FLOWERING MEADOWS, A BIODIVERSE ALTERNATIVE TO LAWNS IN MEDITERRANEAN URBAN SPACES.

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ABSTRACT

The rate of expansion of cities and the subsequent loss of biodiversity demand an approach with a strong focus on local ecology when tackling landscape architecture projects. The Mediterranean landscape is rich in flora and is characterised by a seasonal dynamic that confers on it a value which is unique in Europe. Green spaces are exceptional places that are not only able to accommodate a variety of user functions, but also favour natural processes that bring the public close to nature. This paper attempts to explore the role that green spaces can play in developing biodiversity in urban and peri-urban areas by means of alternatives to the extensive use of lawns, such as flowering meadows. Two cases studies of the implementation of this alternative in the heart of the Iberian Peninsula are presented. The monitoring of the evolution of these case studies throughout the year raises new questions and issues for landscape architecture projects in the Mediterranean context.

1. Introduction

In the landscape of urban green spaces, planting design determines the structure of parks and gardens, their form and potential use, regardless of the scale of the project. The morphological properties and spatial distribution of vegetation condition the visual impact and the resulting aesthetic experience. The parks and gardens of our cities and, by extension, green spaces are most often the places where people interact with 'nature' (Dunnett & Hitchmough, 2004).

The three criteria identified as being necessary for a good planting design, ensuring that it contributes to a better quality of life in cities are; functionality, the link with the environment or ecology, and aesthetics (Robinson, 2006). Landscape architecture projects work with dynamic processes and a high degree of uncertainty (Prominski, 2005; Corner, 2001). Once constructed they are subject to changes that occur over time, in such a way that the plant communities in the initial design proposal are modified in species composition and coverage, due as much to the natural dynamism of their life cycle, as to their interaction with living organisms, including man, and with the environment. As a result the landscape will change with the seasons and over the years, responding to complex ecological processes and human management (Clément, 2007; Dunnett, Swanick & Woolley, 2002; Dunnett & Hitchmough, 2004).

There are three main problems associated with current urban planning for green spaces in Spain; high maintenance costs, excessive water consumption and underuse, often related to the extensive use of lawns as in neighbouring Mediterranean countries (Castro and Ponte-e-Sousa, 2012).

It is the design and objectives of the use of these areas more than the spaces themselves that are called into question. A change in traditional concepts of green spaces is called for where they begin to be considered as a network of free spaces (Fariña and Naredo, 2010). A key issue in addressing these spaces is their multi-functionality, and the consequent need to replace the concept of a residual amorphous green space with one that responds to current challenges (Matos, 2010). One of the structural elements of the landscape that play

a major role in landscape projects is groundcover. Faced with a public demand for year-round green areas, little care has been taken in the specification of groundcover species in many of the green spaces in new urban developments in Spain. In many cases this has been done taking for granted the need for watering and maintenance associated with lawns, often justifying their implementation merely on grounds of aesthetics or low initial planting costs.

Considerable progress has been made in the design of efficient irrigation systems and in new technologies for reducing water and energy consumption. However relatively little research associated to the search for alternatives to grass lawns has been carried out. In a Europe whose relationship with nature and its landscapes are increasingly fragmented there are few innovative projects based on the promotion of biodiversity and valuing the dynamic nature of the Mediterranean landscape.

1.1. A brief history of the use of lawns

The use of cut prairies as a structural element of the landscape in landscape projects dates back to the seventeenth century when André Le Nôtre designed the Vaux le Viconte Gardens in Maincy, France for Nicolas Fouquet. Prairies were used again in Versailles, where they were given the name *Tapis vert*, to mark the central axis leading to the Grand Canal, directing the sight towards the sculpture of Apollo. Although the lawns of that era were not like current lawns, as their appearance was not as homogenous and they contained a greater diversity of species, their maintenance required systematic manual mowing to maintain their ornamental qualities. However they did not require the irrigation that would have been necessary elsewhere in drier climes such as Southern Europe (Filippi, 2011).

