New Zealand Agricultural & Resource Economics Society (Inc.)

Valuing Ecosystem Diversity in South East Queensland: A Life Satisfaction Approach

Christopher Ambrey & Christopher Fleming
Department of Accounting, Finance and Economics
Griffith Business School, Queensland

Paper presented at the 2011 NZARES Conference

Tahuna Conference Centre – Nelson, New Zealand. August 25-26, 2011

Valuing ecosystem diversity in South East Queensland: A life satisfaction approach

Christopher L. Ambrey and Christopher M. Fleming

Department of Accounting, Finance and Economics, Griffith Business School, Queensland, Australia 4111

Abstract

The life satisfaction approach has recently emerged as a new technique in the suite of options available to non-market valuation practitioners. This paper examines the influence of ecosystem diversity on the life satisfaction of residents of South East Queensland, Australia. It is found that, on average, a respondent is willing-to-pay approximately AUD$20,000 in household income per annum to obtain a one-unit improvement in ecosystem diversity. This result indicates that the life satisfaction effects of improvements in ecosystem diversity are substantial, and greater than the welfare effects implied by studies using more conventional non-market valuation techniques.

Keywords: Household, Income and Labour Dynamics in Australia (HILDA); Life Satisfaction; Non-market Valuation; Biodiversity; Ecosystem Diversity.

This paper uses unit record data from the Household, Income and Labour Dynamics in Australia (HILDA) survey. The HILDA project was initiated and is funded by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) and is managed by the Melbourne Institute of Applied Economic and Social Research (Melbourne Institute). The findings and views reported in this paper, however, are those of the authors and should not be attributed to either FaHCSIA or the Melbourne Institute.

1. Introduction

It is well recognised that biodiversity provides many direct and indirect benefits to humans. It is equally well recognised that human activity has contributed to unprecedented rates of biodiversity loss (cf. Secretariat of the Convention on Biological Diversity, 2010). Moreover, projections show continuing and, in many cases, accelerating species extinctions, loss of natural habitat and changes in the distribution and abundance of species over the remainder of the 21st Century (Leadley et al., 2010). Ensuring biodiversity is correctly valued may go some way to halt this decline. As noted in the most recent Global Biodiversity Outlook:

> *Perverse subsidies and the lack of economic value attached to the huge benefits provided by ecosystems have contributed to the loss of biodiversity. Through regulation and other measures, markets can and must be harnessed to create incentives to safeguard and strengthen, rather than to deplete, our natural infrastructure.*
>
> (Secretariat of the Convention on Biological Diversity, 2010 p.12).

At a microeconomic level, valuation enables the benefit of biodiversity preservation (or alternatively the cost of biodiversity depletion) to be included within benefit-cost analyses; at a macroeconomic level, valuation allows national accounts to be augmented to better reflect the impact of economic activity on a society's natural capital. Values may also be used to assess damages for litigation purposes.

Unfortunately there are two main challenges to correctly valuing biodiversity. Firstly, there are a large range of quantifiable indicators of biodiversity, and it is not immediately obvious which indicator is best to use. Secondly, many indicators preferred by ecologists may not be understood by the general public, from whom values must be elicited. Thus, there remains no established framework for valuing biodiversity (Czajkowski et al., 2009; Nijkamp et al., 2008). Techniques and applications that expand our knowledge of biodiversity valuation therefore represent a genuine contribution to the literature.

The purpose of this paper is to use the life satisfaction approach to value ecosystem diversity in South East Queensland (SEQ). Given the many benefits that ecosystems (or more accurately, ecosystem services) provide, it is reasonable to expect to find a positive correlation between human well-being and ecosystem diversity. To date, while many studies have investigated the link between an individual's well-being and their exposure to natural environments (see Bell et al. (2008) and Croucher et al. (2008) for reviews), very few have explored the link between an individual's well-being and the *diversity* of the natural environment to which they are exposed. Moreover, although there is now a considerable literature on life satisfaction in economics, non-market valuation applications are comparatively rare. Thus, to the best of our knowledge, this paper will be the first to value ecosystem diversity using the life satisfaction approach.

The paper proceeds as follows: The remainder of this section is devoted to explaining the choice of ecosystem diversity as the subject of valuation; relevant literature is also briefly reviewed. Section 2 describes the methodological approach taken and data used. Section 3 presents model results. Section 4 discusses and concludes.

1.1. Why ecosystem diversity?

While the goal of valuing *biodiversity* is commendable, information and measurement issues abound, and in almost all cases authors have chosen to narrow the scope of valuation in order to elicit meaningful values (Nijkamp et al., 2008). One means of narrowing the scope is to focus on one of the four levels of diversity (genetic, species, ecosystem, and functional) encapsulated within the broader concept of biodiversity.

There is general agreement among ecologists that the number of species in a particular area (species diversity) is a useful starting point from which to measure biodiversity. However, there is a lack of agreement on the extent of the specific area to be assessed and the definition of what is considered a different species. Moreover, the notion that biodiversity can be measured by the number of species in an area is questionable, as some species are more ecologically important than others; for example, keystone species (as sole representatives of a functional group) and species that are relatively distinct or unique (Christie et al., 2004; Walker, 1995; Weikard, 2002; Weitzman, 1998).

Folke et al. (1996) have suggested that ecosystem diversity, the spatial variety of ecosystem types, may be linked to the prevalence of a limited number of organisms and groups of organisms that seem to drive or control the critical processes needed for ecosystem functioning. It is the preservation of these keystone *processes* that affects the ecosystem's capacity to accommodate external shocks, such as those caused by climate change and human influences. In addition, it is the presence of ecological overlap or 'redundancy'(where the species is not a keystone species) that in fact provides a buffer to ecosystem function in the face of disturbance; that is, provides ecosystem resilience (Walker, 1995). Further, a focus on ecosystem diversity underscores the inherent value of the systems apart from which the multitude of species cannot survive (Lapin and Barnes, 1995) as well as the protection of those species that do not directly contribute to human well-being (Baumgartner, 2004). It is not surprising therefore, that a considerable number of ecologists now advocate the measurement of biodiversity at the level of ecosystem diversity (Nunes et al., 2003).

In regards to genetic and functional diversity, the assessment of the former is difficult, costly and only practical for a small scale; while measurement of the latter is inherently difficult, involving both the assessment of ecosystem functions and their diversity, and is unavoidably limited by the current state of knowledge (Nunes et al., 2003).

1.2. The biodiversity valuation literature

There are many studies that seek to value single or multiple species, with the focus often on charismatic species rather than those of ecological importance. A meta-analysis of single species studies is provided by Richardson and Loomis (2009). A number of studies have sought to value ecosystem services, with a special issue of *Ecological Economics* devoted to this topic in 2000. Neither of these groups of studies, however, can truly be regarded as attempts to value biodiversity. Thus, in a critical review, Nunes and van den Bergh (2001) conclude that while monetary value estimates give unequivocal support to the belief that biodiversity has a significant positive social value, the failure of the empirical literature to apply economic valuation to the entire range of biodiversity benefits suggests that available valuation estimates should be regarded as providing, at best, lower bounds to the value of biodiversity changes.

