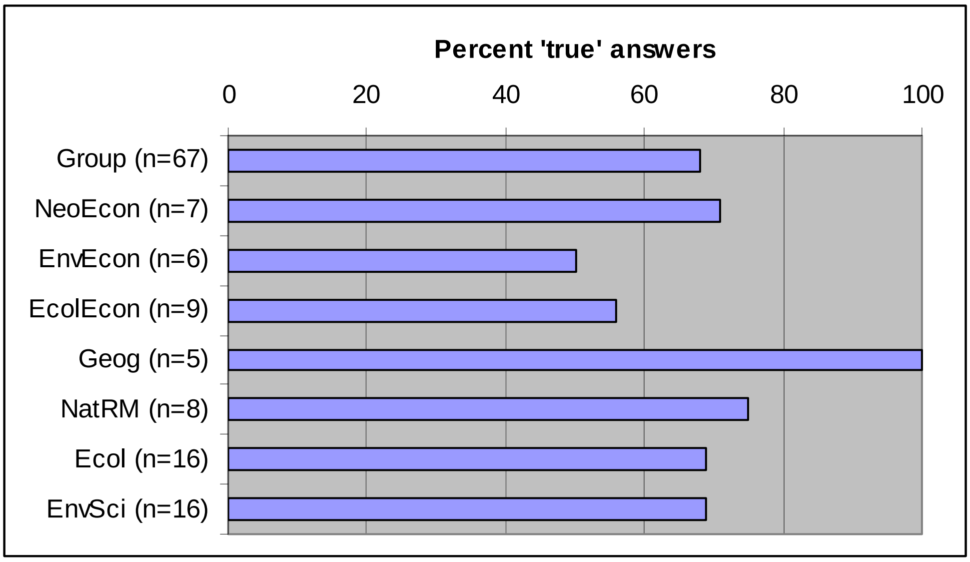


Figure 8.16 Bar chart of true responses to statement 50: "The single best opportunity to make sustainable development happen is to make investments in sustainable practices and technologies attractive to private business and private investment".

The Round 3 questionnaire focussed on global equity and global issues, ecologically sustainable development (ESD) and then briefly with pricing structures, regulation and markets. The first statement that: “the Earth Summit held in Rio de Janeiro in 1992 captured the spirit of a new idealism in which pragmatism was in full harmony with idealism”, only marginally appealed to the panellists with a 50% group ‘true’. Environmental economists and ecological economists were split at 50%, and geographers and natural resource managers were the highest with 75% and 83% respectively (Figure 8.17).

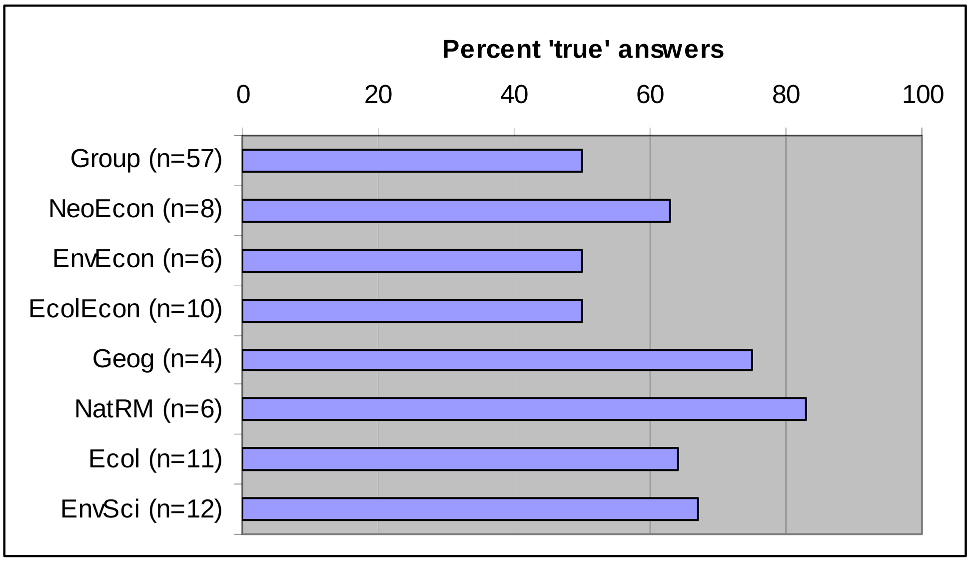


Figure 8.17 Bar chart of the true response to statement/question 51: “The Earth Summit held in Rio de Janeiro in 1992 captured the spirit of a new idealism in which pragmatism was in full harmony with idealism”.

The group true response for statement 56: “The unprecedented levels of wealth due to economic growth are only experienced by a minority of people on earth”, was 96%, with 100% of both ecologists and environmental scientists responding ‘true’. Every discipline voted 100% true in response to statement 57: “Private sector money flow to developing countries is some three times the level of official aid, yet there is little incentive to channel the funds into ESD”. Statement 58 to do with using clear tax signals to encourage individuals and enterprises to act more responsibly towards the environment also scored well for ‘true’, with 96% of the group vote. A bit less convincing was the response to statement 59: “Rational pricing structures can be far more effective tools to help the environment than subsidies and regulations”, with a group vote for true of 68%, and individual votes all above 60%.

Some patterns or trends within and between the disciplines that could be inferred from the results are:

- The environmental and ecological economists were more unequivocal than the neoclassical economists when it came to questions to do with the utility of nature to humans, and they clearly have more confidence in economic valuation methods than any other discipline, while still appreciating the complexities of the economy/environment interface.
- However, surprisingly, all economists had less confidence in money as a measure of preferences than did all natural scientists.
- Environmental and ecological economists disagreed when it came to conjecture as to whether society could put a value on the intangibles under the right experimental conditions.
- Geographers had a very high regard for money as a measure of preferences but absolutely rejected the concept that one must possess money to express them. They also hedged their bets when it came to measuring the immeasurable, with a vote either way.
- Ecologists stood out as being fully in favour of the use of surrogate markets and shadow prices for unpriced goods and services.
- Only ecological economists and environmental scientists did not change their position when the statement “ecosystems are being lost because they do not have prices acting as a negative feedback to keep use in equilibrium with availability”, was later ascribed to economists, with all the other disciplines slipping by up to 20% vote for ‘true’.
- Geographers showed scant regard for the stability and productivity that can be attributed to biodiversity in an ecosystem, yet voted 100% true for Al Gore’s ‘single best’ chance of achieving sustainability by way of private investment in the environment.
- Environmental economists and ecological economists voted the lowest for true for Al Gore’s ‘single best chance’.

- Geographers and Natural Resource Managers were most attracted by the 'warm glow' of a new idealism emerging from the first Earth Summit in Rio in 1992.

Overall the most consistent within the ruling paradigm of their professions appeared to be the environmental and ecological economists. The frequencies of their responses also appeared to be the most closely related to each other, although statistically this was not the case. Testing each pair of sets of responses using the Wilcoxon Signed Ranks test showed the highest significance (by way of) extent of agreement, between Natural Resource Managers and Ecologists (P >.002); followed by Ecological Economists and Ecologists (P >.033); Neoclassical Economists and Ecological Economists (P >.035); Geographers and Ecologists (P >.043) and finally Environmental Economists and Ecological Economists (P >.045). The other 16 pairings were not significant.

8.2.2 Open-ended questions/statements (Text responses)

There were many interesting insights in the text answers to Q19 & 20 and 28-33. They are included in their entirety in Appendix H. Apart from a few responses that dealt with potential difficulties in application, the first statement (Q19):

"Analysts that attempted to measure the intangibles (typically environmental goods and services) have been accused of trying to 'measure the immeasurable', and castigated for trying to apply a monetary value to everything",

received an overwhelming rejection of the sentiments expressed, for example:

- *"I wonder how the accusers (assuming they were well-intentioned) would react if told that the approach may be instrumental in preserving natural areas threatened by exploitation".*

And:

- *"Provided the exercise is placed in context, conditioned and the limitations explored and explained, the exercise has value in providing further insights, and knowledge…especially about what we do not and cannot understand".*

There was less consensus with statement/question 20, with 62% agreeing that while:

"Some neoclassical economists and others are strongly critical of the practise of converting unpriced intangibles to a common monetary unit",

it was not a fair criticism:

- *"They are purists and have no connection with the real world. Ignoring the intangibles in CBA is a real threat to sustainability of ecosystems and life-support systems".*

And:

- *"Are there any good alternative methods of indicating value for ecosystem services?"*

However, in support of the statement, one respondent answered that the criticism is fair "because it (the practise) is both unworkable and unnecessary".

Eighty per cent of the respondents agreed with the statement (Q28):

"An evaluation technique based on people's expressed preferences backed up by the ability to pay raises profound issues to do with anthropocentrism".

One saying, quite rightly "such a technique is based in anthropocentrism", and another:

- *"Yes, certainly, the issue of preferences is strongly related to the anthropocentrism issue. I do think that some attempt to incorporate non-human values should be made, but do recognise that this will (or does) largely occur through non-economic measures".*

Statement 29 elicited an 87% agreement level, many acknowledging that while this was a problem, it can also often be overcome by careful experimental design, and often not:

"An evaluation technique based on peoples' expressed preferences raises profound issues to do with information variability across groups and effects of value aggregation within groups".

Some of the insights were as follows:

- *"Yes, but (it is) not surmountable".*
- *"Different cultures value natural ecosystems differently, and for different reasons. City people and country people behave differently on the land".*
- *"Groups may receive different information or understand common information in different ways irrespective of the technique employed. This is true also for marketed goods".*
- *"Careful statistical analysis may overcome some of these problems. These problems are not just restricted to 'expressed preference' valuation methods".*
- *"True, so that is why it is important in such an evaluation to employ a technique that deals with such variability".*

Question 30 asked the panellists to state what they thought were the "most important issues in trying to ascribe monetary values for intangibles (unpriced goods), typically environmental goods and services?" and rather than state their full response here (they are included in Appendix H), the issues they came up with are listed below:

- *Education and explanation of ecosystem goods and services as a human survival and quality of life argument;*
- *Demonstration (by dollar valuation) of human supporting and human threatening ecosystem performance;*
- *Information (it is almost always very contingent and imprecise);*
- *Credibility (most people do not believe in a common numeraire);*
- *Biophysical data on current uses, and uses under different price and availability regimes;*
- *Inability to accurately price intangibles v economic benefit from development;*
- *Generational factors, ie. would a later generation ascribe different values;*
- *How to factor in the views of those concerned but not directly involved?*
- *Who decides? Whose money? Whose opinion?*
- *Time and place variables;*
- *Depth and breadth of diversity of cultures, economies, values etc.;*
- *Knowledge (needs to detail the major issues for a good);*
- *Hysteresis, ie. time lag in environmental effects, while money value is now;*
- *Lack of knowledge of the linkages and the multipliers;*
- *Lack of knowledge of the impacts of loss or degradation on or off site;*
- *Education/understanding is crucial. Money and intangibles mean different values and different things to different people;*
- *A broad cross-section of respondents to achieve a broad 'community' view;*
- *An appreciation of the loss of value if an intangible ceases to exist;*
- *How we might incorporate non-quantitative values into our decisions;*
- *Lack of agreement between groups;*
- *Accuracy and precision and eliminating bias from development, conservation and political sources;*
- *Good clear methodology, clear assumptions, repeatability, the author's belief systems;*
- *Broad acceptance of the technique;*
- *Trying to value the complexities;*
- *Comparability between groups;*
- *Trying to build in to the model the rights of species other than humans to live on the planet;*

- *Difficulties in establishing the communication framework;*
- *The degree of disturbance to a natural ecosystem;*
- *The amount of change, as measured by alteration or loss, caused by development;*
- *Information, understanding of the importance of ecosystem services;*
- *The intrinsic value of a habitat, how well it is already managed;*
- *Maximising objectivity, minimising value-laden judgements and/or assumptions;*
- *Recognition that monetary value is not everything. It should not drive the debate;*
- *Information and understanding.*

The next question (Q31):

"If trading markets were established for ecosystem goods and services, how do you think this will enhance or finance conservation?"

would have sparked considerable debate in a 'face to face' Delphi, with some panellists responding "to a great degree", "potentially very well" and others "trivial" and "they may not". Others were cautious:

- *"If set up correctly, eg. with clearly defined property rights this could prove beneficial to avoiding exploitation of environmental goods and services. More research is needed though".*

