Universitat de Girona

SOCIOECONOMIC STATUS DETERMINES FLORISTIC PATTERNS IN SUBURBAN DOMESTIC GARDENS: IMPLICATIONS FOR WATER USE AND ALIEN PLANT DISPERSAL IN THE MEDITERRANEAN CONTEXT

Josep PADULLÉS CUBINO

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Universitat de Girona

Doctoral Thesis

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JOSEP PADULLÉS CUBINO

ANY 2015

PROGRAMA DE DOCTORAT EN CIÈNCIES EXPERIMENTALS I SOSTENIBILITAT

Dirigida per Josep Vila Subirós i Carles Barriocanal Lozano

Memòria presentada per optar al títol de doctor per la Universitat de Girona

Universitat de Girona

El Dr. Josep Vila Subirós i el Dr. Carles Barriocanal Lozano, del Departament de Geografia de la Universitat de Girona i del Departament de Geografia Física i Anàlisi Geogràfica Regional de la Universitat de Barcelona, respectivament,

CERTIFIQUEN:

Que aquest treball, titulat "**Socioeconomic Status Determines Floristic Patterns in Suburban Domestic Gardens: Implications for water use and alien plant dispersal in the Mediterranean context**", que presenta Josep Padullés Cubino per l'obtenció del títol de doctor, ha estat realitzat sota la seva direcció.

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Girona, 21 de maig de 2015

"La naturaleza reducida a proporción humana
y puesta al servicio del hombre,
es el más eficaz refugio contra la agresividad
del mundo contemporáneo"

Luís Ramiro Barragán Morfín

(1902-1988; arquitecte i enginyer civil mexicà)

Al meu avi Agustín,
perquè n'hauria estat orgullós.

Publicacions derivades de la tesis doctoral

La present tesis doctoral ha estat redactada en format tradicional tot i que la part de resultats ha estat escrita en forma d'articles. Així, sis dels capítols centrals d'aquest treball, es troben o bé publicats o bé en procés de revisió en revistes indexades al Science Citation Index (SCI) o IN-RECS (veure annex 6). Tot seguit es detalla en quin punt del procés editorial es troba cadascun d'ells. Els factors d'impacte (FI) de les publicacions corresponen a la darrera actualització, de l'any 2013.

1. PADULLÉS, J., VILA, J. & BARRIOCANAL, C. (2015). "Biodiversidad vegetal y ciudad: aproximaciones desde la ecología urbana". *Boletín de la Asociación de Geógrafos Españoles* (acceptat).

   FI SCI: 0,100: Posició 75/76 (Q4) de la categoria *Geography*.

2. PADULLÉS, J., VILA, J. & BARRIOCANAL, C. (2014). "Examining boundaries between garden types at the global scale". *Investigaciones geográficas*, 61 (1), 71-86.

   FI IN-RECS: 0,192. Posició 7/39.

3. PADULLÉS, J., VILA, J. & BARRIOCANAL, C. (2014). "Maintenance, Modifications, and Water Use in Private Gardens of Alt Empordà, Spain". *HortTechnology*, 24 (3), 374-383.

   FI SCI: 0,619. Posició 18/33 (Q3) de la categoria *Horticulture*.

4. PADULLÉS, J., KIRKPATRICK, J.B. & VILA, J. "Water requirements predicted from the characteristics of domestic Mediterranean gardens does not strongly relate to socioeconomic or demographic variables". *Landscape & Urban Planning* (en revisió).

   FI SCI: 2,606. Posició 1/38 (Q1) de la categoria *Urban Studies*.

5. PADULLÉS, J., VILA, J. & BARRIOCANAL, C. "Propagule pressure from invasive plant species in gardens in low-density suburban areas of the Costa Brava (Spain)". *Urban Forestry & Urban Greening* (en segona revisió).

   FI SCI: 2,133. Posició 2/38 (Q1) de la categoria *Urban Studies*.

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   FI SCI: 1,740. Posició 19/42 (Q2) de la categoria *Biodiversity Conservation*.

Acrònims

ABS (Australian Bureau of Statistics)
AENP (Aiguamolls de l'Empordà Natural Park)
AIC (Akaike Information Criterion)
ANOVA (Analysis of variance)
AZ (Arizona)
BUGS (Biodiversity in Urban Gardens in Sheffield)
BVOC (Biogenic Volatile Organic Compound)
CA (California)
CAATEEG (Col·legi d'Aparelladors, Arquitectes Tècnics i Enginyers d'Edificació de Girona)
CBI (City Biodiversity Index)
CIAT (Centro Internacional de Agricultura Tropical)
CIESIN (Center for International Earth Science Information Network)
CIMIS (California Irrigation Management Information System)
CREAF (Centre de Recerca Ecològica i Aplicacions Forestals)
DBRDA (Distance Based Redundancy Analysis)
DGCE (Directorate General for Cadastre Electronic)
EEA (European Environment Agency)
ENPE (Espai Natural de Protecció Especial)
ETP (Evapotranspiració potencial)
EUA (Estats Units d'Amèrica)
GDP (Gross domestic product)
GENCAT (Generalita de Catalunya)
GLM (General Linear Model)
ICC (Institut Cartogràfic de Catalunya)
IDESCAT (Institut d'Estadística de Catalunya)
IE (Irrigation efficiency)
IMA (Institut de Medi Ambient)
IPCC (Intergovernmental Panel on Climate Change)
IPNI (International Plant Name Index)
IR (Irrigation requirements)
IUCN (International Union for Conservation of Nature)
LWR (Lanscape Water Requirements)
MSC (Meteorological Service of Catalonia)
NDVI (Normalized Difference Vegetation Index)
NMDS (Non-Metric Dimensional Scaling)
OCDE (Organització per a la Cooperació i el Desenvolupament Econòmic)
ONG (Organització No Governamental)
ONU (Organització de les Nacions Unides)
PCA (Principal Components Analysis)
PNAE (Parc Natural dels Aiguamolls de l'Empordà)
SMC (Servei Meteorològic de Catalunya)
UHI (Urban Heat Island)
UICN (Unió Internacional per a la Conservació de la Natura)
UK (United Kingdom)
UN (United Nations)
UNEP (United Nations Environment Programme)

UPA (Urban and Peri-urban Agriculture)
US (United States)
USA (United States of America)
VIF (Variance Inflation Factor)
WUCOLS (Water Use Classifications of Landscape Series)
XEMA (Xarxa d'Estacions Meteorològiques Automàtiques)

Agraïments

Hi ha un element imprescindible i necessari per portar a terme una tesis doctoral, i és disposar d'un ambient de treball adequat que permeti desenvolupar la recerca. Això implica des de sentir-se motivat o estar feliç, fins a treballar en silenci o fer fotocòpies a un preu raonable. Doncs bé, en aquest sentit, puc dir que he estat afortunat de trobar-me unes condicions immillorables. Aquestes quatre ratlles són per donar les gràcies a totes les persones que, sabent-ho o no, han col·laborat per fer-me la vida de becari molt més fàcil.

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Resum

En un context de canvi ambiental global en què cada vegada més població viu en ciutats, els béns i serveis que proporcionen els ecosistemes urbans són d'una rellevància especial. Concretament, en l'àmbit mediterrani, l'increment de les àrees urbanes difuses fruit del gran desenvolupament urbanoturístic i els canvis socioeconòmics, ha propiciat un augment considerable del nombre de jardins domèstics. L'estructura i la flora d'aquests ecosistemes tan particulars determinen bona part del consum d'aigua domèstica a la vegada que afecten directament i indirecta els ecosistemes naturals i la qualitat de vida dels residents.

L'objectiu principal de la present tesis, titulada "*Socioeconomic Status Determines Floristic Patterns in Suburban Domestic Gardens: Implications for water use and alien plant dispersal in the Mediterranean context*", és estudiar la composició de la flora dels jardins privats en àrees residencials per tal de (1) predir el seu consum d'aigua potencial i les variables associades a aquest paràmetre, i (2) avaluar el risc potencial d'invasió biològica per part de plantes cultivades en aquests espais. A més, es fa especial èmfasi en la identificació dels factors socioeconòmics, demogràfics i culturals que determinen cada tipus d'enjardinament i la predilecció per determinats grups d'espècies vegetals. Per dur a terme l'estudi es seleccionà una mostra aleatòria d'habitatges unifamiliars distribuïts en àrees residencials de cinc municipis de l'Alt Empordà (Castelló d'Empúries, l'Armentera, l'Escala, Roses i Sant Pere Pescador), totes elles situades al costat o dins del Parc Natural dels Aiguamolls de l'Empordà.

La riquesa florística identificada en els jardins fou elevada, amb més de 600 taxons diferents inventariats en el conjunt d'habitatges visitats. Diversos gradients socioeconòmics i demogràfics com ara la taxa d'ocupació de l'habitatge, el lloc de naixement o el nivell econòmic dels residents, s'associaren a la distribució de la flora en els jardins. A més, s'establiren 4 categories de jardins (semi-natural, hort, gespa i ornamental) en base a la seva composició florística i que foren vinculats a diferents perfils dels residents.

Es determinà també que els jardins de primeres residències són diferents dels jardins de segones residències pel què fa a la vegetació i estructura. Per altra banda, els resultats semblen també indicar que els requeriments hídrics potencials dels jardins són molt

diversos i difícilment predictibles a partir de les característiques socioeconòmiques i demogràfiques dels membres de la llar. No obstant, destaquen el nivell de renda, així com la proporció de membres desocupats de l'habitatge, com a principals variables explicatives d'aquest paràmetre.

Les pràctiques de gestió dels jardins determinen també bona part del consum d'aigua. Així, en la mostra de jardins analitzats, s'estudiaren, entre altres factors, la responsabilitat de la gestió i el disseny del jardí, el sistema de reg utilitzat o la freqüència de reg, per tal d'identificar punts febles en l'ús d'aigua i millorar-ne la seva eficiència. Com a resultats més destacats, cal assenyalar un ús deficient dels sistemes de reg més tecnificats (la qual cosa pot portar a regar en excés aquests espais) i una tendència generalitzada de canvi en l'estructura dels jardins vers un vessant més utilitarista i productiva.

En termes de caracterització de les plantes dels jardins, més de tres quartes parts d'aquestes foren classificades com a exòtiques, principalment originàries d'Àsia i Sud Amèrica, amb un predominant ús ornamental. Tradicionalment, la jardineria, i la horticultura en general, han estat reconegudes com a principals vies d'introducció d'espècies al·lòctones en el medi natural. En aquest sentit, en els jardins inventariats s'identificaren gairebé una quarantena d'espècies considerades com a potencialment invasores a Espanya. Ara bé, no tots aquests taxons han estat citats com a naturalitzats en els espais naturals adjacents, per la qual cosa és recomanable portar a terme activitats de control i seguiment dels tàxons potencialment invasors per tal de prevenir la seva possible introducció en el medi natural.

Resumen

En un contexto de cambio ambiental global en el que cada vez más población vive en ciudades, los bienes y servicios producidos por los ecosistemas urbanos cobran un interés especial. Concretamente, en el ámbito mediterráneo, el incremento de las áreas urbanas difusas fruto del gran desarrollo urbanoturístico y los cambios socioeconómicos, ha propiciado un aumento considerable del número de jardines domésticos. La estructura y la flora de estos ecosistemas tan particulares determinan gran parte del consumo de agua doméstica a la vez que afectan directa e indirectamente los ecosistemas naturales y la calidad de vida de sus propietarios.

El objetivo principal de la presente tesis, titulada "*Socioeconomic Status Determines Floristic Patterns in Suburban Domestic Gardens: Implications for water use and alien plant dispersal in the Mediterranean context*", es estudiar la composición de la flora de los jardines privados en áreas residenciales para (1) predecir su consumo hídrico potencial y las variables asociadas a este parámetro, y (2) evaluar el riesgo potencial de invasión biológica por parte de ciertas plantas cultivadas. Además, se hace especial énfasis en la identificación de los factores socioeconómicos, demográficos y culturales que determinan cada tipo de ajardinamiento y la predilección por determinados grupos de especies vegetales. Para llevar a cabo el estudio se seleccionó una muestra aleatoria de viviendas unifamiliares distribuidas en áreas residenciales de cinco municipios del Alt Empordà (Castelló d'Empúries, L'Armentera, l'Escala, Roses y Sant Pere Pescador), todas ellas situadas junto o dentro del Parque Natural de los Aiguamolls del Empordà.

La riqueza florística identificada en los jardines fue elevada, con más de 600 taxones diferentes inventariados en el conjunto de viviendas visitadas. Varios atributos socioeconómicos y demográficos, tales como la tasa de ocupación de la vivienda, el lugar de nacimiento o el nivel económico de los residentes, se asociaron a la composición de la flora de los jardines. Además, se establecieron 4 categorías de jardines (semi-natural, huerta, césped y ornamental) en base a su composición florística y fueron vinculadas a diferentes perfiles de sus propietarios.

Se determinó también que los jardines de primeras residencias son significativamente diferentes de los jardines de segundas residencias en cuanto a vegetación y estructura. Por otra parte, los resultados parecen indicar también que los requisitos hídricos potenciales de

los jardines son muy diversos y difícilmente predecibles a partir de las características socioeconómicas y demográficas de los miembros del hogar. Sin embargo, destacan el nivel de renta, así como la proporción de miembros desempleados de la vivienda, como principales variables explicativas de este parámetro.

Las prácticas de gestión de los jardines domésticos determinan también gran parte de su consumo hídrico. Así, en la muestra de jardines analizados, se estudiaron, entre otros factores, la responsabilidad de gestión i diseño del jardín, el sistema de riego utilizado o la frecuencia de riego, para identificar puntos débiles en el uso de agua y mejorar así su eficiencia. Como resultados más destacados, cabe señalar un uso deficiente de los sistemas de riego más tecnificados (lo cual puede llevar a regar en exceso estos espacios) y una tendencia generalizada de cambio en la estructura de los jardines hacia una función más utilitarista y productiva.

En términos de caracterización de las plantas de los jardines, más de tres cuartas partes fué clasificadas como exóticas, principalmente originarias de Asia y Sudamérica, con un predominante uso ornamental. Tradicionalmente, la jardinería, y la horticultura en general, han sido reconocidas como principales vías de introducción de especies alóctonas en el medio natural. En este sentido, en los jardines inventariados se identificaron casi una cuarentena de especies consideradas como potencialment invasoras a España. Ahora bien, no todos estos taxones han sido citados como naturalizados en los espacios naturales adyacentes, por lo que es recomendable llevar a cabo actividades de control y seguimiento de los taxones potencialmente invasores para prevenir su posible introducción en el medio natural.

Abstract

Against the backdrop of global environmental change and increasing urban population, goods and services provided by urban ecosystems have taken on a special importance. Of particular interest is the Mediterranean region, where the expansion of sprawling urban areas, as a consequence of the recent tourist development and socioeconomic changes, has led to a considerable increase in the number of domestic gardens. The structure and flora of these ecosystems determine much of domestic water consumption, while directly and indirectly affecting natural ecosystems and the quality of life of homeowners.

The primary aim of this thesis, titled "*Socioeconomic Status Determines Floristic Patterns in Suburban Domestic Gardens: Implications for water use and alien plant dispersal in the Mediterranean context"*, is to study the composition of the flora of private gardens in residential suburbs, in order to: (1) predict potential garden water needs and the variables associated with this parameter; and (2) evaluate the potential risk of biological invasion by certain cultivated species. Additionally, we place special emphasis on the identification of socioeconomic, demographic and cultural attributes that determine landscaping decisions and predilection for certain groups of plant species. To conduct the study, a sample of houses distributed in residential areas of five municipalities of Alt Empordà (Castelló d'Empúries, l'Armentera, l'Escala, Roses and Sant Pere Pescador) was randomly selected. All of these municipalities are located next to the Natural Park of Aiguamolls de l'Empordà.

Overall, plant richness in the gardens was high, with more than 600 different taxa inventoried in all sampled houses. Several demographic and socioeconomic gradients, such as the occupancy rate of the house, the place of birth, and income level, were associated with the distribution of flora. Four categories of gardens (semi-natural, lawn, vegetable and ornamental) were established, based on the floristic composition, and were assessed accordingly to different socioeconomic profiles. We also determined that gardens in primary residences are different to those in secondary homes in regard to structure and vegetation composition. Moreover, the results also suggest that landscape water requirements are very different among gardens and are almost unpredictable from the socioeconomic and demographic characteristics of household members. However, the

level of income and the proportion of non-working members had a positive and significant effect on this parameter.

There is a possibility that garden management habits and practices might determine overall garden water consumption. Therefore, we also studied, among other factors, the management and design responsibility of the garden, the use of different irrigation systems and the irrigation frequency, to identify gaps in the use of water and improve its efficiency. As a result, a lack of watering efficiency was detected among the most sophisticated irrigation systems (which can lead to overwatering), as well as a general trend to change the structure of the gardens towards a more food productive landscape.

In terms of garden plant species characterization, more than three-quarters of these were exotic, mainly from Asia and South America, with predominantly ornamental usage. Traditionally, gardening and horticulture have been considered major pathways of the introduction of alien species. In this regard, we identified approximately forty species which are considered potentially invasive in other regions of Spain. However, to date, not all of these taxa have been found naturalized in adjacent natural areas. Therefore, it is advisable to carry out activities to control and monitor potentially invasive species in order to prevent their likely introduction and spread.

CAPÍTOL 1

INTRODUCCIÓ

1.1 L'ECOLOGIA URBANA: SIGNIFICAT I IMPORTÀNCIA

1.1.1 Objectius, evolució i metodologies de l'ecologia urbana

El progressiu augment de la població urbana a nivell mundial té conseqüències directes sobre el consum de sòl per part d'edificis o infraestructures. Aquest fet sovint es tradueix en una pèrdua d'hàbitats naturals (Kendle & Forbes, 1997), de biodiversitat (Vitousek et al., 1997), o en la contaminació del medi ambient (Rueda, 1995). Per fer front a aquests reptes, l'ecologia urbana juga un paper fonamental.

Durant molts anys, l'ecologia ha centrat el seu interès en les dinàmiques i processos del medi natural sense prendre prou en consideració la realitat urbana i sovint sense integrar la component humana com a agent modelador d'aquests processos (McDonnell & Pickett, 1990). Des de principis del segle XX, però, la idea d'incloure el factor humà com un element més dels ecosistemes urbans ha anat guanyant pes (Adams, 1935; Tansley, 1935; Margalef, 1974). En ple segle XXI, aquests conceptes es troben plenament integrats (McIntyre et al., 2000; Luck & Wu, 2002). Això ha estat possible en bona part gràcies a l'ús de noves tecnologies com ara la teledetecció, la qual ha permès l'obtenció de dades ambientals a gran escala (Mathieu et al., 2007).

En la nova ecologia urbana la "urbanització" es converteix en un procés social al mateix temps que ecològic (Parlange, 1998). Així, la integració de les dues vessants de la ciència contemporània, la natural i la social, és essencial en l'anàlisi dels ecosistemes urbans, fent de l'ecologia urbana una ciència interdisciplinària (Walbridge, 1997).

Wu (2008) distingeix cinc perspectives ecològiques segons l'aproximació dels diferents estudis d'ecologia urbana: l'ecologia a les ciutats (EIC) (1), l'ecologia de les ciutats enteses com estructures socioeconòmiques (EOC-S, 2), i l'ecologia de les ciutats enteses com a ecosistemes (EOC-E, 3), amb tres perspectives derivades que l'autor anomena perspectiva dels sistemes urbans (3), perspectiva integrada dels ecosistemes urbans (4) i perspectiva de l'ecologia del paisatge urbà (5) (Figura 1.1).

A la primera de les aproximacions, la ciutat no és vista com un ecosistema en si mateix, sinó que l'interès ecològic se centra en el coneixement de la natura dins de les àrees urbanes, posant especial èmfasi en hàbitats i grups d'organismes específics. Aquest és un àmbit de recerca molt vinculat a la biogeografia urbana. La segona de les perspectives, per la seva banda, incorpora els principis ecològics en un sistema urbà considerat eminentment socioeconòmic. La tercera perspectiva, anomenada dels sistemes urbans, veu la vessant ecològica i socioeconòmica com dos subconjunts que mantenen relacions però que no es troben integrats entre si. Aquesta integració té lloc a la quarta de les perspectives. Així, en la darrera aproximació, la perspectiva de l'ecologia del paisatge urbà, totes les altres perspectives s'integren i es complementen. A més, també en aquest punt cobra força la necessitat de treballar a diferents escales per analitzar l'heterogeneïtat de les parcel·les dels ecosistemes urbans.

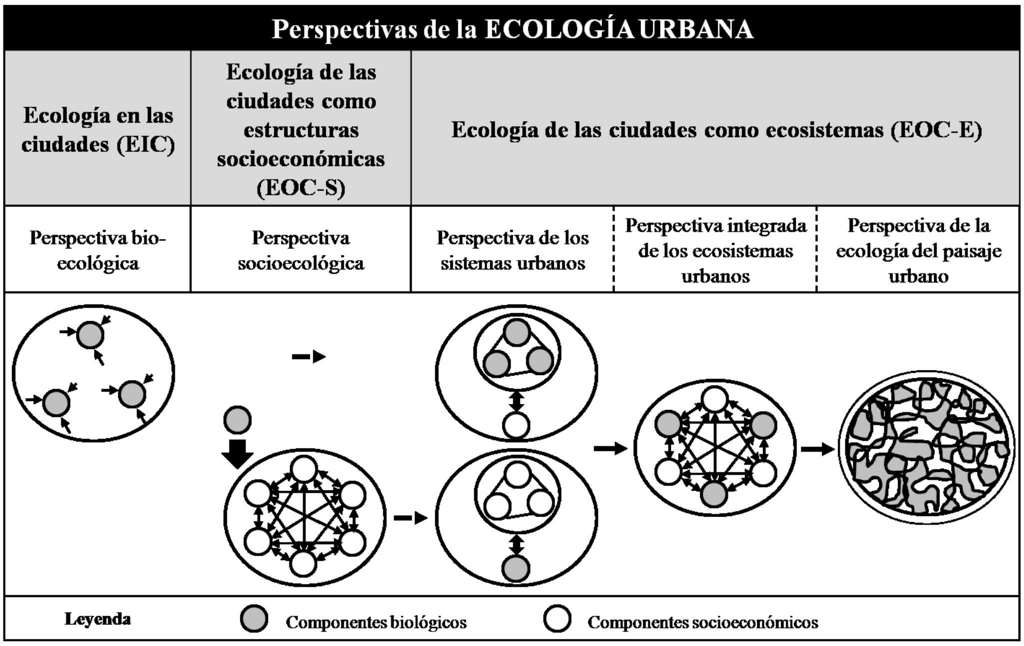


Figura 1.1: Esquema de les cinc perspectives ecològiques en els estudis d'ecologia urbana. Font: Elaborat a partir de Wu, 2008.

Les aproximacions interdisciplinàries i aquelles que reuneixen no només els sectors acadèmics, sinó també els sectors no acadèmics, poden ajudar a crear una plataforma des d'on els problemes ambientals, i socials, convergeixin en la recerca d'una solució conjunta (Cilliers, 2010). Així, per exemple, la incorporació de les tècniques de l'ecologia del paisatge permet prendre en consideració elements com l'escala de treball, la relació entre matriu i la parcel·la, o el disseny de connectors ecològics, totes elles de gran interès per l'ecologia urbana (Wu, 2008).

A nivell internacional diferents estudis han incorporat la vessant més social en els mètodes clàssics de l'ecologia. Així, per explicar els patrons de configuració de la biodiversitat en ecosistemes urbans, alguns opten per incloure factors com la preferència humana (Acar et al., 2007; Kendal et al., 2012a), la rellevància dels factors socioeconòmics (Marco et al., 2010a; Bigirimana et al., 2012; Van Heezik et al., 2013), o les dinàmiques demogràfiques (Roy Chowdhury et al., 2011).

A Espanya diferents autors han ressaltat el paper de l'ecologia urbana i la necessitat d'incorporar-la eficientment en el planejament urbà. Cal destacar els treballs de Rueda (1995) i Terradas (2001), els quals, a part d'oferir reflexions i perspectives generals al voltant d'aquesta disciplina i els seus mètodes, utilitzen referències clares per detallar els processos en el metabolisme de les ciutats. Sens dubte les grans aglomeracions urbanes, com Barcelona i la seva àrea metropolitana, han estat objecte principal d'anàlisi i estudi (Rueda, 1995; Barracó et al., 1999). No obstant això, en general s'han realitzat aproximacions particulars per a un nombre molt limitat de ciutats i per temàtiques molt concretes. Feria i Santiago (2009) van analitzar de forma conceptual i metodològica els serveis ambientals aplicats a l'espai lliure en àrees urbanes. D'aquesta manera, situen el focus d'atenció en les funcions que desenvolupen els processos naturals per millorar i fer més sostenible el medi ambient urbà. Per il·lustrar la rellevància d'incloure aquestes funcions en el planejament urbà sostenible, els autors descriuen algunes experiències recents d'ordenació en el context espanyol com els plans de les àrees metropolitanes de Sevilla o Còrdova. Altres aproximacions han anat vinculades a l'ecologia del paisatge amb treballs sobre connectivitat ecològica i el paper que juguen les grans àrees metropolitanes en aquest procés (Pino & Marull, 2012; Rodríguez-Rodríguez, 2012). També la biodiversitat i els efectes que els factors humans tenen sobre les comunitats vegetals i animals han estat objecte d'estudi i recerca (e.g., Buján et al., 1998; Dana et al., 2002; Murgui, 2009; Mendes et al., 2011). No obstant això, gran nombre d'hàbitats i comunitats dels espais urbans segueixen sent encara desconeguts, i l'ecologia urbana es presenta com una disciplina amb un ampli camp d'investigació i desenvolupament per fer front a aquests reptes (Boada & Capdevila, 2000).

1.1.2 Mètodes de l’ecologia urbana per l’anàlisi de l’estructura vegetal: definició, classificació i patrons

El primer pas per determinar l’àmbit d’aplicació de l’ecologia urbana passa per establir una distinció clara entre aquells espais considerats “urbans” d’aquells que no ho són. L’ús del terme “urbà”, en el context de l’ecologia urbana, i en general de les ciències naturals, està subjecte a diverses interpretacions i definicions, la qual cosa complica la comparació de resultats entre estudis de temàtiques molt similars. Davant d’aquests inconvenients, McIntyre et al. (2000) suggereixen que cada un dels estudis d’ecologia urbana incorpori la seva pròpia definició del concepte urbà i el descrigui segons les seves característiques socioeconòmiques, culturals, demogràfiques o geogràfiques per facilitar les comparacions i la reproductibilitat dels estudis. Algunes publicacions recents han demostrat el potencial que té l’ús de diferents gradients urbans per mesurar i afinar en el concepte “urbà” (e.g., Dow, 2000; Luck & Wu, 2002; Marco et al., 2008). Ara bé, aquesta nova metodologia suposa un altre problema i és que la quantificació d’una variable apropiada per a un estudi pot no ser-ho per a un altre, ja sigui perquè els interessos de la investigació són diferents o bé perquè també ho és l’escala de treball.

Un cop establerta la separació justificada entre les àrees consideres “urbanes” de les “no urbanes”, l’estudi dels ecosistemes urbans ha de centrar el seu interès en la intersecció entre els processos biofísics i socials. Per aconseguir aquesta fita, els marcs de treball i les metodologies utilitzades per l’ecologia urbana han nodrir-se de les tècniques de diferents disciplines per tal d’afinar en les seves conclusions. Dow (2000) afirma que les ciències socials sovint conceben els assentaments urbans segons les funcions que aquests exerceixen en el territori (econòmica, política i cultural) i interpreten el medi físic com un paisatge visual simbòlic o com un producte dels processos de planejament. Per contra, els ecòlegs han destinat tradicionalment els seus esforços cap a àrees no urbanes, o aquelles amb baix impacte antròpic, mentre que els ecosistemes urbans han quedat descuidats. Per tractar aquests assumptes, l’ecologia urbana ha apostat per certs mètodes descrits a continuació, fent especial èmfasi en la classificació de matrius i en els patrons en forma de gradients.

Una de les tècniques emprades per l’ecologia urbana, i que deriva de les tècniques tradicionals de l’ecologia del paisatge, és l’ús de la classificació de la matriu urbana

(Turner, 1989). Mitjançant aquest procediment, i aplicable a diferents escales, les ciutats són descompostes en un gran mosaic de fragments urbans, fragments vegetats i altres usos del sòl (Cadenasso et al., 2007). D'aquesta manera, els ecòlegs del paisatge segueixen un model de mosaic de parcel·les (Forman, 1995), amb el qual el paisatge queda representat com una col·lecció de fragments discrets. Les principals discontinuïtats en la variació ambiental subjacent es representen com a límits discrets entre parcel·les. Posteriorment, amb l'ús de diferents índexs i eines de mesura, es poden quantificar determinats processos i dinàmiques territorials. Aquesta aproximació és d'especial rellevància en àrees periurbanes on sovint es dóna una barreja molt diversa d'usos del sòl i existeixen unes funciones socioeconòmiques, polítiques i ecològiques que afecten els serveis ambientals (Walker et al., 2004).

L'ús d'aquests sistemes de classificació s'ha vist beneficiat recentment pels avenços en les tecnologies de la teledetecció com les imatges satèl·lit multiespectrals que permeten anàlisis de molt alta resolució. Un exemple és el treball de Mathieu et al. (2007), el quals classificaren de forma automàtica, i per a la ciutat de Dunedin (Nova Zelanda), més del 90% dels jardins urbans. Les tècniques en teledetecció, a més, també comencen a tenir aplicació en la predicció de la riquesa d'espècies de fauna en ambients urbans. Així, alguns estudis han arribat a preveure la riquesa i distribució de certes espècies d'aus a partir d'índexs de vegetació, com el NDVI (*Normalized Difference Vegetation Index*), obtinguts a partir de sensors remots i que permeten avaluar si l'objecte que s'observa conté vegetació viva (e.g., Johnson et al., 1998; Bino et al., 2008). Per a l'anàlisi de la biodiversitat urbana a les ciutats, Boada i Sànchez (2011; 2012) proposen la classificació de l'estructura urbana en tres categories: món gris, món verd i món blau. Aquestes categories, al seu torn, han de ser classificades en una sèrie de biòtops.

L'ús de patrons en el camp de l'ecologia urbana és també una eina àmpliament utilitzada per quantificar la relació entre els processos ecològics i l'estructura de les ciutats. Els efectes dels patrons de desenvolupament urbà sobre les funcions dels ecosistemes ha estat ben documentada per Alberti (2005). Ara bé, un cas especial de patrons avalats per gran nombre de treballs científics són els gradients. Segons McDonnell & Pickett (1990) un gradient passa quan hi ha una variació, o un canvi ambiental, que varia de forma ordenada i regular en el temps o en l'espai. Un dels exemples més citats sobre l'eficiència dels gradients és l'estudi de la vegetació segons l'altitud (Whittaker, 1967).

L'aplicació dels gradients en l'àmbit urbà pot ajudar a entendre millor les interaccions entre el desenvolupament urbà i l'estructura dels sistemes ecològics i socials (Alberti et al., 2001). Així, per exemple, aquest mètode permet estudiar les respostes i els canvis de les comunitats vegetals davant dels canvis ambientals graduals (Du Toit & Cilliers, 2011), o bé analitzar una determinada organització espacial segons els processos urbans i ecològics que s'han dut a terme (Luck & Wu, 2002). McDonnell & Hahs (2008) han analitzat més de 200 treballs que utilitzen gradients per tractar l'impacte de la urbanització sobre els organismes. Un dels gradients més utilitzats de forma satisfactòria és el gradient urbà-rural, el qual ordena els espais segons la seva densitat urbana per explicar variacions en les comunitats vegetals o animals, entre d'altres (Luck & Wu, 2002; McDonnell & Hahs, 2008; Du Toit & Cilliers, 2011).

Els tipus de gradients més comuns són els anomenats gradients complexos, i es defineixen per comptar amb més d'una variable de contrast. En aquests casos, cal quantificar, per separat, cadascuna de les variables per reconstruir un gradient indirecte que pugui explicar el màxim de variabilitat possible (McIntyre et al., 2002). Aquest element és d'especial importància en les ciutats ja que els ambients urbans són molt heterogenis i sovint la quantificació dels gradients és dificultosa i està subjecta a diversos factors. Utilitzant aquest recurs és possible reduir la subjectivitat dins dels resultats (Hahs & McDonnell, 2006) i establir comparacions de gradients entre ciutats de tot el món que utilitzin la mateixa metodologia.

Un cas particular de gradients, i que mereixen un tracte diferencial, són aquells que parteixen de dades socioeconòmiques com a base per a la seva confecció. La inclusió d'elements socials quantificables en l'elaboració dels gradients pot enfortir els resultats i ajudar a predir patrons de biodiversitat urbana (Collins et al., 2000; Kinzig et al., 2005).

Diversos estudis han demostrat que la influència dels factors socioeconòmics té conseqüències directes sobre la diversitat florística dels espais urbans (e.g., Hope et al., 2003; Kinzig et al., 2005). Els recursos que disposa un grup poblacional poden limitar o millorar les condicions ambientals per a la persistència d'elements vegetals concrets.

Així, una de les conclusions coincidents entre aquest grup d'estudis, és justament que aquells habitants amb nivells de renda més alts generen àrees urbanes amb major diversitat biològica que aquells que disposen d'un nivell de renda menor. Aquest fenomen descrit per Hope et al. (2003) com "*luxury effect"* (efecte de luxe), s'ajusta a la lògica del gradient socioeconòmic.

L'aplicació de gradients socioeconòmics és una eina eficient per millor la comprensió dels ecosistemes urbans i pot ajudar a gestionar i planejar millor les nostres ciutats. Ara bé, existeixen limitacions en l'aplicació dels gradients socioeconòmics especialment en àrees urbanes gestionades de forma pública. A més, sovint els gradients socioeconòmics es troben estretament associats a gradients biofísics (elevació, qualitat de l'aigua, temperatura, etc.), fet que complica l'anàlisi i pot conduir a conclusions errònies. Així, per exemple, certes zones amb elevada qualitat ambiental o situades en posicions elevades sovint són reservades a grups socials de renta mitja-alta.

En la present tesi, l'ús de gradients ha estat emprat de forma indirecte a partir de diferents paràmetres socioeconòmics i demogràfics. Tal i com es detallarà en les capítols posteriors, aquests factors no han estat integrats conjuntament en forma d'un sol índex sinó que han estat considerats per separat per estudiar la seva importància relativa sobre la composició florística dels jardins domèstics.

1.2 LA BIODIVERSITAT VEGETAL EN ELS AMBIENTS URBANS

1.2.1 La influència de la urbanització en la vegetació

El Conveni sobre la Diversitat Biològica (Nacions Unides, 1992) defineix biodiversitat com el conjunt d'organismes vius que habiten en un ecosistema, o grups d'ecosistemes, i comprèn la diversitat dins de cada espècie (diversitat genètica), la diversitat entre les espècies (diversitat taxonòmica) i la diversitat dels ecosistemes (diversitat ecològica). El procés d'urbanització exerceix influència sobre la biodiversitat, ja sigui tant en aspectes positius (e.g., augment de la diversitat gamma) com negatius (e.g., introducció d'espècies invasores). A més, els humans som físicament, psicològicament i socialment dependents de la diversitat del nostre entorn, tal com ja s'ha descrit en apartats anteriors.

Les espècies presents en àrees urbanes s'originen a partir de tres mecanismes: (1) espècies natives que ja estaven presents abans del desenvolupament urbà, (2) espècies natives que, encara que no es trobaven prèviament de forma natural, s'han desenvolupat en les noves condicions urbanes, i (3) espècies foranes introduïdes a través de l'activitat humana (McKinney, 2006; Williams et al., 2009; Boada & Sànchez, 2011; 2012). Ara bé, no totes aquestes espècies acaben adaptant-se eficientment a aquest nou medi.

El marc de treball proposat per Williams et al. (2009) presenta quatre tipus de filtre segons la pressió de selecció que, de forma conjunta, determinen quines són les espècies que prevalen en un ambient determinat (Figura 1.2). Cadascun d'aquests filtres pot comportar guanys o pèrdues en la flora i la fauna d'una regió. No obstant això, identificar una sola força motriu que generi les variacions en les espècies és complex, ja que diferents filtres poden actuar simultàniament. No s'han d'obviar tampoc les influències que el medi natural exerceix sobre la vegetació dels espais urbans i que poden quedar excloses d'aquest sistema de filtrat (Williams et al., 2009).

El primer dels filtres fa referència a la transformació de l'hàbitat per explicar que cert nombre d'espècies han estat incapaces de persistir en ecosistemes urbans una vegada que la seva àrea de distribució original s'ha vist reduïda com a conseqüència del desenvolupament urbà. Aquest filtre, causa, en general, una pèrdua neta d'espècies encara que els seus efectes poden ser més o menys intensos segons el grau d'urbanització que s'hagi dut a terme. L'existència prèvia d'espais de cultiu influeix també en aquest filtre, ja que l'agricultura hauria causat prèviament un descens en el nombre i abundància d'espècies respecte a l'hàbitat natural original.

En segon lloc, la fragmentació dels hàbitats actua també com a filtre sobre la biodiversitat ja que diversos grups d'espècies requereixen d'àmplies àrees de distribució perquè les seves metapoblacions puguin persistir a llarg termini. Molt sovint aquestes grans àrees no es troben en regions urbanes on el paisatge no construït es sol trobar fragmentat o vagament connectat a través de zones d'embornal. Aquest filtre causa una pèrdua neta d'espècies ja que només aquells tàxons adaptats a persistir en poblacions petites arriben a sobreviure.

En tercera instància, els efectes urbans sobre el medi juguen també un paper destacat en el filtrat de la biodiversitat ja que les àrees verdes urbanes estan subjectes a efectes ambientals que no estan presents, o són menys importants, en altres ecosistemes menys fragmentats (Grimm et al., 2008). Això inclou alts nivells de contaminació atmosfèrica i del sòl, elevades temperatures per l'efecte UHI (*Urban Heat Island*, explicat en 1.2.2), o l'augment de l'estrès hídric, entre d'altres (Pickett et al., 2001, 2011; Grimm et al., 2008). Tots aquests efectes, sumats, determinen l'ocurrència de determinades espècies en els nous hàbitats antropogènics. Alhora, també són responsables dels guanys o pèrdues de tàxons en els fragments d'espai natural aïllats dins de la matriu urbana. Aquest tipus de filtre selecciona només les espècies adaptades a les pertorbacions urbanes (Williams et al., 2009). Aquestes pertorbacions solen tenir un caràcter permanent, inhibint així el procés de successió biològica (Cilliers & Siebert, 2010).

Finalment, i en quart lloc, també les preferències humanes s'apunten com a agent influent sobre els fluxos de biodiversitat en ambients urbans. D'aquesta manera, la composició florística dels hàbitats antropogènics respon en gran mesura a la combinació de dos fenòmens d'incorporació d'espècies: les plantacions amb finalitats hortícoles i el desenvolupament de plantes exòtiques adventícies, és a dir, aquelles plantes que apareixen en aquests ecosistemes de forma no desitjada com podrien ser algunes espècies del gènere *Amaranthus* o *Chenopodium* (Williams et al., 2009). Les preferències humanes exerceixen una forta pressió de selecció sobre el nombre i el tipus d'espècies exòtiques introduïdes en els hàbitats urbans, així com també en la forma en què aquestes són gestionades (Hope et al., 2003; Luck et al., 2009) . La probabilitat que s'estableixi una nova població es troba directament relacionada amb la incorporació del nombre d'individus amb capacitat reproductiva. En aquest sentit, la preferència humana actua com a filtre evident afavorint algunes espècies per sobre d'altres. Williams et al. (2009) conclou que aquestes preferències comporten un augment net del nombre d'espècies del sistema.

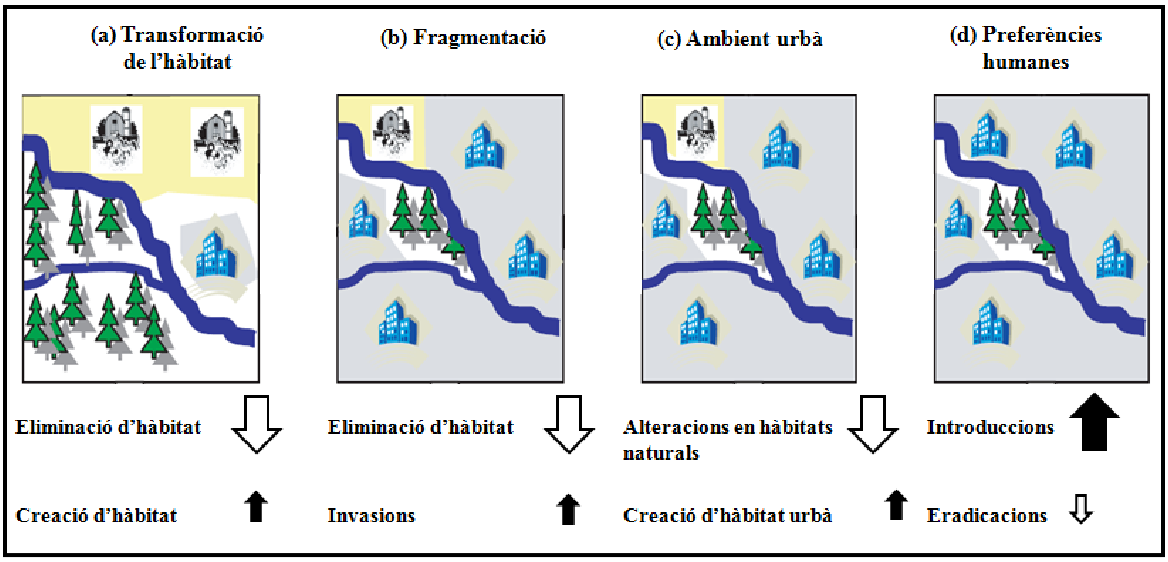


Figura 1.2: Diagrama dels quatre majors filtres urbans que determinen els fluxos de biodiversitat vegetal en ambients urbans. Font: Elaborat a partir de Williams et al., (2009). Les àrees verdes urbanes (icona d'edificis) es poden desenvolupar ja sigui a partir de vegetació nativa (icona d'arbre) o terra agrícola (icona de granja). Les fletxes negres representen guany d'espècies i les blanques perduda d'espècies. La seva grandària és proporcional a la predominança del fenomen dins del filtre.

Existeixen diversos estudis que confirmen tot el que s'ha discutit sobre els efectes de la urbanització i la pressió en el filtrat d'espècies (Sax & Gaines, 2003; McKinney, 2008). En tots ells, es conclou que les àrees urbanes, en general, disposen d'un major nombre d'espècies que les àrees naturals i agrícoles adjacents. És a dir, la diversitat gamma, que equival al nombre total d'espècies entre hàbitats connectats, és major en àrees urbanes que en altres ecosistemes contigus. En aquest context, les àrees perifèriques acullen més biodiversitat que les zones urbanes més cèntriques (Rueda, 1995). McKinney (2006), per la seva banda, s'arriba a la conclusió que la vegetació entre ciutats és més semblant entre si que la vegetació de diferents àrees naturals comparades entre elles. En altres paraules, les àrees urbanes disposen d'una menor diversitat beta (aquella entre hàbitats d'un mateix ecosistema) que les àrees naturals. Així doncs, tot i que la biodiversitat local es pugui veure ampliada per l'arribada d'espècies vegetals exòtiques, la biodiversitat nativa tendeix a disminuir, conduint així la situació general cap a un estadi de "homogeneïtzació biòtica" (Sax & Gaines, 2003). En aquest sentit, Boada i Sànchez (2011; 2012) apunten que hi ha dues estratègies per afavorir la biodiversitat urbana: d'una banda la naturació (estratègies per incrementar el verd urbà sostenible) i per una altra la naturalització (procés de facilitació d'entrada de la biodiversitat faunística d'acord amb la naturació).

En la darrera dècada s'han desenvolupat diferents índexs i estratègies per avaluar la biodiversitat urbana (veure Kohsaka, 2010). Els indicadors urbans són un grup d'eines convencionalment utilitzades per a la comunicació, la formulació de polítiques, monitoratge i avaluació. Des de 1978, hi ha una sèrie d'iniciatives internacionals a gran escala per desenvolupar indicadors urbans que incloguin els elements ambientals i la biodiversitat. Un dels primers estudis en aquest sentit va ser l'anomenat "*Urban Environmental Indicators*", el qual utilitzava per a la seva anàlisi diferents conjunts de dades sobre habitatges i activitats econòmiques (OCDE, 1978). Ara bé, existeix una iniciativa impulsada pel govern de Singapur, i que es troba en fase de desenvolupament, per crear un indicador específic de biodiversitat al context urbà i que s'anomena "índex de biodiversitat urbana" de Singapur (CBI; veure Chan & Djoghlaf, 2009). Per tal de poder generalitzar l'aplicació d'aquest índex, és recomanable identificar l'escala espacial i temporal apropiada (van de Kamp et al., 2003).

El perfeccionament d'aquests índexs ambientals urbans ha de contribuir al desenvolupament sostenible de les àrees urbanes. Això, sens dubte, requereix la integració dels factors econòmics, socials i ambientals per tal de garantir un desenvolupament econòmic que respecti l'equitat social i la protecció del medi ambient. Tot i que existeix un consens general sobre els components ambientals i socioeconòmics que els índexs han de mesurar, hi ha poc consens sobre la manera com aquests s'han de monitoritzar (OCDE, 1997). És necessari, doncs, desenvolupar indicadors eficients i senzills que permetin als responsables de la gestió urbana fer un seguiment i avaluació de les polítiques enfocades a la sostenibilitat de les ciutats.

1.2.2 La importància de la biodiversitat vegetal urbana com a productora de béns i serveis

La diversitat de flora i fauna en els ecosistemes urbans juga un paper essencial en la generació de béns i serveis ambientals per a la comunitat. Aquests beneficis es defineixen com els "que la població humana obté, directament o indirectament, de les funcions dels ecosistemes" (Costanza et al., 1997:1). Els béns produïts per aquests espais verds poden ser aliments, combustible, fibres, o productes farmacèutics i industrials, entre d'altres. Per la seva banda, els serveis que ofereixen els ecosistemes poden ser l'oci, l'educació, la filtració de l'aire, la reducció del soroll, o la prevenció de l'erosió per part del escorriment d'aigües superficials (Cameron et al., 2012).

Les grans àrees metropolitanes solen assolir temperatures més elevades que les àrees rurals adjacents. Aquest fenomen, descrit per Howard (1818-1820) és l'anomenat efecte "illa de calor urbana", i prové del terme anglosaxó "*Urban Heat Island*" (UHI). La relació entre l'espai verd urbà i la mitigació de l'efecte UHI es troba actualment en fase d'estudi (Alexandri & Jones, 2008). Gill et al., (2007) suggereix que un 10% en l'increment de la superfície verda urbana previndria la pujada de 4ºC prevista per als propers 80 anys a la ciutat de Manchester (Anglaterra). Concretament, la presència d'arbres en aquests espais esdevé el factor clau en la reducció de la temperatura urbana, gràcies en part a l'ombra que confereixen però també a la seva elevada evapotranspiració (Akbari et al., 1997). A més, els arbres juguen simultàniament un paper important en la filtració de l'aire i la fixació de diòxid de carboni (Bolund & Hunhammar, 1999). Ara bé, més enllà de la influència dels arbres, també un ampli ventall de tipologies de vegetació disposen d'elevat potencial per refredar l'espai urbà. La situació dels espais verds té conseqüències significatives sobre la regulació tèrmica. Estudis realitzats al continent americà suggereixen que la localització estratègica de les plantes en espais urbans pot reduir entre un 20% - 40% el consum energètic dels edificis (Akbariet al., 1997, 2001). Malgrat l'innegable potencial que té la vegetació urbana per pal·liar l'efecte UHI, la seva efectivitat queda determinada per la disponibilitat d'aigua. Així, per exemple, el refredament potencial a l'abast d'un espai enjardinat constituït de gespa està fortament relacionat amb el reg que se li destina (McPherson et al., 1989). De forma general, queden encara diversos aspectes per resoldre sobre la manera com s'integren i es comparen els paràmetres climàtics i la vegetació a diferents escales (Stewart, 2011).

El balanç de carboni és també un element destacable en el conjunt de serveis dels ecosistemes. Les plantes llenyoses disposen d'una capacitat de fixació de carboni més àmplia que les plantes anuals a causa de la capacitat d'emmagatzematge que té la seva biomassa (Jo & McPherson, 2002). Així, en els jardins domèstics es pot arribar a emmagatzemar una mitjana de $2{,}5x10^3$ g/m^2 de carboni, tenint en compte que un 83% es troba a terra, un 16% en arbres i arbustos i només un 0,6% en espècies vegetals herbàcies

(Jo & McPherson, 2002). Les pràctiques de jardineria amb actituds responsables com la reducció d'herbicides, l'ús d'aigua reciclada, o disposar d'una vegetació heterogènia són també factors que condicionen les emissions de CO_2 i que per tant juguen un paper destacat en el balanç global de producció d'aquest gas (Pouyat et al., 2002).

Algunes plantes, especialment arbres i arbustos, poden alliberar compostos biogenètiques orgànics volàtils (BVOCs), que tenen un elevat potencial per produir ozó quan reaccionen amb òxids de nitrogen resultants de les activitats humanes (Benjamin & Winer, 1997). Les quantitats i característiques específiques dels BVOCs són particulars per a cada espècie, i cal tenir-ho en compte per utilitzar les espècies més adequades a les plantacions i la planificació urbana (Paoletti, 2009). De forma general, hi ha un gran nivell d'incertesa sobre el paper que juga la vegetació urbana en l'eliminació d'aquests contaminants (Pataki et al., 2011).

L'aigua, entesa com a recurs, també pot experimentar variacions en els seus cicles d'entrada i sortida, i esdevenir un factor limitant en el manteniment de la biota o conjunt d'organismes vius dels espais urbans. Les zones verdes ornamentals es troben sovint associades a un elevat consum d'aigua, sobretot en períodes de sequera quan aquestes requereixen d'una major aportació hídrica. Aquest elevat requeriment d'aigua pot, a més, limitar l'accés al recurs per part dels organismes que no disposen d'una aportació artificial. En espais privats, especialment en urbanitzacions amb habitatges unifamiliars amb jardí, el consum d'aigua per a reg pot suposar entre el 30% i el 70% de l'aigua total consumida a les llars (Domene & Saurí, 2003; Salvador et al., 2011). En aquest context de demanda hídrica global, cal afegir, a més, els efectes que durant els propers anys pugui tenir el canvi climàtic sobre aquelles regions més sensibles a les variacions tèrmiques i pluviomètriques com és la regió mediterrània (Sala et al., 2000; Ribas et al., 2010).

Els ecosistemes urbans desenvolupen també una funció en la regulació de l'escorrentia de les aigües superficials i inundacions associades. La vegetació, especialment els arbres, intercepten l'aigua de la precipitació i la mantenen temporalment a la superfície del seu dosser reduint així el seu flux cap a terra (Xiao & McPherson, 2002). A més, la vegetació també mitiga l'efecte de les inundacions en augmentar la infiltració a través del sòl (Dunne et al., 1991). No obstant això, en diverses àrees urbanes, la tendència general és augmentar la superfície pavimentada artificialment (García, 2012). En aquest sentit, Pauleit i Duhme (2000) van comprovar que els espais urbans de baixa densitat estaven vinculats a episodis de inundacions menys severs que aquells espais de major densitat. Per aquest motiu, a Anglaterra, i des de 2008, és necessari un permís per canviar el paviment vegetal per paviment artificial a les llars (Anon, 2009).

Segons Chiesura (2004), l'espai verd de les ciutats també s'usa per a diferents motius de benestar personal com ara la relaxació, l'alliberament de l'estrès de la ciutat, o el gaudi de sensacions positives de contacte amb la natura, entre d'altres. Aquestes experiències tenen conseqüències tant a nivell físic, psicològic com social, influint així en la qualitat de vida dels ciutadans (Clayton, 2007). Algunes investigacions han demostrat, per exemple, que els pacients exposats a ambients naturals durant el seu procés de recuperació es recuperen més ràpid que aquells que ho fan en ambients més edificats i construïts (Ulrich, 1981).

Finalment, els espais verds urbans i periurbans, suposen també una oportunitat per incrementar l'agricultura de subsistència (Domene & Saurí, 2007). Actualment, una setena part de l'aliment del nostre planeta és produïda a través de l'agricultura urbana, incloent també la que té lloc en jardins domèstics (Olivier, 1999). Aquest fet és especialment important en comunitats pobres de països en vies de desenvolupament (Shackleton et al., 2008), però també en molts altres països desenvolupats. A Catalunya, on la presència d'horts en espais residencials és cada vegada més gran, aquests poden arribar a representar fins a un 6,5% del total de la superfície exterior en àrees residencials (García, 2012).

