User participation in urban green commons: exploring the links between access, voluntarism, biodiversity and well being

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Abstract
Polycentric governance and stakeholder participation in natural resource management have potential benefits for both human and environmental well-being. Researchers and decision-makers have attempted to conceptualise the ecological, social and political potential of such semi-formal approaches to urban green space management. However, few studies have quantified the actual benefits in terms of biodiversity and associated ecosystem service provision, or the factors that mediate levels of participation.

The links between biodiversity potential, site access and user participation were explored in a case study comprising ten established examples of organised social-ecological initiatives in the inner-city area of Greater Manchester. At the micro-scale, the case study quantified the levels of community involvement (measured in volunteer hours month^{-1}) in local green commons and the biodiversity potential (assessed using floristic and structural diversity as a surrogate) of the ten sites. Descriptive analysis identified that site spatial and design characteristics affected all three measures and subsequent correlational analyses revealed a high degree of synergy between site use and biodiversity.

The study thereby provides quantitative evidence of the synergistic relationship between green space use and urban biodiversity and, importantly, the positive feedbacks which should result between volunteer input and the local generation of ecosystem services. The study provides support for the promotion of a highly decentralised, stakeholder-led stewardship of green space as a valid consideration in the management of urban ecosystem services.

Introduction
Biodiversity loss can have highly detrimental consequences for human well-being (MEA, 2005; Haines-Young and Potschin, 2013). The rise and promotion of stakeholder-led environmental stewardship has produced many examples of a decentralised approach as an adaptive response to environmental degradation (Gunderson and Holling, 2002; Krasny and Tidball, 2012). The urban environment in particular, as home to most of the world's inhabitants (United Nations, 2007) and the centre of rapidly occurring land-use change associated with biodiversity loss (Marzluff, 2008; McKinney, 2008) presents opportunities for studying the relationship between citizen involvement in natural resource management and levels of local biodiversity. Although such involvement is recommended through policy (CBD, 2001; MEA, 2005) and research (Ernstson et al., 2008; 2010) alike, without empirical evidence of the positive link between user participation in natural resource management and local biodiversity, the benefits of stakeholder involvement have remained largely unconfirmed (Krasny et al., 2014; Fors et al., 2015). This study explored the links between user participation in community-run urban green spaces and their floristic and structural diversity, and as a result highlights the influence of access and design as a mediating factor in this relationship.

Biodiversity and human well-being

The Ecosystem Approach set out by the Convention on Biological Diversity (CBD, 2001) emphasised the importance of global biodiversity for human well-being. The Millennium Ecosystem Assessment (MEA, 2005) developed this link further with a focus on Principle 5 of the Ecosystem Approach, i.e. the salience of ecosystem services. The latter concept encompasses the benefits arising from ecosystem functions and processes across spatial and temporal scales which contribute to human well-being and quality of life (MEA, 2005). The Millennium Ecosystem Assessment classifies ecosystem services into four categories: (1) provisioning services, providing direct concrete goods such as wood or food; (2) regulating services, for example, flood prevention, climate control, or water quality; (3) cultural services, the less tangible recreational, educational, or spiritual benefits; and (4) supporting services in the form of primary production, nutrient cycling, and soil formation. Other versions of the framework have offered alternative classification such as those used in The Economics of Ecosystems and Biodiversity (TEEB, 2008), the Common International Classification of Ecosystem Services (see Haines-Young and Potschin, 2013).

In all of the various systems of classification, the key tenet of biodiversity as the foundation of all ecosystem services, being the basis of life on Earth, is asserted. This global view of social-ecological well-being has been supported by findings in the scientific literature which identify the importance of biodiversity across various scales, habitats and taxonomic groups for ecosystem service production (e.g. von Shirnding, 2002; Burls and Khan, 2005; Worm et al., 2006; Costanza et al., 2007; Pudup, 2008; Niemelä et al., 2010; Mace et al., 2012; Wall and Nielsen, 2012; Haines-Young and Potschin, 2013).

Both the Ecosystem Approach and the Ecosystem Services Framework acknowledge the role of societal choices and action in the preservation of healthy ecosystems and conservation of the biodiversity which supports them. Principle 2 of the Ecosystem Approach requires that management of ecosystems is always decentralised to the lowest appropriate level (CBD, 2004) and the MEA likewise insists on an integrated approach to ecosystem management which promotes stakeholder involvement in decisions relating to environmental management (MEA, 2005).

This concern that human well-being should be related to the integrity of global ecosystems is accompanied by an acknowledgement of the rise of anthropogenic influences on the natural environment which have led to greater changes in ecosystem function during the second half of the twentieth century than any other period in history (MEA, 2005). Such a shift has been associated with unprecedented levels of biological diversity loss (Foley et al., 2005), primarily due to patterns of land-use change associated with a dramatically rising global population (Satterthwaite, 2009; Falloon and Betts, 2010). Such population increase has driven a surge in land-use change through the process of urbanisation, with the majority of the world’s population now dwelling in towns and cities (United Nations, 2007).

Urbanisation: implications for biodiversity and human well-being

Urbanisation is a key driver of land-use change associated with the appropriation of disproportionate levels of ecological resources (Folke et al., 1997). Habitat loss due to urbanisation can result in high extinction rates for native species (Kowarik, 1995; Marzluff, 2008), with lasting consequences not generally witnessed for other land-use change scenarios (Stein et al., 2000). Urban areas generally contain poorer species richness and diversity across all taxonomic groups (Kuhn and Klotz, 2006; McKinney, 2008; Aronson et al., 2014) with increasing population density associated with local extinction of plant species (Thompson and Jones, 1999). Moreover, the process of urbanisation can often be catastrophic for species assemblages, with the resulting land-use types suiting non-native, generalist species (DeCandido et al., 2004; McKinney, 2006; Pauchard and Shea, 2006). Biodiversity loss occurs at the local, regional and global scales directly and indirectly due to human-induced urban sprawl (Grimm et al., 2008).

Such consequences also have a direct impact on the inhabitants of urban areas. The social, environmental, and health-related stresses associated with urban living can be summarised as:

1. *Social*: lack of safe, accessible communal and recreational spaces; high crime rates; and increased deprivation.
2. *Health-related*: increased levels of pollution; poor diet; stress; heightened anxiety; little access to outdoor activities; and lack of natural, open spaces.
3. *Environmental*: loss of biodiversity; land contamination; flood risk; high ecological footprint; climate change; and food security (CABE, 2010; Coutts, 2010).

These factors are all interrelated, and so aligned are human and environmental states of health in the urban setting that they are being increasingly viewed as synergistic, reciprocal phenomena (MEA, 2005; WHO, 2005; Coutts, 2011).

The benefits to urban dwellers arising from the presence of green infrastructure are significant and varied. Studies have shown key gains, through indicators of physical health, mental well-being and longevity, for residents living in proximity to quality urban green space (Kaplan, 1995; Jackson, 2003; Maas et al., 2006; Maller et al., 2006; Gidlöf-Gunnarsson and Öhrström, 2007) as well as for those who seek interaction with nature in urban settings (Pretty et al., 2005; 2007 Bird, 2007; Tzoulas et al., 2007; Marselle et al., 2014; Carrus et al., 2015). Socio-economic factors have been highlighted as factors which mediate the strength of the relationship between green space and health (de Vries et al., 2003; Mitchell and Popham, 2007) but, for all sectors of the urban demography, the association between biodiverse green space and human health is consistently demonstrated as a positive one (Tzoulas et al., 2007; Hartig et al., 2014). Further, research has demonstrated that interaction with green spaces can be, as well a general boon to well-being (Maas et al., 2009; Barton and Pretty, 2010; Coon et al., 2011; Ward Thompson et al., 2014) restorative with respect to specific health conditions. Faber Taylor et al. (2011) found that nature exposure had a positive effect on the reduction of symptoms in children suffering from attention deficit disorder, giving support to Kaplan's (1995) Attention Restoration Theory. Similarly, outdoor green spaces have been shown to offer stress and pain relief to users (Hansmann et al., 2007) and in Australia research has been undertaken which puts forward woodland management as an effective remedy for depression (Townsend, 2006). Increasingly biodiverse spaces in urban areas have been associated with higher measures of subjective well-being (Carrus et al., 2015) and floristic biodiversity specifically has been identified as contributing in a direct linear fashion to urban psychological well-being (Fuller et al., 2007). Such findings are further supported by studies into therapeutic landscapes where structural and vascular plant diversity demonstrate particular efficacy in comparison with non-biodiverse environments (Marcus and Sachs, 2014).