And:

- *"It may distort them immensely, because well-capitalised players may tend to dominate the market for their own purposes/benefits".*

On a positive note:

- *"It brings the value of the ecosystem goods and/or services into the real world of supply/demand, the real price that people pay for those goods and/or services etc."*
- *"This will greatly enhance and potentially finance conservation through a number of ways, most notably trading in carbon credits and possibly in biodiversity credits".*
- *"By mitigation of the impacts of a project, proposal or policy. Eg. Conservation and mitigation banking in the USA".*
- *"It is another tool and could prove useful in purchasing or retaining significant properties to be managed as areas of conservation significance".*
- *"When the cost of protecting the natural system makes the development uneconomic the development or activity will not take place".*

Further controversy arose over the question (32),

"What possibility, do you think, exists for global business capturing markets for ecosystem goods and services?"

with some panellists responding that the possibility was "negligible", "a non-issue", "low probability", and a "bad thing", "the concept horrifies me", while others, “a high possibility and a good thing of course”. Some of the more interesting insights appear below:

- *“Diversity of intangibles and their geographic and national spread will mitigate against corporate control. This is a good thing unless it can be shown there are significant benefits from centralising control”.*
- *“Slim possibility in Western nations. However if you think about carbon trades, a global business will decrease the economic costs for Australia”.*
- *“Greater recognition of ecosystem services provided by less developed countries. May be a good thing if the result is a greater global equity of wealth”.*
- *“There is a big market, and yes it’s good. BP are doing it now”.*
- *“Possibly, but will the markets look for efficiencies and devalue the environment”.*
- *I am not sure whether it would happen. It would be a bad thing if the markets do not lead to on-ground actions leading to environmental improvement. I can see that this might work regardless of whether global business captures the markets”.*

Question 33 was a follow on from Q 32 and most panellists had already made some mention of how they thought capture of ecosystem markets by global business could be avoided. Further insights from the panellists to do with these two questions can be found in Appendix H.

There were no open-ended questions in round two, however the text answers to the statements and questions in round 3 were again very insightful. They are included in their entirety in Appendix I. Discussion points are raised here. In response to question 52:

“The Earth Summit produced a plan to achieve environmentally sustainable development in the 21st century, known as ‘Agenda 21.’ To what extent do you think this was compatible with the emerging global economy?”

Fifty eight per cent of respondents thought that Agenda 21 was not at all compatible. Some key comments, or insights, were as follows:

- *“I think it was essentially at odds with the emerging global economy. ESD has now become a trite phrase reiterated at every chance by large companies who in the vast majority of cases merely pay lip service to the idea of anything remotely connected to…..?”*
- *“Agenda 21 sets the scene for the future in terms of ESD principles but is very idealistic in many ways. Globalisation as it stands, tends to work against many aspects of Agenda 21, which is more about local communities taking control of the maintenance of, say, biodiversity”.*

- *"Difficult to say how compatible it has been because many economies have been in transition and the over-arching effects of the global economy pushed governments to adopt policies/approaches of self-interest. It's compatibility is perhaps in the timing".*
- *"Obviously incompatible as most multi-national businesses continue to burn fossil fuels, over-subscribe usage of fresh water supplies, support deforestation and cropland agriculture, and target profit rather than public good".*

The topic continued to the next question (53):

"To what extent do you think Agenda 21 or ESD is compatible with global inequities?"

Agenda 21 was thought to be not at all compatible with global inequalities by 93% of respondents. The insights were both illuminating and stimulating (see Appendix I), with comments such as "global inequalities are far too wide for agreement", and "A21 could entrench inequality".

Question 54 asked:

"To what extent do you think ESD is compatible with current levels of consumption?"'

Seventy four per cent answered that it was not very or not at all compatible, and others argued that it was change that was required:

- *"Reduced consumption through improved efficiency or waste minimisation coupled with continually improving production techniques will increase compatibility".*
- *"It's not the levels of consumption that are important, but the types, eg. producing some types of foods is less healthy for the environment than others".*
- *Reasonably compatible, more a question in changing the composition of consumption rather than absolute levels".*

Question 55 had a similar theme:

"In some scenarios, to what extent is the status quo better preserved than trying to achieve ESD?

Most respondents answered "to no extent", but added some valuable commentary to qualify their answers:

- *"Those who have faith in human innovation and technology would argue that humans will ultimately solve the current environmental crisis, and that market forces will dictate when and where these new technologies will be introduced".*
- *"Maintaining the status quo is the easier 'do nothing' option. ESD is the only choice if we are prepared to act for the benefit of future generations. ESD might be possible under political pressures within a number of countries".*

- *"Where population growth is low, consumption per capita is low, and pollution is low, the status quo is defensible even if biodiversity is decreasing".*
- *It is better to preserve what is left of our natural landscapes than to convert them to agriculture based on ESD principles. The problem is the D in ESD".*
- *Virtually none. Human beings aspire to certain levels of comfort and well-being, with the western world's standard of living/quality of life now the goal of the 4 billion people living elsewhere on the planet, it would be morally wrong for those who 'have' to preclude the rights of the 'have-nots' to a similar standard of living".*
- *"The status quo (business as usual) is not sustainable in the next several decades. Ecological disaster, financial and economic collapse and cultural/social unrest are already resulting from unsustainable human business".*

The final question in round three (Q60), and in the Delphi Inquiry, was to do with market-based instruments:

"In round 2, 32% of the panellists answered false to the statement about biodiversity. Yet there are solid utilitarian reasons to preserve every scrap of biodiversity. Would you agree with a market-based regulatory framework for bio-prospecting?"

Overall 52% of the respondents answered yes, 24% a qualified yes, and 24% no. Some of the reasons and qualifiers are given below:

- *"No the planet is a living thing that evolves within its own time scale. Man has influenced the planetary systems however a regulatory framework cannot be expected to preserve every scrap of biodiversity in a system too complex for humans to understand. And possibly never will".*
- *"Until there is an accepted market system which can effectively regulate it is difficult to see how other regulatory frameworks can be avoided. I would prefer a market mechanism but do not think we can afford the damage that will be done while we are waiting for it".*
- *"Strongly disagree with your 'every scrap of biodiversity' assertion. There is irrefutable evidence that some biodiversity is redundant! A market based framework for bio-prospecting MAY be worth trying but it is neither necessary nor sufficient".*
- *"No. A market based bio-prospecting framework is very unlikely to preserve biodiversity for future generations".*
- *"All biodiversity needs to be protected as it plays a vital role and often as yet not-understood role in global ecological processes".*

8.3 Attrition

After canvassing and inviting suitable participants for the study, initial acceptance was had by email of 52 potential panellists. However, over the ensuing month, informed consent was only signed and returned by 32 people. Altogether over the lead-up to and the course of the first Delphi round, 57 user-names and passwords were issued. A few panellists advised prior to commencement of their either missing a round or possible withdrawal due to work commitments or possible absence during the time frame of the Delphi.

Round 1 opened on May 8, 2002 by way of email announcement to 50 panellists. After the efflux of three to four weeks 37 (74%) of them had answered the questionnaire. The round was closed on May 31, 2002.

Round 2 opened on June 7, 2002 with 42 panellists, and was declared closed on June 28, 2002 with 34 panellists (81%) answering the questionnaire and 30 (including 4 non-conforming) (71%) completing the spreadsheet for Model 1.

Round 3 opened on July 4, 2002 with 40 panellists and was declared closed on July 26, 2002 with 28 (70%) answering the questions and 23 (including 3 non-conforming) (58%) completing the spreadsheet for Model 2.

Round 4 opened on August 2, 2002 with 33 panellists, there was no questionnaire, and it was declared closed on August 23 with 25 (76%) panellists completing the spreadsheet (zero non-conforming) for Model 3.

There was a core of the panellists who completed all or most of the six components (three questionnaires and three models). 41 individuals completed at least one component (4 individuals missed the first round). Seventeen panellists completed all six components, five missed one component, six missed two components and four missed three components and four others four components. Five of those who answered the first questionnaire did not complete any other component. The Delphi panel reached consensus in all three of the questionnaire rounds. The implications of the consensus and the question and answer content will be synthesised with the other results in Chapter 13. In all 82% of the panellists took part in at least one round (128% of informed consent received), and 64% completed half of the components (100% of informed consent).

Chapter 9

Results of the Multiple criteria Analysis

9.1 Introduction

The Multiple Criteria Analysis (MCA) of ecosystem attributes was designed in conjunction with the philosophical inquiry to assign appropriate weightings and sensitivities to the attributes using a broad-based panel of about 50 experts in the social and natural sciences. The Delphi panellists were asked to nominate their preferred discipline or disciplines, from the choices: Neoclassical Economist, Environmental Economist, Ecological Economist, Geographer, Natural Resource Manager, Ecologist, and Environmental Scientist.

9.2 The Multiple Criteria Models

The spreadsheets supplied to the panellists and instructions are included in Appendix B and the preamble for each round of the Delphi are provided in Appendices E, F and G. The first of the models in the MCA produced an apparently varied response as to individual weightings of ecosystem attributes, yet statistical analysis of the panellists' set of responses proved to show significant concordance for all disciplines, all economists, all scientists and all individual groups with the highest intensity of agreement shown by the neoclassical economists, followed by the environmental economists (Table 9.1). The coefficient of variance for the results for Model 1 ranged from 15.06% to 44.15% (mean 25.73%), with most values in the teens or low 20s.

Table 9.1 Results of Kendall's Coefficient of Concordance (Kendall's *W*) for Model 1 (Anthropocentric Perspective).

Discipline	Kendall's coefficient	N	Significance
All Disciplines	0.339	24	.000
Neoclassical Economists	0.589	4	.001
Environmental Economists	0.466	4	.012
Ecological Economists	0.246	8	.007
All Economists	0.331	16	.000
Geographers and Natural Resource Managers	0.315	8	.002
Ecologists	0.289	11	.000
Environmental Scientists	0.392	10	.000
All Natural Scientists	0.298	29	.000

Note: The coefficient *W* permits the evaluation of the extent of concordance or agreement between three or more sets of data. It has the value 1.0 if the groups agree perfectly and 0.0 if they disagree maximally. The apparent discrepancy in N values is due to discipline overlap.

The second of the models in the MCA again produced an apparently varied response as to individual weightings of ecosystem attributes. This could be indicative of the wide range of value judgements that can apply to human scaling of environmental attributes, yet statistical analysis of the panellist's set of responses proved to show significant concordance for all disciplines, all economists, all scientists, and most groups with the exception only of neoclassical economists and ecological economists. The highest intensity of agreement was with the geographers and natural resource managers (Table 9.2). The coefficient of variance for the results from this model ranged from 15.07% to 43.37% (mean 29.31%), with most values distributed between the late teens and early 30s.

Table 9.2. Results of Kendall's Coefficient of Concordance (Kendall's *W*) for Model 2 (Utilitarian Perspective).

Discipline	Kendall's coefficient	Friedman's chi square	N	Significance
All Disciplines	0.134	51.075	20	.000
Neoclassical Economists	0.289	27.465	5	.094
Environmental Economists	0.320	30.388	5	.047
Ecological Economists	0.147	25.129	9	.156
All Economists	0.175	63.054	19	.000
Geographers and Natural Resource Managers	0.464	70.571	8	.000
Ecologists	0.129	19.583	8	.420
Environmental Scientists	0.230	39.374	9	.004
All Natural Scientists	0.206	97.740	25	.000

Note: The coefficient *W* permits the evaluation of the extent of concordance or agreement between three or more sets of data. It has the value 1.0 if the groups agree perfectly and 0.0 if they disagree maximally. The apparent discrepancy in N values is due to discipline overlap.

The panellists' responses to Model 3 'Balanced Sensitivity' once again appeared to show a wide range of value judgements, particularly with regard to the resistance and resilience of the ecosystem attributes. However the level of agreement within and between all disciplines, all economists, all scientists and most groups with the exception of neoclassical economists, was highly significant. The sample size for neoclassical economists was small, but when analysed with environmental economists (also small), the level of concordance was highly significant. Overall, the highest coefficient of concordance was with the ecological economists followed by the environmental scientists. (Table 9.3). As some of the values were negative it was not possible to use the coefficient of variance as a statistical test for this model. Instead the range of values was used as an alternative measure of dispersion, with the smallest range of values indicating least uncertainty, and the largest range, most uncertainty among the panellists as to the relative ranking of the ecosystem attribute.