1.3 ELS JARDINS DOMÈSTICS URBANS: UN CAS PARTICULAR

1.3.1 Breu història dels jardins domèstics contemporanis

L'espècie humana ha utilitzat l'horticultura, és a dir, el cultiu i cura de les plantes, des de fa més de 3000 anys (Hadidi, 1984). Tot i que en els seus inicis els propòsits de cultiu eren purament utilitaris, algunes cultures més desenvolupades, com la romana, van començar a cultivar les plantes per adornar estèticament seus habitatges i els van atorgar diferents valors (Guillot, 2009). A més, aquests espais jugaven un paper simbòlic en la concepció del "Paradís" i estaven carregats d'elements espirituals (Bennis, 2006). Així, els romans dividien l'espai enjardinat de la casa en quatre parts on plantaven diferents espècies vegetals: hortalisses, flors, plantes aromàtiques o medicinals, i arbres fruiters i xiprers, aquest últim grup molt vinculat al simbolisme espiritual (Guillot, 2009). Ara bé, la jardineria ornamental, tal com la coneixem avui, es va originar a partir del segle XII i XIII (Owen, 1991), i va ser l'expansió colonial, juntament amb el descobriment de noves parts del món, les que van aportar noves espècies en el comerç mundial d'aquest tipus de plantes (Reichard & White, 2001).

Durant l'Edat Moderna, i gran part de la contemporània, els jardins eren dissenyats majoritàriament per arquitectes que donaven resposta als cànons estètics, culturals i ideològics de cada època concreta. Sovint aquests espais es situaven en grans parcel·les d'espai públic per complir, a més, un paper simbòlic, o bé en propietats privades de col·lectius amb elevat poder adquisitiu. No va ser, però, fins al segle XX, que la jardineria entrarà de ple en el planejament urbà de les ciutats.

En les últimes dècades, determinades zones urbanes del litoral Mediterrani han experimentat una reestructuració en forma de procés de dispersió (Dura-Guimerà, 2003; Muñoz, 2003). Aquest procés sovint ha comportat un desenvolupament urbà de baixa densitat amb models de ciutat difusa i amb característiques típiques dels patrons urbans anglosaxons, cosa que difumina encara més la identitat pròpia de cada ciutat (Rueda, 1995; Muñoz, 2007). Aquesta explosió urbanística laxa, ha comportat inevitablement un augment del nombre de jardins domèstics privats. En gran mesura, aquests espais han tendit a ocupar superfícies relativament petites de territori, però la seva elevada proliferació, especialment en àrees residencials, ha suposat grans consums de sòl urbà a gran escala (Goddard et al., 2009).

Els criteris utilitzats per dissenyar, crear i gestionar aquest volum important de jardins responen a diverses variables com ara les característiques urbanes de cada lloc, el nivell socioeconòmic dels seus ocupants o fins i tot qüestions psicològiques i de comportament, entre altres (Hope et al., 2003: Cook et al., 2012). També els patrons historico-culturals han tingut la seva influència en la forma i composició dels jardins domèstics actuals, i això es detecta en una tendència generalitzada que sembla conduir els jardins cap a una globalització de la flora urbana (Faggin & Ignatieva, 2009). Així doncs, creix la importància de preservar el patrimoni local, natural i cultural, per crear ciutats úniques amb ecosistemes particulars que mantingun la biodiversitat local i que alhora asseguin una utilització eficient dels recursos naturals.

1.3.2 Urbanisme difús, jardins domèstics i consum d'aigua

Durant les últimes dècades, bona part de les àrees urbanes del litoral Mediterrani han experimentat un procés en forma de dispersió territorial (Durà, 2003). Aquest procés, anomenat en anglès *urban sprawl*, es caracteritza per un creixement excessiu de les ciutats (Brueckner, 2000) i per una taxa d'urbanització més alta que la taxa de creixement demogràfic (EPA, 2009). També en el mateix període, han tingut lloc canvis importants en l'estructura socioeconòmica que s'han traduït en transformacions severes del paisatge tradicional. La suma d'ambdós processos, dispersió i canvis socioeconòmics, ha comportat un augment del nombre d'assentaments residencials de baixa densitat (Benfield et al., 1999). Aquesta tipologia urbana es caracteritza per patrons típics del planejament urbà anglosaxó i el model de ciutat difusa (León, 2003).

Tot i que es tracta d'un fenomen intrínsec de la història de les ciutats (Glaeser, 2011; Bruegmann, 2005), per entendre el procés de l'urbanisme difús cal retrocedir fins a principis del segle XX a Estats Units (Southwort & Owen, 1993). Des de llavors, la dispersió urbana s'ha caracteritzat per dibuixar extenses zones residencials de baixa densitat, dependents de l'automòbil i destinades a ser ocupades per grups socials de renta mitja-alta. Més enllà de les característiques morfològiques, la dispersió urbana s'associa a la fragmentació social i espacial del territori, comportant la proliferació d'extenses àrees monofuncionals (Couch et al., 2004).

A més, aquest model urbà difús s'ha comprovat que porta associat més impactes ambientals negatius que no pas el model compacte (Rueda, 1995; Parés-Franzi et al., 2006). Un gran nombre d'estudis han explorat aquests impactes en gairebé tots els paràmetres ambientals (Camagni et al., 2002; Cook et al., 2012), destacant la degradació de la qualitat de l'aire (Frank, 2000) i de l'aigua (Otto et al., 2002) o la pèrdua i fragmentació dels hàbitats (U.S. Environmental and Protection Agency, 2009).

Malgrat que durant les dues últimes dècades el procés d'expansió urbana s'ha inspirat, en part, en el marc Europeu d'Ordenació del Territori (Giannakourou, 2005), les polítiques han estat poc eficaces en la contenció del creixement de les ciutats (Chorianopoulos et al., 2010). És per això que cal un nou enfocament de la planificació basat en el monitoratge permanent de l'ús del sòl -juntament amb l'evolució del climàtica i demogràfica- per fer front a la relació entre expansió urbana i la pèrdua creixent de valors ambientals a tota la regió mediterrània (Marull et al., 2009). La promoció d'un creixement urbà en regions policèntriques compactes (Gennaio et al., 2009) és un element clau per aconseguir un desenvolupament més sostenible inspirat en els principis comuns d'equitat i la cohesió espacial (Meijers, 2008).

Una problemàtica d'especial rellevància lligada a l'urbanisme difús és l'augment de la demanda d'aigua per la presència d'habitatges unifamiliars amb jardí (Domene & Saurí, 2006; St. Hilaire et al., 2010). Aquest fenomen pot ser especialment important al sud d'Europa on el clima Mediterrani es caracteritza per llargs períodes de sequera, concretament, durant els mesos d'estiu i coincidint amb el major pic anual de demanda hídrica degut al turisme i a l'agricultura (Parés & Franzi, 2006). En aquest sentit, a Catalunya (Espanya), el govern autonòmic va aprovar el decret 84/2007 "d'adopció de mesures excepcionals i d'emergència en relació amb la utilització dels recursos hídrics" que preveu la prohibició de destinar aigua apta per al consum humà per a activitats com el reg de jardins en cas d'escenaris extrems de sequera.

L'augment de la demanda d'aigua en habitatges de tipus unifamiliar es deu principalment a l'aparició d'usos recreatius exteriors com ara les piscines o la horticultura (Saurí, 2003). En aquest sentit, un estudi desenvolupat a Austràlia l'any 2001 calculà que el 44% de l'aigua domèstica es destinava a usos exteriors (ABS, 2004). De forma similar, Mayer et al. (1999) van comptabilitzar, per a 12 ciutats americanes, que les llars gastaven de mitjana un 58% del total de l'aigua per a usos exteriors, sent la presència de piscina el factor més important en el consum. Per altra banda, altres autors han defensat que la major part del consum d'aigua domèstica té lloc en els jardins tot i que els resultats poden ser significament diferents d'acord amb el sistema de reg utilitzat (Chestnutt & McSpadden, 1991; Renwick & Archibald, 1998). El volum d'aigua consumit en aquests espais es troba directament relacionat amb la tipologia d'enjardinament i la seva cobertura vegetal.

Davant del repte de gestionar millor l'eficiència en el consum d'aigua domèstica, diferents autors han centrat la seva recerca en els jardins domèstics i en els factors que determinen la seva estructura i composició (Larsen & Harlan, 2006; Mustafa et al., 2010; Hurd, 2006; Yabiku, et al., 2008). En una regió àrida d'Arizona (U.S.), Martin et al. (2003) van identificar tres tipus de jardins basats en la vegetació i la intensitat de l'ús de l'aigua:

jardins "mèsics" amb gespa i arbres amb ombra; jardins "xèrics" amb grava i plantes adaptades a la sequera, i jardins "oasis" amb elements mèsics i xèrics. A l'estat de Nou Mèxic (EUA), Hurd (2006) va trobar que la superfície de jardí ocupada per gespa estava directament relacionada amb el nivell educatiu, el preu de l'aigua, i el grau de conscienciació dels propietaris en relació a l'estalvi hídric. A la regió Mediterrània, la gespa és tractada com un element posicional i de distinció socioeconòmica ja que es troba escassa en els ambients naturals de les àrees més àrides (Hirsch, 1976). El principal desavantatge del seu ús en aquest context és el seu elevat requeriment hídric, el qual no pot ésser satisfet pel règim pluviomètric típic dels ambients subàrids. Altres autors han relacionat positivament la presència de gespa en jardins amb aquelles llars amb més ingressos (Domene & Saurí, 2003; Larson et al., 2009). També Larsen i Harlan (2006) van trobar per la ciutat de Phoenix (Arizona, EUA) que, mentre les rendes mitjanes preferien jardins amb vegetació autòctona, les rendes més altes optaven per jardins de tipus "oasis" amb gran número d'espècies exòtiques vistoses i lligades a elevats consums d'aigua.

Justament, s'ha comprovat també que els jardins amb una major demanda hídrica acostumen a disposar de sistemes de reg més tecnificats (Chesnutt & McSpadden, 1991; Mayer et al., 1999; Martin, 2001, Syme et al., 2004; Saurí & Parés, 2005; Endter-Wada et al., 2008). No obstant, l'excés de reg és endèmic en molts jardins (Nielson & Smith, 2005; Salvador et al., 2011) ja que els sistemes de reg automàtic sovint es programen a altes freqüències, sense tenir en compte l'estacionalitat o les necessitats hídriques de les plantes (Martin, 2001). Així, l'eficiència de reg disminueix convertint-se en un punt feble important pel què fa a la gestió dels jardins (e.g., Salvador et al., 2011; Fernández-Cañero et al., 2011).

Als Estats Units hi ha un alt nivell de conscienciació pel què fa al disseny dels jardins i el seu impacte en el consum d'aigua. Això es fa palès a través de conceptes com la "xerojardineria" (St. Hilaire et al,. 2008). La xerojardineria és un mètode desenvolupat a Colorado el 1981 per tal de portar a terme una jardineria de baix consum d'aigua i que inclou set principis bàsics: el disseny i la planificació, l'anàlisi del sòl, l'ús de plantes amb baixos requeriments hídrics, la creació d'àrees cespitoses d'ús pràctic, el reg eficient, l'ús de "mulching" (encoixinats de matèria orgànica per conservar la humitat) i un manteniment eficient del jardí (Wade et al., 2007). Diferents autors suggereixen que la tendència a utilitzar els principis de la xerojardineria augmenta amb el nivell educatiu i el coneixement d'aquestes tècniques (Hurd, 2006; Mustafa et al., 2010; Fernández-Cañero et al., 2011).

Tot i això, s'apunta al preu de l'aigua com un dels factors més importants que controla l'ús de l'aigua residencial (Bauman et al., 1998; Domene & Saurí, 2003). Aquest es sol caracteritzar per una demanda inelàstica ja que les variacions de la demanda són menors que les variacions en el cost de l'aigua (Renzetti, 2002). En aquest sentit, una política adequada del preu de l'aigua pot ser una de les eines més importants per disminuir o fer més eficient el reg dels jardins privats. Per altra banda, i com suggereixen Kjelgren et al. (2000), els esforços de conservació de l'aigua s'haurien de focalitzar especialment en els canvis en les cobertes vegetals, la composició d'espècies, el sistemes de reg i l'educació dels propietaris.

A Espanya les preocupacions envers l'ús de l'aigua en espais enjardinats és relativament recent. L'any 1991, Burés (1991) introduí el concepte xerojardineria i des de llavors s'ha popularitzat i difós àmpliament (Burés, 2000; Fundación Ecología y Desarrollo, 2000; Martín et al., 2004; Labajos, 2004). L'ús d'aigua urbana en jardins domèstics ha estat analitzada en cinc regions espanyoles: el litoral gironí (Garcia, 2012), Barcelona (Domene & Saurí, 2003, 2006), Murcia (Contreras et al., 2006), Saragossa (Salvador et al., 2011) i Sevilla (Fernández-Cañero et al., 2011).

En el primer dels casos, García (2012) identificà quatre tipologies diferents de jardí cadascuna d'elles vinculada a perfils demogràfics concrets. Les necessitats hídriques teòriques de cada jardí foren relacionades positivament amb el nivell d'ingressos de la llar i un major interès en la jardineria per part dels propietaris. A Múrcia, Contreras et al. (2006) establiren, a partir del mètode WUCOLS proposat per Costello et al. (1994; 2000; 2014), un llistat de les espècies més comunament utilitzades en jardineria ornamental conjuntament amb els seus requeriments hídrics teòrics. Utilitzant també aquest mètode, Salvador et al. (2011) arribaren a al conclusió que els jardins de la seva àrea d'estudi eren regats en excés i que aquesta activitat suposava el 46% del consum total d'aigua domèstica. En contra d'aquests resultats, Domene i Saurí (2003) constataren que els jardins eren sovint regats per sota de les seves necessitats, sobretot pel què fa a les superfícies amb gespa. Per la seva banda, Fernández-Cañero et al. (2011), en un estudi realitzat a diferents habitatges amb jardí, destacaren que un 43% d'aquests espais no disposava de sistemes de reg automatitzats. Els mateixos autors conclogueren que els propietaris amb coneixements sobre xerojardineria portaven a terme pràctiques d'ús de l'aigua més sostenibles.

1.3.3 Biodiversitat vegetal en jardins domèstics

Els jardins domèstics, en general, són gestionats de forma privada. Aquest atribut ha comportat que sovint aquests espais quedessin exclosos del balanç global d'espais verds de les ciutats, conduintt així a un biaix substancial respecte al total de zones verdes reals (Gaston et al., 2005b). A Anglaterra, es calcula que els jardins domèstics constitueixen pràcticament una quarta part de la superfície total de cinc de les ciutats més poblades del país (Gaston et al., 2005b; Loram et al., 2007). A la ciutat de Dunedin (Nova Zelanda), el percentatge podria augmentar fins al 36% del total de l'àrea urbana (Mathieu et al., 2007), i a Baltimore (Michigan), fins al 90% del dosser dels arbres es troba en espais privats (Troy et al., 2007). Per tant, tot i que els jardins, de forma individual, solen representar una part relativament petita del territori, quan es consideren com a conjunt abasten una parta considerable de les superfícies urbanes totals (Goddard et al., 2009).

Més enllà dels béns i serveis que els jardins domèstics puguin aportar, ja sigui a la societat o a l'ecosistema en general, aquests espais reuneixen una diversitat biològica considerable i sovint superior a la majoria d'espais urbans més propers (Thompson et al., 2003), i per tant la seva importància ecològica ha de ser considerada en qualsevol presa de decisions (Terradas, 2001). El manteniment d'aquestes estructures semi-naturals comporta, a més, la inversió de capital econòmic per part dels propietaris, i per tant la indústria de l'horticultura juga un paper rellevant en la promoció de la biodiversitat i de les mesures de gestió i estalvi adequades (Lubbe, 2011).

Thompson et al. (2003) proposen dos motius pels quals els jardins domèstics presenten una varietat tan gran d'espècies vegetals: (1) la gran oferta de plantes disponibles a la venda, i (2) l'elevat esforç de manteniment per part dels propietaris i jardiners especialitzats. Aquest esforç sens dubte dota les espècies de l'habilitat antinatural de persistir amb un nombre escàs d'individus. Quant a la primera de les raons cal remarcar que alguns estudis han aportat dades sobre l'àmplia varietat de plantes a la venda amb finalitats ornamentals. Així, a Anglaterra es poden adquirir un total de 70.000 tàxons

(Macaulay et al., 2009), i als Estats Units 90.000 (Isaacson, 2004). A Espanya, l'obra "Flora Ornamental Espanyola" de Sánchez et al. (2000-2010), tot i que encara es troba inacabada, preveu la descripció de més de 11.000 tàxons emprats en jardineria ornamental. Aquesta xifra supera àmpliament els aproximadament 8.300 tàxons descrits en el conjunt de la flora espanyola silvestre (Blanc, 1988). Així doncs, davant aquesta gran disponibilitat de plantes, i afegint que regularment s'incorporen noves espècies a l'oferta, la varietat de tàxons a l'abast de la jardineria és molt extensa. Associat a aquest fet es troba l'augment d'espècies exòtiques que són usades regularment amb propòsits ornamentals. Diversos estudis han analitzat el percentatge d'espècies exòtiques presents en els jardins domèstics: 88% a la regió de Lauris (França) (Marco et al., 2008), 85% a Bujumbura (Burundi) (Bigirimana et al., 2012), o 75% a Trabzon (Turquia) (Acar et al., 2007). Aquesta proporció d'espècies exòtiques pot posar en perill la vegetació autóctona vulnerable dels espais naturals adjacents en cas que les espècies puguin naturalitzar-se i esdevenir invasores (Dehnen-Schmutz et al., 2007a,b).

1.3.4 Factors determinants de l'estructura i composició dels jardins a l'escala de llar

El tipus d'enjardinament de cada llar reflecteix, per una banda, els seus valors utilitaris com ara l'oci, la producció d'aliments o el benestar físic, emocional i social (Harlan et al., 2006; Clayton, 2007; Endter-Wada et al., 2008; Yabiku et al., 2008; Hirsch & Baxter, 2009; Larson et al., 2009). Per l'altra, reflecteix valors no utilitaris com ara el senzill fet de sentir-se orgullós de l'espai familiar (Feagan & Ripmeester, 1999; Endter-Wada et al., 2008; Hirsch & Baxter, 2009). Així doncs, els jardins privats poden representar expressions simbòliques de la identitat dels seus residents (Larsen & Harlan, 2006; Mustafa et al., 2010), alhora que en reflecteixen els ideals personals i socials tenint en compte la manera com els ocupants perceben el món que els envolta (Larson et al., 2009). D'aquesta manera, el tipus de jardí desitjat pot influir en la decisió per adquirir un tipus o un altre d'habitatge o la manera com aquest serà gestionat. Una llar amb jardí, per exemple, pot augmentar el sentiment de pertinença a un lloc (Sime, 1993) o fins i tot el valor de l'habitatge (Syme et al., 1991). Alhora, el jardí pot actuar com a element socialitzador i d'experiència sensorial amb la natura (Bhatti & Church, 2000; 2004).

Diferents estudis constaten que el conjunt de decisions individuals dels residents de la llar tenen més influència en l'estructura vegetal dels jardins domèstics que no pas les característiques ambientals i bioclimàtiques com ara la temperatura, la pluviometria o el tipus de sòl (Hope et al., 2003; Martin et al., 2004; Kirkpatrick et al., 2007; Luck et al., 2009). En aquest context, Martin et al. (2004) i Kinzig et al. (2005) han proposat un marc conceptual basat en les influències humanes anomenades "bottom-up" (de baix a dalt) i "top-down" (de dalt a baix). Els processos "bottom-up" es poden definir com els resultats integrats de les decisions o accions a escala individual o de llar (Kinzig et al., 2005). D'acord amb això, la biodiversitat urbana varia segons les característiques culturals, socials o econòmiques dels residents. Els mecanismes "top-down", per la seva banda, reflecteixen les estratègies de gestió i les decisions a nivell de ciutat (Kinzig et al., 2005). Aquest marc va més enllà de l'anàlisi tradicional dels gradients i explica com els humans afecten la biodiversitat en el medi urbà. Els fluxos i activitats d'informació es classifiquen segons el seu grau d'influència "bottom-up" o "top-down". Ara bé, s'ha de considerar que la incidència de les característiques socioeconòmiques i culturals dels residents en els patrons de biodiversitat urbana és major en espais privats que en espais públics (Andersson et al., 2007).

Totes aquestes influències es tradueixen en preferències i pràctiques de gestió específiques per part dels residents. Ara bé, hi ha dos grans grups de factors: els cognitius i els què fan referència a l'estructura de la llar. Els factors cognitius abasten les actituds i judicis dels residents, com ara els valors, creences i normes, mentre que l'estructura de la llar involucra atributs personals i patrimonials com ara el nivell de renda o l'antiguitat de l'habitatge. Aquest darrer grup sembla imposar restriccions més fortes pel què fa a les decisions sobre el tipus de jardí i les seves característiques ecològiques que no pas els factors d'actitud i cognitius (Cook et al., 2012).

Val a dir, però, que les preferències dels propietaris no sempre estan d'acord amb l'opció de jardí escollit, sobretot en aquells jardins que són visibles per la resta de població (Hurd 2006; Larsen i Harlan, 2006). Això es deu principalment a les regulacions i normatives imposades per institucions administratives, sovint de caire municipal, que inhibeixen les preferències dels propietaris. Aquest fet és menys comú en jardins posteriors o *backyards* que queden resguardats de la mirada de la gent (Larsen & Harlan, 2006). Per tant, els patis o jardins visibles pel públic sempre són representacions de la condició social o una adaptació a la normativa urbanística vigent. Per contra, els jardins que queden amagats solen reflectir els ideals dels residents basats en els seus valors personals i el seu estil de vida (Larsen & Harlan, 2006).

Els estudis qualitatius basats en l'opinió dels residents posen de relleu que els valors personals són prioritaris en la determinació de la tipologia de jardí, així per exemple les preferències estètiques hi juguen un paper determinant (Martin et al., 2003; Spinti et al., 2004; Nielson & Smith, 2005; Hirsch & Baxter, 2009). Per altra banda, les preferències per jardins ben cuidats en front de jardins "salvatges" varien segons la seva estètica, la seguretat física que ofereixen als seus residents (e.g., espais de gespa perquè els nens i nenes juguin sense perill) i els serveis ambientals que proporcionen (Jorgensen et al., 2007; Mustafa et al., 2010; Zheng et al., 2011).

La preocupació pel medi ambient és també una prioritat alhora de decidir l'estil de jardí, tot i que sovint es donin contradiccions. Així, moltes persones opten per jardins de tipus xèric per tal de reduir l'aigua de rec, malgrat que altres serveis ambientals com ara la millora de la qualitat de l'aire es trobin més vinculats a espais cespitosos o a altres tipologies de jardí (Larson et al., 2009). D'acord amb això, Larson et al. (2010) argumenten pel cas de Phoenix (Arizona, EUA) que la presencia de gespa es troba relacionada amb una voluntat biocèntrica dels residents en el moment de dissenyar els seus jardins. És a dir aquestes jardins responen a una clara vocació mediambientals que menysté en canvi que aquests espais tenen un impacte més gran en un recurs tan escàs a la zona com és l'aigua.

Ara bé, aquest darrer tipus de jardins coberts per gespa són més aviat escollits per la seva seguretat i comoditat per a practicar-hi activitats de lleure que no pas pels seus valors ecològics. D'aquesta manera, diverses investigacions prèvies han arribat a la conclusió que els valors ambientals dels propietaris no sempre es tradueixen en pràctiques ecològiques als jardins. Així, per exemple, Yabiku et al. (2008) van demostrar que els residents amb unes fortes actituds envers les pràctiques sostenibles i mediambientals (indicat a través de l'escala "Nou Paradigma Ecològic"[1] [veure Dunlap et al., 2000]) rebutjaven de forma significativa la opció de jardí mèsic.

[1] Es tracta d'una eina de mesura de la visió "pro-ecològica" del món. Es basa en què les diferències en el comportament o actitud es poden explicar a partir dels valors subjacents, d'una visió concreta del món, o d'un paradigma (Van Liere & Dunlap, 1980). L'escala es construeix a partir de les respostes individuals a quinze afirmacions que mesuren el grau d'acord o desacord a certs principis considerats ecològics (Dunlap et al., 2000; Dunlap, 2008). S'utilitza àmpliament en l'educació ambiental i altres activitats a l'aire lliure.

En aquesta línia, la gent amb consciencia ambiental o "preocupada" pel medi ambient tendeixen a utilitzar els seus patis i jardins de forma més intensiva que d'altres, especialment amb un major ús de productes químics (Templeton et al., 1999; Robbins et al., 2001; Robbins & Birkenholtz, 2003). Aquests resultats, per altra banda, poc intuïtius, són consistents amb la construcció social de la natura, en la qual els residents consideren les zones verdes urbanes pròpiament com a "naturalesa" pura (Larson et al., 2009).

A més dels factors actitudinals o cognitius, també els atributs personals, els interessos i les habilitats dels residents determinen les característiques dels jardins i les pràctiques de la seva gestió a l'escala de la llar. El nivell de renda, per exemple, s'ha associat positivament amb el tipus de cobertura vegetal i el nivell de biodiversitat (e.g., Mennis, 2006; Boone et al., 2010; Bigirimana et al., 2012). Tal i com s'ha comentat anteriorment, la relació positiva entre el nivell d'ingressos d'una llar i la diversitat vegetal del seu jardí va ser descrita pels ecòlegs com "efecte luxe" (*luxury effect* en anglès) (Hope et al., 2003). Els científics de les ciències socials, per la seva banda, han anomenat a aquest fenomen "efecte prestigi" (*prestige effect* [Martin et al., 2004; Kinzig et al., 2005; Grove et al., 2006; Hope et al., 2006; Troy et al., 2007; Lubbe et al., 2010; Bigirimana et al., 2012]). A part, els recursos econòmics també influencien la gestió del jardins ja que restringeixen la capacitat de modificar-los (Templeton et al. 1999; Hurd et al. 2006; Boone et al. 2010). En concret, el volum d'ingressos de la llar pot arribar a predir les preferències pel jardí (Larsen & Harlan, 2006), els temps de reg o el consum exterior d'aigua (Osmond & Hardy, 2004; Sovocool et al., 2006; Harlan et al., 2009; Polebitski & Palmer, 2010). D'aquesta manera, en estudis duts a terme a diferents regions d'Estats Units, s'ha comprovat que els residents amb ingressos mitjans tendeixen a preferir gespa (Larsen & Harlan, 2006), mentre que residents amb alt nivell adquisitiu estan més disposats a obtenir plantes natives cultivades localment (Curtis & Cowee, 2010).

Hi ha, però, altres atributs dels residents i de l'habitatge que també contribueixen a determinar el tipus de jardí cultivat. Al litoral de Girona (Catalunya), per exemple, Garcia et al. (2013a), establiren 4 tipologies de jardí (Figura 1.3). Cadascuna d'aquestes tipologies responia a un perfil de propietari i de llar concrets, amb diferències significatives pel què fa a l'edat, el grau d'ocupació laboral, la presència de piscina, la mida total de la llar o el tipus d'ocupació residencial. En un altre estudi al sud-oest dels Estats Units, es va detectar que els residents de llarga durada, aquells amb nens petits i les dones preferien jardins amb gespa més que no pas jardins xèrics (Martin et al., 2003;

Spinti et al., 2004; Larsen & Harlan, 2006; Yabiku et al., 2008; Larson et al., 2009). Les diferències pel què fa al gènere s'atribueixen als tradicionals rols socials que situen a la dona com a mestressa de la llar i cuidadora de la mainada i l'home com a gestor principal del jardí i amb preferències per espais que requereixen baix manteniment (Yabiku et al., 2008; Larson et al., 2009). Van den Berg i Van Winsum-Westra (2010) van trobar evidències que suggereixen que les dones aprecien més els jardins que els homes.

Figura 1.3: Exemples de fotografies de les 4 tipologies de jardins descrites per Garcia et al. (2013a): gespa (a dalt, esquerra), hort (a dalt, dreta), ornamental (a baix, esquerra) i arbrat (a baix, dreta). Font: Garcia et al. (2013a).

Les característiques de l'habitatge influeixen també de forma destacada el tipus d'enjardinament practicat. Així, la mida del jardí s'ha descrit com una variable positivament relacionada amb el grau de biodiversitat vegetal, ja que, en general, jardins més grans acullen també més diversitat d'espècies (Smith et al., 2005; Loram et al., 2008; Bernholt et al., 2009; Van Heezik et al., 2013). L'edat o antiguitat de l'habitatge, per altra banda, també s'ha associat positivament amb el tipus de coberta vegetal en sistemes mèsics (Grove et al., 2006; Smith et al., 2006). Fins i tot el llegat dels promotors immobiliaris pel què fa a elements del jardí o de l'habitatge s'ha demostrat que poden condicionar l'estructura dels jardins (Larsen & Harlan, 2006).

Finalment, altres aspectes de caire cultural poden afectar significativament la composició dels jardins. A Australia, Head et al. (2004) van analitzar les influències dels antecedents culturals de diferents grups ètnics en l'estructura dels jardins. Mentre que els residents del sud-est asiàtic optaven per patis amb hortalisses i arbres fruiters, aquells amb origen europeu eren principalment ornamentals. A més, els jardins constitueixen un element de presentació social (Larsen & Harlan, 2006; Yabiku et al., 2008). Així per exemple, a Las Cruces (U.S.), es demostrà que els natius no preferien les plantes del desert als seus jardins, ans el contrari, suposadament com a estratègia de integració social (St. Hilaire et al., 2003). En la mateixa línia, Zmyslony i Gagnon (2000) apunten, en un estudi dut a terme a Montreal (Canadà), que la similitud entre jardins davanters d'un mateix carrer es relaciona amb la proximitat i similitud amb altres llars semblants com a resultat del mimetisme social i cultural.

1.3.5 La horticultura ornamental com a principal via d'introducció d'espècies invasores

Moltes plantes naturalitzades poden tenir impactes negatius sobre la flora i la fauna autòctona d'una regió (Vitousek et al., 1996; Williams, 1997; Ewel et al., 2000). Gran part d'aquestes espècies provenen d'espais cultivats pels humans i, un cop escapen del seu confinament, poden tenir la capacitat de prevaldre de manera autònoma en el medi extern (Reichard & White, 2001; Sanz-Elorza et al., 2009; Dehnen-Schmutz et al., 2007b). L'horticultura ornamental, concretament, ha estat reconeguda com la principal via d'introducció de plantes invasores a molts països desenvolupats (Sanz-Elorza et al., 2004; Dehnen-Schmutz et al., 2007a), i la gestió incontrolada dels residus de jardineria pot actuar com un focus molt eficient de dispersió (Batianoff & Franks, 1998; Sullivan et al., 2005).

A Alemanya, es calcula que el 50% de flora invasora va ser introduïda de forma deliberada i més de la meitat té un origen ornamental (Kühn & Klotz, 2006). Per la seva banda, a la República Txeca, el 53% de la flora introduïda deliberadament té el mateix origen ornamental (Pyšek et al., 2002), i a Austràlia el 65% de les plantes establertes entre 1971 i 1995 van ser introduïdes amb aquests mateixos propòsits (Groves, 1998). A

Espanya, Sanz-Elorza et al., (2004) calculen que aproximadament un 12% del total de la flora del país està constituïda per flora exòtica, i un 48% d'aquesta ha tingut l'horticultura i la jardineria com a causa d'introducció principal.

La investigació en invasions biològiques ha seguit diferents tendències en els últims anys. Un dels eixos centrals ha estat la descripció d'aquelles característiques biològiques que fan que una espècie sigui potencialment invasora. Baker (1974) indica diferents atributs biològics associats a aquest tipus de plantes com una elevada taxa de producció de llavors, una ràpida fase vegetativa per arribar abans a la fase reproductiva, o una elevada capacitat de dispersió de llavors o esqueixos. Actualment, amb l'augment de l'activitat humana i el conseqüent moviment d'organismes arreu del món, l'objectiu central és descobrir què distingeix les espècies introduïdes invasores d'aquelles que són igualment introduïdes però no presenten aquest caràcter invasor (Muth & Pigliucci, 2006). D'altra banda, també és fonamental analitzar la "invasibilitat"[2] dels ecosistemes per tal de caracteritzar i descriure aquells ambients més vulnerables i susceptibles de patir invasions biològiques (Pyšek et al., 1995; Vilà et al., 2007).

La predicció del potencial invasor de les espècies introduïdes pot ajudar a prevenir impactes ambientals negatius. Així, per exemple, les espècies vegetals invasores poden tenir efectes sobre els ecosistemes naturals com extincions a nivell local, canvis en la composició del sòl, competència al·lelopàtica per la producció de toxines, o un elevat consum d'aigua (Schwartz, 1997). La identificació precoç de les espècies potencialment invasores, per tant, ha d'ajudar a protegir els espais naturals i estalviar costos en les pràctiques d'eradicació (Moles et al., 2008). Ara bé, el procés de caracterització de la invasivitat es troba subjecte a diferents variables com la disponibilitat d'informació o els canvis en el temps, la qual cosa es complica encara més la seva determinació (Muth & Pigliucci, 2006). Per altra banda, per tal d'evitar generalitzacions en els riscos associats a les espècies invasores, és imprescindible considerar cada espècie cas per cas (Kowarik, 2011).

Els nous estudis d'anàlisi de la invasivitat comencen a incorporar nous marcs de treball que inclouen no només una anàlisi dels trets biològics de les espècies invasores, sinó també informació sobre les comunitats vegetals natives i les condicions ambientals i

[2] Propietats de l'ecosistema d'introducció que afecten la supervivència de les espècies al·lòctones (Lonsdale, 1999).

socials de les àrees potencialment envaïdes (Moles et al., 2008). Per tant, ja no es tracta només de buscar aquells trets biològics que ajudin a comprendre el potencial invasor d'una espècie, sinó que cal anar més enllà per entendre les circumstàncies ecològiques i socials particulars de cada ambient, com ara el grau d'alteració o la presència de nínxols disponibles, o el context socioeconòmic en què es produeixen les invasions. A més, l'estudi de la component humana, i concretament de la influència del comportament i les preferències personals, s'apunta com un ampli camp d'investigació per recórrer i que pot ajudar a aclarir els patrons de selecció i d'incorporació d'espècies invasores en els ecosistemes urbans.

Tenint en compte l'augment de l'activitat humana arreu del món, les problemàtiques associades a invasions biològiques es preveu que s'aguditzin en els propers anys (Myers et al., 2000). No obstant això, està per veure si en determinants contextos, com ara en grans àrees urbanes de països desenvolupats, i les seves perifèries, les taxes d'invasió i d'incorporació de noves espècies exòtiques es mantenen o fluctuen en el temps.

1.3.6 El paper del jardí domèstic en la conservació biològica i la sensibilització ambiental

Tot i la creixent presa de consciència del potencial dels jardins privats com a eina de conservació, poques investigacions s'han ocupat d'avaluar l'estat de la vida salvatge d'aquests ambients. Aquest fet es deu, principalment, al fet que aquests jardins són vistos com a ecosistemes febles on l'accés és complicat a causa del seu caràcter privat. La majoria d'estudis en jardins domèstics s'han dut a terme en països desenvolupats i prenent un sol jardí com a element d'estudi per analitzar les seves característiques al llarg d'un període prolongat de temps (Owen, 1991). Ara bé, els estudis a curt termini de diversos jardins domèstics estan prenent força en diferents centres d'investigació, destacant notablement el projecte BUGS (*Biodiversity in Urban Gardens in Sheffield*), que inclou el mostreig de la flora i la fauna de més de 300 jardins de diferents ciutats d'Anglaterra (e.g., Gaston et al., 2005a; Smith et al., 2006; Loram et al., 2008). Estudis similars s'han realitzat a Nord Amèrica (Fetridge et al., 2008), la resta d'Europa (Marco et al., 2008), Àsia (Acar et al., 2007; Jaganmohan et al., 2012), o Àfrica (Lubbe, 2011; Bigirimana et al., 2012). En països en vies de desenvolupament destaca el paper del "hort familiar" ("*homegarden*" en termes anglosaxons) per al manteniment econòmic i alimentari de les llars (Fernandes i Nair, 1986). Aquesta tipologia de jardí posseeix funcions diferents respecte als jardins urbans en països desenvolupats i alberguen alts nivells de biodiversitat singular especialment en àrees tropicals (Kumar & Nair, 2004). En el cas de la conca Mediterrània cal lamentar la pràctica inexistència d'estudis d'aquests tipus (Agelet et al., 2000).

D'altra banda, la protecció de la flora dels jardins és important ja que proporciona hàbitat i aliment a diferents espècies (Kendle & Forbes, 1997). La gran riquesa de tàxons, juntament amb la gran extensió que poden arribar tenir les àrees enjardinades, proporciona moltes oportunitats de conservació en diferents llocs. La conservació d'aquests espais privats queda, en gran part, fora de l'abast de les administracions públiques, i per tant els recursos que es poden destinar per a aquest propòsit són molt limitats. Diversos països, com Anglaterra o els Estats Units, compten amb organitzacions i ONGs que promouen estratègies denominades "*wildlife-friendly*" per apropar la importància ecològica dels jardins cap a una opinió pública sovint escèptica envers la conservació d'aquests espais (Goddard et al., 2009). A més, alguns governs en països com Austràlia i Anglaterra, han publicat documents per animar a la població civil a participar de la preservació del seu espai natural més proper, afavorint així la conservació de la naturalesa urbana (Goddard et al., 2009).

L'esforç de conservació té com a element fonamental la valoració que l'ésser humà fa de l'espai natural que l'envolta (Kendle & Forbes, 1997; Miller, 2005). Ara bé, aquesta vinculació i interès està minvant amb el pas del temps sota un procés anomenat "*environmental generational amnesia*" (Kahn, 2002). Aquest procés descriu com cada nova generació té menys sensibilitat ambiental que la generació precedent a causa d'una progressiva disminució del contacte directe amb la natura en una època on predomina la cultura urbana i es redueix l'experiència vivencial més directa amb la naturalesa.

Tenint en compte aquests plantejaments, l'eix central de la conservació en espais urbans s'ha de centrar en millorar la qualitat de vida dels seus habitants més que en la conservació entesa com a tal (Miller, 2005). No obstant això, cada tipologia d'àrea verda urbana ha de ser analitzada per separat per avaluar el seu paper en la conservació de la biodiversitat (Terradas, 2001). Per aconseguir aquests propòsits es disposa d'eines com l'educació ambiental, l'ús d'un llenguatge comprensiu per comunicar-se amb els gestors, la implicació de diferents actors del territori (Miller & Hobbs, 2002), o la inclusió de disciplines de diferents àmbits que permetin una visió més àmplia de conceptes com "biodiversitat" o "conservació" (Cilliers et al., 2004). En aquest sentit, els jardins domèstics serveixen de punt de contacte entre l'espai natural i l'espai urbà, i també com a instrument per apropar els valors ecològics i socials dels ecosistemes a la societat. Per tant, l'aprofitament d'aquests espais ha d'afavorir una presa de consciència global cap a la protecció del medi natural.

1.4 OBJECTIUS GENERALS I ESPECÍFICS

El progressiu augment de les àrees urbanes a nivell mundial converteixen els jardins domèstics en ecosistemes clau per la preservació de la biodiversitat urbana i els serveis ambientals. Entendre els factors que determinen la composició de la seva flora pot ajudar a gestionar millor determinades problemàtiques com el reg ineficient dels jardins o el progressiu augment d'espècies exòtiques invasores amb origen ornamental. Per aconseguir-ho, és necessària una aproximació multidisciplinar que integri tècniques tant de les ciències socials com de les ciències naturals. En aquest sentit, diversos estudis d'àmbit internacional han explorat les relacions entre la biodiversitat vegetal dels jardins i els perfils de la població resident. No obstant, són pocs els què ho han fet al nivell de llar i amb informació precisa i detallada de l'estructura completa de la flora dels jardins i de les característiques demogràfiques i socioeconòmiques dels seus propietaris. A més, abans d'aquesta tesi, no existia cap anàlisi específic de la flora dels jardins privats a Catalunya ni a la resta de l'Estat espanyol.

L'OBJECTIU PRINCIPAL d'aquesta tesis ha estat **analitzar la flora dels jardins domèstics del litoral empordanès per avaluar (1) els factors socioeconòmics que determinen els seus requeriments hídrics potencials i (2) el potencial risc d'invasió biològica**.

Per acomplir-ho, s'han generat els següents OBJECTIUS ESPECÍFICS:

1) A escala global, identificació dels factors que determinen la composició de la flora dels jardins (Capítol 3).

2) A escala de llar, càlcul dels requeriments hídrics dels jardins i exploració de les variables socioeconòmiques que ajuden a predir aquesta variable (Capítol 4).

3) Avaluació de la gestió, manteniment i ús de l'aigua en els jardins mostrejats (Capítol 5).

4) Estudi de l'estructura de la flora dels jardins en relació a la pressió de propàgul d'espècies exòtiques potencialment invasores (Capítol 6).

1.5 ESTRUCTURA DE LA TESI

Tota la recerca duta a terme en aquest treball ha estat englobada i sintetitzada en 12 capítols, 6 dels quals constitueixen el cos central de la tesis i han estat redactats en format d'article científic.

El **Capítol 1** es va elaborar a partir del buidat bibliogràfic de diferents publicacions sobre espais verds urbans i ecologia urbana. La recopilació es va dur a terme a partir del material obtingut de diferents bases de dades com ara ISI Web of Knowledge o Scopus. Com a resultat es van recopilar més de 100 documents que foren sintetitzats i integrats en un marc de treball que permet una aproximació a l'estudi de la vegetació de les ciutats des del punt de vista de l'ecologia urbana. Aquest capítol ha permès establir, doncs, la base conceptual i metodològica per desenvolupar de la resta de capítols.

Per tal de detallar els mètodes i tècniques emprats per donar resposta als objectius de recerca, es va redactar el **Capítol 2** on s'especifica, entre d'altres, el procés de selecció de l'àrea d'estudi i de la mostra d'habitatges, la recopilació de dades o el procés de treball de camp.

Ja entrant en els resultats, el **Capítol 3** es centra en l'anàlisi dels factors determinants de la distribució d'espècies vegetals en diferents jardins i a escala global. Per fer-ho, es van utilitzar els catàlegs florístics de 44 treballs d'arreu del món i dades sociodemogràfiques de diferents fonts. L'estudi, a part d'avaluar la importància relativa de les variables ambientals en front de les variables socials i culturals pel que fa a la distribució d'espècies, va permetre explorar els límits entre les tipologies de jardins a partir de les seves dissimilituds taxonòmiques.

Al **Capítol 4**, i com a pas previ per donar coherència a la metodologia emprada en els capítols posteriors, es va establir un procediment per equiparar el càlcul del coeficient de jardí (Costell & Jones, 1994; Costello et al., 2000, 2014) a la pròpia àrea d'estudi. Aquesta tècnica que permet calcular de forma aproximada els requisits hídrics teòrics dels jardins va ser concebuda per un ús exclusiu al estat de californià d'Estats Units. Com a resultat del present treball, s'ofereixen les indicacions per tal de transportar eficientment aquest mètode de càlcul al nostre context territorial.

Posteriorment, l'ús de l'aigua en els jardins, juntament amb el seu manteniment, gestió i transformació van ser analitzats en relació a diferents paràmetres de l'estructura dels espais exteriors els habitatges (**Capítol 5**). En aquesta secció, el treball d'enquesta va ser clau per descriure les pràctiques dutes a terme pels propietaris. De forma específica, es va avaluar l'autoria del disseny del jardí i el seu manteniment regular, el sistema de reg (regadora, mànega, aspersió, degoteig, etc.), la freqüència de reg, les modificacions dutes a terme en l'estructura del jardí en els darrers 5 anys o les transformacions previstes, entre d'altres. Aquesta part de l'estudi va permetre detectar punts febles quant a l'ús eficient d'aigua en jardineria domèstica.

Al **Capítol 6** es va realitzar un salt d'escala per analitzar a nivell d'habitatge les mateixes relacions exposades en el Capítol 3. Així, a partir d'una mostra representativa de llars, es va obtenir per a cadascuna d'elles l'inventari exhaustiu de la flora del seu jardí. Aquestes dades permeteren identificar quatre tipologies bàsiques de jardins i aproximar els requeriments hídrics dels jardins de forma individual. Un model estadístic va ajudar a determinar els factors socioeconòmics més importants que ajuden a predir aquest consum d'aigua potencial.

Les diferències entre l'estructura i la flora dels jardins de primeres i segones residències es va analitzar en el **Capítol 7**. Així, en aquest apartat es varen establir quines espècies són característiques de cada classe d'habitatge i quin tipus de cobertura dels espais exteriors hi predomina. A més, es van descriure també els perfils sociodemogràfics del residents de cada tipologia d'habitatge i es va comparar l'efecte que tenen aquestes característiques i el llegat urbanístic i dels propietaris en la composició de la flora domèstica.

En el **Capítol 8**, es va treballar entorn de conceptes com el risc d'invasió biològica per part d'espècies potencialment invasores en els jardins o la pressió de propàgul que aquestes poden exercir sobre els espais naturals. Aquest darrer factor ha estat reconegut com un dels més importants en l'èxit d'invasió biològica. En aquest sentit, la flora dels jardins es va classificar segons exòtica o autòctona. Per altra banda, es van incloure de nou les variables socioeconòmiques en un model per predir diferents paràmetres de riquesa vegetal. A més, s'hi va incorporar aspectes cognitius com ara les raons dels propietaris per posseir un tipus o altre de jardí. La font d'obtenció de plantes, així com la freqüència en que aquestes són incorporades, varen ser també examinades per detectar els punts clau on cal incidir per regular la demanda d'espècies exòtiques amb caràcter invasiu.

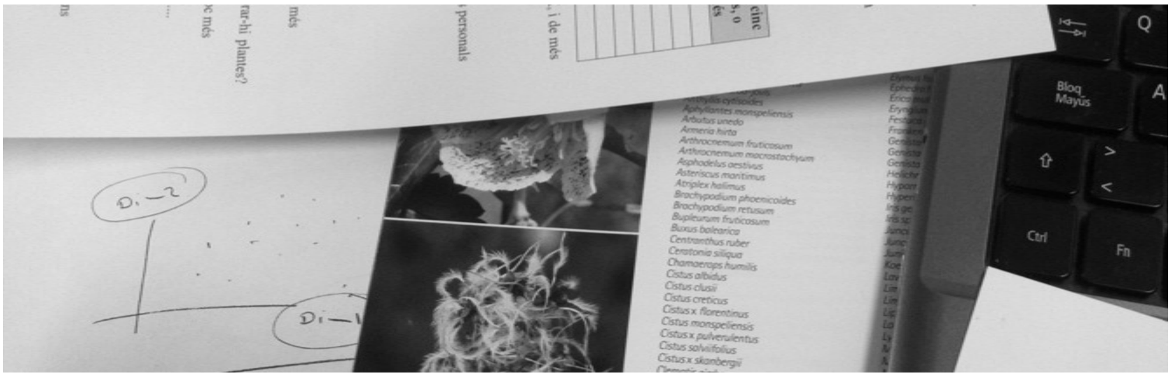
Els resultats obtinguts en els sis capítols anteriors van ser sintetitzats i discutits de forma conjunta en el **Capítol 9**. A més, s'inclouen les conclusions generals de la tesis en català (**Capítol 10**) i anglès (**Capítol 11**) i algunes prospectives de futur sobre possibles noves línies de recerca (**Capítol 12**).

Finalment, es van incloure les fonts bibliogràfiques utilitzades en l'estudi així com els diferents annexes completaris de la informació detallada al llarg del text principal.

Val a dir que els sis capítols centrals de la tesis es presenten en format d'article científic. Això pot donar lloc a certes redundàncies pel què fa a les introduccions i apartats metodològics. Per evitar repeticions innecessàries els annexes i les referències han estat agrupades al final de la tesi. Els capítols centrals han estat escrits en llengua anglesa. N'és una excepció el quart capítol, que va ser escrit en català. Els capítols finals 9 i 12 de discussió general i prospectives de futur van ser escrits també en català, al igual que el primer capítol introductori.

CAPÍTOL 2

METODOLOGIA



2.1 SELECCIÓ DE L'ÀREA D'ESTUDI

L'àrea d'estudi es troba en la zona litoral de la comarca de l'Alt Empordà al nord-est de Catalunya i de la península ibèrica (42º14'53'' N, 3º6'47'' E; Figura 2.1). Tenint en compte l'objectiu d'aquesta tesis pel què fa a l'anàlisi del risc d'invasió biològica, es va escollir el Parc Natural dels Aiguamolls de l'Empordà (PNAE; UICN categoria V) com a espai natural protegit de base per a l'estudi. D'aquesta manera, es seleccionaren, en primera instància, les àrees residencials més properes a aquest espai ubicades en els municipis de Castelló d'Empúries, L'Armentera, L'Escala, Sant Pere Pescador i Roses.

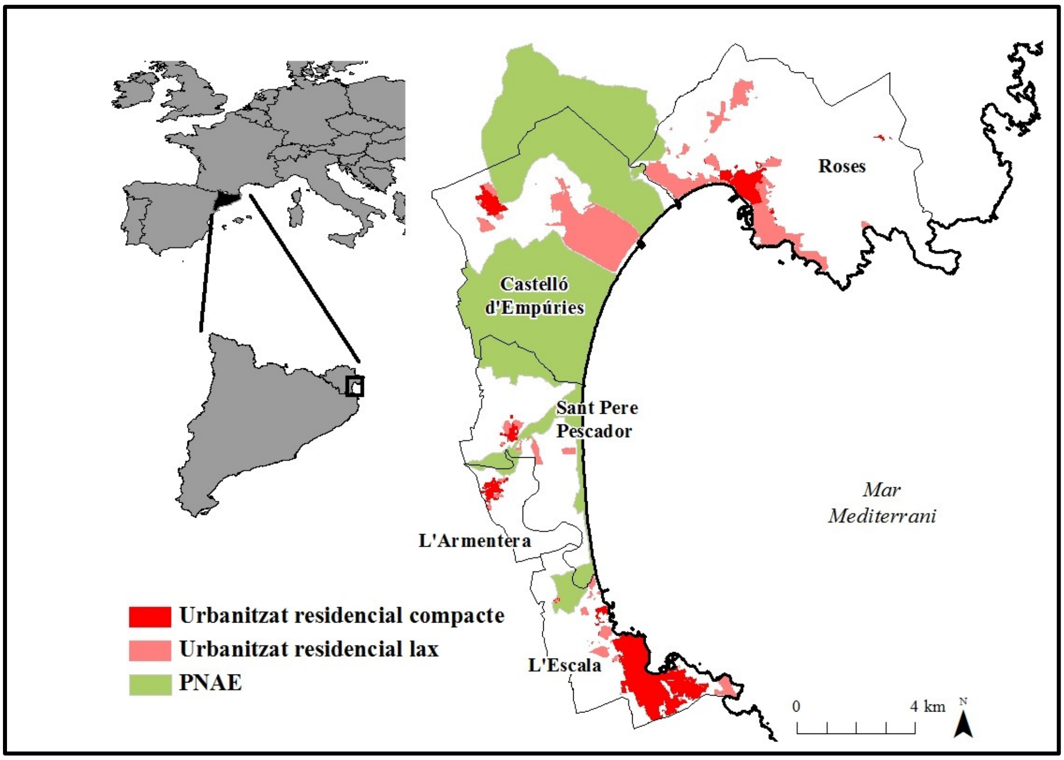


Figura 2.1: Localització dels cinc municipis inclosos en l'àrea d'estudi. Es mostren també les diferents àrees d'urbanitzat residencial (compacte i lax), així com els límits del Parc Natural dels Aiguamolls de l'Empordà (PNAE).

De forma sintètica, els criteris que portaren a la selecció de l'àrea d'estudi van ser:

- **Estudi emmarcat en el projecte "Noves pautes de consum i gestió de l'aigua en espais urbanoturístics de baixa densitat. El cas de la Costa Brava (Girona) (Referència: CSO2010-17488**): La present tesis es troba vinculada a l'esmentat projecte i per tant el seu àmbit d'estudi quedà adscrit a aquest context territorial. A més, d'aquesta manera s'afavoreix la comparació de resultats amb estudis previs i de característiques similars desenvolupats en el marc del mateix grup de recerca com és el treball de García (2012).

- **Presència del Parc Natural dels Aiguamolls de l'Empordà (PNAE):** Es tracta d'un espai natural de 4731 hectàrees amb un elevat valor ecològic, històric i cultural. Al llarg dels anys, la presència humana ha modelat en bona part el seu paisatge majoritàriament degut a les activitats agropecuàries o turístiques. Les característiques dels seus hàbitats (litorals, antropitzats, aquàtics, etc.) fa que sigui un espai especialment vulnerable als processos de canvi ambiental global (Llausàs & Barriocanal, 2009) i a possibles invasions biològiques (Vilà et al., 2007). De fet, actualment gairebé el 8% de la flora al parc és introduïda i el control i l'eradicació de plantes invasores genera elevats costos econòmics (Gesti, 2000). Aquesta situació és encara més difícil de mantenir en un context de crisi econòmica. A més, l'estructura del parc, dividida en dos grans polígons, i la forta pressió urbanística a la que està sotmès, fan que sigui un cas d'estudi excel·lent per analitzar la pressió de propàgul d'espècies potencialment invasores.