Perhaps the most comprehensive attempt to value biodiversity is that of Christie et al. (2006; 2004). Focus groups are used to identify ecological concepts of biodiversity that are important and relevant to the public, with attributes tested including recognised species, rare unfamiliar species, habitat quality, and ecosystem functions. The key conclusion drawn was that the public has positive valuation preferences for most, but not all, aspects of biodiversity, and they are largely indifferent to how biodiversity protection is achieved. Extending these efforts, Czajkowski et al. (2009) find, in the context of the Bialowieza Forest in Poland, that the protection of rare and iconic species was not the most important aspect of biodiversity conservation, rather respondents preferred protection of natural ecological processes. Most recently, Juutinen et al. (2011) explore tourism and recreational values associated with biodiversity, finding that increased biodiversity was highly valued by national park visitors.

1.3. Valuing the environment using life satisfaction data

Research into life satisfaction (or happiness) is increasingly the *foci* of a great deal of empirical investigation in economics, a review of which is provided by Clark et al. (2008). A small, but growing, body of the literature suggests that external influences, in particular natural environments, are key drivers of life satisfaction (cf. Ambrey and Fleming, 2011a; Brereton et al., 2008b; Smyth et al., 2008). It is from this literature that the life satisfaction approach to non-market valuation has developed. Simply, this approach entails the inclusion of non-market goods as explanatory variables within micro-econometric functions of life satisfaction along with income and other covariates. The estimated coefficient for the non-market good yields first, a direct valuation in terms of life satisfaction, and second, when compared to the estimated coefficient for income, the implicit willingness-to-pay for the non-market good in monetary terms (Frey et al., 2009).

The approach offers several advantages over more conventional non-market valuation techniques, particularly those used to value biodiversity. For example, the approach does not ask individuals to directly value the non-market good in question (as is the case in contingent valuation and, to a lesser extent, choice modelling). Instead, individuals are asked to evaluate their general life satisfaction. This is perceived to be less cognitively demanding, as specific knowledge of the good in question is not required, nor are respondents asked to perform the unfamiliar task of placing a monetary value on a non-market good. Further, the approach avoids the problem of lexicographic preferences, where respondents to contingent valuation or choice modelling questionnaires demonstrate an unwillingness to trade off the non-market good for income (Spash and Hanley, 1995). There is also no reason to expect strategic behaviour or social desirability bias in relation to the good being valued (Welsch and Kuhling, 2009).

The life satisfaction approach nonetheless has some potential limitations. Crucially, self-reported life satisfaction must be regarded as a good proxy for an individual's utility. While not without its critics (cf. Smith, 2008), evidence in support of the use of this proxy is provided by Frey and Stutzer (2002) and Krueger and Schkade (2008). Furthermore, in order to yield reliable non-market valuation estimates, self-reported life satisfaction measures must: (1) contain information on respondents' global evaluation of their life; (2) reflect not only stable inner states of respondents, but also current affects; (3) refer to respondents' present life; and (4) be comparable across groups of individuals under different circumstances (Luechinger and Raschky, 2009). While a comprehensive review of these necessary conditions is beyond the scope of this paper, there is growing evidence to support the suitability of individual's responses to life satisfaction questions for non-market valuation (cf. Frey et al., 2009).

In applying the life satisfaction approach there is another limitation to consider; the estimation of the income coefficient. There is now a large literature showing that individuals compare current income with past situations and/or the income of their peers. Therefore, both relative *and* absolute income matter (cf. Clark et al., 2008; Ferrer-i-Carbonell, 2005). As a result, when absolute income is included as an explanatory variable in life satisfaction regressions, small estimated income coefficients are common. This underestimation of the effect of income on life satisfaction contributes to large marginal willingness-to-pay estimates (Luechinger, 2009).

It is also important to acknowledge that there is some debate in the literature about the nature of the relationship between the hedonic pricing and life satisfaction approach to non-market valuation. Some authors take the view that the life satisfaction approach values only the residual benefits (or costs) of the non-market good not captured in housing or labour markets (cf. Luechinger, 2009; van Praag and Baarsma, 2005). More recently, Ferreira and Moro (2010) suggest that the relationship depends on whether the hedonic markets are in equilibrium or disequilibrium, as well as on the econometric specification of the life satisfaction function. If the assumption of equilibrium in the housing market holds, then no relationship should exist between local biodiversity and life satisfaction, because housing costs would fully adjust to compensate. If however a significant relationship is found, then residual benefits must remain.

In an early example of the life satisfaction approach being used in practice, Welsch (2002) uses cross-section data on reported well-being for 54 countries to value urban air pollution. The author finds that, on average, an individual needs to be given USD$70 per annum compensation in order to accept a one-kiloton per capita increase in urban nitrogen dioxide load. While the valuation of air quality dominates the literature (cf. Ferreira and Moro, 2010; Luechinger, 2009; MacKerron and Mourato, 2009), other non-market environmental goods valued via the life satisfaction approach include airport noise (cf. van Praag and Baarsma, 2005), climate (cf. Ferreira and Moro, 2010; Frijters and van Praag, 1998; Rehdanz and Maddison, 2005), scenic amenity (cf. Ambrey and Fleming, 2011b), floods (cf. Luechinger and Raschky, 2009) and drought (Carroll et al., 2009). A review of many of these studies is provided by Welsh and Kuhling (2009).

Of most relevance to this study, while not seeking to value diversity in monetary terms, Fuller et al. (2007) demonstrate that the psychological benefits gained by users of green space increase with levels of species richness. Similarly, at a country level, Rehdanz (2007) finds the higher the number of bird or mammal species, or the lower the percentage of bird species threatened, the more satisfied people are. In a unique hybrid contingent valuation – life satisfaction approach, where respondents report their level of life satisfaction in response to a series of hypothetical scenarios, Yao and Kaval (2009) attempt to investigate the link between the well-being of New Zealand residents and native biodiversity in their local area. Somewhat unexpectedly, the authors find that, with the exception of urban residents who had lived at their current location for less than six years, increases in native biodiversity are welfare reducing for most respondents.

2. Method and data

The life satisfaction model takes the form of an indirect utility function for individual *i* in location *k* as follows:

$$U_{i,k} = \alpha + \beta_1 \ln(y_{i,k}) + \beta_2 x_{i.k} + \beta_3 a_{i,k} + \beta_4 \delta_{i,k} + \varepsilon_{i.k} \quad i = 1 \dots I, k = 1 \dots K \quad (1)$$

Where $y_{i,k}$ is household income, x is a vector of socio-economic and demographic characteristics including age, marital status, employment status, education and so forth, $a_{i,k}$ is a spatially weighted average measure of ecosystem diversity for the collection district (CD)[1] in which the respondent resides and $\delta_{i,k}$ is the primary sampling unit to which the individual belongs. In the micro-econometric life satisfaction function, the individual's true utility is unobservable; hence self-reported life satisfaction is used as a proxy.