Table 9.3. Results of Kendall's *W* for Model 3 (Balanced Sensitivity).

Discipline	Kendall's W	Friedman's Chi Square	N	Significance
All Disciplines	0.295	139.938	25	.000
Neo-classical Economists	0.262	24.875	5	.165
Neo-classical & Environmental Economists	0.246	37.350	8	.007
Ecological Economists	0.479	72.847	8	.000
All Economists	0.331	100.752	16	.000
Geographers & Natural Resource Managers	0.338	44.949	7	.001
Ecologists	0.333	69.662	11	.000
Environmental Scientists	0.355	74.122	11	.000
All Natural Scientists	0.319	175.819	29	.000

Note: The coefficient *W* permits the evaluation of the extent of concordance or agreement between three or more sets of data. It has the value 1.0 if the groups agree perfectly and 0.0 if they disagree maximally. The apparent discrepancy in N values is due to discipline overlap.

The mean value of the attributes in Model 3 was sorted in ascending order, with the lowest value representing those attributes most endangered and with least resistance and resilience, and the highest, those least endangered and with the most resistance and resilience. The range of values was then used to convert all values to positive, with the lowest being one and the highest the most important, ie. the most at risk. These values were then normalised to a total of one for all attributes. The resulting decimals were then used as multipliers of the mean of weightings of Models 1 and 2 to show the sensitivity of each attribute to threats, risk, uncertainty and precaution.

Each of the three models presented had six different criteria, for which maximum weightings were supplied. Panellists were not obliged to assign the maximum weighting for the criteria to the attribute, ie. they could assign less if they wished. Criteria for the first model were anthropocentric, biophysical and economic, however, the maximum weights were assigned to the anthropocentric criteria (Essential for human life, and desirable but not essential for human life). Ecosystem health was ranked second most important as being essential for planetary life support, and maintenance of natural capital, a surrogate for intergenerational equity. The importance rankings for the three models are shown in Table 9.4.

Table 9.4. Relative importance rankings of the attributes for each of the models

Attribute	**Model 1**	**Model 2**	**Mean Models 1&2**	**Model 3**	**Final Importance Rank**
Stabilisation Services					
Gas regulation	1	1	1	8	5
Climate regulation	2	8	4	7	6
Disturbance regulation	10	18	13	9	9
Water regulation (hydrological cycle)	3	5	3	20	19
Erosion control and soil retention	11	13	12	3	3
Biological control	14	15	15	5	7
Refugia	13	16	14	2	2
Regeneration Services					
Soil formation	15	17	16	19	20
Nutrient cycling and storage	5	11	7	15	13
Assimilation of waste	9	9	9	12	11
Purification (clean air, water)	7	3	5	10	8
Pollination (movement of gametes)	12	19	17	14	14
Biodiversity	6	4	6	1	1
Production of Goods					
Water supply (catchment)	4	2	2	13	12
Food production	8	10	8	18	18
Raw materials	17	7	11	16	16
Genetic resources	16	6	10	4	4
Life Fulfilling Services					
Recreation opportunities	19	12	19	17	17
Aesthetic, cultural and spiritual	18	14	18	6	10
Other non-use values (bequest, etc)	20	20	20	11	15

Model 1 results indicate that humans ascribe most value to a stable atmosphere and climate, clean air and water, the capacity of the environment to cycle and assimilate nutrients and pollutants, biodiversity and food production. Model 2 criteria consisted of direct and indirect use, non-use, option, bequest and existence values. In this model, while the results are similar in many ways, climate was seen to be less important, and raw materials and genetic resources more important, which is consistent with the utilitarian perspective. Model 3, which dealt with threats, risk, uncertainty, precaution and the resistance and resilience of ecosystems, provides a rather different perspective, with higher importance given to biodiversity, refugia, biological control, genetic resources, and erosion control and soil retention. These are clearly ecosystem attributes that are endangered in one way or another. Finally the result of the sensitivity analysis qualifies the results in terms of the non-pecuniary preference values ascribed by the panellists with the highest ranking given to attributes that are either endangered or essential for human life, or both.

The top ten are given in Table 9.5. Interestingly an insight into human value preferences for the present as opposed to the future is also evidenced here, with attributes such as ‘soil formation’ shown as least important. Clearly there is little humans can do to influence ‘soil formation’, which while obviously extremely important, is measured in thousands to tens of thousands of years. A counterpoint to this is that ‘erosion control and soil/sediment retention’ is ranked third in the order of importance. This attribute is manifest in the present time.

Table 9.5. The ten ecosystem services ranked most important.

Attribute	Rank	Attribute	Rank
Biodiversity	1	Climate regulation	6
Refugia	2	Biological control	7
Erosion control/soil retention	3	Purification (clean air, water)	8
Genetic resources	4	Disturbance regulation	9
Gas regulation	5	Aesthetic, cultural & spiritual	10

The final weights for the ecosystem attributes are given in Table 9.6. A summary of the MCA presented to the panellists as part of the feedback after round 4 is included in Appendix G. The nominal weighting of 5 for each ecosystem attribute adds up to 100 for all 20 attributes, or 100% of the full suite of services. Accordingly the weightings ascribed by the panellists for each model were also normalised to a total of 100, such that the weightings for the full suite of services were constrained within an overall total non-pecuniary weighting for subsequent sensitivity analysis and application in the valuation table.

Table 9.6 Final weights for the ecosystem attributes (goods and services).

Attribute	Mod 1	Mod 2	Mean 1&2	Mod 3	Imp/rank Mod 3	Normalised Rank	Weight	Final Weight
Biodiversity	5.46	5.34	5.40	-2.62	9.14	0.092	0.497	0.099
Refugia	4.92	4.79	4.86	-2.30	8.82	0.089	0.431	0.086
Erosion control	5.02	4.91	4.97	-0.74	7.26	0.073	0.363	0.073
Genetic resources	4.75	5.26	5.01	-0.68	7.20	0.072	0.363	0.073
Gas regulation	6.22	5.79	6.01	0.82	5.70	0.057	0.345	0.069
Climate regulation	5.80	5.17	5.49	0.34	6.18	0.062	0.341	0.068
Biological control	4.89	4.81	4.85	0.04	6.48	0.065	0.316	0.063
Purification	5.44	5.36	5.40	1.20	5.32	0.054	0.289	0.058
Disturbance regulation	5.14	4.66	4.90	0.90	5.62	0.057	0.277	0.055
Aesthetics	3.71	4.85	4.28	0.20	6.32	0.064	0.272	0.054
Assimilation of waste	5.19	5.08	5.14	1.62	4.90	0.049	0.253	0.051
Water supply	5.68	5.53	5.61	2.70	3.82	0.038	0.216	0.043
Nutrient cycling	5.66	5.04	5.35	2.88	3.64	0.037	0.196	0.039
Pollination	5.02	4.44	4.73	2.78	3.74	0.038	0.178	0.036
Other non-use values	3.00	3.63	3.32	1.60	4.92	0.050	0.164	0.033
Raw materials	4.70	5.23	4.97	3.60	2.92	0.029	0.146	0.029
Recreation opportunities	3.49	4.96	4.23	3.60	2.92	0.029	0.124	0.025
Food production	5.29	5.06	5.18	4.18	2.34	0.024	0.122	0.024
Water regulation	5.75	5.32	5.54	5.52	1.00	0.010	0.056	0.011
Soil formation	4.87	4.78	4.83	5.44	1.08	0.011	0.052	0.010
	101	102.1	100.01		99.32	1.000	5.003	1.001

Note: The nominal weighting of 5 for each ecosystem attribute adds up to 100 for all 20 attributes, or 100% of the full suite of services. Accordingly the weightings ascribed by the panellists for each model were also normalised to a total of 100.

Statistical analysis of all the individual weightings assigned by the panellists to the attributes/criteria in the three models showed a significant extent of agreement between them in all but a few cases where N was small. The values for *W* were not particularly high, generally less than 0.5, due to the variability in the data. Kendall's *W* was calculated again for all disciplines, all economists and all natural scientists for each model using the mean of each discipline's weightings for each model in order to 'smooth' the data and ascertain the intensity of agreement between the blocks. The results are shown in Table 9.7. In Model 1, the 'Anthropocentric' perspective, all scientists have a marginally higher intensity of agreement than all economists, which does not indicate any particular influence the choice of criteria may have had on either discipline. However, in Model 2, the 'Utilitarian' perspective, the economists have a more than marginally higher intensity of agreement than the scientists, which could be attributed to the utilitarian value construct of most economists as opposed to the intrinsic value construct of most scientists.

The ranking of the attributes for Model 2 (Table 9.4) would appear to confirm that indeed the direct and indirect 'use' goods and services were more important (at least to the economists) for this model.

Table 9.7 Results of Kendall's coefficient of concordance for the mean of each discipline's weightings for the attributes/criteria in each model.

Model 1 'Anthropocentric Perspective				
Discipline	Friedmans Chi Sq	Kendall's W	N	Significance
All disciplines	109.638	0.824	7	.000
All economists	48.748	0.856	3	.000
All scientists	66.365	0.873	4	.000
Model 2 Utilitarian Perspective				
Discipline	Friedmans Chi Sq	Kendall's W	N	Significance
All disciplines	101.130	0.760	7	.000
All economists	49.145	0.862	3	.000
All scientists	60.017	0.790	4	.000
Model 3 Balanced Sensitivity				
Discipline	Friedmans Chi Sq	Kendall's W	N	Significance
All disciplines	98.697	0.742	7	.000
All economists	39.570	0.694	3	.004
All scientists	66.581	0.876	4	.000

The results for Model 3, 'Balanced Sensitivity', were very different with scientists much more than marginally in agreement than economists. While risk and uncertainty are primarily economic concepts, these and more particularly, the other four criteria, are very much in the everyday parlance of natural scientists. Again, the rankings reflect a quite different perspective for this model (see Table 9.4). As the purpose of this research is to assess the value of ecosystem goods and services extant, the last model for the MCA as reflecting threatening processes as well as stability factors, is considered to be appropriate as a multiplier of the first two models (the multiplicands) to reflect sensitivity.

The mean is the most useful of the measures of central tendency, and while the median is used as the appropriate statistic for the unimproved land value (*MUV*) in the bioregion due to the skewness of the data, in these models the range of values is constrained by the maximum weights assigned to the criteria in each model. For example, in Model 1, panellists had to choose between criteria 1 or 4, 2 or 5 and 3 or 6. The maximum value could be no more than 12, and the minimum, 3 (if the panellist chose to downgrade the weighting to the smallest integer). In Model 2, each criterion could logically have a value for each attribute, and if maximum weights are assigned, the total for each attribute would be 21, and the minimum say 3 up to 6, if the panellist believed some criteria did not apply and downgraded others. In Model 3 the range is greater owing to the negative values and the possible choice options of the panellists. At the most extreme, a panellist may assign no negative weightings and the total positive weightings, resulting in +15. Conversely a panellist may assign maximum negative values and no positive values, resulting in –10. The range is still only 25. There were only a few non-conforming returns for Models 1 and 2, however these were not rejected on the grounds of outlying data, but a basic misunderstanding on behalf of the panellist as to how the spreadsheet was to be completed. Accordingly the arithmetic mean of the panellists' weightings (the sample population) for each attribute in each model is regarded as the most appropriate measure of central tendency to use to derive the final ranking and weight of the attributes to use in the equation and the valuation table.

CHAPTER 10
RESULTS OF THE CONCEPTUAL MODELLING

10.1 Introduction
The valuation table was designed as a simple computational model in Microsoft Excel©, to not only record the status of the ecosystem integrity of the subject land, with the attributes present or not present based on the valuer's field notes, but also to also serve as a template for insertion of all the other variables:

- the median value for the bioregion (*MUV*),
- the *UFpa* (and the capitalisation rate used to derive it from the *MUV*),
- the level of provision of ecosystem goods and services (upper and lower limits),
- the final weighting of the attributes,
- the area of the subject land.

Instructions as to how to complete it are given in Chapter 7. Completed valuation tables for all of the tenures in the WTWHA are included as Appendix J. The table can be used at both the individual tenure scale and the landscape scale, however in the latter, a conceptual model is required to assess the extent of provision of ecosystem goods and services. There is a great deal of literature supporting the role tropical rainforests play in the global budget, with most if not all of the ecosystem goods and services at their highest level of provision in these precincts, accordingly tropical rainforests were adopted as the 'benchmark' for the conceptual model (Holdridge 1967; Holdridge *et al*., 1971; Lugo 1988; Mooney 1988; Grove 2000).