- **Elevada presència d'habitatges unifamiliars amb característiques heterogènies:** La població total de l'àrea d'estudi a l'any 2013 era aproximadament de 45.219 habitants (IDESCAT, 2013). A més, la zona, conjuntament amb la resta de territori de la Costa Brava, és coneguda per ser una de les destinacions turístiques més importants del sud d'Europa. Des de la segona meitat del segle XX, el turisme ha donat lloc a un desenvolupament sense precedents d'expansió i d'ampliació de les zones urbanes, destacant, entre d'altres, la creació de la marina Empuriabrava l'any 1967. En aquest sentit, en els últims 30 anys el nombre total d'habitatges s'ha duplicat i el 68% són ara residències secundàries ocupades parcialment al llarg de l'any. D'altra banda, el nombre de residents s'ha triplicat, i aproximadament el 38% provenen d'altres parts d'Europa, especialment França i Alemanya (IDESCAT, 2014). Aquestes estructures suburbanes relativament recents, juntament amb l'heterogeneïtat social, ha donat lloc a una estructura poblacional amb característiques demogràfiques i culturals molt diverses. Això, sens dubte es tradueix també en tipologies de jardins molt variats. L'anàlisi dels perfils poblacionals pot ajudar a entendre millor els tipus d'enjardinament practicat i el volum d'aigua consumit en el seu manteniment.

- **Característiques bioclimàtiques homogènies:** El clima de la zona d'estudi és típicament mediterrani, amb temperatures mitjanes anuals d'aproximadament 15ºC, tot i que aquestes poden oscil·lar entre els 30ºC de mitjana a l'estiu fins als 3ºC de mitjana al hivern. La precipitació mitjana anual, concentrada principalment a la tardor i a la primavera, és 623 mm. Durant el període estival són comuns els episodis d'aridesa i dèficit hídric (Figura 2.2). Tota la zona es troba situada en una gran plana i a una altitud mitjana de 9,2 m sobre el nivell del mar. Tenint en compte aquests factors i el fet que es tracta d'una àrea relativament reduïda, es garanteix que les variables bioclimàtiques romanguin pràcticament constants en tota l'àrea d'estudi. Així, eliminant al màxim la influència de les variables ambientals, és possible avaluar millor el pes que tenen els factors urbanístics, socioeconòmics, demogràfics i cognitius en la composició de la flora dels jardins.

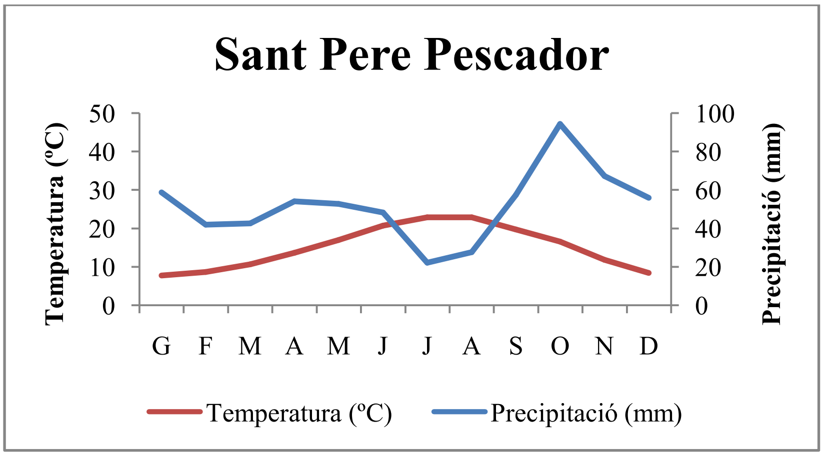


Figura 2.2: Climograma de temperatures i precipitacions de l'estació meteorològica de Sant Pere Pescador. Font: Elaborat a partir de dades obtingudes al portal RuralCat (2015) per al registre de 2007 a 2015.

2.2 SELECCIÓ DE LA MOSTRA

A partir dels criteris esmentats anteriorment, es va portar a terme diferents fases per a determinar una mostra representativa d'habitatges a visitar. En primer lloc, es va obtenir la cartografia digitalitzada d'usos i cobertes del sol de l'Alt Empordà del portal web del Centre de Recerca Ecològica i Aplicacions Forestals (CREAF, 2013). D'aquesta manera, i mitjançant el software ArcGis 10 (ESRI, 2012), es va extreure una capa amb tots els polígons corresponents a urbanitzacions laxes dels municipis circumdants del PNAE. Aquesta capa d'informació va ser seleccionada com a base per a la delimitació de les àrees residencials incloses en l'estudi.

Paral·lelament, es va incorporar al programari un altre arxiu cartogràfic vectorial amb tots els espais naturals de protecció especial (ENPEs) de Catalunya (GENCAT, 2013). D'aquest, es va extreure una capa amb els polígons corresponents al PNAE. La capa resultant fou ampliada a partir d'un procediment "*buffer*" que permeté englobar totes les àrees compreses en un radi de 1 kilòmetre de distància del PNAE. Aquesta distància va ser considerada com aquella amb una influència més directe per part de la dispersió de llavors, o altres parts vegetatives de les plantes, d'espècies potencialment invasores (Thomson et al., 2011). Val a dir, però, que certes espècies invasores en ciutats poden dispersar-se cap a àrees naturals situades a més de 50 kilòmetres de distància degut, principalment, a causes mecàniques d'origen antròpic (McDonald et al., 2009).

La capa resultat d'aquesta procediment es va creuar amb la capa obtinguda prèviament i que contenia les urbanitzacions laxes. Mitjançant aquest mètode, es va obtenir una nova capa amb totes les àrees residencials suburbanes que es trobaven a menys d'1 kilòmetre del PNAE. Aquestes àrees van ser considerades com aquelles amb una major influència quant a pressió de propàgul d'espècies potencialment invasores en l'espai natural, i per tant van esdevenir l'objecte d'estudi.

En una segona fase, es va obtenir la cartografia cadastral de tots els habitatges situats en la capa vectorial anterior (DGCE, 2012). Així, es van seleccionar només aquells habitatges de caire unifamiliar aïllat, unifamiliar aparellat o unifamiliar adossat. Finalment, la població total, o univers, de l'estudi va quedar conformada per 6587 habitatges.

En la tercera fase, es va determinar el nombre representatiu de cases a enquestar a partir de la formula proposada per Lynch et al. (1974; Eq. [2.1]). Aquest mètode ha estat prèviament emprat per Abdoellah et al. (2006) en l'estudi de la flora de jardins i és especialment adient per recopilar dades de caire socioeconòmic a partir d'enquestes (Lynch et al., 1974).

$$n = \frac{N\, Z^2 p(1-p)}{Nd^2 + p(1-p)} \quad [2.1]$$

On n = mida de la mostra; N = mida de la població total o univers; Z = valor de la variable normal (1,96) per a un interval de confiança del 0,95; p = proporció més alta possible (0,5); d = error mostral (0,1).

Fent servir la fórmula anterior, es va determinar que el nombre mínim d'habitatges a enquestar per obtenir una mostra respresentativa era de 94. No obstant, per tal d'assegurar encara una major representativitat i donar consistència a l'anàlisi estadística de les dades, es va optar per augmentar aquesta xifra fins als 260 habitatges, el qual representa un 4% de la població univers total.

Mitjançant l'eina "*subset features*" del software ArcGis 10 (ESRI, 2012) es van seleccionar aleatòriament els 260 habitatges de la capa vectorial cadastral. Quant l'accés a una de les cases seleccionades no fou possible, es visità una altra casa situada al mateix carrer i a la dreta de la casa original. Per tal d'incloure el màxim de residents secundaris i facilitar la identificació de les espècies, les visites es van realitzar entre Maig i Juliol de 2013.

2.3 RECOLLIDA DE DADES

El procés de recollida de dades durant el treball de camp es va dividir en tres parts: per una banda, la descripció de l'estructura de la llar i del jardí, per l'altra, la identificació de la flora i, finalment, la recopilació d'informació demogràfica, socioeconòmica i de gestió del jardí per part dels propietaris.

2.3.1 Descripció de l'espai exterior dels habitatges

Cadascun dels habitatges va ser descrit en funció de les diferents cobertes del sòl. En total es van establir vuit categories: casa, piscina, hort, vegetació espontània, gespa artificial, gespa, àrea cultivada (excloent gespa; principalment arbres, arbustos i flors) i àrees no cultivades (excloent vegetació espontània; principalment àrees pavimentades). Per a cada llar es va calcular l'àrea de cadascuna d'aquestes cobertes a partir d'ortofotoimatges de 0,1 m x 0,1 m de píxel obtingudes a partir de l'Institut Cartogràfic de Catalunya (ICC, 2013). Es va anotar també la presència d'elements decoratius de tipus "*mulching*", és a dir, encoixinats de matèria orgànica que ajuden a conservar la humitat del sòl i que sovint són utilitzats com a substitutius de la gespa. En l'annex 3 del present treball es pot consultar el model de formulari utitlizat per completar aquesta tasca.

2.3.2 Identificació i descripció de la biodiversitat vegetal

Es va inventariar tota la flora present als jardins incloent aquella present en basses i testos. No obstant, per a les gespes, s'inventarià només una parcel·la aleatòriament seleccionada de 0,5 m^2. Totes les plantes es van classificar segons si s'havien trobat en la gespa, l'hort, la vegetació espontània o formant part d'arbres, arbustos i flors. Els jardins sense plantes també van ser mostrejats i analitzats per tal de conèixer els motius que porten a preferir aquest tipus de jardí o pati. En l'annex 3 del present treball es pot consultar el model de formulari utitlizat per completar aquesta tasca.

La identificació de les plantes es va realitzar a partir de literatura especialitzada (e. g. Pañella, 1970; Bellido, 1998; Sánchez et al., 2000; Bolós et al., 2005). Per aquelles plantes en què no es va poder arribar a determinar l'espècie, s'anotà només el gènere. La nomenclatura científica dels taxons segueix el "*International Plant Name Index*" (IPNI, 2013). Cada planta, a més, va ser assignada a una forma vital d'acord amb la classificació de Raunkiaer (1934). En total es van establir 6 classes: faneròfits, camèfits, hemicriptòfits, geòfits, teròfits i epífits.

Les plantes van ser classificades com a autòctones o exòtiques seguint Bolós et al. (2005). Així, les espècies exòtiques es defineixen com espècies que no són autòctones d'una unitat geogràfica determinada (en aquest cas Catalunya). Algunes d'aquestes espècies exòtiques poden dispersar-se al medi natural convertint-se en introduïdes. Ara bé, si la seva reproducció és suficient per mantenir una població estable, aquestes es consideren naturalitzades. Finalment, quan les espècies naturalitzades, gràcies a la producció d'abundant descendència reproductiva, tenen el potencial de dispersar-se per grans àrees i a una distància considerable dels llocs d'introducció, s'anomenen invasores. En aquest estudi, la corologia de les plantes es va establir a partir de Sánchez et al. (2000) i Bolós et al. (2005) amb els següents elements regionals: Àfrica, Àsia, Austràlia i Nova Zelanda, Amèrica del Nord, Amèrica del Sud, Euràsia, Europa, Àsia i Àfrica, Europa, Mediterranis, cosmopolites (si la seva distribució és global o pràcticament global) i híbrids (varietats cultivades).

2.3.3 Contingut de l'enquesta

Per tal d'avaluar diferents paràmetres referents a l'estructura socioeconòmica de llar i els hàbits de gestió del jardí, es va configurar una enquesta formada en la seva totalitat per preguntes tancades de tipus test (Annex 4). Les qüestions van ser agrupades en 4 seccions:

1) Característiques de l'habitatge: Aquest apartat incloïa preguntes referents al règim de tinença de l'habitatge, la seva edat o si es tractava de residències primàries o secundàries, entre d'altres.

2) Característiques socioeconòmiques dels residents: Incorporava diferents paràmetres per ajudar a descriure el perfil dels ocupants de la llar (edat de la persona enquestada, sexe, nivell educatiu i de renda, etc.)

3) Elements i gestió del jardí: En aquesta secció s'inclogueren qüestions com ara la freqüència de reg, la freqüència amb què s'incorporen noves plantes, l'autoria del disseny i gestió del jardí, etc.

4) Aspectes cognitius: Concretament, aquest bloc es prestà a recollir les raons pels quals els propietaris havien optat per tenir un jardí amb les característiques determinades.

Davant la gran diversitat de nacionalitats dels residents de l'àrea d'estudi, l'enquesta va ser traduïda a 5 idiomes: català, castellà, anglès, francès i alemany (Annex 4).

2.4 REALITZACIÓ DEL TREBALL DE CAMP

Per tal d'assegurar al màxim la taxa d'èxit en la realització de l'enquestes, es va elaborar una carta de presentació informativa que es lliurava a la bústia dels propietaris amb un interval de 7 a 10 dies abans de la visita. La carta va ser distribuïda, a més, per altres habitatges similars situats al mateix carrer que l'habitatge objectiu. D'aquesta manera, es pretenia informar als propietaris a priori sobre dels detalls de l'estudi, el seu àmbit, els objectius, el seu contingut, la política de confidencialitat de dades i els detalls de contacte. Cada carta va ser també escrita en català, castellà, anglès, francès i alemany (Annex 2).

Un equip de dos investigadors es va encarregar de realitzar conjuntament el total de les visites. El treball de camp començà amb una prova pilot a 10 habitatges situats a l'Armentera per tal d'avaluar el millor mètode d'enquesta i homogeneïtzar aspectes formals. Cada investigador anava equipat amb el seu carnet d'identificació de la UdG per facilitar el reconeixement ràpid de la institució per part dels propietaris i afavorir la necessària confiança per part dels ocupants de l'habitatge. En cada visita, mentre un investigador s'ocupava de recopilar informació sobre l'estructura i composició florística del jardí, l'altre, simultàniament, realitzava l'enquesta als residents. Sempre que fou possible, es va enquestar a la persona a càrrec de la gestió i manteniment del jardí. Finalment, es realitzaren un total de 258 enquestes. El temps mig per enquesta fou d'aproximadament 20 minuts.

2.5 CÀLCUL DELS REQUERIMENTS HÍDRICS DELS JARDINS

Els requeriments hídrics dels jardins es poden arribar a determinar de forma aproximada tenint en compte diferents factors. Els més importants són el clima local i el tipus d'espècies presents (Salvador et al., 2011). Altres factors inclouen la coexistència en un mateix espai de més d'un estrat d'espècies (per exemple arbres, arbustos i gespa) o modificacions de les condicions microclimàtiques.

Els estudis sobre la determinació dels requeriments hídrics han acostumat a seguir tres aproximacions metodològiques. La primera opció és posar els requeriments hídrics al nivell dels valors de l'evapotranspiració de referència (ET_0; Haley et al., 2007). Aquesta comparació seria eficient en cas que tota l'àrea enjardinada estigués ocupada per gespa. La segona opció es basa en l'estimació directa dels requeriments hídrics a partir de l'ús d'instruments com ara sensors volumètrics d'aigua en el sòl o lisímetres (Brown et al., 2001; Morari & Giardini, 2001; White et al., 2004). Un darrer grup d'autors (Domene & Saurí, 2003; Contreras et al., 2006; Salvador et al., 2011; Nouri et al., 2013) segueixen la metodologia proposada per Costello et al. (1994; 2000; 2014), que desenvolupa el mètode WUCOLS per determinar les necessitats hídriques.

El mètode WUCOLS (*Water Use Classification of Landscape Species*) va ser proposat per Costello et al. (1994; 2000) i utilitzat per aproximar els requeriments hídrics dels jardins. La tècnica es basa en l'aplicació d'un coeficient de paisatge (K_L) que es multiplica per l'evapotranspiració de referència (ET_0) per tal d'obtenir els requeriments de reg nets (IR_n; Eq. [2.2]).

$$IR_n = K_L\, ET_0 \quad [2.2]$$

Seguint l'Equació [2.3], el paràmetre K_L es determina com el producte del factor d'espècie (k_s), el factor de densitat (k_d) i el factor de microclima (k_{ms}).

$$K_L = k_s\, k_d\, k_{mc} \quad [2.3]$$

El factor d'espècie depèn del tipus de planta present al jardí i els seus requeriments hídrics associats. Costello i Jones (2014) van tabular aquests valors per a més de 3000 espècies a sis àrees de Califòrnia. Les espècies van ser classificades segons si presentaven requeriments hídrics molt baixos (VL [k_s<0,10]), baixos (L [0,10≤k_s≤0,30]), moderats (M [0,40≤ k_s≤0,60]) o alts (H [0,70≤k_s≤0,90]).

El factor de densitat modifica el factor d'espècie adaptant-lo al conjunt d'àrea foliar de totes les espècies del jardí. Si els arbres o arbustos només cobreixen parcialment el sòl, k_d presenta valors entre 0,50 i 0,90. Si la superfície del sòl es troba completament coberta per plantes, k_d pren un valor de 1,00. Finalment, si dues o més espècies coexisteixen en la mateixa porció de terra formant diferent capes, k_d s'assigna a valors entre 1,10 i 1,30.

Les condicions ambientals poden variar significativament entre jardins. Alguns elements urbans com ara els edificis, paviments i zones ombrejades tenen una forta influència en la temperatura, la velocitat i la direcció del vent, la humitat, la intensitat de la llum i altres paràmetres meteorològics. En aquest sentit, el factor de microclima s'utilitza per corregir aquestes variacions i pot oscil·lar entre 0,50 i 1,30 segons el grau d'afectació dels elements urbans (Costello et al., 2000).

CHAPTER 3

EXAMINING FLORISTIC BOUNDARIES BETWEEN GARDEN TYPES AT THE GLOBAL SCALE[3]

[3] PADULLÉS, J., VILA, J. & BARRIOCANAL, C. (2014). "Examining boundaries between garden types at the global scale". *Investigaciones geográficas*, 61 (1), 71-86.

3.1 ABSTRACT

Gardens represent important sources of goods and services for their owners. This functionality translates directly into the types of plants cultivated in a given garden, and terminology has been developed to distinguish each category of garden according to its purpose. The factors explaining the differentiation and distribution of gardens have not previously been explored at the global scale. In this study, the plant lists for 44 gardens from around the world were analyzed to explore their taxonomic similarities and the factors shaping each garden. Several biophysical and socioeconomic variables were examined at the appropriate scale for their roles in garden species distribution. Physical and climatic factors (temperature, rainfall, potential evapotranspiration and distance between settlements) were found to be significantly related with species makeup; all of these factors were less important than GDP per person, a proxy for household income, which was determined to be the primary driver of garden composition. All of the studied socioeconomic factors, such as language similarity among settlements and population density, were significant drivers of species distribution. However, the present analysis omits a number of variables due to data unavailability, such as garden size and owner gender, which have been previously recognized as influences on garden plant composition. The genera cultivated in different gardens were found to be very different from each other, and the definitions of each type are hard to establish from these data alone. Finally, the implications of likely future income variations, such those caused by severe economic crisis, and global climate change on bio-cultural diversity and food security are discussed.

3.2 INTRODUCTION

Humans have cultivated their immediate living environments since the Neolithic (Brownrigg, 1985), and some of these cultivated areas, particularly those adjacent with or close to the homes of their owners and smaller than the average size of an agricultural plot, are commonly classified as gardens (Vogl et al., 2004). The exact definition of "garden" depends heavily on context, and according to Vogl et al. (2004), an ethnoecological approach to garden classification might include a generic category for "garden" along with several specific subcategories (e.g., "coffee garden", "field garden", "home garden", "cocoa garden"). Therefore, classifying gardens at the regional scale is not always straightforward, and any labeling effort should be accompanied by the precise definitions of the variables and gradients used to distinguish between types. At the global scale, many types of gardens, each with different plant composition and purpose, have been described. However, most scientific literature has classified gardens into only two groups: domestic gardens (e.g., Daniels & Kirkpatrick, 2006; Loram et al., 2008, Bigirimana et al., 2012), and homegardens (e.g., Kumar & Nair, 2004; Blanckaert et al., 2004; Das & Das, 2005). The key element linking all types of gardens is that local residents have autonomy over the space, although they may delegate this responsibility to others, such as professional designers or hired gardeners (Cameron et al., 2012).

Domestic gardens have been defined by Gaston et al. (2005b) as the private spaces adjacent to or surrounding dwellings and they may be composed of lawns, ornamental and vegetable plots, ponds, paths, patios or temporary buildings such as sheds and greenhouses. In the same way, Bhatti and Church (2000) describe a domestic garden as an area of enclosed ground, cultivated or not, within the boundaries of an owned or rented dwelling, where plants are grown and other materials are arranged spatially. Depending on the characteristics of the cities and towns in which they are located, domestic gardens can contribute nearly one third of the total urban area (Domene & Saurí, 2003; Gaston et al., 2005b; Mathieu et al., 2007). Therefore, studies regarding domestic gardens have traditionally focused on urban biodiversity (Smith et al., 2006; Davies et al., 2009; Doody et al., 2010), ecosystem services (Tratalos et al., 2007; Cameron et al., 2012), socio-economic patterns for greening, (Luck et al., 2009; Hunter & Brown, 2012), water consumption (Syme et al., 2004; Hurd, 2006) and even psychology and well-being (Clayton, 2007; Freeman et al., 2012).

The term "homegarden", also known as the "kitchen garden", "dooryard garden", or "agroforestry homegarden" (among many other variations), has received several definitions, although none has gained universally acceptance (Kumar & Nair, 2004). Homegardens have been primarily described as social and economic units of rural households, in which crops, trees, shrubs, herbs and livestock are managed to provide food, medicine, shade, cash, poles and socio-cultural functions (Christanty, 1990; Campbell et al., 1991; Shackleton et al., 2008). Fernandes and Nair (1986) reported that homegardens should therefore be considered as intensively cultivated agroforestry systems managed within the compounds of each household. In a predominantly subsistence-oriented economy, homegardens provide an array of outputs (Jose & Shanmugaratnam, 1993), but although many are used for food and commercial production, others contain only lawn and ornamental species (Vogl et al., 2004). This broad definition of the term has led to the characterization of homegardens as a category with indeterminate boundaries. The existing scientific research regarding homegardens has mostly been conducted in tropical areas and is oriented towards ethnobotany (Agelet et al., 2000; Eichemberg et al., 2009), agroforestry production and food security (Wezel & Bender, 2003; Kumari et al., 2009), ecology (Gajaseni & Gajaseni, 1999; Kumar, 2011) or biodiversity issues (Kabir & Webb, 2008; Akinnifesi et al., 2010).

The precise differences between these two garden categories are still unclear, and their characteristic features are often mixed in practice. Generally, "domestic gardens" are associated with urban environments, while "homegardens" are mainly considered as rural agroforestry systems (Vogl et al., 2004). Furthermore, homegardens are associated with a more utilitarian perspective, while domestic gardens are mainly cultivated for recreational and aesthetic value. However, many other types of garden have been described, and others remain unexplored. The processes of global change and the specific characteristics of each region blur the boundaries of garden types, and the classification of gardens is not always easy.

The distribution of cultivated plants, unlike that of native vegetation, is influenced by many factors beyond biophysical variables such as temperature, precipitation and the movement of land masses (Kendal et al., 2012b). Indeed, socio-economic variables (e.g., population and housing density, education, age, home ownership, income) have been described as better predictors of the vegetation cover in private gardens than biophysical variables (Hope et al., 2003; Luck et al., 2009; Marco et al., 2010a). In the same way, colonialism has resulted in widely dispersed cities with similar cultivated landscapes, which mimic those of their shared colonial homeland (Reichard & White, 2001; Ignatieva & Stewart, 2009). Therefore, the cultural background and behavior of residents can partly overcome the natural tendencies of plant dispersal (Head et al., 2004).

There has been almost no attempt to describe the composition and distribution of the flora of gardens at the global scale (Thompson et al., 2003). The number of studies that document the differences in species composition between gardens is also limited (Cameron et al., 2012), but floristic surveys and plant inventories of these ecosystems have increased in recent years (e.g., Albuquerque et al., 2005; Daniels & Kirkpatrick, 2006; Tynsong & Tiwari, 2010), providing the opportunity to analyze them at the global scale. Kendal et al. (2012b) explored the distribution patterns for all types of cultivated urban flora at the global scale and concluded that physical variables, especially mean annual temperature, were the most important to species composition. However, the importance of social factors on the distribution of cultivated plants was also documented. In the present study, a similar methodology with a focus on private gardens and accurate data at the appropriate scale is used.

This study aims to refine the classification gardens described in the scientific literature and to assess the factors determining their plant composition. Plant inventories for 44 sets of gardens from around the world are compared according to their previous classification (e.g., “domestic gardens”, “homegardens”, and “mixed gardens”). A comparison of global garden vegetation may provide clues about the structure, cultivation and use of these spaces in different societies around the world. Moreover, a better understanding of the distribution of cultivated vegetation in urban and rural gardens will contribute towards the better management of natural resources, conservation of biodiversity in anthropogenic environments and enhancement of food security worldwide.

3.3 MATERIAL AND METHODS

3.3.1 Selection of plant inventories

Publications containing plant garden inventories were obtained by searching titles, abstracts and keywords within Web of Science, Scopus, Google Scholar, and other relevant journals not included in these databases. Several key terms were searched (e.g., garden*, yard, lawn, plant*, flor*, vegetat*), both alone and in multiple combinations, until no new relevant publications were found. The keywords were also searched in several combinations using “AND” and “OR” statements to generate more accurate results. Further studies were obtained from the references of previously located studies. The term “garden”, for the purpose of this study, is defined as the private area around a home used for the planting of ornamental plants as well as for the production of food and other agricultural products. Furthermore, a garden must be cultivated for leisure, home consumption or as a means of generating income. Garden studies without plant inventories, along with those in which plant inventories were mixed with other environments or garden types, were excluded. Floristic surveys which could not be assigned to a specific location with precise coordinates were also discarded. Finally, the garden typology, main research question(s), key words, and type of plants inventoried for each study were also recorded.

3.3.2 Selection of variables

Several physical and socioeconomic variables were collected to analyze the distribution patterns of garden flora at the global scale. Accurate data were selected at the appropriate scale to describe particular locations within countries. The climatic data included mean annual temperature (ºC), mean annual rainfall (mm), and monthly potential evapotranspiration (mm). Mean annual temperature and rainfall were obtained from each study or, when not reported by the authors, from the World Meteorological Organization (WMO, 2013). Potential evapotranspiration was calculated using the methods of Willmott and Kenji (2001) with a gridded raster of a 50x50 km cell. Distances in kilometers between each location were calculated using the great-circle method.

The socioeconomic data presented in the literature differed for each study; therefore, different sources were examined to obtain proxy data for multiple variables. The selected variables were chosen according to those considered significantly influential in Kendal et al. (2012b) and other scientific publications (e.g., Hope et al., 2003; Marco et al., 2008; Luck et al., 2009; Bigirimana et al., 2012). Population density (persons/km^2) in the year 2000 was used as a proxy for the urban to rural gradient and was obtained using the gridded raster method (25x25 km) of CIESIN and CIAT (2005). Gross Domestic Product (GPD; millions of US $), obtained from CIESIN (2002), was used as a proxy for household income. In this case, more recent data were unavailable, values for the year 1990 were taken from a gridded raster (25x25 km) based on the SRES B2 Scenario. Dominant language family, obtained from the map in Goode (2006), was chosen as a proxy for the influence of cultural background. As the specific language of each community was not reported in all of the articles, a broader scale was selected, reducing the number of categories and amplifying the influences of cultural background and colonialism. When more than one location was used in a study, average values were generated for each variable and the plant inventory; the centroid between all points was used for great circle distances.

The uses of a given garden are reflected by its plants. Therefore, different types of gardens are associated with different cultivated plants. Each paper reviewed categorizes its surveyed gardens in a distinct way. The descriptions and categorizations given by the authors are reported in the classification of each inventory. However, no distinction has been made between “homegarden”, “home garden”, house garden” and “home-garden”. All of these terms have been included in the same category as “homegarden”.

3.3.3 Data analysis

The plant inventories were examined for orthographic mistakes and standardized according to The International Plant Name Index database (IPNI, 2013). Genus was selected as an appropriate taxonomic category for meaningful statistical analysis (Krebs, 1999; Kendal et al., 2012b). To reduce the stochastic noise, those genera present at relative frequencies of less than 6.82% were excluded from the study. For the same reasons, plant inventories containing less than 20 genera were also discarded. The variables obtained through Geographical Information Systems (potential evapotranspiration, GDP and population density) were processed with ArcGis v10 (ESRI, 2012). Non-metric Multidimensional Scaling (NMDS) with the Bray-Curtis dissimilarity index (Faith et al., 1987) was run with the *vegan* package in R 2.15.2 (Team R.D.C., 2012) and used to investigate the relative taxonomic similarities between garden flora. A stress value is used to measure the goodness-of-fit of the ordination (>0.2 provides a satisfactory representation in reduced dimensions). The "envfit" function in the *vegan* package (Oksanen, 2008) was used to examine the relationships of selected variables with the ordination axes, and fitted variables were overlain on the NMDS graphs with arrow tips at the coordinates of fitted variables.

A standard linear regression model was applied to test the significance of different environmental, socioeconomic and cultural variables against the dissimilarity level of the different inventories. The Bray-Curtis dissimilarity index was set as the dependent variable and was transformed by squaring to improve the normality of residuals. The independent variables selected for the model were pairwise differences in mean annual temperature, mean annual rainfall, mean annual potential evapotranspiration, GDP per person, population density and distance between settlements. All of these variables were transformed by taking the square root to improve the normality of the residuals. Coded dummy variables for the differences between garden types and dominant language families were also included in the model (0=same, 1=different). A stepwise procedure using the Akaike Information Criterion (AIC) was conducted to obtain the most adjusted linear regression model, and multicollinearity was measured using the Variance Inflation Factor (VIF). The spatial correlation between the environmental data and the distances between each settlement was tested using the Mantel test with the package *ade4*. Because no significant result was observed (p=0.078) for this test, spatially weighted regression was not conducted (Lichstein et al., 2002; Kendal et al., 2012b).

3.4 RESULTS AND DISCUSSION

A total of 44 plant lists from different studies covering a global distribution were selected to analyze the floristic dissimilarities between gardens (Figure 3.1). The main research questions, key words and interests for all of the studies were examined to analyze their research purposes and to classify them into synthetic research categories. Five main categories were established: biodiversity, ethnobotany, agroforestry production, ecology and landscaping. Each study could be classified into one or more of these categories. Biodiversity issues (65.9%) were the most prevalent among the research, but ethnobotany (31.82%) and agroforestry production (27.27%) were also of significant importance to garden research. Plant uses were recorded in more than 75% of the studies, most of them studies of homegardens. Because many categories were applied to describe plant uses (e.g., timber, medicinal, food, fruit, fencing, construction), only those coincident for all plant inventories were selected for the present study. Using this approach, plants used for food supply were the most important category (57.97%), followed by medicinal (30.19%) and ornamental species (26.7%). A single plant may have multiple uses and can be classified into several categories simultaneously.

A set of 688 genera was included in the meta-analysis. The most frequent cultivated genera among the inventories were *Citrus* (86.36%), *Musa* (79.55%), *Capsicum* (77.27%), *Mangifera* (77.27%) and *Carica* (75%) (Figure 3.2). Only 3.17% of the studies had no genera in common. However, 96.41% of the inventories had a Bray-Curtis dissimilarity index of over 0.5, suggesting that the plants grown in gardens around the world are substantially different.

The NMDS ordination (Figure 3.3a) represents the taxonomic dissimilarities between all of the samples according to their categories. Temperature was calculated to be the strongest environmental gradient (R^2=0.61), but many other physical and social environmental gradients, including potential evapotranspiration (R^2=0.50), GDP per person (R^2=0.47) and Germanic spoken languages (R^2=0.47), were also significantly related to plant type (p<0.005). Two main clusters were identified, separating those gardens grown in temperate regions from those grown in hot regions. No clear differentiation was found between arid, tropical and subtropical gardens.

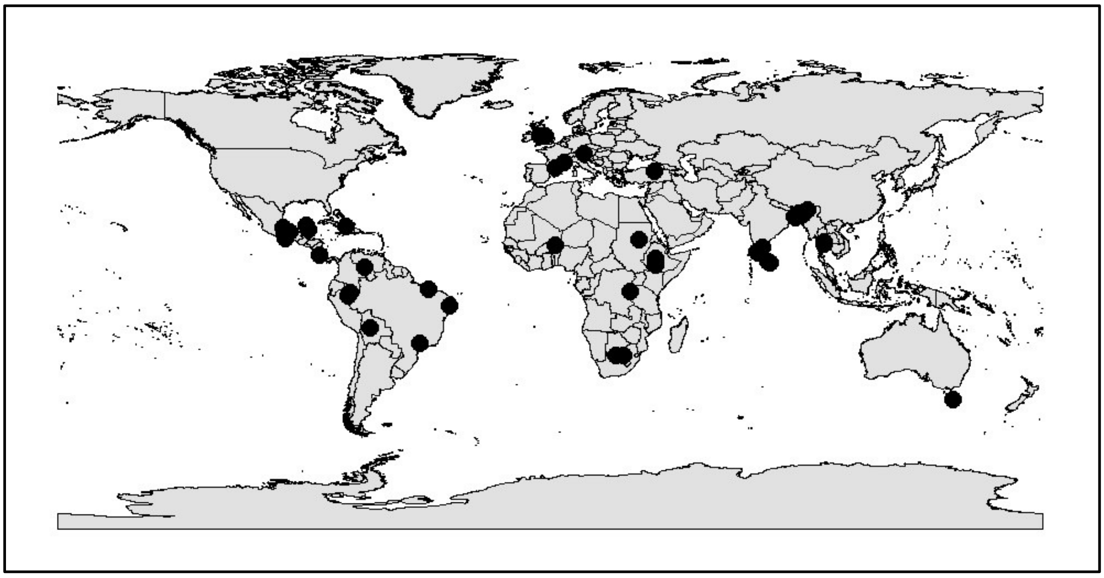


Figure 3.1: Locations of the 44 plant inventories compiled for this study. Those inventories representing more than one settlement are located using their geographical centroids.

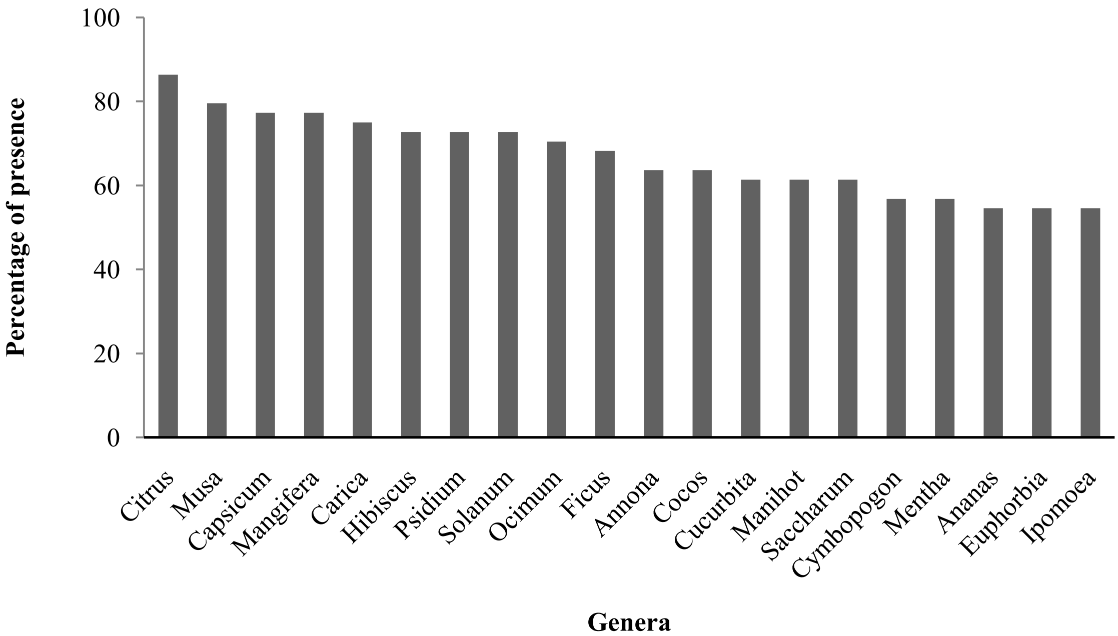


Figure 3.2: The 20 most representative genera across all inventories and their relative frequencies.

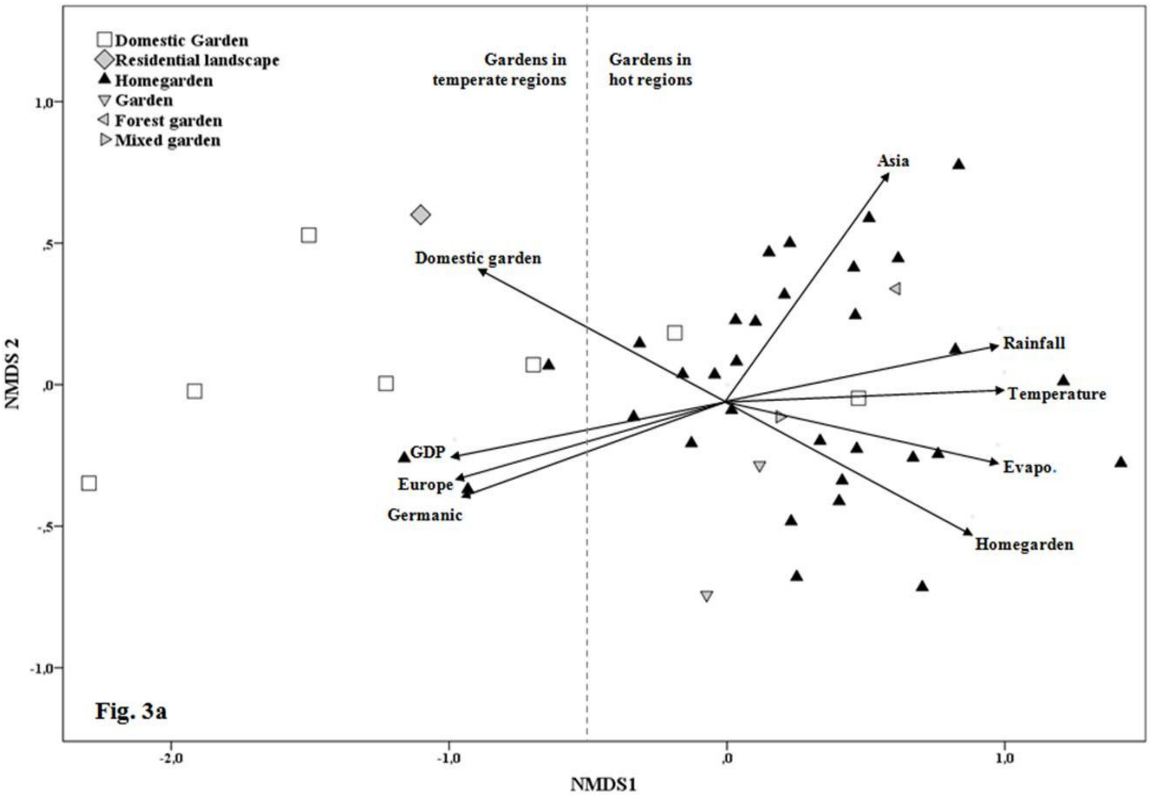

Domestic Garden
Residential landscape
Homegarden
Garden
Forest garden
Mixed garden
Gardens in temperate regions
Gardens in hot regions
Asia
Domestic garden
Rainfall
Temperature
Evapo.
Homegarden
GDP
Europe
Germanic
NMDS 2
NMDS1
1,0
,5
,0
-,5
-1,0
-2,0
-1,0
,0
1,0

Fig. 3a

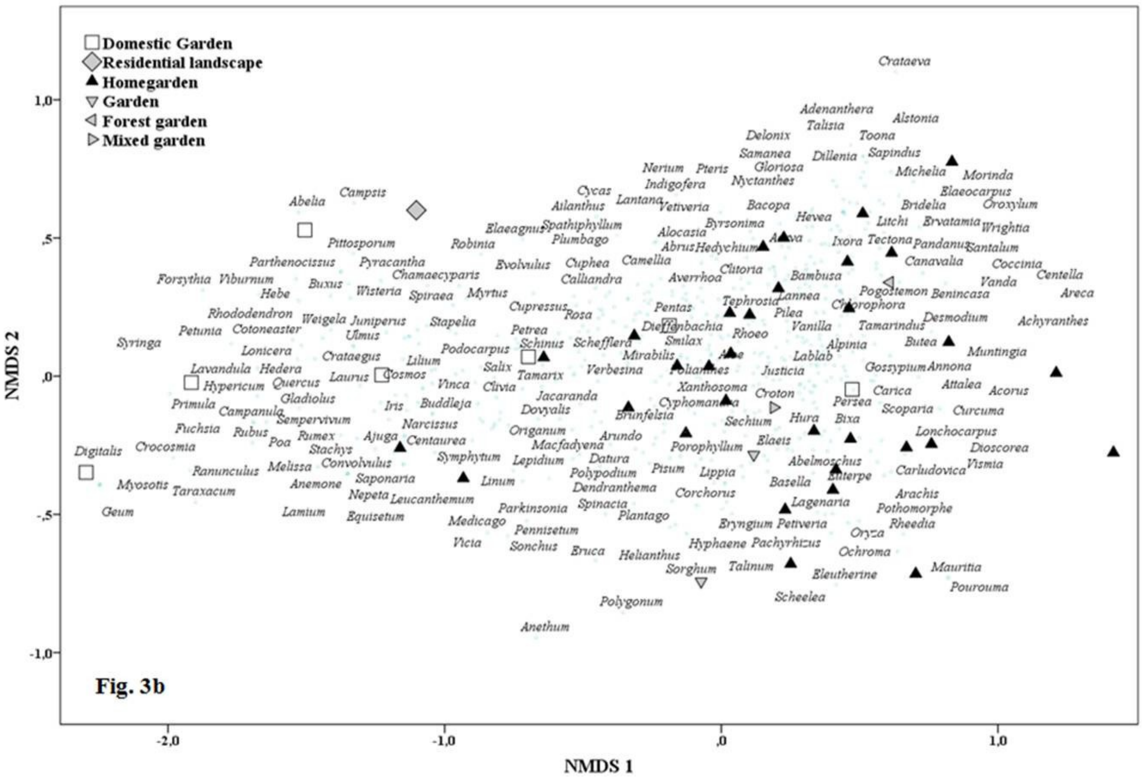

Domestic Garden
Residential landscape
Homegarden
Garden
Forest garden
Mixed garden
Crataeva
Adenanthera
Alstonia
Talisia
Delonix
Toona
Samanea
Dillenia
Sapindus
Nerium
Pteris
Gloriosa
Michelia
Morinda
Indigofera
Nyctanthes
Elaeocarpus
Cycas
Lantana
Bridelia
Oroxylum
Abelia
Campsis
Ailanthus
Vetiveria
Bacopa
Hevea
Litchi
Ervatamia
Wrightia
Spathiphyllum
Byrsonima
Elaeagnus
Plumbago
Alocasia
Pittosporum
Robinia
Abrus
Hedychium
Aralia
Ixora
Tectona
Pandanus
Santalum
Parthenocissus
Pyracantha
Evolvulus
Cuphea
Camellia
Canavalia
Coccinia
Chamaecyparis
Clitoria
Centella
Forsythia
Viburnum
Buxus
Calliandra
Averrhoa
Bambusa
Vanda
Wisteria
Myrtus
Pogostemon
Benincasa
Areca
Hebe
Spiraea
Lannea
Tephrosia
Chlorophora
Rhododendron
Weigela
Juniperus
Cupressus
Rosa
Pentas
Pilea
Achyranthes
Petunia
Cotoneaster
Stapelia
Vanilla
Tamarindus
Desmodium
Ulmus
Petrea
Dieffenbachia
Rhoeo
Syringa
Podocarpus
Schinus
Schefflera
Smilax
Alpinia
Butea
Muntingia
Lonicera
Crataegus
Mirabilis
Aloe
Lablab
Lavandula
Hedera
Lilium
Salix
Verbesina
Polianthes
Justicia
Gossypium
Annona
Hypericum
Quercus
Laurus
Cosmos
Tamarix
Vinca
Clivia
Xanthosoma
Croton
Carica
Attalea
Acorus
Gladiolus
Jacaranda
Primula
Campanula
Iris
Buddleja
Dovyalis
Cyphomandra
Persea
Scoparia
Curcuma
Sempervivum
Narcissus
Brunfelsia
Sechium
Hura
Bixa
Fuchsia
Rubus
Rumex
Ajuga
Origanum
Arundo
Digitalis
Crocosmia
Poa
Stachys
Centaurea
Macfadyena
Porophyllum
Elaeis
Lonchocarpus
Dioscorea
Convolvulus
Symphytum
Lepidium
Datura
Abelmoschus
Vismia
Ranunculus
Melissa
Saponaria
Polypodium
Pisum
Lippia
Carludovica
Myosotis
Anemone
Linum
Dendranthema
Basella
Euterpe
Taraxacum
Nepeta
Leucanthemum
Spinacia
Corchorus
Arachis
Parkinsonia
Lagenaria
Pothomorphe
Geum
Lamium
Equisetum
Medicago
Plantago
Bryngium
Petiveria
Rheedia
Pennisetum
Oryza
Vicia
Hyphaene
Pachyrhizus
Sonchus
Eruca
Helianthus
Ochroma
Sorghum
Talinum
Eleutherine
Mauritia
Pourouma
Scheelea
Polygonum
Anethum
NMDS 2
NMDS 1
1,0
,5
,0
-,5
-1,0
-2,0
-1,0
,0
1,0

Fig. 3b

Figure 3.3 a) Non-metric Multidimensional Scaling Analysis (NMDS) ordination plot of the Bray-Curtis distance between each garden's cultivated flora (Stress=0.152). Each symbol represents a different garden type according to the classifications of the authors. Grey symbols indicate categories that were also classified as homegardens or domestic gardens in the scientific literature. Physical and social environmental gradients calculated as significant (*p*<0.05) are represented as vectors indicating the direction of the environmental gradient (Germanic=Languages with the same Germanic origin; Evapo.=Potential Evapotranspiration; GDP=Gross Domestic Product per person). b) Genera with a frequency of greater than 9.09% are shown in the ordination. To avoid label overlapping, only the most common genera are represented.

Genera were mapped on the ordination to clarify which scored highly for each NMDS axis (Figure 3.3b). For the first NMDS axis, *Digitalis*, *Geum* and *Myosotis* scored positively, while *Centella*, *Areca*, *Achyranthes* scored negatively. Genera that scored highly on the second NMDS axis included *Crataeva*, *Adenanthera* and *Alstonia* in the positive direction and *Anethum*, *Polygonum* and *Scheelea* in the negative direction.

Multiple linear regression (Table 3.1) shows that all of the significant variables included in the model explain more than 50% of the total dissimilarity variation with the adjusted R^2. Difference in GDP is the strongest significant variable explaining taxonomic dissimilarity. Other physical and social variables, such as difference in mean annual temperature and distance between settlements, were also determined to be important significant co-variables. To a lesser extent, differences in potential evapotranspiration, family language, garden typology, and mean annual rainfall were found to be moderately but significantly related with taxonomic dissimilarity. Population density, intended as a proxy for the urban-to-rural gradient, was also found to be a significant variable in the model. The VIF values indicate a slight but acceptable multicollinearity between differences in mean annual temperature and potential evapotranspiration.

Table 3.1: Results from the multiple linear regression of selected variables on the Bray-Curtis dissimilarity matrix (Adjusted R-squared: 0.5361). All selected variables were included in the final model (AIC=-1037.605). VIF values are included to interpret multicollinearity. P-value defined as *p<0.01. **p<0.001.

	Coefficient	***VIF***
Constant	0.2336**	
Square root of difference in GDP per person (millions of US $)	0.0133**	1.7
Square root of difference in mean annual temperature (ºC)	0.0527**	2.3
Square root of distance between study sites (km)	0.0000**	1.2
Square root of difference in potential evapotranspiration (mm)	0.0090**	2.1
Settlements with different dominant language family	0.0504*	1.3
Studies of different garden type	0.0323*	1.4
Square root of difference in mean annual rainfall (mm)	0.0010*	1.1
Square root of population density (persons/km^2)	-0.0014*	1.2

3.4.1 Boundaries between "domestic gardens" and "homegardens"

The results of the present study indicate that many gardens have been inventoried from different regions and territorial contexts around the world. Each author applies the most appropriate descriptive label for his or her study garden according the research interests of the work. Globally, but especially in tropical areas, homegardens have attracted more scientific attention due to their roles in food production and agrobiodiversity conservation. In contrast, garden studies of developed countries in temperate areas have mainly focused on domestic gardens to analyze issues related to urban biodiversity, such as biological invasions, or other matters like garden water consumption. The dissimilarities between garden floristic compositions suggest that there is a slight distinction between domestic gardens and homegardens, although the boundaries between the categories are not distinct, especially in warmer regions. Many taxa are present in all types of gardens regardless of classification, confirming that the differences of garden types are subtle and dependent on their purposes and particular characteristics. In agreement with this view, homegardens located in temperate areas have more genera in common with nearby domestic gardens than with other homegardens in warmer regions. Regarding taxonomic dissimilarities within the categories, domestic gardens are significantly more different from each other than are homegardens. However, the latter gardens also differ depending on multiple biophysical, socioeconomic and cultural factors. In this respect, homegardens have been impacted by “acculturation”, the process through which a culture is transformed by the widespread adoption of cultural traits from another society. This process has direct consequences on the plant species grown in gardens and the extent to which they are used (Caballero, 1992). Thus, traditionally managed homegardens are under the threat of transformation into more homogeneous gardens.

3.4.2 Factors correlated to plant diversity in gardens

The present study suggests that plant diversity in selected gardens from around the world is significantly related to many physical, socioeconomic and cultural variables. The results suggest that temperature, which has been long been considered as the primary driver of plant distribution, is less important than differences in GDP per person. However, temperature, distance between settlements and potential evapotranspiration remain very important significant variables in the explanation of the taxonomic dissimilarity between gardens. To a lesser extent, cultural background (settlements sharing the same language family), garden type, mean annual rainfall and population density also contribute positively to differences in cultivated genera.

Physical and climatic variables, specifically temperature, act as important filters of plant distribution. Kendal et al. (2012b), using similar methodology, concluded that the main driver of global distribution for plants cultivated in green urban areas was temperature. In the current study, difference in mean annual temperature was an important factor in plant distribution but was not the main predictor. Distance between settlements was also a significant influential variable. The distribution of plants cultivated in gardens, unlike that of native flora, does not necessarily follow spatial correlation patterns, because their dispersion is caused by both natural and anthropogenic processes. According to the inventories analyzed in the present study, homegardens have similar percentages of native and alien plants. In domestic gardens, an average of three quarters of the species are alien. Therefore, distance between settlements has a powerful effect on the former type. Differences in mean annual potential evapotranspiration and in mean annual rainfall were both included in the model, although the latter variable had limited explanatory power.

This result can be explained by the manipulation of climate through human activities such as irrigation whereby the contribution of extra water compensates for the lack of rain. In contrast, temperature is difficult to alter in outdoor gardens without the construction of greenhouses or similar structures.

Among the socioeconomic and cultural variables considered in the analysis, the explanatory power of GDP per person is most significant. A relationship between human resource abundance and plant diversity in urban ecosystems has been observed in many cities and is named the “luxury effect” (Hope et al., 2003). Social scientists also call this phenomenon the “prestige effect”, and it involves the symbolic display of identity and social status beyond economic ability (Martin et al., 2004; Kinzig et al., 2005; Grove et al., 2006; Troy et al., 2007). For example, Lubbe et al. (2010) reported that garden plants in high-class neighborhoods have mainly ornamental functions, while those of lower-class neighborhoods have more utilitarian functions. According to the present study, gardens in regions with low GDP per person are typically classified as homegardens and contain more utilitarian plants, such as fruit, vegetables, or timber plants, which are nearly absent from gardens in wealthier areas. Ornamental woody plants are characteristic of urban domestic gardens in temperate regions. Because private management is the most common management style among the analyzed gardens, a great range of goods and services could be obtained from them by their owners. Conversely, public gardens handled by governments fulfill other functions and are not as closely linked to the income and personal preferences of local people.

Regions sharing the same dominant language family have a lower taxonomic dissimilarity index, confirming the significant role of cultural background on the distribution of garden species at the global scale. This influence has been reported to be especially prevalent in colonized areas (Crosby, 1996; Ignatieva & Stewart, 2009; Kendal et al., 2012b). In terms of garden type, a taxonomically justifiable distinction does exist between the two main categories. The predominant species in domestic gardens include *Hedera helix*, *Lonicera sp.*, *Hydrangea macrophylla*, *Lavandula sp.*, *Rosa sp*., and *Rosmarinus officinalis*, while the most prevalent plants in homegardens include *Citrus sp.*, *Mangifera indica*, *Musa paradisiaca*, *Capsicum anuum* and *Carica papaya*. However, taxonomic matches between these two groups are still abundant, and the classification of gardens must depend on variables beyond floristic composition. Population density was shown to be negatively related with taxonomic dissimilarity. Therefore, gardens in densely populated areas are much more similar than are gardens in sparsely populated regions. Previous research has documented that people tend to prefer plants for their own gardens that are growing in nearby gardens (Zmyslony & Gagnon, 1998; Nassauer et al., 2009), and this effect may be amplified in urban areas.

