

# Biodiversity, environmental health and human well-being: analysis of linkages and pathways

Prince Osei-Wusu Adjei · Frank Kwaku Agyei

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**Abstract** Well-being, a condition of positive physical, social and mental state of life, has become a prime focus of research in recent years as people seek to achieve and sustain it. Interacting with the natural environment has been established as a way of acquiring well-being benefits. However, the extent to which well-being depends on various aspects of the environment particularly biodiversity has received less attention. This paper examines the relationship between the level of biodiversity in an environment and human well-being. The depression and happiness scale was employed to sample 236 visitors of eight green spaces in Anglesey and Gwynedd, North Wales, while also noting socio-demographic and environmental factors such as perceived naturalness, density of visitors and noise level to establish the relationship. In each green space, the levels of native and introduced plant diversity were estimated. The paper established that level of ecological diversity determines level of people's wellness and happiness derived from a green environment. Visitors to green spaces with higher plant diversity receive higher levels of happiness. Significantly too, diversity of introduced species was a better predictor than native plant diversity. Perceived naturalness, density of visitors and visitors' age was also predictors of happiness. It is concluded that increasing the level of biodiversity in an environment could improve people's well-being. However, the finding about introduced versus native species deserves more attention.

**Keywords** Biodiversity · Natural environment · Happiness · Environment health · Human well-being

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P. O.-W. Adjei (✉)  
Department of Geography and Rural Development, KNUST, Kumasi, Ghana  
e-mail: princeosei2@hotmail.com

F. K. Agyei  
Forestry Research Institute of Ghana, Kumasi, Ghana  
e-mail: frankkagyei@yahoo.com

## 1 Introduction

Well-being, a condition of positive physical, social and mental state, has always been the prime focus of human attention (Conceicao and Bandura 2008). Throughout history, people have always had the belief that interacting with the natural environment provides well-being benefits. Sacred areas in the form of protected forests, nature endowed areas and wildlife conservation have been part of many cultures and are still thriving in many African and Asian societies (Frumkin 2001; Burns 2006). In many urbanised areas, trees and parks are established to improve the environment and enhance peoples' quality of life (Heimlich 1989). Considerable evidence (see a review by Bowler et al. 2010) suggests that interacting with nature has significant linkages with human well-being. However, the extent to which peoples' well-being depends on various aspects of the environment, particularly biodiversity, has not received much scholarly attention (see Fuller et al. 2007; Luck et al. 2011). The paper applies happiness as a measure of well-being and examines the relationship between human well-being and the level quality of biodiversity in the natural environment.

Happiness is a blurry notion which has several meanings to many people. In the sense of well-being assessment following Roger (2008), happiness refers to what benefits a person, is in his interest or makes one's life go best for him. It consist of a person's overall emotional condition; for one to be happy, his emotional condition has to be positive (Otake et al. 2006). Conceptual distinctions of well-being and happiness are not adequately clear in the literature, but the assumption is that as one's life gets well he becomes happy (Roger 2008). Veenhoven (2006) shares the view that when well-being and happiness are used in broader sense, they all stand for the same thing symbolising good life. But when one wants to be specific, happiness tends to denote life satisfaction, while well-being denotes pleasure. Bracho (2009) argues that happiness is part of well-being so as people obtain improved well-being, they automatically get happy. He adds that people who are happy tend to have both well-being and contentment. The well-being component expresses one's external happiness, and the contentment conveys one's internal happiness. Bruni and Porta (2007) describe that well-being is a bigger concept than happiness and it includes four main components: pleasant emotions, unpleasant emotions, life evaluation and domain satisfaction. They add that happiness is a balance between positive and negative affect.

The short depression and happiness scale, a 6-item self-report scale (Joseph et al. 2004), is adopted to measure happiness level of visitors to eight green spaces in Anglesey and Gwynedd, North Wales. Plant communities were sampled in the green spaces, and the diversities for woody and non-woody plants (both native and introduced types) were estimated using the Shannon–Weiner diversity index ( $H'$ ). The level of naturalness and wilderness of the green spaces was estimated using a ten-point Likert scale. The density of visitors and traffic noise in the green spaces was collected together with socio-demographic information including visitors' age, gender, income, marital and employment status using standard questionnaires. The study generated three-candidate happiness models setting the happiness and biodiversity data as the focus for the main analysis, while the socio-demographic and environmental factors were considered as possible predictor variables. The general linear model analysis tool of SPSS was used to analyse the three-candidate happiness models.