As shown by Ferreira and Moro (2010) and Welsch (2006), it is possible to estimate the willingness-to-pay (denoted WTP) for a marginal change in ecosystem diversity by taking the partial derivative of ecosystem diversity and the partial derivative of the natural log of household income, as follows:

$$WTP = \frac{\frac{\partial a_{i,k}}{\partial U}}{\frac{\partial ln(y_{i,k})}{\partial U}} = \frac{\partial a_{i,k}}{\partial ln(y_{i,k})} = \bar{y}\frac{\widehat{\beta_3}}{\widehat{\beta_1}} \quad (2)$$

Where $\bar{y}$ is the mean value of household income. If non-marginal changes are to be valued, the Hicksian welfare measures of compensating and equivalent surplus can be employed. In this case, the compensating surplus is the amount of household income an individual would need to receive (pay) following a deterioration (improvement) in the level of ecosystem diversity in his or her CD, in order to remain at his or her initial level of utility. Compensating surplus (denoted CS) can be calculated as follows:

$$CS = -\exp\left[\overline{\ln(y)} + \frac{\widehat{\beta_3}}{\widehat{\beta_1}}(a^1 - a^2)\right] + \bar{y} \quad (3)$$

Where a^1 is the initial, and a^2 the new level of ecosystem diversity. Similarly, the equivalent surplus is the amount of household income an individual would need to receive or pay in order to obtain the level of utility following a change, *if the change did not take place*. Equivalent surplus (denoted ES) can be calculated as follows:

$$ES = \exp\left[\overline{\ln(y)} + \frac{\widehat{\beta_3}}{\widehat{\beta_1}}(a^2 - a^1)\right] - \bar{y} \quad (4)$$

2.1. South East Queensland bioregion

The study area, the SEQ *bioregion*, covers an area of 59,403 square kilometres within Queensland, Australia (Figure 1) and is one of eighty-five bioregions in Australia. Bioregions are large, geographically distinct areas of land with common

[1] The CD is the smallest spatial unit in the Australian Standard Geographical Classification. Australian Bureau of Statistics, 2010. Australian Standard Geographical Classification, Catalogue No. 1216.0, Canberra.

characteristics such as geology, landform patterns, climate, ecological features, and plant and animal communities (Australian Government, 2011).

The SEQ *region*, occupying the southern half of the SEQ bioregion, is the most densely populated part of Queensland, experiencing rapid population growth over the previous two decades. In 2007 Brisbane City, the principle urban centre of the SEQ region, was the second fastest growing urban centre in the developed world (Newman, 2007) and the resident population of the region is projected to increase by 44 per cent, to 4.4 million, by 2031 (Office of Economic and Statistical Research, 2010).

Accompanying this significant population growth has been continued biodiversity loss as a result of native habitat degradation and fragmentation, competition from introduced plant and animal species, and climate change. For example, between 1997 and 2005 there was a 26 per cent decline in the abundance of the iconic koala (*Phascolarctos cinereus*) on the Koala Coast in the SEQ bioregion, an area recognised as one of the most significant natural koala populations in Australia (McAlpine et al., 2006). In all, the SEQ bioregion appears to be at a critical threshold, where increased development throughout the urban footprint is likely to lead to increasing loss and degradation of remaining ecosystems and their fauna (Peterson et al., 2007). Thus, there is little doubt that the issue of biodiversity loss is a pertinent one for the region.

[Insert Figure 1 here]

2.2. Household, Income and Labour Dynamics in Australia

The measure of self-reported life satisfaction and the various internal socio-economic and demographic characteristics are obtained from Wave 5 of the HILDA survey.[2] First conducted in 2001, by international standards the HILDA survey is a relatively new nationally representative sample and owes much to other household panel studies conducted elsewhere in the world; particularly the German Socio-Economic Panel and the British Household Panel Survey. For a recent review of progress and future developments of the HILDA survey see Watson and Wooden (2010)

The life satisfaction variable is obtained from individuals' responses to the question: *'All things considered, how satisfied are you with your life?'* The life satisfaction variable is an ordinal variable, the individual choosing a number between 0 (totally dissatisfied with life) and 10 (totally satisfied with life).

Of particular importance to the valuation aspect of this paper is the definition of household income. The income measure employed is the natural log of self-reported nominal disposable household income with imputed values for missing data. Consistent with the findings of Wooden et al. (2009), we find no statistical difference between imputed and reported values. For further detail about the imputation method used, see Hayes and Watson (2010).

In terms of model estimation, Ferrer-i-Carbonell and Frijters (2004) identified the treatment of time-invariant unobserved factors as critical to the validity of results. Specifically, the error term captures measurement errors as well as unobserved

[2] Wave 5 is employed as it closely matches the date of collection of the spatial ecosystem diversity data. Further, Wave 5 includes a range of personality trait questions, thus allowing personality traits to be controlled for in model estimation.

characteristics. Thus, results can be obscured by personality traits that aren't taken into account (Bertrand and Mullainathan, 2001). Extending the efforts of Shields et al. (2009) an attempt is made to capture the heterogeneity that arises from differences in personality through the inclusion of additional variables, namely: extraversion; agreeableness; conscientiousness; emotional stability; and openness to experience. These personality trait variables are commonly known as the 'Big Five' (Saucier, 1994). Social desirability bias is also controlled for by the inclusion of a variable indicating whether or not the individual was interviewed in the presence of another person.

2.3. Spatial data

Ecosystem diversity data is constructed via a Biodiversity Assessment and Mapping Methodology and provided, for each remnant unit[3] in the SEQ bioregion, by the Department of Environment and Resource Management (formerly the Queensland Environmental Protection Agency). The methodology was developed in order to provide a consistent approach for assessing biodiversity values at the landscape scale in Queensland, using vegetation mapping data generated or approved by the Queensland Herbarium. It is used by the Department of Environment and Resource Management to generate Biodiversity Planning Assessments for the bioregions in eastern Queensland most under pressure from development (Queensland Environmental Protection Agency, 2002).

The methodology has applications for identifying areas with various levels of significance for biodiversity reasons. These include threatened ecosystems or *taxa*, large tracts of habitat in good condition and buffers to wetlands or other types of habitat important for the maintenance of biodiversity or ecological processes. However, natural resource values such as dryland salinity and soil erosion potential are not dealt with explicitly, nor are cultural heritage, scenic amenity or wilderness values. For this reason, the method is described as a biodiversity assessment tool, not a conservation assessment tool in its broadest sense (Queensland Environmental Protection Agency, 2002).

As noted in Section 1.1, the focus of this study is on ecosystem diversity. Within the Biodiversity Assessment and Mapping Methodology this is measured via the Simpson's diversity index (Simpson, 1949). This index incorporates the ecosystem diversity concepts of 'richness' (number of different ecosystems) and 'evenness' (relative abundance), and ranges between zero and one, with high scores representing areas of high densities of regional ecosystems and ecotones (transitional areas between ecosystems). A worked example of calculating the Simpson's diversity index is provided as Appendix A. Having calculated an index value, the Department of Environment and Resource Management than categorises each remnant unit on a scale of one to four, as illustrated in Table 1 below.

[Insert Table 1 here]

The resultant category score is then used to create a spatially weighted average score for each individual's CD. *A priori* it is expected that a higher degree of ecosystem diversity would support greater keystone species important for supporting ecosystem

[3] The remnant unit is the basic planning unit for assessing biodiversity significance. It is equivalent to a single polygon on a map approved by the Queensland Herbarium: Queensland Environmental Protection Agency, 2002. Biodiversity Assessment and Planning Methodology. Biodiversity Planning Unit, Brisbane.

functioning, promote ecosystem resilience and thus enhance human well-being. All of the explanatory variables included within the model are summarised in Table 2. Descriptive statistics are provided as Appendix B.

