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# Where have all the parks gone? Changes in Dublin's green space between 1990 & 2006

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## Abstract

Between 1990 and 2006, the Dublin Region was amongst the most rapidly growing urban areas in Europe. The increase in population and industry presents particular challenges for spatial planning. The aim of the Urban Environment Project (UEP, [www.uep.ie](http://www.uep.ie)) is to provide spatial data and forecasts of future land-use patterns by using dynamic urban modelling which will underpin the development of decision-support tools for planners and policy-makers. For this study, we are using UEP landcover datasets to specifically address the question of what changes in urban green space (GS) occurred over a period of rapid growth (1990 – 2006). GS provides many functions within a city, ranging from the biotic (habitat provision, corridors of dispersal, reservoir populations) to the abiotic (storm water control, carbon sequestration, temperature regulation, increased property values). Over the study period (1990 – 2006) artificial urban surfaces have increased by 30% (by 8926 ha). Although the overall percentage of GS to built fabric stayed roughly constant over time (at about 23%), the losses and gains of GS were not evenly distributed throughout the city. GS was mainly lost near the city centre, where it converted to built areas. The GS gained was at the perimeter of the city to the detriment of agricultural land and semi-natural vegetation types. The result is a net loss of vegetated surfaces both within and outside the city. We discuss the possible implications of these changes in Dublin's GS.

**Keywords:** *Green space; landuse change; biodiversity; development; Dublin.*

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## 1 Introduction

This study provides a summary of landcover changes, in particular the changes in urban green space (GS), within the four local authorities (Fingal, Dublin City, South Dublin and Dún Laoghaire-Rathdown) containing and surrounding Dublin City over the period 1990 – 2006, and discusses the implications of those changes for urban biodiversity, urban heat island and storm events.

## 2 Dublin City: boom town

Dublin City and the surrounding regions have undergone unprecedented economic growth in the past decade (Williams and Shiels, 2002). It is the dominant factor of the urban landscape of Ireland in terms of demography, employment and enterprise (Bannon et al., 2000). Population growth and economic development, as well as house type and price, were significant drivers of land-use change in

the Greater Dublin Area. As house prices rose in Dublin, many people were pushed towards the rural fringes of the city where it was cheaper to buy or build a house. Personal housing preferences also played an important role as rural living is considered the Irish housing ideal (Mitchell, 2004). This preference is realised in single-family houses in open countryside with the benefits of the proximity to the capital or other urban areas. A planning regime which imposed few constraints on the conversion of agricultural areas to low-density housing areas facilitated this realisation. Nearby rural towns and villages grew at the expense of Dublin City as urban-rural migration continued, with growth radiating outward along the lines of road and rail transport links (Williams et al., 2007). The city's transport system contributed to this trend. Commuting times within Dublin are long and the lack of orbital roads and rail networks means that to get from one side of the city to the other often necessitates a journey through the centre. It is frequently quicker to commute from outside Dublin to the centre rather than from one side to the other (EEA, 2006). As housing prices, and hence land prices, rose many areas

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of GS were converted to residential, commercial and transport uses.

Defining what one means by ‘green space’ can be difficult. As noted by Lofvenhaft et al. (2002) urban ecological data is often heterogeneous in nature, with differing terminology leading to confusion of the terms nature, park, green space etc. A city contains a range of green spaces, from managed parks and sports pitches to fragments of semi-natural areas (Savarda et al., 2002). For the purposes of this paper GS, is all vegetated areas within or adjacent to the urban fabric within Dublin, such as public parks, sports pitches, golf courses, and relict stands of semi-natural vegetation.

### 3 Greenspace

It has long been established that the area of GS is an important determinant correlated with species richness, and hence biodiversity (Angold et al., 2006; Chamberlain et al., 2007). Large patches are also more successful at intercepting migrant organisms, hence patch area affects the abundance and richness of the community it supports (Gutzwiller et al., 1992). Besides the gross physical dimensions of patches of GS, patch shape influences both the community structure and the physical conditions within the patch (Hamazaki, 1996). The effects of patch shape vary between species. It would be expected that elongated patches (i.e. high perimeter-area ratios) would intercept more motile species. This can be the case (Hamazaki, 1996) but it can also have the opposite effect, whereby area sensitive species avoid edge habitat, which becomes proportionally more of the total patch area as patch shape becomes more elongated (Davis, 2004). This effect is particularly evident in small patches (von Haaren and Reich, 2006).