The evidence suggests that visitors at green spaces with higher biodiversity have higher happiness level. Diversity of introduced species explains more of the variation in happiness between respondents than native plant diversity. Positive relation exists between visitors' happiness and perceived naturalness, but the relation is weaker than the relation between

happiness and biodiversity. Age, sound level and density of visitors predict happiness. Sound level and density of visitors relate negatively to happiness, with the degree of the effect being higher for sound level. The effect of age is not consistent in all the models tested though it relates positively to happiness in the supported models. In the next section, a contextual background on the relationship between socio-demographic and environmental factors and peoples' well-being is provided. This is followed by the approach for data collection and analysis. The final section presents the results and discussion of the study as well as the conclusions drawn from the study.

## 2 Socio-demographic, environmental factors and well-being: theoretical review

Previous studies have shown some form of relationships between peoples' well-being and their socio-demographic and economic conditions. For example, evidence indicates positive relationship between people's income and their well-being (Easterlin 2001). Using samples from UK (Clark and Oswald 1994) and Switzerland (Frey and Stutzer 2000), studies reported positive but weak relationship between income and well-being. Elsewhere, for instance, in Germany, van Praag et al. (2003) recorded positive and strong relationship. The evidence further shows that growth in per capita income in rich countries does not reflect an increase in happiness (Easterlin 1995; Blanchflower and Oswald 2000; Frey and Stutzer 2002). For example, between 1958 and 1989, Japan recorded above fivefold increment in GDP per capita without any significant change in happiness (Easterlin 1995). Generally, however, it is argued that peoples' well-being improves with increases in their income and that the effect is stronger in less rich countries.

Other factors such as age, marital and employment status are established to have association with human well-being. It is argued that the well-being of people is influenced by their age. Matured adults have increased well-being benefits and reduced depression problems than younger adults. Older adults have higher happiness and life satisfaction (Herzog and Rodgers 1981), reduced negative emotions (Carstensen et al. 2000), frequent encounter of positive effect (Mroczek and Kolarz 1998), lower anxiety and depression levels (George et al. 1988) compare to younger adults. Charles et al. (2003) agreeing with Mroczek and Kolarz (1998) observed that older adults can recall very few negative scenes than younger adults and thus reduce the pains they might have induced if they had pondered on the negative issues. Isaacowitz and Smith (2003) examined data from Berlin and reported lower levels of both positive and negative effects among older adults. They argue that the lower levels of negative effects among older adults do not necessarily improve their subjective well-being. The same is stressed by socio-emotional selectivity theory which states that there is the tendency for ageing people to attain better emotional qualities but that does not make them to have higher positive effect (Cartensen et al. 1999).

Significantly too, marital status predicts peoples' well-being. Married people have higher physical and psychological well-being benefits compared to never-married people, and the never-married people have more well-being benefits than people who were previously married such as the divorced or separated (Gove et al. 1990; Glenn and Weaver 1979). Robins and Regier (1991) reported that in the USA, major depression disorders exist in the order '1.5 % for adults who are married, 2.4 % for those who never married, 4.1 % for adults who divorced once and 5.8 % for adults who have divorced twice'. Coombs and West (1991) concluded that married people are less alcoholic, live longer, are unlikely to commit suicide and experience a number of psychological benefits. It is explained that marriage creates social support (House et al. 1988), bond (Shapiro and Keyes 2007), makes

people free from loneliness (Glenn 1975) and lessens the pains one has to pass through as there is a partner to confide in (Gove et al. 1990).

Much the same manner, unemployment has negative effect on the well-being of people particularly on their mental and physical health (Clark and Oswald 1994). Waters and Moore (2002) reported higher levels of psychological pain and depression among unemployed people. An earlier study by Goldsmith et al. (1996) gave similar report as they use data from USA to demonstrate that people who do not have job tend to have reduced self-worth, reduced self-esteem and higher prevalence of depression symptoms. It has been noted that the well-being of the unemployed tends to be higher if the community or society they live in have higher unemployment rate (Clark 2003). Another stand is projected by the incentive theory which holds the view that unemployment does not lead to any serious well-being losses. It explains that people who are not employed do have enough well-being benefits that prevent them to be depressed (Raisanen 2002 cited in Ervasti and Venetoklis 2006).