When the landscape style pioneered by the Englishman William Kent burst onto the scene in the eighteenth century, it broke with the marked geometric structure of the French Baroque garden and lawns once again became the protagonists of any naturalist designs in the art of gardening. The English School, with Capability Brown at its head, made lawns fashionable among the British aristocracy. With views of extensive lawns, gently rolling hills and abundant water dominated by a manor house with infinite landscapes bordered by

lawns and woods. From England the fashion would reach the properties of the most influential figures in the United States. From their beginnings, the main drawback of lawns was the need for frequent mowing. In 1868 the lawnmower was invented in England and the first manual spiral lawnmower reached the United States of America. In 1919 the lawnmower engine became available and increasingly affordable for middle class American families. As the affordability of lawns increased they became a popular fixture among the middle classes, as can be seen from the sale of lawnmowers in the United States between 1950 and 1974 (increasing from 1 to 7 million) (Filippi, 2011).

During the nineteenth century the fashion for lawns also reached Southern Europe, despite the limiting weather conditions and distinct gardening and landscape traditions that require better adapted solutions (Rubió i Tudiri, 2006). From 1970 lawns become indispensible and their use spreads rapidly thanks to developments in the irrigation technology industry. From this time the landscape becomes homogenized and simplified, becoming an ideal image for residents of Southern Europe as well as their northern neighbours (Filippi, 2011). In fact, quality standards for what we now understand as a lawn; a surface of a homogeneous green, uniform throughout the year, fine textured and well trimmed, were brought in after the Second World War. These standards were consolidated at the same time as fertilizer chemicals, pesticides and selective herbicides appeared on the market due to the development of intensive agriculture and were also applied to these plant surfaces (Filippi, 2011).

The economic and environmental costs associated with lawns in the Mediterranean climate are essentially due to the need to irrigate with quantities of up to 2,000 l/m^2 of water a year in the most extreme cases (Filippi, 2011). Furthermore lawn maintenance is highly demanding in terms of nutrient requirements (nitrogen, phosphorus and potassium), root aeration, lawn mowing and edging and application of selective herbicides for the removal of broadleaf species where high quality lawns are demanded. On the other hand, quality grass lawns usually contain no more than 3 or 4 grass species. The need for continual cutting impedes the formation of ears and therefore seeds, enhancing the vegetative reproduction of the plants. In this respect they are of limited attraction to wildlife and thus, of little interest from the point of view of biodiversity.

1.2. Biodiveristy in urban green spaces. Contemporary landscape architecture projects in Europe.

Advances in the 1960s in the science of ecology permeated urban landscape policy and practice in Central and Northern Europe (Woudstra, 2004). From the 1990's, various landscape architects have developed their approaches to planting design, incorporating ecological criteria focused on the design of the groundcover of extensive areas, often looking to promote biodiversity and reduce the maintenance costs of urban green spaces. This has been helped in recent decades by a growing concern about the continued loss of biodiversity and increased interest among the population in ecology (*Ecosystems and Biodiversity, the role of cities*, 2005; Montes et al., 2011). Each of these landscape architects has their particular approach. Some examples are given below.

Peter Latz does not plan what vegetation to use in his landscape projects, simply leaving the plants to colonize the old structures of the post-industrial landscapes (Silva, 2003). In his project for Druisborg's old steel works, wildflower meadows and woods occupy the space in a chaotic manner, permitting the expression of the force of nature. He takes advantage of the old factory structures and of the old railroad tracks to shape the space, creating different areas for gathering, walkways at various levels and viewpoints along them. He defines his projects as an archetypal dialogue between the domesticated and the wild.

Another German landscape architect, Heiner Luz, combines concerns for ecology with aesthetic considerations. He uses both native and cultivated plant species and their varieties. He studies the morphological aspects of plants and works with few elements resulting in clear and simple projects. His references are communities of wild vegetation, where only a few dominant species are responsible for the overall appearance and seasonal changes in the landscape. However, the floral diversity of his projects depends on species that associate with dominant ones. If we get down to detail, we can see that unity and harmony prevail within diversity (Luz, 2001). Luz selects a limited number of species, ensuring the longest possible flowering periods and then incorporates other species creating diversity in the landscape.