Many other factors not included in the present analysis have been shown to influence the floristic composition of gardens at different scales and with different effects. Several studies have indicated that housing or farming age and size can positively contribute to the greater biodiversity of homegardens (Kumar et al., 1994; Larsen & Harlan, 2006; Eichemberg et al., 2009). Education, gender, median house value and even home ownership are also influential factors in determining the types of plants grown by people in their gardens (Yabiku et al., 2008; Larson et al., 2009; Zhou et al., 2009). Especially in domestic gardens, preferences linked to aesthetic value have also been described as important drivers of plant choices (Martin et al., 2003; Spinti et al., 2004; Nielson & Smith, 2005). On a broader scale, political legacy, as measured through a steep socio-economic gradient, was found to be a relevant explanatory variable for plant diversity in the city of Tlokwe in South Africa (Lubbe et al., 2010).

3.4.3 Gardens flora and biodiversity conservation

Gardens from around the world host a wide range of species incorporated from many sources, both natural and artificial. This elevated species richness, combined with the large area that gardens occupy at the global scale, provides many opportunities for conservation. Several studies have recognized the potential value of horticultural flora to biological diversity and their role in providing resources to wildlife (Owen, 1991; Kendle & Forbes, 1997; Smith et al., 2006; Davies et al., 2009). Tropical homegardens preserve a number of landraces and cultivars, as well as rare and endangered species (Watson & Eyzaguirre, 2002). However, the future transformation of these ecosystems may be determined by social trends (Wiersum, 2006). The taxonomic comparison of selected plant inventories indicates that a substantial percentage of gardens have high levels of taxonomic dissimilarity despite their relative closeness. Therefore, gardens may be considered heterogeneous habitats, with distinct territorial idiosyncrasies that result in a great variety of species. In rural environments, protecting the identity of a territory entails preserving the natural values of its gardens. Small variations in several socioeconomic variables, such as income level or population density, may affect biodiversity patterns. Furthermore, ornamental horticulture has been recognized as the main route by which invasive plant species are introduced into developed countries (Dehnen-Schmutz et al., 2007a; Sanz-Elorza et al., 2009), and the uncontrolled management of garden wastes can act as a source for the establishment of these non-native plants (Batianoff & Franks, 1998; Sullivan et al., 2005; Rusterholz et al., 2012). In urban areas, the focus of conservation should also consider the quality of life of the inhabitants (Miller, 2005). Environmental education, the use of a common language for communication with decision makers and planners, the involvement of different stakeholders, and even the inclusion of experts from different scientific disciplines can offer a wider perspective on terms such as “diversity” or “conservation” (Miller & Hobbs, 2002; Cilliers et al., 2004). Gardens can serve as an interface between the natural and the urban and can contribute to the incorporation of ecological values into society. Therefore, the importance of gardens should encourage global awareness of environmental protection.

3.4.4 Food security, economic crisis and their likely impact on garden floras

The main reason for gardening is the satisfaction of the needs and requirements of the garden’s owners. However, these needs are not always the same in all places and at all times. For example, the food security guaranteed through urban and peri-urban agriculture (UPA) has long been considered a significant component of the livelihood strategies for many households (Frankenberger & McCaston, 1998; Marsh, 1998; Bernholt et al., 2009; Thompson et al., 2009). Approximately one-seventh of the total world food production is obtained through UPA, which includes the contributions of gardens (Olivier 1999). In tropical developing countries, homegardens may contribute over one third of the total calories and protein consumed (Torquebiau, 1992). This production may be obtained directly through the harvest of edible fruit, vegetables, nuts and other products, or it may be obtained indirectly by selling the enhanced and sustained production. For this reason, homegarden production is worthy of recognition as a source of “health” food, which offers many important intangible benefits (Kumar & Nair, 2004). Because gardens are dynamic environments, they are relatively sensitive to changes in environmental and socioeconomic conditions. Therefore, a severe economic situation may cause changes in the way garden plants are grown in developed countries. Social groups and families that are closer to poverty thresholds may change the structure and functionality of their gardens to readapt them for food production. In other areas, gardeners may alter their production focus from subsistence to semi-commercial or commercial production according to market forces (Peyre et al., 2006). These changes may alter the vegetation structures of gardens, resulting in the dominance of exotic crops and plants instead of traditional production systems and their associated ecosystem services. However, more research is needed to clarify how gardens evolve and which factors cause change. This knowledge, combined with research conducted in other disciplines, would help in establishing viable strategies for the improvement of household nutritional security.

3.4.5 Limitations of available data

An exhaustive literature review was conducted to find inventories of garden plants from around the world. However, data were not available from all geographical and climatic areas, with a particular lack of research in North America and Northern Asia. Therefore, more research on garden plants is necessary, especially in temperate areas. Additionally, the criteria of the selected inventories varied widely between studies. Several of the selected plant lists were incomplete, including only the most representative species or those considered useful or cultivated, which may have biased the results, although the main conclusions remain robust. Regarding the variables used in the meta-analysis, data were selected to match the appropriate working scale. However, these data may not be sufficiently precise or detailed for some regions.

The socioeconomic dataset was obtained completely from external sources and was less detailed than the physical and climatic data. Moreover, these data were used as proxies for income or cultural background. Any analysis that combines these data is inherently complex and should be assessed carefully. Many other data were not included in the analysis due to unavailability, including education level, gender, age soil type, and these factors have been previously described as important influences on garden floristic composition (see, for example, Cook et al., 2012). Much about the global distribution of garden plants remains to be explored, and the present results should be interpreted in light of the existing scientific literature on these issues (Hope et al., 2003; Ignatieva & Stewart, 2009; Kendal et al., 2012b).

3.5 CONCLUSIONS

The analysis of taxonomic dissimilarities between the 44 plant lists from gardens around the world revealed conclusive information about the key factors determining their floristic differences. Unexpectedly, climatic and physical factors, particularly temperature, were not the main drivers of garden species distribution, although they were significantly related. Difference in GDP per person, used here as a proxy for household income, was instead the most important factor. The urban and rural green spaces of private property are usually exploited by their owners to obtain goods and services. This situation creates interests, benefits and opportunities that do not exist in public cultivated areas. Therefore, income level was able to exceed the significance of the physical and climatic variables that explain the botanical distribution for most of Earth's ecosystems. Other socio-economic variables, such as urban density (used as a proxy for the urban-to-rural gradient) and regions sharing the same language family, also shape the composition of garden flora at the global scale.

Many garden types have been described in the scientific literature in a variety of territorial and ethnoecological contexts, although "domestic gardens" and "homegardens" are the most used labels. Urban domestic gardens are associated with high rent residential urban areas in developed countries with temperate environments. In contrast, homegardens are typically associated with rural sites in hot and tropical environments with lower income levels and a predominantly subsistence economy. The present analysis provides significant insight into the differentiation of these two categories. However, boundaries between the types based on taxonomic similarities are still difficult to establish, and no precise criteria have been obtained. Furthermore, not all types of gardens have been studied and inventoried for all regions, and further research is necessary to analyze the biological structure of gardens and their species distribution at the global scale. Gathering information about the owners of these gardens is also essential for establishing strong comparisons. Further research should focus on determining the differences between gardens according to the variables used in a particular analysis.

Gardens are dynamic ecosystems that evolve over time and face the challenge of constantly adapting to current societal pressures. Alterations in socioeconomic dynamics can cause changes in the structure of gardens and their biodiversity. Moreover, severe economic crisis or situations resulting from global climate change may lead to significant changes in the uses of gardens. In near future, gardens currently for leisure in some areas may be converted into gardens for food production, and those already cultivated for subsistence may become more market-oriented. Future research should be concerned with exploring the factors that cause these changes in each territorial context. Knowledge of the trends that determine plant garden composition, and of the ways economic and climate change may affect them, will provide information about how to manage the bio-cultural diversity of gardens.

CAPÍTOL 4

EQUIPARACIÓ AGROCLIMÀTICA PER A LA IMPLEMENTACIÓ DEL MÈTODE DEL COEFICIENT DE JARDÍ A LA REGIÓ COSTANERA DE GIRONA

4.1 RESUM

Una de les metodologies més eficients per al càlcul de les necessitats hídriques dels jardins correspon al mètode del "coeficient de jardí". Aquesta tècnica incorpora un llistat, anomenat WUCOLS (*Water Use Classifications of Landscape Species*), amb les principals espècies vegetals utilitzades en jardineria ornamental i els seus requeriments hídrics potencials per tal que aquestes es mantinguin en condicions òptimes al llarg del temps. L'àmbit d'aplicació d'aquest llistat és exclusiu de l'estat de Califòrnia a Estats Units. L'objectiu d'aquest treball és presentar una proposta per a la seva adaptació i implementació a la regió costanera de Girona. Amb aquesta finalitat s'aplica una metodologia que permet equiparar una de les sis regions californianes descrites a WUCOLS, en concret la regió 3, amb el clima del litoral gironí tot utilitzant els valors de l'evapotranspiració de referència (ET_o).

4.2 INTRODUCCIÓ

En l'àmbit mediterrani occidental, la situació d'escassetat dels recursos hídrics s'ha vist notablement incrementada, en l'últim decenni, per un canvi en el model urbà que ha comportat una substitució de la ciutat mediterrània compacta per un model residencial difús hereu de la tradició anglosaxona (Rueda, 1999). Aquest nou patró urbanístic, molt associat a la presència de jardins domèstics, suposa una gran ineficiència en el consum d'aigua respecte al model de ciutat mediterrània (Parés-Franzi et al., 2006).

Els jardins es troben sovint associats a un elevat consum d'aigua, sobretot en períodes de sequera quan aquests requereixen d'una major aportació del recurs. En el model de casa i jardí, característic de moltes urbanitzacions, el consum d'aigua per a reg port arribar a representar entre el 30% i el 70% de l'aigua total consumida a les llars (Heras, 2003; Domene & Saurí, 2006; Salvador et al., 2011; Syme 2004.)

En aquest context, la configuració dels paisatges vegetals urbans amb un ús sostenible de l'aigua pren un valor especial (Kjelgren, 2000). Els jardins domèstics, doncs, es presenten com un element clau d'estudi i anàlisi on aplicar els principis de la xerojardineria (Wade et al., 2007; Burés, 1993). Aquest terme fou legalment registrat l'any 1981 pel "*Denver Water Department*" i fa referència al conjunt de coneixement i tècniques que permeten fer un ús eficient i sostenible de l'aigua quan aquesta s'incorpora als jardins (Contreras, 2005; Fernández-Cañero et al., 2011; Wade et al., 2007). L'adopció dels conceptes i tècniques de la xerojardineria pot suposar un estalvi anual del 33% per al conjunt del consum aigua domèstica, i fins a un 76% d'estalvi si es fa referència només a l'aigua aplicada al reg (Sovocool & Morgan, 2005).

Un dels principis rectors de la xerojardineria destaca justament la necessitat de regar eficientment i alhora utilitzar sistemes de reg adequats per a cada part del jardí (Burés, 1993). Amb el propòsit de desenvolupar aquest principi, l'any 1991 es presentà el "Mètode del Coeficient de Jardí" (Costello et al., 2000), i que compta amb tres objectius principals: la conservació de l'aigua entesa com a recurs, la disminució del manteniment dels jardins i el manteniment de la qualitat paisatgística (Costello et al., 2000; Contreras, 2005). Seguint aquest mètode es poden estimar els requeriments hídrics de cada jardí. La classificació WUCOLS (*Water Use Classifications of Landscape Species*), generada per

Costello i Jones (1994; 2000; 2014), inclou un llistat amb més de 3.000 espècies tabulades segons els seus requeriments hídrics. Aquestes necessitats són establertes per a cadascuna de les sis regions climàtiques proposades de l'àmbit californià.

El present estudi té per objectiu l'assignació de la regió agroclimàtica de la regió costanera de Girona a una de les sis regions californianes incloses en la guia WUCOLS de tal manera que es puguin traslladar quines serien les necessitats hídriques de les espècies vegetals en aquesta part de la conca mediterrània.

4.3 METODOLOGIA

4.3.1 Àmbit d'estudi i estacions XEMA

La regió costanera de les comarques de Girona (Figura 4.1), amb més de 250 quilòmetres de longitud, es troba localitzada entre la frontera Espanya-França (Portbou), al nord, i el riu Tordera (Blanes), al sud. Inclou 3 comarques: Alt Empordà (9 municipis), Baix Empordà (10 municipis) i la Selva (3 municipis).

Pel que fa al clima, l'àrea gaudeix d'un clima suau pròpiament mediterrani. La temperatura mitjana anual oscil·la entre els 14 °C i els 20 °C, sent els mesos més calorosos el juliol i l'agost amb mínimes de 16 °C i màximes de 35 °C (Clavero et al., 1996). Les precipitacions mitjanes es troben entre els 500 mm i els 800 mm anuals, sent el mes de novembre el mes plujós (RuralCat, 2012). A més, bona part de la Costa Brava es troba sotmesa a dèficits hídrics anuals d'entre 200 mm i 300 mm (Clavero et al., 1996).

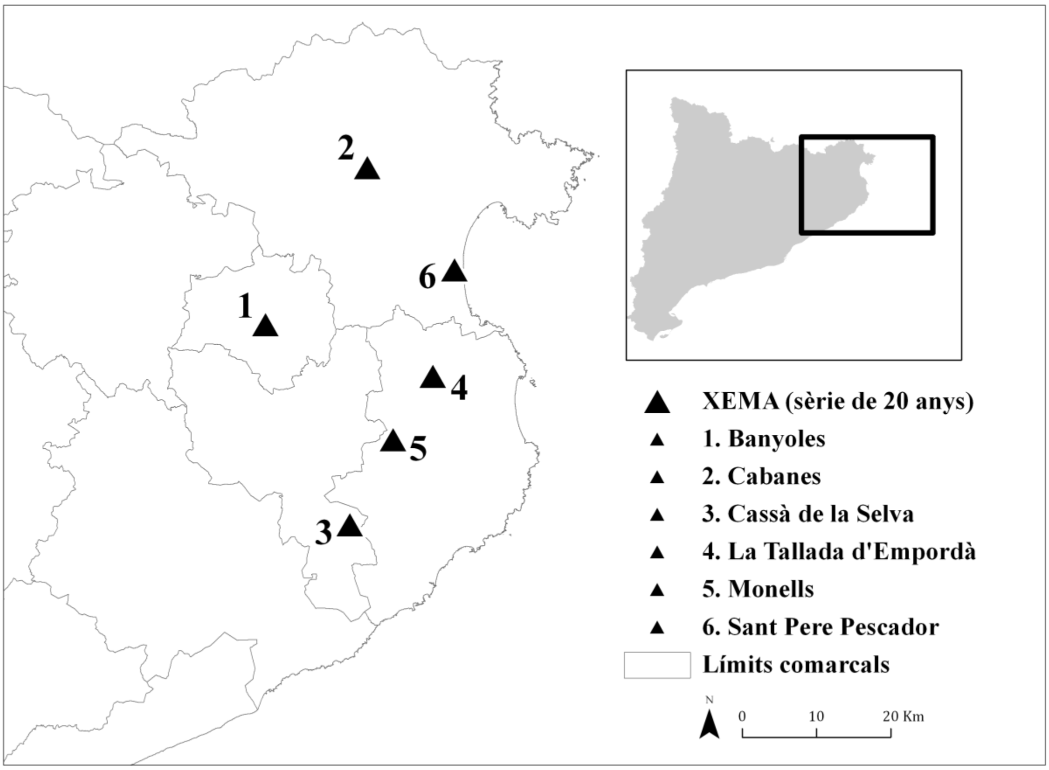


Figura 4.1: Localització de l'àrea d'estudi i les estacions XEMA seleccionades. Font: Elaboració pròpia a partir de dades de l'Institut Cartogràfic de Catalunya (ICC).

La obtenció de les dades agrometeorològiques que conformen aquest estudi es realitzà a partir de sis estacions XEMA (Xarxa d'Estacions Meteorològiques Automàtiques) gestionades a través del Servei Meteorològic de Catalunya (SMC), (Figura 4.1 i Taula 4.1). La seva selecció es basa en (1) proximitat a l'àrea d'estudi, i (2) disponibilitat de sèries històriques per als valors d'evapotranspiració de referència de més de 10 anys.

Taula 4.1: Codi i ubicacions de les estacions XEMA emprades en l'estudi (veure mapa de la Figura 4.1).

CODI	Municipi	Altitud (m)	UTM X	UTM Y
BNY	Banyoles	176	482708	4662940
CSL	Cassà de la Selva	171	494031	4636048
CBN	Cabanes	31	496369	4684011
TMP	La Tallada d'Empordà	15	505220	4655976
STP	Sant Pere Pescador	4	508088	4670256
MNL	Monells	60	499849	4647456

Font: Xarxa d'Estacions Meteorològiques Automàtiques de la Generalitat de Catalunya.

4.3.2 Dades agrometeorològiques

Les dades emprades per la comparació agroclimàtica d'aquest estudi corresponen als valors de l'evapotranspiració de referència (ET_0). Aquest paràmetre es defineix com l'evapotranspiració d'un cultiu de gramínies de 8–10 cm d'alçada, suficient regat, ben abonat i en bon estat sanitari (Doorembos & Pruitt, 1990). La seva determinació té lloc a partir de diferents dades climàtiques i l'aplicació d'equacions matemàtiques. En aquest sentit, totes les fonts consultades per a l'elaboració d'aquest treball han utilitzat la metodologia de Penman-Monteith en el càlcul de ET_0 (Monteith, 1965; Smith et al., 1990).

Els valors de ET_0 referents a la regió de Califòrnia s'obtingueren a partir de les dades CIMIS (*California Irrigation Management Information System*) provinents del *Reference Evapotranspiration Map* (Jones et al., 1999). Les seves unitats originals es convertiren a "mm/mes". Pel que fa a la regió de la Costa Brava, i tal i com s'ha descrit anteriorment, els valors s'obtingueren a partir de les sèries històriques de les sis estacions XEMA seleccionades per al període de 1989 a 2009 (RuralCat, 2012). Ambdues series, CIMIS i XEMA, ofereixen els valors mitjans diaris per a cada mes de ET_0 i poden ésser consultades en l'annex 1 d'aquest treball.

4.3.3 Comparació dels valors de ET_0

Seguint les pautes del treball de Contreras (2005) en què s'aplicà el mateix procediment per a la regió de Múrcia, es procedí a validar de forma estadística les similituds agrometeorològiques entre l'àrea d'estudi i les diferents regions californianes.

L'anàlisi es realitzà mitjançant el programari estadístic R 2.11.1 (Team R.D.C., 2012). Prèviament es comprovà que totes les sèries de dades responien a una distribució normal a partir del test de Shapiro-Wilk (α=0,05) (Saphiro & Wilk, 1965). Tot seguit, es van comparar tots els parells de sèries CIMIS – XEMA, amb un total de 18 x 6 = 108 parells de sèries. Per analitzar la similitud es realitzà un *t-test* de contrast d'hipòtesis per a diferència de mitjanes de mostres aparellades, amb α=0,05. Es calculà també l'interval de confiança per a una probabilitat del 95%.

4.4 RESULTATS

De l'anàlisi estadística i l'aplicació del test de Shapiro-Wilk es desprèn que totes les sèries utilitzades per l'estudi compleixen amb una distribució normal. A la Taula 4.2 es presenten les relacions entre els parells de dades XEMA/CIMIS. Els resultats de les comparacions entre les mitjanes de ET_0 per a cada més (annex 1) mostren que al comparar la sèrie de la zona CIMIS C1 amb cadascuna de les estacions XEMA, s'obté, per al 100% de casos, que la mitjana de les diferències mensuals és igual a zero ($p \geq 0,05$), i per tant les regions comparades són climàticament equivalents. Per a la resta de regions CIMIS no existeix coincidència per a cap de les estacions XEMA.

L'àmbit de l'àrea CIMIS C1 es troba inclosa en dues regions WUCOLS: la número 1 (Costa Nord-Centre), i també la número 3 (Costa Sud) (Costello et al., 2000). En la Taula 4.3 es presenten les equivalències expressades per Costello (2000), així com les obtingudes en aquest treball i en el treball de Contreras (2005).

Taula 4.2: Quadre resum comparatiu entre les zones CIMIS (columnes) i les estacions XEMA (files) pels seus valors mitjans de ET_o diaris de cada mes.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
BNY	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CSL	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CBN	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TMP	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STP	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MNL	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

x = No es rebutja H_0, ($p \geq 0{,}05$); - = Es rebutja H_0, ($p<0{,}05$).

Taula 4.3: Regions WUCOLS adoptades i les seves aproximacions.

REGIÓ WUCOLS	ZONES ET_0 CIMIS*	ZONES ET_O MEDITERRÀNIA
1. Costa Nord-Centre	1, 2, 3, 4, 6, 8	Regió de Múrcia**, Costa Brava
2. Vall central	12, 14, 15, 16	
3. Costa Sud	1, 2, 4, 6	Costa Brava
4. Valls interiors del Sud i contraforts	9	
5. Desert alt i intermedi	14, 17	
6. Desert baix	18	

*Costello & Jones, 2000, **Contreras, 2005.

4.5 DISCUSSIÓ

Els resultats de les comparacions dels valors mitjans d'evapotranspiració de referència diaris de cada mes entre les 18 zones CIMIS i les 6 estacions agrometeorològiques XEMA pot justificar l'assignació de la regió de la Costa Brava a la zona CIMIS C1. Aquesta zona és descrita per Jones et al., (1999), com a "franja de planes litorals amb boira densa" i disposa dels valors de ET_o més baixos de Califòrnia. A la vegada, el clima de la Costa Brava s'equipara a les condicions climatològiques de les regions WUCOLS 1 (Costa Nord-Centre) i/o 3 (Costa Sud).

Analitzant el llistat WUCOLS (Costello & Jones, 2014), s'observa que les regions 1 i 3 comparteixen els mateixos factors d'espècie per aproximadament el 87% del total de plantes. Així doncs, les diferències entre ambdues regions són reduïdes. No obstant això, els valors del coeficient d'espècie per a la regió 3 són, per a la majoria de casos, més estrictes que no pas en la regió 1, la qual cosa denota un grau d'estrès hídric major en la regió 3 respecte de la 1 (valors de k_s i ET_o majors).

En l'estudi desenvolupat per Contreras (2005), conduit per a tota la regió de Múrcia i seguint el mateix mètode que el present treball, es va concloure que el clima murcià podia ésser equiparat a la regió WUCOLS 1 (Costa Nord-Centre). L'estudi prengué com a unitat d'anàlisi una comunitat autònoma sencera, i per tant una regió geogràfica més àmplia i climàticament més diversa que la regió costanera de Girona. Aquest fet podria comportar una homogeneïtzació climàtica que obviaria les diferències subregionals alhora que podria conduir a una assignació massa generalista. No obstant això, totes les estacions emprades per Contreras (2005) comptaven amb valors de ET_o més alts que les regions utilitzades en el cas català. Es pot concloure, doncs, que les espècies vegetals de Múrcia habiten en condicions més àrides respecte el cas català.

Amb tot, malgrat que en el nostre cas es tracta d'un àmbit geogràfic més reduït i amb característiques agroclimàtiques més homogènies que tota la regió de Múrcia, no ha estat possible d'assignar una única regió WUCOLS a l'àrea d'estudi. Ara bé, pels raonaments exposats, hom pot concloure que la regió WUCOLS que millor s'equipara a la regió de la Costa Brava correspon a la regió 1 (Costa Nord-Centre). Els principals motius són que (1) presenta valors més baixos de k_s -i per tant també de ET_o- que la regió 3 i (2) que la Costa Brava és un àmbit més reduït i menys àrid (ET_0 anuals menors) que el conjunt de la regió de Múrcia (regió WUCOLS 1), i per tant en cap cas se li pot assignar una regió WUCOLS més àrida o agroclimàticament més estricte.

Així, és convenient remarcar que cal avaluar a l'aplicació de WUCOLS de forma individualitzada a qualsevol indret de la regió costanera de Girona. Les característiques bioclimàtiques poden diferir substancialment al llarg del territori, i per tant és recomanable estudiar la seva implementació per a cada localització concreta.

4.6 CONCLUSIONS

L'objectiu últim d'aquest treball ha estat presentar una metodologia que permetés aplicar el mètode del "coeficient de jardí", i per tant el llistat WUCOLS, a la regió mediterrània de la Costa Brava. D'aquesta manera es pretén disposar d'un instrument avalat per tal d'aproximar d'una forma objectiva el càlcul de les necessitats hídriques de les espècies vegetals emprades en jardineria i així gestionar millor els jardins i els recursos hídrics que s'hi destinen. Conèixer bé les plantes, i les seves necessitats, són un element clau en la xerojardineria cada dia més freqüent, però també en la racionalització de la demanda d'aigua. Alguns treballs, com el de Salvador et al., (2011) per al cas de Saragossa, ja han implementat el mètode del "coeficient de jardí" amb èxit. A la regió costanera catalana, aquesta metodologia es troba encara en fases inicials.

Finalment cal remarcar que el mètode emprat en aquest estudi representa només una aproximació a l'assimilació de les realitats climàtiques de les dues àrees, litoral gironí i californià. Malgrat que ambdues zones es consideren climatològicament molt semblants, els mètodes per quantificar aquesta semblança poden ésser discutits i cal avaluar la incorporació de nous criteris per afinar més en una determinació definitiva.

CHAPTER 5

MAINTENANCE, MODIFICATIONS AND WATER USE IN PRIVATE GARDENS OF ALT EMPORDÀ (SPAIN)[4]

[4] PADULLÉS, J., VILA, J. & BARRIOCANAL, C. (2014). "Maintenance, Modifications, and Water Use in Private Gardens of Alt Empordà, Spain". *HortTechnology*, 24 (3), 374-383.

5.1 SUMMARY

Water scarcity in developed countries along the Mediterranean coast may be aggravated in the near future due to rising water demand. The recent growth of low-density urban developments in these regions has led to an increase in the number of private domestic gardens. These particular landscapes may account for a large proportion of total domestic water use. This paper examines the features and management practices of private gardens in relation to their relative water requirements. To calculate this variable, we use a method based on the relative water needs of garden species and the area of vegetation cover. In addition, transformations in the layouts of the gardens over the last 5 years, as well as various expected changes, are assessed. In total, 258 domestic gardens along the coast of Catalonia were investigated and their owners interviewed. A list of all plants growing in the gardens was recorded. The results indicate that the presence of turf is related to professional landscaping design, property age and swimming pool presence. Moreover, gardens with greater landscape water requirements have more efficient watering systems. We present a progressive strategy for garden restructuring that may reduce water use while increasing the number of orchards and fruit trees.

5.2 INTRODUCTION

Water stress across Europe may increase in the near future due to growing population numbers, lifestyle changes and more frequent droughts (EEA, 2009). The associated growing water demand may affect water availability, especially in developed countries of the Mediterranean region (United Nations Environment Programme/Mediterranean Action Plan-Plan Bleu, 2009). To ensure adequate water supply and to control demand for this resource, many international organizations, including the United Nations and European Union, have proposed the application of various comprehensive management plans (EEA, 2009; United Nations-Water, 2012). The effective implementation of such strategies requires precise knowledge of the water management practices used in each territorial and socio-economic context.

In the northwestern Mediterranean region, expanding urban areas significantly affect water demand (Domene & Saurí, 2006). Social preferences towards single-family houses, characteristic of Anglo-Saxon town planning, have led to an increase in domestic outdoor water consumption (Garcia et al., 2013b; Saurí, 2003). This low-density urban model has been found to consume more water per capita than compact planning models (Askew & McGuirk, 2004; Parés-Franzi, 2005). Moreover, negative impacts across virtually all environmental parameters have been correlated with this form of residential development (Camagni et al., 2002; Cameron et al., 2012).

Approximately half of all domestic water usage takes place in outdoor areas (Domene & Saurí, 2006; Mayer et al., 1999; Salvador et al., 2011; Syme et al., 2004). Previous research reveals that garden irrigation represents a large portion of this consumption (Chestnutt & Mcspadden, 1991; Renwick & Archibald, 1998). Several investigations have been conducted in recent years to understand the factors shaping garden management and design and the consequent impact on water consumption (Hurd et al., 2006; Larsen & Harlan, 2006; Mustafa et al., 2010; St. Hilaire et al., 2008; Yabiku, et al., 2008). Focusing on New Mexico (U.S.), Hurd et al. (2006) demonstrated that the proportion of a garden occupied by turf is correlated with water price, the level of owner education and the degree of owner awareness about the importance of water conservation. In the metropolitan area of Barcelona (Spain), Domene and Saurí (2003) found turf to be featured predominantly in the gardens of high-income neighborhoods. Larsen and Harlan

(2006) also reported in a study carried out in Phoenix (AZ, U.S.) that vegetation types found in front yards are related to income level. In the U.S., preferences toward xeriscape gardens were found to be dependent on variables such as gender, the presence of children in the house and owner knowledge of garden plants (Larson et al., 2009; St. Hilaire et al., 2010; Yabiku et al., 2008).

In Spain, despite major concerns about water consumption issues, few studies have explored this matter at length. Garcia et al. (2013a) identified in the coastal area of Girona (Catalonia, northeast of Spain) four garden typologies (lawn, vegetable, ornamental and tree) and classified them according to their relative water needs and the socio-economic profiles of the residents who owned them. Studying the Aljarafe region (Andalusia, southern Spain), Fernández-Cañero et al. (2011) concluded that private gardens are inefficiently watered and mainly grown for aesthetic purposes without regard for environmental considerations. Furthermore, the authors reported that decisions to hire a professional maintenance service strongly depend on total garden area. A study in Zaragoza (Aragon, northeastern Spain), suggested that 60% of the surveyed gardens were overwatered (Salvador et al., 2011). However, in the metropolitan region of Barcelona, Domene and Saurí (2003) reported opposing data, where it was observed that garden irrigation generally did not meet plant watering requirements. These conflicting results suggest that more research is needed to understand the mechanisms determining water irrigation management habits and their connections to the structure and features of private urban landscapes.

Water requirements of private urban gardens may be calculated using several different factors, for which climate, plant composition and the proportion of vegetated areas are the most relevant considerations. The Water Use Classifications of Landscape Species (WUCOLS) method proposed by Costello et al. (2000) allows one to calculate landscape water requirements based on a procedure that replaces the crop coefficient with a landscape coefficient. This method has been used effectively in several studies to assess water management practices in urban landscapes (Domene & Saurí, 2003; Endter-Wada et al., 2008; Nouri et al., 2013; Salvador et al., 2011).

In Catalonia, where the Alt Empordà is located, drought episodes in 2007 and 2008 spurred a prohibition against reallocating water suitable for human consumption to household outdoor uses such as watering gardens; this is outlined in Decree 84/2007

(Generalitat de Catalunya, Legislative Decree 84/2007). Related water restrictions may become more commonplace in the context of global climate change (Stocker et al., 2013; Llebot, 2010). To effectively address this type of scenario in the future, precise knowledge of irrigation practices in private landscapes is needed to establish enhanced management measures adapted to each situation.

The aims of this paper were (1) to assess water management practices in domestic urban gardens in Alt Empordà, (2) to analyze landscape elements, structure and irrigation systems in relation to relative landscape water requirements, (3) to explore the characteristics and motivations behind garden renovations carried out over the last 5 years in order to assess water-saving attitudes, and (4) to examine future changes in private landscape design and their consequent effects on water demand.

5.3 MATERIALS AND METHODS

5.3.1 Study area

The Alt Empordà is situated in northeastern Spain [lat. 42º14'53'' N, long. 3º6'47'' E (Figure 5.1)]. Low-density residential suburbs included in the study are distributed into five municipalities, occupying a total area of 128 km^2. All of the suburban settlements are located around Aiguamolls de l'Empordà Natural Park (47.31 km^2), an extremely valuable lowland coastal area (Saurí et al., 2000). The total population of the area is 45219 inhabitants (IDESCAT, 2014). The traditional agricultural landscape has changed drastically over the last 60 years with the expansion of urban areas from tourism. Within the last 30 years, the total number of houses has doubled, and 68% are now secondary residences only occupied for some portion of the year, particularly the summer months. Moreover, the number of residents has tripled and approximately 38% are from other parts of Europe, especially France and Germany (IDESCAT, 2014).

The climate is typically Mediterranean, with average annual temperatures of approximately 15 ºC, oscillating from 30 ºC in the summer to 3 ºC in the winter. The average annual rainfall, mainly concentrated from autumn to spring, is 623 mm. The entire area is located at an average height of 9.2 m above sea level.

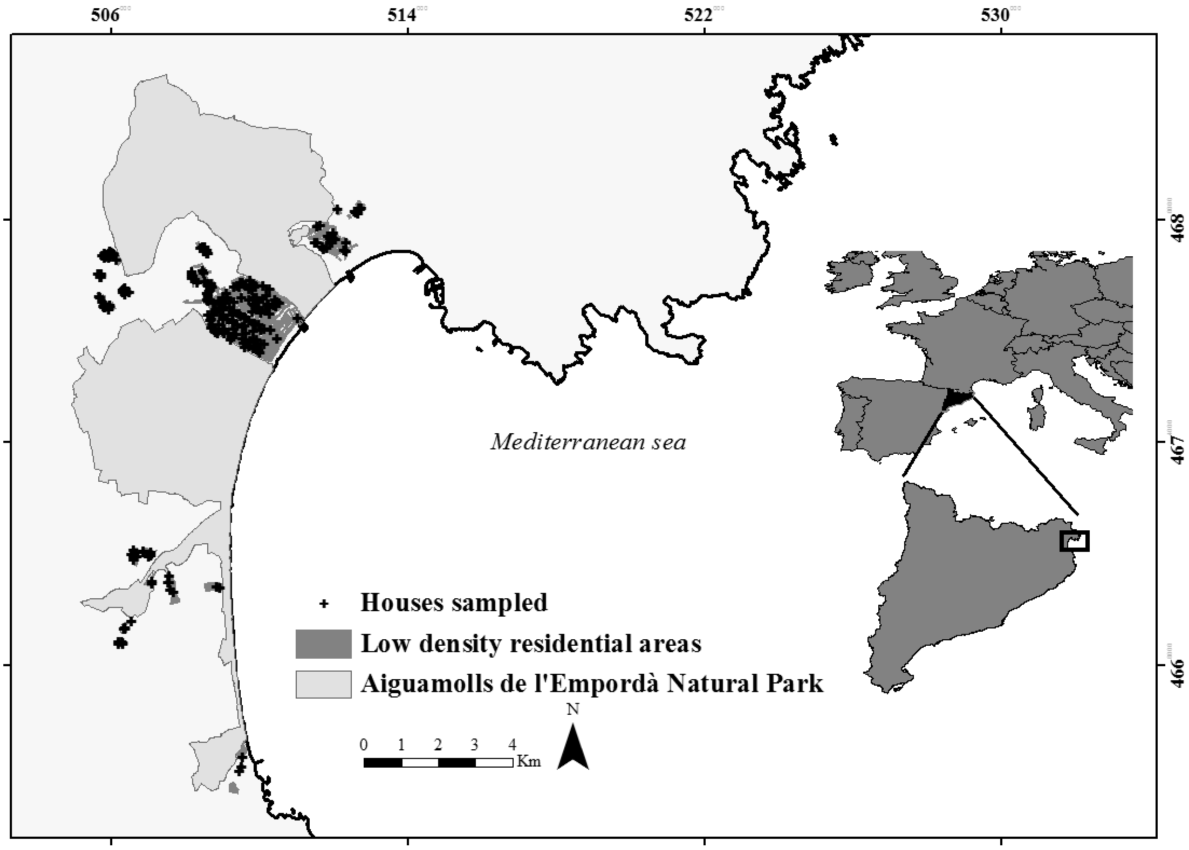


Figure 5.1. Locations of the sampled residences in Alt Empordà (Spain). 1 km=0.6214 mile.

5.3.2 Sample selection

We studied residential areas within 1 km of the Natural Park of Aiguamolls de l'Empordà (International Union for Conservation of Nature, category V). Using data from the cadastre (DGCE 2012) and ArcGIS 10 (ESRI, 2012) a layer containing all detached, semi-attached and attached single-family houses was obtained. Following the method outlined by Lynch et al. (1974) and the ArcGIS 10 tool "*subset features,*" we randomly selected a representative sample of 258 households from 6587 plots. When access to a selected house was not possible, the next house to the right on the same street was chosen. To include secondary residents in the survey and facilitate plant identification, all of the data were collected from May to July 2013.

5.3.3 Data collection

All plants growing in the 258 private gardens were tabulated, including those in pots and ponds. For turf, a randomly selected plot of 0.5 m^2 for each household was analyzed. For those plants that could not be identified at the species level, the genus was recorded. Each species was assigned to a single life form in accordance with the classification proposed by Raunkiaer (1934). Accordingly, plants were classified as phanerophytes (mostly trees and large shrubs), chamaephytes (mostly dwarf shrubs and some perennial herbs), hemicryptophytes (mainly biennial and perennial herbs, including those in which buds grow from a basal rosette), geophytes (mostly plants surviving as a bulb, rhizome, tuber or root bud) and therophytes (including all annual plants). Native plants were classified following the methods of Bolós et al. (2005).

A team of the same two researchers visited all of the selected households. The first researcher recorded plant composition while the second researcher conducted face-to-face surveys with each owner. The survey was designed to obtain information on the following: (1) characteristics of the property and the garden (e.g., age of the building, authorship of landscape design), (2) garden management practices, (3) irrigation scheduling and systems used, (4) changes in the garden structure over the last 5 years and (5) expected changes to be made in the near future. The questionnaire contained dichotomous and multiple-choice questions.

Land cover data were also recorded during the survey. This category was classified into eight different sub-categories: house, swimming pool, orchard, spontaneous vegetation, synthetic turf, turf, cultivated area (excluding turf; mainly trees, bushes and flowers) and non-cultivated area (excluding spontaneous vegetation; mainly paved areas). The presence of mulching, either organic or inorganic, was also recorded. Using ArcGIS (ESRI, 2012), each land cover area was calculated from georeferenced orthoimages (ICC, 2013).

5.3.4 Calculation of net irrigation requirements

The WUCOLS method was proposed by Costello et al. (2000) and used to estimate net irrigation requirements (IR_n). The technique is based on the application of a landscape coefficient (K_L) calculated from Eq. [5.1] as a function of the species factor (k_s), the density factor (k_d) and the microclimate factor (k_{mc}) that vary between and within different landscape vegetation types.

$$K_L = k_s k_d k_{mc} \quad [5.1]$$

The k_s parameter depends on the type of plant and the related water requirements. Based on expert evaluation, Costello and Jones (2014) tabulated these values for more than 3000 ornamental species in six areas of California. Species were classified in four main categories of water demands: very low [VL ($k_s \leq 0.10$)], low [L ($0.10 < k_s \leq 0.30$)], moderate [M ($0.40 \leq k_s \leq 0.60$)], and high [H ($0.70 \leq k_s \leq 0.90$)].

The k_s values of the first Californian areas were assigned to the plants inventoried in the gardens evaluated in this study. This region was chosen as the most climatically similar to our study site (Contreras et al., 2006). Species with VL water requirements were given a k_s of 0.1, while average values were used for L (0.2), M (0.5) and H (0.8) categories. Turf species were classified as cool season grasses (k_s=0.8) or warm season grasses (k_s=0.6) following Costello et al. (2000). Domesticated plants used for edible purposes were assigned to H water requirements. Moreover, all cacti not included in Costello and Jones (2014) were assigned to L water demands using a conservative approach. Both weeds and those species in pots or ponds were excluded from this part of the study as they do not meet the assumptions of standard conditions proposed by Costello et al. (2000). Only 50 plants (7.9%) were discarded because they do not appear in the WUCOLS list.

For each type of vegetation cover (trees, shrubs and flowers, orchards and turf), only one value of k_s was proposed. Continuing with a conservative approach, this was calculated as the maximum k_s value of all plants inventoried in each vegetation cover. Plots of spontaneous vegetation were excluded, as they do not usually require any maintenance.

Densely planted gardens have a higher evapotranspiration than those less densely planted; therefore, a k_d factor is required to modify the species factor in these cases. In this work, a value of k_d=0.8 was used for orchards and vegetation covers with one level of vegetation (trees or shrubs). If the landscape was represented by turf alone, or by two levels of vegetation (with trees and shrubs or flowers), a k_d of 1.0 was used. Those landscapes with three levels of vegetation featuring turf and trees, shrubs and flowers were assigned a k_d of 1.2.

Many gardens include a variety of microclimates, from cool, shaded areas protected from heat to very sunny areas or those exposed to the wind. This variability is incorporated through the k_{mc} factor. In this study, a value of 0.7 was assigned to all households, as all landscapes were located in protected areas (Salvador et al., 2011).

Finally, net irrigation requirements [IR_n (mm m^2 day $^{-1}$)] were calculated according to Eq. [5.2], as the sum of the products of the K_L of each vegetation cover and the reference evapotranspiration [ET_0 (mm day^{-1})] and the area of each vegetation cover [A_v (m^2)]. Note that IR_n is equivalent to landscape evapotranspiration.

$$IR_n = \sum_{i=1}^{n} K_{Li}\, ET_0\, A_{vi} \quad [5.2]$$

The resulting IR_n values were sorted again and gardens were classified into four groups (very low, low, moderate and high). Each of the divisions was statistically split into quartiles.

5.3.5 Data analysis

For nominal variables, the chi-square test for homogeneity was used. Spearman's rank correlation coefficient was used to analyze correlations between non-normally distributed continuous numerical variables. For numerical variables, the non-parametric Kruskal-Wallis analysis of variance (ANOVA) test was used to compare garden groups. When the result was significant, post hoc paired comparisons were performed following the methods of Dunn (1964). All analyses were conducted using SPSS (version 19 for Windows; IBM Corp., Armonk, NY). Significance was determined at $p < 0.05$.

5.4 RESULTS AND DISCUSSION

5.4.1 Garden features

Garden area influences many of the decisions made by homeowners in terms of both garden design and maintenance. In this study, garden size varied between 37 and 2273 m^2 with a mean value of 283 m^2. This last number is comparatively lower than those reported in many other garden studies (Bernholt et al., 2009; Bigirimana et al., 2012; Marco et al., 2008), all of which were over 600 m^2. This value is, however, higher than that reported by Gaston et al. (2005b), for which a mean value of 151 m^2 was reported for private gardens of Sheffield (U.K.). Fifty-one per cent of garden area consisted of paved areas and other artificial surfaces, while 49% consisted of vegetation. The average area occupied by trees, shrubs and flowers was 80 m^2 (28%), while turf occupied 54 m^2 (19%) and orchards took up 4 m^2 (1%). Table 5.1 shows garden cover area according to the four IR_n garden groups. The amount of surface occupied by spontaneous vegetation, orchard and synthetic turf, as well as the proportion of households with mulching elements, were not found to vary significantly among groups. Surface area occupied by trees, bushes and flowers, turf, pavement and other artificial surfaces significantly increased as IR_n increased.

Table 5.1: Mean of garden features, for each category of garden according to net irrigation requirements (IR_n) found in Alt Empordà (Spain).

	Garden categories based on IR_n [z,y]			
Garden features	**VL**	**L**	**M**	**H**
Plant richness [mean ± SD]	23^{a} ± 13	32^{b} ± 14	34^{b} ± 15	48^{c} ± 19
Outdoor area dedicated to [mean ± SD (m^2)]:				
Trees, bushes and flowers	18.2^{a} ± 13.3	49.2^{b} ± 21.9	70.2^{b} ± 48.0	176.6^{c} ± 126.2
Orchard	0.7 ± 2.3	2.0 ± 6.5	4.3 ± 10.0	9.2 ± 32.6
Spontaneous vegetation	2.8 ± 16.3	1.0 ± 5.4	-	-
Turf	5.8^{a} ± 18.7	16.1^{a} ± 45.0	34.12^{b} ± 37.5	156.5^{c} ± 184.9
Synthetic turf	4.5 ± 12.7	1.4 ± 7.3	1.2 ± 4.9	2.4 ± 19.6
Swimming pool	9.2^{a} ± 13.0	$13.0^{a,b}$ ± 14.5	$12.2^{a,b}$ ± 15.2	18.6^{b} ± 19.1
Pavement and other artificial surfaces	109.6^{a} ± 69.8	$137.0^{a,b}$ ± 78.8	$153.4^{a,b}$ ± 123.1	169.4^{b} ± 101.1
Gardens with mulch (%)	25.0	29.7	34.4	22.7

[z]Classification of gardens based on IR_n as very low (VL), low (L), moderate (M) and high (H).
[y]Any two means within a row not followed by the same letter are significantly different by Dunn's test at $p < 0.05$.
1 m^2=10.7639 ft^2

Associations among different vegetation covers, housing characteristics and management practices are included in Table 5.2. Turf was only present in 46% of the cases. According to St. Hilaire et al. (2008), in areas such as the Mediterranean region, where water is scarce or expensive, turf ratios tend to be low.

The presence of turf was also found to be positively correlated with property age (χ^2=14.42; df=3; p<0.01). Older buildings, possessing gardens up to 51 years old, as well as newly built gardens of barely 2 years, were found in the sampled houses. This correlation may suggest that new building owners opt for more xeriscape landscaping to reduce water consumption. Moreover, gardens with turf were also associated with professional landscaping design (χ^2=5.77; df=1; p<0.05). This finding implies that households that can afford the cost of turf maintenance can also hire a professional landscaper to design the garden. In this sense, it is worth highlighting that professional landscapers might promote turf species adapted to the particular climate in which a garden is being designed. The positive relationship between turf and pool presence was also confirmed (χ^2=3.55; df=1; p<0.05).

Gardens with trees, shrubs and flowers were positively associated with building age (χ^2=18.14; df=3; p<0.01) and secondary residences (χ^2=4.06; df=1; p<0.05). In contrast, the presence of orchards is highly dependent on whether a garden is located at a primary residences (χ^2=8.40; df=3; p<0.01) and whether there is a swimming pool in the yard (χ^2=4.37; df=1; p<0.05). These results suggest that the gardens of households inhabited year-round hold productive purposes while the gardens of secondary residences are mostly ornamental. In other studies, garden plants in low-income neighborhoods have been found to have a utilitarian function, while in high-standing neighborhoods, they mainly have an ornamental function (Bigirimana et al., 2012; Douglas & Lawrence, 2011).

Table 5.2: Housing characteristics and garden management practices for several vegetation covers in Alt Empordà (Spain)[z].

	Automatic sprinkling[y]		Type of residence[y]		Landscaper design[y]		Swimming pool[y]		Building age[x]	
	χ^2	r_φ	χ^2	r_φ	χ^2	r_φ	χ^2	r_φ	χ^2	r_φ
Vegetation covers:										
Trees, bushes and flowers	0,30	0,03	4,06*	0,13	0,33	0,04	1,30	0,07	18,14**	0,27
Turf	35,56**	0,37	1,91	-0,09	5,77*	0,15	3,55*	0,12	14,42**	0,24
Orchard	0,50	-0,04	8,40**	-0,18	2,86	-0,11	4,37*	-0,13	1,52	0,08
Spontaneous vegetation	0,99	-0,06	3,50	-0,12	0,04	0,01	0,12	-0,02	4,16	0,13

[z]For each association Chi-square (χ^2) and Phi (r_φ) values are presented.

[y]Chi-square test based on dichotomous responses (df=1): "use of automatic sprinkling" (0=no, 1=yes), "kind of residence" (0=secondary residences, 1=primary residences), "professional landscaper design" (0=no; 1=yes), presence of swimming pool (0=no, 1=yes).

[x]Chi-square test based on four types of responses (df=3): building age (less than 5 years old/5-20 years old/20-51 years old/more 51 than years old).

*, **significant at $p < 0.05$ or 0.01, respectively.

5.4.2 Vegetal biodiversity

A total of 635 genera and species were identified in all of the sampled gardens, the most abundant of which were rose (*Rosa* sp.) (58.3%), olive (*Olea europaea*) (45.6%), Japanese spindle (*Euonymus japonicas*) (44.0%), lemon (*Citrus limon*) (43.2%) and Canary Island date palm (*Phoenix canariensis*) [42.1% (Table 5.3)]. Recent studies assessing garden plant biodiversity have reported considerably different numbers of species: 1116 in Sheffield (Smith et al., 2006), 973 in Lauris, France (Marco et al., 2008), 567 in Bujumbura, Burundi (Bigirimana et al., 2012), 235 in Bangalore, India (Jaganmohan et al., 2012) and 116 in Niamey, Niger (Bernholt et al., 2009). Although the proportion of exotic plants is usually higher than that of native plants, these percentages vary considerably between gardens (see Bigirimana et al., 2012). In our study, 68% of all plants were exotic.

Of all plants studied, 81% correspond to ornamental species, 15% to weeds, 9% to edible plants and 2% to plants with other uses (note that the sum of percentages may differ from 100% as some of the same species can be used for multiple purposes). These data suggest that the gardens in the study area are mainly grown for aesthetic reasons.

The mean number of species per garden was 34.0, although there may be significant differences between groups (Kruskal Wallis H=56.1; df=3; $p<0.01$). A positive correlation exists between plant richness and IR_n (Spearman's rho=0.528; $p<0.01$). Previous research has shown plant richness to be influenced by socio-economic and cultural factors (e.g., Hope et al., 2003; Martin et al., 2003). Determining the best predictors of plant richness for each unique situation may be a key factor in guiding water management policies.

The most abundant life forms found were phanerophytes (40.6%) and chamaephytes (21.9%). This indicates that the private landscapes in our study area mainly consist of mature plant communities. Comparatively, these consolidated gardens may require less irrigation than younger gardens. In contrast to reports by Smith et al. (2005) in Sheffield (U.K.), the number of plants in these two categories was found to be correlated with house age (Spearman's rho=0.28; $p<0.01$). Therefore, water managers should focus on assessing water use in young and newly built gardens composed of unconsolidated plant communities and less established plants.

Table 5.3: The 50 most abundant species and their relative frequencies in sampled gardens in Alt Empordà (Spain). For each plant, the table shows relative frequency, family, life form (LF), uses, native and water requirement according to the species factor (k_s).

Common name	Scientific name	Relative frequency (%)	Family	LF[z]	Use[y]	Native	k_s[x]
Rose	*Rosa* sp.	58.3	Rosaceae	Ph	Or		M
Olive	*Olea europaea*	45.6	Oleaceae	Ph	Or	X	VL
Japanese spindle	*Euonymus japonicus*	44.0	Celastraceae	Ph	Or		L
Lemon	*Citrus limon*	43.2	Rutaceae	Ph	Or, Ed		M
Canary island date palm	*Phoenix canariensis*	42.1	Arecaceae	Ph	Or		L
Rosemary	*Rosmarinus officinalis*	41.3	Lamiaceae	Ch	Or	X	L
Crassula	*Crassula* sp.	40.5	Crassulaceae	Th	Or		L
Mint	*Mentha* sp.	38.6	Lamiaceae	H	Or		L
Garden geranium	*Pelargonium zonale*	38.6	Geraniaceae	Ch	Or		M
Sago palm	*Cycas revoluta*	38.2	Cycadaceae	Ph	Or		M
African daisy	*Osteospermum* sp.	37.8	Asteraceae	Ch	Or		L
English ivy	*Hedera helix*	36.7	Araliaceae	Ph	Or, We	X	M
Oleander	*Nerium oleander*	35.9	Apocynaceae	Ph	Or	X	L
Annual bluegrass	*Poa annua*	34.4	Poaceae	Th	We	X	-
Hydrangea	*Hydrangea macrophylla*	33.6	Hydrangeaceae	Ph	Or		M
Ice plant	*Lampranthus* sp.	33.2	Aizoaceae	H	Or		L
Bougainvillea	*Bougainvillea* sp.	30.1	Nyctaginaceae	Ph	Or		L
Mock orange	*Pittosporum tobira*	30.1	Pittosporaceae	Ph	Or		L
Orange	*Citrus sinensis*	28.2	Rutaceae	Ph	Or, Ed		M
Lavender	*Lavandula angustifolia*	28.2	Lamiaceae	Ch	Or	X	L
Yellow wood sorrel	*Oxalis corniculata*	27.8	Oxalidaceae	Th	We	X	-

Italian cypress	*Cupressus sempervirens*	27.4	Cupressaceae	Ph	Or		L
Palmer's sedum	*Sedum palmeri*	27.0	Crassulaceae	Ch	Or		L
Tall fescue	*Festuca arundinacea*	26.6	Poaceae	H	Or	X	CS
Crimson bottlebrush	*Callistemon citrinus*	25.5	Myrtaceae	Ph	Or		L
Asparagus fern	*Asparagus densiflorus*	24.7	Asparagaceae	Ch	Or		M
Sweet bay	*Laurus nobilis*	24.7	Lauraceae	Ph	Or	X	L
Hens and chickens	*Echeveria* sp.	23.9	Crassulaceae	Ch	Or		L
Common sow thistle	*Sonchus oleraceus*	23.2	Asteraceae	Th	We	X	-
Parsley	*Petroselinum crispum*	22.8	Apiaceae	H	Ed	X	H
Petunia	*Petunia* sp.	22.8	Solanaceae	Th	Or		-
Thyme	*Thymus vulgaris*	22.8	Lamiaceae	Ch	Or	X	M
Aloe	*Aloe vera*	22.4	Xanthorrhoeaceae	Ph	Or, Me		L
Marguerite daisy	*Chrysanthemum* sp.	21.6	Asteraceae	Th	Or		M
Tomato	*Solanum lycopersicum*	21.6	Solanaceae	Th	Ed		H
Agapanthus	*Agapanthus praecox*	20.5	Amaryllidaceae	G	Or		M
Mediterranean fan palm	*Chamaerops humilis*	20.1	Arecaceae	Ph	Or	X	L
Calla lily	*Zantedeschia aethiopica*	20.1	Araceae	G	Or		M
Canna	*Canna × generalis*	19.7	Cannaceae	H	Or		M
Spider plant	*Chlorophytum comosum*	19.7	Asparagaceae	H	Or		L
Pink/carnation	*Dianthus* sp.	19.7	Caryophyllaceae	Ch	Or		M
Euryops	*Euryops pectinatus*	19.7	Asteraceae	Ph	Or		L
Horseweed	*Conyza* sp.	19.3	Asteraceae	Th	We		-
Strawberry	*Fragaria vesca*	18.9	Rosaceae	Ch	Ed	X	M
Iris	*Iris* sp.	18.9	Iridaceae	G	Or		M
Lantana	*Lantana camara*	18.9	Verbenaceae	Ph	Or		L
American arborvitae	*Thuja occidentalis*	18.9	Cupressaceae	Ph	Or		M
Aloe	*Aloe maculata*	18.5	Xanthorrhoeaceae	Ph	Or		L

Canary Island rose	*Aeonium arboreum*	18.1	Crassulaceae	Ch	Or	L
Chilean jasmine	*Mandevilla laxa*	18.1	Apocynaceae	Ph	Or	M

[z]Life form (LF): phanerophytes [Ph (mostly trees and large shrubs)], chamaephytes [Ch (mostly dwarf shrubs and some perennial herbs)], therophytes [Th (including all annual plants)], geophytes [G (plants surviving as a bulb, rhizome, tuber or root bud)] and hemicryptophytes [H (mainly biennial and perennial herbs)].