10.2 The Conceptual Model and Valuation Tables for Ecosystems
The conceptual models for level of protection (LOP) and land use classification (LUC) were used to derive the upper and lower limits of ecosystem service provision as per the methodology (Appendix D), for the various land tenure categories in the WTWHA (Table 10.1). The valuation

table was completed for each of the nine tenure categories and these are included as Appendix J.

Table 10.1. The upper and lower limit of provision of ecosystem services in the tenure categories derived from the conceptual models

Tenure	Parcels	Area (ha)	% of WHA	Lower Limit (%)*	Upper Limit (%)
National Parks	21	285,744	32	92	99
State forests	32	347,300	39	84	92
Timber reserves	5	74,163	8	66	84
Various reserves and dams	64	10,207	1	66	79
Unallocated state land	203	60,515	7	56	72
Perpetual leases	11	132	0.01	56	66
Expiring leases	138	86,897	10	56	66
Leasehold: mines & energy	6	24	0.003	56	66
Leasehold: DPI & EPA	43	3,093	0.35	56	66
Freehold & similar	204	17,341	2	48	66
Roads, Esplanades, Railways		5,696	0.6	39	48
Rivers		3,308	0.4	48	84
Total	**727**	**894,420**	**100**		

Note: *% of maximum provision of ecosystem goods and services (=100%).

The model was developed in order to be able to assess the level of provision of ecosystem services on a landscape scale using broad parameters that could be readily applied using existing land information systems. There were two versions devised to take into account most conditions applicable in Australia, and to be used as a cross check. The models were the level of protection (LOP) model, and the land use characteristic (LUC) model. One of the ways to allow for risk and uncertainty in a valuation is by applying a range of capitalisation rates (*cr*) to the capital value (*MUV*) to produce an upper and lower range of *UFpa.* However, owing to the higher degree of uncertainty in assessing the level of provision of ecosystem services on a landscape scale, than uncertainty to do with the cost of money, setting an upper and lower limit of provision of ecosystem services was resolved to be the more cautious approach. The triangulation models have a range of values for vegetation cover and species richness from zero to 100 per cent on the sides of the triangle (Figures 7.1 and 7.2 and Appendix D), and the primary determinants for the level of provision of ecosystem services in the model were arranged along the base with the highest level of protection or most productive ecosystem type in the centre. Level of protection and productivity decreased towards the basal apices: as disturbance increased, so did the capitalisation rate. As the parameters for the LOP and LUC models yielded a variety of results depending on the information available, and the match with, for example the tenure categories in the landscape, and any other available indicators, judgement was required.

For the WTWHA, the tenure categories include a range of vegetation types and canopy cover, yet all were protected by virtue of inclusion in the protected area management framework. The tenure categories were best used as a measure of past disturbance, which were also reflected in the zoning system adopted by the management authority (see Chapter 1). 'State of the Wet Tropics' reporting and the development of environmental indicators is explicitly embedded in WTMA's management framework and statutory obligations under the World Heritage Convention (UNESCO 1997, WTMA 1997). The core set of indicators were selected by the management agency on the basis that they were:

- relevant to management objectives;
- scientifically valid;
- suited to a policy framework;
- credible, easy to understand and unambiguous;
- part of the management cycle;
- focussed on the use of information;
- clearly linked to the environmental outcome being monitored; and
- spatially explicit;

(WTMA 1997). The indicators were incorporated into a modified OECD 'pressure-state-response' model, where more importance was placed on condition as being the 'trigger' to warrant further consideration of 'pressure' before implementing a 'response' (WTMA 1997). Demands of the growing regional population have led to increased need for land dedicated to infrastructure (power transmission corridors, roads, dams etc.). This, along with the recreational pressure by locals and visitors for more infrastructure and opportunities has resulted in the need for an integrated visitor monitoring system that will use biophysical monitoring and visitor and community surveys to assess condition (WTMA 2001). However, studies in North America and Canada have shown that visitor activities only impact on a very small part of a protected area, generally less than 0.1% ie. by their nature they are highly localised due to visitors being 'contained' within access areas, tracks, campgrounds and picnic areas (Trottier and Scotter 1975; Bratton *et al.,* 1978; Cole 1982). WTMA identify community infrastructure as being the greatest deleterious impact by way of ecological fragmentation (WTMA 2001), yet while this is undoubtedly true, depending on the impact, these sites can still contribute substantially to the overall ecosystem services being generated in a landscape. Higher order tenure ie. level of protection, is increasing in the heritage area due to expiring leases and buy-back, as well as transfer of state forests to the protected area estate under the *Nature Conservation Act 1992* (WTMA 2001). Threats to the region apart from current human disturbance include what is thought to be partly a function of past human disturbance, and manifest in rainforest dieback, caused by *Phytophthora cinnamomi,* which is threatening up to 14% of the heritage area and has been linked to forest type, parent rock type and nearness to past logging/snigging tracks mostly in the uplands (Gadek *et al.,* 2001).

The state of the WTWHA, the implications of the zoning system, and the degree of past and current human disturbance implicated by the tenure categories, were taken into consideration when arriving at the upper and lower limits of provision of ecosystem services for the tenure categories in the WTWHA. National Parks represent the highest level of protection in the heritage area. The LOP model was used to determine the upper and lower limits of ecosystem services for National Parks as being 99% and 92% respectively, the latter due to disturbance (cyclone), dieback, feral animals and weed invasion (Figures 10.1 and 10.2). The range was 7%, and the market capitalisation rate used in the valuation table (Appendix J), 6.5%, both indicating low risk and low uncertainty. Provision of ecosystem services by State Forests was determined from the LOP models, as being included in the protected area framework they were clearly more productive than State Forests that were not included, ie. they were still being logged.

The upper and lower limits for State Forests were 92% and 84% respectively, the latter using the LOP model for 'conservation area' (Figure D3 in Appendix

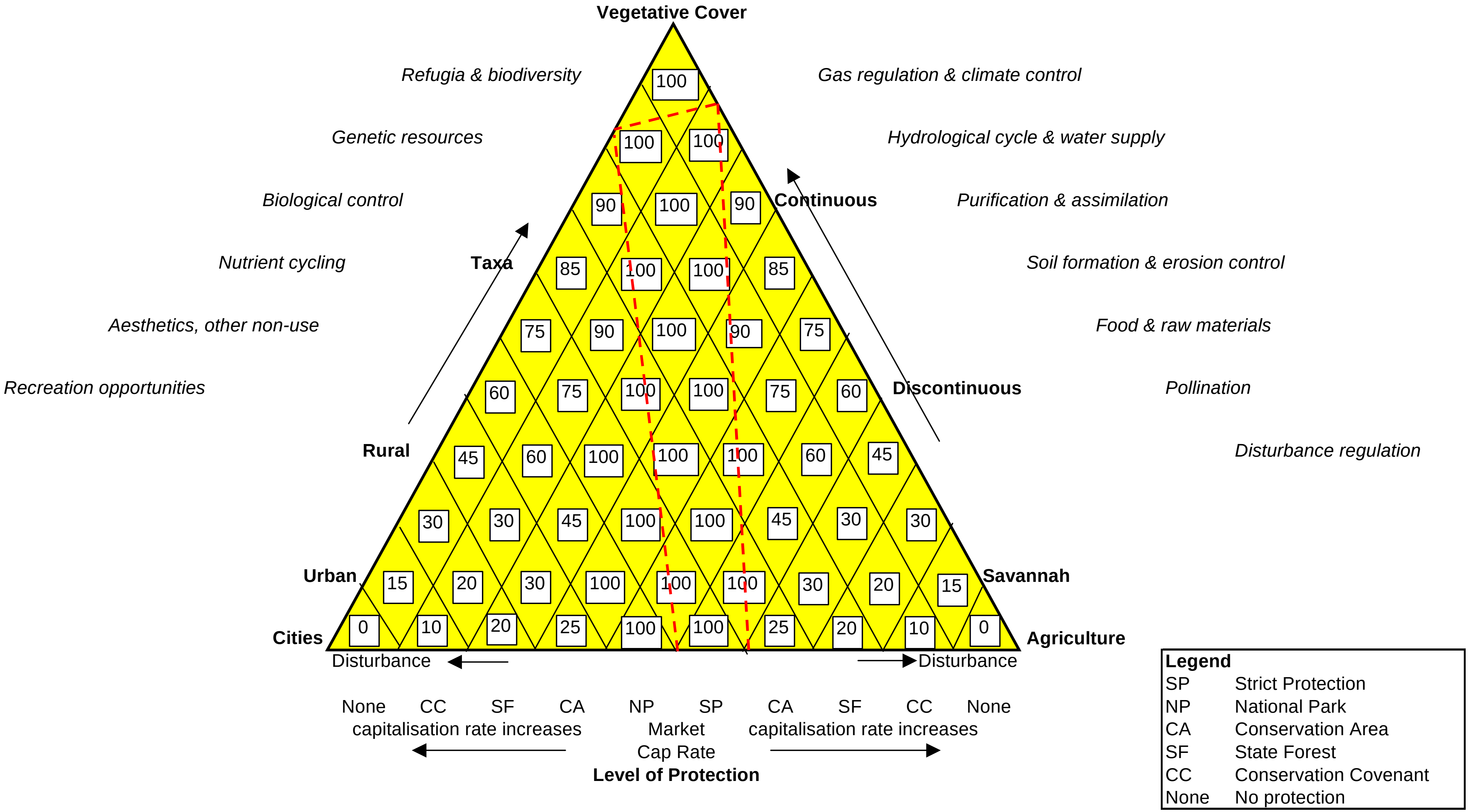


Figure 10.1. Triangulation model to assess extent of ecosystem services intact under a given level of protection or no protection
Scoring: Calculate the mean of the values within the diamonds included in the selection as well as those the dotted line passes through.

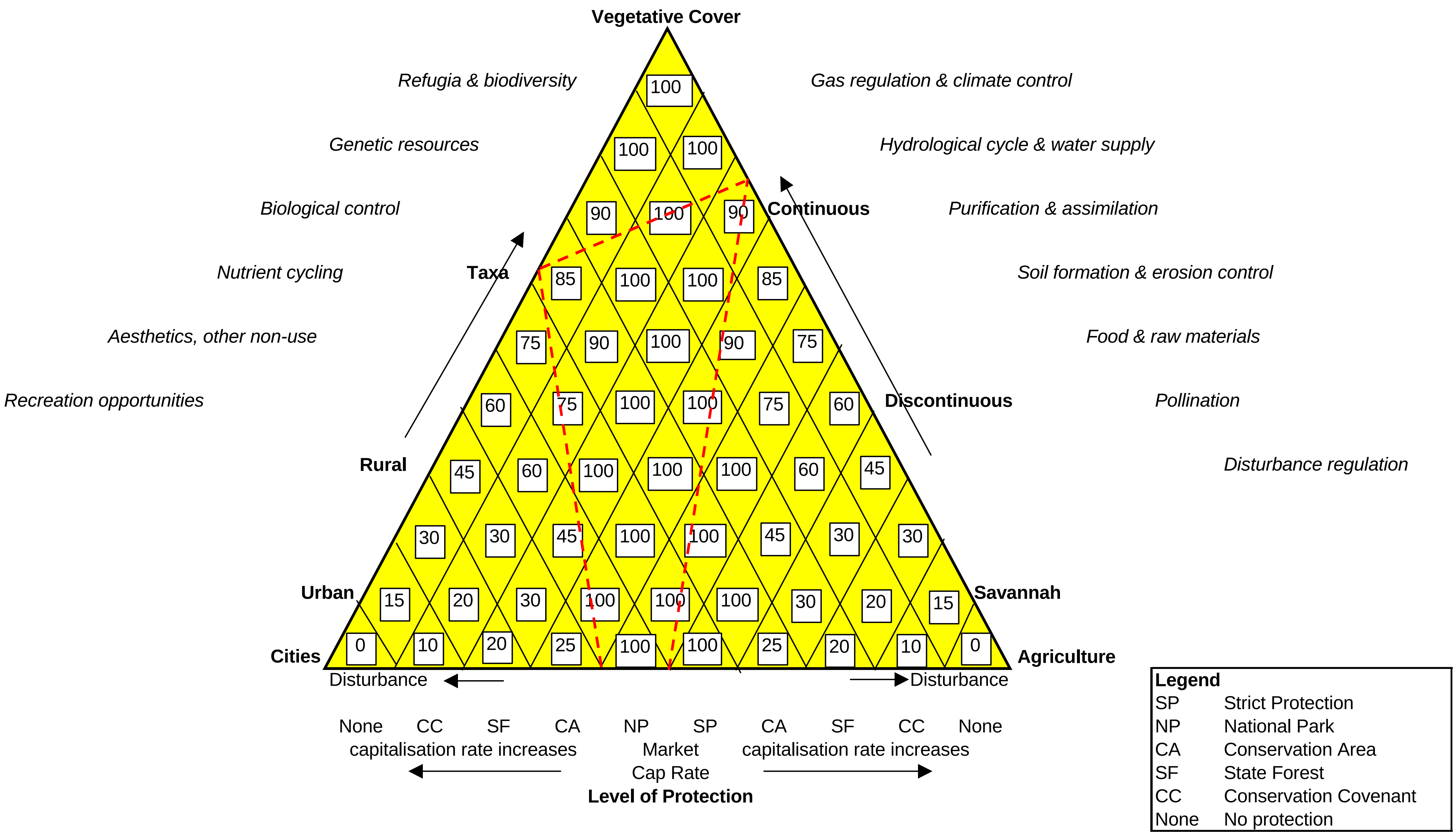


Figure 10.2 Triangulation model to assess extent of ecosystem services intact under a given level of protection or no protection

Scoring: Calculate the mean of the values within the diamonds included in the selection as well as those the dotted line passes through.