In England, James Hitchmough and Nigel Dunnett have focused their research since the early 90s on the design of flowering meadows with great visual impact. Their aims include the promotion of biodiversity, creation of habitats for local wildlife; reduction of planting and maintenance costs; and for the meadows to remain attractive for several months a year in order to respond to social expectations (Hitchmoug & Dunnett, 2004). While Hitchmough adheres to the aesthetic of American flowering meadows, choosing mostly broadleaf species, forbs, with the only maintenance being annual mowing, Dunnett works with annuals. Given the limited availability of wild flora of interest in Britain, both use exotic species as well as native ones (Dunnett & Hitchmough 2004, Hitchmough, 2008). The seed mixtures they use contain a limited number of species (10 at most), of which some must be long flowering and reliable in terms of their ability to germinate. Their flower meadows are maintained over time by means of self-seeding.

Gilles Clément has worked from 1979 as a Landscape Architect and professor at The Versailles National School of Landscape Architecture. His particular way of approaching landscape design departs from the natural dynamics of abandoned spaces. Creator of the concept of *le jardin en movement (*the *garden in motion*)*,* he is interested in 'following the natural flow of the plants' in order ‘to do as much as possible for and least against' to enhance biodiversity and enhance the biological quality of the soil with the least possible maintenance and fewest resources (Clément, 2007). Clément has made numerous interventions following these principles since his first project in La Vallee where he started by acquiring an abandoned field to create his own garden, respecting the ecological, structural and aesthetic changes that occurred over time, with small interventions on his part. Clement first applied this concept in André-Citroën Park, Paris (1986), which was inaugurated in 1999. Other examples include Matisse Park in Lille (1990) or more recently the Tecnoforum esplanade (2008), in Rochelle.

In landscape design whose groundcover is appropriate in the Mediterranean context, it is important to note that the dynamics of these meadows, with regard to their immediate aesthetic appearance will differ from examples found in Central and Northern Europe. The annual rainfall characteristic of the Mediterranean determines the adaptation of plants and is reflected in the landscape characteristic of this region: green in autumn, in flower in spring and golden in summer. This singularity typical of the Mediterranean landscape is,

on the other hand, that which confers upon it, in our view, its greatest appeal and brand identity.

2. Case study

In this section two cases are presented in which we have begun to study the dynamics of two meadows designed and sown in the Mediterranean in an attempt to draw conclusions that are valid for the specific planting for groundcover in this context.

The two case studies presented here were carried out in the town of Illescas (Toledo). One in a newly created city park north of the town and the other on a roundabout located in the green space of a new industrial park currently being developed (Figure 1).