It is important to note that the methodology of assessing patch shape can be scale dependent. Simple measures of shape, e.g. perimeter-area ratios, can vary with the size of the patch, i.e. holding shape constant, an increase in patch size will cause a decrease in the perimeter-area ratio. To avoid this scale dependency more complex methods of shape assessment must be employed; e.g. measuring the complexity of patch shape compared to a standard shape (square or almost square) of the same size (Patton, 1975).

When considering land-use change it is important to consider the nature of that change, i.e. the nature of the current land-use in contrast to its previous condition. This is important from many perspectives. Some land-use change has obvious con-

sequences, e.g. conversion from vegetated to built surface results in reduced habitat space, carbon sequestration capacity, evapotranspirational cooling, etc. Others are not so clear cut, e.g. the conversion from agricultural to park lands may have a positive or negative effect on the local ecology depending on original farming practices (Bracken and Bolger, 2006) versus park design (Colding, 2007). Thus it is important to track the types of land-use change that occur so these effects can be investigated.

The layout of GS within a city affects the biotic and abiotic processes within that city. As has been noted (Pauleit and Duhme, 2000; Tso, 1996; Whitford et al., 2001), the amount of GS cover within a city has a profound effect on the daytime temperature, and the amount of run-off that must be dealt with after precipitation events (Bolund and Hunhammar, 1999). Urban GS has been described as islands of habitat surrounded by an ‘urban ocean’ (Fernandez-Juricic and Jokimaki, 2001). These ‘islands’ not only provide habitat for species but can also act as corridors that aid dispersal (Forman and Baudry, 1984; Spellerberg and Gaywood, 1993). As these ‘islands’ disappear due to development it becomes increasingly difficult for populations of flora and fauna to ‘island-hop’, that is, to disperse through the urban fabric. As populations become increasingly isolated from each other the risk of local extinction rises and the process of (re-) colonisation becomes more problematic (von Haaren and Reich, 2006).

### 4 Objectives

The objectives of this study were to examine:

- The change in overall characteristics of GS in the city, i.e. area and shape between patches of GS.
- The conversion history of GS, i.e. what land-use classes GS has been converted to or created from.
- The spatial configuration of losses and gains of GS within the city boundaries over the period 1990 – 2006.

### 5 Methodology

#### 5.1 Land-use dataset

The land-use dataset was created by digitising high resolution satellite imagery of the region using the MOLAND (Modelling land-use Dynamics) nomen-

clature<sup>1</sup>, an extension of the hierarchical nomenclature of CORINE (Coordination of Information on the Environment) with a specific focus on urban development. The minimum mappable unit (MMU) employed for the MOLAND dataset is one hectare in urban areas and three hectares in rural areas. The 2006 dataset was generated by ERA Maptec Ltd. using the 2000 MOLAND dataset and optical satellite imagery acquired for the reference year of 2006. The images included one high resolution scene from the Quickbird satellite and a number of medium resolution scenes from the French sensor, SPOT 5. In many cases, photo interpretation was assisted by the use of ancillary spatial datasets and County Development Plans (CDPs). To backdate to 1990, imagery for 1990 was re-interpreted and incorporated into the dataset. All time periods were represented in this single dataset. The dataset was interrogated using the ESRI ArcMap Geographic Information System (GIS).

## 5.2 Analysis of GS characteristics over time

### 5.2.1 GS area and perimeter

Within the study area changes in the total area covered by GS, mean GS patch area and perimeter and range of GS patch area and perimeter were calculated using GIS.

### 5.2.2 Measures of Shape

FRAGSTATS is a computer software program designed to compute a wide variety of landscape metrics for categorical map patterns. Two FRAGSTATS metrics were used; shape index and fractal dimension index, to assess the shape of GS patches within Dublin in 1990 and 2006.

*Shape Index (SI)*: This unitless metric corrects for the size problem of the perimeter-area ratio index (see above) by adjusting for a square (or almost square) standard and, as a result, is the simplest and perhaps most straightforward measure of overall shape complexity. This metric is derived by dividing patch perimeter by the minimal possible patch perimeter for a maximally compact patch of the corresponding patch area. Shape index has a range of values from 1 to  $\infty$ ; a value of 1 is returned when the patch is maximally compact (i.e., square or almost square) and increases without limit as patch shape becomes more irregular.

*Fractal Dimension Index (FDI)*: This is a more complex unitless shape metric. FDI is calculated

as twice the logarithm of patch perimeter divided by the logarithm of patch area; the perimeter is adjusted to correct for the raster bias in perimeter. Values can range between 1 and 2, 1 for shapes with very simple perimeters such as squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters. Using this metric is appealing because it reflects shape complexity across a range of patch sizes.