[Insert Table 2 here]

3. Results

Two techniques are employed in model estimation, ordinary least squares (OLS) and ordered probit by maximum likelihood estimation. This is similar to the estimation strategies employed by Brereton et al. (2008b), Shields et al. (2009) and Smyth et al. (2008). In terms of evaluating the appropriateness of the estimation strategy, it is important to consider whether life satisfaction self-reports are assumed to be ordinal or cardinal. If assumed to be ordinal, then the coefficients obtained via OLS are biased and inconsistent, in which case the use of an ordered probit model is more appropriate (Hill et al., 2008). However, many authors (cf. Ferrer-i-Carbonell and Frijters, 2004) have shown that estimates of the determinants of life satisfaction are virtually unchanged whether one models the ordinal nature of the variable (as implied by the use of ordered probit) or treats the responses as cardinal (implied by the use of OLS); contingent on individual heterogeneity being addressed appropriately. Finally, as we include explanatory variables at different spatial levels, standard errors are adjusted for clustering (cf. Moulton, 1990).

3.1. Model results

For brevity, only the results of the ordered probit model are presented and discussed.[4] The estimated results for Equation 1 are presented in Table 3. The explanatory power of the model, as measured by a pseudo R^2 of 0.0940, is comparable to other studies of this type (cf. Shields et al., 2009).

In regards to socio-economic and demographic characteristics, the results largely support the existing literature and *a priori* expectations. That is, life satisfaction is U-shaped in age, reaching a minimum at the age of 40. As also reported by Shields et al. (2009), and Ambrey and Fleming (2011a) respondents of Aboriginal and/or Torres Strait Islander origin are found to be more satisfied with their lives than the general population. Immigrants from English speaking countries are found to be less satisfied than the native born. Respondents who self-report having poor English speaking skills are found to be less satisfied than those who speak English well or very well. In terms of marital status, only being separated is found to have a statistically significant negative effect on life satisfaction. As is found by many authors (cf. Brereton et al., 2008b; Margolis and Myrskyla, 2010; Shields et al., 2009) a larger number of resident children in a household lowers a respondent's life satisfaction.

Consistent with the literature (cf. Ambrey and Fleming, 2011a; Shields et al., 2009; Wooden et al., 2009), having a long-term health condition is associated with lower levels of life satisfaction, with the greatest impact felt by those with a severe health condition. With regards to education, tertiary educated respondents are found to be less satisfied than those with all other education levels.

In terms of employment status, being employed part-time, being unemployed and being a non-participant are all associated with higher levels of life satisfaction than

[4] As expected, results do not differ greatly between the two estimation techniques. OLS model results are available from the authors on request.

working full-time. The positive effect of being employed part-time is consistent with other Australian studies (cf. Shields et al., 2009; Shields and Wooden, 2003), although is in stark contrast to studies elsewhere (cf. Brereton et al., 2008b; Moro et al., 2008). The finding of a positive association between life satisfaction and unemployment is somewhat unusual, perhaps reflecting the very low unemployment rate of 4.80 per cent in Queensland at the time the data was gathered and thus suggesting that indeed, for some, unemployment is a 'lifestyle choice'. The finding of a positive relationship between life satisfaction and unemployment in areas of below average unemployment is also found by Brereton et al. (2008a) for the case of Ireland. As expected, higher levels of household income are found to be associated with higher levels of life satisfaction.

The use of personality trait controls increases the model's explanatory power by 30 per cent. The results show that three of the Big Five personality trait variables are statistically significant at the one per cent level, with higher degrees of extraversion, agreeableness and emotional stability all associated with higher levels of life satisfaction. In contrast to much of the literature (cf. Ambrey and Fleming, 2011a; Shields et al., 2009; Wooden et al., 2009), there is no evidence of social desirability bias, with others being present during the interview having no significant effect on self-reported life satisfaction.

Finally, of particular importance to this study, ecosystem diversity, as measured by the Simpson's diversity index described above, is found to have a positive and significant (at the 5 per cent level) effect on life satisfaction, with an estimated coefficient of 0.06780.

[Insert Table 3 here]

Following the procedure described in Equation 2, the average implicit willingness-to-pay in terms of annual household income, for a one-unit improvement in ecosystem diversity, is $20,244.86. Given, on average, there are 2.5 people living in each household in the sample, this implies a per-capita willingness-to-pay of approximately $8,100.

Similarly, a one standard deviation (1.1995) improvement in scenic amenity from the mean yields a compensating surplus of $19,078.52, thus suggesting, following such an improvement, an individual is able to sacrifice approximately $19,000 in annual household income and remain at the initial level of utility. The comparable equivalent surplus estimate is $31,565, suggesting an individual would require an increase in annual household income of approximately $31,500 for such an improvement *not to occur*.

4. Discussion

The objective of this paper is to investigate and quantify in monetary terms the welfare effects of ecosystem diversity on life satisfaction in SEQ. In so doing, the paper makes a significant contribution to the existing biodiversity valuation literature as well as to the small, but growing, body of literature employing the life satisfaction approach to value environmental goods and services. The rapid decline in biodiversity at a local and global level, coupled with projections of further future declines, suggests that this is an issue of great importance.

We find that increases in ecosystem diversity have a positive and economically significant effect on life satisfaction, and that on average an individual is willing-to-pay approximately $20,000 in annual household income for a one-unit improvement in ecosystem diversity, measured on a 4-point scale. While it is difficult to compare with existing studies employing more conventional non-market valuation techniques, it is reasonable to conclude that this estimate is at the upper end of valuations found in the literature. Whether this is due to biases inherent within the life satisfaction approach, or more a reflection of the fact that (as concluded by Nunes and van den Bergh (2001)) existing studies generally fail to value all of the benefits of biodiversity, is a matter for further research. Nevertheless, these estimates indicate that there are significant life satisfaction impacts of increased ecosystem diversity and that the preservation, or improvement, of existing levels of ecosystem diversity is welfare enhancing. The challenge for policy makers is to adequately manage the pressures of projected population and economic growth in rapidly growing regions such as SEQ.

From a theoretical perspective, these value estimates point towards a substantial residual shadow value associated with ecosystem diversity that is not captured in housing costs or wages. Consistent with earlier life satisfaction valuation literature (cf. Luechinger, 2009; van Praag and Baarsma, 2005), this finding challenges the validity of the assumption of equilibrium in housing and wage markets, which underpins many models of choice. These results, therefore, provide further support for the use of the life satisfaction approach as a complement to the hedonic method when attempting to value non-market goods.

As a final note, it should be acknowledged that implicit in the economic valuation of ecosystem diversity is the assumption that ecosystem diversity is substitutable. Given the irreplaceable nature of biodiversity and the limitations of current knowledge, a cautious approach is advocated when weighing up the relative costs and benefits of projects, policies or programs that may lead to declines in biodiversity.

Acknowledgements

This research would not have been possible without data provided by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA), the Department of Environment and Resource Management (Biodiversity Planning and Assessment Unit), the Office of Urban Management, the Queensland Department of Infrastructure and Planning, and the Australian Bureau of Statistics.