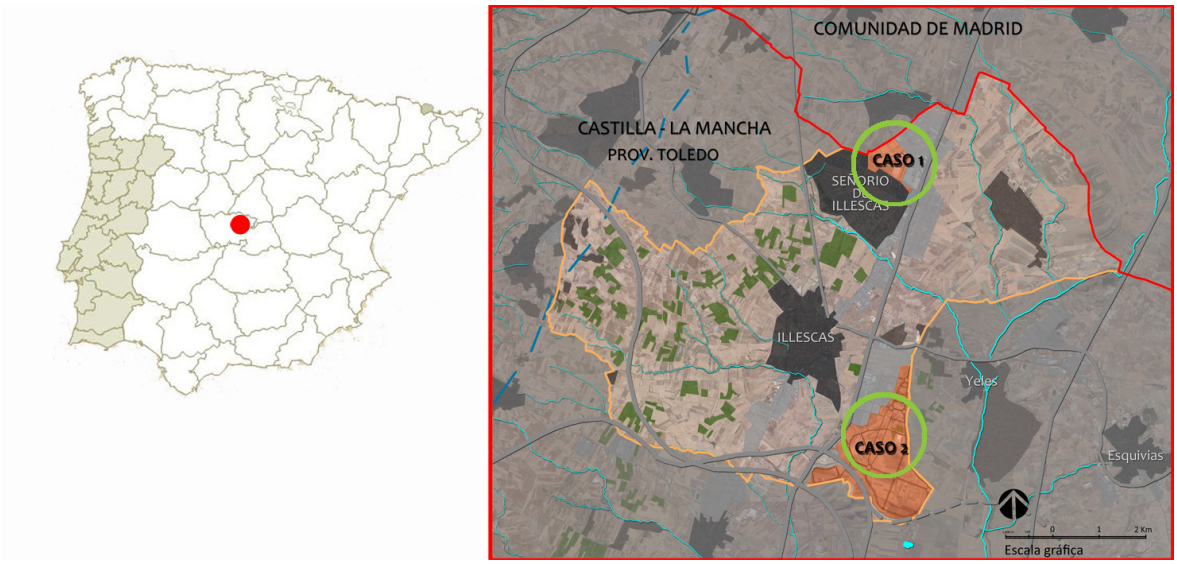

Figure 1.- Location of area of case study. Source: adapted aerial photograph

Both case study areas are located in the heart of the Castilian plateau, at an altitude of around 600 m above sea level. The climatic area corresponds to the continental Mediterranean eucontinental subtype, and both areas are located in the Mesomediterranean bioclimatic (annual temperature 15.4ºC) of ombroclimate on the borderline between dry and semiarid (annual rainfall 357 mm / year) (Rivas Martínez, 1983; 1987; 1999). Located on basic soils (pH = 8 in the Northern zone, pH = 9, in the Southern zone), to the north the

soils are detrital Quaternary silts and sandy reddish arkosic sands from the degradation of the Griñon-Las Rozas ramp; while in the South it is a Tertiary transition area from the middle to lower Miocene, characterized by micaceous sands, silts and limestones (Middle Miocene) evaporite and carbonate set of plasters and gypsum-lower Miocene marls medium loamy soils with low permeability, low organic matter (<1%). In both cases previous farming use has resulted in bare soils with no vegetation cover, with the exception of the typical field, or arvense vegetation cover adapted to constant tillage.

The climax vegetation in this area corresponds to holm oak or kermes oak shrubland (Kermes continental) and xeric pine forests of Aleppo pine (*Pinus halepensis*) (Izco, 1984; Rivas Martínez, 1987 and Sainz, 2010). The stages of substitution are inland scrub basophiles (rosemary, thyme, gorse, salvia, lavandula and spartium).

Currently, the existing vegetation is of anthropic origin. In the urban areas this has resulted from rapid residential growth incorporating ornamental tree and shrub species into the environment. In the agricultural areas it is the result of the ancient dryland farming techniques applied to the production of barley and olive crops.

2.1. Case study 1. Semi-perennial meadow in an urban park

In an urban park designed in 2009, the groundcover of all the inaccessible areas (5.5 ha) was sown with a mixture of herbaceous and woody plants adapted to local soil and climate conditions in a proportion of 88% and 12%, respectively, in order to initiate the processes of ecological succession. The seed mix was made up of pioneer species of grasses such as *Agropyron cristatum* and *Dactylis glomerata*, and leguminous plants including *Medicago sativa* and *Onobrychis viciifolia* to add nitrogen to the soil and maintain the green aspect of the meadow for most of the year even in the absence of irrigation. Sowing was carried out in October 2011. During 2013 the only maintenance carried out was a mowing in late September. Between 2013 and 2014 we monitored the evolution of this meadow, making monthly visits to record its appearance, coverage and floral composition (using the phytosociological method adapted from Braun-Blanquet). We compared the data obtained from two 6x4m plots: an experimental plot (plot 1) that was sown with the project mixture and a control plot (white) on which the mixture had not been sown. A photographic record

was compiled and data was recorded about the presence of insects (butterflies) along a selected route through the park.

The results obtained for coverage and floral composition of the two plots are given in Table 1. The floral inventory and relative coverage of the plot was recorded in April, the month of maximum plant growth. The numerical relationship refers to the percentage of coverage with respect to total surface area following the Braun-Blanquet nomenclature:

5: 75-100% ; **4**: 50-75%; **3**: 25-50%; **2**: 10-25%; **1**: 1-10% y + < 1%

Table 1.- Evolution of coverage and floral composition. Case study 1 (2014)

		Plot 1	**White**	**Plot 1**	**White**	**Plot 1**	**White**
	Date	27/02/2014		27/03/2014		28/04/2014	
	Coverage	95%	40%	99%	60-70%	100%	90%
	Average height (cm)	30	<5	40	<5	60	15
	General dominant colour	green	soil	green	green	green - white	green - yellow
1	*Medicago sativa*					3	
2	*Moricandia arvensis*					+	
3	*Onobrychis viciifolia*					+	
4	*Anthemis arvensis*					4	
5	*Calendula arvensis*					+	
6	*Carduus bourgeanus*					+	1
7	*Diplotaxis virgata*						1
8	*Erodium cicutarium*						+
9	*Echium plantagineum*						+
10	*Plantago coronopus*						+
11	*Silybum marianum*						+
12	*Avena barbata*					+	
13	*Bromus diandrus*					1	4
14	*Bromus rubens*					+	
15	*Bromus hordeaceus*					+	
16	*Hordeum murinum* subsp. *leporonium*					+	
17	*Lolium perenne*					+	