Sense of place has been cited as a key element in fostering community identity and well-being (Williams and Stewart, 1998; Davenport and Anderson, 2005; MEA, 2005), and studies have demonstrated that naturalistic spaces and healthy urban environments can be instrumental in creating a positive sense of place among communities (Stedman, 2003; ODPM, 2004; Kudryavtsev et al., 2012; Tidball and Stedman, 2013).

Given the pressures placed on ecosystem functioning by urbanisation, existing green space within cities, and the management thereof, have become vitally important for biodiversity conservation (Kong et al., 2010; Kowarik, 2011; Barrico et al., 2012; Tscharntke et al., 2012; Rupprecht et al., 2015) and the associated production of ecosystem services (Niemelä et al., 2010; Kaczorowska et al., 2015; Sandifer et al., 2015; Speak et al., 2015). Although studies of biodiversity have often taken a landscape-scale approach (Waldhardt, 2003; Kim and Pauleit, 2005; Tscharntke et al., 2005; 2012; Nelson et al., 2009; Chalker-Scott, 2015), the significance of individual, small pockets of green space in urban areas for biodiversity is receiving increasing support (Smith et al., 2006; Davies et al., 2009; Goddard et al., 2010; Cameron et al., 2012). Domestic gardens in particular have been championed as important biodiverse elements in urban ecosystem management (Thompson et al., 2003; Goddard et al., 2010; 2013; Cameron et al., 2012) with allotment and community gardens, among other forms of urban agriculture such as green roofs, likewise demonstrating high species richness (Orsini et al., 2014; Lin et al., 2015; Speak et al., 2015). Furthermore, domestic and communal gardens, although limited by size, may by virtue of their biological richness and heterogeneity, contribute to urban ecological resilience according to the theory of ecological land-use complementation (Colding, 2007).

Civic ecological management of urban green commons

Due to the potential for biological diversity from community-managed gardens and green commons, combined with the obvious associated gains in achieving a sense of place, individual well-being and social cohesion (Krasny and Tidball, 2015), civic ecology in urban areas has become an important topic of research. Francis (1987) suggests that community-managed open spaces, although often overlooked by land authorities, offer an alternative to municipal urban parks which are attractive to certain user groups. Here the author demonstrated that recreation taking place at an urban community garden involved greater levels of physical activity than those occurring in a city park. Subsequently, studies have shown that community-led horticultural initiatives can serve to alleviate the social-environmental stresses of urban living through constructive and innovative use of green commons. For example, it has been suggested that such practices help participants in terms of improved diet (Alaimo et al., 2008; Kazmierczak et al., 2013); access to food (Metcalf and Widener, 2011); personal well-being (Hynes and Howe, 2004; Pudup, 2008); and better quality of life factors, such as reduced crime (Kuo et al., 1998; 2001), community cohesion (Okvat and Zautra, 2011) and sense of place (Krasny and Tidball, 2015). They have also been championed as methods of "cultivating" citizenship (Pudup, 2007), adding to and preserving local ecological memory (Barthel et al., 2010), as well as contributing to green infrastructure in the urban landscape in line with the UK government's insistence on the importance of green infrastructure in urban landscapes (Defra, 2011).

The benefits to human well-being to be gained through proximity to, interaction with and physical activity in natural environments (De Vries et al., 2003; Kingsley et al., 2009; Defra, 2010a; Coutts, 2010; 2011; Krasny and Tidball, 2015) have been presented as potentially reciprocal by readers in natural resource management theory (Dearborn and Kark, 2010; Barthel et al., 2010; Ernstson et al., 2008; 2010; Tidball and Stedman, 2013) and decision-makers at a policy level (Defra, 2010b; UK NEA, 2011). Stakeholder participation has been championed as a key element in environmental stewardship which could contribute to the adaptive capacity of social-ecological systems (Gunderson and Holling, 2002; Ernstson et al., 2010; Colding and Barthel, 2013). Krasny and Tidball (2012) have presented a variety of examples of civic-ecological participation in environmental stewardship which demonstrate great potential regarding the adaptive co-management of urban ecosystems. However, the same authors have identified a lack of evidence to support the positive claims that such community-led initiatives contribute directly to the production of ecosystem services (Krasny et al., 2014). Without empirical evidence of the positive link between user participation in natural resource management and local biodiversity, the benefits of stakeholder involvement have remained largely unconfirmed (Krasny et al., 2014; Fors et al., 2015).

Furthermore, much work has been carried out to evaluate the implications for human well-being and sense of place due to urban green commons (Bird, 2007; Pudup, 2008; Okvat and Zautra, 2011), particularly when under stakeholder stewardship (Wakefield et al., 2007; Okvat and Zautra, 2011; Tidball and Stedman, 2013), but the factors which influence levels of user participation in the first instance have yet to be clearly determined. Although, the politics and processes of involvement of citizen participation in green space management (Fraser et al., 2006; Rosol, 2010) and the variety of participatory approaches (Stringer et al., 2006) have been clearly documented, measures of continued use of community spaces by stakeholders have not been sufficiently described, nor the aspects of design and access which influence such use. A greater understanding of the issues affecting participation in the use and stewardship of urban green commons would inform an attempt to harness the social and ecological benefits which may issue from such stakeholder involvement.

Urban-ecological initiatives in North-west England

The Greater Manchester area has a rich history of civic ecological action stretching back to the dawn of the industrial revolution (Ritvo, 2010). In modern times, organisations such as the Manchester Environmental Resource Centre initiative (MERCi), the Environment Network for Manchester (EN4M), the Hulme Community Garden Centre, the Kindling Trust and Action for Sustainable Living (AfSL) have continued this historical precedent, delivering environmental and educational projects across the city (Lockwood, 2009 Kindling Trust, 2015; AfSL, n.d.). A network of sites consisting of green commons under management by groups of local residents has emerged across the conurbation. These offer examples of the kind of user participation in natural resource management which may provide benefits to local biodiversity and, thereby, enhance the production of ecosystem services.

Such instances of stakeholder-managed urban green commons present a salient opportunity for an exploration of the links between levels of use in urban green space and associated biodiversity. Moreover, such communally managed sites offer a unique perspective on factors influencing participation, given their varied geography and the approaches to site design and access that they offer, ranging from free public access in municipal recreational land to gated sites with scheduled access to secured private gardens.

While research has demonstrated that user participation and green space and ecology-based activities can help redress both the *social* and *health-related* stresses of urban living (summarised above), there is still little evidence to support the benefits of user participation in alleviating the *environmental* stresses of urbanisation associated with biodiversity loss. Research on the links between user-led green space management and biodiversity, as well as on those factors that influence levels of participation, is necessary to better understand the role of civic involvement in urban ecosystem management and inform effective design and planning of user participation in urban green spaces.

Methodology

In order to explore the links between access, community participation and biodiversity within the city, a comparison of ten sites associated with four types of community-led green space management (community gardens, community allotments, pocket parks, and community orchards) was conducted.

All ten sites, regardless of type, were communally-managed spaces, autonomous in their planning and choice of on-site cultural methods. They are described as *semi-formal* in that they are community-led endeavours but with the cooperation of the authorities and land-owners, unlike, for example, guerrilla approaches to urban greening (see Hardman and Larkham, 2014). Type descriptions are presented in Table 1.