[y]Plant uses: ornamental (Or), edible (Ed), medicinal (Me) and weed (We);

[x]Species factor (k_s): weeds/no data (-), very low (VL), low (L), moderate (M), and high (H), cold season turf species (CS)

Turfgrass species offer the significant ecological function of reducing erosion and allowing for more efficient rainwater use. However, if inadequately maintained or if occupying oversized areas, these species can also waste a significant amount of water (Wade et al., 2007). The most common turfgrass plant recorded in the sampled gardens was tall fescue (*Festuca arundinacea*) (26.6%), which is unlikely to be the species most suited to the summer conditions of the study area. Though this cold-season plant maintains a healthy appearance in the winter, it requires large amounts of water in summer in return for minimal ornamental value. In smaller proportions, we also identified English ryegrass (*Lolium perenne*), Bermuda grass (*Cynodon dactylon*), Kentucky bluegrass (*Poa pratensis)*, bent grass (*Agrostis* sp.) and St. Augustine grass (*Stenotaphrum secundatum*). In this sense, more appropriate drought-tolerant and non-invasive species, such as Japanese lawn grass (*Zoysia japonica*), should be promoted.

5.4.3 Landscape management and design

Owners were asked about the design and maintenance requirements of their gardens (Table 5.4). Many of the water needs and functional characteristics of a garden depend on the initial garden design. A well-planned garden should take into account a set of parameters such as hydrozone plant groupings and the local climate, topography, and native vegetation (Wade et al., 2007). Although almost 52% of owners were involved in the design of their gardens, professional landscaper intervention was especially important in 25.2% of all cases. This contrasts the results of Fernandez-Cañero et al. (2011) in Aljarafe (Spain), which showed a higher proportion (86.3%) of owners involved in the design of their gardens.

Table 5.4: Percentage of gardens reported by owners in relation to their landscape management and design in Alt Empordà (Spain).

	n.r.[z]	Nobody	Myself	Relatives	Landscape professional	Together with relatives	Other situations
Who designed the garden? (%)	1.6	-	37.6	18.6	25.19	14.3	2.7
Who selected the plants? (%)	2.3	0.4	51.2	22.5	3.10	16.3	4.3
Who prunes and mows the garden? (%)	3.1	0.4	48.1	18.2	11.24	14.0	5.0
Who waters the garden? (%)	2.7	-	60.1	16.7	3.49	15.1	1.9

[z]n.r.=no response.

Table 5.5: Percentage of sampled gardens using distinct irrigation systems for each part of the garden in Alt Empordà (Spain).

		Garden features						
	Do not use	All	Turf	Trees	Bushes	Flowers and pots	Orchard	Other
Hand watering with hose (%)	37.2	48.1	3.1	1.16	0.8	7.4	0.8	1.6
Hand watering with watering can (%)	71.3	14.3	1.2	-	0.4	11.6	0.8	0.4
Sprinkling. Manual activation (%)	91.1	5.8	1.9	-	0.4	0.8	-	-
Sprinkling. Automatic activation (%)	83.7	10.9	5.0	-	-	0.4	-	-
Drip irrigation. Manual activation (%)	93.8	4.3	0.4	-	-	0.8	0.4	0.4
Drip irrigation. Automatic activation (%)	90.7	5.4	0.4	-	0.4	2.3	0.8	-

With respect to management practices, household members performed the maintenance of their gardens in 80.3% of all cases. Similar values were obtained in Georgia (U.S.), where three of every four owners were engaged in landscape maintenance (Varlamoff et al., 2001), and in Aljarafe (Spain), where 83% of the owners performed up keep (Fernández-Cañero et al., 2011). Professional gardening companies were employed for garden pruning and mowing in 11.2% of the cases. This percentage is considerably lower than the 16-43% reported in surveys from Ohio, North Carolina and Oregon in the U.S. (Robbins et al., 2001; Osmond & Hardy, 2004; Nielson & Smith, 2005). It is therefore important to promote environmental and xeriscape education for homeowners through water conservation campaigns.

5.4.4 Garden irrigation

One of the most important factors for predicting actual water use is the type of irrigation system (Endter-Wada et al., 2008). As shown in Table 5.5, roughly half of the respondents use a hose to water all parts of the garden. A watering can is only used by 28.7% of the respondents, mostly for watering potted plants. In contrast, drip irrigation, which has 75% to 90% efficiency (Fuentes, 2003), is used in less than 10% of all cases. Overall efficiency is lacking, with 77.7% of gardens not equipped with automated irrigation. This percentage is higher than the 43% reported in gardens of Aljarafe (Spain, Fernández-Cañero et al., 2011), and the 69.1% presented in a study developed by the America Water Works Association Research Foundation (Mayer et al., 1999), which surveyed regions across the U.S. Although automated systems are often programmed to dispense large amounts of water regardless of season and the needs of plants (Martin, 2001), the use of these systems nevertheless allows for greater control, efficiency and adjustments to the amount of water applied. These features reduce the cost of general maintenance while also saving water (Fernández-Cañero et al., 2011; Martín et al., 2004).

As was expected, the presence of turf was found to be positively associated with the use of automatic sprinkler irrigation (χ^2=35.56; df=1; p<0.01). Although only 16% of respondents use this method, most apply it without taking the different hydrozones into account.

We classified households by irrigation system into the four IR_n garden groups. As illustrated in Table 5.6, the number of households using drip or sprinkler irrigation systems increases as IR_n increases (χ^2=29.00; df=3; p<0.01). Thus, in gardens with higher IR_n, the presence of automatic sprinkler irrigation (31.3% of all cases) and drip irrigation that is either manual (10.0%) or automatic (8.8%) is especially significant. Accordingly, in distinct studies developed in Australia (Syme et al. 2004), Spain (Domene et al., 2005) and the U.S. (Chesnutt and McSpadden, 1991), it was shown that households with more sophisticated and efficient watering systems also possess more water-intensive gardens than those using traditional irrigation techniques. In contrast, households with very low IR_n rely primarily on hose (56.3%) and watering can (27.5%) use.

Table 5.6: Percentage of gardens using distinct watering systems and classified according to net irrigation requirements (IR_n) in Alt Empordà (Spain).

	Garden categories based on IR_n^z			
	VL	**L**	**M**	**H**
Hand watering with hose (%)	56.3	50.0	51.3	45.0
Hand watering with watering can (%)	27.5	23.8	22.5	18.8
Sprinkling. Manual activation (%)	6.3	8.8	6.3	7.5
Sprinkling. Automatic activation (%)	2.5	5.0	13.8	31.3
Drip irrigation. Manual activation (%)	2.5	5.0	2.5	10.0
Drip irrigation. Automatic activation (%)	5.0	7.5	8.8	8.8

^{z}Classification of gardens based on IR_n as very low (VL), low (L), moderate (M) and high (H).

With respect to watering frequency, Table 5.7 shows that more than half of the gardens (57.4%) were not watered during the winter, while 36.4% were watered every day during the summer. These results contrast those of Fernandez-Cañero et al. (2011), who reported that almost half of the gardens in that study (48.8%) were watered daily in summer, with a large majority (70%) not being watered in winter. Larson et al. (2010) suggested that frequent summer irrigation was associated with garden maintenance for neighborhood appearance while winter irrigation was related to biocentric (environmentally oriented) worldviews. Surprisingly, only 1.2% of the respondents claimed to water the garden only when necessary. This result is likely due to a lack of knowledge concerning plant garden maintenance.

Table 5.7: Percentage of gardens based on the frequency of watering in each season in Alt Empordà (Spain).

	n.r.[z]	Every day	Alternate days	Every 3 days	Every week	Do not water	When necessary
Winter (%)	8.9	1.6	2.3	3.9	14.0	57.4	12.0
Summer (%)	3.5	36.4	24.0	18.2	14.0	2.7	1.2

[z]n.r.=no response.

Table 5.8: Percentage of gardens based on the time of day of watering in Alt Empordà (Spain).

	n.r.[z]	Morning	Noon	Afternoon	Evening	Night	Morning and night	Depending on the season	Indifferent
Time of day to water the garden (%)	4.1	6.6	0.4	11.2	40.7	5.9	4.3	21.7	5.0

[z](n.r.=no response).

Garden owners were asked what time of day they usually water their garden (Table 5.8). Approximately half of the respondents water the garden in the evening or at night. However, only 21.7% of the owners modulate irrigation depending on the season, and 5.0% are indifferent to these issues. These trends could be improved by promoting more sustainable garden management practices.

5.4.5 Garden transformation

The questionnaire asked owners about changes made to the layouts of their gardens over last 5 years and the motivations for these changes (Table 5.9). At least three quarters of the respondents have made some meaningful changes during this period. Similarly, in a study in Phoenix (AZ, U.S.), Larsen and Harlan (2006) reported that 70% of respondents made changes in their landscapes. The most common modification reported in these studies was the addition of vegetation. In contrast, our study indicated that the most frequent modification was turf removal, performed in 12.4% of the households. The main reasons for this movement were to save water (25.0%), to save time (22.7%) and for garden beautification (22.7%). Less prevalent transformations executed for water-saving purposes included the installation of synthetic turf and irrigation system replacement. Other common changes included plant replacement, tree removal, fruit tree planting and paving parts of the garden. The main modifications planned in the near future as reported by the owners were plant incorporation (18 cases), paving part of the garden (10 cases) and orchard construction (7 cases).

Although there is no direct relationship between the drought episodes of 2007 and 2008 and such garden transformations, a general trend towards water-saving is evident during this period. According to planned changes reported by the owners, this phenomenon seems likely to persist in the near future. As such, garden transformations that are implemented not strictly for saving water, such as paving, installing synthetic turf or upgrading the watering system, may play an indirect but important role in reducing water demand. These findings suggest that gardens are slowly being adapted to the current climatic and socio-economic conditions. This may prove highly important when future drought episodes once again activate restrictions on garden water use.

Table 5.9: Total number of expected and realized changes (2008-13) in private landscapes and the proportion of total changes based on distinct circumstances in Alt Empordà (Spain).

	Total changes (no.)		Reasons for realized changes (%)					
	Expected	Realized[z] 2008-13	Saving water	Saving money	Saving time	To make my garden beautiful	To improve the recreational space	Other
Pavement of part of the garden	10	23	3.7	7.4	22.2	18.5	40.7	7.4
Make an orchard	7	9	-	-	-	30.0	10.0	60.0
Remove turf	1	32	25.0	2.27	22.7	22.7	18.2	9.1
Install turf	4	5	-	-	25.0	50.0	25.0	-
Install artificial turf	3	7	25.0	12.5	-	50.0	12.5	-
Remove plants	-	15	16.7	11.1	27.8	16.7	22.2	5.6
Add or change plants	18	27	-	3.03	18.2	57.6	21.2	-
Remove trees	2	26	-	-	3.7	40.7	51.9	3.7
Plant of fruit trees	4	23	10.3	10.3	10.3	48.3	17.2	3.5
Change the watering system	4	6	36.4	18.2	36.4	9.09	-	-
Install mulching elements	-	6	-	-	-	12.5	62.5	25.0
Install or retire decorative features	-	12	-	8.3	-	50.0	41.7	-
Build a swimming pool	-	11	-	-	-	18.2	63.6	18.2

[z]Each garden may have more than one reason to apply changes.

5.5 CONCLUSIONS

The main goal of this study was to assess water management practices in private urban gardens of Alt Empordà (Spain). More than half of the outdoor spaces studied were found to be composed of pavement or other artificial surfaces. However, the vegetated surfaces may consume a large proportion of domestic water. Thus, detecting inefficiencies in garden water use is essential for guiding policies and water management measures and for adapting to climate change.

One of the most compelling results of this research is the significant correlation found between turf use and property age, swimming pool presence and, most importantly, automatic sprinkler irrigation use. Although 77% of the gardens do not use an automatic irrigation system, results show that more efficient watering systems are used as landscape irrigation requirements increase.

The high proportion of ornamental plant species discovered in this study indicates that the sampled gardens are mainly cultivated for aesthetic purposes. However, an increase in the number of orchards has been detected over the last 5 years, likely in response to the economic crisis developing in the country since 2008. This fact appears to complement the growing number of fruit trees reported in the same period. These observations may embody a general trend toward changes in the functions of household gardens, which could increase water consumption in order to enhance household food security.

Garden maintenance, design and associated activities are mainly performed by the homeowner together with other household members. It is therefore important to promote environmental education through water conservation campaigns.

In absolute terms, there has not been a significant number of changes made to the structure of gardens over the last 5 years. However, it should be emphasized that the most frequently applied modification was turf removal, performed mainly for water conservation. The assimilation of data from continuing studies on home garden modification may reveal a general trend towards reducing water consumption.

Overall, the results of this study may inform urban and water planners to appropriately manage water demand in low-density developments through a better understanding of the effects of garden features and landscape management on water use. Governments and water companies in the Costa Brava region have the responsibility to have a more holistic view and be sensitive to urban and social realities. Moreover, developers and buyers should promote a shift to more appropriate housing options for the Mediterranean climate. The use of lower-quality water for irrigation (i.e., from rainwater tanks) should be recommended by urban horticulture guides, while managers should carefully monitor how suburban residential areas evolve in the near future and promote alternative sources for irrigation water. If these considerations are followed, the impact of future drought episodes might be reduced.

CHAPTER 6

WATER REQUIREMENTS PREDICTED FROM THE CHARACTERISTICS OF DOMESTIC MEDITERRANEAN GARDENS DO NOT STRONGLY RELATE TO SOCIOECONOMIC OR DEMOGRAPHIC VARIABLES[5]

[5] PADULLÉS, J., KIRKPATRICK, J.B. & VILA, J. "Water requirements predicted from the characteristics of domestic Mediterranean gardens does not strongly relate to socioeconomic or demographic variables". *Landscape & Urban Planning* (under review).

6.1 ABSTRACT

Gardeners can consume a large proportion of total domestic water use, depending on their garden type and gardening style. We calculated water requirements of gardens based on species composition and land cover, and determined whether they can be predicted from the socioeconomic, demographic and cultural characteristics of households. We recorded the plant species composition, garden cover types, and demographic, socioeconomic and cultural characteristics of 258 households in urban areas along the Mediterranean coast of Catalonia. The distribution of the 635 species in these gardens were the input to a cluster analysis, in which semi-natural gardens, vegetable gardens, lawn gardens and ornamental gardens formed strong floristic groups, with ornamental gardens predicted to require the least water inputs and lawn gardens the most. Vector fitting in ordination space indicated that the main floristic gradients in the garden vegetation were related to the occupancy rate of the house, birthplace, income and the percentage of people not working in the household. However, only income and a lack of work were related to our water requirement variable, reflecting the expense of water and the propensity of the retired to be temporary residents. We conclude that individual attitudes may be more important than socioeconomic status and demography in explaining garden water use.

6.2 INTRODUCTION

More than half of the global human population lives in urban areas (United Nations, 2013). On the Mediterranean coast, residential areas are extensive (Dura-Guimera, 2003; Muñoz, 2003). Private gardens collectively constitute most of the vegetated land in these sprawling and expanding urban areas (Domene & Saurí, 2003; Gaston et al., 2005b; Mathieu et al., 2007). However, these gardens are poorly-known (Colding et al., 2006), particularly their plant species composition (Marco et al., 2008).

Private gardens provide physical and mental benefits to their owners (Niemelä, 1999; Dunnett & Qasim, 2000). The garden has been increasingly associated with private leisure and social interaction (Bhatti & Church, 2000). Everyday human-plant relations in gardens have been widely explored (Hitchings, 2003; Christie, 2004; Power, 2005; Longhurst, 2006; Head & Muir, 2006; 2007). These relations may vary temporally, leading to cultural landscapes that reflect shared customs, the original decisions of developers, and the ideals of residents (Gobster et al., 2007; Romig, 2010). Floristic diversity is not only a result of cultural preferences, but is also linked to the diversity of practices, exchanges between gardeners and physical characteristics of the environment (Marco et al. 2014).

Variation in garden species composition and cover is known to be strongly related to socioeconomic status and demographic attributes (e.g. Martin et al., 2003; 2004; Hope et al., 2003; Kirkpatrick et al. 2007; Marco et al., 2010a; Lubbe et al., 2010; Bigirimana et al., 2012; Padullés et al., 2014b). The influence of motivations and attitudes, which may be culturally determined, on garden diversity patterns can be strong (Kinzig et al., 2005; Van Heezik et al., 2013), as with the planting and removal of garden trees (Kirkpatrick et al., 2012). In other examples, the presence of lawn in gardens has been related to the water price, level of education and the degree of awareness of the importance of water conservation (Domene & Saurí, 2003; Hurd, 2006), species composition strongly relates to aesthetic preferences, such as those for flower size and foliage color (Kendal et al., 2012a) and preference for xeric garden landscapes may reflect strong environmental attitudes and beliefs (St. Hilaire et al., 2010; Yabiku et al., 2008).

The nature of particular gardens strongly affects water use, in a context in which global climatic change has been predicted to worsen water scarcity in the Mediterranean region

(Sala et al., 2000). Social preferences for private gardens reminiscent of those in English planned towns immensely increases outdoor water use (Askew & McGuirk, 2004). In Australia (Syme et al., 2004), the United States (Mayer et al., 1999) and Spain (Domene & Saurí, 2006; Salvador et al., 2011) about half of domestic water consumption occurs outdoors, making an understanding of the ways in which society, culture, demography and environment interact to create gardens with varying water requirements important in the planning of water conservation.

Households in low-density suburban developments of the Catalan Mediterranean coast are highly socio-culturally diverse (Statistical Institute of Catalonia, 2013; Garcia et al., 2013a), managed by and making them suited to investigation of the above question. Spanish private gardens are inefficiently watered (Fernández-Cañero et al., 2011; Salvador et al., 2011), perhaps explaining why contradictory results have been obtained when comparing landscape water needs with water use (Domene & Saurí, 2003; Salvador et al., 2011).

Rather than the landscape, we take the garden itself as the centrepiece of the water conservation problem, applying a method to deduce relative water requirements from species composition and the covers of surface classes, such as lawn. A previous paper examines the ways in which the gardeners, whose gardens we examine herein, utilized water in the context of recent garden design changes (Padullés et al., 2014a). In the present paper we determine whether variation in gardens and water requirements of gardens can be predicted from the socioeconomic and demographic characteristics of the household. If such a relationship exists, this knowledge can be used to more effectively direct incentives and regulations related to water needs. If it is weak, identifying and targeting attitude groups is likely to be more effective.

6.3 MATERIALS AND METHODS

6.3.1 Study area

The study was conducted in low-density residential areas of five municipalities in the Alt Empordà region (42°14’53’’ N, 3º6’47’’ E) in Catalonia (north-eastern Spain; Figure 6.1). We looked at residential areas within one km of the Natural Park of Aiguamolls de l’Empordà (IUCN, category V).

In the past 30 years the population of the wider region has tripled and the number of houses doubled. Approximately 38% of residents are foreigners, mostly from France and Germany (IDESCAT, 2013). Currently 68% of houses are second residences. The population density of the study area is high (351.90 people km^{-2}). The economy of the region is based on tourism.

The daily average temperature is 15 ºC, varying from 30 °C in summer to 3 °C in winter (MSC, 2014). The average annual rainfall is 623 mm. The average potential evapotranspiration (ET_0) in all five municipalities during the summer months (July, August and September) is 104 mm. The study area is located at an average height of 9.2 m above sea level.

6.3.2 Selection of samples

Using ArcGis 10 (ESRI, 2012) and the information contained in the Spanish official cadastre (DGCE 2012), a layer with all detached, semi-attached and attached single-family houses in the study area was obtained. The digital cadastral database used in this study was a digital map showing property boundaries and their type of residence. Using the method of Lynch et al. (1974), we randomly selected a sample of 258 households. When access to a selected house was not possible, the next house in the same street was chosen. All data were collected from early May to late July 2013.

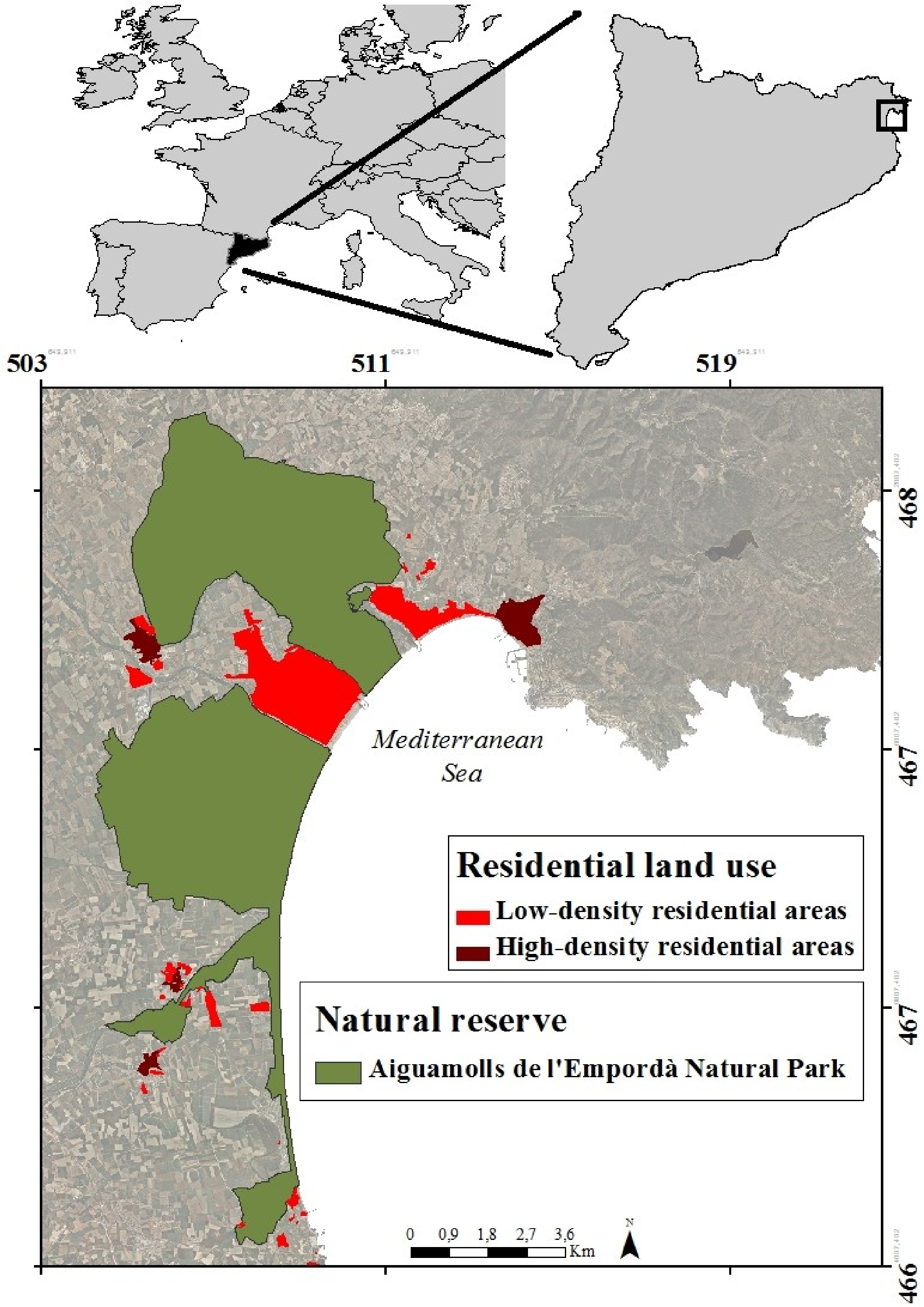


Figure 6.1: Location of the surveyed low-density residential areas in Catalonia.

6.3.3 Data collection

For the purpose of this study, a garden is defined as “an area of enclosed ground, cultivated or not, within the boundaries of an owned or rented dwelling, where plants are grown and other materials are arranged spatially” (Bhatti & Church, 2000:1). In each domestic garden, all plants were inventoried, including those in pots and ponds. However, for lawns, a randomly selected plot of 0.5 m^2 in each household was inventoried. Species were recorded by garden cover type: lawn, vegetable garden, spontaneous vegetation and ornamental gardens (that is, trees shrubs and flowerbeds). Species that could not be identified during the visits were collected, photographed and identified following Sánchez et al. (2000), and other specialized literature (e. g. Pañella, 1970; Bolós et al., 2005; Bellido, 1998). For those plants that could not be identified to species level, the genus was recorded. Scientific nomenclature follows the International Plant Name Index (IPNI, 2013). Each species was assigned to one life form according to the Raunkiær (1934) classification: phanerophytes (mainly trees and large shrubs), chamaephytes (mainly dwarf shrubs and some perennial herbs), hemicryptophytes (mostly biennial and perennial herbs, including those in which buds grow from a basal rosette), geophytes (mainly plants surviving as a bulb, rhizome, tuber, or root bud), and therophytes (all annual plants). The natural distribution of plants was determined from Sánchez et al. (2000) and Bolós et al. (2005). Taxa were also allocated to alien or native categories according to Bolós et al. (2005).

To characterize and measure outdoor land covers, we used the information gathered during the field survey and orthoimages of 0.1 m × 0.1 m pixel size obtained from the Cartographic Institute of Catalonia (ICC, 2013). Each image had been previously georeferenced. Using ArcGis 10 (ESRI, 2012) the area of the outdoor features was measured. Seven polygon layers were created: swimming pool, vegetable garden, spontaneous vegetation, synthetic lawn, lawn, cultivated area (excluding lawn; mainly trees, bushes and flowers) and non-cultivated area (excluding spontaneous vegetation; mainly paved areas).

A survey was conducted of the 258 households visited during the field work. Whenever possible, we surveyed the household member who took primary responsibility for the garden. The questionnaire consisted of closed questions investigating housing and socio-demographic characteristics (Table 1). We also gathered information regarding household water consumption during the year 2012 (reported in bills and grouped by trimesters), water sources used to irrigate the garden and the mode of garden watering.

6.3.4 Calculating relative water requirements

The text related to the methods in 2.4 largely follows Padullés et al. (2014a). The WUCOLS (Water Use Classifications of Landscape Species) method proposed by Costello et al. (1994; 2000; 2014) was used to estimate landscape water requirements (LWR). The technique is based on the application of a landscape coefficient (K_L), which is directly proportional to the species factor (k_s), the density factor (k_d) and the microclimate factor (k_{mc}) (Eq. [6.1]).

$$K_L = k_s k_d k_{mc} \quad [6.1]$$

The k_s parameter depends on the type of plant and the related water requirements. Costello and Jones (2014) tabulated these values for more than 3000 ornamental species in six areas of California. Species were classified as presenting very low requirements (VL; k_s<0.10), low requirements (L; 0.10≤k_s≤0.30), moderate requirements (M; 0.40≤ k_s≤0.60), and high requirements (H; 0.70≤ k_s≤0.90).

Due to climatic similarity, the k_s values of the first Californian areas were assigned to the plants inventoried in the gardens evaluated in this study (Contreras et al., 2006). Species with VL water requirements were given a k_s of 0.1, while average values were used for L (0.2), M (0.5), and H (0.8) categories. Turf species were classified as cool season grasses (k_s=0.8) or warm season grasses (k_s=0.6) following Costello et al. (2000). Plants grown for edible purposes were assigned to H water requirements as they are grown for food production. Furthermore, all cacti not included in Costello and Jones (2014) were assigned to L water demands using a conservative approach (Domene & Saurí, 2003). To meet the standard conditions proposed by Costello et al. (2000), both weeds and species in containers or ponds were excluded from this part of the study. Only 50 species (7.9%) were discarded because they do not appear in the WUCOLS list.

Continuing with a conservative approach, we calculated separately for each garden the k_s factor of the three cultivated garden covers (lawn, vegetable garden and trees, shrubs and flowers) as the maximum k_s value of all plants inventoried in these land covers. Plots containing only spontaneous vegetation were assigned a k_s of 0.4 as they were watered in almost all cases. Gardens with no plants were included in the study because our aim was to measure all outdoor water needs and thus paved gardens must be taken into account. Paved areas were assumed to have zero water needs.

The density of vegetation (k_d) and microclimate (k_{mc}) can modify K_L. The k_d reflects the collective leaf area of all planted species. There is no standardized system for evaluating it. In the present study, a value of k_d=0.8 was used for vegetable gardens and vegetation covers with one level of vegetation (trees or shrubs). Landscapes represented by turf alone, or by two levels of vegetation (with trees and shrubs or flowers), were given a k_d of 1.0. Those landscapes with three levels of vegetation featuring turf and trees, shrubs, and flowers were assigned a k_d of 1.2 (cf. Costello et al., 2000). For the k_{mc} factor, a value of 0.7 was assigned to all households as all landscapes were located in sheltered areas and were well-drained (Salvador et al., 2011; Padullés et al., 2014a).

Landscape evapotranspiration (ET_L; millimetres per square meter per day) was calculated following Eq. [6.2], in which K_L is the landscape coefficient of each vegetation cover (dimensionless), ET_0 the reference evapotranspiration (millimetres per day) and ER the effective rainfall calculated using the method proposed by Brouwer & Heibloem (1986) (cf Salvador et al., 2011; Hof et al., 2014).

$$\mathrm{ET_L} = \mathrm{ET_0 K_L} - \mathrm{ER}\ [6.2]$$

Landscape evapotranspiration does not represent the real water demand of garden plants, which is also strongly influenced by the efficiencies of different forms of irrigation. Therefore, the LWR (millimeters per day) for each garden was obtained following Eq. [6.3], in which ET_L is the landscape evapotranspiration of each vegetation cover type (millimeters per square meter per day), IE the irrigation efficiency (ranging from 0 to 1) and A_{vi} the area of the four distinct vegetation covers (square meters).

$$LWR = \sum_{i=1}^{n} \frac{ET_L}{IE} A_{vi} \quad (3)$$

A determination of IE is challenging. As yet, a standard method has not been established. In our study, estimations were based on an assessment of the design and performance of the irrigation system (Costello et al., 2000). First, we determined the irrigation system applied in each cultivated vegetation cover. Then, an IE of 0.6 was assigned to areas irrigated with hose, 0.75 to areas watered with sprinkler systems, 0.8 to zones irrigated with watering can and 0.9 to areas with drip irrigation (Fuentes, 2003; Costello et al., 2000). Average values were generated when more than one system was applied simultaneously in a same area.

The WUCOLS method approximates the water needed to achieve an acceptable level of plant health and aesthetics in cultivated ornamental landscapes. A study recently conducted in South Australia concluded that this technique produces the best estimation of urban vegetation water requirements (Nouri et al., 2013). In addition, other studies have successfully applied this methodology in the study of water use in urban domestic gardens in Spain (Domene & Saurí, 2003; Salvador et al., 2011; Padullés et al., 2014a; Hof & Wolf, 2014).

6.3.5 Data analysis

The Bray-Curtis coefficient (Bray & Curtis, 1957) was used to compute compositional dissimilarities between all pairs of gardens. This coefficient was chosen because it has been shown to be robust and effective for community analysis (Faith et al., 1987). The dissimilarity matrix was ordinated in one to four dimensions, using non metric multidimensional scaling (NMDS) (Kruskal, 1964) with the *vegan* package in R 3.0.3 (R Team R.D.C., 2012). Using the “envfit” function, socioeconomic, demographic and cultural gradients (Table 6.1) were fitted on the ordination as linear vectors showing the direction of the environmental gradients (Oksanen, 2008). The type of residence (permanent vs. secondary) and the average age of family members were omitted due to collinearity with other variables. Transformations were applied to the variables in order to reduce skew and to improve the normality of residuals. The age of the building and the percentage of unemployed and retired people were squared while the number of residents was natural-log transformed. Categorical variables were codified as dummy variables.

A cluster analysis was conducted to obtain an empirical classification of the different landscapes using the scores on the four dimensions of the ordination as input. Hierarchical and non-hierarchical methods were combined. First, a hierarchical clustering using Ward's method and Euclidian distance was performed. Then, we used the centroids of the optimum solution as seed for k-means classification in order to improve the results. SPSS (SPSS, Inc. 2010) software was used for clustering analysis.

To identify indicator species of each assemblage, the IndVal method proposed by Dufrêne and Legendre (1997) was used. This asymmetric technique is based on an indicator value index that takes into account the presence or absence of species in a prior partitioning of sites (Legendre & Legendre, 1998). A randomization procedure is used to test the statistical significance of species' indicator values (Dufrêne & Legendre, 1997). Bigirimana et al. (2012) had previously tested this methodology for the study of garden plant biodiversity.

We determined whether the average values for structural variables were significantly different between the clusters using non-parametric Kruskal-Wallis tests in R 3.03 (R Team R.D.C., 2012). This test was chosen due to suspicion that the data did not meet the assumptions of normality and homoscedasticity (Higgins, 2005). When the result was significant, post hoc paired comparisons were performed following Dunn (1964). Chi-square was used to determine the strength of relationships between categorical variables and garden types. In this case, post-hoc test were based on adjusted standardized residuals following the methods proposed by Beasley & Schumacker (1995). Spearman's rank correlation coefficient was used to analyze correlations between non-normally distributed continuous numerical variables.

A stepwise linear regression was run with R 3.0.3 (Team R.D.C., 2012) to assess which socioeconomic and demographic variables were related to relative water needs for the data set as a whole. Thirteen cases were excluded due to missing data. The best model had the lowest Akaike Information Criterion (AIC) value. The variables selected in the vector fitting process were included in this model (Table 6.1). The same transformations were also applied to meet assumptions of normality and homoscedasticity. No dummy transformations were applied to ordinal categorical variables in this case.

Data from 97 surveyed households (those providing information from their water bills) were used to calculate the rank order correlation between LWR and domestic water consumption during the hottest season (third trimester of 2012).

6.4 RESULTS

A total of 635 species and genera were recorded from the 258 gardens. The most abundant taxa were *Rosa* spp. (151), *Olea europaea* (118), *Euonymus japonicus* (114), *Citrus limon* (112) and *Phoneix canariensis* (108). Out of the 133 families, those with the highest number of taxa were Asteraceae (8.18%), Poaceae (4.56%), Rosaceae (4.25%), Cactaceae (3.93%) and Lamiaceae (3.93%). More than a half of the species were trees or shrubs (phanerophytes 40.72%, chamaephytes 21.70%). Hemicryptophytes constituted 14.31% of all species, therophytes 14.15%, geophytes 8.18% and epiphytes 0.94%. Eighty-two percent of the taxa were ornamental, 15% were weeds, 11% were grown for edible purposes and 1% for other reasons.

The mean outdoor area of all surveyed plots was 296.5 m^2. The vegetated part of the outdoor area occupied, on average, 46.6% of this surface. Lawn covered an average of 57.4% of the vegetated area and trees, shrubs and flowers 26.1% (Table 6.1). Four assemblages were described as semi-natural garden, vegetable garden, lawn garden and ornamental garden (Table 6.2).

The semi-natural garden (n=57) had the biggest mean garden area of all groups (186 m^2). It mainly consisted of volunteer species (59%) and the most representative life forms were phanerophytes (38%) and hemicryptophytes (24%). Few of the characteristic species require watering for survival in the Catalonian climate. The proportion of spontaneous vegetation was the highest of all groups (Kruskal-Wallis H=41.50; df =3; $p<0.01$).

Table 6.1: LWR, garden surfaces and socioeconomic variables describing each category of gardens of Catalonia: Semi-natural gardens (S), vegetable gardens (V), lawn gardens (L) and ornamental gardens (O) (mean ± sd.) found in Catalonia. Kruskal–Wallis tests were performed and different letters indicate significant differences (*p*<0.05) between classes.

Variables	**S**	**V**	**L**	**O**	**Test statistic and significance**
Garden features and surfaces					
LWR (mm per day)	8295^{a} ± 2238	5669^{b} ± 768	$8802^{a,b}$ ± 1371	$5513^{a,b}$ ± 894	Kruskal-Wallis H=8.552 (p<0.05)
Outdoor area (m^2)	362^{a} ± 213	209^{b} ± 154	338^{a} ± 342	293^{a} ± 174	Kruskal-Wallis H=27.589 (p<0.01)
Outdoor area dedicated to (%):					
Trees, bushes and flowers	26 ± 16	24 ± 14	21 ± 14	27 ± 16	Kruskal-Wallis H=5.438 (p≥0.1)
Pavement and other artificial surfaces	47^{a} ± 20	$50^{a.b}$ ± 23	$55^{a.b}$ ± 24	59^{b} ± 19	Kruskal-Wallis H=12.659 (p<0.01)
Vegetable garden	0.3^{a} ± 1.2	4.7^{b} ± 8.4	1.2^{a} ± 4.9	0.1^{a} ± 0.5	Kruskal-Wallis H=46.666 (p<0.01)
Lawn	5^{a} ± 11	6^{a} ± 14	12^{b} ± 18	4^{a} ± 10	Kruskal-Wallis H=15.192 (p<0.01)
Synthetic lawn	0.5 ± 2.5	1.0 ± 4.3	1.0 ± 5.6	2.1 ± 8.5	Kruskal-Wallis H=1.415 (p<0.1)
Spontaneous vegetation	18^{a} ± 20	$12^{a.b}$ ± 21	$4^{b.c}$ ± 13	1^{c} ± 6	Kruskal-Wallis H=41.498 (p<0.01)
Swimming pool	$4^{a,b}$ ± 4	3^{a} ± 5	5^{b} ± 6	6^{b} ± 6	Kruskal-Wallis H=15.096 (p<0.01)
Presence of mulching (%)	29.8	20.9	37.3	25.3	Chi-square=4.569 (p≥0.1)
Socioeconomic, demographic and housing characteristics					
Age of the building	29.4^{a} ± 11.1	22.0^{b} ± 11.5	22.9^{b} ± 11.9	30.2^{a} ± 10.1	Kruskal-Wallis H=25.688 (p<0.01)
Secondary residences (%)	40.4	11.9	39.0	68.0	Chi-square=46.197 (p<0.01)
Number of residents	2.2 ± 1.0	2.5 ± 0.9	2.6 ± 1.2	2.1 ± 0.7	Kruskal-Wallis H=13.195 (p<0.01)

Average age of family members	$57.8^{a} \pm 19.6$	$54.5^{b} \pm 17.9$	$51.8^{b} \pm 19.8$	$64.3^{c} \pm 14.2$	Kruskal-Wallis H=17.325 ($p<0.01$)
Non-working members (%)	$63.4^{a} \pm 44.6$	$44.6^{b} \pm 43.9$	$51.7^{b} \pm 46.0$	$80.8^{c} \pm 37.3$	Kruskal-Wallis H=26.549 ($p<0.01$)
Place of birth (%)					Chi-square=68.331 ($p<0.01$)
Catalonia	17.5	34.3	32.2	16.0	
Rest of Spain	10.5	44.8	28.8	4.0	
Rest of the world	71.9	20.9	39.0	80.0	
Income level (m€/year; %)					Chi-square=25.290 ($p<0.01$)
Low (less than 18)	46.5	39.0	25.5	24.0	
Medium (between 18 and 42)	37.2	55.9	43.1	36.0	
High (more than 42)	16.3	5.1	31.4	40.0	
Occupancy rate of the house (Months per year; %)					Chi-square=45.287 ($p<0.01$)
Low (LOR; less than 4)	16.1	3.0	20.3	23.0	
Medium (MOR; between 4 and 8)	23.2	7.5	15.3	40.5	
High (HOR; more than 8)	60.7	89.6	64.4	36.5	
Years since living in the house (%)					Chi-square=5.948 ($p\geq0.1$)
Less than 4	12.5	11.9	8.6	12.3	
Between 4 and 15	44.6	53.7	50.0	35.6	
More than 15	42.9	34.3	41.4	52.1	
Level of education (%)					Chi-square=23.765 ($p<0.01$)
First grade: Primary school. or less	21.1	47.8	37.9	16.7	
Second grade: Secondary and/or technical school	50.9	32.8	32.8	41.7	
Third grade: university degree or higher	28.1	19.4	29.3	41.7	

Vegetable gardens (n=67) had the lowest yard surface with a mean size of 108 m^2 although mean number of species per garden was the highest (37.85). The proportion of yard cultivated as vegetable garden was significantly different between this cluster and clusters 1 and 4 (Kruskal Wallis H=46.67; df=3; $p<0.01$). The percentage of edible plants was the highest of all groups and account for 25% of all species in the cluster. However, ornamental plants (45%) and weeds (25%) had more species than edible plants in this group. The vegetables and some ornamentals required supplementary water.

Lawn gardens (n=59) were characterized by 9 taxa cultivated for ornamental purposes. Mean garden size was 164 m^2 and 24% of this surface was occupied by lawn, the highest percentage within all assemblages. Predominant lawn taxa were *Festuca arundinacea*, *Lolium perenne* and *Poa pratensis*, all them considered as cold season grasses (Costello et al., 2000). Other characteristic plants were trees such as *Olea europaea* and *Citrus limon*, or plants used for hedges, such as *Cupressocyparis* × *leylandii*.

Ornamental gardens (n=75) had a mean size of 109 m^2. All characteristic plants included in this category were cultivated as ornamentals and were mainly trees and shrubs. Both the percentages of garden area occupied by synthetic lawn and pool were the highest of all groups. A large proportion of characteristic species (61%) had very low or low water requirements while almost one third (31%) had moderate water needs.

Table 6.2: Characteristic species of the gardens of Catalonia sorted by their IV values and the four assemblages. For each taxa, table shows life form: phanerophytes (Ph), chamaephytes (Ch), terophytes (Th), geophytes (G) and hemicrytophytes (H); most common uses: ornamental (Or), edible (Ed), medicinal (Me) and weeds (We); native distribution (X) and water requirement (k_s): none (empty), very low (VL), low (L), moderate (M), high (H), warm season grass (WG; k_s=0.6), cold season grass (CG; k_s =0.8), missing in the WUCOLS list (/).

	IV	LF	Use	Native	k_s
Characteristic species of the semi-natural garden (W)					
Euonymus japonicus Wall.	28.79	Ph	Or		L
Pittosporum tobira [Dryand.]	24.57	Ph	Or		L
Phoenix canariensis Hort. Ex Chabaud	22.32	Ph	Or		L
Conyza spp.	20.25	Th	We		
Sonchus oleraceus L.	19.92	Th	We	X	

Dactylis glomerata L.	17.65	H	We	X	
Equisetum ramosissimum Desf.	17.43	Ph	We	X	
Bellis perennis L.	15.23	H	We	X	
Hordeum murinum L.	14.56	H	We	X	
Hibiscus syriacus L.	14.22	Ph	Or		L
Euphorbia helioscopia L.	13.54	Th	We	X	
Bromus diandrus Roth	13.09	Th	We	X	
Cynodon dactylon (L.) Pers.	12.44	H	Or	X	WG
Taraxacum officinale F.H.Wigg.	12.24	H	We	X	
Thuja orientalis L.	11.13	Ph	Or		M
Anagallis arvensis L.	10.76	Th	We	X	
Abelia × grandiflora (Rovelli ex André) Rehder	8.81	Ph	Or		M
Cerastium glomeratum Thuill.	8.67	Th	We	X	
Sonchus tenerrimus L.	8.66	Th	We	X	
Medicago lupulina L.	8.4	H	We	X	
Sagina apetala Ard.	8.15	Th	We	X	
Oryzopsis miliacea (L.) Beck	7.5	Ch	We	X	
Phyllostachys aurea Riviere & C.Riviere	7.24	Ph	Or		L
Plantago lagopus L.	7.02	Th	We	X	
Plantago lanceolata L.	6.97	H	We	X	
Cortaderia selloana Asch. & Graebn.	6.93	H	Or		VL
Elaeagnus × ebbingei Door.	6.89	Ph	Or		L
Picris echioides L.	6.67	Th	We	X	
Chenopodium spp.	6.64	Th	We	X	
Spiraea japonica L.f.	4.1	Ph	Or		M
Cedrus deodara (D. Don) G.Don.	3.51	Ph	Or		L
Ricinus communis L.	3.51	Ph	Or		/
Rubus ulmifolius Schott	3.51	Ph	We	X	
Spathiphyllum spp.	3.51	Ch	Or		/
Characteristic species of the vegetable garden (V)					
Allium cepa L.	35.82	G	Ed		H
Poa annua L.	27.85	Th	We	X	
Mentha spp.	26.98	H	Me	X	L
Oxalis corniculata L.	25.32	Th	We	X	
Zantedeschia aethiopica (L.) Spreng.	22.13	G	Or		M
Aloe vera (L) Burm.f.	16.99	Ph	Me		L
Sedum palmeri S.Watson	16.93	Ch	Or		L
Narcissus spp.	16.77	G	Or		VL
Solanum lycopersicum L.	16.43	Th	Ed		H
Petroselinum crispum (Mill.) Nyman	15.55	H	Ed		H
Allium spp.	15.37	G	We	X	
Iris spp.	14.31	G	Or		M
Fragaria vesca L.	14.29	Ch	Ed		M
Plectranthus australis R.Br.	13.86	Ch	Or		M
Echeveria spp.	12.79	Ch	Or		L
Hatiora gaertneri (Regel) Barthlott	12.67	Ch	Or		L

Cyclamen persicum Mill.	12.21	G	Or		L
Ophiopogon japonicus (L.f.) Ker Gawl	11.94	G	Or		M
Nephrolepis cordifolia (L.) C.Presl.	11.52	G	Or		M
Dianthus spp.	11.43	Ch	Or		M
Veronica persica Poir.	11.42	Th	We	X	
Aloysia tryphilla Britton	10.73	Ph	Me		L
Schefflera arboricola Hayata	10.15	Ph	Or		/
Clivia miniata (Lindl.) Bosse	10.12	Ch	Or		M
Hemerocallis spp.	10	G	Or		M
Stellaria media Cirillo	9.88	Th	We	X	
Lactuca sativa L.	9.05	Ch	Ed		H
Lotus corniculatus L.	8.92	H	We	X	
Silene pseudoatocion Desf.	8.56	Th	Or		M
Foeniculum vulgare Mill.	8.47	Ch	We	X	
Cardamine hirsuta L.	8.29	Th	We	X	
Crepis biennis (L.) Babc.	8.17	Th	We	X	
Calendula officinalis L.	7.84	Ch	Or		/
Trifolium spp.	7.69	H	We	X	
Brassica oleracea L.	7.49	Ch	Ed		H
Cucumis sativus L.	7.46	Th	Ed		H
Capsicum annuum L.	7.22	Th	Ed		H
Tradescantia fluminensis Vell.	7.17	Ch	Or		M
Mammillaria spp.	6.74	H	Or		L
Cucurbita pepo L.	6.66	Th	Ed		H
Daucus carota L.	6.25	G	Ed	X	H
Allium sativum L.	6.08	G	Ed		H
Tulipa spp.	6.08	G	Or		/
Galium aparine L.	6.04	Th	We	X	
Beta vulgaris L.	5.97	H	Ed	X	H
Justicia brandegeeana Wassh. & L.B.Sm.	5.97	Ph	Or		M
Parthenocissus quinquefolia (L.) Planch.	5.97	Ph	Or		M
Capsella bursa-pastoris (L.) Medik.	5.1	Th	We	X	
Medicago sativa L.	4.61	H	We	X	
Solanum melongea L.	4.61	Ch	Ed		H
Liriope muscari L.H.Bailey.	4.48	G	Or		M
Matricaria recutita L.	4.48	Th	Or	X	
Paeonia suffruticosa Andrews	4.48	G	Or		M
Characteristic species of the lawn garden (L)					
Olea europaea L.	29.61	Ph	Or	X	VL
Cycas revoluta Thunb.	21.62	Ph	Or		M
Citrus limon (L.) Osbeck	20.1	Ph	Or		M
Festuca arundinacea	19.93	H	Or	X	CG
Lolium perenne L.	15.39	H	Or	X	CG
Buxus sempervirens L.	12.49	Ph	Or		M
Poa pratensis L.	9.23	H	Or	X	CG
Ilex aquifolium L.	7.71	Ph	Or		L

Cupressucyparis × leylandii (A.B.Jacks. & Dallim.) Dallim.	6.49	Ph	Or		M
Characteristic species of the ornamental garden (O)					
Nerium oleander L.	31.67	Ph	Or	X	L
Osteospermum spp.	30.8	Ch	Or		L
Lantana camara L.	22.11	Ph	Or		L
Petunia spp.	20.93	Th	Or		/
Callistemon citrinus (Curtis) Skeels	19.56	Ph	Or		L
Bougainvillea spp.	19.41	Ph	Or		L
Lampranthus spp.	17.79	H	Or		L
Aeonium arboreum Webb & Berthel.	17.48	Ch	Or		L
Crassula spp.	17.03	Th	Or		L
Carpobrotus spp.	16.74	Ch	Or		L
Yucca guatemalensis Baker.	16.45	Ph	Or		VL
Agapanthus praecox Willd.	15.45	G	Or		M
Chamaerops humilis L.	15.18	Ph	Or		L
Hibiscus rosa-sinensis L.	15.1	Ph	Or		M
Chrysanthemum spp.	14.49	Th	Or		M
Aloe arborescens Mill.	14.27	Ph	Or		L
Gazania spp.	14.21	Ch	Or		M
Aptenia cordifolia (L.f.) Schwantes	13.79	Ch	Or		L
Plumbago auriculata Lam.	13.64	Ph	Or		L
Euryops pectinatus Cass.	13.37	Ph	Or		L
Mandevilla laxa (Ruiz & Pav.) Woodson	13.3	Ph	Or		M
Agave americana L.	12.97	H	Or		VL
Lantana montevidensis (Spreng.) Briq.	12.6	Ch	Or		L
Chlorophytum comosum (Thunb.) Jacques	11.42	H	Or		L
Mirabilis jalapa L.	10.98	G	Or		VL
Lobelia erinus L.	10.67	Th	Or		H
Opuntia ficus-indica (L.) Mill.	9.21	Ph	Or		VL
Tagetes spp.	8.72	Th	Or		M
Platycodon grandiflorus A.DC.	8.51	H	Or		M
Lilium spp.	8.31	G	Or		M
Solanum jasminoides Paxton	7.34	Ph	Or		M
Tradescantia pallida (Rose) D.R.Hunt	6.78	Ch	Or		M
Cotoneaster lacteus W.W.Sm.	6.16	Ph	Or		L
Cercis siliquastrum L.	5.72	Ph	Or		M
Calendula arvensis L.	4.17	Th	Or	X	/
Kalanchoe laxiflora Baker	4	Ch	Or		L

The proportion of outdoor area occupied by pool was significantly lower in the vegetable gardens in comparison with lawn and ornamental gardens (Kruskal Wallis H=15.10; df=3; p<0.01). Furthermore, lawn and ornamental gardens have a greater proportion of paved area (almost 60% of the overall outdoor surface) than the other garden types. Mulching was present in all groups but was especially important in lawn (37%) and semi-natural (30%) gardens.

Mean values of LWR were highest for lawn gardens and least for ornamental gardens (Table 6.1). Over 50% of the households were occupied by foreign residents (Table 6.1), mostly from France and Germany. Eighty percent of the owners of ornamental gardens were born abroad. For 68 % of the ornamental garden owners the house in Catalonia was a second residence. Most of the owners of ornamental gardens were not currently working (80.8%), mostly because they were retired. Vegetable gardens tended to be owned by those of Spanish or Catalonian origin. In this group, just 5.1% of the owners had high incomes, although the lowest income levels were associated with semi-natural gardens.