Noise interferes people's usual performance and usually creates undesirable health effects in people's life (Miedema 2007; WHO 1999). These undesirable health effects, which may include mutilation of psychological, physical or social functioning, can be of temporary or long-term nature (WHO 1999). Due to the detrimental effect of noise, Miedema (2007) emphasises the importance of people having the strength to resist stressing effects of noise. Niemann et al. (2006) claim that in addition to having physical impact in people's life, it also has emotional reactions which could be more detrimental if individuals with such effects do not have enough ability to cope it. Stansfeld et al. (2005) studied the effect of road traffic and aircraft noise on children's general health and cognitive performance. They observed that children who are exposed to aircraft noise had significant recognition impairment, but their conceptual recalls were not affected. This paper contributes to the knowledge base of factors that influence human well-being with emphasis on linkages between environmental conditions and human well-being.

## 2.1 Measures of well-being

Several methods have been developed for well-being measurement but none of them stands out as the best measure of well-being (Offer 2006). These methods can be put into two broad categories—objective and subjective methods. The objective methods indirectly measure well-being through the use of facts on social, environmental and economic data. The most employed single objective measure has been the gross domestic product (GDP). The reason for using GDP as a measure of well-being is due to the belief that as people's income increases, their consumption and utility also increase. However, it is not clear how increase in consumption increases one's well-being. Again concerns have been raised on the failure of GDP to capture all the facets of human life (Conceicao and Bandura 2008). Against these limitations coupled with sceptics concern on the need to consider non-economic dimensions of well-being, people's levels of nutrition, education and so forth in well-being measures have become important considerations for well-being measurement (Offer 2006). For example, Human Development Index, the most widely used well-being measure focuses on one's income, education and health status (Newton 2007). Societies have become more affluent, and economic indicators seem not to give full account of people's well-being status. Hence, even though such indicators are good in measuring one's well-being, they should not be used as the main measures (Conceicao and Bandura 2008).

Currently, subjective well-being measures are becoming popular due to the awareness that people's assessment of their own lives provides a comprehensive appraisal of their well-being. These measures merge people's judgement of their life contentment with their

sentimental appraisal of mood and emotions (Newton 2007). It evaluates a person's quality of life, involving questions demanding respondents to rate their well-being levels. Empirical evidence has been raised to justify the reliability and robustness of such measures (Strack et al. 1991).

### 3 Data collection and analysis

#### 3.1 Study area

The research area consisted of green spaces within Anglesey and Gwynedd Councils in North Wales (Fig. 1). These areas included a garden, green path, a park, woods and nature reserves. The sites were selected to represent gradients of biodiversity and sound levels. Twelve sites were selected, but eight were put into gradients of biodiversity based on the Shannon Index values. Morfa Abber, Coedydd Abber and Spinnies Reserves are wetland nature areas close to the sea and serve as bird hides. Spinnies consists of a small woodland with a series of ponds and a lagoon—Aberogwen Lagoon. Newborough Forest is 951 hectares in size, of which approximately 689 ha is currently wooded and the remainder is salt marsh, existing open areas and recreational facilities. Bible Garden, Love Lane and Caernarfon Park are located in city centres and are characterised by sundry flowering plants. Cegin Valley is a woodland corridor with magnificent views and is of paramount importance for a wide range of different species, some of which are rare. Therefore, Caernarfon park, Bible Garden, Love Lane and Cegin Valley were closer to city centres and highways.

#### 3.2 Measuring plant diversity

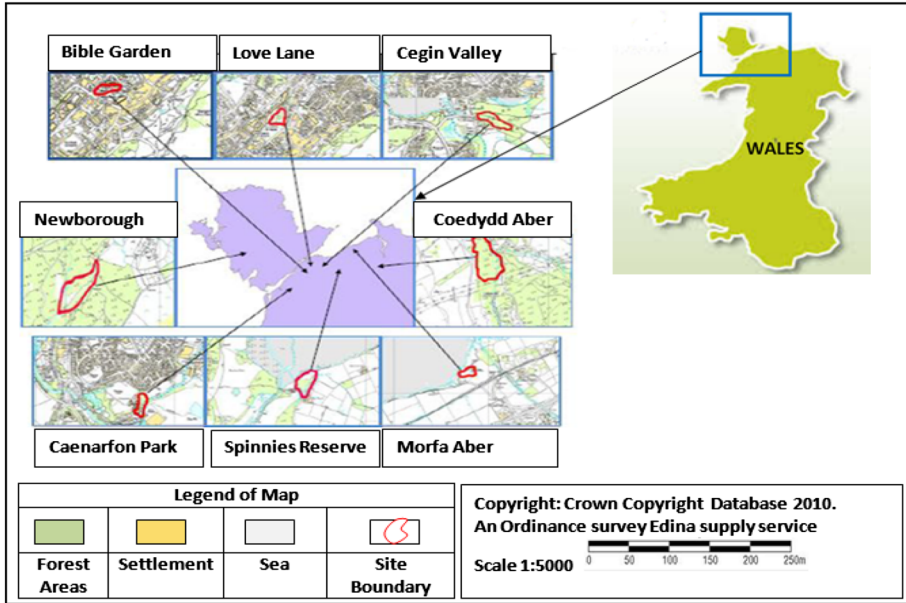
In June 2011, plant communities were sampled in each of the green spaces. Ordnance Survey (2010) MASTERMAP data for the sites and Hawth's analysis tool (ArcGIS extension) were used to generate random points. GPS unit was used to locate the points on each site to make quadrates at each point location. Both woody and non-woody plants were surveyed. For surveying the woody plants, quadrates of  $10 \times 10$  m dimensions were used. Species of the woody plants (for both native and introduced types) and their abundances (absolute numbers were counted) were identified within each of the quadrates using three nature guide books (Hammond 2002; Richardson and Gale 1994; Walters 2000). The same protocol was used for identifying species of non-woody plants (for both native and introduced types) and their abundances with  $1 \times 1$  m quadrates, but in this case species, abundance was estimated in percentages. The Shannon–Weiner diversity index ( $H'$ ) was used in calculating plant diversities (Eq. 1).