Table 1 Case study types and descriptions

Site type	*Type description*	*Number of examples*
Community gardens	Multi-use, amenity green space in residential areas. Some emphasis on horticulture, high variety of design approaches.	3
Community allotments	New or pre-existing plots on established allotment sites under communal management.	3
Community orchards	Communal spaces dedicated primarily to cultivation of soft or hard fruit. Occurring in areas of expansive pre-existing recreational green space.	2
Pocket parks	Small (< 300m²) sites occurring in areas of very high surface sealing. Highly improvised approach to ecological intensification (e.g. green roofs/façades, raised bed systems).	2

The location of the ten case study sites within the study area is presented in Figure 1 and Table 2 presents the essential data on the sites: details of site size, leadership, funding and user base.

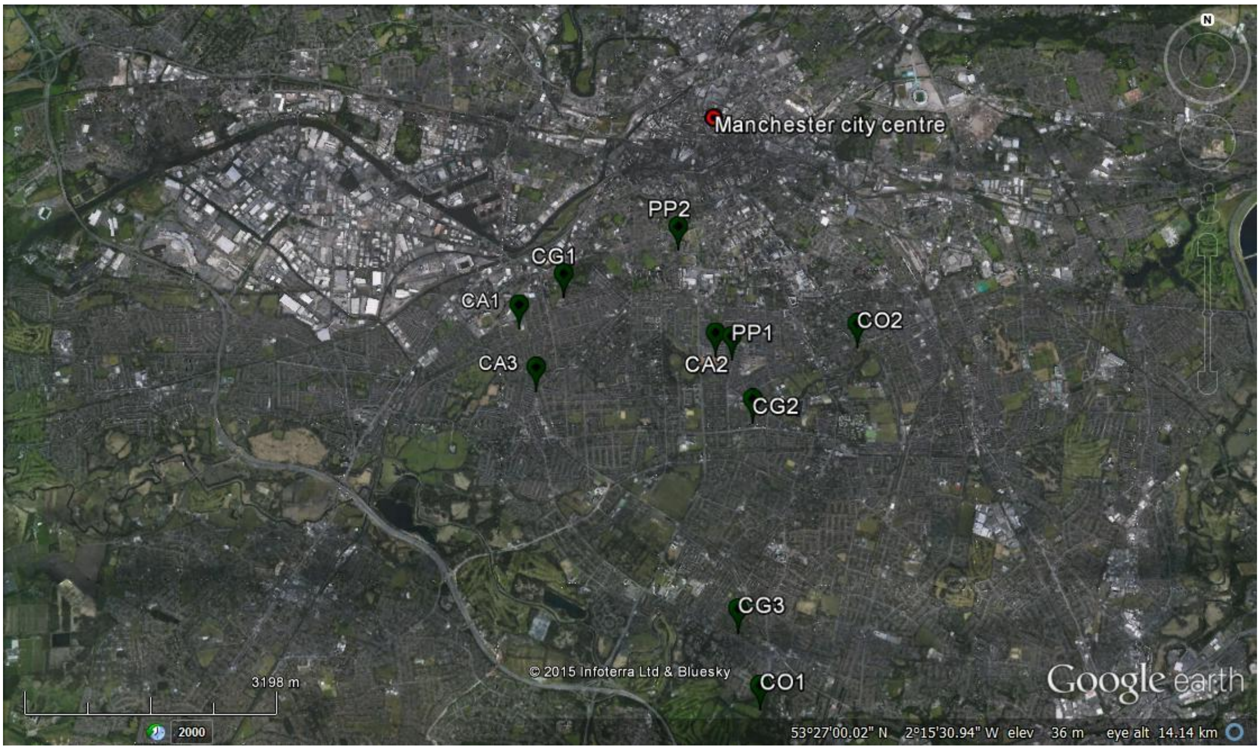

Figure 1 Location of the case study sites
Source: Google Earth 7.0. 2015. *Manchester, 53°27'00.02"N, 2°15'30.94"W, elevation 36m.* [Accessed 27 August 2015]. Available from: http://www.google.com/earth/index.html

Table 2 Key and basic site information

Site	*Total area (m^2)*	*Presence of a primary gatekeeper*	*Main partners/funders*	*Main users*	*Year commenced*
CG1	936	No	Trafford safer stronger communities fund/Trafford Partnership	Adjacent school and local residents	2007
CG2	1530	Yes	City South Housing Association	Local residents and external volunteers	2012
CG3	560	No	Didsbury Dinners community interest company	Local residents	2012
CA1	950	No	Trafford Council, BlueSci social enterprise	Local residents and BlueSci service users	2009
CA2	780	Yes	Adactus Housing Association	Local residents and school visits	2011
CA3	630	Yes	Manchester City Council	Local residents and school visits	2009
CO1	1044	No	Didsbury Dinners community interest company	Local residents	2011
CO2	1734	Yes	Manchester City Council/Friends of Birch Fields Park	Local residents and Friends of Birch Fields	2007
PP1	215	Yes	Manchester City Council/Adactus Housing Association	Local residents	2011
PP2	217	Yes	Self-funded not-for-profit	Community payback, schools, local residents and social prescribing	2012

Site access and setting
Data relating to the accessibility of each site were collected by acquiring information on access criteria (public or private), security (i.e. use of perimeter fencing) and opening times (where applicable). This information was gathered from site gatekeepers and by direct observation.

Biodiversity potential
To achieve quantifiable measures of biodiversity potential provided by sites of communal green space, a rapid assessment approach to site evaluation which focuses on vegetation structure was employed (Tzoulas and James, 2010). In the assessment, the percentage cover (according to the Domin scale of land coverage after Westmacott and Worthington, 1994) of each type of vegetative structure, defined using categories developed by Freeman and Buck (2003), is estimated using a method adapted from Tandy's Isovist technique. In the first step of the assessment, a point is given for the presence of each vegetative structural layer. A final Domin value is then created by adding or subtracting points according to built cover extent as follows:
-1 point for built layer Domin 6: 26-33% cover; -2 for built layer Domin 7: 34-50%; -3 for built layer Domin 8: 51-75%; -4 for built layer Domin 9: 76-90%; -5 for built layer Domin 10: 91-100%; +1 point for built layer Domin 5: 11-25%; +2 for built layer Domin 4: 4-10%; +3 for built layer Domin 3: <4% with many individuals; +4 for built layer Domin 2: <4% with several individuals; +5 for built layer Domin 1: <4% with few individuals.
The resulting measure is then combined with the number of genera of vascular plants observed (1 point for every 6 genera) to give a combined score for overall biodiversity. The original method was

modified in order that it could be better applied to the case study sites. The method was piloted on areas considerably larger than those sites selected for this research and, for practical purposes, circular sampling points consisting of a minimum of 10% of the total site area were established and surveyed. As all ten sites selected in this work were less than 2000 m^2 (see Table 2), it was possible for the sites to be sampled in their entirety by using the original visual estimate technique to record vegetative structure from a single vantage point and by subsequently employing line transects to identify and record vascular plant species.

Levels of community participation

An evaluation of site-specific levels of community participation was enabled through measures adopted from Natural England (2014) protocols for indicators of social benefits arising from Nature Improvement Areas. These protocols were prepared for the Nature Improvement Area scheme and are listed under the indicator sub-theme: *social impacts and well-being* (Natural England, 2014).

From these protocols, the level of community participation taking place at the case-study sites as volunteer hours $month^{-1}$ was adopted as a measure of local user participation. Evidence of voluntarism was gathered from gatekeepers of case-study sites responsible for volunteer co-ordination and with information on levels of site access and use. Information on volunteer hours per month during the growing season (March to October) (DECC, 2013) was gathered as a measure of community involvement. Volunteer hours relating specifically to physical activities, such as gardening, were recorded over a period spanning March 2013 to December 2013; data relating to administrative activities were not a focus of this research and therefore were not included in the analysis.

Variation in volunteer hours was explored through observation of site location, security and access. The association between volunteer input and floristic biodiversity was used as a basis of evaluation, as the latter has been demonstrated to be an effective tool in assessments of urban biodiversity (Tzoulas and James, 2010) and in identifying positive links between biodiversity and ecosystem services in both non-urban (Costanza et al., 2007; De Bello et al., 2010) and urban (Tratalos et al., 2007; Kong et al., 2010; Niemelä et al., 2010) environments. Moreover, floristic biodiversity in urban areas has been linked directly to human well-being (Fuller et al., 2007; Carrus et al., 2015) and posited as an ecosystem service in its own right (UK NEA, 2011). This approach therefore provided a sound basis for the identification of biodiversity potential associated with user participation as well as informing a discussion on the implications for the wider production of ecosystem services.