References

Ambrey, C., Fleming, C., 2011a. The influence of the natural environment and climate on life satisfaction in Australia, Griffith University Discussion Paper in Economics and Business Statistics No. 2011-01, Brisbane.

Ambrey, C., Fleming, C., 2011b. Valuing scenic amenity using life satisfaction data, Griffith University Discussion Paper in Economics and Business Statistics No. 2011-02, Brisbane.

Australian Bureau of Statistics, 2010. Australian Standard Geographical Classification, Catalogue No. 1216.0, Canberra.

Australian Government, 2011. Australia's bioregions, Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Baumgartner, S., 2004. Optimal investment in multi-species protection: Interacting species and ecosystem health. EcoHealth 1, 101-110.

Bell, S., Hamilton, V., Montarzino, A., Rothnie, H., Travlou, P., Alves, S., 2008. Greenspace and quality of life: A critical literature review, Greenspace Scotland Research Report, Stirling.

Bertrand, M., Mullainathan, S., 2001. Do people mean what they say? Implications for subjective survey data. The American Economic Review 91, 67-72.

Brereton, F., Clinch, J., Ferreira, S., 2008a. Employment and life-satisfaction: Insights from Ireland. The Economic and Social Review 39, 207-234.

Brereton, F., Clinch, J., Ferreira, S., 2008b. Happiness, geography and the environment. Ecological Economics 65, 386-396.

Carroll, N., Frijters, P., Shields, M., 2009. Quantifying the costs of drought: New evidence from life satisfaction data. Journal of Population Economics 22, 445-461.

Christie, M., Hanley, N., Warren, J., Murphy, K., Wright, R., Hyde, T., 2006. Valuing the diversity of biodiversity. Ecological Economics 58, 304-317.

Christie, M., Warren, J., Hanley, N., Murphy, K., Wright, R., Hyde, T., Lyons, N., 2004. Developing measures for valuing changes in biodiversity: Final report, Department for Environment, Food and Rural Affairs, London.

Clark, A., Frijters, P., Shields, M., 2008. Relative income, happiness, and utility: An explanation for the Easterlin Paradox and other puzzles. Journal of Economic Literature 46, 95-144.

Croucher, K., Myers, L., Bretheron, J., 2008. The links between greenspace and health: A critical literature review, Greenspace Scotland Research Report, Stirling.

Czajkowski, M., Buszko-Briggs, M., Hanley, N., 2009. Valuing changes in forest biodiversity. Ecological Economics 68, 2910-2917.

Ferreira, S., Moro, M., 2010. On the use of subjective well-being data for environmental valuation. Environmental & Resource Economics 46, 249-273.

Ferrer-i-Carbonell, A., 2005. Income and well-being: An empirical analysis of the comparison income effect. Journal of Public Economics 89, 997-1019.

Ferrer-i-Carbonell, A., Frijters, P., 2004. How important is methodology for the estimates of the determinants of happiness? The Economic Journal 114, 641-659.

Folke, C., Holling, C., Perrings, C., 1996. Biological diversity, ecosystems, and the human scale. Ecological Applications 6, 1018-1024.

Frey, B., Luechinger, S., Stutzer, A., 2009. The life satisfaction approach to environmental valuation, Discussion Paper No. 4478. Institute for the Study of Labor (IZA), Bonn.

Frey, B., Stutzer, A., 2002. What can economists learn from happiness research? Journal of Economic Literature 40, 402-435.

Frijters, P., van Praag, B., 1998. The effects of climate on welfare and well-being in Russia. Climatic Change 39, 61-81.

Fuller, R., Irvine, K., Devine-Wright, P., Warren, P., Gaston, K., 2007. Psychological benefits of greenspace increase with biodiversity. Biology Letters 3, 390-394.

Hayes, C., Watson, N., 2010. HILDA Imputation Methods, HILDA Project Technical Paper Series No. 2/09, Melbourne.

Hill, R., Griffiths, W., Lim, G., 2008. Principles of Econometrics, third ed. John Wiley & Sons, New Jersey.

Juutinen, A., Mitani, Y., Mantymaa, E., Shoji, Y., Siikamaki, P., Svento, R., 2011. Combining ecological and recreational aspects in national park management: A choice experiment approach. Ecological Economics 70, 1231-1239.

Krueger, A., Schkade, D., 2008. The reliability of subjective well-being measures. Journal of Public Economics 92, 1833-1845.

Lapin, M., Barnes, B., 1995. Using the landscape ecosystem approach to assess species and ecosystem diversity. Conservation Biology 9, 1148-1158.

Leadley, P., Pereira, H., Alkemade, R., Fernandez-Manjarres, J., Proenca, V., Scharlemann, J., 2010. Biodiversity scenarios: Projections of 21st century change in biodiversity and associated ecosystem services, Secretariat of the Convention on Biological Diversity, Montreal.

Luechinger, S., 2009. Valuing air quality using the life satisfaction approach. The Economic Journal 119, 482-515.

Luechinger, S., Raschky, P., 2009. Valuing flood disasters using the life satisfaction approach. Journal of Public Economics 93, 620-633.

MacKerron, G., Mourato, S., 2009. Life satisfaction and air quality in London. Ecological Economics 68, 1441-1453.

Margolis, R., Myrskyla, M., 2010. A global perspective on happiness and fertility, Working Paper No. 2010-025. Max Plank Institute for Demographic Research, Rostock.

McAlpine, C., Rhodes, J., Callaghan, J., Bowen, M., Lunney, D., Mitchell, D., Pullar, D., Possingham, H., 2006. The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: A case study of koalas in Queensland, Australia. Biological Conservation 123, 153-165.

Moro, M., Brereton, F., Ferreira, S., Clinch, J., 2008. Ranking quality of life using subjective well-being data. Ecological Economics 65, 448-460.

Moulton, B., 1990. An illustration of a pitfall in estimating the effects of aggregate variables on micro units. Review of Economics and Statistics 72, 334-338.

Newman, C., 2007. Lord Mayor opens landmark Brisbane event, Council Newsroom, Brisbane.

Nijkamp, P., Vindigni, G., Nunes, P., 2008. Economic valuation of biodiversity: A comparative study. Ecological Economics 67, 217-231.

Nunes, P., van den Bergh, J., 2001. Economic valuation of biodiversity: sense or nonsense? Ecological Economics 39, 203-222.

Nunes, P., van den Bergh, J., Nijkamp, P., 2003. The Ecological Economics of Biodiversity: Methods and Policy Applications. Edward Elgar, Cheltenham.

Office of Economic and Statistical Research, 2010. Queensland regional profiles: SEQ region, Queensland Treasury, Brisbane.

Peterson, A., McAlpine, C., Ward, D., Rayner, S., 2007. New regionalism and nature conservation: Lessons from South East Queensland, Australia. Landscape and Urban Planning 82, 132-144.

Queensland Environmental Protection Agency, 2002. Biodiversity Assessment and Planning Methodology. Biodiversity Planning Unit, Brisbane.

Queensland Environmental Protection Agency, 2007. Biodiversity Planning Assessment: South East Queensland 3.5. Biodiversity Planning Unit, Brisbane.

Rehdanz, K., 2007. Species diversity and human well-being: A spatial econometric approach, Working Paper No. FNU-151. Hamburg University Centre for Marine and Atmospheric Science, Hamburg.