$$H' = - \sum_{i=1}^s (p_i \ln p_i) \quad (1)$$

where  $p_i$  is the proportion of individuals in the  $i$ th species and  $s$  is the number of species.

#### 3.3 Measuring happiness

Users of the green spaces from 7 June 2011 to 30 June 2011 between 10 a.m. and 5 p.m. daily were sampled. Preliminary survey revealed that very few and almost the same people visit the sites each day. The study aimed at meeting a target of 30 respondents for each site.



**Fig. 1** Map of Wales, UK showing the locations and distributions of the study sites in Gwynedd and Anglesey Councils

Anybody that visited the sites during the survey period was invited to participate in the study, and those who were willing were asked to complete the questionnaire. The short depression and happiness scale (Table 1) was used to measure visitors' happiness level. The SDHS is a 6-item self-report scale designed to rapidly measure both depression and happiness (Joseph et al. 2004). Three items enquired one's positive thoughts and bodily experiences, and the other three items asked negative thoughts and bodily experiences. Responses were made on a four-point Likert scale from never to often on the statement, 'Please indicate how much you agree or disagree with each item concerning your engagement with this place at this moment'. Items with negative thoughts, feelings and bodily experiences (1, 3 and 6) were reverse-scored, so respondents scored between 0 and 18 inclusive, with higher scores indicating greater frequency of positive thoughts and feelings and lower frequency of negative thoughts and feelings (Joseph and Lewis 1998). Happiness value for each of the sites as average of the individual happiness values of the sites was calculated.

### 3.4 Measuring perception of naturalness

The questions 'how natural is this place?' and 'how wild is this place' were used to assess how people perceived the naturalness of the sites. Respondents were asked to score the place from 0 to 10 for level of naturalness and level of wilderness, with higher score indicating greater level of naturalness and wilderness. It was explained to respondents that naturalness of an area denotes 'the level at which that area occurs without artificial influence (Machado 2004) and wilderness area denotes area that maintains its natural features and lacks any permanent human habitation (Green and Paine 1997)'. Perception of

**Table 1** Items of the short depression–happiness scale: respondents' responses were put in a rate on a four-point Likert scale; never (0), rarely (1), sometimes (2) and often (3)

	Items	Responses			
		Never	Rarely	Sometimes	Often
1	I feel dissatisfied				
2	I feel happy				
3	I feel cheerless				
4	I feel pleased				
5	I feel enjoyable				
6	I feel meaningless				

naturalness value for each respondent as the average of the values for level of naturalness and level of wilderness was calculated. Perception of naturalness value for each site as the mean of the individual perception of naturalness values of the sites was also calculated.

### 3.5 Quantifying socio-demographic factors, traffic noise and density of people

Socio-demographic information such as age, gender, income, marital and employment status of respondents was collected. For classifying respondents into income ranges, Carrera and Beaumont (2010)'s income classes were used.

In addition, traffic noise in each of the sites with Extech 407736 digital sound level meter was measured. The sound level meter was held at 20 cm away from each respondent and at 1.5 m above the ground floor. A period of 10 s was allowed before taking the reading. The reading recorded was the equivalent continuous sound level (LAeq). Traffic noise for each site was calculated as the average of the individual traffic noise values of the sites.