Results

Case study site descriptions: initial surveys

Information on the site management and the design for each of the chosen case-studies was gathered through initial site visits and surveys undertaken to establish the site layout. Although general similarities across the sites were found, cases differed according to their typology. Figures 2a to Figure 2d present representative images of each site type

a) **b)** **c)** **d)**

Figure 2 Site types: (a) community garden; (b) community allotment; (c) community orchard; (d) pocket park

Biodiversity potential

A biodiversity measure obtained using the rapid assessment approach of Tzoulas and James (2010) provided a surrogate score to evaluate site contribution to biodiversity potential. Data for the original site assessments are shown in Table 3.

Table 3 Biodiversity assessment data

Site	*Final Domin value*	*Genera vascular plants*	*Biodiversity score*
CG1	6	84	20
CG2	7	107	25
CG3	8	52	16
CA1	8	110	27
CA2	8	90	24
CA3	7	96	23
CO1	11	34	17
CO2	9	68	21
PP1	3	60	13
PP2	5	55	15

Biodiversity scores varied from 13 at the lowest to a highest score of 27. The low variance and high modality of the data were of note, considering that the method employed by the rapid assessment did not take site area into account and no effort was made to normalise for the considerable differences in site area during the data collection. In ecology, the species-area curve concept predicts that, at local levels, the number of species increases proportionally with the area increase (Rice and Kelting, 1955). The data were subsequently standardised by site area, calculating scores as a ratio $100m^{-2}$. This standardisation effectively placed greater emphasis on the variation between site characteristics in terms of genera richness and structural diversity. Accordingly, the biodiversity-area ratio scores in Table 4 show a coefficient of variation of 0.59 (as opposed to the coefficient of 0.23 in the original scores).

Table 4 Site biodiversity-area ratio scores

Site	*Biodiversity-area ratio*	*Type mean*	*Type cv*
CG1	2.14		
CG2	1.63	2.21	0.28
CG3	2.86		
CA1	2.84		
CA2	3.08	3.19	0.13
CA3	3.65		
CO1	1.63		
CO2	1.21	3.23	0.97
PP1	6.05		
PP2	6.91	6.48	0.09

Community participation

Data collected on monthly volunteer hours invested in each site along with information pertaining to site access and setting are presented in Table 5.

Table 5 Case study site access

Site	*Volunteer hours month^{-1}*	*Access*	*Security/perimeter fencing*
CG1	40	Public access	Yes
CG2	288	Limited access	Yes
CG3	200	Private	Yes
CA1	220	Limited access	Yes
CA2	300	Limited access	Yes
CA3	200	Limited access	Yes
CO1	20	Public access	No
CO2	80	Public access	No
PP1	150	Private	Yes
PP2	210	Limited access	Yes

The green space type that displayed the highest values in terms of voluntarism was community allotment, followed closely by community garden. Community orchards showed the highest variation in volunteer hours $100m^{-2}$ and scored lowest overall. There was considerable variation in data collected for the number of volunteer hours associated with each site. Data on volunteer hours per month at sites which allowed free public access appeared to be lower than those where access was limited. Sites were grouped according to level of access (public, limited and private) and, based on these criteria, entered into a one-way ANOVA to compare mean volunteer hours per month. The ANOVA model revealed significant group mean differences ($F(2) = 19.798$; $p = 0.001$), with post-hoc testing (Games-Howell) showing significantly lower mean values for sites with public access compared to those where access was limited (mean difference = 195 ±86 hours month^{-1}; $p = 0.001$). Sites providing limited access likewise scored highest overall for the case study in terms of volunteer hours per month (mean = 242 ±49). As with the biodiversity assessment, the data relating to volunteer hours month^{-1} were adjusted by creating a ratio of these values 100m^{-2}. The results of this conversion are presented in Table 6.

Table 6 Site levels of voluntarism month^{-1} 100m^{-2}

Site	*Volunteer hours month^{-1} 100m^{-2}*	*Type mean*	*Type cv*
CG1	25.64		
CG2	19.61	27.11	0.31
CG3	36.07		
CA1	24.53		
CA2	44.62	34.69	0.29
CA3	34.92		
CO1	2.20		
CO2	4.96	3.58	0.54
PP1	74.42		
PP2	98.16	86.29	0.19

The values for monthly voluntarism, standardised by site area, show a significant increase in variation from the original values in Table 5 with a coefficient of variation of 0.82.

To gain an understanding of the influence of volunteer effort on biodiversity potential, a linear regression was performed with volunteer input, measured in hours month^{-1} 100m^{-2}, as the predictor variable. The relationship is visualised in Figure 3.

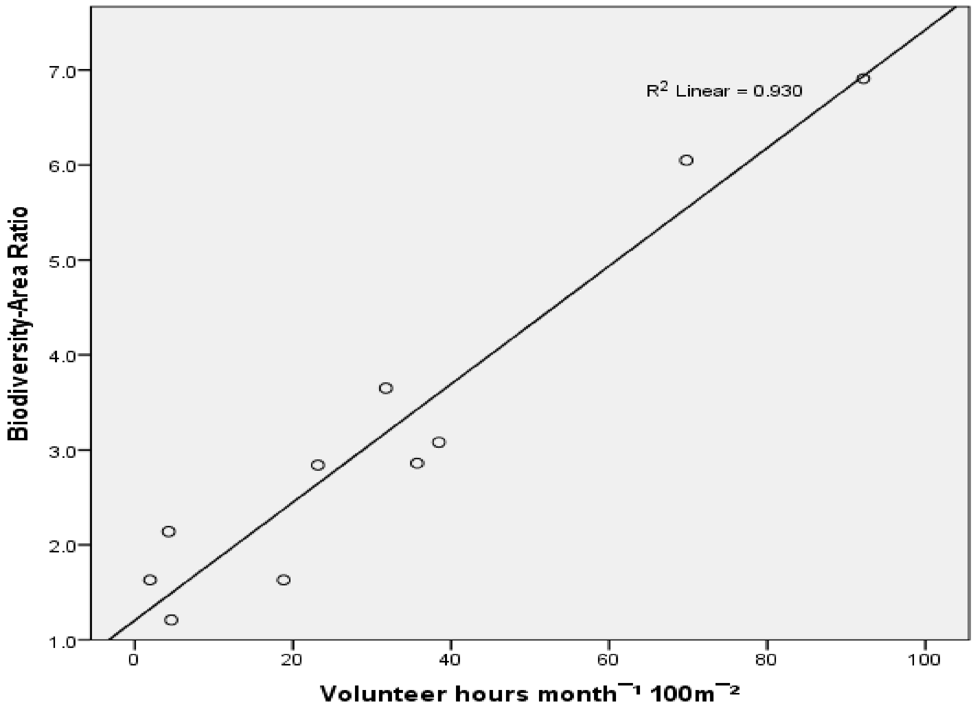

Figure 3 Effect of volunteer effort on biodiversity area ratio
Note: $p < 0.001$.

According to the regression analysis, site volunteer input accounted for 93% of the variation in site biodiversity potential. With a beta coefficient of 0.923, the equation predicts that, for the case study scenario, every hour increase a day in volunteer effort 100m^{-2} was associated with a corresponding

BAR increase of 1.83. In terms of vascular plant richness, the same increase in volunteer effort accompanied an increase of 8 genera for the same unit area on the predicted baseline value (i.e. no volunteer effort) of approximately 2 genera $100m^{-2}$.