Rehdanz, K., Maddison, D., 2005. Climate and happiness. Ecological Economics 52, 111-125.

Richardson, L., Loomis, J., 2009. The total economic value of threatened, endangered and rare species: An updated meta-analysis. Ecological Economics 68, 1535-1548.

Saucier, G., 1994. Mini-markers: A brief version of Goldberg's unipolar Big-Five markers. Journal of Personality Assessment 63, 506-516.

Secretariat of the Convention on Biological Diversity, 2010. Global Biodiversity Outlook 3, Montreal.

Shields, M., Price, S., Wooden, M., 2009. Life satisfaction and the economic and social characteristics of neighbourhoods. Journal of Population Economics 22, 421-443.

Shields, M., Wooden, M., 2003. Marriage, children and subjective well-being, A paper presented to the Australian Institute of Family Studies conference, Melbourne.

Simpson, E., 1949. Measurement of diversity. Nature 163, 688.

Smith, V., 2008. Reflections on the literature. Review of Environmental Economics and Policy 2, 292-308.

Smyth, R., Mishra, V., Qian, X., 2008. The environment and well-being in urban China. Ecological Economics 68, 547-555.

Spash, C., Hanley, N., 1995. Preferences, information and biodiversity preservation. Ecological Economics 12, 191-208.

van Praag, B., Baarsma, B., 2005. Using happiness surveys to value intangibles: The case of airport noise. Economic Journal 115, 224-246.

Walker, B., 1995. Conserving biological diversity through ecosystem resilience. Conservation Biology 9, 747-752.

Watson, N., Wooden, M., 2010. The HILDA survey: Progress and future developments. The Australian Economic Review 43, 326-336.

Weikard, H., 2002. Diversity functions and the value of biodiversity. Land Economics 78, 20-27.

Weitzman, M., 1998. The Noah's ark problem. Econometrica 66, 1279-1298.

Welsch, H., 2002. Preferences over prosperity and pollution: Environmental valuation based on happiness surveys. Kyklos 55, 473-494.

Welsch, H., 2006. Environment and happiness: Valuation of air pollution using life satisfaction data. Ecological Economics 58, 801-813.

Welsch, H., Kuhling, J., 2009. Using happiness data for environmental valuation: Issues and applications. Journal of Economic Surveys 23, 385-406.

Wooden, M., Warren, D., Drago, R., 2009. Working time mismatch and subjective well-being. British Journal of Industrial Relations 47, 147-179.

Yao, R., Kaval, P., 2009. The connection between biodiversity and well-being: A New Zealand case study, University of Waikato Department of Economics Working Paper No. 02/09, Hamilton.

Table 1: Indicators and rating for ecosystem diversity

Rating	Low (=1)	Medium (=2)	High (=3)	Very High (=4)
	The remnant unit has a Simpson's diversity index that is <25% of the maximum value for the bioregion.	The remnant unit has a Simpson's diversity index that is 25% to 50% of the maximum value for the bioregion.	The remnant unit has a Simpson's diversity index that is 50% to 75% of the maximum value for the bioregion.	The remnant unit has a Simpson's diversity index that is >75% of the maximum value for the bioregion.

Source: Queensland Environmental Protection Agency (2002)

Table 2: Model variables

Variable name	Definition
Age	Age of respondent in years
Age squared	Age of respondent in years squared
Male	Dummy variable = 1 if respondent is male
ATSI	Dummy variable = 1 if respondent is of Aboriginal and/or Torres Strait Islander origin
Immigrant English	Dummy variable = 1 if respondent is born in a Main English Speaking country (Main English Speaking countries are: United Kingdom; New Zealand; Canada; USA; Ireland; and South Africa)
Immigrant non-English	Dummy variable = 1 if respondent is not born in Australia or a Main English Speaking country
Poor English	Dummy variable = 1 if respondent speaks English either not well or not at all
Married	Respondent is legally married
Defacto	Respondent is in a defacto relationship
Separated	Respondent is separated
Divorced	Respondent is divorced
Widow	Respondent is a widow
Number of children	Number of respondent's own resident children in respondent's household at least 50 per cent of the time and number of own children who usually live in a non-private dwelling but spend the rest of the time mainly with the respondent
Lone parent	Dummy variable = 1 if respondent is a lone parent
Mild health condition	Respondent has a long-term health condition, that is a condition that has lasted or is likely to last for more than six months, and this condition does not limit the type or amount of work the respondent can do
Moderate health condition	Respondent has a long-term health condition limiting the amount or type of work that the respondent can do
Severe health condition	Respondent has a long-term health condition and cannot work
Year 12	Respondent's highest level of education is Year 12
Certificate or diploma	Respondent's highest level of education is a certificate or diploma
Bachelors degree or higher	Respondent's highest level of education is a Bachelors degree or higher
Employed part-time	Respondent is employed and works less than 35 hours per week
Unemployed	Respondent is not employed but is looking for work
Non-participant	Respondent is a non-participant in the labour force, including retirees, those performing home duties, non-working students and individuals less than 15 years old at the end of the last financial year
Self employed	Dummy variable = 1 if the respondent is self employed
Disposable income (ln)	Natural log of equivalentised disposable household income
Extraversion	Degree of extraversion (scale 1 to 7)
Agreeableness	Degree of agreeableness (scale 1 to 7)
Conscientiousness	Degree of conscientiousness (scale 1 to 7)
Emotional stability	Degree of emotional stability (scale 1 to 7)
Openness to experience	Degree of openness to experience (scale 1 to 7)
Others present	Dummy variable = 1 if someone was present during the interview
Inner	Dummy variable = 1 if respondent resides in inner regional Australia

Outer	Dummy variable = 1 if respondent resides in outer regional Australia
Remote	Dummy variable = 1 if respondent resides in remote Australia, very remote Australia or is migratory
Ecosystem diversity	Spatially weighted Simpson's diversity index generalised to a 4 point scale

Omitted cases are: Female; Not of indigenous origin; Country of birth Australia; Speaks English well or very well; Never married and not de facto; Not a lone parent; Does not have a long-term health condition; Year 11 or below; Not self employed (employee, employee of own business, unpaid family worker); Employed working 35 hours or more per week; No others present during the interview or don't know – telephone interview; Major city.