Thus, the density of people around each respondent was calculated. This was done by counting all visitors that fell within 10, 20 and 30 m ranges from each of the respondent. The counting was done during the same time when the respondents were answering their happiness questionnaires; 10, 20 and 30 m ranges were used because the preliminary visits showed that visitors who were separated by a distance beyond 30 m range do not influence each other significantly. Most of the visitors came alone and those who came in groups usually walked side by side, so a distance beyond 30 m did not influence respondents. Density of people within the 10, 20 and 30 m ranges was calculated for each site as the average of people that fell within those categories for all respondents.

### 3.6 Modelling

The happiness and biodiversity data were the focus for the main analysis of this study. Socio-demographic and other environmental factors such as age of respondents, income level, gender, perception of naturalness, sound level and density of people as possible covariates (predictor variables) were considered. The general linear model analysis tool, multiple regression of PASW statistics (version 18) and Microsoft Excel spreadsheet were used to perform all the analyses. The general linear model was used because it was necessary to test whether the various possible predictor variables do predict the response variable (in this case happiness).

The distribution of the data for normality using the Kolmogorov test was done. The happiness data were slightly skewed to the positive direction, so logarithm transformation



(LG10) was applied on it. The logarithm-transformed happiness data for the data analysis were used. Descriptive statistics were computed to explore all the variables. Means and standard deviations were used to describe continuous variables, while categorical variables were summarised into frequencies. For assessing variations among categorical variables such as gender of respondents, employment status and marital status, chi-square test was employed. Similarly, analysis of variance was used in comparing mean differences among continuous variables such as sound level, age of respondents, density of people and perception of naturalness.

Three models of happiness were used in the analysis to explore the relation between happiness and levels of biodiversity (Table 2). Age, perception of naturalness, income level, sound level and density of people were used as covariate factors in each of the model.

## 4 Results

### 4.1 Characteristics of green spaces

Plant diversity (for native, introduced and total species) varied across the eight sites (Table 3). Caernarfon Park and Coedydd Aber recorded higher diversity values for total plant, native and introduced species, whereas Bible Gardens and Morfa Aber recorded lower values for all cases. Spinnies Reserve recorded higher values for native and introduced plant diversities but had a lower value for total plant diversity. Comparatively, Newborough Forest, Love Lane and Cegin Valley recorded moderate diversity values for all cases.

Sound levels differed across the sites, ranging from 46.20 dB to 53.77 dB (Table 4). The highest was recorded at Morfa Aber, and the lowest was recorded at Cegin Valley. The variation in sound levels across the sites was significant ( $F(7, 228) = 63.782; P < 0.01$ ). Except Bible Gardens and Morfa Aber which recorded lower values for perception of naturalness, the remaining sites recorded higher values. The variation was significant across the sites [ $F(7, 228) = 28.816, P < 0.001$ ]. The distribution of density of people for 10, 20 and 30 m ranges varied between all the eight sites [ $F(7, 228) = 15.924, 23.600, 24.725$ , respectively,  $P < 0.001$  for all cases]. There was no significant variation among density of people in the 10, 20 and 30 m ranges within each of the green spaces. Subsequent analysis involving density of people considered only densities at 10 m ranges.

### 4.2 Characteristics of sample population

A total of 236 individuals aged 18 and over were interviewed across the eight sites. In all, 26 people (out of a target of 30 people) responded to the questionnaire at Morfa Aber, but targets for all the other sites were met. On the whole, respondents in Bible Gardens and Love Lane had lower ages, whereas those in Caernarfon Park and Morfa Aber had higher ages. The variation in ages between the sites was statistically significant [ $F(7, 228) = 15.131; P < 0.01$ ]. Male distributions were more or less equal in proportion across the sites except in Caernarfon Park where the highest number of males was recorded ( $\chi^2 = 1.89, df = 7, P > 0.05$ ). Majority of the visitors were married; such trend was observed across all the eight sites. Only Coedydd Aber and Cegin Valley recorded individuals who were widowed. The distribution of marital status varied significantly across the sites ( $\chi^2 = 63.8, df = 14, P < 0.05$ ). While majority of the respondents were employed, it was only Caernarfon Park which recorded people who were unemployed. There was a significant variation in employment status ( $\chi^2 = 86.4, df = 21, P < 0.001$ ).