The highest percentages of properties with high occupancy rates fell in the vegetable garden (89.6%) and semi-natural garden (60.7%) categories. In contrast, almost 25% of the houses in the ornamental garden category were occupied less than 4 months per year. Almost half of the houses had been occupied by the current householders for a period of time between 4 and 15 years, with little variation between garden categories. The well-educated tended to have ornamental gardens, while the less well-educated tended to have either vegetable or lawn gardens.

The NMDS ordination (Figure 6.2) shows taxonomic dissimilarity being most strongly related to high occupancy rates (HO; R^2=0.29), non-Spanish residents (BW; R^2=0.23), Spanish residents (BS; R^2=0.18), high incomes (HI; R^2=0.17) and the percentage of non-working household members (NW; R^2=0.16) (p<0.001). To a lesser extent it is also related to the age of the building (AB), low occupancy rates (LO), the number of residents (NR), primary education (PE) and low incomes (LI). No significant correlation was found between plant species composition and the duration of occupancy or higher education.

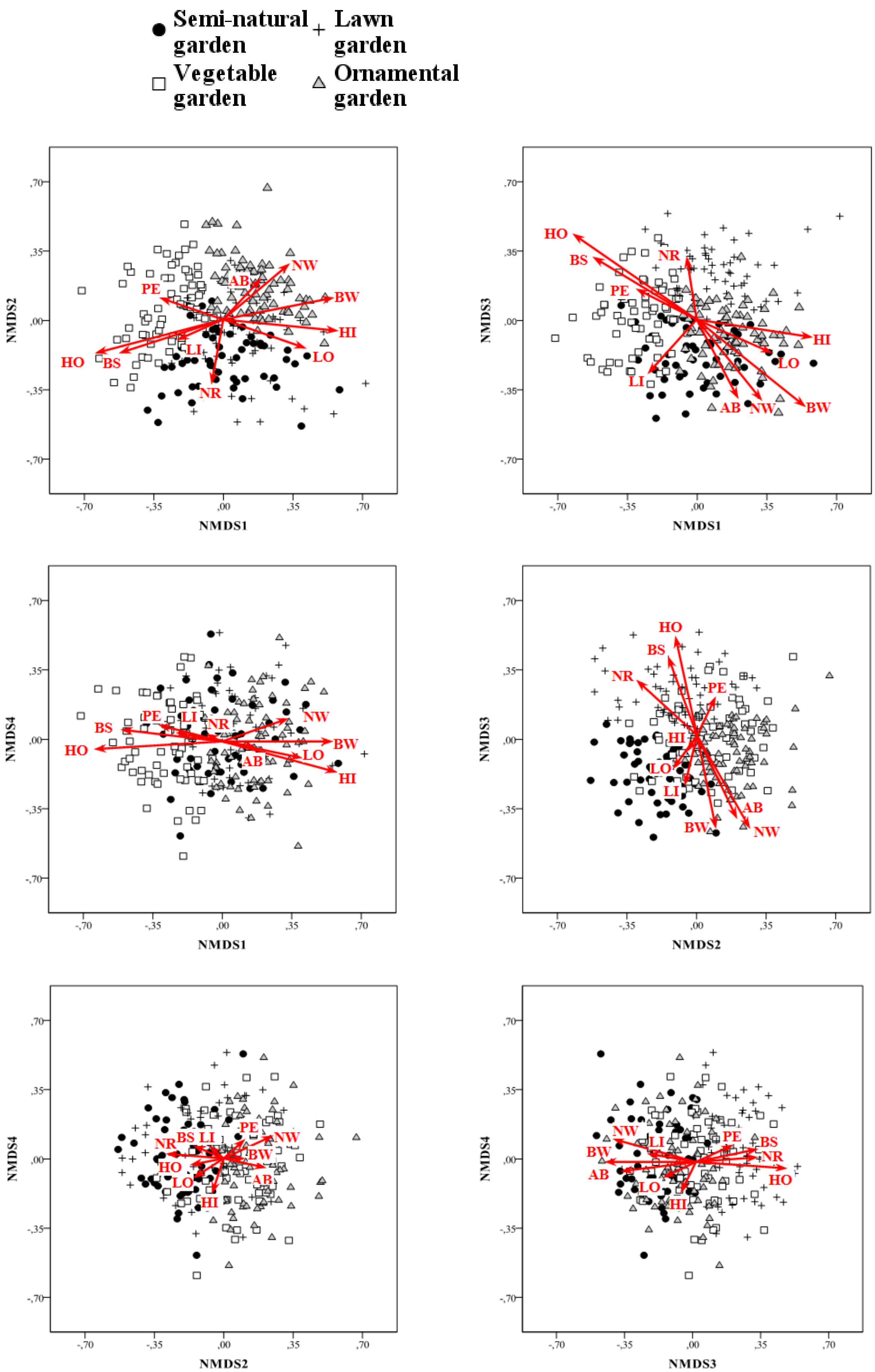

Semi-natural garden
Lawn garden
Vegetable garden
Ornamental garden
NMDS1
NMDS2
NMDS3
NMDS4
HO
BS
PE
LI
NR
AB
NW
BW
HI
LO

Figure 6.2: Result of the Non-Metric Multidimensional Scaling (NMDS) for the flora of 258 inventoried gardens in the Mediterranean coast of Catalonia (Stress=0.18; if stress>0.2 provides a satisfactory representation in reduced dimensions). Symbols represent each typology of garden according to the legend. Significant (*p*<0.05) socioeconomic cultural and housing gradients are plotted on the ordination as vectors. Arrows have been added to categorical variables for a more understandable representation of the results. Length of the vector is positively related to the strength of the gradient: AB is age of the building, BS refers to Spanish owners, BW is non-Spanish residents HI is high income, HO is high occupancy rates, LI is low incomes, LO is low occupancy rate, PE is primary education, NR is equivalent to the number of residents in the house and NW refers to the percentage of non-working household members.

6.4.1 Predictors of relative water requirements in gardens

The age of the building, the number of residents, the birthplace and the level of education had no effect on the water needs of the garden (Table 6.3). Neither had the occupancy rate of the house nor the duration of occupancy. However, income and the percentage of non-working members of the household had a significant effect, albeit very weak, with a combined R^2 for the two variables of 9.1%.

Table 6.3: Stepwise linear regression effects of socioeconomic and demographic variables on landscape irrigation requirements (R^2=9.1%) in Catalonia ($^{\dagger}p<0.1$, $^{*}p<0.05$, $^{**}p<0.01$). Akaike Information Criterion (AIC)=4378.445.

	LWR			
Variables	**Estimation**	**Std. error**	**t-value**	**P**
Intercept	-12791.91	6213.03	-2.059	0.018*
Percentage of non-working members	51.10	19.49	2.622	0.009**
Income level	3641.69	1190.05	3.060	0.003**
Occupancy rate of the house	2513.18	1303.09	1.929	0.056†
Years since living in the house	2342.04	1243.11	1.884	0.061†

6.4.2 Water supply and irrigation systems

A positive correlation was found between the LWC and summer water bills (Spearman's rho=0.435, $p<0.01$), indicating that garden water use contributed substantially to household water consumption. Eighty-four percent of interviewed residents irrigated their gardens with water from the public network. Water from private wells was used in 7% of all cases, while only 5% used rainwater tanks alone or in combination with water other sources.

Irrigation by hose was by far the most popular system, used by more than 50% of the householders in each group (Figure 6.3). Sprinkler irrigation was the second most used system, except in ornamental gardens, in which watering cans played a strong role. Moreover, the proportion of houses using sprinkler irrigation was significantly higher in lawn gardens (Chi-square=12.156; $p<0.01$) than in other garden types. Drip irrigation was little used (Figure 6.3).

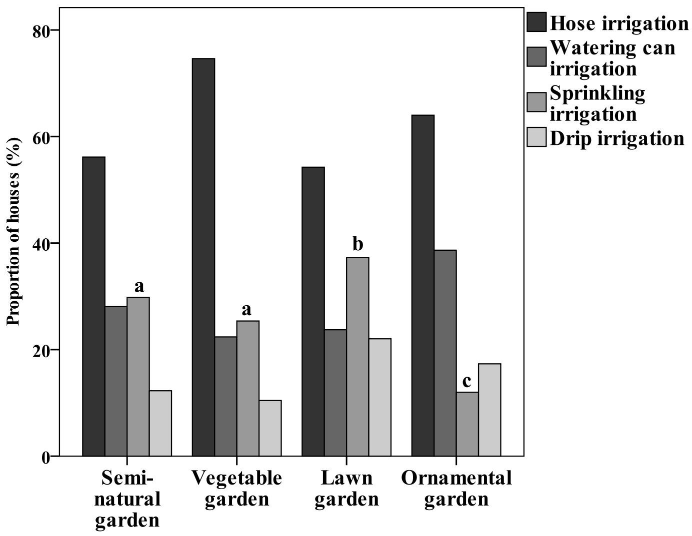


Figure 6.3: Percentage of sampled gardens using distinct irrigation systems according to the four garden categories in Catalonia. Chi-square tests were performed and different letters indicate significant differences (*p*<0.05) among classes.

6.5 DISCUSSION

The high gamma richness of our gardens is not unusual (Smith et al., 2006; Marco et al., 2008; Bigirimana et al., 2012; Van Heezik et al., 2013). Neither is the strong influence of socioeconomic and demographic attributes of garden owners on garden characteristics (Kirkpatrick et al. 2007; Marco et al., 2010a; Lubbe et al., 2010; Bigirimana et al., 2012). The high proportion of holiday or permanent houses for foreign retirees makes our Catalonian suburbs very different in their socioeconomic relationships with gardens than the dormitory suburbs that are the usual object of study (e.g. Smith et al., 2006; Daniels & Kirkpatrick, 2006; Van Heezik et al., 2013).

Our four types of gardens are similar to those discriminated by Garcia et al. (2013a) from other Mediterranean suburbs. The poorly-maintained semi-natural gardens, with their high numbers of volunteer species, are non-tended by non-Spanish permanent residents with low incomes. The permanently resident Spanish on similar incomes tend to create productive vegetable gardens. The rural and cultural background of the household members might be decisive in this choice, which, in a general context of economic crisis, is precautionary. The non-biodiverse lawn gardens have well-tended recreational infrastructure, such as swimming pools. They seem to be the choice of the young and wealthy. The ornamental gardens are well tended but low maintenance, reflecting the annual migratory lifestyle of their typically non-Spanish well off retired owners.

Household income was the best predictor of the tendency to have a water demanding garden because water is expensive. Outdoor water consumption is also positively influenced by income in the U.S. (Osmond & Hardy, 2004; Sovocool et al. 2006; Harlan et al. 2009; Polebitski & Palmer, 2010). There may be a maximum level of income at which water consumption is maintained despite an increase in wealth (Flörke & Alcamo, 2004). Our richer households were more likely to own a garden that required high inputs of water for all other types than the vegetable garden. There is an economic return to the low income household from expenditure on watering vegetables. Nonetheless, vegetable gardens might also be cultivated for cultural and health reasons. The influence of the proportion of the household that does not work on potential water requirements in gardens may reflect the high proportion of well off retired people who occupy their houses only part of the year, and are therefore motivated to have a garden that will survive without watering.

Despite the above logical relationships between potential water requirements as judged by garden composition and income and employment status, the level of explanation from these variables was extremely low, and other socioeconomic and demographic variables did not contribute.

Educational level was not included in our model although this factor was found to be positively associated to income when predicting domestic water savings (Flack & Greenberg, 1987; De Olivier, 1999). A number of studies also showed that education moderated the desirability of mesic and xeric landscapes with contradictory results (Hurd, 2006; Mustafa et al., 2010; Garcia et al., 2013a), indicating that conclusions should be made in geographical, temporal and socio-cultural context.

Overall, our outcome suggests that there might be much attitudinal variation within socioeconomic and demographic classes (Garcia et al., 2013b), and that it is this variation that is directly influencing the nature and water needs of gardens. However, Aitken et al. (1994) suggested that attitudes expressed towards water conservation do not always represent the extent of water consumption. Other factors such as the effect of local policies, the pricing of water, the presence of professional water managers or even the legacy of urban developers, might also shape private landscapes structure and therefore water needs.

6.5.1 Limitations

Equivalences between LWR and real water use must be considered conservative, as empirical studies have showed that actual irrigation behavior in domestic gardens is independent of actual net irrigation requirements (Wentz & Gober, 2007; Endter-Wada et al., 2008; Salvador et al., 2011). Calculations of LWR were performed taking into account all standard conditions and assumptions proposed by the authors (Costello et al., 1994; 2000). Unfortunately, due to the particularities of each garden and a lack of standard methods for estimating parameters, such as irrigation efficiency, deviations from real garden water use must be assumed.

Our study focused on the relevance of socioeconomic, demographic and cultural factors of homeowners on LWR. Other factors omitted in this study, such as residents' gardening motivations, their likely rural background or their socio-professional status, have been previously described as important influences on domestic water use.

6.6 CONCLUSIONS

Our results suggest that there is price elasticity in demand for water among all except householders with vegetable gardens. There is therefore potential for reducing water demand among most of those with higher purchasing power by increasing prices. However, such a price increase would be at the cost of disadvantaging the poorer Spanish who grow their own food. A socially and environmentally more desirable option may be strategic regulation of use. Prohibition of the use of water on lawns during summer months and restriction of other watering to hand held devices in early morning or late evenings are stratagems that have proven effective in conserving water in drought-prone Australian cities. The water-profligate Catalonian lawn gardener may be encouraged to switch their mesic lawn to other lawn types with lower water requirements, or to harden more surfaces. Those with ornamental and semi-natural gardens will be encouraged to shift their species composition more to the xeric end, or to store rainwater to keep their most mesic plants alive. At the least, they will require less water to achieve the same ornamental end, because of reductions in evaporative loss.

If education were to be adopted as the main strategy for Catalonian water conservation, our results suggest that it should be targeted at the wealthier permanent residents with lawn gardens.

CHAPTER 7

FLORISTIC AND STRUCTURAL DIFFERENTIATION BETWEEN GARDENS OF PRIMARY AND SECONDARY RESIDENCES IN THE COSTA BRAVA (CATALONIA, SPAIN)[6]

[6] PADULLÉS, J., VILA, J. & BARRIOCANAL, C. "*Floristic and structural differentiation between gardens of primary and secondary residences in the Costa Brava (Catalonia, Spain)*". Urban Ecosystems (under review).

7.1 ABSTRACT

Urban sprawl along the Mediterranean coast is characterized by single-family houses and domestic gardens. Many new residences are secondary homes for socio-demographically diverse tourists. We explore the differences between the residence types in terms of their garden structures and plant compositions using socioeconomic and legacy attributes. Outdoor areas of 245 primary and secondary homes were investigated to determine plant compositions, land cover and household characteristics. Then, the outdoor land cover was compared between the two residence types. Vector fitting in ordination space assessed the influences of socioeconomic and legacy effects on plant compositions. Finally, generalized linear models (GLMs) assessed the influence of these variables on garden structures. Relevant differences exist in the plant compositions of primary and secondary residences. Furthermore, secondary residences have larger areas of trees, shrubs, flowers and swimming pools, while vegetable gardens are more common at primary residences. Overall, socioeconomic effects appeared to strongly constrain the features of household gardens.

7.2 INTRODUCTION

Over the last few decades, changes in urban growth patterns have been notably intense along the Spanish Mediterranean coast (EEA, 2006). In particular, recent urban development has led to the creation of new suburbs, i.e., urbanization, which is characterized by low-density urban sprawl (Durà, 2003; Martí, 2005; Nel·lo, 2001). The concept of dispersion includes not only settlements physically separated from existing urban areas but also estates located outside of consolidated urban cores (Valdunciel, 2011).

The idea of residential development has its roots in the tradition of the garden-city model developed in Britain and the USA in the early twentieth century, and it emerged as an attempt to synthesize the advantages of the city and the country (Bruegmann, 2005). Historically, in Mediterranean cities, wealthy residents owned summer cottages near the city, in addition to their primary urban residence (Fraguell, 1994). Both traditions emerged in Catalonia in the 1920s and materialized in the construction of the first home-garden projects for the bourgeoisie (Valdunciel, 2011).

At the end of the 1960s, American cities and then European cities began an inexorable trend of decentralizing the population and economic activities and reducing urban densities (Durà, 2003). Many urban functions, in terms of infrastructure, were spread over a more expansive territory; thus, the phenomenon of urbanization and/or city sprawl was initiated (Dematteis, 1998). Berry (1976) empirically confirmed the loss of population in metropolitan areas in favor of bordering regions and noted that there was a structural change in the urbanization process: counter-urbanization. Since the 1980s, several studies noted the same phenomenon in European cities and interpreted it as the expression of a change in the life cycle of urban development, moving from "urbanization" to "de-urbanization" (Cheshire & Hay, 1989; Hall & Hay, 1980; van den Berg et al., 1982).

During this period, the coast of Catalonia (NE Spain) developed a model of mass tourism based on the production of a large number of hotel establishments, holiday resorts and services (Martí & Pintó, 2012). A substantial part of the tourism demand, from overseas and from within the metropolitan region of Barcelona and other large cities nearby, began to show interest in accommodations for secondary residences, i.e., residential tourism.

According to Fraguell (1994), between 1960 and 1970, secondary residences in the Costa Brava increased from 4000 to over 28000. During the 1970s, growth continued; in 1981, approximately 73,300 secondary residences had been established. Over 1996–2001, 1543 single residential houses were built each year; between 2002 and 2008, this number increased to 2400 (CAATEEG, 2014). In 2011, approximately 105,000 secondary residences were established, which was approximately 47% of the total households in the Costa Brava (IDESCAT, 2014). In the first stage of development, housing was located in privileged spaces, such as bays and beaches; however, in later stages, housing increasingly occupied inland areas (Valdunciel, 2001).

The progressive adoption of the dispersed urban model was partially favored by an overall increase in income, a higher dependence on the private automobiles, a strong filtering process by the property market and a lack of planning, which led to socialization of secondary residences (Camagni & Gibelli, 2002). The combination of urban and social phenomena has resulted in notably different demographic and socioeconomic characteristics of the urbanized populations compared with the population living in high-density urban areas (Garcia et al., 2013a). Moreover, houses in low-density residential areas gradually switched from being almost exclusively secondary residences to becoming permanent residences (Catalán et al., 2008).

Sprawl attenuates the levels of over-densification in central districts but also standardizes the landscape and homogenizes urban environments (Catalán et al., 2008; EEA, 2006). Colonialism and globalization have caused widely dispersed cities to have similar cultivated landscapes (Ignatieva & Stewart, 2009), although global biotic homogenization is not fully established (La Sorte et al., 2007).

Specifically, domestic gardens, which may account for a large proportion of suburban areas (Goddard et al., 2009; Loram et al., 2007), reportedly host high levels of plant gamma biodiversity (Daniels & Kirkpatrick, 2006; Lubbe et al., 2010; Smith et al., 2006) and provide valuable ecosystem services (see Cook et al., 2012). At the global scale, few studies have examined floristic similarities among gardens and the factors that shape plant distributions. In this regard, Padullés et al. (2014a) concluded that worldwide gardens (including home gardens and domestic gardens) are significantly different in terms of plant compositions; socioeconomic factors seem to impose stronger constraints than biophysical factors. At the household scale, different demographic, cultural and socioeconomic characteristics of garden owners have been related to plant richness and composition (Bigirimana et al., 2012; Hope et al., 2003; Lubbe et al., 2010). In addition, cognitive factors translated into motivations, attitudes and preferences toward gardening practices may also determine the structure of a household's outdoor space (Kendal et al., 2012a; Larsen & Harlan, 2006; Larson et al., 2009).

This study reports the findings of a survey of households in low-density suburban areas of the Costa Brava in northeastern Catalonia (Spain). The area is favored by owners of second homes and is one of the most popular national and international tourist destinations in the country. The study was designed to (1) expose the socioeconomic and demographic differences in household owners of primary and secondary residences; (2) compare plant richness and compositions of both types of residences; and (3) assess the relative importance of the selected socioeconomic and legacy variables (and their relation with the residence type) on garden plant compositions and outdoor land cover structure. Our hypothesis is that, although low-density suburbs in the study area are heterogeneous in terms of socioeconomic status, the type of residences also determines the garden composition and design. The results may be useful for promoting more environmentally friendly urban landscapes and for directing urban planning policies in the context of the increasing water demand.

7.3 MATERIAL AND METHODS

7.3.1 Study area

The study area comprised low-density suburban developments from 5 municipalities of the Costa Brava (Northeast Catalonia, Spain), which is within 1 km of the Natural Park of the Aiguamolls de l'Empordà (International Union for Conservation of Nature category V). Four of these municipalities (Roses, Castelló d'Empúries, Sant Pere Pescador and l'Escala) are located in coastal areas, while the other (l'Armentera) is located inland (Figure 7.1; Table 7.1). The total population of these municipalities was approximately 45360 in 2013 (IDESCAT, 2014). The entire area is 128 km^2 and is located at an average height of 9.2 m above sea level. The climate is typical Mediterranean, with an average annual temperature of 15 ºC, fluctuating from 30 ºC in the summer to 3 ºC in the winter. The average annual rainfall, which is mainly concentrated in the autumn and spring, is 623 mm (MSC, 2014).

In recent decades, tourism has led to unprecedented development of urban land, mainly for hotels and recreational residences. Within the last 30 years, the total number of houses has doubled, and 68% are now secondary residences (IDESCAT, 2014). Two remarkable residential marinas are found in the area: Santa Margarita and Empuriabrava; the latter is the largest residential marina in Europe. Suburban residents differ significantly in terms of their social background and status compared with those living in the neighborhoods of more compact cities. In particular, a high percentage of suburban residents are non-natives. In Castelló d'Empúries, for instance, 49% of inhabitants in 2011 were foreign, primarily from France and Germany (IDESCAT, 2014).

7.3.2 Sample selection

Using the information contained in the cadastre (DGCE 2012), a layer with all detached, semi-attached and attached single-family houses was obtained. Approximately 6,600 single-family houses were located in the study area. Of this population, a sample of 258 households was randomly selected using the method proposed by Lynch, Hollnsteiner, and Corvar (1974) and the "subset features" tool in ArcGis 10 (ESRI, 2012). Of the 258 surveys, only 245 were used in this analysis due to missing data. A sample size calculation based on a Poisson distribution confirmed that the sample included a representative proportion of the population.

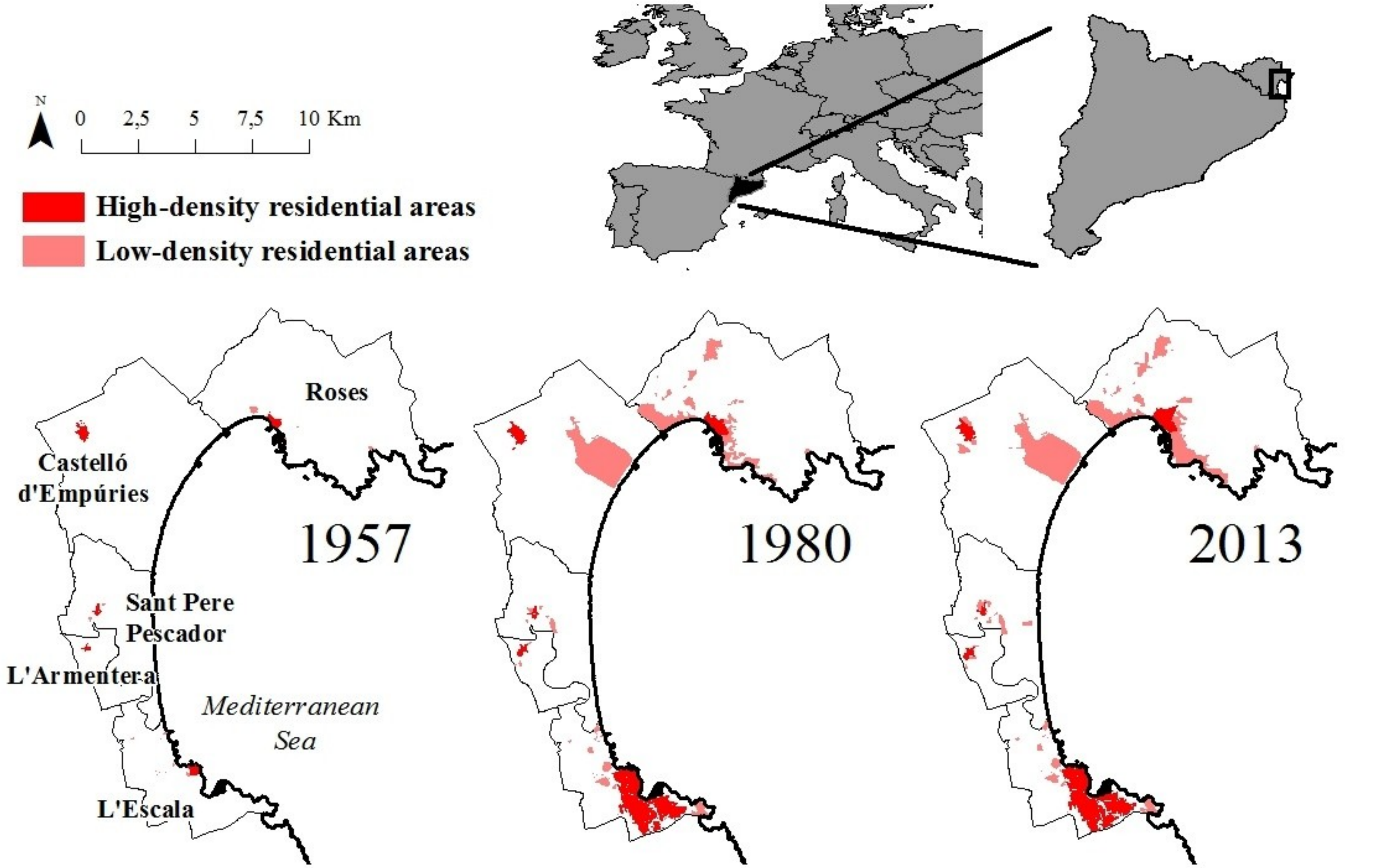


Figure 7.1: Location of the surveyed municipalities and their urban land evolution (1957-2013). Land use data from 1957 and 1980 were obtained from Martí (2012).

Table 7.1: Description of urban municipalities in the Costa Brava.

Municipality	Population (2013)[a]	Area (km^2)[a]	Households (1981)[a]	Households (2011)[a]	Increase in number of households (1981-2011) (%)	Proportion of secondary residences (2011)	Number of households in analysis
L'Escala	10513	16	8008	14994	187	66	3
Castelló d'Empúries	11910	42	6447	16412	255	67	184
Roses	19891	46	11362	25712	226	60	25
L'Armentera	871	6	435	754	173	38	10
Sant Pere Pescador	2175	18	795	1636	206	38	23
Total	45360	128,5	27047	59508	220	63	245

[a]Values for the municipalities include all people, land area and households.

7.3.3 Data collection

In our study, a garden is defined as "an area of enclosed ground, cultivated or not, within the boundaries of an owned or rented dwelling, where plants are grown and other materials are arranged spatially" (Bhatti & Church, 2000, p. 1). To characterize household outdoor surfaces, we used ortho-images with a pixel size of 0.1 m × 0.1 m that were obtained from the Cartographic Institute of Catalonia (ICC, 2013). Each image had been previously corrected. Using ArcGis 10 (ESRI, 2012), the area of the outdoor features was measured. Six polygon layers were created: swimming pool, vegetable garden, spontaneous vegetation, lawn, trees, shrubs and flowers and artificial surfaces (mainly paved areas). All data obtained from this classification were validated in the field.

All plants growing in the 245 private gardens were inventoried, including those in pots and ponds. For turf, a randomly selected plot of 0.5 m^2 for each household was analyzed. For those plants that could not be identified at the species level, the genus was recorded. Scientific nomenclature follows the International Plant Name Index (IPNI, 2013). Native plants were classified following the methods of Bolós et al. (2005). To include secondary residents in the survey and facilitate plant identification, all of the data were collected from May to July 2013.

The questionnaire was organized into three sections: (i) physical characteristics of the dwelling and outside space; (ii) socio-demographic information on household owners; and (iii) a series of questions concerning preferences and/or reasons for gardening. The questionnaire items addressing preferences were designed as Likert-type statements that were rated on a five-point scale ranging from 1 ("completely disagree") to 5 ("completely agree"). Eight items were used to measure the reasons for gardening: "to add aesthetic value to my house" (RG1); "to connect with nature" (RG2); "to have a hobby" (RG3); "to produce food and other household products" (RG4); "to have a place to relax" (RG5); "to perform domestic activities, such as eating and drying clothes" (RG6); "to have an area for recreational and leisure activities" (RG7); and "to add economic value to my house" (RG8). A scale variable could not be calculated due to the lack of internal consistency (Cronbach's alpha=0.01); thus, each item (RG1, RG2, RG3, etc.) was compared with the type of residence independently.

7.3.4 Data analysis

First, we descriptively explored a set of housing and socio-demographic variables regarding the type of residence owned using the nonparametric Mann-Whitney U-test. This test was chosen because the data likely did not meet the assumptions of normality and homoscedasticity (Higgins, 2005). The chi-squared test was used for comparisons among the types of residences with regard to the other discrete variables.

To facilitate interpretation of the results, principal components analysis (PCA) with varimax rotation was conducted with the set of housing and socio-demographic variables (minus the garden size and household size). This step helped identify linear combinations of the original variables. Factors with eigenvalues greater than 1 and items with a load factor above 0.4 formed the basis for interpreting the results (Hair et al., 1999). At the end of the PCA, two factors were extracted from the six original variables, explaining approximately 56% of the variance (Table 7.2). The KMO index was 0.52, indicating that a considerable intercorrelation existed among the variables; therefore, a PCA was appropriate. Accordingly, Bartlett's test of sphericity (Chi-square=203.24, df=15, $p<0.01$) confirmed that significant correlations existed among the variables, indicating that the model factor was relevant. Because we aimed to identify which factors better defined each type of residence (based on the average differences between them), a Welch's corrected t-test was conducted. Any significant result regarding the comparison test between the two types of residences indicates that the averages significantly differ. All of the analysis was conducted using SPSS (version 19 for Windows; IBM Corp., Armonk, NY).

The second part of the study sought to elucidate the actual interaction of the residence type and garden structure and composition. The Bray-Curtis coefficient (Bray & Curtis, 1957) was used to compute the compositional dissimilarities between all pairs of gardens according to their plant compositions. This coefficient is known to be robust and effective for community analysis (Faith et al., 1987). The dissimilarity matrix was constructed in one to four dimensions using nonmetric multidimensional scaling (NMDS) (Kruskal, 1964) with the *vegan* package in R 2.15.2 (Team R.D.C., 2012). A stress value is used to measure the goodness-of-fit of the ordination (>0.2 provides a satisfactory representation in reduced dimensions). Using the *envfit* function, principal components coupled with RG5 and RG6 variables were fitted to the ordination as linear vectors to show the direction of the gradients. The type of residence (primary vs. secondary) was also included in the analysis as a single factor by considering the interactions among the variables.

Table 7.2: Rotated component matrix of principal component analysis (PCA; varimax rotation with Kaiser normalization).

Variable	Components	
	1	2
Age of the building	0.741	
Average age of household	0.840	
Length of residence	0.639	
Level of education		0.685
Birth place		0.691
Income level		0.755

Cluster analysis was conducted to obtain an empirical classification of the different landscapes using the scores of the four dimensions of the ordination as input. Two cluster centroids were used as a seed to perform k-means nonhierarchical clustering. The resulting assemblages were compared, using a Chi-square test, with the type of residence to determine the strength of the relationships between floristic and residential groups.

Indicator plant species of primary and secondary residences were established using the function *multipatt* in the *indicspecies* package in R. This asymmetric technique is based on the indicator value (IndVal) index that accounts for the presence or absence of species in a priori partitioning of sites (Legendre & Legendre, 1998). A randomization procedure is used to test the statistical significance of species' indicator values (Dufrêne & Legendre, 1997). However, by default, the *multipatt* function uses an extension of the original IndVal method because the function looks for indicator species of both individual site groups and combinations of site groups, as explained in De Cáceres et al., (2010).

Generalized linear models (GLM) were used to investigate the relative contribution of each principal component and residence type in relation to the surfaces of each type of outdoor surface, i.e., artificial surfaces, trees, shrubs and flowers, lawns, vegetable gardens, and swimming pools (spontaneous vegetation was excluded from the analysis as it only could be found in four study cases). This method of analysis was chosen because of the non-normal distribution of the five dependent variables. For artificial land cover, trees, shrubs and flowers, a Poisson distribution was chosen. However, the preliminary results returned scaled deviance values, indicating that the Poisson distribution was over-dispersed. To correct for this, the scale parameter was changed to a Pearson Chi-Square, which corrected the overdispersion (Hutcheson & Sofroniou, 1999). This part of the analysis was conducted in SPSS using the GLM analysis tool and a log link function. For the three other land cover types (vegetable garden, lawn and swimming pool), a zero inflated Poisson regression was used due to the large proportion of households without these types of land cover types (Long, 1997). Vuong tests were used to determine the improvement in the zero-inflated models over ordinary Poisson regression models (Vuong, 1989). The *zeroinfl* function in the MASS package in R was used for these tests. The information criterion (AIC) was chosen as the most appropriate strategy for selecting the proper covariance structure (Kincaid, 2005).

7.4 RESULTS

7.4.1 Socioeconomic and demographic characteristics of primary and secondary residences

Table 7.3 shows the average values and frequencies of the different housing, socioeconomic and attitudinal variables according to the type of residence (primary vs. secondary), along with the results of the various statistical tests applied. According to the results, secondary residences included in the analysis are significantly older than the primary residences. Regarding household age, secondary homes were significantly older on average (approximately 65 years) compared with primary homes (53 years). As expected, 83% of the Spanish individuals dwelled in a primary residence, while 62% of the foreign residents owned a secondary home. Regarding income levels, primary residences had a larger number of individuals with medium and low income levels (66% and 75%, respectively) compared with secondary residences (34% and 25%, respectively). Approximately 56% of secondary home owners had higher incomes than primary home owners. A similar trend can be observed regarding the variable "educational level".

Residents of secondary homes appeared to have lived in the study area longer (58% of the total for more than 21 years). Only two of the reasons for owning a garden differed between residence types. Residents of secondary homes preferred to cultivate their gardens to have a place to relax (RG5), while owners of primary residences preferred to use their gardens for domestic activities, such as eating and drying clothes (RG6).

The results from the rotated factor matrix are presented in Table 7.2. Regarding the loadings of each variable, the principal components are interpreted as follows: PC 1 represented 30.23% of the total variance and included the age of the building, the average age of the household and the length of residence (legacy effects). The rotated factor loadings (RFLs) were positive for all variables that provided evidence that positive values of this factor could represent those elderly residents who had invested in buying a second home a long time ago and still live there. PC 2 represented 25.61% of the total variance and combined level of education, birthplace and income level (socioeconomic effects). The positive RFL of all these variables suggested that positive values of this component fit with those of wealthy people who are more highly educated and are mostly born in foreign countries.

Welch's unpaired *T*-Test confirmed that both legacy effects and socioeconomic effects differed between residence types (*T*-test=23.98; $p<0.01$; *T*-test=23.69; $p<0.01$, respectively). All principal components mentioned here were included in the following GLM and vector fitting processes.

Table 7.3: Socio-economic/demographic characteristics and reasons for gardening according to the type of residence.

Socio-economic and demographic characteristics		**Total**	**Primary residences**	**Secondary residences**	**Test statistic and significance**
N	Total number of households in analysis	245	140	105	-
Average age of the building	Years	26.16	23.99	29.28	Mann-Whitney, U=6051.5; p<0.01
Garden size	m^2	138.00	135.90	141.04	Mann-Whitney, U=6930.5; p≥0.05
Average age	Years	57.86	52.83	65.10	Mann-Whitney, U=4863.5; p<0.01
Household size	Number of residents	2.33	2.42	2.19	Mann-Whitney, U=7004.0; p≥0.05
Place of birth	Spain (%)	46.87	82.50	17.50	Chi-square=51.63 (p<0.01)
	Rest of the world (%)	53.13	38.24	61.76	
Income level (m€/year)	Low (less than 18) (%)	26.56	75.00	25.00	Chi-square=21.81 (p<0.01)
	Medium (between 18 and 42) (%)	34.77	66.29	33.71	
	High (more than 42) (%)	38.67	41.41	58.59	
Length of residence (years)	Low (less than 10) (%)	33.20	65.88	34.12	Chi-square=12.42 (p<0.01)
	Medium (between 11 and 20) (%)	38.67	65.66	34.34	
	High (more than 21) (%)	28.12	41.67	58.33	
Level of education	First grade: Primary school or lower (%)	31.25	65.00	35.00	Chi-square=6.10 (p<0.05)
	Second grade: Secondary and/or technical school (%)	39.06	63.00	37.00	
	Third grade: University degree or higher (%)	29.69	47.37	52.63	

Continue in next page

Reasons for gardening					
RG1	Score	4.32	4.31	4.33	Mann-Whitney, *U*=7925.0; $p \geq 0.1$
RG2	Score	3.60	3.49	3.76	Mann-Whitney, *U*=7026.0; $p \geq 0.1$
RG3	Score	2.72	2.74	2.69	Mann-Whitney, *U*=7532.0; $p \geq 0.1$
RG4	Score	1.47	1.52	1.39	Mann-Whitney, *U*=7599.5; $p \geq 0.1$
RG5	Score	4.16	3.79	4.70	Mann-Whitney, *U*=3133.5; $p<0.01$
RG6	Score	3.91	4.07	3.68	Mann-Whitney, *U*=6380.5; $p<0.01$
RG7	Score	3.98	3.97	4.00	Mann-Whitney, *U*=7926.0; $p \geq 0.1$
RG8	Score	1.07	1.04	1.10	Mann-Whitney, *U*=7657.0; $p \geq 0.1$

7.4.2 Plant richness and composition in primary and secondary residences

A total of 630 plant species were recorded in the 245 household gardens included in the analysis. Of these species, 76% were exotic. Figure 7.2 shows the average values for the species groups per plot. Neither the overall plant richness nor the exotic plant richness appeared to be significantly different between the primary and secondary residences. However, the native plant richness is significantly higher in primary residences. Two hypotheses are offered to explain this result: (1) primary residences have more weeds; or (2) primary homeowners have a sense of attachment to their location and likely prefer autochthonous species.

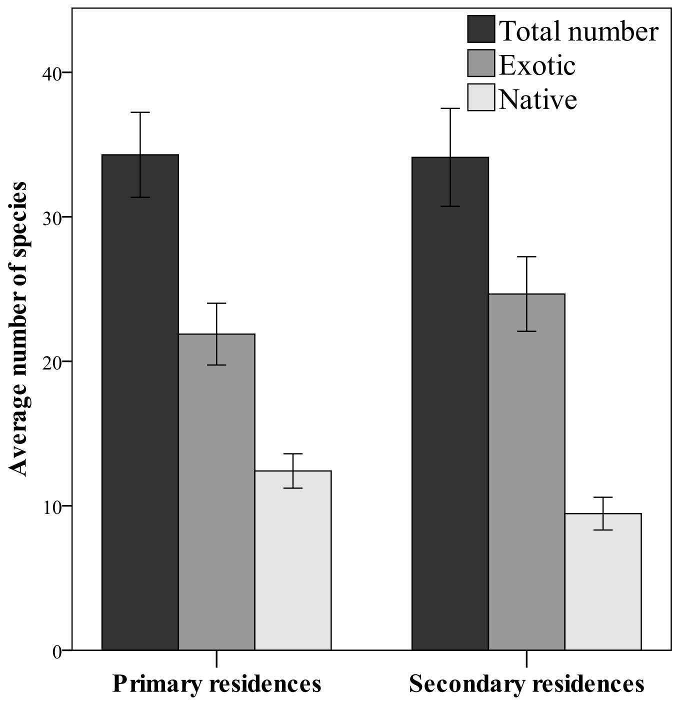


Figure 7.2: Average species numbers and confidence intervals across all plots for native and exotic plant species in the primary and secondary residences of the Costa Brava (Spain). The number of native species is significantly higher in primary residences ($p<0.01$, Mann-Whiney U-Test).

Garden plants are mainly cultivated for ornamental purposes in both primary (74%) and secondary (77%) residences, although a higher proportion of edible plants (9%) and weeds (15%) could be found in primary homes compared with secondary homes (8% and 13%, respectively). Table 7.4 presents the indicator plants of each residence type. Among the characteristic species of primary residences, the presence of weeds, such as *Oxalis corniculata*, *Sonchus oleraceus*, *Euphorbia helioscopia* or *Taraxacum officinale*, and edible species, such as *Prunus avium*, *Lactuca sativa* or *Phaseolus vulgaris*, are highlighted. Moreover, secondary residences are mainly represented by ornamental species, such as *Nerium Oleander*, *Bougainvillea* sp., *Chamaerops humilis* or *Lantana camara.*

The NMDS ordination (Figure 7.3) showed that taxonomic dissimilarity was most strongly related to socioeconomic effects (R^2=24), legacy effects (R^2=18%), the type of residence (R^2=9%) and preferences for gardens as a place of relaxation (R^2=9%). Although no separate clusters were obtained among all of the plots, the association between the two empirical assemblages obtained through the k-means method and the residence types was confirmed (Chi-square=45.98; df=1; p<0.01). These results may suggest that plant compositions would indeed be different between primary and secondary residences.

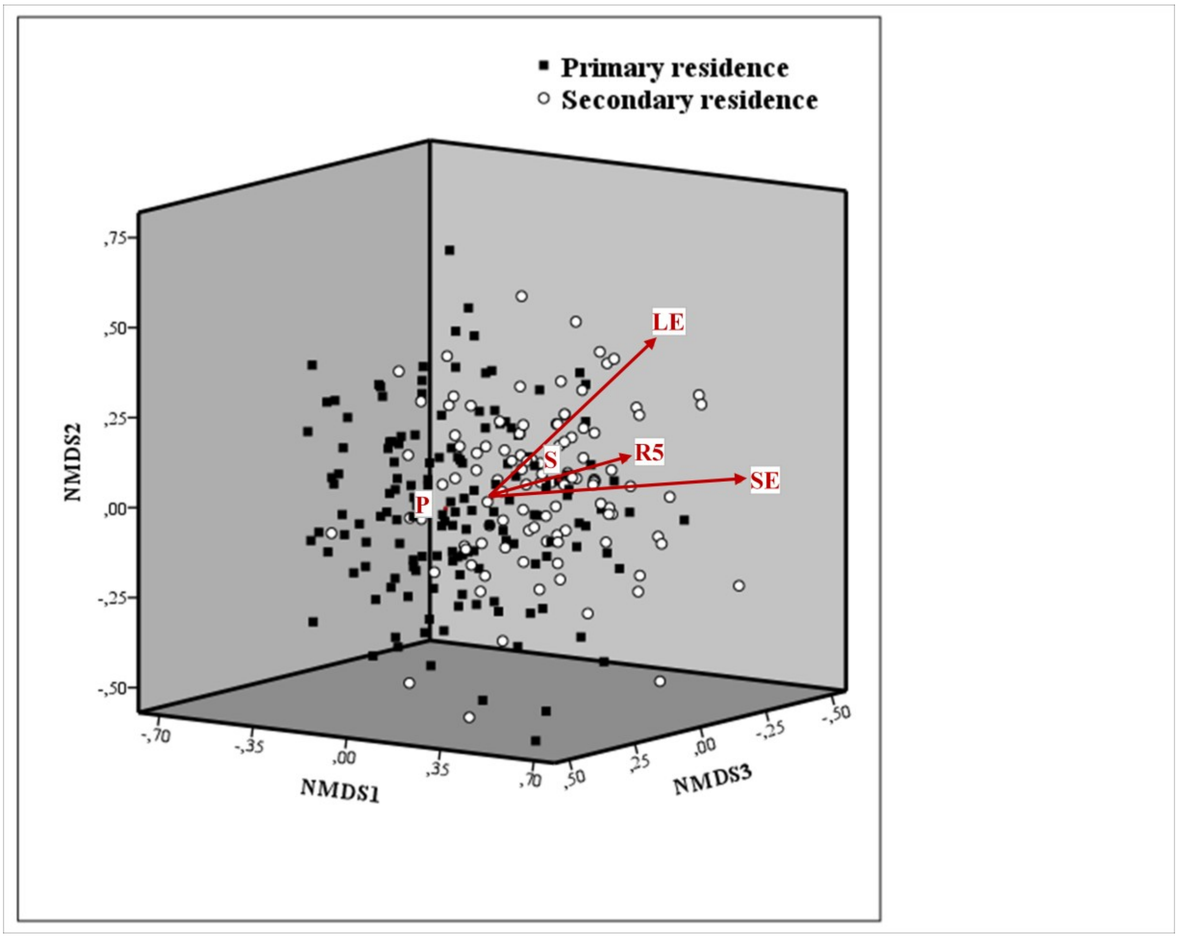


Figure 7.3: A nonmetrical multidimensional scaling analysis (NMDS) ordination plot of the Bray-Curtis distance between each plot (Stress=0.19). The first three dimensions are shown. Each symbol represents one sampled household. Significant (*p*<0.05) variables are fitted on the ordination as vectors showing the directions of the gradient. The length of the vector indicates the strength of the gradient. The factor "type of residence" is also represented. SE is "socioeconomic effects", LE is "legacy effects", R5 is "preferences for gardens to have a place to relax", P is "primary residences" and S refers to "secondary residences".

Table 7.4: Indicator species of primary and secondary residences according to the IndVal method. The observed frequency of each species at each type of residence, the plant use, and immigration status of the plant are presented.

Species name	**Observed frequencies in households (%)**		**Stat.**	***p*-level**	**Type of residence**	**Plant use**	**Immigration status**
	Main	**Secondary**					
Abies alba Mill.	6	1	0.23	0.04	Primary	Ornamental	Native
Agave americana L.	5	17	0.36	0.01	Secondary	Ornamental	Exotic
Allium schoenoprasum L.	9	20	0.37	0.01	Secondary	Edible	Exotic
Alocasia macrorrhizos (L.) G. Don	6	0	0.24	0.01	Primary	Ornamental	Exotic
Aloe juvenna Brandham & S. Carter	0	4	0.20	0.03	Secondary	Ornamental	Exotic
Bougainvillea sp.	19	46	0.57	<0.01	Secondary	Ornamental	Exotic
Capsella bursa-pastoris (L.) Medik.	5	0	0.22	0.05	Primary	Weed	Native
Carpobrotus sp.	5	15	0.34	0.01	Secondary	Ornamental	Exotic
Chamaerops humilis L.	12	31	0.48	<0.01	Secondary	Ornamental	Native
Cotoneaster lacteus W. W. Sm.	3	10	0.28	0.03	Secondary	Ornamental	Exotic
Euphorbia helioscopia L.	25	9	0.43	<0.01	Primary	Weed	Native
Euphorbia pseudocactus A. Berger	0	4	0.20	0.02	Secondary	Ornamental	Exotic
Foeniculum vulgare Mill.	8	1	0.27	0.02	Primary	Weed	Native
Hatiora gaertneri (Regel) Barthlott	13	3	0.33	0.01	Primary	Ornamental	Exotic
Hibiscus rosa-sinensis L.	11	25	0.42	<0.01	Secondary	Ornamental	Exotic
Jacobaea maritima (L.) Pelser & Mejiden	1	9	0.27	0.01	Secondary	Ornamental	Native
Lactuca sativa L.	11	3	0.29	0.03	Primary	Edible	Exotic
Lantana camara L.	13	29	0.45	<0.01	Secondary	Ornamental	Exotic
Lantana montevidensis (Spreng.) Briq.	5	13	0.32	0.02	Secondary	Ornamental	Exotic

Mandevilla laxa (Ruiz & Pav.) Woodson	12	28	0.44	<0.01	Secondary	Ornamental	Exotic
Musa × paradisiaca L.	0	7	0.26	<0.01	Secondary	Ornamental	Exotic
Nerium oleander L.	22	56	0.64	<0.01	Secondary	Ornamental	Exotic
Ocimum basilicum L.	5	14	0.32	0.02	Secondary	Or., Ed.	Exotic
Opuntia ficus-indica (L.) Mill.	5	13	0.31	0.03	Secondary	Ornamental	Exotic
Oxalis corniculata L.	39	12	0.55	<0.01	Primary	Weed	Native
Parietaria judaica L.	11	2	0.31	0.01	Primary	Weed	Native
Phaseolus vulgaris L.	5	0	0.22	0.05	Primary	Edible	Exotic
Plantago lanceolata L.	8	1	0.27	0.02	Primary	Weed	Native
Platycodon grandiflorus A. DC.	5	12	0.29	0.04	Secondary	Ornamental	Exotic
Plumbago auriculata Lam.	6	22	0.42	<0.01	Secondary	Ornamental	Exotic
Prunus avium (L.) L.	17	5	0.36	0.01	Primary	Edible	Native
Pyrus communis L.	5	0	0.22	0.05	Primary	Edible	Exotic
Schefflera arboricola Hayata	17	6	0.36	0.02	Primary	Ornamental	Exotic
Senecio vulgaris L.	6	0	0.24	0.01	Primary	Weed	Native
Sonchus oleraceus L.	33	10	0.51	<0.01	Primary	Weed	Native
Sonchus tenerrimus L.	13	3	0.32	0.01	Primary	Weed	Native
Stellaria media Cirillo	13	4	0.32	0.01	Primary	Weed	Native
Taraxacum officinale F. H. Wigg.	14	5	0.32	0.05	Primary	Weed	Native
Taxus baccata L.	1	7	0.25	0.01	Secondary	Ornamental	Native
Trifolium sp.	13	3	0.32	0.01	Primary	Weed	Native
Yucca guatemalensis Baker.	10	26	0.43	<0.01	Secondary	Ornamental	Exotic

7.4.3 Predictors of outdoor land use areas

Figure 7.4 shows the proportion of the six outdoor land cover types according to the residence type. Outdoor areas of both primary and secondary residences are mainly dominated by artificial surfaces, representing more than half of the total area. Trees, shrubs and flowers also compose a large share of the land cover in both residence types and compose a significantly larger share in secondary homes. In contrast, as expected, the proportion of outdoor area occupied by vegetable gardens appeared to be significantly higher in primary residences. Moreover, swimming pools of secondary homes tended to occupy a significantly larger proportion of the space compared with primary residences.

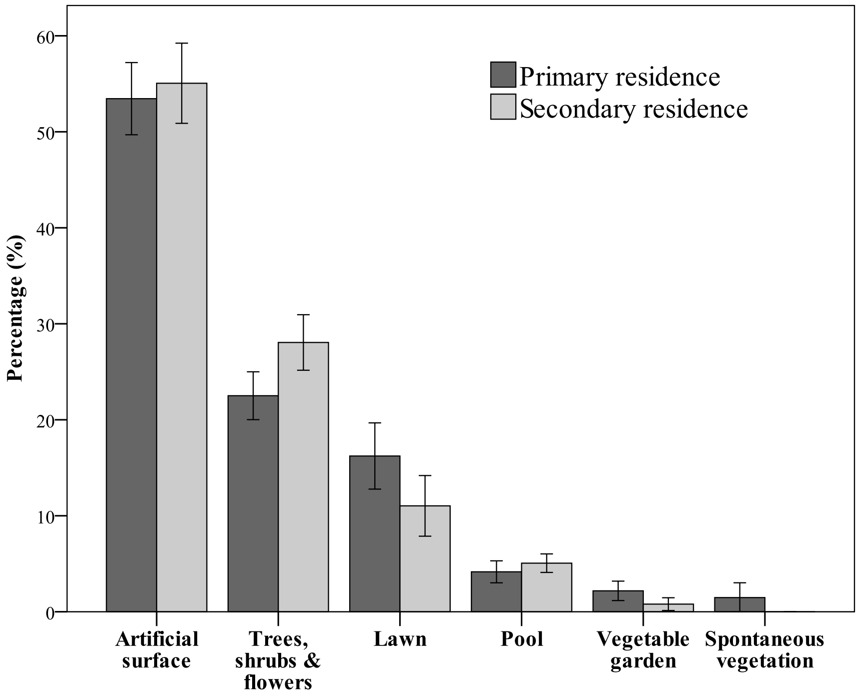


Figure 7.4: Characterization of primary and secondary residences in the Costa Brava (Spain) according to the percentages and confidence intervals of land use of outdoor areas (aggregated). The proportion of outdoor area occupied by trees, shrubs, flowers and pools is significantly higher in secondary residences (*p*<0.05, Mann-Whiney U-Test), whereas the percentage area occupied by vegetable gardens is significantly lower in this typology (*p*<0.05, Mann-Whiney U-Test).

The overall results of the GLM for the five outdoor variables are found in Table 7.5. The omnibus test, which uses a likelihood ratio to test goodness-of-fit, indicated that the models are a good fit for artificial surfaces and areas occupied by trees, shrubs and flowers. For the remaining three variables (vegetable garden, lawn and swimming pool areas), Vuong's test confirmed that the zero-inflated models were superior to the standard Poisson model. Socioeconomic effects had a significant negative influence on vegetable garden areas. Therefore, Spanish residents with low to medium incomes and educational levels owned significantly larger orchards. The opposite was observed with artificial areas, trees, shrubs, flowers and swimming pool areas. Accordingly, secondary residences were more likely to contain a larger swimming pool. The interactions of both types of variables (residence type and socioeconomic and legacy effects) also had a significant effect on two land cover types. Primary residences with positive socioeconomic effects tended to have fewer artificial surfaces, suggesting that upper social classes from foreign countries preferred vegetated gardens. However, primary residences with positive legacy effects had larger swimming pools, which might indicate that older residents that had been living in the same house for a long time were more likely to own a large pool.