This example, National Park: 92%

D) and the former the LOP model for ‘tropical rainforests’ (Figure D2 in Appendix D). The range was 8% and the capitalisation rate 7% (Appendix J), reflecting a marginally higher level of risk and uncertainty. Timber Reserves were determined using the LOP model for ‘state forest’ as the lower limit (66%, Figure D4 in Appendix D) and the LOP model for ‘conservation area’ as the higher limit (84%, Figure D3 in Appendix D), which encompasses both the LUC models for wet sclerophyll (79% Figure D5 in Appendix D) and dry sclerophyll (76% Figure D6 in Appendix D). The range was 16% and the capitalisation rate 7.5% (Appendix J), reflecting an increased level of uncertainty, and marginally more risk. The tenure category ‘Various Reserves and Dams’ was assessed using the LUC model with the highest limit ‘wet sclerophyll forest’ at 79% (Figure D5 in Appendix D) and the lowest limit, again the LOP model for ‘state forest’ at 66% (Figure D4 in Appendix D). The range was smaller (13%) and the capitalisation rate the same as for ‘timber reserves’ (7.5%). The tenure category ‘Unallocated State Land’ represents rather an unknown area, and as such the range for uncertainty used was the same as for Timber Reserves (16%), but the capitalisation rate a quarter of a point higher (7.75%). The upper and lower limits for Unallocated State Land were 56% (LOP conservation covenant: Figure D7 in Appendix D) and 72% (halfway between LOP state forest Figure D4 and LUC wet sclerophyll Figure D5 in Appendix D). All Leasehold Land whether expiring or perpetual was allocated the range (56-66%), based on the LOP conservation covenant (Figure D7 in Appendix D) and LOP state forest models (Figure D4 in Appendix D). Capitalisation rate was increased marginally to 8% (Appendix J). Freehold Land was allocated a larger range (48-66%), and was based on the LOP ‘no conservation: savannah/agriculture’ (Figure D8 in Appendix D) and LUC ‘grasslands’ (Figure D9 in Appendix D) models for the lower limit and the LOP ‘state forest’ (Figure D4 in Appendix D) model for the higher limit. The capitalisation rate was increased a quarter of a point to 8.25% (Appendix J). The tenure category ‘Roads, Esplanades, Railways’ includes grassland verges and mangrove ecosystems in the littoral zones, while in some cases they are highly disturbed and most at risk, substantial ecosystem processes still function. This category was allocated the range 39-48%, 39% being the LOP parameter ‘no conservation: cities/urban’ (Figure D10 in Appendix D) and the LUC parameter 'desert' (Figure D11 in Appendix D) and the higher limit based on the LOP 'no conservation: savannah/agriculture' (Figure D8 in Appendix D) and LUC 'grasslands' (Figure D9 in Appendix D) models. Capitalisation rates were increased by three quarters of a point to 9% (Appendix J). Finally, 'Rivers' were allocated the largest range (36%) as probably being the least studied as to their contribution to all of the ecosystem attributes, but less at risk than more static ecosystems. The capitalisation rate for rivers was dropped to 7.5% (Appendix J). The allocation for Rivers most closely resembles the range of that for LUC 'grasslands' (lower limit ~48%: Figure D9 in Appendix D) and LOP 'no protection: savannah/agriculture' (48%: Figure D8 in Appendix D) to LOP 'conservation area' (upper limit 84%: Figure D3 in Appendix D). The upper and lower limits of provision of ecosystem services in the tenure categories in the WTWHA, and the capitalisation rate applied to the *MUV* for each tenure category is shown in Figure 10.3.

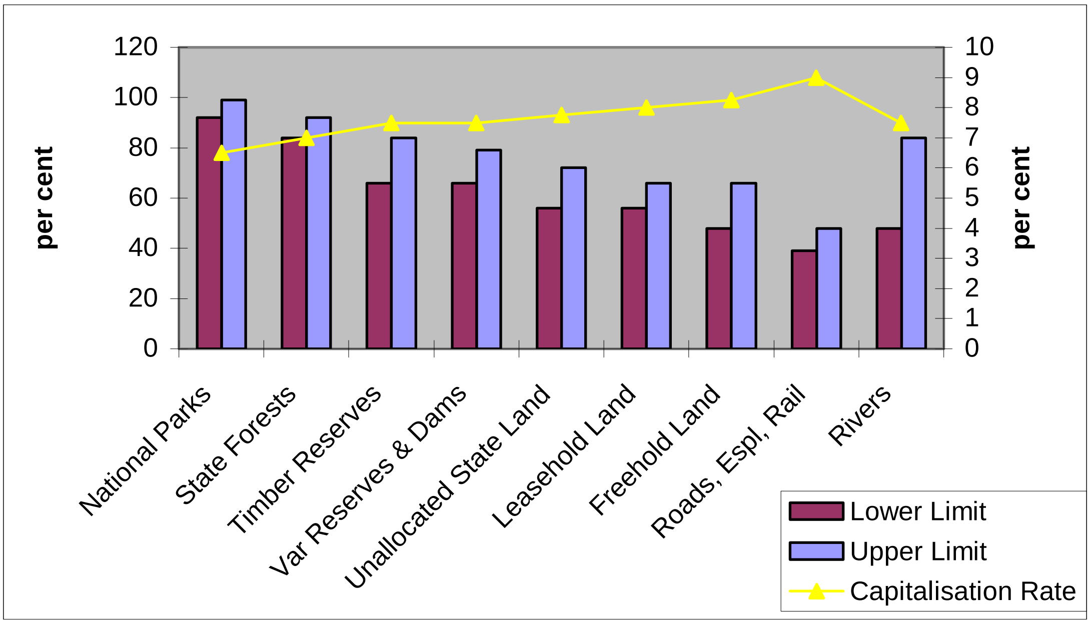


Figure 10.3. Upper and lower limits of provision of ecosystem services in the tenure categories in the WTWHA derived from the conceptual models and increasing capitalisation rates reflecting risk and disturbance.

Although the higher capitalisation rates for the tenure categories most disturbed reflect a higher *UFpa,* this is mostly offset by the lower level of provision of ecosystem goods and services on an areal or spatial scale. The concept of higher capitalisation rates due to risk or uncertainty, in, for example: more disturbed ecosystems, is paramount in any economic evaluation. Moreover while the most disturbed tenures, ie. leasehold, freehold, roads, railways etc., have a higher *UFpa,* in the WTWHA they constitute only a small portion of the whole area under protection. Therefore, while it is important to include the value of these minor disturbed tenure categories in the overall value of the WTWHA, they have little real affect on the value (~10% of the value attributed to 13% of the land area).

Chapter 11
The Aggregate and Individual Values of Ecosystem Goods and Services in the Wet Tropics World Heritage Area

11.1 Introduction

Justification of the use of the median unimproved value (*MUV*) in the WTWHA bioregion, or any other bioregion, relies on six valid assumptions empirically derived from valuation practice.

1. The *MUV* is a valid measure of the revealed preferences of the community in the bioregion with regard to what they are willing to pay for land to put to a multitude of uses. The *MUV* is thus, *sensu stricto,* directly related to the use of land.
2. The *MUV* reflects the level of development, or more precisely, the 'magnitude' of the *MUV* reflects the level of development in the bioregion.
3. The *MUV* has an exponential relationship with human population density in a region (Chapter 13)
4. The *MUV* also reflects the potential for further development, as the courts insist that the unimproved value takes into consideration all other development, including infrastructure in the bioregion.
5. The *MUV* also reflects allotment size. Smaller allotments are valued at a higher rate than *broadacres* due to the costs associated with subdivision and the margin for profit expected by the developer.
6. The level of development and the allotment size is directly relevant to, and reflects scarcity of ecosystem goods and services.

Justification for the capitalisation of the *MUV* to determine the value of the flow of benefits emanating from terrestrial ecosystems in the form of ecosystem goods and services relies on the valuation and economic principles of opportunity cost, rent (the production function), and the legal and economic definition of *Usufruct.* It is standard procedure in valuation practice to apply as many methods as are applicable or warranted in each case and compare them. The *MUV* has been determined by the use of comparable sales which were subject to scrutiny by valuation agencies charged with the responsibility of determining unimproved value for rating and taxation purposes. The capitalisation rate was determined by a study of the market and the elements of risk for each tenure category in the WTWHA.

11.2 The Surrogate Market

The median unimproved value of land in the Wet Tropics Bioregion as at June 30th 2002 was \$3,810.02 hectare^{-1}. The bioregion is administered by eleven local governments, some of which are totally within the boundaries of the bioregion (Hinchinbrook, Cardwell, Johnstone, Eacham and Douglas Shires and Cairns City) and others with only a small part of their administrative area within the bioregion (Thuringowa, Herberton, Atherton, Mareeba and Cook Shires). The total value of the rateable land in each LGA in the bioregion is given in table 11.1, along with the area of that land. The outliers were the largest and least developed shires, Cook, Herberton and Mareeba, and the most developed, Cairns City.

Table 11.1 Total rateable value of land in the eleven LGAs represented in the Wet Tropics Bioregion as at 30th June 2002

Local Government Area	**Total Land Area** (Hectares)	**Alienated Land** (Hectares)	**Rateable Value** (Dollars)	**Dollar Value** per Hectare
Cook Shire		5548440	97,324,240	17.54
Mareeba Shire	5388476	4194377	384,843,420	91.75
Herberton Shire		993449	92,386,550	93.00
Hinchinbrook Shire	247207	179101	464,679,440	2594.51
Eacham Shire	112400	52535	183,805,350	3498.72
Cardwell Shire	290100	96700	368,429,100	3810.02
Thuringowa		169983	860,828,043	5064.20
Atherton Shire	62182	52358	293,278,890	5601.42
Johnstone Shire		75214	476,226,650	6331.62
Douglas Shire	238600	50106	491,603,500	9811.27
Cairns City	168750	74790	3,840,000,000	51343.76

11.3 The Values

Finally, using the complete methodology: the median unimproved property value for the bioregion; the current cost of money (capitalisation rates start at 6.5% for the National Parks and increase with risk), the weights assigned by the panellists to the individual services, and the conceptual models to determine the level of provision of ecosystem services in each tenure in the

WTWHA; that is by applying the models and equations and using the valuation tables (Appendix J), the total value of the ecosystem goods and services in the Wet Tropics of Queensland World Heritage Area was estimated to be between AUD$188 million and AUD$211 million year^{-1} at June 30, 2002 (Table 11.2). This value is a net annual value, ie. the value is after all costs associated with the lands, including conservation, are deducted. The per hectare value of the full suite of ecosystem services, or *UFpa* ha^{-1}, starts at $247.65 year^{-1} net for the National Parks, and increases for the tenure categories with increasing capitalisation rates to reflect scarcity as the level of protection decreases, disturbance increases and the level of provision of services decreases.