**Table 2** Variables in happiness models

Variables	Model 1	Model 2	Model 3
Gender	✓	✓	✓
Marital status	✓	✓	✓
Employment status	✓	✓	✓
Perception of naturalness	✓	✓	✓
Income level	✓	✓	✓
Sound level	✓	✓	✓
Density of people	✓	✓	✓
Age	✓	✓	✓
Native plants diversity		✓	
Diversity of Introduced plants			✓
Total wood diversity	✓		

**Table 3** Study sites, sizes and Shannon index values

Study sites	Size (acres)	H'		
		Native Plants	Introduced Plants	Both native and Introduced species
Caernarfon park	3.8	2.12474	1.61652	2.65172
Bible garden	2.2	1.30574	0.66342	0.9850
Love lane	6.5	1.78579	1.34825	2.12526
Cegin valley	13	1.98243	1.07511	1.38000
Spinnies reserve	8	2.55883	2.50090	1.33000
Morfa Aber	1.5	1.01985	0.54885	1.83174
Coedydd Aber	17	2.46925	2.57098	2.42194
Newborough forest	21	1.86330	1.45969	1.53426

**Table 4** Mean values for perception of naturalness, density of people and sound levels

Name of green areas	Perception of naturalness		Density of people		Sound levels	
	Mean	SD	Mean	SD	Mean	SD
Bible garden	5.40	1.192	6.50	5.488	52.91	2.446
Cegin valley	8.37	.765	1.27	.521	46.65	1.830
Spinnies	8.10	.845	1.47	.900	46.20	.956
Morfa Abber	5.85	1.223	1.73	1.116	53.77	2.344
Coedydd Abber	8.37	.999	2.43	3.501	49.29	1.389
Caernarfon park	7.70	1.291	1.43	.728	51.63	2.482
Love lane	8.10	1.668	1.57	.817	51.14	1.661
Newborough forest	7.83	1.117	1.37	.669	50.51	1.006

#### 4.3 Happiness items analysis

The items of the happiness questionnaire have acceptable internal consistency,  $\alpha = 0.738$  (Table 5). All the six items were worthy to be maintained: deletion of item 1 would produce the greatest increase, but its exclusion would increase alpha by only 0.018. The

items 1 and 3 did not correlate very well with the total scale ( $r = 0.301$  and  $0.460$ , respectively).

#### 4.4 Happiness, demographic and environmental variables

Table 6 shows how the perception of naturalness, sound level, age, density of people and plant diversity relate to happiness. In all models, perception of naturalness and age relates to happiness. In models 2 and 3, sound levels do not relate to happiness, while in model 1, density of people does not relate to happiness. The relationship was positive for perception of naturalness and diversities of native, introduced and total plant species. In contrast, sound level and density of people relate negatively to happiness. In models 1 and 3, age relates positively to happiness, while in model 2, it relates negatively to happiness. In all models, the strength of the relationship was strongest for plant diversity. Perception of naturalness recorded stronger relationship than age, sound level and density of people. Model 3 has the highest adjusted  $R^2$  (it explains 47 % of the variation, the highest of any of the models tested), suggesting that diversity of introduced species explains more of the variation in happiness between respondents than the other two measures of diversity tested (total plant diversity and native plant diversity).

The model with the highest  $R^2$  value (model 3) retains perception of naturalness, age, density of people and diversity of introduced species as predictors of happiness. Figure 2 presents the coefficient estimates for the most supported model. This illustrates that older people who visit natural environment with high biodiversity and few visitors are most likely to be happier.

## 5 Discussions and conclusions

### 5.1 Level of biodiversity and human happiness

The results provide the evidence that visitors at the green spaces with higher biodiversity have higher happiness. The evidence shows that diversity of introduced species explains more of the variation in happiness between visitors than the other two measures of diversity tested. Nature has multiple stimuli which are softer and pleasing to the human mind (Burns 2006). The pleasing stimuli in nature might be responsible for freeing the human brain of surplus activities (Yogendra 1958) and improves it (Furnass 1979). It could be that the stimuli are linked to the morphological features of plants (shape and colour of flower, leaf, crown and stem) and green spaces with higher biodiversity tend to have higher levels and combinations of morphological features. Green spaces with more colourful flowers and plant types are more attractive than areas with few flowers and plant types, and as a result, may have stronger impact on the brain. The level of biodiversity in places like Caernarfon Park, Spinnies Reserve and Coedydd Aber is higher and thus may have several morphological features which will all contribute to produce an enhanced pleasing effect to visitors. The effect, however, may be lower in Bible Gardens and Morfa Aber which do have fewer plant types. Introduced plant diversity has stronger effect on visitors' happiness because the types of introduced species at the green spaces may have morphological features which are more attractive to the respondents than the native species.