Discussion

Previous research has already demonstrated the positive links between green space use and human well-being (e.g. Bird, 2007; Coutts, 2010; 2011) with horticultural activities proving particularly effective in this regard (Hynes and Howe, 2004; Pudup, 2008, Alaimo et al., 2008; Kazmierczak et al., 2013). Likewise biodiversity and nearby nature have been posited as significant boons to human health in urban settings (Kaplan, 1995; Jackson, 2003; Maas et al., 2006; Maller et al., 2006; Gidlöf-Gunnarsson and Öhrström, 2007). Hitherto, however, and despite claims in the literature supporting the merits of civil ecological movements (Ernstson et al., 2010; Krasny and Tidball, 2012; Colding and Barthel, 2013), no positive link between levels of use and species richness of urban green space had been clearly delineated (Krasny et al., 2014; Fors et al., 2015). The research presented here provides evidence for such a link specifically that between user participation and urban biodiversity.

As such, community participation in local management of green commons offers one means by which the usually accepted trend of decreasing species diversity associated with urbanisation (Niemelä et al., 2002; Marzluff, 2008; McDonnell and Hahs, 2008) can be redressed. In this sense, the findings of this research echo those in recent literature which have championed the value of urban domestic gardens as comprising important ecological networks which may make significant contributions to urban biodiversity conservation (Smith et al., 2006; Davies et al., 2009; Goddard et al., 2010; Goddard et al., 2013). The contribution of community gardening initiatives to such ecological networks carries with it the added potential for the creation and strengthening of social-ecological networks which, if acknowledged by agencies at higher levels of governance, could contribute to the resilience of urban resource management.

Levels of community-led ecological participation associated with increasing biodiversity potential in pockets of urban green space (see Figure 3) suggest that synergistic benefits are indeed possible for human–nature relationships in urban areas. The significance of this relationship goes beyond a simple linear relationship between community involvement in urban green space management and the biodiversity to be found within such spaces. The potential for wider positive feedbacks associated with this relationship may be significant, given the importance of biodiversity for urban ecosystem services and human well-being (Niemelä et al., 2010; Kaczorowska et al., 2015; Sandifer et al., 2015; Speak et al., 2015). By revealing a co-occurrence in levels of stakeholder involvement and biodiversity, this work provides an example of how civic ecological action can fulfil two of the key tenets shared by both the Ecosystem Approach and the Millennium Ecosystem Assessment: the centrality of biodiversity for human well-being and the decentralisation of natural resource management. Powered by stakeholder involvement, the magnitude of which (measured in volunteer hours) being directly proportional to the biodiversity measure, the civic ecological practices presented here provide a working example of how positive social-ecological feedbacks may be achieved.

The occurrence of such feedbacks, as observed in this case study, may be significantly mediated by public green space design. Specifically, biodiversity measures were influenced by site accessibility, as a function of the latter's bearing on levels of user participation (Table 5/Figure 3).
Site-specific factors related to accessibility appeared to influence levels of volunteer input at the case-study sites. Level of site access in particular was effective in delineating sites in terms of volunteer input with a moderate degree of limitation to public access appearing to be optimal for user participation (see Table 5). The data presented in Table 5 and subsequent ANOVA based on site access type revealed that sites with free "public" access exhibited much lower levels of voluntarism $month^{-1}$ compared to those with "private" and, particularly, "limited" access. Therefore, the effect of security and access on voluntarism was clearly borne out with sites surrounded by secure perimeter

fencing and employing a limited schedule of public access achieving a greater total number of volunteer hours. Accordingly, pocket parks, consisting of the lowest total area, and with limited access, exhibited the highest values for volunteer hours month^{-1} 100m^{-2} (see Table 6).

The latter observation also highlights another salient feature of the case study site assessments: that relating to site size. Standardising the data on volunteer effort month^{-1} by site area, as values 100m^{-2}, revealed that those larger sites in the case study were associated much lower voluntarism. This effect was underlined by the fact that sites in the study with total areas above 1000m^2 achieved the lowest scores for volunteer hours month^{-1} 100m^{-2} (see Table 6). This effect is not surprising, given that larger sites would naturally require greater management resources, which, in the form of volunteering effort, are only available in finite proportions within user groups. The community orchard sites in particular exhibited low values for volunteer hours standardised by site area. The size and location of these sites dictated that they did not feature any sort of perimeter security, and access was freely available to the public. Furthermore, sites were located necessarily where large amounts of green space were available, namely in or near municipal parks, recreational land and local nature reserves. This state of being "out-of-the-way" of some sites may explain to some degree why they are under-used, under-developed in terms of on-site amenities and have a smaller volunteer base than other sites. Although site access has been proposed as an issue that affects the management and sense of place associated with community-managed spaces (Kurtz, 2001), the data presented in this paper have addressed a lack of understanding concerning the physical factors affecting stakeholder involvement in urban green commons.

Another factor affecting community participation may stem from the activities which take place at each site. Community orchards are generally managed with much less intensity than gardens and allotments. Orchards involve a comparatively minimal amount of environmental engineering and, therefore there may simply be less opportunity for physical activity due to their design. That said, a greater number of volunteer hours month^{-1} were recorded at CO2 than at CO1 by a factor of four. This is likely due to the forest garden approach of CO2, a management style which involves greater structural complexity and maintenance requirements than the more traditional methods adopted at CO1. Similarly, allotments and community gardens, which combine areas designated for food production and other horticultural activities with recreational and communal spaces, require more intensive maintenance. Therefore, incorporating a greater degree of complexity and multi-functionality in the design of community orchards could significantly increase user participation. In this regard, the findings echo those of previous studies into the character of smaller community-managed gardens versus larger, more accessible green spaces: Francis (1981) concluded that such gardens offer a greater degree of interaction through, primarily horticultural, physical activity. That structural complexity, and associated management intensity, offers a basis for greater volunteer involvement has implications for user participation, well-being and the generation of local biodiversity and associated ecosystem services. Increased management requirements offer opportunities for participation with the resulting physical activity through horticultural and site maintenance promoting participant health (Hynes and Howe, 2004; Alaimo et al., 2008). In turn, as demonstrated here, site biodiversity levels grow proportional to volunteer input and, given the primacy of horticultural activity in community-managed spaces, productivity in terms of food provision may also be a key gain from more intensively managed communal spaces.

The impact of site size in particular on access, volunteer input and associated biodiversity levels would benefit from further research. That species richness is influenced by habitat size is well documented in ecological research (Rice and Kelting, 1955; Rosenzweig, 1995), but that there exists a parallel between the "colonisation" of green space by species and that by environmental volunteers is a new proposition. This aspect is worthy of further investigation given the interrelated nature of the biodiversity, use and access related to urban green space. Increasing the body of case studies on the effect of site area on user participation, species richness and the wider production of ecosystem services may reveal important trends related to species-area relationships and site size-productivity.

The positive association between voluntarism and biodiversity and the relatively lower levels of activity observed at larger sites has implications for the planning of green space at the city scale. Previous studies have highlighted the biodiversity of other micro-habitats such as urban domestic gardens (Thompson et al., 2003) and the contribution which they may make to ecological resilience in the wider landscape (Colding, 2007). The work presented here likewise supports the positive contribution of micro-habitats which, as a function of their use and multi-functionality, exhibited higher levels of species richness than did larger sites. The implication is therefore that networks of smaller community-managed spaces may support greater levels of both stakeholder stewardship and, as a result, species diversity than larger bodies of green space. User participation in green space production, if encouraged and implemented into green networks within cities could thereby provide highly desirable positive feedbacks in terms of human and environmental health and resilience.

References

AfSL (Action for Sustainable Living) n.d.. *Funders - See who funds our work and projects*. [online] Available at: http://www.afsl.org.uk/about/funders/ (accessed 15 Jan. 2015).

Alaimo, K., Packnett, E., Miles, R. and Kruger, D. 2008. Fruit and vegetable intake among urban community gardeners. *Journal of Nutrition, Education and Behavior* **40**(2): 94–101.

Aronson, M., La Sorte, F., Nilon, C., Katti, M., Goddard, M., Lepczyk, C., Warren, P., Williams, N., Cilliers, S., Clarkson, B., Dobbs, C., Dolan, R., Hedblom, M., Klotz, S., Kooijmans, J., Kuhn, I., MacGregor-Fors, I., McDonnell, M., Mortberg, U., Pysek, P., Siebert, S., Sushinsky, J., Werner, P. and Winter, M. 2014. A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. *Proceedings of the Royal Society B: Biological Sciences*. **281**(20133330): 1–8.