Table 11.2 The total value of ecosystem goods and services in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Range AUD$Millions per annum	Upper Range AUD$Millions per annum
National Parks	21	285,744	32.0	65.440	69.987
State forests	32	347,300	39.0	77.728	85.198
Timber reserves	5	74,163	8.0	13.978	17.688
Various reserves and dams	64	10,207	1.0	1.928	2.305
Unallocated state land	203	60,515	7.0	9.998	13.132
Leasehold land	198	90,146	10.4	15.379	18.126
Freehold & similar	204	17,341	2.0	2.616	3.054
Roads, Esplanades, Railways		5,696	0.6	0.762	0.938
Rivers		3,308	0.4	0.454	0.792
TOTAL VALUE OF THE TENURE CATEGORIES IN THE WHA				**188.283**	**211.220**

The total values of each of the four groups of ecosystem attributes, namely stabilisation services, regeneration services, production of goods and life fulfilling services are shown in Tables 11.3, 11.4, 11.5 and 11.6. These are followed by values for the individual ecosystem attributes derived from the equations 7.1, 7.2 and 7.3, the conceptual models (Appendix D) and valuation tables (Appendix J), in Tables 11.7 to 11.26.

Table 11.3 The total value of stabilisation services in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	27.669	29.774
State forests	32	347,300	39	33.067	36.217
Timber reserves	5	74,163	8	5.944	7.566
Various reserves and dams	64	10,207	1	0.818	0.979
Unallocated state land	203	60,515	7	4.253	5.468
Leasehold land	198	90,146	10.4	5.478	6.456
Freehold & similar	204	17,341	2	1.112	1.297
Roads, Esplanades, Railways		5,696	0.6	0.324	0.398
Rivers		3,308	0.4	0.193	0.337
TOTAL VALUE OF STABILISATION SERVICES IN THE WHA				**78.858**	**88.492**

Table 11.4 The total value of regeneration services in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	19.075	20.527
State forests	32	347,300	39	22.797	24.968
Timber reserves	5	74,163	8	4.098	5.216
Various reserves and dams	64	10,207	1	0.564	0.675
Unallocated state land	203	60,515	7	2.932	3.770
Leasehold land	198	90,146	10.4	4.508	5.313
Freehold & similar	204	17,341	2	0.767	0.894
Roads, Esplanades, Railways		5,696	0.6	0.223	0.275
Rivers		3,308	0.4	0.133	0.233
TOTAL VALUE OF REGENERATION SERVICES IN THE WHA				**55.097**	**61.871**

Table 11.5 The total value of production of goods in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	11.002	11.840
State forests	32	347,300	39	13.149	14.401
Timber reserves	5	74,163	8	2.364	3.008
Various reserves and dams	64	10,207	1	0.325	0.389
Unallocated state land	203	60,515	7	1.691	2.174
Leasehold land	198	90,146	10.4	1.939	2.285
Freehold & similar	204	17,341	2	0.442	0.516
Roads, Esplanades, Railways		5,696	0.6	0.129	0.158
Rivers		3,308	0.4	0.077	0.134
TOTAL VALUE OF PRODUCTION OF GOODS IN THE WHA				**31.118**	**34.905**

Table 11.6 The total value of life fulfilling services in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	7.292	7.846
State forests	32	347,300	39	8.714	9.544
Timber reserves	5	74,163	8	1.567	1.994
Various reserves and dams	64	10,207	1	0.216	0.258
Unallocated state land	203	60,515	7	1.121	1.441
Leasehold land	198	90,146	10.4	1.723	2.031
Freehold & similar	204	17,341	2	0.293	0.342
Roads, Esplanades, Railways		5,696	0.6	0.085	0.105
Rivers		3,308	0.4	0.051	0.089
TOTAL VALUE OF LIFE FULFILLING SERVICES IN THE WHA				**21.062**	**23.650**

As it was important to determine whether individual ecosystem services were present or absent, and if present the extent to which they are functional, it must be possible to be able to account for them separately. In order to do this weightings provided by the Delphi panel and the multiple criteria analysis were used to estimate the contribution of individual holdings and landscapes using the conceptual models (Appendix D) and valuation tables (Appendix J). The values of individual ecosystem goods and services in the tenure categories in the WTWHA are shown in Tables 11.7 – 11.26.

Table 11.7 The total value of gas regulation in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	4.492	4.834
State forests	32	347,300	39	5.369	5.880
Timber reserves	5	74,163	8	0.965	1.228
Various reserves and dams	64	10,207	1	0.133	0.159
Unallocated state land	203	60,515	7	0.690	0.888
Leasehold land	198	90,146	10.4	1.062	1.251
Freehold & similar	204	17,341	2	0.181	0.211
Roads, Esplanades, Railways		5,696	0.6	0.053	0.065
Rivers		3,308	0.4	0.031	0.055
TOTAL VALUE OF GAS REGULATION IN THE WHA				**12.976**	**14.571**

Table 11.8 The total value of climate regulation in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	4.427	4.764
State forests	32	347,300	39	5.291	5.795
Timber reserves	5	74,163	8	0.951	1.210
Various reserves and dams	64	10,207	1	0.131	0.157
Unallocated state land	203	60,515	7	0.680	0.875
Leasehold land	198	90,146	10.4	1.046	1.233
Freehold & similar	204	17,341	2	0.178	0.208
Roads, Esplanades, Railways		5,696	0.6	0.052	0.064
Rivers		3,308	0.4	0.031	0.054
TOTAL VALUE OF CLIMATE REGULATION IN THE WHA				**12.787**	**14.360**

Table 11.9 The total value of disturbance regulation in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	3.581	3.853
State forests	32	347,300	39	4.279	4.721
Timber reserves	5	74,163	8	0.769	0.979
Various reserves and dams	64	10,207	1	0.107	0.128
Unallocated state land	203	60,515	7	0.550	0.708
Leasehold land	198	90,146	10.4	0.846	0.997
Freehold & similar	204	17,341	2	0.145	0.169
Roads, Esplanades, Railways		5,696	0.6	0.042	0.052
Rivers		3,308	0.4	0.025	0.044
TOTAL VALUE OF DISTURBANCE REGULATION IN THE WHA				**10.344**	**11.617**

Table 11.10 The total value of water regulation in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	0.716	0.771
State forests	32	347,300	39	0.856	0.937
Timber reserves	5	74,163	8	0.154	0.196
Various reserves and dams	64	10,207	1	0.022	0.026
Unallocated state land	203	60,515	7	0.112	0.144
Leasehold land	198	90,146	10.4	0.172	0.203
Freehold & similar	204	17,341	2	0.029	0.034
Roads, Esplanades, Railways		5,696	0.6	0.009	0.011
Rivers		3,308	0.4	0.005	0.009
TOTAL VALUE OF WATER REGULATION IN THE WHA				**2.075**	**2.331**

Table 11.11 The total value of erosion control and soil/sediment retention in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	4.753	5.114
State forests	32	347,300	39	5.680	6.221
Timber reserves	5	74,163	8	1.021	1.300
Various reserves and dams	64	10,207	1	0.141	0.168
Unallocated state land	203	60,515	7	0.730	0.939
Leasehold land	198	90,146	10.4	1.123	1.324
Freehold & similar	204	17,341	2	0.191	0.223
Roads, Esplanades, Railways		5,696	0.6	0.055	0.068
Rivers		3,308	0.4	0.033	0.058
TOTAL VALUE OF EROSION CONTROL IN THE WHA				**13.727**	**15.415**

Table 11.12 The total value of biological control in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	4.102	4.414
State forests	32	347,300	39	4.902	5.369
Timber reserves	5	74,163	8	0.881	1.121
Various reserves and dams	64	10,207	1	0.122	0.146
Unallocated state land	203	60,515	7	0.630	0.811
Leasehold land	198	90,146	10.4	0.969	1.142
Freehold & similar	204	17,341	2	0.165	0.193
Roads, Esplanades, Railways		5,696	0.6	0.048	0.059
Rivers		3,308	0.4	0.029	0.05
TOTAL VALUE OF BIOLOGICAL CONTROL IN THE WHA				**11.848**	**13.305**

Table 11.13 The total value of refugia in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	5.999	6.025
State forests	32	347,300	39	6.691	7.329
Timber reserves	5	74,163	8	1.203	1.531
Various reserves and dams	64	10,207	1	0.166	0.198
Unallocated state land	203	60,515	7	0.861	1.106
Leasehold land	198	90,146	10.4	1.323	1.560
Freehold & similar	204	17,341	2	0.225	0.263
Roads, Esplanades, Railways		5,696	0.6	0.066	0.081
Rivers		3,308	0.4	0.039	0.068
TOTAL VALUE OF REFUGIA IN THE WHA				**16.573**	**18.161**

Table 11.14 The total value of soil formation in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	0.651	0.701
State forests	32	347,300	39	0.778	0.852
Timber reserves	5	74,163	8	0.145	0.185
Various reserves and dams	64	10,207	1	0.020	0.024
Unallocated state land	203	60,515	7	0.104	0.134
Leasehold land	198	90,146	10.4	0.160	0.189
Freehold & similar	204	17,341	2	0.027	0.032
Roads, Esplanades, Railways		5,696	0.6	0.008	0.010
Rivers		3,308	0.4	0.005	0.008
TOTAL VALUE OF SOIL FORMATION IN THE WHA				**1.898**	**2.135**

Table 11.15 The total value of nutrient cycling and storage in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	2.539	2.732
State forests	32	347,300	39	3.034	3.323
Timber reserves	5	74,163	8	0.545	0.694
Various reserves and dams	64	10,207	1	0.075	0.090
Unallocated state land	203	60,515	7	0.390	0.502
Leasehold land	198	90,146	10.4	0.600	0.707
Freehold & similar	204	17,341	2	0.103	0.120
Roads, Esplanades, Railways		5,696	0.6	0.030	0.037
Rivers		3,308	0.4	0.018	0.031
TOTAL VALUE OF NUTRIENT CYCLING IN THE WHA				**7.334**	**8.236**

Table 11.16 The total value of assimilation of waste, attenuation, detoxification in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	3.321	3.573
State forests	32	347,300	39	3.968	4.346
Timber reserves	5	74,163	8	0.713	0.908
Various reserves and dams	64	10,207	1	0.097	0.117
Unallocated state land	203	60,515	7	0.510	0.656
Leasehold land	198	90,146	10.4	0.785	0.925
Freehold & similar	204	17,341	2	0.132	0.154
Roads, Esplanades, Railways		5,696	0.6	0.039	0.047
Rivers		3,308	0.4	0.023	0.04
TOTAL VALUE OF ASSIMILATION IN THE WHA				**9.588**	**10.766**

Table 11.17 The total value of purification (clean air, water) in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	3.776	4.063
State forests	32	347,300	39	4.513	4.942
Timber reserves	5	74,163	8	0.811	1.032
Various reserves and dams	64	10,207	1	0.111	0.133
Unallocated state land	203	60,515	7	0.580	0.746
Leasehold land	198	90,146	10.4	0.892	1.052
Freehold & similar	204	17,341	2	0.151	0.176
Roads, Esplanades, Railways		5,696	0.6	0.044	0.054
Rivers		3,308	0.4	0.026	0.046
TOTAL VALUE OF PURIFICATION IN THE WHA				**10.904**	**12.244**

Table 11.18 The total value of pollination in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	2.344	2.522
State forests	32	347,300	39	2.801	3.068
Timber reserves	5	74,163	8	0.504	0.641
Various reserves and dams	64	10,207	1	0.069	0.082
Unallocated state land	203	60,515	7	0.360	0.463
Leasehold land	198	90,146	10.4	0.554	0.653
Freehold & similar	204	17,341	2	0.093	0.109
Roads, Esplanades, Railways		5,696	0.6	0.027	0.033
Rivers		3,308	0.4	0.016	0.028
TOTAL VALUE OF POLLINATION IN THE WHA				**6.768**	**7.599**