The results consent with Fuller et al. (2007), who reported that people who interact with green spaces with higher species richness have higher ability to reflect an increased distinct identity than people who interact with green spaces with fewer species richness. However,

**Table 5** Internal consistency of happiness items

Scale mean if item deleted	Scale variance if item deleted	Corrected item—total correlation	Cronbach's alpha if item deleted
13.64	2.332	0.301	0.756
13.82	2.005	0.570	0.671
13.47	2.224	0.460	0.705
13.41	2.064	0.614	0.660
13.42	2.159	0.553	0.679
13.30	2.526	0.387	0.725

Cronbach's alpha = 0.738

the effect observed in this study is weaker than the one in Fuller et al. (2007). The results also agree with Luck et al. (2011) who reported positive relation between neighbourhood well-being and range of natural features which include species richness and abundance of birds. Again, the effect in this study is weaker than the one in Luck et al. (2011). This study included more predictor variables in the happiness models than the models in Fuller et al. (2007) and Luck et al. (2011). This could be the reason why this study recorded weaker effect between happiness and level of biodiversity.

## 5.2 Perception of naturalness, socio-environmental factors and human well-being

The results show a positive association between human well-being in terms of happiness and perceived naturalness. The association between happiness and level of biodiversity is stronger than that between happiness and perceived naturalness. When people interact with the natural environment, their spiritual, emotional and cognitive well-being improve (Kaplan and Kaplan 1989; Mental health foundation 2000). This explains why people seek to get closer to nature (Wilson 1984). The satisfaction people obtain from interacting with the natural environment make them happy and that this happiness could relate to the level of naturalness of that location.

The results show that age, sound level and density of visitors predict happiness. Sound level and density of visitors relate negatively to happiness. The degree of the effect is higher for sound level. The effect of age is not consistent in all the models tested though it relates positively to happiness in the most supported model. Previous studies have shown that ageing has a natural ability to induce frequent encounter of positive effects in people so as people grow old, they naturally become happier (Charles et al. 2003; Mroczek and Kolarz 1998). This natural ability for an ageing person to be happier could be responsible for such observation. This outcome falls in line with earlier observation by Herzog and Rodgers (1981) who reported that as people grow old, their happiness and life satisfaction improve. It also agrees with Diener and Suh (1997) who reported that people's well-being improves as they aged. Similarly, it agrees with Mroczek and Kolarz (1998) who reported the existence of higher levels of positive effect and reduced levels of negative effect in older adults than younger adults. However, the result is contrary to Isaacowitz and Smith (2003) who reported lower positive effect among old adults when compared to young adults.

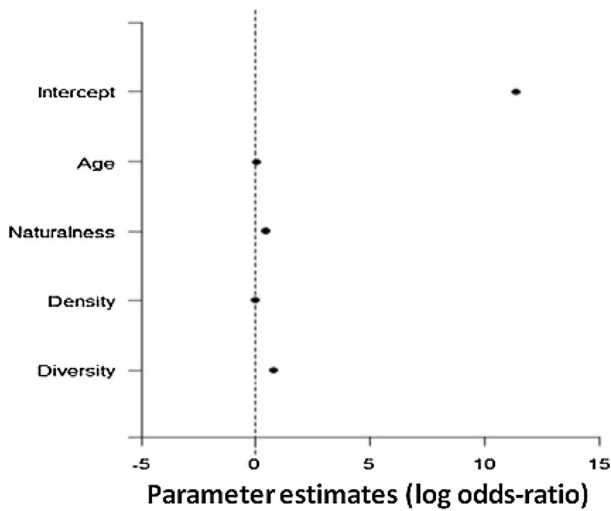
Noise is known to impede the normal functioning of human actions (Miedema 2007; WHO 1999), so people in noisy environment have to resist noisy interferences and that might reduce the level of amusement they may be enjoying. That could be the reason for