### 5.3 Examination of the conversion history of Dublin's GS stock

Using ArcMap, all GS patches within the study area were identified as belonging to one of three categories:

- unchanged between 1990 and 2006;
- patches that converted to GS from another land-use over the time period; and
- patches that converted from GS to another land-use over the time period.

The data for these patches were exported to MS Excel and analysed.

### 5.4 Examination of spatial distribution of GS

Using ArcMap the percentage of GS patches within each of the three categories were found within 1 km, 5 km, 7.5 km, 10 km and 20 km of the city centre, taken as O'Connell Bridge (53° 20' 50"N, 6° 15' 33"W).

## 6 Results

### 6.1 Change in overall GS characteristics

The total urban surface (including the built environment as well as GS) of Dublin increased from 29,694 ha in 1990 to 39,263 ha in 2006, which is a gain in urban surface of 32% over these 16 years (Figure 1).

An extra 73 patches of green space have appeared in Dublin over the period between 1990 and 2006 (Figure 2, Table 1). This corresponds to an absolute increase in total GS area from 7,137 ha to 9,271 ha and an increase in the total perimeter of GS. However, the percentage of urban surface covered in GS stayed constant at around 24% over this time period (Table 1).

### 6.2 Shape

Although Dublin gains 2134.13 ha of GS, with a corresponding increase of 228.24 km GS perimeter

<sup>1</sup> Further details of the MOLAND landcover classes can be found at <http://moland.jrc.ec.europa.eu/>

**Table 1** – Green space in Dublin: 1990, 2006 and change.

	Units	1990	2006	Change
No. of patches	–	911	984	73
Total GS area	(ha)	7137	9271	2134
% of total urban surface	(%)	24.0	23.6	–0.4
Minimum patch area	(ha)	>0.01	>0.01	0.00
Maximum patch area	(ha)	575	575	0.00
Total GS perimeter	(m)	1,102,674	1,330,914	228,240
Minimum patch perimeter	(m)	185.73	304.52	118.80
Maximum patch perimeter	(m)	23,021.45	23,021.45	0.00

**Table 2** – Shape metrics. Both the mean patch shape and patch shape corrected for patch size are shown.

	Shape Index (SI)		Fractal Dimension Index (FDI)	
	Mean	Area Weighted	Mean	Area Weighted Mean
1990	1.6707	2.4045	1.1165	1.1819
2006	1.7102	2.5023	1.1198	1.1877
Change	0.0395	0.0978	0.0033	0.0058

FRAGSTATS metrics suggest shape complexity remains relatively unchanged between the time periods (Table 2, on page 4).

### 6.3 Conversion history of GS patches

Table 3 provides a summary of the land-use change to and from GS. 295 patches convert from another land-use to GS and 222 convert from GS to another land-use. However 281 of the patches that become GS were originally vegetated, whereas only two of the 1990 GS patches change to another vegetated land-use by 2006. Thus there is a net loss of 206 vegetated patches between 1990 and 2006.

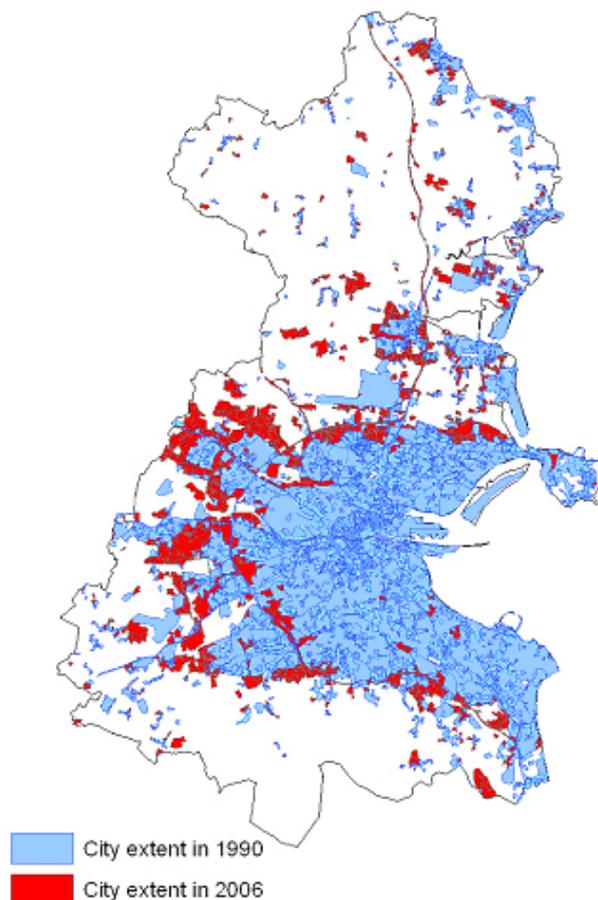
In terms of area lost, these 206 patches correspond to 596.6 ha of vegetated space; to put this in context the Phoenix Park (Europe’s largest urban park) has an area of 709 ha (McElligott et al., 2002).