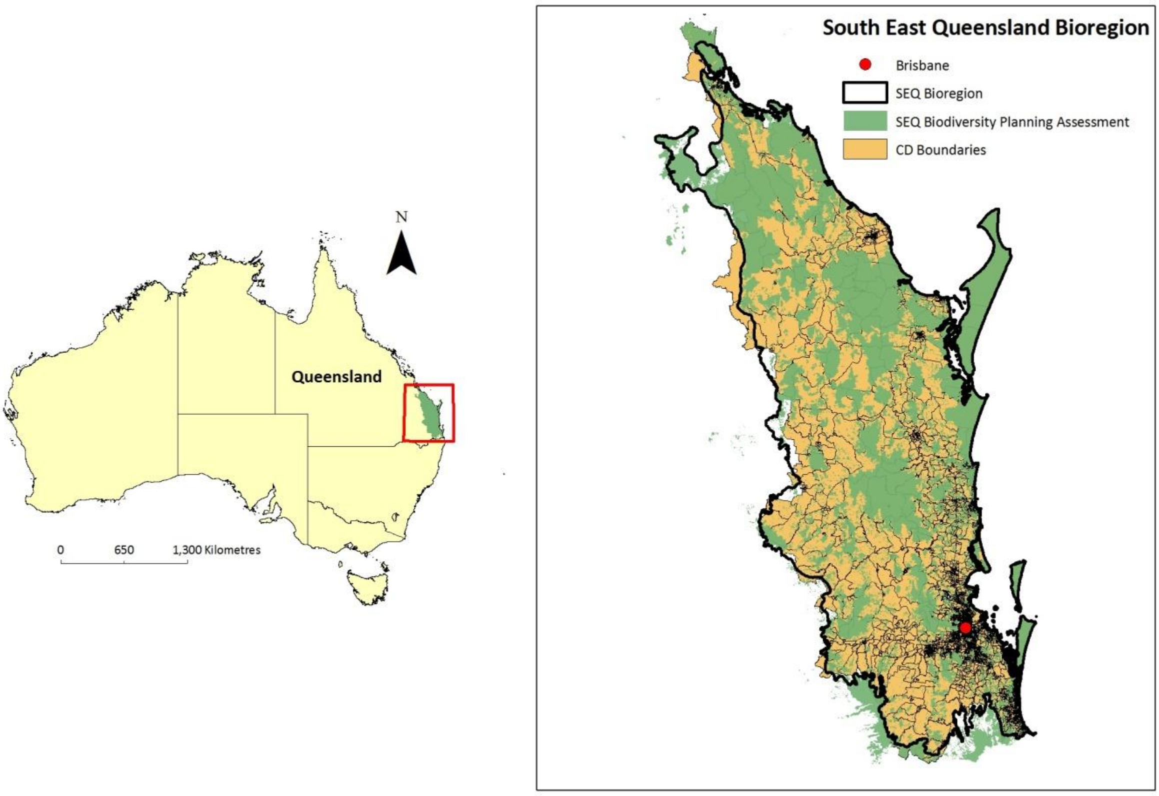
Table 3: Model results

Variable name	Probit estimate (standard error)	Variable name	Probit estimate (standard error)
Age	-0.04056*** (0.01033)	Certificate or diploma	-0.69446 (0.06425)
Age squared	0.00051*** (0.00011)	Bachelors degree or higher	-0.16131** (0.08021)
Male	0.06280 (0.06111)	Employed part-time	0.17595*** (0.06769)
ATSI	0.62310*** (0.20038)	Unemployed	0.30896* (0.17416)
Immigrant English	-0.19622** (0.08688)	Non-participant	0.33956*** (0.10265)
Immigrant non-English	-0.07991 (0.11036)	Self employed	0.14825 (0.11106)
Poor English	-0.82022* (0.43105)	Disposable income (ln)	0.16149*** (0.50089)
Married	0.11822 (0.11412)	Extraversion	0.10838*** (0.03057)
Defacto	0.07521 (0.11424)	Agreeableness	0.20537*** (0.03767)
Separated	-0.71980*** (0.18591)	Conscientiousness	0.00123 (0.02833)
Divorced	0.00474 (0.13139)	Emotional stability	0.15782*** (0.03081)
Widow	0.04052 (0.20901)	Openness to experience	-0.00558 (0.03477)
Number of children	-0.69401** (0.03389)	Others present	-0.14601 (0.06305)
Lone parent	-0.16848 (0.12044)	Inner	-0.09217 (0.11990)
Mild health condition	-0.25404** (0.09879)	Outer	0.60431 (0.37164)
Moderate health condition	-0.42303*** (0.09004)	Remote	-0.03219 (0.21232)
Severe health condition	-1.19785** (0.46253)	Ecosystem diversity	0.06780** (0.03272)
Year 12	0.26038 (0.17275)		
Summary statistics			
Number of observations	1784		
Likelihood ratio	-2657.28		
Pseudo R^2	0.0940		

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Omitted cases are: Female; Not of indigenous origin; Country of birth Australia; Speaks English well or very well; Never married and not de facto; Not a lone parent; Does not have a long-term health condition; Year 11 or below; Not self employed (employee, employee of own business, unpaid family worker); Employed working 35 hours or more per week; No others present during the interview or don't know – telephone interview; Major city.

Figure 1: SEQ Bioregion

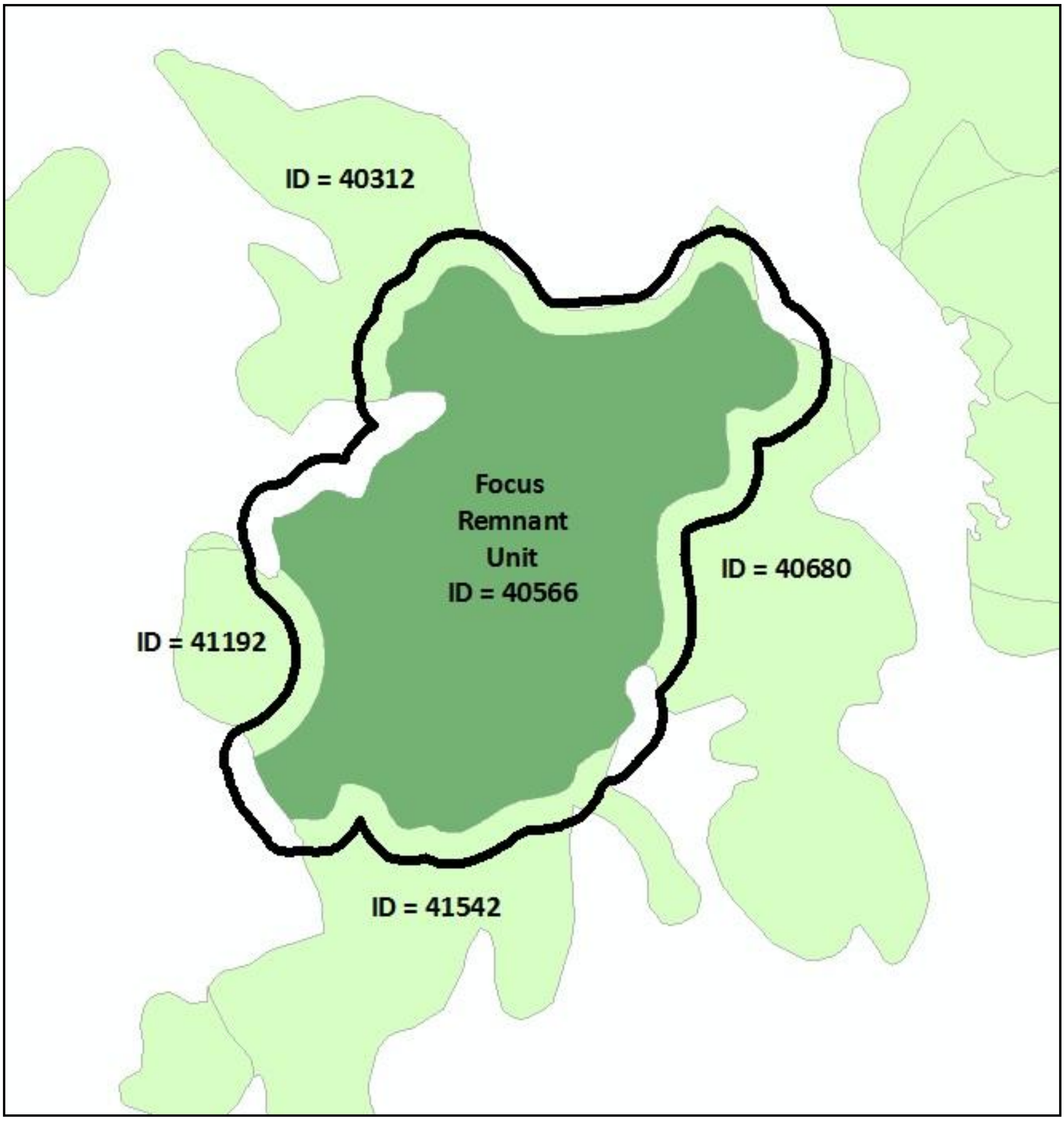


Source: Queensland Environmental Protection Agency (2007)