**Table 6** Happiness models as a function of demographic and environmental variables

Variables	Coefficient	SE	F values	Degrees of freedom	P values
<b>Model 1</b>					
Intercept	1.190	.056	510.200	1	0.000
Gender	0.002	.000	0.115	1	0.735
Marital status	0.004	.005	1.162	2	0.315
Employment status	0.006	.004	0.397	3	0.755
Perception of naturalness	0.013	.006	53.112	1	0.000
Income level	0.000	.002	0.042	1	0.838
Sound level	-0.003	.003	11.660	1	0.001
Density of people	-0.001	.001	1.599	1	0.207
Age	0.001	.001	4.078	1	0.045
Total plant diversity	0.017	.005	10.462	1	0.001
<b>Model 2</b>					
Intercept	1.010	.062	275.681	1	0.000
Gender	0.000	.000	0.012	1	0.912
Marital status	0.003	.005	0.995	2	0.371
Employment status	0.007	.004	0.568	3	0.637
Perception of naturalness	0.011	.006	37.009	1	0.000
Income level	0.000	.002	0.028	1	0.866
Sound level	0.000	.003	0.192	1	0.662
Density of people	-0.002	.001	4.360	1	0.038
Age	-0.002	.001	3.810	1	0.002
Diversity of native species	0.030	.007	18.900	1	0.000
<b>Model 3</b>					
Intercept	1.063	.055	413.499	1	0.000
Gender	0.001	.000	0.044	1	0.835
Marital status	0.003	.005	0.931	2	0.396
Employment status	0.008	.004	0.915	3	0.434
Perception of naturalness	0.012	.005	44.976	1	0.000
Income level	0.000	.002	0.006	1	0.940
Sound level	0.000	.003	0.052	1	0.819
Density of people	-0.002	.001	4.868	1	0.028
Age	0.001	.001	3.154	1	0.007
Diversity of introduced species	0.020	.004	25.166	1	0.000

Adjusted  $R^2$ : model 1 = 0.412, model 2 = 0.433, model 3 = 0.447

observing negative association between noise level and happiness. The outcome agrees with Hygge et al. (1996) and Stansfeld et al. (2005) who both reported negative association between noise and well-being. The explanation for the negative association between density of visitors and happiness could be that the presence of many people in a particular green space might obstruct visitors' visual appreciation of the plants and consequently reduces their amusement in that site. Moreover, many people in a site may increase the background noise when groups of visitors engage in conversations. However, gender,



**Fig. 2** Parameter coefficient values for the generalised linear model predicting happiness. The higher the estimate (except for density of people) the more likely visitors will be happy. The *central circles* are the mean coefficient estimate for each parameter, and *lines* indicate 95 % confidence intervals

income, marital and employment status did not show sign of prediction on happiness. The result is contrary to studies which reported an association between happiness and income (Frey and Stutzer 2000; Easterlin 2001; van Praag et al. 2003), marriage (Odegaard 1946; Coombs and West 1991) and employment (Clark and Oswald 1994; Waters and Moore 2002; Goldsmith et al. 1996).

### 5.3 Implications for policy and conservation works

The discovery that happiness associates positively with both the level of biodiversity in an environment and perceived naturalness has implications for health policies, conservation works, ecological health and sustainable development. The health systems should consider using the natural environment efficiently as a remedy in improving people's lives. Already, applications of this knowledge are in existence, but the focus all this while has been creating green spaces within built environments without necessarily considering the quality of such areas. It should be noted that factors such as sound level, density of visitors and visitor's age influenced the results, so applications of this knowledge should consider the type of population and the natural setting in question. Other organisations such as urban planners, children and nursing homes could also use this knowledge to improve their built environments by incorporating accessible green spaces of high biodiversity in them. Although the evidence showed that introduced diversity was a better predictor of happiness than native diversity, yet the kind of introduced species in the green spaces were managed. Besides, perceived naturalness (i.e. not looking like planted garden) is also important. It is suggested that the green spaces should be planted with attractive plants and flowers.

The motivation behind establishing community parks, churchyards and gardens in towns and urban centres has been to provide leisure places and improving the quality of people's life (Heimlich 1989; Page and Johnston 2008). An extension of that should be to focus such places primarily on biodiversity conservation. With the recognition that

biodiversity matters for human well-being and that introduced species have much weight on visitors well-being, urban planners should aim at improving the biodiversity content of community parks and gardens, with much focus on enhancing the proportion of introduced plant species. In this way, biodiversity will be conserved and visitors to such places will also achieve improved well-being benefits. The general public should be made aware of the role green spaces play on their well-being. This might help to obtain their support in biodiversity conservation works, especially in urban places.

## 6 Conclusions

The results show that green spaces can vary in levels of biodiversity and happiness benefits derived from them. Many health centres are incorporating green spaces into their environments to enhance people's quality of life (Page and Johnston 2008). If the aim is to maximise the happiness and well-being benefits, urgent action is needed to improve the levels of biodiversities in these areas. Community parks, gardens and nature areas are established in towns and urban centres to enhance the quality of the built environment (Heimlich 1989). The design of such areas should consider improving the biodiversity in them.

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