### 6.4 Spatial distribution of losses and gains of GS

The loss and acquisition of GS patches by the city is spatially uneven. Over 60% of the GS lost is within 7.5 km of the city centre, while only 20% of the new GS patches are within this area (Figure 3). It should be noted that of the GS patches extant in 1990, 22.61% have converted to built land-uses by 2006.

## 7 Discussion

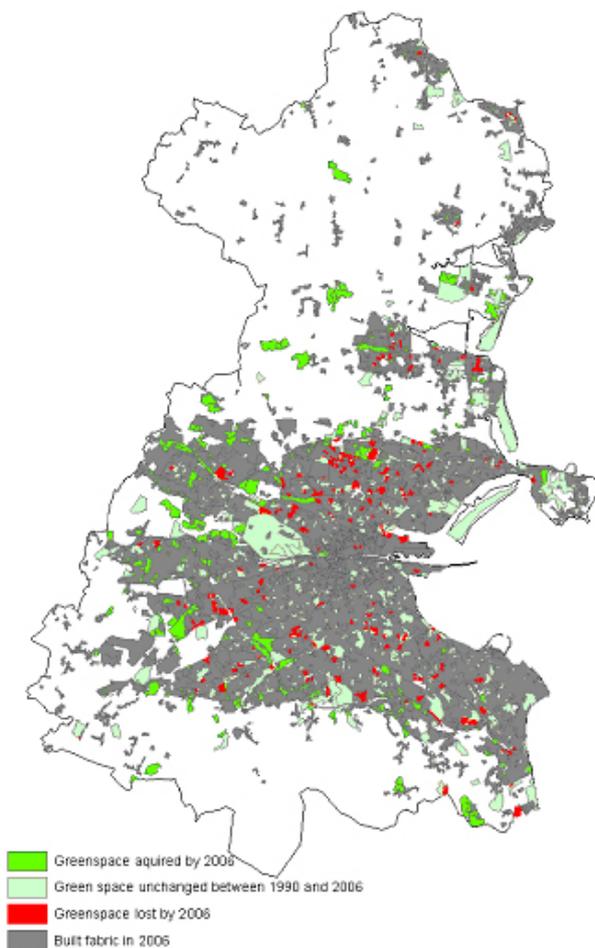
What do the results tell us about GS in the Dublin region? Clearly, the GS present in 1990 has undergone considerable change by 2006. Some areas that were formerly GS have changed to another land-use and vice versa. The loss of GS from Dublin’s centre



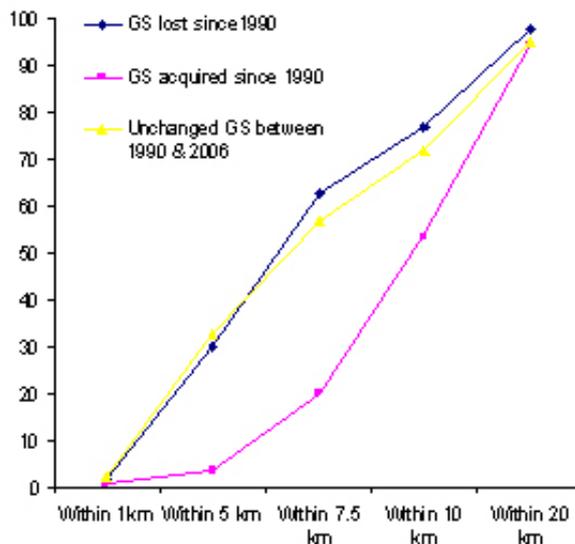
**Figure 1** – Growth of urban surfaces (including the built environment as well as green space) within the Dublin counties between 1990 and 2006. Blue denotes the city’s extent in 1990 and red its extent in 2006.