Barrico, L., Azul, A., Morais, M., Pereira Coutinho, A., Freitas, H. and Castro, P. 2012. Biodiversity in urban ecosystems: plants and macromycetes as indicators for conservation planning in the city of Coimbra (Portugal). *Landscape and Urban Planning*. **106**(1): 88–102.

Barthel, S., Folke, C. and Colding, J. 2010. Social-ecological memory in urban gardens: retaining the capacity for management of ecosystem services. *Global Environmental Change*. **20**(2): 255–265.

Barton, J. and Pretty, J. 2010. What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science and Technology*. **44**(10): 3947-55.

Bird, W. 2007. *Natural Thinking: Investigating the link between the Natural Environment, Biodiversity and Mental Health.* London: Royal Society for the Protection of Birds.

Burls, A. and Khan, W. 2005. Human health and nature conservation. *BMJ*. **331**: 1221–1222.

CABE (Commission for Architecture and the Built Environment). 2010. *Green Infrastructure: What Needs To Be Done?* London: CABE. Available at: http://www.cabe.org.uk/grey-to-green/what-needs-to-be-done

Cameron, R., Blanusa, T., Taylor, J., Salisbury, A., Halstead, A., Henricot, B. and Thompson, K. 2012. The domestic garden: its contribution to urban green infrastructure. *Urban Forestry and Urban Greening*. **11**(2): 129–137

Carrus, G., Scopelliti, M., Lafortezza, R., Colangelo, G., Ferrini, F., Salbitano, F., Agrimi, M., Portoghesi, L., Semenzato, P. and Sanesi, G. 2015. Go greener, feel better? The positive effects of biodiversity on the well-being of individuals visiting urban and peri-urban green areas. *Landscape and Urban Planning*. **134**: 221–228.

CBD (Convention on Biological Diversity). 2001. *Global Biodiversity Outlook*. Montreal: Secretariat of the Convention on Biological Diversity.

CBD (Convention on Biological Diversity). 2004 *The Ecosystem Approach, (CBD Guidelines)*. Montreal: Secretariat of the Convention on Biological Diversity.

Chalker-Scott, L. 2015. Nonnative, noninvasive woody species can enhance urban landscape biodiversity. *Arboriculture and Urban Forestry*. **41**(4): 173–186.

Colding, J. 2007. 'Ecological land-use complementation' for building resilience in urban ecosystems. *Landscape and Urban Planning*. **81**: 46–55.

Colding, J. and Barthel, S. 2013. The potential of ‘Urban Green Commons’ in the resilience building of cities. *Ecological Economics*. **86**: 156–166.

Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J. and Depledge, M. 2011. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Journal of Epidemiology and Community Health*. **45**(5): 1761-1772.

Costanza, R., Fisher, B., Mulder, K., Liu, S. and Christopher, T. 2007. Biodiversity and ecosystem services: a multi-scale empirical study of the relationship between species richness and net primary production. *Ecological Economics*. **61**: 478–491.

Coutts, C. 2010. Public health ecology. *Journal of Environmental Health*. **72**(6): 53–55.

Coutts, C. 2011. Putting the capital “E” environment into ecological models of health. *Journal of Environmental Health*. **74**(4): 26–29.

Davenport, M. and Anderson, D. 2005. Getting from sense of place to place-based management: an interpretive investigation of place meanings and perceptions of landscape change. *Society & Natural Resources*. **18**(7): 625–641.

Davies, Z., Fuller, R., Loram, A., Irvine, K., Sims, V. and Gaston, K. 2009. A national scale inventory of resource provision for biodiversity within domestic gardens. *Biological Conservation*. **142**(4): 761–771.

Dearborn, D. and Kark, S. 2010. Motivations for conserving urban biodiversity. *Conservation Biology*. **24**(2): 432–440.

De Bello, F., Lavorel, S., Diaz, S., Harrington, R., Cornelissen, J., Bargett, R., Berg, M., Cipriotti, P., Feld, C., Hering, D., Martins da Silva, P., Potts, S., Sandin, L., Sousa, J., Storkey, J., Wardle, D. and Harrison, P. 2010. Towards an assessment of multiple ecosystem processes and services via functional traits. *Biodiversity and Conservation.* **19**: 2873–2893.

DeCandido, R., Muir, A. and Gargiullo, M. 2004. A first approximation of the historical and extant vascular flora of New York City: implications for native plant species conservation. *Journal of the Torrey Botanical Society*. **131**(3): 243.

DECC (Department for Energy and Climate Change). 2013. *Thermal Growing Season in Central England*. London. DECC.

Defra (Department for the Environment, Food and Rural Affairs). 2010a. *What Nature Can Do for You*. London. Defra.

Defra (Department for the Environment, Food and Rural Affairs). 2010b. *An Invitation to Shape the Nature of England. London*. Defra.

Defra (Department for the Environment, Food and Rural Affairs). 2011. *The Natural Choice: Securing the Value of nature*. London. Defra.

De Vries, S., Verheij, R., Groenewegen, P. and Spreeuenberg, P. 2003. Natural environments - healthy environments? An exploratory analysis of the relationship between greenspace and health. *Environment and Planning*. **35**: 1717-1731.

Ernstson, H., Barthel, S., Andersson, E. and Borgström, S. 2010. Scale-crossing brokers and network governance of urban ecosystem services: the case of Stockholm. *Ecology and Society.* **15**(4): 28. Available at: http://www.ecologyandsociety.org/vol15/iss4/art28/

Ernstson, H., Sörlin, S. and Elmqvist, T. 2008. Social movements and ecosystem services–the role of social network structure in protecting and managing urban green areas in Stockholm. *Ecology and Society.* **13**(2): 39. Available at: http://www.ecologyandsociety.org/vol13/iss2/art39/

Falloon, P. and Betts, R. 2010. Climate impacts on European agriculture and water management in the context of adaptation and mitigation: the importance of an integrated approach. *Science of the Total Environment*. **408**(23): 5667–5687.

Foley, J., Defries, R., Asner, G., Barford, C., Bonan, G., and Carpenter, S. 2005. Global consequences of land use. *Science.* **309**(5734): 570–574.

Folke, C., Jansson, Å., Larsson, J., and Costanza, R., 1997. Ecosystem appropriation by cities. *Ambio* **26**: 167–172.

Fors, H., Frøik Molin, J., Anna Murphy, M. and Konijnendijk van den Bosch, C. 2015. User participation in urban green spaces – for the people or the parks? *Urban Forestry and Urban Greening.*

Francis, M. 1987. Meanings attached to a city park and a community garden in Sacramento. *Landscape Research*. **12**(1): 8-12.

Fraser, E., Dougill, A., Mabee, W., Reed, M. and McAlpine, P. 2006. Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management*. **78**(2): 114-127.

Freeman, C. and Buck, O. 2003. Development of an ecological mapping methodology for urban areas in New Zealand. *Landscape and Urban Planning*. **63**: 161–173.

Fuller, R., Irvine, K., Devine-Wright, P., Warren, P. and Gaston, K. 2007. Psychological benefits of greenspace increase with biodiversity. *Biology Letters*. **3**(4): 390–394.

Gidlöf-Gunnarsson, A. and Öhrström, E. 2007 Noise and well-being in urban residential environments: the potential role of perceived availability to nearby green areas. *Landscape and Urban Planning.* **83**: 115–126.

Goddard, M. A., Dougill, A. J. and Benton, T. G. 2010. Scaling up from gardens: biodiversity conservation in urban environments. *Trends in Ecology and Evolution*. **25**(2): 90–98.

Goddard, M. A., Dougill, A. J. and Benton, T. G. 2013. Why garden for wildlife? Social and ecological drivers, motivations and barriers for biodiversity management in residential landscapes. *Ecological Economics*. **86**: 258–273.