A comparison of the evolution of the coverage of both plots highlights the difference between the two. In the case of the plot sown with the project seed mix almost 100% of the surface is covered in February, while in the plot that was not sown, on the same date there

is only 40% coverage. The unsown plot only reaching 90% coverage in late April. This is primarily due to the type of species found: an abundance of *hemicryptophytes* (perennials) in the first case (*Medicago sativa*) and *therophytes* (annuals) in the second, where short cycle grasses dominate. Other aspects that differentiate the two plots are pasture height (30 to 60cm in the first case, less than 15 cm in the second), the duration of the green colour (which remains in the first case, whereas in the second it only lasts until the end of May). In terms of species composition and their relative cover, differences are also observed: in the first where leguminous plants and composites dominate, compared to the white plot where grasses dominate.

The results of the recording of the seasonal fluctuations in the park throughout the seasons and their relation to the presence of insects are given in Figure 2, where the greater abundance in May and June of butterflies and other pollinators (different species of bees, hornets and wasps) stands out.

Figure 2.- Evolution of the meadow and the presence of insects

2.2. Case study 2. Meadow with annuals on a roundabout

The second case study presented is the experimental sowing of a roundabout in a new industrial development to the east of the town of Illescas, on the border with the municipality of Yeles (Toledo). The roundabout measures nearly 6,000 m^2 with olive trees transplanted from neighbouring plots on half of this area.

Figure 3.- Aerial photograph. Source: tafyr.

The idea behind the treatment of this roundabout, as with the two other roundabouts (Figure 3), was to emulate the adjacent crop fields, incorporating flora typical of these environments to help develop an understanding of the local dynamics of the landscape and its relation to agriculture. One of these roundabouts was used to assess ruderal plant communities adapted to anthropic environments, frequently disregarded as 'weeds' and which often constitute the few remaining refuges for wildlife in these areas of intensive agriculture. These plant communities include species of flower, above all spring flowering

plants, in addition to other earlier or later flowering species of great beauty, which attract pollinators.

In 2012 a first sowing was done with a standard mixture used in the cultivation of organic olive groves and incorporating species that attract pollinators and beneficial insects. This first trial presented an unacceptable appearance to the developer by late May in the spring of 2013 and it was thus mowed. In the autumn of 2013 the ground was ploughed again and prepared for a second sowing, to be carried out in December of that year, with a mixture of seeds designed to correct the previous one and which took into account the following: the average height of the meadow was to be less than 50-70 cm to allow for better visibility of the olive grove, the maximum possible duration of flowering and maximum presence of species attractive to pollinators. The seed mixture contained 45% leguminous plants, 20% grasses and 25% composites as the main families.

As with case study 1, the zone was visited on a monthly basis to compile a photographic record of the general appearance of the roundabout and the adjacent olive grove. A 6x4m plot on the roundabout was selected to carry out an inventory of the species present, changes in coverage and presence of insects. The results are given in Table 2.

Table 2.- Evolution of coverage and floral composition. Case study 2 (2014).

		Plot	**White**	**Plot**	**White**	**Plot**	**White**	**Plot**	**White**
	Date	27/02/2014		27/03/2014		28/04/2014		12/05/2014	
	Coverage	<1%	5%	1%	10%	70%	80%	70-80%	0%
	Average height (cm)	<2	<2	<5	<5	10-20	40-50	50	-
	Dominant colour	soil	soil	soil	soil	green-yellow	green - blue	green yellow	soil
1	*Carduus bourgeanus*						5		
2	*Sonchus asper*						+		
3	*Calendula arvensis*							2	
4	*Diplotaxis virgata*							1	
5	*Matricaria camomilla*							2	
6	*Chrysanthemum coronarium*							+	
7	*Coriandrum sativum*							1	
8	*Diplotaxis erucoides*							1	
9	*Echium plantagineum*							+	
10	*Papaver roheas*							+	