Table 7.5: Beta values for housing variables in the GLM analyses. AIC values are also shown.

Parameters		Artificial surface	Trees, shrubs and flowers	Vegetable garden	Lawn	Pool
AIC		15206	17677	1340	13402	1482
Intercept		4.929**	4.278**	1.772	0.194	0.274
Residence type[a]		-0.023	0.066	0.146	0.223	-0.820*
	Legacy effects	0.097	0.245	0.592	0.466	0.756*
	Socioeconomic effects	-0.190**	-0.004	-0.244	0.023	-0.062
Legacy effects		-0.006	0.247	-0.182	-0.248	-0.094
Socioeconomic effects		0.312**	0.220*	-0.589**	-0.245	0.411*

[a]Primary residence is the reference category.
*, ** Significant at p<0.05 and 0.01, respectively.

7.5 DISCUSSION AND CONCLUSION

The difference between primary and secondary homes was examined to determine whether the occupancy characteristics affect household garden structures and plant compositions. The results indicate that differences in the functionality of both residence types have translated into subtle plant differences. Primary homes hosted high native plant richness, suggesting that their residents exhibit stronger place attachment (Hay, 1998). However, the assumption of Misetic (2006) and Stedman (2006) that individuals can develop a strong bond and identification with the location of their secondary or holiday home may be applicable in some circumstances.

The social heterogeneity in suburban developments of the Costa Brava has also generated a mosaic of lifestyles and a variety of gardens. As reported in other private landscape studies, garden characteristics are usually influenced by socioeconomic and demographic attributes of household owners (Acar et al., 2007; Kirkpatrick et al., 2007; Lubbe et al., 2010; Marco et al., 2010b; van Heezik et al., 2013). Along these lines, garden plants in exclusive neighborhoods mainly have an ornamental function, while those in popular neighborhoods have a more utilitarian function (Bigirimana et al., 2012). In our case study, a higher proportion of vegetable garden species and weeds were found in primary residences where the average socioeconomic status is lower. Food security guaranteed through urban and peri-urban agriculture has long been considered a significant component of the livelihood strategies for many households (Bernholt et al., 2009; Thompson et al., 2009). The economic crisis that has plagued the country since 2008 may have favored an increase in these types of species in residential landscapes (Padullés et al., 2014b). Furthermore, due to the return of former members, which supports the trend towards more productive gardens (Garcia et al., 2013a), the real estate crisis may increase the household sizes. Other significant changes derived from economic fluctuations may affect low-density suburban areas in the near future (i.e., a decline in housing construction, a decrease in the arrival of newcomers or the abandonment of suburban spaces).

In terms of garden structure, the comparisons suggested that areas devoted to trees, shrubs, flowers, lawns and swimming pools differ among residence types. Accordingly, Garcia et al. (2013a) reported that secondary residents opposed lawn gardens significantly more often than primary residents in another region of Catalonia (Spain). This finding might be explained by the elevated maintenance required by this type of vegetation throughout the year. Nevertheless, swimming pools were found to be larger in secondary residences, i.e., globally, high water-demanding landscapes may result (Hof & Wolf, 2014).

Based on our results, variations in socioeconomic characteristics of household owners may also change the garden land cover structure. Specifically, higher socioeconomic status, represented here by wealthy residents, mainly foreigners, with elevated educational levels, would have garden areas occupied by more artificial surfaces, trees, shrubs, flowers and swimming pools. In contrast, this group would cultivate few vegetable gardens. In other garden studies conducted in Spain, income has generated contradictory results in terms of preferences for land cover types (Domene & Saurí, 2003; Garcia et al., 2013a). However, this variable is positively correlated with higher plant diversity (Hope et al., 2003; Kinzig et al., 2005; van Heezik et al., 2013). Regarding educational level, Troy et al. (2007) also found this variable to be a good predictor of the proportion of private properties that were actually vegetated. In addition, Garcia et al. (2013a) also concluded that residents with elementary educational levels preferred vegetable gardens in their yards. Nevertheless, private landscapes may become a symbol of social conformity or status, particularly in Anglo-Saxon urban landscaping (Askew & McGuirk, 2004).

Legacy effects were less significant than socioeconomic attributes in both plant composition and garden structure. Secondary residences included in our study were relatively old buildings that have been occupied by the same residents for a long time. Troy et al. (2007) found a strong *legacy* effect with respect to the presence of trees in neighborhoods. In our case, although plant composition was strongly related to a household's legacy, the garden structure was not significantly related to any of the land cover areas. This result contradicts the expected results, i.e., that a significant association exists between legacy effects and the area cultivated for vegetable production. In this regard, we expected that households with higher legacy effects would dedicate their yard to the production of food as a result of the likely rural background of the owners (Head et al., 2004). However, contradictory results may be found in the scientific literature. Preferences for manicured lawn gardens were associated with both older homeowners

(Van den Berg & Van Winsum-Westra, 2010) and households with children (Yabiku et al., 2008). The interactions between residence types and legacy effects suggested that primary homes built long ago and occupied for many years contain significantly larger swimming pools. In the past, real estate companies and the media remarkably contributed to the increased idealization of commercialized yards with pools and grass (Garcia et al., 2013a).

Overall, these results provide the first general perspective on how household outdoor areas are organized in the rather unexplored framework of primary and secondary residences. Floristic and structural characteristics of the gardens of both residential types are a consequence of the functional characteristics provided by the owners in an attempt to improve their quality of life. Differences in outdoor characteristics should be assessed by managers to carefully monitor how suburban residential areas evolve in the future. The socioeconomic and demographic changes taking place in the Mediterranean context will definitely alter the dynamics of these urban landscapes. An integrative approach at the city, urban and suburban scale should be implemented for a better understanding of the role of domestic gardens. Finally, all these issues should be addressed when implementing compulsory municipal urban ordinances that promote more Mediterranean and environmentally friendly private landscapes.

CHAPTER 8

PROPAGULE PRESSURE FROM INVASIVE PLANT SPECIES IN GARDENS IN LOW-DENSITY SUBURBAN AREAS OF THE COSTA BRAVA (SPAIN)[7]

[7] PADULLÉS, J., VILA, J. & BARRIOCANAL, C. "Propagule pressure from invasive plant species in gardens in low-density suburban areas of the Costa Brava (Spain)". *Urban Forestry & Urban Greening* (under second review).

8.1 ABSTRACT

A substantial proportion of the cultivated plants in urban domestic gardens in Europe are exotic species. Among these species, a large number may become invasive, causing negative impacts on natural areas. To prevent this situation, the early detection of invasive species and the assessment of propagule pressure play a key role. In this study, we analyse the flora of 258 domestic gardens in the Costa Brava to explore the importance of these factors in these urban ecosystems. Of the 635 taxa identified, 68% were exotic (77% considering only cultivated plants). Moreover, 39 species were considered potentially invasive in Spain, although only 25 were present within the limits of the adjacent Aiguamolls de l'Empordà Natural Park (AENP). The results from multiple regression models showed that all plant biodiversity parameters (overall plant richness and exotic and native plant richness) were strongly related to the garden area, the occupancy rate of the house and the different socio-economic and cognitive characteristics of the household members. A distance-based redundancy analysis (dbRDA) showed that the invasive species composition was related to the garden area, the age of the building, the income level and the proportion of non-working residents. We also detected that garden centres were by far the most used source of horticultural species, although garden plants were replaced and/or renewed after relatively long periods of time. We conclude that influencing homeowners' preferences by providing more detailed information in garden centres and nurseries may lead to the creation and restructuring of more native and environmentally friendly private landscapes.

8.2 INTRODUCTION

In recent decades, suburban areas of the Mediterranean coast have undergone a process of urban expansion (Durà, 2003; Muñoz, 2003). This process has often resulted in low-density urban developments typical of the Anglo-Saxon sprawling city models (Rueda, 1995). In addition, this lax urban explosion has led to an increase in the number of domestic gardens. To a considerable extent, these spaces have tended to occupy relatively small areas, but their high proliferation, especially in scattered residential areas, has led to the large-scale occupation of urban land (Goddard et al., 2009).

Gamma biodiversity in private gardens is higher than that in the surrounding natural and agricultural habitats (Sax & Gaines, 2003; Kühn et al., 2004; McKinney, 2008). In Spain, Sánchez et al. (2000) proposed a preliminary list of over 11,000 taxa used in horticulture. This number exceeds by far the 8,300 taxa described in the entire native Spanish flora (Blanco, 1988). In terms of this great plant availability, and considering that new species are regularly incorporated into the horticultural offerings, the variety of taxa available to gardeners is very extensive.

A large proportion of the flora of these urban gardens flora is exotic (Dehnen-Schmutz et al., 2007a). Several studies have analysed the percentage of exotic species in garden flora: for example, 88% in the region of Lauris (France) (Marco et al., 2008.), 85% in Bujumbura (Burundi) (Bigirimana et al., 2012) and 75% in Trabzon (Turkey) (Acar et al., 2007). Some of these taxa can escape from gardens and become established independently in the wild (Reichard & White, 2001; Dehnen-Schmutz et al., 2007b; Sanz-Elorza et al., 2009). These plants, if they become invasive, may cause negative impacts on the flora and the fauna of natural areas (Vitousek et al., 1996; Williams, 1997; Ewel et al., 1999).

In this regard, ornamental horticulture, in particular, has been described as one of the main sources of invasive plants in many developed countries (Sanz-Elorza et al., 2004; Dehnen-Schmutz et al., 2007a), and the uncontrolled management of garden waste may act as a highly efficient pathway of dispersion (Batianoff & Franks, 1998; Sullivan et al., 2005). In Germany, it is estimated that 50% of the invasive plants were introduced deliberately, and more than half of these species were ornamental (Kühn & Klotz, 2006). In the Czech Republic, 53% of the flora introduced deliberately also had an ornamental origin (Pyšek et al., 2002), and in Australia, 65% of the plants established between 1971 and 1995 were introduced for horticultural purposes (Groves, 1998). In Spain, Sanz-Elorza et al. (2004) estimated that approximately 12% of the total flora of the country consists of exotic species, and 48% of these exotics had horticulture and gardening as the main causes of primary introduction.

Given the increasing human activity around the world, problems associated with biological invasions are expected to become increasingly severe (Myers et al., 2000). In light of this, a particular region's socio-economic, cultural and cognitive factors are of special interest, especially in regard to the role they play in the dispersion of cultivated invasive species. Elucidating these factors would also be of particular value to understanding the patterns in which potentially invasive species are incorporated into urban and suburban environments. Moreover, the early identification of potentially invasive species can help to protect natural areas and reduce costs in eradication practices (Moles et al., 2008).

To meet this goal, new studies of invasiveness should obtain information regarding the social and cultural characteristics of the human communities in potentially invaded areas (Moles et al., 2008). The influence of individual behaviours and preferences may also be crucial to clarify the patterns by which gardeners choose to plant potentially invasive species. These data could then be used to understand the intensity with which invasive species are introduced (i.e., propagule pressure; Lockwood et al., 2005).

The analysis of the plant diversity patterns in these urban ecosystems requires an interdisciplinary approach involving both natural and social sciences (Parlange, 1998; Grimm et al., 2000; McIntyre et al., 2000; Alberti et al., 2003). Previous research has identified different factors, such as the residents' individual attitudes, the social structure of the household and the urban characteristics, as significant drivers of the plant diversity in urban domestic gardens (see Cook et al., 2012). In addition, the historical and cultural legacy has influenced the composition of current domestic gardens (Faggi & Ignatieva, 2009). This legacy might be detected in the widespread trend that seems to be leading urban green areas towards a globalisation of the urban flora, although the majority of urban plants are native to the world's cities (Aronson et al., 2014).

As a contribution to the study of plant invasion, our paper analyses the flora in domestic gardens surrounding the Aiguamolls de l'Empordà Natural Park (AENP) in the Costa

Brava region (northeastern Catalonia, Spain). In a previous study we determined that gardens in the study area were designed and maintained mainly by homeowners (Padullés et al., 2014a). Therefore, the socio-economic characteristics and household members' reasons for gardening were also collected during the fieldwork, in order to interpret their relationship with garden flora. In another study, Garcia et al. (2013a) described four types of gardens, also in Girona Province. Preferences for these four types of gardens were found to be related to various socio-economic and demographic variables. In the present study, we go one step further and use constrained ordination techniques to determine the influence of socio-economic attributes and cognitive factors on potentially invasive species composition. Specifically, the following questions are answered:

a) What is the proportion of exotic flora in domestic gardens in the Costa Brava?

b) What is the proportion of invasive and potentially invasive garden species that have already at least been naturalised in the adjacent natural areas?

c) What is the association between housing and socio-economic characteristics and the distinct biodiversity parameters and invasive plant distribution in the gardens?

d) What are the sources for obtaining garden plants and the frequency of plant renewal?

8.3 MATERIALS AND METHODS

8.3.1 Study area

The study was conducted in low-density suburban developments in 5 municipalities of the Costa Brava (northeastern Catalonia, Spain; Figure 8.1). The total population in the study area was approximately 45,219 inhabitants in 2013 (IDESCAT, 2014). The area is known as one of the most important tourist destinations of southern Europe (Prat & Cànoves, 2012). Over the last 60 years, tourism has led to an unprecedented development of sprawling and expanding urban areas. In this regard, 68% of all houses are now secondary residences and 38% of the population comes from countries other than Spain (IDESCAT, 2014). These relatively new suburban structures, coupled with social heterogeneity, have resulted in the population presenting remarkably different demographic characteristics.

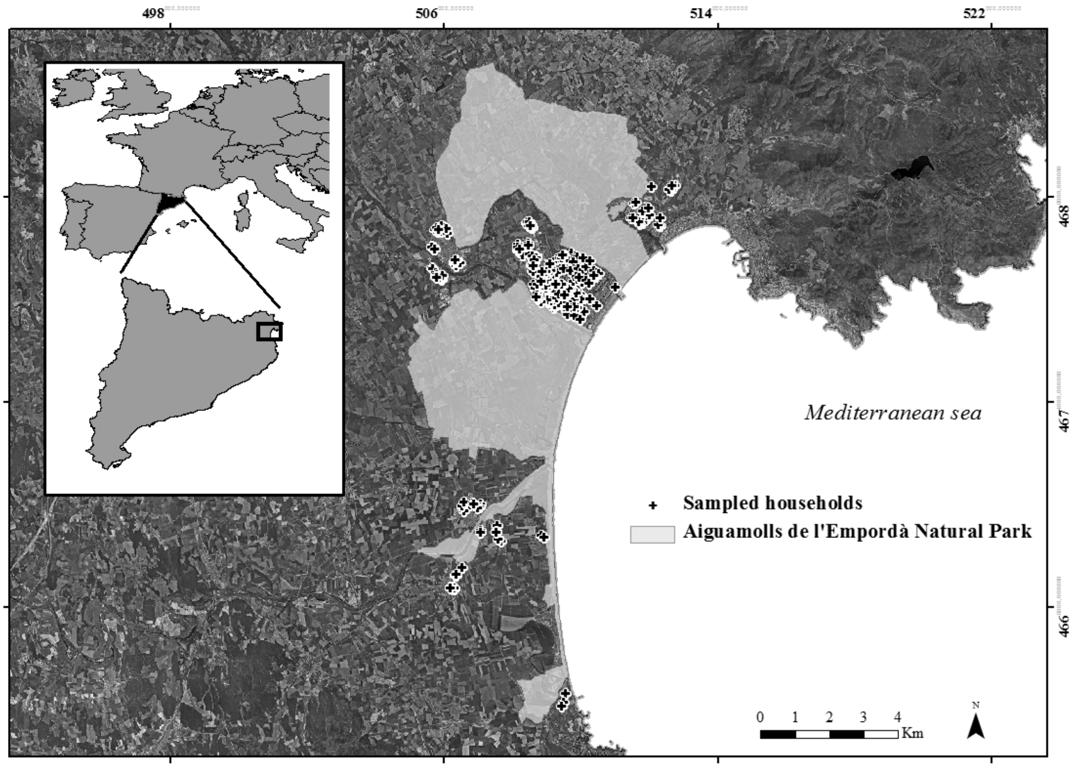


Figure 8.1: The study area showing the Aiguamolls de l'Empordà Natural Park (AENP) and the sampled households.

The region is relatively flat, with an average elevation of 9.2 m a.s.l. The mean annual precipitation is 623 mm, and the mean annual temperature is 15 ºC (MSC, 2014).

All suburban settlements included in the study were located surrounding the Aiguamolls de l'Empordà Natural Park (AENP). This protected area has been established as a category V area in the International Union for Conservation Nature (IUCN) classification. AENP constitutes an important wetland coastal region with many ecological values and offers an excellent opportunity to study interactions between people and nature. Moreover, some of the ecosystems of the park are highly vulnerable to biological invasions (Vilà et al., 2007). As a result, almost 8% of the flora in the park has been introduced, and the control and eradication of invasive plants incur high economic and environmental costs (Gesti, 2000).

8.3.2 Sample selection

The study area contained approximately 60,000 houses. In our study, we included residential areas within 1 km of the AENP, for a total of 6,500 single-unit houses. A layer with all detached, semi-attached and attached single-family houses was obtained using ArcGIS 10 (ESRI, 2012) and the information contained in the cadastre (DGCE, 2012). Following the method of Lynch et al. (1974), we randomly selected a sample of 258 houses using the tool "*subset features*" in ArcGIS 10. Sample-size calculation through the Poisson distribution confirmed that this sample includes a sufficiently large proportion of the population to be representative. When access to a selected house was not possible or in the case of a rented holiday home, the next house situated to the right on the same street was chosen. To include secondary residents and facilitate plant identification, data collection was conducted during the holiday season from May to July in 2013.

8.3.3 Data collection

For the purpose of this study, a garden is defined as an area of enclosed vegetated ground within the boundaries of an owned or rented dwelling. We recorded the composition of plant species from a total of 258 domestic gardens, even those found in containers and ponds. For turf grass, a randomly selected plot of 0.5 m^2 was analysed for each household.

Species were identified according to the specialised literature (e.g., Bellido, 1998; Bolós et al., 2005; Sánchez et al., 2000), and the scientific nomenclature follows "The International Plant Name Index" (2014). While garden plants are often subspecies or cultivars, we did not attempt to classify plants below the species level. For those plants that could not be identified at the species level, the genus was recorded. During the interview held with each household, data were gathered only on cultivated plants that are detectable in the spring. Each species was assigned to one life form in accordance with the Raunkiær (1934) classification: phanerophytes (Ph), chamaephytes (Ch), geophytes (G), therophytes (Th), hemicryptophytes (H) and epiphytes (Ep). Plant uses (ornamental, edible, weeds and others) were recorded by consulting homeowners.

Plants were classified as native or exotic following Bolós et al. (2005). Exotic species are defined as species that are not indigenous to a given geographical unit (in this study, Spain). Some of these exotic plants may spread into the wild, becoming casual species. These species are further qualified as naturalised if their reproduction is sufficient to maintain a stable population. Finally, when naturalised species have the potential to spread over a large area due to the production of abundant reproductive offspring at a considerable distance from sites of introduction, they are considered invasive. Inventoried taxa were classified as potentially invasive following Sanz-Elorza et al. (2004) and Andreu et al. (2012). The presence of exotic plant species in the AENP was obtained from Gesti (2000).

Natural plant distribution follows Sánchez et al. (2000) and Bolós et al. (2005) with the following elements: Africa, Asia, Australia and New Zealand, North America, South America, Europe, Eurasia, Europe, Africa and Asia, Mediterranean (if its range covers only the Mediterranean basin), Cosmopolitan (if its range extends across all or most of the world), Hybrids (cultivar varieties) and Unknown (Un).

A team of two investigators performed all surveys. Whereas the first researcher recorded the plant composition, the second performed face-to-face surveys with the household owners. The survey was designed to obtain information related to (1) the physical characteristics of the house and the garden, (2) socio-demographic information of the whole family and (3) the habits and customs for incorporating plants.

In the second section of the survey, which collected the main socio-demographic information of the whole family, six variables were chosen for analysis: the proportion of non-working members (retired and unemployed members, excluding children), the number of residents, the birthplace, the income level, the occupancy rate of the household and the highest level of education in the household (Table 8.1).

8.3.4 Data analysis

As a preliminary step for the analysis, thirteen households were excluded due to missing data. With the 245 remaining cases, we explored the relative importance of the selected independent variables using multiple regressions in R (Team R.D.C., 2012) against the overall species richness, the exotic plant species richness and the native species plant richness. The independent variables included in the model were garden area, age of the building, number of residents, income level, birth place, proportion of non-working members, occupancy rate of the house, level of education and eight different reasons for gardening. As shown in Table 8.1, the numerical variables were transformed to reduce the skewness and improve the normality of the residuals. The dependent variables were also natural log-transformed. Moreover, whereas discrete categorical variables were coded as dummy, ranked variables were introduced in the models as numerical. Multicollinearity was measured with the Variance Inflation Factor (VIF) using the *vif* function in the *car* package in R.

Due to a small sample size, Akaike's second order Information Criterion (AICc) was used to rank and build the final models (Burnham & Anderson, 2002). All combinations of models were calculated using the "dredge" function in the R package MuMIn (Barton, 2011). The final models were those with the lowest AICc. The relative importance of the regressors was tested using the metric "lmg", which decomposes R^2 into contributions that add up to the total R^2 (function *calc.relimp* in the *relaimpo* package in R; Grömping, 2006).

Spatial autocorrelation could generate an underestimation of error terms and an overestimation of the significance of variables (Legendre, 1993). The existence of spatial autocorrelation was tested by correlating the regression residuals with the distance matrix using Moran's index in all final models (Dormann et al. 2007). As no evidence of spatial autocorrelation was observed ($p \geq 0.05$), spatially weighted regressions were not used in this study.

Table 8.1: Socio-economic and demographic variables and reasons for gardening used in the analysis.

Predictors		
Housing characteristics	**Transformations**	**Mean^z ± SD**
Garden area (m^2)	ln(x)	131.32 ± 150.29
Age of the building (years)	x^2	26.24 ± 11.67
Socio-economic characteristics	**Transformations/categories**	
Non-working members (%)	x^2	61.23 ± 44.74
Number of residents	ln(x)	2.33 ± 0.97
Place of birth	Catalonia	60 (24.51)
	Rest of Spain (reference category)	53 (21.79)
	Rest of the world	132 (53.70)
Income level (m€/year)	Low (less than 18)	65 (26.56)
	Medium (between 18 and 42)	85 (34.56)
	High (more than 42)	95 (38.93)
Occupancy rate of the house per year (months per year)	Low (fewer than 4)	39 (15.95)
	Medium (between 4 and 8)	55 (22.57)
	High (more than 8)	151 (61.48)
Level of education	First level: Primary school or less	78 (31.91)
	Second level: Secondary and/or technical school	94 (38.52)
	Third level: University degree or higher	73 (29.57)

Continue in next page

Reasons for gardening	Semantic distance scores	
To provide aesthetic value to my house (colour, shape, varieties of plants, etc.)	Strongly agree (5), agree (4), undecided/neutral (3), disagree (2), or strongly disagree (1).	4.31 ± 0.93
To have some contact with nature	“	3.59 ± 1.30
To entertain me as a hobby	“	2.72 ± 1.26
To obtain food and other household products	“	1.48 ± 1.04
To have a place to relax (reading, sitting, sunbathing, etc.)	“	4.15 ± 0.91
To engage in domestic activities such as eating, drying clothes, etc.	“	3.90 ± 1.16
To be used for recreational and leisure activities	“	3.98 ± 1.06
To provide higher economic value to my home	“	1.08 ± 0.45

[z]Actual number of households and % in brackets are provided for socio-economic categorical variables.

To analyse the relationships between invasive species composition and household characteristics, a data matrix with the presence/absence of the invasive species in each garden was created. Only species with more than three occurrences were taken into account. Differences in the invasive species distribution among the gardens were analysed by a distance-based redundancy analysis (dbRDA; Bray-Curtis distance) because these variables respond in a linear manner to the changes in the predictor variables (McArdle & Anderson, 2001). The explanatory variables included in the analysis were classified into three groups: housing characteristics (age of the building and garden area), the socio-economic attributes of the residents (place of birth, income level, occupancy rate of the house, level of education, number of residents and proportion of non-working members) and the owners' reasons for gardening (Table 8.1). This part of the analysis was performed with the *vegan* package in R.

8.4 RESULTS

8.4.1 Natural distribution and characteristics of garden flora

The 258 surveyed gardens harboured relatively high plant species richness, with 635 different species identified in a combined area of 35.69 m^2. The mean number of species per garden was 34.03 (±17.81). The majority of species were uncommon, with 69% appearing in less than 5% of the locations sampled. Approximately 68% of all species growing in the investigated gardens were exotic (Appendix 5). This percentage increased to 77% if only cultivated species were considered. The exotic species originated mainly from Asia (28%), South America (26%), Africa (18%) and North America (9%) (Table 8.2). The majority of species (82%) were planted as ornamental, although weeds (15%) and edible plants (11%) were also frequent. More than 60% of the species were either trees or shrubs (mainly phanerophytes and chamaephytes).

Table 8.2: Natural distribution of the 635 plants inventoried in gardens in the Costa Brava.

Natural distribution	Native status^z		Total
	Native	Alien	
Africa	-	76 (18)	76 (12)
Asia	-	119 (28)	119 (19)
Australia & New Zealand	-	22 (5)	22 (3)
North America	1 (0)	41 (9)	42 (7)
South America	-	111 (26)	111 (17)
Europe	41 (20)	10 (2)	51 (8)
Eurasia	62 (31)	11 (3)	73 (11)
Europe, Africa & Asia	26 (13)	1 (0)	27 (4)
Mediterranean	63 (31)	13 (3)	76 (12)
Cosmopolitan	8 (4)	4 (1)	11 (2)
Hybrids	-	25 (6)	25 (4)
Unknown	2 (1)	-	2 (0)
Total	203 (68)	432 (32)	635 (100)

^{z}number of species and %, in brackets.

8.4.2 Factors associated with floristic richness

Different parameters of plant diversity were incorporated as dependent variables in the multiple regressions (Table 8.3). Results from the *vif* function reported no multicollinearity among variables (*vif* values<3). The fit of the model was best for overall species richness (R^2=0.49). This variable, coupled with exotic plant richness, was positively correlated with the garden area, the age of the building, the occupancy rate of the household and the proportion of non-working members. In addition, these variables were related to the homeowners' preferences for gardens that provide contact with nature and entertainment as a hobby. Unexpectedly, exotic plant richness was the only variable positively related to household income, whereas native species were negatively correlated with this variable. Overall species richness was also positively correlated with owners' preferences for gardens that provide aesthetic value to the house. Native species richness was positively correlated with the garden area, high occupancy rates of the house and the homeowners' preferences for having a garden to provide contact with nature. The same variable was negatively correlated with the number of residents and the preferences for gardens that provide aesthetic value to the house. Overall, the preferences for gardens that provide contact with nature were the most important regressors in all models (with the exception of native plant richness), thereby overcoming garden area.

The dbRDA (Figure 8.2) indicated that the first two ordination axes explain 86% of the fitted variation (explained size-related attributes), although they comprise only 5% of the total variation. The garden area, the age of the building, the income level and the proportion of non-working members are the main factors explaining the distribution of invasive species. The first axis (3.5% explained variance, canonical correlation 72.1%) correlates with the proportion of non-working members and the age of the building. The second axis (0.8% explained variance, canonical correlation 13.2%) mainly correlates with the garden area and the overall household income. The potentially invasive species that had high positive scores on the first dbRDA axis included *Lantana camara, Agave americana* and *Opuntia ficus-indica,* and those with high negative scores included *Conyza* sp., *Crepis sancta* and *Cereus peruvianus.* Species that had high positive scores on the second dbRDA axis included *Passiflora caerulea*, *Ipomoea indica* and *Cereus peruvianus,* and those with high negative scores included *Opuntia ficus-indica*, *Gazania* sp. and *Stenotaphrum secundatum*.

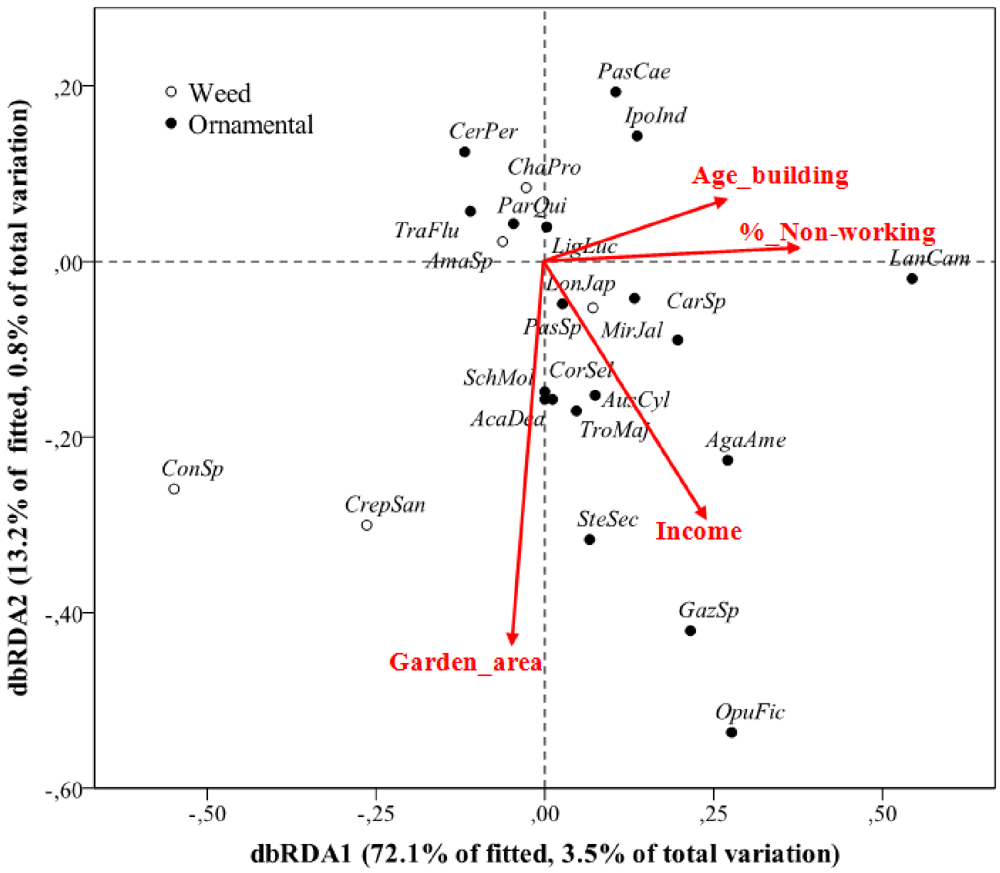


Figure 8.2: Distance-based RDA ordination biplot representing the distribution of potentially invasive plants according to the variables studied. See Table 8.1 for details on variables and other correlates. Plant name abbreviations are as follows: AcaDea (*Acacia dealbata*), AgaAme (*Agave americana*), AmaSp (*Amaranthus* sp.), AusSp (*Austrocylindropuntia* sp.), CarSp (*Carpobrotus* sp.), CerPer (*Cereus peruvianus*), ChaPro (*Chamaesyce prostrata*), CorSel (*Cortaderia selloana*), ConSp (*Conyza* sp.), CreSan (*Crepis sancta*), GazSp (*Gazania* sp.), IpoInd (*Ipomoea indica*), LanCam (*Lantana camara*), LigLuc (*Ligustrum lucidum*), LonJap (*Lonicera japonica*), MirJal (*Mirabilis jalapa*), OpuFic (*Opuntia ficus-indica*), PasCae (*Passiflora caerulea*), ParQui (*Parthenocissus quinquefolia*), PasSp (*Paspalum* sp.), SchMol (*Schinus molle*), SteSec (*Stenotaphrum secundatum*), TraFlu (*Tradescantia fluminensis*), TroMaj (*Tropaeolum majus*).

Table 8.3: Selection results for multiple regression models: parameters of plant species diversity in Costa Brava gardens. Models shown are those with the lowest AICc.

Predictors	Overall species richness		Exotic species richness		Native species richness	
	β-coef.	**RI**	**β-coef.**	**RI**	**β-coef.**	**RI**
Independent housing variables						
Garden area	0.33***	**0.17**	0.24***	**0.11**	0.42***	**0.20**
Age of the building	0.18***	0.04	0.21***	0.06	-	
Independent socio-economic variables						
Household income	-		0.13***	0.01	-0.13***	0.02
Occupancy rate of the house (months/year)	0.17***	0.02	0.12**	0.00	0.21***	0.04
Non-working members (%)	0.10**	0.03	0.15***	0.05	-	
Independent variables of reasons for gardening						
To provide aesthetic value to my house	-0.08*	0.01	-		-0.11**	0.02
To have some contact with nature	0.36***	**0.19**	0.34***	**0.16**	0.28***	**0.12**
To entertain me as a hobby	0.18***	0.06	0.21***	0.06	-	
To engage in domestic activities such as eating, drying clothes, etc.	-		-		0.10**	0.01
AICc	2041.16		1915.57		1603.26	
Adjusted R^2	0.49		0.44		0.41	

For each independent variable, the standardised regression coefficient (β-coefficient), its relative importance (RI) and the significance level (**p*<0.1. ***p*<0.05. ****p*<0.01) are presented. Bold numbers indicate the most important predictors.

8.4.3 Plant source and frequency of change

Homeowners were asked about the main source for obtaining plants for their gardens (Table 8.4). As we expected, garden centres, coupled with nurseries and florists, were the most frequented sources, with 200 of the respondents always buying plants at these establishments. The second most common source of garden plants was gifts from friends and neighbours. Approximately 50 of the respondents indicated they had added plants that were given to them as gifts. Markets and supermarkets accounted for almost the same percentage as gifts from friends and neighbours. Although few homeowners trust in landscaping companies and designers to provide plants for their gardens (16 cases), those who did had not used any other source of species. Other plant sources, such as one's own cuttings or those taken from nature, were also used but in very low frequencies (less than 6 cases).

Table 8.4: Sources for obtaining plants and the periodicity with which they are frequented, as reported by homeowners in residential areas of the Costa Brava. The results are shown in absolute numbers (n=252; six cases were omitted due to missing data).

	Never	Hardly ever	Sometimes	Usually	Always
Garden centre/nursery/florists	29	7	12	4	200
Presents from friends/neighbours	203	1	10	17	21
Market/supermarket	207	6	17	4	18
Landscaping company/designer	236	1	-	-	15
Own cuttings	234	1	6	6	5
Wild, taken from nature	247	2	3	-	-

Half of the respondents always incorporate the same plants, whereas 31% usually incorporate new plants. The remaining 19% of respondents never incorporate plants into their gardens. Table 8.5 shows the frequency with which homeowners add plants to their garden. Understandably, seasonal, annual and perennial plants are the most frequently renewed, with half of the respondents (127 cases) planting them at least once per year.

More than 70% of the owners (178 cases) never, or hardly ever, incorporate new trees, palms and conifers, lawn species, cactuses or succulents. Fruit trees, vegetables, shrubs, vines, and aromatic and culinary species are mostly added (over 44% of all cases) only when replacing dead individuals.

8.4.4 Invasive and potentially invasive plants in the AENP

Thirty-seven exotic species in gardens in the Costa Brava were also present within the limits of the AENP (Appendix 5). Among these, 15 species were casual and 22 have been naturalised. The most abundant ornamental exotic species found in the AENP were *Iris* sp., *Ficus carica*, *Gazania* sp., *Punica granatum*, *Aptenia cordifolia* and *Agave americana*.

Moreover, thirty-nine garden plants were considered as invasive somewhere else in Spain (Sanz-Elorza et al., 2004; Andreu et al., 2012). Out of these, only 25 were found in the AENP (Table 8.6). The invasive species found in high proportions in the sampled gardens were *Lantana camara*, *Passiflora caerulea*, *Austrocylindropuntia* sp., *Tropaeolum majus* and *Stenotaphrum secundatum*.

Table 8.5: Frequency of species incorporation in gardens in the Costa Brava, classified by plant type and reported by homeowners. The results are shown in absolute numbers (n=253; five cases were omitted due to missing data).

	Never or hardly ever	Every half year	Every year	Every two years	Every five years or more	Only when replacing dead plants
Lawn	231	-	-	3	4	15
Seasonal plants, annuals and perennials	45	29	98	12	6	64
Aromatic, medicinal and culinary plants	76	3	16	5	4	149
Ornamental shrubs and vines	123	2	5	6	5	113
Cactus and succulents plants	218	-	4	6	9	16
Ornamental trees, palms and conifers	178	2	3	-	6	64
Fruit trees and vegetables	46	-	20	3	5	179

Table 8.6: Invasive and potentially invasive species detected in domestic gardens in the Costa Brava sorted by their frequency of occurrence. Plant uses and presence within the AENP are also shown.

Taxa	Frequency (%)[z]	Use[y]	AENP[x]
Conyza sp.	19.31	W	X
Lantana camara L.	18.92	O	
Gazania sp.	15.83	O	X
Agave americana L.	10.42	O	X
Mirabilis jalapa L.	9.65	O	X
Carpobrotus sp.	9.27	O	X
Opuntia ficus-indica (L.) Mill.	8.49	O	X
Lonicera japonica Thunb.	7.34	O	X
Passiflora caerulea L.	7.34	O	
Ipomoea indica (Burm.) Merr.	6.95	O	X
Austrocylindropuntia sp.	6.56	O	
Tradescantia fluminensis Vell.	6.18	O	X
Tropaeolum majus L.	6.18	O	
Cortaderia selloana Asch. & Graebn.	5.41	O	X
Crepis sancta (L.) Babc.	5.41	W	X
Paspalum sp.	5.41	W	X
Acacia dealbata Link	5.02	O	X
Stenotaphrum secundatum (Walter) Kunzte	4.63	O	
Cereus peruvianus (L.) Mill.	4.25	O	
Amaranthus sp.	3.09	W	X
Ligustrum lucidum Aiton f.	2.32	O	
Schinus molle L.	2.32	O	
Chamaesyce prostrate (Aiton) Small	1.54	W	X
Parthenocissus quinquefolia (L.) Planch.	1.54	O	X
Acer negundo L.	1.16	O	X
Eucalyptus globulus Labill.	1.16	O	
Robinia pseudoacacia L.	1.16	O	X
Arundo donax L.	0.77	O	X
Eleusine tristachya (Lam.) Lam.	0.77	W	X
Helianthus tuberosus L.	0.77	O	X
Lippia nodiflora (L.) Rich. In Michx.	0.77	O	X
Opuntia monacantha Haw.	0.77	O	
Ricinus communis L.	0.77	O	
Senecio mikanioides Walp.	0.77	O	
Sporobolus indicus (L.) R.Br.	0.77	W	X
Cyperus eragrostis Vahl	0.39	W	X
Elaeagnus angustifolia L.	0.39	O	

Eschscholzia californica Cham.	0.39	O	
Senecio inaequidens DC.	0.39	W	X

[z]Frequencies of all inventoried species may be found in Appendix 5.
[y]Uses: O=ornamental; W=weed.
[x]Confirmed presence of species within the AENP: X=present.

8.5 DISCUSSION

8.5.1 Plant biodiversity in domestic gardens in the Costa Brava

Our results for the gardens in the Costa Brava reinforce the idea previously reported by other researchers that domestic gardens host a high level of plant biodiversity mainly composed of woody and perennial species (Smith et al., 2006; Acar et al., 2007; Marco et al., 2008; Bernholt et al., 2009; Bigirimana et al., 2012; Jaganmohan et al., 2012). The proportion of cultivated exotic species was quite high (77%) when compared to that reported in other private gardens in the world (56–88%; see Bigirimana et al., 2012). These alien plants come from an extraordinarily diverse phytogeographical origin. Approximately half of all the inventoried plants are typical either of the Mediterranean basin or other climatically similar regions, such as the temperate areas of Asia and Africa. Hence, a large proportion of plants are well adapted to the Mediterranean climate. This trend has also been observed in other Mediterranean gardens, such as those in Lauris in France (Marco et al., 2008) and in Trabzon City in Turkey (Acar et al., 2007).

Apart from a few popular species, most of the taxa have low frequency values, which is not unusual (Smith et al., 2006; Acar et al., 2007; Loram et al., 2008; Marco et al., 2008). This finding may be explained by the interaction of two opposite social attitudes, namely, conformity versus individualism (Jim, 1993; Marco et al., 2008). On the one hand, conformity, generally defined as the tendency to act or think like other members of a group, is usually expressed by spatial similarities among the most popular species. Individualism is generally articulated by the heterogeneity of horticultural flora.

8.5.2 Factors correlated with garden plant richness parameters

The explanatory power of our model (49% for overall plant richness) was inferior to that of similar studies in the Nigerian city of Niamey (Bernholt et al., 2009) and Dunedin in New Zealand (van Heezik et al., 2013). In this regard, what distinguishes our study from other multispecies comparative studies is the inclusion of socio-demographic variables together with householders' attitudes and behaviours in terms of their reasons for gardening. This integrative approach may allow for a better understanding of gardening practices and landscape plant distribution.

Garden size and preferences for gardens that provide contact with nature had the highest explanatory power in all the models. Although garden area has previously been reported as a powerful predictor of garden plant diversity (Smith et al., 2005; Daniels & Kirkpatrick, 2006; Marco et al., 2008; Bernholt et al., 2009; van Heezik et al., 2013), the owners' reasons for gardening and the influence that this may have on plant diversity remains poorly explored. Here, we have proven that the owners' preferences may have a higher explanatory power than garden area in predicting garden plant richness. In a previous study of the region of Ballart (Australia), Kendal et al. (2012a) found that people's preferences for garden plants were related to aesthetic traits such as the flower size, the leaf width and the foliage colour. Similarly, other sociological studies on gardening practices have highlighted that the attraction for decorative gardens generates gardens with more plant species (see Larson et al., 2009). Conversely, in our case, the preference for aesthetic gardens was negatively correlated with overall and native plant species richness, whereas the preference for gardens that provide contact with nature was by far the most important predictor of overall and exotic plant diversity parameters.

In the Costa Brava, a great proportion of houses are secondary residences that are lived in for less than half the year. As was expected, these types of residences have significantly less plant diversity than primary residences. This finding might indicate that residents occupying the house most of the year own gardens with higher plant biodiversity because they have more time for their maintenance. An in-depth analysis has to be carried out concerning both types of residences, not only in terms of garden plant richness and composition, but also in the structure of outdoor areas and owner traits.

The age of the house was positively associated with plant diversity in all models except for native plant species richness. This factor has been previously described as a good predictor of garden plant species diversity but with contradictory results (Smith et al., 2005; Loss et al., 2009; van Heezik et al., 2013). In our case, older houses contain more diverse gardens with an abundance of exotic species.

The positive relationship between household income and plant diversity in gardens was first described by Hope et al. (2003). In recent years, many studies have reaffirmed this relationship, concluding that garden plant diversity is higher in the gardens of rich neighbourhoods than in poor districts (e.g., Lubbe et al., 2010; Bigirimana et al., 2012). However, in our study area, this relationship could not be proved for all plant diversity parameters. As a result, household income was only a positive indicator in the exotic plant species richness model but was a negative indicator in the native plant species richness model. This fact may be explained by two different causes. First, owners with higher incomes are mostly foreign residents dwelling in secondary residences and who do not experience much place attachment. This means they may cultivate more exotic plants. Second, owners with lower incomes have gardens with a large number of weeds, which increases native plant diversity.

The results also revealed that an increase in the percentage of a household's non-working members would favour garden plant species diversity. This predictor was not previously tested for any garden plant model, although Garcia et al. (2013a) found that this parameter contributed to a preference for ornamental gardens or lawn gardens in the Mediterranean suburbs of Girona (Spain). Our finding may be explained by the fact that this social group devoted more time to garden maintenance.

Other variables, such as the number of residents, the place of birth and the different reasons for gardening, were not included in any model, nor was the level of education, described by Troy et al. (2007) as a good predictor of the proportion of private properties that were vegetated. In this sense, Luck et al. (2009) concluded that it is difficult to establish the direction of causality with regard to the relationship between vegetation and education.

Finally, it is worth considering that garden vegetation may have a time-lagged response to the socio-economic attributes of householders (Luck et al., 2009). Therefore, socio-economic characteristics from previous years may explain more variation in vegetation cover than contemporary measures. Future research on plant biodiversity should incorporate these fluctuations to perform more accurate analyses.

8.5.3 Factors correlated with invasive species composition

Our study provides new evidence of the strong influence that homeowners' socio-economic and demographic attributes have on garden plant diversity and floristic gradients (Marco et al., 2010a; Lubbe et al., 2010; Bigirimana et al., 2012). Although much of the variation in the data set was unexplained, our results suggest that several socio-economic (household income and proportion of non-working residents) and housing characteristics (age of the building and garden area) were related to invasive plant composition in gardens in the Costa Brava. In terms of these results, and in accord with Cook et al. (2012), it is worth highlighting that household and property attributes, such as the age of the building and the household income, appear to impose stronger constraints on the landscaping decisions and ecological characteristics than landscaping preferences and behaviours. Thus, although aesthetic preferences are often a top priority in explaining groundcover choices (Martin et al., 2003; Spinti et al., 2004; Nielson & Smith, 2005; Hirsch & Baxter, 2009; Larson et al., 2009), this approach may be inefficient when only invasive species are considered. Moreover, the role of landscaping choices and preferences has been widely explored in the study of garden structure (see Larson et al., 2009) but has not been studied at the floristic scale.

According to our results, weeds and ornamental invasive species can be found mixed into the gardens. Although garden area and the age of the house have been described as influential factors in determining garden plant biodiversity (e.g., Smith et al., 2005; van Heezik et al., 2013), as far as we know, these factors had not been previously used as explanatory variables for predicting garden plant species composition. Patterns seem to indicate that larger gardens host a number of invasive trees, weeds and turf species. The influence of the age of the house and the proportion of non-working members (mainly elder retired owners) suggests that different invasive species could have entered the system at different times. Therefore, urban planning and garden aesthetic norms in each context might have a powerful influence on the propagule pressure of invasive species.

Gavier-Pizarro et al. (2010) found a clear association between invasive plant species richness and income level in New England (U.S.). What is new in our research is the finding that differences in income also affect invasive plant distribution. Specifically, the results suggest that higher incomes favour the presence of different drought-tolerant invasive species, such as *Opuntia ficus-indica* or *Gazania* sp. To control and prevent the introduction of certain groups of invasive species, strategies should therefore take the socio-economic status of garden owners into account.

8.5.4 Pathways for introduction of invasive and potentially invasive species

The success of species colonisation is strongly influenced by propagule pressure (Mulvaney, 2001; Dehnen-Schmutz et al., 2007b; Hanspach et al., 2008). Because this parameter is difficult to express quantitatively, many proxies have been used, such as the availability and prices in the horticultural trade (Dehnen-Schmutz et al., 2007b), economic activity (Taylor and Irwin, 2004), the total planting area (Křivánek & Pyšek, 2008) and the garden plant abundance (Marco et al., 2010b). The main factor that sets our study apart from these studies is the inclusion of two new parameters: the analysis of horticultural plant sources and the rate at which species are renewed in gardens.

In this regard, our results revealed that in the Costa Brava, garden centres, coupled with nurseries and florists, are by far the most frequented sources of plants. Thus, the responsibility of these establishments in preventing the introduction of new potentially invasive species is crucial. A good place to start may be environmental education to promote understanding of the terms “native”, “alien” and “invasive”. A recent study in Norway revealed that gardeners do not participate in the alien-native dichotomy constructed by scientists and environmental policymakers (Qvenild et al., 2014), and therefore there is still a long way to go in this respect. Adopting good labelling practices, working in cooperation with other stakeholders or substituting available invasive species are, for instance, efficient strategies that can be found in the “Code of conduct on Horticulture and Invasive Alien Plants” (Heywood & Brunel, 2011). Future research should also focus on the criteria applied by customers when obtaining garden plants. Such knowledge would enable the development of new strategies and policies to guide ornamental plant demand and control urban biotic standardisation (Bowring et al., 2009).

Plants acquired through exchange with neighbours and friends are also quite common in gardens in the Costa Brava. As a result, gardens become a centre for sociability (Dubost, 1997; Nail, 1999; Marco et al., 2010a). This social network may contribute to the escape of species into neighbouring public and wild lands, as exotic species that multiply easily are preferred for gardens (Marco et al., 2010a).

Approximately one-third of the respondents reported that they usually incorporate new plants into their gardens. Moreover, apart from some specific groups of species (fruit trees and vegetables; seasonal, annual and perennial plants; aromatic and culinary species), plants are not usually substituted unless the original plants die. Ornamental plants are characterised by an unusually long persistence due to the maintenance effort exerted by homeowners (Thompson et al., 2003). Thus, the replacement fee of garden species is presumably lower than that in natural ecosystems, and species variations do not frequently occur. These findings suggest these urban ecosystems are relatively resistant to the entrance of new potentially invasive species. Nevertheless, assessing the risk of alien species invasion requires an integrative approach because many variables influence the invasion success (i.e., the vulnerability of adjacent habitats, the horticultural trade, the dispersal vectors, etc.). In this regard, species in cities may disperse to protected areas located up to 50 km away (McDonald et al., 2009), and the dumping of garden waste has been detected as a factor that influences plant dispersal (Sullivan et al., 2005; Foxcroft et al., 2008).

A small proportion of the plants found in gardens at the study site are listed as invasive or potentially invasive in Spain. Some species, such as *Agave americana*, *Mirabilis jalapa* and *Carpobrotus* spp. (specifically *C. edulis* and *C. acinaciformis*), found in relatively high frequencies in the gardens, are widely distributed in the adjacent natural areas. However, a considerable number of the plants inventoried in the gardens and considered invasive somewhere else in Catalonia, or even in Spain, have not yet been detected in the AENP. Therefore, it is essential to establish management measures to prevent the introduction of species such as *Lantana camara*, *Passiflora caerulea* and *Stenotaphrum secundatum*. The trade of these plants is not regulated by Spanish legislation (Spain, Real Decreto-Ley 630/2013). Moreover, the likely impact on the environment and the degree of introduction of other potentially invasive species found in gardens, such as *Imperata cylindrica*, *Pyracantha* sp. and *Aptenia cordifolia*, should be determined.

Finally, the prevalence of exotic plant species adapted to the Mediterranean climate has been discussed in other sections of this paper (see also Acar et al., 2007; Marco et al., 2008). On the one hand, preferences for this type of species can reduce garden water consumption, but on the other hand, such preferences may increase the risk of biological invasion in the Mediterranean region (Ewel et al., 1999; Marco et al., 2008). Informative campaigns involving homeowners should promote approaches that encourage both the conservation of water resources and the conservation of native vegetation.

8.6 CONCLUSIONS

In summary, the findings presented herein contribute valuable insights towards regarding garden vegetation structure, factors related to floristic parameters and the propagule pressure of invasive species. This study views gardens as complex ecosystems dominated by exotic plant species. The replacement of these species by new plants, although not frequent, may incorporate new potentially invasive species into the system. In this case, the propagule pressure of the new invasive species may increase, negatively affecting adjacent natural areas. The selection of invasive garden species was found to be strongly influenced first by socio-economic and demographic characteristics of the households and second by the housing characteristics. In this regard, the resistance of these ecosystems against potentially invasive species mostly depends on the attitudes and behaviours of the homeowners in relation to their perception of their gardens. Therefore, the study of the characteristics of households in each context is essential to better understanding which characteristics of residents suggest that they are more likely to incorporate potentially invasive species into their gardens.

To influence homeowners' preferences and guide them towards more environmentally friendly landscapes, it is highly recommended to provide precise and useful information in garden centres and nurseries on plant invasions because these venues are the main sources of garden plants. Moreover, efforts in the control of biological invasions should focus on potentially invasive species not yet widespread in natural areas. In our case, species such as *Lantana camara*, *Passiflora caerulea* and *Stenotaphrum secundatum*, among others, should be monitored to prevent their likely spread into areas of the AENP. Governments and administrations should promote and update laws to prevent the trade of these species in vulnerable areas. In this respect, the early detection of invasive species is the key factor in minimising the environmental and economic impact of biological invasions.

CAPÍTOL 9

DISCUSSIÓ GENERAL

9.1 FACTORS DETERMINANTS DEL TIPUS D'ENJARDINAMENT

La distribució de les plantes cultivades, a diferència de la vegetació autòctona, està influenciada per molts factors més enllà de les variables biofísiques com ara la temperatura, les precipitacions o la pròpia deriva continental (Kendal et al., 2012b). De fet, pels cas dels jardins privats, les variables socioeconòmiques, com ara la densitat de població, el nivell educatiu, el model de tinença de la propietat o la renda familiar, s'han descrit com a predictores de la distribució vegetal sovint amb major poder explicatiu que altres variables biofísiques (Hope et al., 2003; Luck et al., 2009; Marco et al., 2010a). De la mateixa manera, el colonialisme i els processos de globalització han donat lloc a que ciutats molt separades en l'espai puguin acollir parcs i jardins molt similars (Reichard & White 2001; Ignatieva & Stewart, 2009). Per tant, els antecedents culturals i el comportament dels residents poden arribar a ser més determinants que les tendències naturals de dispersió de les plantes (Head et al., 2004).