Grimm, N., Faeth, S., Golubiewski, N., Redman, C., Wu, J., Bai, X. and Briggs, J. 2008. Global change and the ecology of cities. *Science*. **319**(5864): 756–760.

Gunderson, L. and Holling, C. eds. 2002. *Panarchy: Understanding Transformations in Human and Natural Systems*. Washington, DC: Island Press.

Haines-Young, R. and Potschin, M. 2013. *Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August–December 2012*. EEA Framework Contract No EEA/IEA/09/003. Available at: http://www.cices.eu or www.nottingham.ac.uk/cem

Hansmann, R., Hug, S. and Seeland, K. 2007. Restoration and stress relief through physical activities in forests and parks. *Urban Forestry and Urban Greening*. **6**(4): 213-225.

Hardman, M. and Larkham, P. 2014. *Informal Urban Agriculture: The Secret Lives of Guerrilla Gardeners*. London. Springer.

Hartig, T., Mitchell, R., de Vries, S. and Frumkin, H. 2014. Nature and Health. *Annual Review of Public Health*. **35**: 207-228.

Hynes, H. and Howe, G. 2004. Urban horticulture in the contemporary United States: personal and community benefits. *Acta Horticulturae*. **643**: 171–181. DOI: 10.17660/ActaHortic.2004.643.21

Jackson, L. 2003. The relationship of urban design to human health and condition. *Landscape and Urban Planning*. **64**(4): 191–200.

Kaczorowska, A., Kain, J., Kronenberg, J. and Haase, D. 2015 (in press). Ecosystem services in urban land use planning: integration challenges in complex urban settings: case of Stockholm. *Ecosystem Services*.

Kaplan, S. 1995. The restorative benefits of nature: toward an integrative framework. *Journal of Environmental Psychology*. **15**(3): 169–182.

Kazmierczak, A., Connelly, A., and Sherriff, G. 2013. *Growing Manchester Programme Final Evaluation Report*. Manchester: University of Manchester Press.

Kim, K. and Pauleit, S. 2005. Landscape metrics to assess the ecological conditions of city regions: application to Kwangju City, South Korea. *International Journal of Sustainable Development & World Ecology.* **12**(3): 227–244.

Kindling Trust. 2015. *Funders & Supporters The Kindling Trust*. Available at: http://kindling.org.uk/funders-supporters [accessed 15 Jan. 2015].

Kingsley, J., Townsend, M. and Henderson-Wilson, C. 2009. Cultivating health and wellbeing: members' perceptions of the health benefits of a Port Melbourne community garden. *Leisure Studies*. **28**(2): 207–219.

Kong, F., Yin, H., Nakagoshi, N. and Zong, Y. 2010. Urban green space network development for biodiversity conservation: identification based on graph theory and gravity modeling. *Landscape and Urban Planning*. **95**(1–2): 16–27.

Kowarik I. 1995. On the role of alien species in urban flora and vegetation. In: Pyšek P., Prach K., Rejmánek M. and Wade M. eds. *Plant Invasions: General Aspects and Special Problems*. Amsterdam: SPB Academy, pp. 85–103.

Kowarik, I. 2011. Novel urban ecosystems, biodiversity, and conservation. *Environmental Pollution.* **159**(8–9): 1974–1983.

Krasny, M., Russ, A., Tidball, K. and Elmqvist, T. 2014. Civic ecology practices: Participatory approaches to generating and measuring ecosystem services in cities. *Ecosystem Services*. **7**:177-186.

Krasny, M. and Tidball, K. 2012. Civic ecology: a pathway for Earth Stewardship in cities. *Frontiers in Ecology and the Environment*. **10**(5): 267–273.

Krasny, M. and Tidball, K. 2015. *Civic Ecology: Adaptation and Transformation from the Ground Up*. Cambridge, MA: MIT Press.

Kudryavtsev, A., Krasny, M. and Stedman, R. 2012. The impact of environmental education on sense of place among urban youth. *Ecosphere*. **3**(4): 1–15.

Kuhn, I. and Klotz, S. 2006. Urbanization and homogenization: comparing the floras of urban and rural areas in Germany. *Biological Conservation*. **127**(3): 292–300.

Kuo, F., Bacaicoa, M. and Sullivan, W. 1998. Transforming inner-city landscapes: trees, sense of safety and preference. *Environment and Behavior*. **30**(1): 28–59.

Kuo, F. and Sullivan, W. 2001. Environment and crime in the inner city: does vegetation reduce crime? *Environment and Behaviour*. **33**: 343–367.

Kurtz, H. 2001. Differentiating multiple meanings of garden and community. *Urban Geography*. **22**(7): 656–670.

Lin, B., Philpott, S. and Jha, S. 2015. The future of urban agriculture and biodiversity-ecosystem services: challenges and next steps. *Basic and Applied Ecology*. **16**(3): 189–201.

Lockwood, R. 2009. *Hulme Community Garden Centre Annual Report*. [ebook] Manchester. Hulme Community Garden centre, p. 5. Available at: http://hulmegardencentre.org.uk/doc/AnnualReport2008.pdf

Maas, J., Verheij, R., de Vries, S., Spreeuwenberg, P., Schellevis, F. and Groenewegen, P. 2009. Morbidity is related to a green living environment. *Journal of Epidemiology and Community Health*. **63**(12): 967-973.

Maas, J., Verheij, R., Groenewegen, P., de Vries, S. and Spreeuwenberg, P. 2006. Green space, urbanity, and health: how strong is the relation? *Journal of Epidemiology and Community Health*. **60**(7): 587–592.

Mace, G., Norris, K. and Fitter, A. 2012. Biodiversity and ecosystem services: a multilayered relationship. *Trends in Ecology and Evolution*. **27**(1): 19–26.

Maller, C., Townsend, M., Pryor, A. and Brown, P. 2006. Healthy nature, healthy people: 'contact with nature' as an upstream health promotion intervention for populations. *Health Promotion International*. **21**(1): 45–54.

Marcus, C. and Sachs, N. 2013. *Therapeutic Landscapes: An Evidence-Based Approach to Designing Healing Gardens and Restorative Outdoor Spaces*. New Jersey: Wiley and Sons.

Marselle, M., Irvine, K. and Warber, S. 2014. Examining Group Walks in Nature and Multiple Aspects of Well-Being: A Large-Scale Study. *Ecopsychology*. **6**(3): 134-147.

Marzluff, J. 2008. *Urban Ecology*. New York. Springer Science and Business Media.

McDonnell M. and Hahs A. 2008. The use of gradient analysis studies in advancing our understanding of the ecology of urbanizing landscapes: current status and future directions. *Landscape Ecology*. **23**: 1143–1155.

McKinney, M. 2006. Urbanization as a major cause of biotic homogenization. *Biological Conservation*. **127**(3): 247–260.

McKinney, M. 2008. Effects of urbanisation on species richness: a review of plants and animals. *Urban Ecosystems*. **11**: 161–176.

MEA (Millennium Ecosystem Assessment). 2005*. Ecosystems and Human Well-being: Health Synthesis.* Washington, DC: Island Press.

Metcalf, S. and Widener, M. 2011. Growing Buffalo's capacity for local food. *Applied Geography.* **31**(4): 1242–1251.

Mitchell, R. and Popham, F. 2007. Greenspace, urbanity and health: relationships in England. *Journal of Epidemiology and Community Health*. **61**(8): 681-683.

Natural England. 2014. Indicator: S&E06_S: Number of volunteer hours on NIA activity. Available at: http://nia.naturalengland.org.uk/protocols/S&E06_S.pdf (accessed 14 September 2015).

Nelson, E., Mendoza, G., Regetz, J., Polasky, S., Tallis, H., Cameron, D., Chan, K., Daily, G., Goldstein, J., Kareiva, P., Lonsdorf, E., Naidoo, R., Ricketts, T. and Shaw, M. 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment*. **7**(1): 4–11.

Niemelä, J., Kotze, D. J., Venn, S., Penev, L., Stoyanov, I., Spence, J., Hartley, D. and Montes de Oca, E. 2002. Carabid beetle assemblages (Coleoptera, Carabidae) across urban-rural gradients: an international comparison. *Landscape Ecology.* **17**: 387–401.