Appendix A: Calculation of the Simpson's Diversity Index

This Appendix illustrates the calculation of the Simpson's diversity index for remnant unit No. 40566. Note that remnant units may contain one or more regional ecosystem. To measure the Simpson's diversity index, a buffer is placed around the focus remnant unit reflecting its shape. The width of the buffer is derived using the modal area of all remnant units within the bioregion (rounded to the nearest 50 metres). The index for the focus remnant unit is calculated within the total buffered area (Queensland Environmental Protection Agency, 2002). Figure A1 below shows the remnant units captured in a buffer around remnant unit 40566. The areas in white illustrate landscape that has been cleared of vegetation.

Figure A1: Remnant unit 40566 and buffer



Source: Queensland Environmental Protection Agency (2002)

To calculate the Simpson's diversity index, as shown in Equation A1, you need the number of regional ecosystems in the buffered region (m) and the squared proportional area (P_i^2) of each regional ecosystem.

$$SDI = 1 - \sum_{i=1}^{m} P_i^2 \qquad \text{(A1)}$$

Table A1 below illustrates the composition of the focus remnant unit and those remnant units that make up the buffer. In this instance, each remnant unit contains at least two regional ecosystems. Each regional ecosystem is identified by three numbers. For example, with respect to the regional ecosystem identified by 12.12.18, the first number indicates the bioregion the regional ecosystem belongs to, the second number distinguishes the land zone (a simplified geology/substrate landform classification) of the regional ecosystem, and the third number denotes the different vegetation type unique to the regional ecosystem system. It can be observed that the focus remnant unit contains two different regional ecosystems: 12.12.18 (65% of the total area of the remnant unit); and 12.12.13 (35% of the total area). Further detail on the regional ecosystem classification framework is provided by the Queensland Environmental Protection Agency (2002).

Table A1: Remnant unit composition

Remnant unit ID	**Total remnant area (hectares)**	**Regional ecosystem**	**Percentage of regional ecosystem within remnant unit**	**Regional ecosystem (hectares)**
40566	1509.6494			
(focus unit)		12.12.18	65%	981.2721
		12.12.13	35%	528.3773
40312	131.4257			
		12.12.8	70%	91.9980
		12.12.7	20%	26.2851
		12.12.5	10%	13.1426
40680	110.6867			
		12.12.8	70%	77.4807
		12.12.7	20%	22.1373
		12.12.5	10%	11.0687
41192	54.9167			
		12.12.18	65%	35.6958
		12.12.13	35%	19.2208
41542	102.6260			
		12.12.8	70%	71.8382
		12.12.7	20%	20.5252
		12.12.5	10%	10.2626

Source: Queensland Environmental Protection Agency (2002)

Based on the information presented in Table A1, Table A2 outlines the calculation of the index for the focus remnant unit (40566).

Table A2: Regional ecosystems and percentage of area

Regional ecosystem	Regional ecosystem as a proportion of the total area of regional ecosystems	p_i^2
12.12.8	0.1264	0.0160
12.12.7	0.0361	0.0013
12.12.5	0.0181	0.0003
12.12.18	0.5326	0.2837
12.12.13	0.2868	0.0823
Total	**1.0000**	**0.3836**

Source: Queensland Environmental Protection Agency (2002)

Thus, from Equation A1, the Simpson's diversity index for remnant unit 40566 is 1 - 0.33836 = 0.6164.

Appendix B: Descriptive Statistics

Variable name	Mean	Minimum	Maximum	Standard deviation	Percentage values 1	Percentage values 0
Life satisfaction	7.8980	1	10	1.3574	n.a.	n.a.
Age	42.4479	15	90	17.3290	n.a.	n.a.
Age squared	2101.9490	225	8100	1601.2487	n.a.	n.a.
Male	0.4630	0	1	0.4988	46.3	53.7
ATSI	0.0219	0	1	0.1463	2.2	97.8
Immigrant English	0.1222	0	1	0.3276	12.2	87.8
Immigrant non-English	0.0639	0	1	0.2446	6.4	93.6
Poor English	0.0017	0	1	0.0410	0.2	99.8
Number of children	0.7074	0	8	1.0794	n.a.	n.a.
Married	0.4916	0	1	0.5001	49.1	50.9
De-facto	0.1441	0	1	0.3512	14.4	85.6
Separated	0.0303	0	1	0.1714	3.0	97.0
Divorced	0.0751	0	1	0.2636	7.5	92.5
Widow	0.0348	0	1	0.1832	3.5	96.5
Lone parent	0.1059	0	1	0.3078	10.6	89.4
Mild health condition	0.0964	0	1	0.2952	9.6	90.4
Moderate health condition	0.1586	0	1	0.3654	15.9	84.1
Severe health condition	0.0062	0	1	0.0783	0.6	99.4
Year 12	0.0224	0	1	0.1481	2.2	97.8
Certificate or diploma	0.3100	0	1	0.4626	31.0	69.0
Bachelors degree or higher	0.1777	0	1	0.3824	17.8	82.2
Employed part-time	0.2136	0	1	0.4099	21.3	78.7
Self employed	0.0706	0	1	0.2563	7.1	92.9
Unemployed	0.0320	0	1	0.1759	3.2	96.8
Non-participant	0.3038	0	1	0.4600	30.4	69.6
Household income (ln)	10.7835	5.7900	12.7523	0.6808	n.a.	n.a.
Others present	0.3453	1	0	0.4756	34.5	65.5
Extraversion	4.4391	1	7	1.0560	n.a.	n.a.
Agreeableness	5.3263	1	7	0.9668	n.a.	n.a.
Conscientiousness	5.0883	1	7	1.0602	n.a.	n.a.
Emotional stability	5.0734	1	7	1.0918	n.a.	n.a.
Openness to experience	4.2409	1	7	1.0331	n.a.	n.a.
Biodiversity significance	2.6283	1	4	0.8295	43.3	56.7
Ecosystem diversity	2.1668	1	3.9189	1.1995	n.a.	n.a.

Omitted cases are: Female; Not of indigenous origin; Country of birth Australia; Speaks English well or very well; Never married and not de facto; Not a lone parent; Does not have a long-term health condition; Year 11 or below; Not self employed (employee, employee of own business, unpaid family worker); Employed working 35 hours or more per week; No others present during the interview or don't know – telephone interview; Major city.