Table 11.19 The total value of biodiversity in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	6.445	6.936
State forests	32	347,300	39	7.703	8.436
Timber reserves	5	74,163	8	1.385	1.762
Various reserves and dams	64	10,207	1	0.191	0.228
Unallocated state land	203	60,515	7	0.991	1.274
Leasehold land	198	90,146	10.4	1.523	1.795
Freehold & similar	204	17,341	2	0.259	0.302
Roads, Esplanades, Railways		5,696	0.6	0.075	0.093
Rivers		3,308	0.4	0.045	0.078
TOTAL VALUE OF BIODIVERSITY IN THE WHA				**18.617**	**20.904**

Table 11.20 The total value of water supply in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	2.799	3.012
State forests	32	347,300	39	3.346	3.664
Timber reserves	5	74,163	8	0.601	0.765
Various reserves and dams	64	10,207	1	0.083	0.100
Unallocated state land	203	60,515	7	0.430	0.553
Leasehold land	198	90,146	10.4	0.662	0.780
Freehold & similar	204	17,341	2	0.113	0.132
Roads, Esplanades, Railways		5,696	0.6	0.033	0.041
Rivers		3,308	0.4	0.020	0.034
TOTAL VALUE OF WATER SUPPLY IN THE WHA				**8.087**	**9.081**

Table 11.21 The total value of food production in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	1.562	1.681
State forests	32	347,300	39	1.867	2.045
Timber reserves	5	74,163	8	0.336	0.427
Various reserves and dams	64	10,207	1	0.047	0.056
Unallocated state land	203	60,515	7	0.240	0.309
Leasehold land	198	90,146	10.4	0.369	0.435
Freehold & similar	204	17,341	2	0.064	0.074
Roads, Esplanades, Railways		5,696	0.6	0.019	0.023
Rivers		3,308	0.4	0.011	0.019
TOTAL VALUE OF FOOD PRODUCTION IN THE WHA				**4.545**	**5.069**

Table 11.22 The total value of raw materials in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	1.888	2.032
State forests	32	347,300	39	2.256	2.471
Timber reserves	5	74,163	8	0.406	0.516
Various reserves and dams	64	10,207	1	0.056	0.067
Unallocated state land	203	60,515	7	0.290	0.373
Leasehold land	198	90,146	10.4	0.446	0.526
Freehold & similar	204	17,341	2	0.076	0.089
Roads, Esplanades, Railways		5,696	0.6	0.022	0.027
Rivers		3,308	0.4	0.013	0.023
TOTAL VALUE OF RAW MATERIALS IN THE WHA				**5.453**	**6.124**

Table 11.23 The total value of genetic resources in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	4.753	5.114
State forests	32	347,300	39	5.680	6.221
Timber reserves	5	74,163	8	1.021	1.200
Various reserves and dams	64	10,207	1	0.141	0.168
Unallocated state land	203	60,515	7	0.730	0.939
Leasehold land	198	90,146	10.4	1.123	1.324
Freehold & similar	204	17,341	2	0.191	0.223
Roads, Esplanades, Railways		5,696	0.6	0.055	0.068
Rivers		3,308	0.4	0.033	0.058
TOTAL VALUE OF GENETIC RESOURCES IN THE WHA				**13.727**	**15.315**

Table 11.24 The total value of recreation opportunities (nature based) in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	1.628	1.751
State forests	32	347,300	39	1.945	2.130
Timber reserves	5	74,163	8	0.350	0.445
Various reserves and dams	64	10,207	1	0.048	0.057
Unallocated state land	203	60,515	7	0.250	0.322
Leasehold land	198	90,146	10.4	0.385	0.453
Freehold & similar	204	17,341	2	0.065	0.076
Roads, Esplanades, Railways		5,696	0.6	0.019	0.023
Rivers		3,308	0.4	0.011	0.020
TOTAL VALUE OF RECREATION OPPORTUNITIES IN WHA				**4.701**	**5.277**

Table 11.25 The total value of the aesthetic, cultural and spiritual (existence values) in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	3.516	3.783
State forests	32	347,300	39	4.201	4.636
Timber reserves	5	74,163	8	0.755	0.961
Various reserves and dams	64	10,207	1	0.105	0.125
Unallocated state land	203	60,515	7	0.540	0.965
Leasehold land	198	90,146	10.4	0.831	0.979
Freehold & similar	204	17,341	2	0.142	0.166
Roads, Esplanades, Railways		5,696	0.6	0.041	0.051
Rivers		3,308	0.4	0.025	0.043
TOTAL VALUE OF AESTHETIC, CULTURAL AND SPIRITUAL VALUES IN THE WHA				**10.156**	**11.439**

Table 11.26 The total value of Other Non-Use Values (Bequest, Option and Quasi Option Values) in the tenure categories in the WTWHA as at June 30, 2002.

Tenure Category	Parcels	Area	% of WHA	Lower Limit AUD$Millions per annum	Upper Limit AUD$Millions per annum
National Parks	21	285,744	32	2.148	2.312
State forests	32	347,300	39	2.568	2.812
Timber reserves	5	74,163	8	0.462	0.587
Various reserves and dams	64	10,207	1	0.063	0.076
Unallocated state land	203	60,515	7	0.330	0.425
Leasehold land	198	90,146	10.4	0.508	0.598
Freehold & similar	204	17,341	2	0.086	0.100
Roads, Esplanades, Railways		5,696	0.6	0.025	0.031
Rivers		3,308	0.4	0.015	0.026
TOTAL VALUE OF OTHER NON-USE VALUES				**6.205**	**6.967**

As stated above, the *UFpa* ha^{-1} for National Parks was $247.65, however the *UFpa* ha^{-1} for the other tenure categories, adjusted by the level of provision of services is given in Table 11.27, the lowest being $149.16 ha^{-1} for roads, railways and esplanades.

Table 11.27 The *Usus Fructus per annum* for the tenure categories adjusted for the decreasing level of protection and increasing disturbance (increasing capitalisation rate) and by the mean of the upper and lower limit of provision of services.

Tenure Category	Capitalisation Rate	*UFpa*	Lower Limit %	Upper Limit %	*UFpa x mean limits*
National Parks	6.50	$247.65	92	99	$236.51
State Forests	7.00	$266.70	84	92	$234.70
Timber Reserves	7.50	$285.75	66	84	$214.31
Various reserves and dams	7.50	$285.75	66	79	$207.17
Unallocated state land	7.75	$295.28	56	72	$188.98
Leasehold land	8.00	$304.80	56	66	$185.93
Freehold & similar	8.25	$314.33	48	66	$182.31
Roads, Esplanades Railways	9.00	$342.90	39	48	$149.16
Rivers	7.50	$285.75	48	84	$188.60

In this valuer’s considered opinion the total value of ecosystem goods and services in the Wet Tropics World Heritage Area of Queensland, as at June 30th 2002, is in the range AUD$188 to AUD$211 million year^{-1}. Values for the groups of ecosystem services and individual goods and services are as shown in Tables 11.3 – 11.26.

Chapter 12

Summary of the Methodology and Results

12.1 Introduction

The median unimproved capital value of the rateable land in the Wet Tropics Bioregion was used as a surrogate capital market for land that hosts terrestrial ecosystem services, whether alienated from the crown or in the public domain. Using the principles of property valuation, the shadow prices for ecosystem goods and services (the *Usus Fructus per annum*) provided by public and other land in the Wet Tropics Bioregion of Queensland were derived from this surrogate capital market. That is, by applying an appropriate capitalisation rate, the annual value (in human terms) of the flow of benefits to planetary life-support functions was determined. A multiple criteria analysis, using the 20 identified ecosystem attributes (Table 7.1) and three models with six different criteria for each model was undertaken in order to establish the non-pecuniary weightings and sensitivities for the attributes. A panel of experts was used to establish expert opinion as to the need for the research and the relative rankings of the attributes for each model. Ecosystem integrity, or the level to which each land tenure category in the WTWHA provides ecosystem services on a landscape scale, was determined by the use of two conceptual models (the LOP and the LUC models) along with a valuation table to enter the data and compute results.

12.1.2 The Surrogate Market and Shadow Prices

The unimproved capital value of land in the Wet Tropics Bioregion was obtained from the eleven Local Government Authorities represented in the region and a median value of $3810.02 per hectare computed for the unrateable land. Shadow prices for the ecosystem goods and services as a flow of benefits from land were calculated using the following equations:

The *Usus Fructus per annum (UFpa)* was thus represented by the equation:

$$UFpa(\$/ha) = MUV(\$/ha) \times cr(\%).$$

Where *cr* is the capitalisation rate.

(Equation 7.1)

As both alienated and un-alienated land provide ecosystem services it is important to be able to estimate the extent to which the land contributes to the overall contribution. Depending on the level of disturbance, other human activities on the land can co-exist with the provision of ecosystem services. Therefore on a landscape scale, total value of a whole ecosystem *(TVw)* is represented by the equation:

TVw = *UFpa* x area(ha) x *esi*(%)   Equation 7.2

Where *esi* is the extent to which ecosystem services are intact.

Shadow prices for the individual ecosystem attributes were derived from the panellists' contributions (the weights) during the Delphi study. The total value of an individual ecosystem attribute *(TVi)* was represented by the equation:

TVi = UFpa x area(ha) x *esi*(%) x *wt*. ….Equation 7.3

Where *wt* is the final weighting of the attribute (a decimal).

The shadow price or *UFpa* for the full suite of services was \$247.65 ha^{-1} using a capitalisation rate of 6.5%. Capitalisation rates increased for the tenure categories as level of protection decreased and disturbance increased. The range of shadow prices was from \$247.65 ha^{-1} $year^{-1}$ for National Parks that were 100% intact to \$342.90 ha^{-1} $year^{-1}$ for freehold land, however the latter figure would only apply to fully intact remnants at risk in an otherwise disturbed environment. Adjusting these shadow prices to reflect the level of provision of ecosystem services on a landscape scale, with varying capitalisation rates to reflect risk and uncertainty, and ecosystem services that coexist with other land uses, results in a range of shadow prices (*UFpa)* from \$149.16 ha^{-1} $year^{-1}$ for 'roads, railways and esplanades' to \$236.51 ha^{-1} $year^{-1}$ for 'National Parks' 95.5% intact (mean of the upper and lower limits) (Table 11.27).

12.1.3 The Delphi Questionnaires

For the closed ended questions (true/false) the panel reached consensus in all three rounds, and some of the main conclusions that could be drawn from the responses were:

- The concepts of a surrogate market and shadow prices in the absence of a market are an acceptable way of measuring the value of intangibles;

- The contingency valuation method is an acceptable way of measuring the value of intangibles, only if the survey respondents are targeted and selected on the basis of their knowledge of the resource in question. This would appear to rule out community or random surveys;
- Conventional economics is totally inappropriate for dealing with environmental problems;
- The complexity of the environment obfuscates modelling links between the environment and the economy; and
- Continuing ecosystem loss is due to the lack of a rational pricing mechanism for ecosystem goods and services.

The highest level of agreement between the disciplines were with the Natural Resource Managers and Ecologists, followed by the Ecological Economists and Ecologists, Neoclassical Economists and Ecological Economists, Geographers and Ecologists and the Environmental Economists and Ecological Economists.

Answers to the open-ended questions (text answers) showed very strong support for attempts to value the environment, yet recognised the difficulties inherent in using peoples' expressed preferences (WTP) as a measure. The most important issues raised to do with placing a value on the environment were education, knowledge, information and understanding. Future trading markets in ecosystem services were seen by most to be an aid to financing conservation provided they were set up properly, with a division of opinion as to whether global markets would capture them, and if it was a good thing. Agenda 21 was regarded as neither compatible with emerging global markets nor global inequities, and ESD not compatible with the current levels of consumption.

12.1.4 The Multiple Criteria Analysis

There was significant agreement for 'all disciplines', 'all economists' and 'all scientists' in all three models, and there was significant agreement within the disciplines in most cases, the exceptions being where N was small. The values for Kendall's W were not particularly high, generally less than 0.5, due to the variability in the data. Kendall's W was calculated again for all disciplines, all economists and all natural scientists for each model using the mean of each discipline's weightings for each model in order to 'smooth' the data and ascertain the intensity of agreement between the blocks. In model 1, the 'Anthropocentric' perspective, all scientists had a marginally higher intensity of agreement than all economists, However, in model 2, the 'Utilitarian' perspective, the economists had a more than marginally higher intensity of agreement than the scientists, which could be attributed to the utilitarian value construct of most economists as opposed to the intrinsic value construct of most scientists. The economists confirmed that indeed the direct and indirect 'use' goods and services were more important for this model. Conversely, the scientists were much more than marginally in agreement than the economists in model three, 'Balanced Sensitivity', with the criteria risk and uncertainty primarily economic concepts, these and more particularly, the other four criteria, are very much in the everyday idiom of natural scientists.