Niemelä, J., Saarela, S., Söderman, T., Kopperoinen, L., Yli-Pelkonen, V.,Väre, S. and Kotze, D. 2010. Using the ecosystem services approach for better planning and conservation of urban green spaces: a Finland case study. *Biodiversity and Conservation*. **19**(11): 3225–3243.

ODPM (Office of the Deputy Prime Minister). 2004. *Creating Sustainable Communities: Greening the Gateway*. London. ODPM.

Okvat, H. and Zautra, A. 2011. Community gardening: a parsimonious path to individual, community, and environmental resilience. *American Journal of Community Psychology*. **47**(3–4): 374–387.

Orsini, F., Gasperi, D., Marchetti, L., Piovene, C., Draghetti, S., Ramazzotti, S., Bazzocchi, G. and Gianquinto, G. 2014. Exploring the production capacity of rooftop gardens (RTGs) in urban agriculture: the potential impact on food and nutrition security, biodiversity and other ecosystem services in the city of Bologna. *Food Security*. **6**(6): 781–792.

Pauchard, A. and Shea, K. 2006. Integrating the study of non-native plant invasions across spatial scales. *Biological Invasions*. **8**(3): 399–413.

Pretty, J., Peacock, J., Hine, R., Sellens, M., South, N. and Griffin, M. 2007. Green exercise in the UK countryside: effects on health and psychological well-being, and implications for policy and planning. *Journal of Environmental Planning and Management*. **50**(2): 211–231.

Pretty, J., Peacock, J., Sellens, M. and Griffin, M. 2005. The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research*. **15**(5): 319–337.

Pudup, M. 2008. It takes a garden: cultivating citizen-subjects in organized garden projects. *Geoforum*. **39**(3): 1228–1240.

Rice, E. and Kelting, R. 1955. The species-area curve. *Ecology*. **36**(1): 7–11.

Ritvo, H. 2010. *The Dawn of Green: Manchester, Thirlmere and Modern Environmentalism.* Chicago: University of Chicago Press.

Rosenzweig, M. 1995. *Species Diversity in Space and Time*. Cambridge: Cambridge University Press.

Rosol, M. 2010. Public Participation in Post-Fordist Urban Green Space Governance: The Case of Community Gardens in Berlin. *International Journal of Urban and Regional Research*. **34**(3): 548-563.

Rupprecht, C., Byrne, J., Garden, J. and Hero, J.-M. 2015. Informal urban green space: a trilingual systematic review of its role for biodiversity and trends in the literature. *Urban Forestry and Urban Greening*. DOI: http://dx.doi.org/10.1016/j.ufug.2015.08.009

Sandifer, P., Sutton-Grier, A. and Ward, B. 2015. Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: opportunities to enhance health and biodiversity conservation. *Ecosystem Services*. **12**: 1–15.

Satterthwaite, D. 2009. The implications of population growth and urbanization for climate change. *Environment and Urbanization*. **21**(2): 545–567.

Smith, R., Thompson, K., Hodgson, J., Warren, P. and Gaston, K. 2006. Urban domestic gardens (IX): composition and richness of the vascular plant flora, and implications for native biodiversity. *Biological Conservation* **129**(3): 312–322.

Speak, A., Mizgajski, A. and Borysiak, J. 2015. Allotment gardens and parks: provision of ecosystem services with an emphasis on biodiversity. *Urban Forestry and Urban Greening*. http://dx.doi.org/10.1016/j.ufug.2015.07.007

Stedman, R. C. 2003. Sense of place and forest science: toward a program of quantitative research. *Forest Science*. **49**: 822–829.

Stein B., Kutner L. and Adams J. 2000. *Precious Heritage*. Oxford. Oxford University Press

Stringer, L., Dougill, A., Fraser, E., Hubacek, K., Prell, C. and Reed, M. 2006. Unpacking "participation" in the adaptive management of social–ecological systems: a critical review. *Ecology and Society* **11**(2): 39. Available at: http://www.ecologyandsociety.org/vol11/iss2/art39/

TEEB (The Economics of Ecosystems and the Environment). 2008. *An Interim Report*. Wesseling: European Communities.

Thompson, K., Austin, K., Smith, R., Warren, P., Angold, P. and Gaston, K. 2003. Urban domestic gardens (I): Putting small-scale plant diversity in context. *Journal of Vegetation Science*. **14**(1): 71.

Thompson, K. and A. Jones. 1999. Human population density and prediction of local plant extinction in Britain. *Conservation Biology*. **13**: 185-189.

Tidball, K. and Stedman, R. 2013. Positive dependency and virtuous cycles: from resource dependence to resilience in urban social-ecological systems. *Ecological Economics*. **86**: 292–299.

Townsend, M. 2006. Feel blue? Touch green! Participation in forest/woodland management as a treatment for depression. *Urban Forestry and Urban Greening*. **5**(3): 111–120.

Tratalos, J., Fuller, R., Warren, P., Davies, R. and Gaston, K. 2007. Urban form, biodiversity potential and ecosystem services. *Landscape and Urban Planning*. **83**: 308–317.

Tscharntke, T., Clough, Y., Wanger, T., Jackson, L., Motzke, I., Perfecto, I., Vandermeer, J. and Whitbread, A. 2012. Global food security, biodiversity conservation and the future of agricultural intensification. *Biological Conservation*. **151**(1): 53–59.

Tscharntke, T., Klein, A., Kruess, A., Steffan-Dewenter, I. and Thies, C. 2005. Landscape perspectives on agricultural intensification and biodiversity: ecosystem service management. *Ecology Letters.* **8**(8): 857–874.

Tzoulas, K. and James, P. 2010. Making biodiversity measures accessible to non-specialists: an innovative method for rapid assessment of urban biodiversity. *Urban Ecosystems*. **13**: 113–127.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemelä, J. and James, P. 2007. Promoting ecosystem and human health in urban areas using Green Infrastructure: a literature review. *Landscape and Urban Planning*. **81**(3): 167–178.

UK NEA (United Kingdom National Ecosystem Assessment). 2011. *UK National Ecosystem Assessment: Understanding Nature's Value to Society.* London. UK NEA.

United Nations, Department of Economic and Social Affairs. 2007. *World Urbanisation Prospects: 2007 Revision*. New York: United Nations.

von Shirnding, Y. 2002. Health and sustainable development: can we rise to the challenge? *The Lancet*. **360**(9333): 632–637.

Wakefield, S., Yeudall, F., Taron, C., Reynolds, J. and Skinner, A. 2007. Growing urban health: community gardening in South-East Toronto. *Health Promotion International*. **22**(2): 92–101.

Waldhardt, R. 2003. Biodiversity and landscape: summary, conclusions and perspectives. *Agriculture, Ecosystems & Environment*. **98**(1–3): 305–309.

Wall, D. and Nielsen, U. 2012. Biodiversity and ecosystem services: is it the same below ground? *Nature Education Knowledge.* **3**(12): 8.

Ward Thompson, C., Aspinall, P. and Roe, J. 2014. Access to Green Space in Disadvantaged Urban Communities: Evidence of Salutogenic Effects Based on Biomarker and Self-report Measures of Wellbeing. *Procedia - Social and Behavioral Sciences*. **153**: 10-22.

Westmacott, R. and Worthington, T. 1994. *Agricultural Landscapes: A Third Look.* Northampton: Countryside Commission.

WHO (World Health Organisation). 2005. *Ecosystems and Human Well-Being: Health Synthesis*. Geneva. WHO.

Williams, D. and Stewart, S. I. 1998. Sense of place: an elusive concept that is finding a home in ecosystem management. *Journal of Forestry*. **96**(5): 18–23.Worm, B., Barbier, E., Beaumont, N., Duffy, J., Folke, C., Halpern, B., Jackson, J., Lotze, H., Micheli, F., Palumbi, S., Sala, E., Selkoe, K., Stachowicz, J. and Watson, R. 2006. Impacts of biodiversity loss on ocean ecosystem services. *Science*. **314**(5800): 787–790.