		Plot	White	Plot	White	Plot	White	Plot	White
	Date	27/02/2014		27/03/2014		28/04/2014		12/05/2014	
11	*Erodium cicutarium*							+	
12	*Medicago orbicularis*							+	
13	*Trifolium resupinatum*							+	
14	*Borago officinalis*							+	
15	*Centaurea cyanus*							+	
16	*Salvia verbenaca*							+	
17	*Diplotaxis catholica*							+	
18	*Calendula officinalis*							+	
19	*Avena barbata*							+	
20	*Lolium perenne*							+	
21	*Bromus matritensis*							+	

Despite it having been a good year for autumnal rains the results demonstrate a failure of species to germinate until well into spring. This may have been the result of planting in December. Coverage measured 70-80% in April, both in the case of the roundabout and in the adjacent olive grove. In the latter the abundance of thistles (*Carduus bourgeanus*) resulted in the decision taken by the developer to plough the land in early May.

The differences in composition and morphology of the meadows that resulted from the standard seed mixture and the other seed mixture selected can be clearly seen by comparing the pictures taken in April 2013 and April 2014. In 2014 a more homogeneous meadow is achieved, allowing better visibility of the olive grove.

April 2013

April 2014

Figure 4.- Appearance of the roundabout in April 2013 and April 2014

In the floral inventory, carried out in May 2014, in comparison with the adjacent olive grove, where thistles cover the whole area, a remarkably large number of species were identified on the roundabout plot.

Figure 5.- View of the olive grove adjacent to the roundabout (in the background) dominated almost exclusively by thistles (*Carduus bourgeanus*) (May 2014).

Figure 6.- General view of the roundabout. The dominant colour is the yellow of *Calendula* and *Diplotaxis* (May 2014).

Secondly the lack of leguminous plants and grasses present in the 2013 mix is notable, with flower species dominating. With regards to the duration of flowering, we observed that a few species were responsible for the general colour on the roundabout despite the flowering being quite brief (April-May). These species are *Calendula arvensis* and *officinalis, Matricaria camomilla*, together with species from the genus *Diplotaxis*.

The presence of pollinators or small insects is unsurprisingly limited to these months of flowering (April-May), establishing the presence of bees, ladybirds and other beetles but few butterflies, possibly due to the frugality of flowering.

Figure 7.- *Coccinella septempunctata* on *Matricaria arvensis*

Figure 8.- Insects from the family *Melyridae* on *Calendula arvensis*

Figure 9.- Monitoring of the control plot (February – June 2014)

3. Final considerations

In the Mediterranean region, given the importance of its broad biodiversity to the European context and the opportunities this provides, it is necessary to review the way plant groundcover projects for large areas are planned, to incorporate ecological criteria and the preservation and promotion of biodiversity, in addition to other criteria of a functional and aesthetic nature.

For these design proposals to be accepted by the public and serve as spaces for biodiversity, we feel that the seed mixtures should essentially consist of flower species with strong visual impact and a homogeneous height, and should avoid the inclusion of grasses. This will additionally result in design proposals that are not only more attractive in terms of biodiversity but from the point of view of their acceptance to the public.

Such groundcover can consist of perennial or semi-perennial meadows, or meadows using annual species adapted to conditions of constant disturbance or stress. We feel that it is not the use of commercial seed mixtures that should be limited but rather that there should be an improvement in the specific design of those mixes based on the objectives of each project. Due to the wide variety of Mediterranean flora we support giving priority to native species, but do not rule out other species that may be adapted or naturalized, provided that the selected species are not invasive or may alter neighbouring habitats. The use of local species also encourages us to value our landscape and its natural dynamics, thus contributing to a change of mentality in public preferences.

Increasing the biodiversity associated with flowering meadows and, as a consequence their aesthetic appeal, may also foster awareness of ecology, thus optimising the educational potential of these green areas.

Of the two cases studied, case 1 appears to provide the greatest opportunity to attract pollinating insects, particularly butterflies. The maintenance of these meadows should be adapted to the life cycle of these insects if their presence is to be encouraged.

Experimenting with mixtures of flower species is proposed, reducing the number of species in the mixture, gambling on a higher proportion of 2-3 particularly high impact species and always sowing in early autumn.

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