The final weightings for the ecosystem goods and services are shown in Table 12.1 in the order and groups the attributes were originally presented in Table 7.1. In order of importance, the ecosystem goods and services are:

1. Biodiversity
2. Refugia
3. Erosion control and soil/sediment retention
4. Genetic resources (medicines, scientific and technological resources)
5. Gas regulation (atmospheric composition)
6. Climate regulation (temperature, rainfall)
7. Biological control (populations, pest/disease control)
8. Purification (clean water, air)
9. Disturbance regulation (ecosystem resilience)
10. Aesthetics, cultural and spiritual (existence value)
11. Assimilation of waste and attenuation, detoxification
12. Water supply (catchment)
13. Nutrient cycling and storage (including carbon sequestration)
14. Pollination (movement of floral gametes)
15. Other non-use values (bequest and quasi option values)
16. Raw materials (that sustainable portion of gross primary production, timber, fibre etc.)
17. Recreation opportunities (nature-based tourism)

18. Food production (that sustainable portion of GPP)
19. Water regulation (hydrological cycle)
20. Soil formation

Table 12.1 Final weights of the ecosystem goods and services.

Group	Type	Weight
Stabilisation Services	Gas regulation (atmospheric composition)	0.069
	Climate regulation (temperature, rainfall)	0.068
	Disturbance regulation (ecosystem resilience)	0.055
	Water regulation (hydrological cycle)	0.011
	Erosion control and soil/sediment retention	0.073
	Biological control (populations, pest/disease control)	0.063
	Refugia (habitats for resident and transient populations)	0.086
Regeneration Services	Soil formation	0.010
	Nutrient cycling and storage (including carbon sequestration)	0.039
	Assimilation of waste and attenuation, detoxification	0.051
	Purification (clean water, air)	0.058
	Pollination (movement of floral gametes)	0.036
	Biodiversity	0.099
Production of Goods	Water supply (catchment)	0.043
	Food production (that sustainable portion of GPP)	0.024
	Raw materials (that sustainable portion of GPP, timber, fibre etc.)	0.029
	Genetic resources (medicines, scientific and technological resources)	0.073
Life Fulfilling Services	Recreation opportunities (nature-based tourism)	0.025
	Aesthetic, cultural and spiritual, (existence values)	0.054
	Other non-use values (bequest and quasi option values)	0.033

12.1.5 The Conceptual Models and Valuation Table

The valuation table was used for both individual property holdings and for the landscape scale assessments. For individual holdings, it was used to record the status of the ecosystem integrity of the subject land, with the attributes present or not present, based on the valuer's field notes, and served as a template for insertion of all the other variables. For assessments on a landscape scale the conceptual model was also used along with any other data available to determine the relevant parameters, vegetation cover, species richness (taxa), and the LOP or LUC models. As the parameters for the LOP and LUC models yielded a variety of results depending on the information available, and the match with, for example the tenure categories in the landscape, and any other available indicators, judgement was required.

The capitalisation rates for the tenure categories, the conceptual model/models used to derive the upper and lower limit of provision of ecosystem services, and the upper and lower limits used in the valuation tables are given in Table 12.2.

Table 12.2 Capitalisation rates and conceptual models used to determine upper and lower limits of provision of ecosystem services.

Tenure Category	Capitalisation Rate	Conceptual models used (Appendix D)	Upper and lower limits
National Parks	6.50%	LOP D1 & D2	99 & 92%
State forests	7.00%	LOP D2 & D3	92 & 84%
Timber reserves	7.50%	LOP D3 & D4, LUC D5 & D6	84 & 66%
Various reserves and dams	7.50%	LOP D4, LUC D5	79 & 66%
Unallocated state land	7.75%	LOP D7, LOP D4 LUC D5	72 & 56%
Leasehold land	8.00%	LOP D4 & D7	66 & 56%
Freehold & similar	8.25%	LOP D4 & D8, LUC D9	66 & 48%
Roads, Esplanades, Railways	9.00%	LOP D8 & D10, LUC D9 & D11	48 & 39%
Rivers	7.50%	LOP D3 & D8, LUC D9	84 & 48%

Although the tenure categories in the WTWHA included a range of vegetation types and canopy cover, all were protected by virtue of inclusion in the protected area management framework. WTMA identified community infrastructure as being the greatest deleterious impact by way of ecological fragmentation, yet depending on the impact these sites can still contribute substantially to the overall ecosystem services being generated in a landscape. Higher order tenure ie. level of protection, is increasing in the heritage area due to expiring leases and buy-back, as well as transfer of state forests to the protected area estate under the *Nature Conservation Act 1992* (WTMA 2001). The state of the WTWHA, the implications of the zoning system, and the degree of past and current human disturbance implicated by the tenure categories, were taken into consideration when arriving at the upper and lower limits of provision of ecosystem services for the tenure categories in the WTWHA.

12.1.6 The Values

The values were derived from five components, the median unimproved value of land in the bioregion as a surrogate market (*MUV*), the production function of the land (the *UFpa*), the extent to which the ecosystem services were functioning on a landscape scale (*esi*), the weight of each attribute (*wt*) and the area of the land in the tenure category (ha). The equation for the total value of an individual ecosystem attribute in an areal context is thus:

TVi = *MUV* x *UFpa* (%) x *esi* (a decimal) x *wt* (%) x area (ha) Equation 7.3

And the value of a whole ecosystem is represented by the equation:

TVw = *MUV* x *UFpa* (%) x *esi* (a decimal) x area (ha) Equation 7.2

The *MUV* is a measure of human preferences based on empirical data available from local government authorities. The *MUV* reflects the level of development in a region, the potential for further development, allotment size and scarcity of ecosystem services. The *UFpa* is the production function of land in its natural state and is expressed as a capitalisation rate (%).

Substituting results in these equations for example for the highest ranking attribute, biodiversity in National Parks (lower limit):

TVi_{biodiv} = \$3810.02 x 6.5% x 92% x 0.099 x 285744 (ha)

= \$6,445,264 $year^{-1}$

And for the full suite of ecosystem services in the National Parks only at the lower limit of provision

$TVw_{NatParks}$ =\$3810.02 x 6.5% x 92% x 285744 (ha)

= \$65,103,678 $year^{-1}$

Any differences in the values are due to rounding and the use of several sets of decimals to arrive at the results (see valuation tables in Appendix J ~ a total difference of .001 in weighting represented \$0.22, which when multiplied by 285744 hectares resulted in a difference of about \$65,000 $year^{-1}$), however this degree of accuracy is not required in valuations of this type or magnitude. Suffice to say, in the case of these two examples, the value of the lower limit of biodiversity in the National Parks alone is \$6.4 million $year^{-1}$ and the lower limit of the whole suite of goods and services in the National Parks alone is \$65 million year^{-1}. A final summary of the all of the values is presented in Table 12.3.

The values only apply to a certain point in time as the components used to derive them are themselves variables. The *MUV* for each LGA will vary as to the temporal regularity of valuations and provision of this information to the LGAs for rating purposes. *UFpa* will vary as to the cost of money and investment in other comparable securities in the economic system. The measure of ecosystem integrity, *esi,* will vary as to condition of the subject land, level of protection and land use. The weights will only change if further studies are done which reflect other preferences for the relative importance of the attributes, or environmental conditions change such that certain attributes become more or less at threat. The area of the tenure categories may change as some land is elevated to a higher order tenure (State Forest to National Park), and other land subverted to a lower order tenure, such as for increased infrastructure in the region.

The opinions of values given in this thesis are current as at June 30, 2002. It is the further opinion of this researcher that the values will remain relatively current for perhaps 12 months from June 30, 2002, owing to the range of values put forward. A review of the values will require a reassessment of the *MUV* by contact of all of the LGAs in the bioregion, a review of the economic factors that affect the *UFpa*, and an investigation as to what may have changed in the ensuing period that will have an effect on the other three variables. Using the models, tables and spreadsheets developed in this study, it is estimated that the values could be reviewed in a time frame of about one month.

Table 12.3. Annual values or shadow prices of the individual ecosystem goods and services (attributes) totalled for all the tenure categories in the WTWHA.

Ecosystem Good or Service/Attribute	National Parks Lower $000/yr	National Parks Upper $000/yr	State Forests Lower $000/yr	State Forests Upper $000/yr	Timber Reserve Lower $000/yr	Timber Reserve Upper $000/yr	Var Res & Dams Lower $000/yr	Var Res & Dams Upper $000/yr	Unalloc. Land Lower $000/yr	Unalloc. Land Upper $000/yr	Leasehold Lower $000/yr	Leasehold Upper $000/yr	Freehold Lower $000/yr	Freehold Upper $000/yr	Roads, rail etc. Lower $000/yr	Roads, rail etc. Upper $000/yr	Rivers Lower $000/yr	Rivers Upper $000/yr	Totals Lower $000/yr	Totals Uppe $000/
Gas regulation	4492	4834	5369	5880	965	1228	133	159	690	888	1062	1251	181	211	53	65	31	55	12976	145
Climate regulation	4427	4764	5291	5795	951	1210	131	157	680	875	1046	1233	178	208	52	64	31	54	12787	143
Disturbance regulation	3581	3853	4279	4721	769	979	107	128	550	708	846	997	145	169	42	52	25	44	10344	116
Water regulation	716	771	856	937	154	196	22	26	112	144	172	203	29	34	9	11	5	9	2075	23
Erosion control	4753	5114	5680	6221	1021	1300	141	168	730	939	1123	1324	191	223	55	68	33	58	13727	154
Biological control	4102	4414	4902	5369	881	1121	122	146	630	811	969	1142	165	193	48	59	29	50	11848	133
Refugia	5999	6025	6691	7329	1203	1531	166	198	861	1106	1323	1560	225	263	66	81	39	68	16573	181
Soil formation	651	701	778	852	145	185	20	24	104	134	160	189	27	32	8	10	5	8	1898	21
Nutrient cycling	2539	2732	3034	3323	545	694	75	90	390	502	600	707	103	120	30	37	18	31	7334	82
Assimilation of waste	3321	3573	3968	4346	713	908	97	117	510	656	785	925	132	154	39	47	23	40	9588	107
Purification	3776	4063	4513	4942	811	1032	111	133	580	746	892	1052	151	176	44	54	26	46	10904	122
Pollination	2344	2522	2801	3068	504	641	69	82	360	463	554	653	93	109	27	33	16	28	6768	75
Biodiversity	6445	6936	7703	8436	1385	1762	191	228	991	1274	1523	1795	259	302	75	93	45	78	18617	209
Water supply	2799	3012	3346	3664	601	765	83	100	430	553	662	780	113	132	33	41	20	34	8087	90
Food production	1562	1681	1867	2045	336	427	47	56	240	309	369	435	64	74	19	23	11	19	4515	50
Raw materials	1888	2032	2256	2471	406	516	56	67	290	373	446	526	76	89	22	27	13	23	5453	61
Genetic resources	4753	5114	5680	6221	1021	1200	141	168	730	939	1123	1324	191	223	55	68	33	58	13727	153
Recreation	1628	1751	1945	2130	350	445	48	57	250	322	385	453	65	76	19	23	11	20	4701	52
Aesthetic,	3516	3783	4201	4636	755	961	105	125	540	965	831	979	142	166	41	51	25	43	10156	117
Other non-use values	2148	2312	2568	2812	462	587	63	76	330	425	508	598	86	100	25	31	15	26	6205	69
Totals	**65440**	**69987**	**77728**	**85198**	**13978**	**17688**	**1928**	**2305**	**9998**	**13132**	**15379**	**18126**	**2616**	**3054**	**762**	**938**	**454**	**792**	**188283**	**2112**

Note: This table should be read in conjunction with Tables 2 and 11, which provide the the area (ha) of the tenure categories, the capitalisation rate, the UFpa, the upper and lower limits (%) and the UFpa adjusted for the level of provision of ecosystem services. The *UFpa* across tenures thus ranges from $210 to $236 per ha pa, and within tenures from $247.65 to 342.90 per ha pa before adjustment (ie. 100% provision), and $149.16 to $236.51 per ha pa after adjustment.