**Table 3** – Summary of green space changes from 1990 land-use to 2006 land-use.

Green space Acquired since 2006	No. of patches	Area (ha)
Total conversions from vegetated surfaces to GS	281	2738.06
Total conversions from built surfaces to GS	14	100.57
Total	295	2838.63
Green space Lost by 2006	No. of patches	Area (ha)
Total conversions from GS to vegetated surfaces	2	7.32
Total conversions from GS to built surfaces	220	697.17
Total	222	704.49
Net loss of GS		596.6



**Figure 2** – Change in greenspace within the Dublin counties between 1990 and 2006. Grey denotes built fabric in 2006, red denotes green space lost by 2006, bright green denotes green space acquired by 2006 and light green denotes green space unchanged between 1990 and 2006.



**Figure 3** – The percentage of GS patches within 1 km, 5 km, 7.5 km, 10 km and 20 km of the city centre.

is concurrent with the current trend of ‘compaction’ recommended by the CEC (1990), where new development takes place on land already within the city limits. Initially advocated as a way of increasing space for city dwellers while at the same time reducing transport, energy and material consumption (Breheny, 1997) compaction tends to result in loss of GS within a city as undeveloped land becomes increasingly valuable (Sandstrom et al., 2006). There is a wealth of evidence to now conclude that any compaction of a city must be carefully planned to address the effects of loss of GS within a city (Farber et al., 2006; Lofvenhaft et al., 2002; Tso, 1996; Whitford et al., 2001), and even the Irish government is taking note (Natura Environmental Consultants, 2008).

There are several biotic consequences associated with changes to and from GS. Let us examine changes to GS first. In 2006, 295 patches previ-

ously classified as another land-use have become GS. However the majority (281) of these patches were originally classified as a vegetated area of some type (e.g. forest, pasture, etc.). The effect on biodiversity is difficult to interpret. For example two patches convert from broad-leaf forest to GS, this likely would negatively impact biodiversity as woodland species would lose habitat and park management could include clearing understory vegetation to discourage antisocial behaviour (Jones, 2002). The other 279 patches convert from some form of agricultural use to urban green space. As the city expands former farmlands are absorbed and land once used for grazing or cereals becomes parks, pitches and play areas. It is well known that agricultural practices can lead to reductions in biodiversity (van der Valk, 2002), so to assess the net change in biodiversity more information is needed regarding the original farming practices and subsequent park management styles of the affected areas.

In contrast to the above, of the 222 patches which change from GS to another land-use, only 2 change to a vegetated land-use (pasture), the rest becoming some form of built land. This has the obvious consequence of reducing potential habitat for flora and fauna.

Thus we see that the initial results reporting a net gain of 73 patches of GS are misleading. When we discount conversions to or from vegetated areas to GS it becomes apparent that Dublin loses 206 patches of vegetated area, which together account for almost 600 ha. This most likely has very negative implications for biodiversity. Most of the loss of GS occurs adjacent to or in close proximity to other GS patches; this is likely to isolate the remaining patches and impede the flow of organisms between the city and the surrounding countryside (Figure 2).

The conversion of almost 600 ha of vegetated area to urban fabric will alter the energy and material flow through the city. As has already been mentioned, the abiotic effects of a loss of urban GS are detrimental (Tso, 1996; Whitford et al., 2001). Most of the GS lost is within about 7 km of the city centre (see Figure 2). As more GS is lost to impermeable artificial surfaces this will likely increase the urban heat island and increase run off during precipitation events. The data suggest the need to monitor such changes. Since Ireland's climate is predicted to become increasingly seasonally extreme with increases in both average winter precipitation (Sweeny and Fealy, 2002) and 'extreme precipitation events' (Dunne et al., 2008), this loss of GS can be expected to exacerbate flood events.

Clearly, examining GS in isolation is not sufficient to consider the effect changes in land-use have had on the biodiversity of Dublin City. Further work is needed to examine the changes to all types of vegetated land in and around Dublin City, as this will provide a truer picture of how Dublin's flora has been altered during this period of unprecedented development. Also, while the UEP datasets allow researchers to visualise changes in landcover at a fine spatial scale over time, the resolution is still too coarse to capture biologically important features such as tree lines, hedgerows and, possibly most important in this context, private gardens. These features are important as they can connect otherwise distant areas of GS (Diekotter et al., 2008; Forman and Baudry, 1984; Gaston et al., 2005). A next step in our work will be to assess the extent of the private garden stock in Dublin using remote sensing (Mathieu et al., 2007) and examine the connectivity between areas of GS within the city.

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