Kendal et al. (2012b) van explorar els patrons de distribució de tot tipus de flora urbana cultivada a escala mundial arribant a la conclusió que les variables biofísiques, i en especial la temperatura, eren els factors més importants en la distribució d'aquestes espècies. Seguint una metodologia similar, els resultats del **Capítol 3** del present treball suggereixen que la composició vegetal dels conjunts de jardins seleccionats d'arreu del món es relaciona significativament amb diverses variables físiques, socioeconòmiques i culturals. No obstant, els resultats indiquen que la temperatura, que durant molt de temps ha estat considerada com el principal impulsor de la distribució de les plantes (Woodward & Williams, 1987), té menor poder explicatiu, en aquests ambients, que les diferències en el PIB per càpita de cada regió.

Les conseqüències d'aquest fet poden comportar variacions sobtades de l'estructura dels jardins, ja que al ser ambients dinàmics, són relativament sensibles davant dels canvis tant de les condicions ambientals com socioeconòmiques (Alberti & Marzluff, 2004). Així doncs, una situació de crisis econòmica greu podria causar variacions en l'estructura vegetal dels jardins, sobretot en països desenvolupats. En aquest sentit, els grups socials i les famílies que es trobin més a prop dels llindars de la pobresa podrien optar per canviar l'estructura i funcionalitat dels seus jardins per tal de readaptar-los a la producció d'aliments. En concordança, al **Capítol 5**, es constata que en els últims 5 anys ha augmentat el nombre d'horts i arbres fruiters en jardins a la zona d'estudi. Sens dubte, això pot alterar també els patrons de consum d'aigua a escala domèstica.

En aquesta línia, i tal i com es detalla en el **Capítol 7**, els habitatges de residències principals es caracteritzen per acollir una major proporció de plantes amb usos alimentaris i vegetació espontània. Per contra, les segones residències acullen proporcionalment més espècies ornamentals i els seus espais exteriors tenen superfícies més grans destinades a arbres, arbustos, flors i també piscines. Es conclou també en aquest apartat que els factors socioeconòmics són més influents sobre l'estructura dels jardins que no pas el llegat històric dels habitatges. La tendència generalitzada de canvi gradual de segones residències cap a habitatges principals al llarg de tota la costa Mediterrània es preveu que comporti canvis substancials en l'estructura d'aquests espais privats (Catalán et al., 2008).

Tots aquests resultats guarden relació amb els obtinguts al **Capítol 6,** també realitzat a escala de la llar. En aquesta part de l'estudi es va comprovar que la composició florística dels 258 jardins mostrejats estava relacionada amb diferents gradients socioeconòmics, sent els més significatius l'elevada taxa d'ocupació de l'habitatge, l'origen dels residents, el seu nivell de renda i el percentatge de membres desocupats de la llar. Aquesta marcada influència dels atributs socioeconòmics i demogràfics ha estat prèviament descrita en altres estudis (Kirkpatrick et al., 2007; Marco et al., 2010a; Lubbe et al., 2010; Bigirimana et al., 2012).

L'elevada proporció de cases de vacances i residències secundàries ocupades sovint per residents estrangers fa que les àrees residencials objecte d'estudi siguin molt heterogènies quant a les seves característiques socioeconòmiques (Garcia et al., 2013a). Això es tradueix directament amb la varietat de plantes cultivades i el tipus d'enjardinament practicat. En el **Capítol 6** es van establir 4 tipologies diferents de jardí: salvatge, hort, gespa i ornamental. Prèviament, García et al. (2013a) havien detectat tipologies de jardins molt similar en altres suburbis de la regió litoral gironina. Cadascuna d'aquestes tipologies fou associada a diferents perfils socioeconòmics, destacant que els jardins de tipus hort eren gestionats majoritàriament per residents permanents amb baix nivell de renda, mentre que els jardins ornamentals reflectien l'estil de vida migratori dels residents estrangers amb elevat poder adquisitiu.

En el **Capítol 8** es va incloure també en l'anàlisi les preferències dels residents per tal d'avaluar la importància dels factors cognitius en l'estructura del jardí. Així, malgrat que les preferències estètiques solen ser prioritàries per explicar el tipus de cobertura vegetal en jardins (Martin et al., 2003; Spinti et al., 2004; Nielson & Smith, 2005; Hirschand & Baxter, 2009; Larson et al., 2009), en el present estudi les preferències per jardins productius van tenir un major transcendència vinculada, possiblement, a una arrelada tradició d'horts familiars.

9.2 L'ÚS D'AIGUA I PRÀCTIQUES DE GESTIÓ EN JARDINS DOMÈSTICS

Aproximadament la meitat del consum total d'aigua domèstica té lloc en espais exteriors de l'habitatge (Domene & Saurí, 2006;. Mayer et al., 1999;. Salvador et al., 2011; Syme et al., 2004). Investigacions prèvies han revelat que el reg del jardí representa bona part d'aquest consum (Chestnutt & McSpadden, 1991; Renwick & Archibald, 1998). Per aquest motiu, és imprescindible conèixer els factors que determinen el tipus d'enjardinament i de retruc els seus requeriments hídrics. L'anàlisi de les característiques dels jardins, així com de les pràctiques de la seva gestió, és clau per orientar polítiques i regulacions d'estalvi i eficiència en l'ús de l'aigua.

En el present estudi, les necessitats hídriques dels jardins van ser calculades a partir del mètode WUCOLS (*Water Use Classifications of Landscape Species*) proposat per Costello et al. (2000) i que permet aproximar aquest paràmetre a partir de l'anomenat "coeficient de paisatge" (**Capítols 4**, **5** i **6**). Aquest mètode havia estat prèviament i eficaçment utilitzat per avaluar les pràctiques de gestió de l'aigua en diferents tipologies de jardins urbans (Domene & Saurí, 2003; Endter-Wada et al., 2008; Nouri et al., 2013; Salvador et al., 2011). Tot i això, no ens consta que cap estudi havia utilitzat abans la composició florística completa dels jardins per realitzar aquest càlcul.

Com a resultats principals, en el **Capítol 6** es va detectar que els factors socioeconòmics amb major poder explicatiu dels requeriments hídrics eren el nivell de renda i el percentatge de membres de la llar jubilats o desocupats. Les llars més riques tenen més probabilitats de tenir un jardí que requereixi d'elevades aportacions d'aigua en tots els casos, excepte en els jardins amb hort. En aquest darrer cas, existeix un retorn econòmic de la despesa d'aigua cap a les llars amb ingressos més baixos. El poder adquisitiu de la llar ja havia estat predit per altres estudis com una variable explicativa de la demanda hídrica (Sovocool et al., 2006; Endter-Wada et al., 2008; Harlan et al., 2009). La influència de la proporció de membres desocupats sobre els requeriments hídrics, pot reflectir l'alta proporció de jubilats acomodats que ocupen la casa només estacionalment, i que per tant opten per jardins que sobreviuen sense reg.

Els jardins amb menors requeriments hídrics són, precisament aquells amb més superfície artificial. Així, en el **Capítol 5** es va evidenciar que més de la meitat dels espais exteriors dels habitatges estaven pavimentats. D'altra banda, les segones residències acullen de forma significativa piscines de majors dimensions, la qual cosa pot comportar que aquest col·lectiu residencial tingui consums d'aigua per càpita majors que no les residències principals (**Capítol 7**; Hof and Wolf, 2014). La gespa, per la seva banda, estava present en menys de la meitat dels casos. D'acord amb St. Hilaire et al. (2008), en àrees com la regió mediterrània, on l'aigua és escassa i cara, les ràtios de superfície ocupades per gespa tendeixen a ser baixes. La gestió d'aquests espais exteriors, al igual que en resultats reportats per altres estudis (Varlamoff et al., 2001; Fernández-Cañero et al., 2011), és majoritàriament duta a terme pels mateixos propietaris.

L'eficiència de reg registrada és deficient, amb més de tres quartes parts dels jardins sense reg automatitzat i de degoteig. A més, aquest percentatge és considerablement superior al que assenyalen altres jardins d'Espanya (Fernández-Cañero et al., 2011) i Estats Units (Mayer et al., 1999). Val a dir, però, que els jardins amb majors requisits hídrics, són també els que disposen de sistemes de reg més tecnificats, com ara el degoteig automàtic o manual, tant en el nostre estudi com en la bibliografia consultada (Chesnutt & McSpadden, 1991; Syme et al., 2004; Domene et al., 2005).

També en el **Capítol 5** es fa referència a les transformacions aplicades i previstes d'aplicar en els jardins per tal de conèixer les tendències a les que es troben sotmeses aquests espais. Aquest coneixement és d'especial interès per preveure i respondre a possibles canvis en els patrons de consum d'aigua (Larsen & Harlan, 2006). Així, la modificació més freqüent duta a terme fou l'eliminació de gespa. Com a raons principals d'aquest canvi s'atribuïren l'estalvi hídric, l'estalvi de temps i l'embelliment del jardí. Per altra banda, les principals modificacions previstes foren la incorporació de noves plantes.

Molt lligat amb aquesta darrera qüestió i el tipus de planta seleccionada pels jardins, es destaca, en el **Capítol 8,** que existeix una prevalença de plantes exòtiques adaptades al clima mediterrani. D'una banda, les preferències per a aquest tipus d'espècies poden reduir el consum d'aigua del jardí però, per l'altra, poden augmentar el risc d'invasió biològica en la regió mediterrània ja que aquest grup de plantes estan més adaptades a situacions d'aridesa (Ewel et al., 1999; Marco et al., 2008). Caldria, doncs, promoure campanyes informatives dirigides als propietaris d'habitatges per tal de buscar l'equilibri entre l'ús dels recursos hídrics i la vegetació autòctona i al·lòctona.

Finalment, i com s'apunta en el **Capítol 6**, l'ús potencial de l'aigua en els jardins ha estat vagament predit per les variables seleccionades. Aquest resultat suggereix que podria haver-hi grans diferències d'actitud dins de les classes socioeconòmiques i demogràfiques, i que aquesta variació és precisament la que influeix més directament sobre la naturalesa i l'ús eficient de l'aigua dels jardins.

9.3 BIODIVERSITAT VEGETAL I PRESSIÓ DE PROPÀGUL D'ESPÈCIES INVASORES EN JARDINS DOMÈSTICS

L'important paper socio-ecològic que desenvolupen els jardins domèstics en les ciutats ha estat àmpliament explorat (veure Cook et al., 2012). La biodiversitat gamma, per exemple, es va trobar que era major en aquests ambients que en ecosistemes naturals i agrícoles adjacents (Sax & Gaines, 2003; Kühn et al., 2004;. McKinney, 2008). En concordança amb aquest fet, en el **Capítol 6**, es rebel·la que l'alta biodiversitat gamma dels jardins mostrejats no és inusual, sinó que s'anivella amb els resultats obtinguts en altres regions de tot el món (Smith et al., 2006; Bernholt et al., 2009; Bigirimana et al., 2012; Jaganmohan et al., 2012). Tampoc són excepcionals les baixes freqüències amb què foren inventariats la majoria de taxons (Acar et al., 2007; Loram et al., 2008; Marco et al., 2008; Smith et al., 2006).

Pel què fa a l'origen de la flora inventariada, en el **Capítol 8** es detalla com la proporció d'espècies exòtiques cultivades era relativament alta (77%) quan es compara amb aquella reportada en altres estudis en jardins privats d'arreu del món (56-88%, veure Bigirimana et al., 2012). Pràcticament la meitat del total de plantes identificades eren típiques o bé de la conca Mediterrània o bé d'altres regions climàticament similars, com ara zones temperades d'Àsia i Àfrica. Això significa que una gran part de les plantes es troben adaptades al clima mediterrani. Aquesta tendència també s'ha observat en altres jardins mediterranis com els de Lauris a França (Marco et al., 2008) o a la ciutat turca de Trabzon (Acar et al., 2007). A més, aquest fet concorda amb allò exposat en el **Capítol 5**, en el qual es constata que els jardins amb espècies adaptades al clima de la regió requereixen menys reg addicional i s'ajusten als principis de la xerojardineria (Wade et al., 2007). Per altra banda, al **Capítol 7** es va trobar que les residències principals acollien significativament més espècies natives que no pas les secundàries, la qual cosa suggereix que els seus propietaris poden tenir un major arrelament o connexió amb l'indret on viuen (Hay, 1998).

També al **Capítol 5** s'obtingué que els jardins amb major consum hídric acumulaven una riquesa vegetal major. Per altra banda, diferents paràmetres de riquesa i diversitat vegetal van ésser relacionats amb els factors socioeconòmics, demogràfics i de característiques de la llar (**Capítol 8**). Destaquen com a variables explicatives més importants, per exemple, l'àrea total del jardí (Daniels & Kirkpatrick, 2006; Marco et al., 2008), l'edat de l'edifici (Smith et al., 2005; Van Heezik et al., 2013) o la taxa d'ocupació de la llar.

Un resultat inesperat fou que el nivell de renta de les llars no es trobava relacionat amb la riquesa vegetal total. Això contrasta amb els resultats d'estudis previs en els quals es va trobar que la riquesa i la diversitat vegetal era més alta en els jardins dels barris rics que en els dels barris més pobres (Lubbe et al., 2010; Bigirimana et al., 2012). Aquesta relació positiva entre el nivell d'ingressos de les llars i la riquesa de plantes als jardins va ser descrita per primera vegada per Hope et al. (2003) com "efecte luxe" (*luxury effect*). Ara bé, en el nostre estudi el nivell de renta es va relacionar positivament amb el la riquesa d'espècies exòtiques i negativament amb la riquesa d'espècies natives. Aquest fet es pot explicar per dues raons principals. En primer lloc, perquè els propietaris amb ingressos més alts solen ser residents estrangers que ocupen segones residències i que per tant tenen un menor arrelament. Això pot comportar que tendeixin a cultivar més espècies exòtiques (Brook, 2003). En segon lloc, perquè els propietaris amb rendes més baixes tenen jardins amb una gran varietat de vegetació espontània i de plantes comestibles, cosa que pot augmentar significativament la riquesa vegetal autòctona.

Pel què fa al risc d'invasió biològica, cal recalcar que una part reduïda però significativa de la flora exòtica dels jardins pot escapar-se d'aquests ambients i colonitzar espais naturals propers (Sanz-Elorza et al., 2004). Les problemàtiques associades a les invasions biològiques s'han aguditzat especialment en la última dècada (Pyšek et al., 2006;

Richardson & Pyšek, 2008). L'èxit de colonització d'aquestes espècies està fortament influenciat per la pressió dels propàguls (Mulvaney, 2001;. Dehnen-Schmutz et al., 2007b; Hanspach et al., 2008). Atès que aquest paràmetre és difícil d'expressar quantitativament, s'han utilitzat molts indicadors com ara la oferta i els preus en el comerç hortícola (Dehnen-Schmutz et al., 2007b), l'activitat econòmica (Taylor & Irwin, 2004), l'àrea total de plantació (Křivánek & Pyšek, 2008) o l'abundància de plantes de jardí (Marco et al., 2010b). El tret principal que diferencia el present d'estudi d'altres és la inclusió de dos nous paràmetres: la font d'obtenció de plantes hortícoles i la periodicitat amb què aquestes es renoven (**Capítol 8**).

Com a resultat destacat en aquest aspecte, s'ha de dir que la majoria de plantes exòtiques citades fora dels jardins a l'àrea d'estudi (Gesti, 2000) es troben llistades com a invasores o potencialment invasores a Catalunya (Andreu et al., 2012). Algunes espècies com ara *Agave americana*, *Mirabilis jalapa* o *Carpobrotus* sp. (concretament *C. edulis* i *C. acinaciformis*), trobades amb freqüències relativament altes als jardins, es troben àmpliament esteses per les àrees naturals adjacents. No obstant això, un nombre considerable de plantes inventariades i reconegudes com a invasores en altres indrets de Catalunya encara no han estat detectades en els espais naturals propers. Així doncs, és essencial establir mesures de gestió encaminades a prevenir la introducció d'espècies com ara *Lantana camara*, *Imperata cylindrica*, *Passiflora caerulea* o *Stenotaphrum secundatum*. A més, el comerç d'aquest darrer grup de plantes no està regulat per llei (Espanya, Real Decret-Llei 630/2013).

Per tot això, les accions de prevenció davant de possibles invasions biològiques són considerades com a millor alternativa per davant de mesures d'eradicació i control ja que són més eficients i ambientalment desitjables (Pyšek & Richardson, 2010). En aquest sentit, els centres de jardineria, principal font d'obtenció de plantes per als jardins analitzats, tenen un paper fonamental per tal d'afavorir espècies natives o altres espècies sense reconegut potencial invasor. Tot i que en el **Capítol 8** es suggereix que els jardins domèstics són ecosistemes urbans relativament impermeables a l'entrada de noves espècies invasores o potencialment invasores, és necessari avaluar el risc d'invasió des d'un enfocament integrador ja que factors com ara la invasibilitat, és a dir, les propietats dels ecosistemes que afecten la supervivència de les espècies al·lòctones (Lonsdale, 1999), la pròpia capacitat invasora de les espècies o els vectors de dispersió, influeixen significativament en l'èxit d'invasió biològica (Gassó, 2008).

CAPÍTOL 10

CONCLUSIONS (en Català)

Prenent com a punt de referència els objectius de la tesis, arribem a les següents conclusions.

En relació als objectius generals:

- Les necessitats hídriques teòriques dels jardins domèstics de l'àrea d'estudi han estat escassament predites a partir dels factors socioeconòmics i demogràfics de les llars. No obstant això, destaca el poder explicatiu del nivell de renda dels residents i la proporció de membres desocupats a la llar. En aquest sentit, s'apunta que l'actitud i el comportament dels propietaris podrien explicar la major part de la variació.

- Catorze espècies trobades en els jardins, malgrat tenir un reconegut potencial invasor en altres àrees d'Espanya, no han estat citades com a naturalitzades en els espais naturals adjacents. Així doncs, és convenient fer un seguiment i control d'aquests tàxons per tal d'avaluar-ne la seva potencial introducció i expansió. De la mateixa manera, caldria mantenir una regulació normativa estricta, actualitzada i adaptada a cada regió territorial concreta per tal de minimitzar la introducció d'espècies potencialment invasores a través del comerç hortícola. En aquest sentit, els centres de jardineria, principal font d'obtenció de plantes per als jardins analitzats, s'apunten com a element fonamental per afavorir el comerç d'espècies natives i exòtiques sense potencial invasor.

En relació als objectius específics:

a) Factors determinants del tipus d'enjardinament

- A escala global, el nivell econòmic de cada regió particular sembla tenir més influència sobre la distribució vegetal dels jardins que no pas altres variables físiques o climàtiques com ara la temperatura o el règim pluviomètric. Aquest fet trenca amb la teoria clàssica de distribució de les plantes en hàbitats naturals. A més, té conseqüències clares i directes sobre la dinàmica dels jardins en termes de seguretat alimentària, conservació biològica i patrons de consum d'aigua. Val a dir, però, que seria recomanable completar l'estudi ampliant el número de casos i disposant de dades més acurades per tal de validar aquest resultat preliminar.

- Les diferents tipologies de jardí proposades per la literatura convencional (*homegardens*, *domestic gardens*, *mixed gardens*, etc.) poden ser difícilment establertes a partir de seves dissimilituds taxonòmiques. En aquest sentit, la funció predominant de cada tipus de jardí, atorgada pels respectius propietaris, s'apunta com el factor clau per explicar la classificació.

- A escala de llar, diferents gradients socioeconòmics i demogràfics, entre els quals destaca la taxa d'ocupació de l'habitatge, l'origen dels residents, el seu nivell de renda i el percentatge de membres desocupats, es troben significativament relacionats amb la composició florística dels jardins.

- Existeixen diferències notables entre el tipus d'enjardinament practicat en residències principals i secundàries. Per una banda, la composició vegetal és sensiblement diferent, amb un predomini d'espècies espontànies i verdures en residències principals. Per altra banda, els espais exteriors dels habitatges de segones residències tenen superfícies majors ocupades per arbres, arbustos i flors, així com també piscines. La interacció entre el tipus de residència i els efectes socioeconòmics i de llegat són determinants de l'estructura del jardí.

b) L'ús d'aigua i pràctiques de gestió en jardins domèstics

- Tot i que pràcticament la meitat de les superfícies exteriors dels habitatges unifamiliars es troben pavimentades o formades per altres elements artificials, la presència de gespa, associada a elevats consums d'aigua, es donà en un 46% dels casos. Aquest element vegetal es va relacionar amb l'edat de l'habitatge, la presència de piscina i l'ús de sistemes de reg d'aspersió automàtica. L'ús de sistemes de reg automàtic, ja siguin d'aspersió o de degoteig, fou escàs, amb només un 23% dels jardins amb aquest tipus de tecnologia.

- Es va detectar un augment considerable del nombre d'horts en jardins en els últims 5 anys, probablement en resposta als canvis socioeconòmics esdevinguts durant aquest període. Aquest fet sembla complementar-se amb un increment del nombre d'arbres fruiters també reportat per al mateix interval de temps. Aquestes observacions podrien estar reflectint una tendència de canvi en les funcions generals dels jardins ornamentals que comportaria un augment del consum d'aigua domèstica així com de seguretat alimentària a les llars.

c) Biodiversitat vegetal i pressió de propàguls d'espècies invasores en jardins domèstics

- L'anàlisi de la composició florística dels jardins de l'Alt Empordà reforça la idea, prèviament obtinguda en altres investigacions, que els jardins domèstics acullen una elevada biodiversitat vegetal gamma constituïda principalment per espècies llenyoses i perennes de tipus ornamental. Malgrat aquesta elevada biodiversitat, la majoria d'espècies (69%) es trobaren en proporcions inferiors al 5%.

- Un 68% de la flora inventariada en els jardins era exòtica provinent principalment d'Àsia i Sud Amèrica. Aquest percentatge ascendeix fins al 77% considerant només les espècies cultivades. Les residències principals tenen significament més espècies natives.

- Les variables predictores més importants de la riquesa total d'espècies vegetals en els jardins han estat, per ordre d'importància, les prefències per jardins on tenir contacte amb la natura i la mida del jardí. Igualment, han estat també rellevants les preferències per jardins on dur a terme activitats de hobby, l'edat de l'habitatge, la proporció de membres desocupats o la taxa d'ocupació de l'habitatge.

- El nivell de renda, obtingut en altres estudis com una variable positivament vinculada amb la riquesa vegetal total, es va trobar positivament associat amb la riquesa d'espècies exòtiques, i negativament relacionat a la riquesa d'espècies natives. Aquest fet es pot explicar per dues raons principals. En primer lloc, perquè els propietaris amb ingressos més alts solen ser residents estrangers que ocupen segones residències i que per tant tenen un menor arrelament. Això pot comportar que tendeixin a cultivar més espècies exòtiques. En segon lloc, perquè els propietaris amb rendes més baixes tenen jardins amb una gran varietat de vegetació espontània i de plantes comestibles que pot augmentar significativament la riquesa vegetal autòctona.

- Els jardins domèstics són ecosistemes urbans relativament resistents a l'entrada de noves espècies potencialment invasores. No obstant això, és necessari avaluar el risc d'invasió des d'un enfocament integrador que inclogui altres paràmetres com ara la invasibilitat, la biologia de les espècies, els vectors de dispersió o els efectes del canvi ambiental global, entre d'altres.

CHAPTER 11

CONCLUSIONS (in English)

In accordance with the initial objectives of this thesis, we reach the following conclusions:

In relation to the overall objectives:

- Water requirements predicted from the characteristics of gardens are not strongly related to demographic and socioeconomic household variables. However, the income level of residents and the proportion of unemployed household members have a low but significant explanatory power. In this regard, identifying and targeting attitude groups are likely to be more effective.
- Fourteen species found in gardens and described as potentially invaders in other areas of Spain have not yet been cited as naturalized in adjacent natural areas. Therefore, it is highly recommended to control the spread of these taxa and assess their potential introduction and expansion. Similarly, authorities should maintain strict regulatory rules –which are updated and adapted to each specific territorial region– in order to minimize the introduction of potentially invasive species through horticultural trade. In this regard, garden centers, the primary sources of plants in the sampled gardens, are a key element in promoting the trade of native as well as exotic species without the potential for invasiveness.

In relation to the specific objectives:

a) Factors determining landscaping practices

- Globally, the economic level of each particular region seems to have a greater influence on the distribution of garden plant species than do other physical or climatic variables, such as temperature or rainfall. This contradicts the classical theory of the distribution of plants in natural habitats. In addition, this fact might have direct and clear consequences on the dynamics of gardens in terms of food security, biodiversity conservation and water use patterns. It is worth highlighting that this part of the study should be enhanced by increasing the number of cases and obtaining more accurate data to validate and support our preliminary results.

- The different types of garden proposed in the conventional literature (home gardens, domestic gardens, mixed gardens, etc.) can hardly be established from taxonomic dissimilarities. In this regard, the predominant function of each type of garden (provided by their respective owners) is pointed out as a key factor in explaining the classification.
- At the household scale, the distribution of garden floras is significantly related to different socioeconomic and demographic gradients, such as the occupancy rate of the house, the origin of the residents, their income level and the percentage of unemployed members.
- There are remarkable differences between the private landscapes of primary and secondary residences. On the one hand, plant composition is significantly different, with a predominance of spontaneous species and vegetables in primary residences. On the other hand, the outdoor areas of secondary homes have larger surfaces occupied by trees, shrubs, flowers and swimming pools. The interaction between the type of residence and socioeconomic and legacy effects are relevant to the structure of the gardens.

b) Water use and management practices in domestic gardens

- Although almost half of the outer surfaces of the sampled houses were paved or covered with other artificial elements. The presence of grass, associated with high water consumption, occurs in 46% of all cases. This garden cover element was related to the age of the house, the presence of a swimming pool and the use of automatic sprinkler irrigation systems. The use of automatic irrigation systems (whether sprinkling or dripping) was low, with only 23% of gardens employing this technology.

- We detected an increase in the number of orchards in the last 5 years, probably in response to the socio-economic changes that occurred during this period. This seems to be complemented by an increase in the number of fruit trees in the same interval of time. These observations could reflect a changing trend in the general functions of ornamental gardens, which may lead to an increase in domestic water consumption and household food security.

c) Plant biodiversity and propagule pressure from invasive species in domestic gardens

- The analysis of the floristic composition of the gardens in Alt Empordà reinforces an idea that was obtained previously in other studies, namely that domestic gardens host high gamma plant biodiversity which is constituted mainly of woody and perennial ornamental species. Despite this high biodiversity, most species (69%) were found in proportions lower than 5%.
- Sixty-eight per cent of the flora found in gardens was exotic, mainly from Asia and South America. This percentage rises to 77% if considering only cultivated species. Primary residences have significantly more native species.
- The most important predictors of overall plant richness are (in order of importance): preferences for gardens that provide contact with nature and the size of the garden area. Moreover, other relevant variables are: preferences for gardens cultivated as a hobby, the age of the building, the proportion of unemployed household members and the occupancy rate of the house.
- Income level has been described in other studies as a variable that is positively related to overall plant richness. Here, it was found to be positively associated with exotic plant richness and negatively related to native species richness. This fact may be explained by two different causes. First, owners with higher incomes are mostly foreign residents dwelling in secondary residences and who do not experience much place attachment. This means they may cultivate more exotic plants. Second, owners with lower incomes have gardens with a large number of weeds, which increases native plant diversity.

- Domestic gardens are urban ecosystems relatively resistant to the entry of new, potentially invasive species. However, it is necessary to evaluate the risk of invasion from an integrated approach that includes other parameters such as invasibility, species biology, dispersal vectors or the effects of global environmental change, among others.

CAPÍTOL 12

PROSPECTIVES DE FUTUR

Aquesta tesis lògicament ha deixat encara alguns buits de coneixement vinculats a les qüestions tractades i per altra banda ha servit per dibuixar possibles noves línies de recerca futura. En aquest sentit, es requereix més investigació per tal de comprendre les interaccions entre els agents que determinen la gestió dels paisatges urbans i els serveis socials o ecològics que aquests ambients generen a diferents escales. La investigació interdisciplinària pot ajudar a aclarir aquestes dinàmiques multi-escalars. Per fer-ho, cal que totes les disciplines, tant de les ciències naturals com les socials, uneixin esforços en base a un marc conceptual integrador. D'aquesta manera, alguns dels punts suggerits a continuació podran ser examinats i investigats amb l'eficiència necessària:

- **Anàlisi dels processos i patrons ecològics dels jardins a través de diferents contextos geogràfics:** Aquest punt és especialment important per tal d'afavorir un coneixement global que permeti comparar quantitativament i qualitativament els processos ecològics d'aquests espais com ara el cicle de l'aigua, els cicles biogeoquímics o la pròpia dinàmica de les comunitats. Per fer-ho, podria realitzar-se un estudi de casos basats en literatura existent o bé elaborar un nou estudi amb diferents casos, tots ells examinats amb la mateixa aproximació metodològica.

- **Estudi de la dinàmica dels serveis dels ecosistemes urbans a diferents escales:** Els serveis ambientals que ofereixen les àrees urbanes, i en especial els jardins, han estat ben documentats especialment en els últims anys. Ara bé, una aproximació que permetés establir la rellevància d'aquests factors (regulació de la temperatura, balanç de carboni, depuració d'aire, etc.) a diferents escales, ja sigui a escala de la llar, de barri o de ciutat, podria ser especialment útil per orientar el planejament urbà.

- **Construcció d'instruments de mesura clars i comparables per quantificar les variables actitudinals que influeixen en la composició dels jardins:** Com s'ha descrit en apartats anteriors, una bona part de la variació en la composició i estructura dels jardins privats es deu a factors cognitius dels propietaris. Ara bé, la quantificació i valoració d'aquests factors no és sempre senzilla, i per això cal desenvolupar eines que permetin mesuraments eficients i reproduïbles en altres regions.

- **Anàlisi de les interaccions entre la component humana i els ecosistemes urbans a diferents escales:** En el present treball s'ha analitzat la relació entre la influència antròpica i l'estructura d'una tipologia concreta d'àrea urbana com són els jardins domèstics. A més, l'escala de treball ha estat molt precisa a nivell de llar. Per tal de complementar els resultats i conclusions obtinguts aquí, seria recomanable ampliar l'estudi a un major rang d'ecosistemes urbans (e.g. zones ecotó, terraplens, parcs públics) i considerar-los també a diferents escales.

- **Descripció del paper de les institucions públiques i privades en parcs i jardins urbans:** El paper que juguen les diferents administracions i institucions (públiques i privades) en la determinació de l'estructura de parcs i jardins ha estat poc analitzada a un nivell multi-escalar. Quantificar el pes que tenen variables com el preu de l'aigua, la incidència d'ordenances urbanes, o les campanyes de màrqueting, sobre l'estructura dels paisatges urbans pot ajudar a conèixer millor l'evolució d'aquests ecosistemes.

- **Influència de l'evolució dels usos i cobertes del sòl, i el context geogràfic, en les decisions preses avui sobre l'estructura de parcs i jardins:** La incorporació de la variable "temps" en l'estudi de la vegetació dels jardins pot permetre d'analitzar la rellevància que han tingut les transformacions en els usos i cobertes del sòl, i en especial en la matriu urbana, sobre el tipus d'enjardinament practicat. Aquesta part ha estat sovint descuidada en els estudis d'aquestes característiques.

- **Jardins domèstics del litoral Mediterrani i el seu paper en la resiliència socio-ecològica:** Els canvis socioeconòmics, demogràfics i culturals que estan tenint lloc en les àrees urbanes del litoral de la Mediterrània, especialment deguts a la crisis econòmica i immobiliària, poden comportar alteracions significatives en l'estructura de les àrees urbanes residencials. Aquests canvis poden incloure una tendència a la baixa en la construcció d'habitatges, una disminució en l'arribada de nouvinguts o fins i tot l'abandó de certs espais suburbans. A més, poden influir sobre la pressa de decisions dels propietaris dels habitatges i per tant en la composició i gestió dels seus jardins. És un exemple d'això la modificació de la funció dels jardins d'ornamental a productiu. L'anàlisi de la capacitat d'adaptació d'aquests ecosistemes és d'especial importància per entendre millor les dinàmiques que donen forma als sistemes ecològics i socials. En aquest sentit, seria interessant estudiar l'evolució d'aquestes ecosistemes en el temps i analitzar les conseqüències que aquests canvis comportarien en el consum d'aigua domèstica i en la seguretat alimentària.

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ANNEXES

Annex 1: Valors mitjans diaris de ET_o per cada mes a les zones CIMIS i per a les estacions XEMA (mm/dia).

		Gen.	Feb.	Mar.	Abr.	Mai.	Jun.	Jul.	Ago.	Set.	Oct.	Nov.	Des.	Total anual (mm)
CIMIS	**C1**	0,76	1,27	2,03	2,79	3,30	3,81	3,81	3,30	2,79	2,03	1,02	0,51	838
	C2	1,02	1,52	2,54	3,30	3,81	4,32	4,06	3,81	3,30	2,29	1,52	1,02	991
	C3	1,52	2,03	3,05	4,06	4,32	4,83	4,57	4,32	3,56	2,79	2,03	1,52	1176
	C4	1,52	2,03	2,79	3,81	4,32	4,83	4,83	4,57	3,81	2,79	2,03	1,52	1184
	C5	0,76	1,52	2,79	3,56	4,57	5,33	5,33	4,83	3,81	2,54	1,27	0,76	1113
	C6	1,52	2,03	2,79	4,06	4,57	5,33	5,33	5,08	4,06	3,05	2,03	1,52	1262
	C7	0,51	1,27	2,03	3,3	4,32	5,33	6,10	5,33	4,06	2,29	1,02	0,51	1102
	C8	1,02	1,52	2,79	4,06	5,08	5,33	6,10	5,33	4,32	2,79	1,52	0,76	1255
	C9	1,78	2,54	3,3	4,32	4,83	5,59	6,10	5,59	4,83	3,30	2,29	1,52	1400
	C10	0,76	1,52	2,54	3,81	4,83	6,10	6,60	5,84	4,32	2,54	1,27	0,76	1247
	C11	1,27	2,03	2,54	3,81	4,83	6,10	6,60	6,10	4,83	3,05	1,78	1,29	1600
	C12	1,02	1,78	2,79	4,32	5,42	6,60	6,60	5,84	4,57	3,05	1,52	0,76	1354
	C13	1,02	1,78	2,54	4,06	5,33	6,60	7,37	6,35	4,83	3,05	1,52	0,76	1633
	C14	1,27	2,03	3,05	4,32	5,42	6,60	7,11	6,35	4,83	3,30	1,78	1,28	1448
	C15	1,02	2,03	3,05	4,83	6,10	6,86	7,11	6,35	4,83	3,30	1,78	1,02	1471
	C16	1,27	2,29	3,30	4,83	6,35	7,37	7,62	6,86	5,33	3,56	2,03	1,27	1588
	C17	1,52	2,54	3,81	5,08	4,97	7,62	8,13	7,11	5,59	3,56	2,29	1,52	1689
	C18	2,03	3,05	4,32	5,84	5,47	8,13	7,87	7,11	5,84	4,06	2,54	1,78	1819
XEMA	**BNY**	0,80	1,04	1,88	2,50	3,35	3,95	4,17	3,49	2,53	1,64	0,95	0,67	836
	CSL	0,72	1,05	1,86	2,39	3,30	3,84	4,24	3,70	2,47	1,59	0,87	0,57	825
	CBN	0,82	1,17	2,08	2,67	3,32	3,95	4,35	3,82	2,63	1,67	1,02	0,70	875
	TMP	0,69	1,02	1,94	2,52	3,27	3,79	4,19	3,66	2,37	1,47	0,86	0,60	818
	STP	0,78	1,10	1,98	2,59	3,26	3,75	3,99	3,51	2,56	1,64	0,94	0,66	830
	MNL	0,78	1,17	1,88	2,55	3,35	4,36	4,42	3,97	2,66	1,68	0,99	0,65	868

Annex 2: Exemplars en Català, Castellà, Anglès, Francès i Alemany de les carta de presentació enviada a les llars seleccionades per l'estudi.

Girona, Juny/Juliol de 201X

Benvolguts/des,

Des de l'Institut de Medi Ambient de la Universitat de Girona i el Departament de Geografia de la Universitat Autònoma de Barcelona estem realitzant un estudi que forma part del projecte "*Noves pautes de consum i gestió de l'aigua en espais urbanoturístics de baixa densitat*" per a conèixer les **espècies vegetals** més utilitzades en **jardineria domèstica**.

En particular, la finalitat que es persegueix amb aquest estudi és conèixer la relació entre les característiques socials i culturals de cada habitatge amb les plantes que es poden trobar en el seu jardí. Aprofitar aquest coneixement és de vital importància per tal d'orientar la **política en matèria d'aigües** cap a una gestió que promogui un ús més **eficient, respectuós i sostenible del recurs**.

Per aconseguir aquest objectiu, posem en marxa una primera fase de l'estudi basada en la recollida d'informació a través d'enquestes vinculades a la composició de plantes dels jardins domèstics dels habitatges. En total s'ha seleccionat una mostra de 300 llars en urbanitzacions distribuïdes per diferents municipis de la comarca de l'Alt Empordà (**Castelló d'Empúries, L'Armentera, L'Escala, Sant Pere Pescador i Roses**).

Per tant, li demanem la seva col·laboració i participació a l'hora d'omplir aquest senzill qüestionari amb l'ajut de l'enquestador/a. Sempre que sigui possible, seria important que l'enquesta es realitzés a l'exterior del seu habitatge a fi que l'enquestador/a pugui fer-se una idea més acurada de les característiques del seu jardí.

En el cas que vostè hagi rebut aquesta carta a la seva bústia, en un termini no superior a 7 dies ens posarem en contacte amb vostè a fi de poder concertar un dia i hora per tal de realitzar l'enquesta.

Respondre a les qüestions que es plantegen li ocuparà només 15 minuts. Els seus resultats seran emprats amb finalitats exclusivament científiques. A més, es garanteix l'anonimat dels participants i que aquestes dades seran tractades i custodiades amb respecte per a la intimitat i amb les garanties de la **Llei 15/1999 de 13 de desembre, de Protecció de Dades de Caràcter Personal**.

Volem agrair per endavant la seva col·laboració i participació per a dur a terme aquest estudi, amb la seguretat que la seva aportació serà molt valuosa per aquesta investigació.

Rebi una cordial salutació,

Josep Padullés Cubino (josep.padulles@udg.cat)
Josep Vila Subirós (josep.vila@udg.cat)
Carles Barriocanal Lozano (carles.barriocanal@udg.cat)
Responsables de l'Estudi

Universitat de Girona   UAB Universitat Autònoma de Barcelona

Per qualsevol dubte ens trobarà a la Facultat de Lletres, Universitat de Girona, Plaça Ferrater Mora, 1, 17071 Girona. Telèfons: 972 418999 – 972418778

Girona, Junio/Julio de 201X

Estimados/as,

Desde el Instituto de Medio Ambiente de la Universidad de Girona y el Departamento de Geografía de la Universidad Autónoma de Barcelona estamos realizando un estudio que forma parte del proyecto "*Nuevas pautas de consumo y gestión del agua en espacios urbanoturísticos de baja densidad*" para conocer las **especies vegetales** más utilizadas en **jardinería doméstica**.

En particular, su finalidad es conocer la relación entre las características sociales y culturales de cada vivienda con las plantas que se hallan en su jardín. Aprovechar este conocimiento es de vital importancia para orientar la **política en materia de aguas** hacia una gestión que promueva un uso más **eficiente, respetuoso y sostenible del recurso**.

Para conseguir este objetivo, ponemos en marcha la primera fase del estudio basada en la recogida de información a través de encuestas vinculadas a la composición de plantas de los jardines domésticos de las viviendas. En total se ha seleccionado una muestra de 300 hogares en urbanizaciones distribuidas por diferentes municipios de la comarca del Alt Empordà (**Castelló d'Empúries, L'Armentera, L'Escala, Sant Pere Pescador y Roses**).

Por lo tanto, pedimos su colaboración y participación para rellenar este sencillo cuestionario con la ayuda del encuestador/a. Siempre que sea posible, sería importante que la encuesta se realizara en el exterior de su vivienda para que el encuestador/a pueda hacerse una idea más precisa de las características de su jardín.

En caso de que usted haya recibido esta carta en su buzón, en un plazo no superior a 7 días nos pondremos en contacto con usted a fin de poder concertar un día y hora para realizar la encuesta.

Responder a las cuestiones que se plantean le ocupará sólo 15 minutos. Sus resultados serán utilizados con fines exclusivamente científicos. Además, se garantiza el anonimato de los participantes y que estos datos serán tratados y custodiados con respeto para la intimidad y con las garantías de la **Ley 15/1999 de 13 de diciembre, de Protección de Datos de Carácter Personal.**

Queremos agradecer de antemano su colaboración y participación para llevar a cabo este estudio, con la seguridad de que su aportación será muy valiosa para esta investigación.

Reciba un cordial saludo,

Josep Padullés Cubino (josep.padulles@udg.cat)
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Responsables del Estudio

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Girona, June/July 201X

Welcome,

The Institute of Environment of the University of Girona and the Department of Geography of the Autonomous University of Barcelona are carrying out a study that is part of the project "*New consumption patterns and water management in low density urban-tourist spaces*" to know which are the mostly cultivated **plant species in domestic gardens**.

In particular, the purpose that is pursued with this study is to examine the relationship between social and cultural features of each household with the plants growing on its garden. Harnessing this knowledge is critical to **orientate the waters policies** towards a management that promotes a **respectful, sustainable and more efficient use of the water.**

To achieve this objective, we start off a first phase of the study based on the collection of information through surveys about urban domestic garden plant composition. In total a sample of 300 homes in estates has been selected in different towns of the Alt Empordà region (**Castelló d'Empúries, L'Armentera, L'Escala, Sant Pere Pescador and Roses**).

Therefore, we ask you for your collaboration and participation when filling out this simple survey with the help of the pollster. Whenever it is possible, it would be important that the survey was carried out outdoor because the pollster can make a more accurate idea about the characteristics of your garden or courtyard.

If you have received this letter in your mailbox, in a deadline not later than 7 days we will get in touch with you in order to agree a day and an hour to poll you.

It will take you no more than 15 minutes answer the survey. Its results will be used exclusively for scientific purposes. It is not necessary to say that the anonymity of the participants is guaranteed and these data will be treated and will be guarded with respect for the privacy and with the guarantees of the **Law 15/1999 of 13 December, of Protection of Personal Data.**

We want to thanks for advance your collaboration to carry out this study, with the certainty that your contribution will be very valuable when searching directed solutions to the conservation and the good use of the water.

Kind regards,

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Carles Barriocanal Lozano (carles.barriocanal@udg.cat)
Project managers

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For any doubt, query or clarification please find us in: Facultat de Lletres, Universitat de Girona, Plaça Ferrater Mora, 1, 17071 Girona. Telèfons: 972 418999 – 972418778

Gérone, Juin/Juillet 201X

Bonjour,

Depuis l'Institut de l'Environnement de l'Université de Gérone et du Département de Géographie de l'Université Autonome de Barcelone nous menons une étude qui fait partie du projet "*Nouveaux modes de consommation et de gestion d'eau dans les zones de faible densités urbano-touristiques*" pour connaître les espèces végétales plus utilises dans le jardinage.

En particulier, l'objectif poursuivi par cette étude est de savoir la relation entre les caractéristiques sociales et culturelles de chaque logement avec les plantes qui peuvent se trouver dans votre jardin. Utiliser cette information va nous servir pour guider **la politique en matière de gestion de l'eau** afin de promouvoir une organisation plus **efficace, respectueuse et durable des ressources.**

Pour atteindre cet objectif, nous avons lancé la première phase de l'étude basée sur des informations collectées par des sondages la composition des plantes dans les jardins des appartements. En tout, nous avons sélectionné un échantillon de 300 foyers répartis dans les zones résidentielles de différentes municipalités situées dans le *Comarca de l'Alt Empordà* **(Castelló d'Empúries, L'Armentera, L'Escala, Sant Pere Pescador, Roses).**

Par conséquent, nous demandons votre collaboration et votre participation en remplissant ce questionnaire simple à l'aide de l'enquêteur/trice. Si possible, il est important que le questionnaire soit rempli à l'extérieur de votre maison afin que l'intervieweur soit en mesure de se faire une meilleure idée des caractéristiques de votre jardin ou de la cour.

Si vous avez reçu cette lettre dans votre boîte aux lettres, dans un délai de sept jours, nous prendrons contact avec vous afin de convenir d'une date et d'une heure pour remplir le questionnaire.

Répondre aux questions ne lui prendra que 15 minutes. Les résultats seront utilisés pour des fins purement scientifiques. Pas la peine de répéter qu'ils se garantissent l'anonymat des participants et que ces données seront gardées dans le respect de la vie privée avec les garanties de la **Loi 15/1999 du 13 décembre, de la Protection des Données Personnelles.**

Nous vous remercions d'avance pour votre collaboration et participation pour mener à bien cette étude, avec l'assurance que votre contribution sera précieuse lors de la recherche de solutions visant à la conservation et utilisation appropriée de l'eau qui est une ressource d'une grande valeur.

Cordialement,

Josep Padullés Cubino (josep.padulles@udg.cat)
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Responsables de l'Etude

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En cas de doute vous nous trouverez a la Faculté de Lettres, Université de Gérone, Place Ferrater Mora, 1, 17071 Gérone. Téléphones: 972 418777 – 972418717

Girona, Juni/Juli 201X

Sehr geehrte Damen und Herren,

Das Institut für Umwelt von der Universität Girona und das Geographie Department der Autonomen Universität Barcelona führen eine Studie aus, die Teil der des Projektes *“Nuevas pautas de consumo y gestión del agua en espacios urbanoturísticos de baja densidad” (Neue Konsummuster und Wasserwirtschaft in gering besiedelten urbaner-tourismus Gebiete),* um mehr über die Pflanzenarten die in heimischen Gärten verwendet werden zu erfahren.

Insbesondere möchte wir die Beziehung zwischen sozialen und kulturellen Besonderheiten der einzelnen Haushalten, mit dem im Garten befindlichen Pflanzenarten erörtern. Dieses Wissen ist entscheidend für die **Wasserpolitik** gegenüber einer Verwaltung, die eine **effizientere, respektvolle und nachhaltige Ressourcennutzung** Förden soll.

Um dieses Ziel zu erreichen, starten wir die erste Phase der Studie basierend auf die Informationserfassung durch Meinungsumfragen und die Zusammensetzung der Pflanzen in heimischen Gärten zu erfahren. Insgesamt haben wir eine Stichprobe von 300 Haushalten in Wohngebiete in verschiedenen Gemeinden der Region des Alt Empordà (**Castelló d’Empúries, L’Armentera, L’Escala, Sant Pere Pescador und Roses**) ausgewählt. Daher bitten wir Sie um Ihre Mitarbeit und Teilnahme an diesen einfachen Fragebogen.

Wenn Sie diesen Brief in Ihrem Briefkasten eingegangen ist, spätestens, wenn 7 Tage vergangen sind, werden wir uns mit Ihnen Verbindung aufnehmen, um den Fragebogen einzusammeln. Am selben Tag wird ein Techniker den Pflanzenbestand in Ihrem Garten aufnehmen.

Das Ausfüllen des Fragenbogens dauert nur 15 Minuten. Ihre Ergebnisse werden für rein wissenschaftliche Zwecke verwendet. Darüber hinaus wird die Anonymität der Teilnehmer garantiert und die Daten werden mit dem größten Respekt für die Privatsphäre bearbeitet unter der Garantie des Gesetzes **Ley 15/1999 vom 13. Dezember de Protección de Datos de Carácter Personal (zum Schutz personenbezogener Daten).**

Wir danken Ihnen im Voraus für Ihre Mitarbeit und Beteiligung an dieser Studie, mit der Gewissheit, dass Ihre Eingaben von unschätzbarem Wert für die Forschung sein werden, verbleiben wir mit freundlichen Grüßen,

Josep Padullés Cubino (josep.padulles@udg.cat)
Josep Vila Subirós (josep.vila@udg.cat)
Carles Barriocanal Lozano (carles.barriocanal@udg.cat)
Verantworliche der Studie

Universitat de Girona

Universitat Autònoma de Barcelona

Für weitere Fragen stehen wir Ihnen jederzeit zur Verfügung: Facultat de Letras, Universität Girona, Plaza Ferrater Móra 1, 17071 Girona. Telefon: 972 418999 – 972418778

Annex 3: Exemple de formulari sobre la composició i estructura dels jardins analitzats.

FORMULARI SOBRE LA COMPOSICIÓ FLORÍSTICA DE JARDINS

Investigador/a: *Codi enquesta: núm:* __________ *punt GPS*_____

Data:

I. Característiques de l'espai exterior de l'habitatge i del jardí (in situ)

I.4) Composició florística

Espècie	Nº subàrea	Número de peus	Sòl (S)/ Test (T)	Aprofit.

I.2) Quina és la tipologia d'habitatge?

- ☐ Pis
- ☐ Pis amb jardí i/o piscina comunitària
- ☐ Unifamiliar aparellada
- ☐ Adossada o entre mitgera
- ☐ Unifamiliar aïllada

I.3) Estanding orientatiu de l'habitatge.

- ☐ Baix
- ☐ Mitjà
- ☐ Alt

I.4) Indiqueu la presència dels següents elements en la parcel·la:

Element	Presència
Zones *mulching*	
Gespa plantada	
Àrea vegetal espontània	
Àrea pavimentada	
Hort	
Bosc	
Piscina	
Altres usos:	
Altres usos:	

I.5) Percentatge de cobertura vegetal de cadascuna de les subàrees del jardí i visibilitat d'aquestes des de l'exterior de la propietat.

Subàrea	Nom/ Descripció	% cobert.	Visible (S, N)	Insolació (T, M, B)	Recer del vent (S, N)
Subàrea 1					
Subàrea 2					
Subàrea 3					
Subàrea 4					

I.6) Esquema de la parcel·la (col·locar cada subàrea):

II.1) Descripció de les característiques de la parcel·la visitada a través d'ortofotoimatge.

	Superfície (m^2)
Superfície de la parcel·la	
Superfície urbanitzada	
Superfície vegetada	
Superfície gespa	

Annex 4: Exemplars en català, castellà, anglès, francès i alemany de les enquestes realitzades als residents de les llars analitzades.

ENQUESTA SOBRE LA COMPOSICIÓ FLORÍSTICA DELS JARDINS

A. Característiques de l'habitatge

A.1) És aquest habitatge de propietat?
☐ Sí ☐ No

A.2) En el cas que sigui de propietat, de quina manera va adquirir aquest habitatge?
☐ Autopromoció (compra de parcel·la i posterior construcció)
☐ Promotor immobiliari, primera mà.
☐ Particular o contractista, primera mà.
☐ Promotor immobiliari, segona mà.
☐ Particular o contractista, segona mà

A.3) Tipus d'ocupació de l'habitatge:
☐ Residència principal ☐ Residència secundària

A.4) En el cas de ser una residència secundària de propietat, marqui amb una **X** amb quina freqüència acostuma a ocupar l'habitatge:
Caps de setmana: ☐ Un per mes ☐ Dos per mes ☐ Tres per mes ☐ Gairebé tots els caps de setmana ☐ Cap
Dies festius: ☐ Cap ☐ Pocs ☐ La meitat ☐ La majoria ☐ Tots
Durant el període de vacances:
Període de l'any, aproximadament **(mesos de l'any)**: ....

A.5) En el cas de ser una residència secundària de propietat, on es troba la seva residència principal?
Localitat:........................... País:...........................

A.6) Edat de l'habitatge:
☐ Menys de 5 anys ☐ De 11 a 20 anys ☐ De 31 a 50 anys
☐ De 6 a 10 anys ☐ De 21 a 30 anys ☐ 51 anys, o més

B. Aspectes socioeconòmics

B.1) Sexe: ☐ Dona ☐ Home

B.2) País de naixement: ....

B.3) Edat: .... B.4) Edat altres membres de la llar: ....

B.5) Indiqui, mitjançant un cercle, el nombre de persones, incloent-se vostè, que viuen a la seva llar i que es troben en la situació següent:

a. Estudiant: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
b. Treballant: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
c. A l'atur: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
d. Jubilat: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
e. Altres situacions: ....

B.6) Sectors professionals (núm. persones).
a. Agricultura/ramaderia (....)
b. Indústria (....)
c. Serveis (....)
d. Construcció (....)

B.7) Quants anys fa que viu en aquest habitatge?
☐ Menys de 2 anys ☐ de 2 a 4 anys ☐ de 5 a 9 anys
☐ de 10 a 14 anys ☐ de 15 a 20 anys ☐ 21 anys o més

B.8) Quina és la seva formació acadèmica?
☐ Ha anat menys de 5 anys a l'escola.
☐ Ha cursat estudis de primària o cinc cursos aprovats d'EGB, o equivalent.
☐ Ha cursat estudis de segon cicle (BUP, COU, FP, LOGSE, ESO i BAT)
☐ Ha cursat estudis universitaris (diplomatura, enginyeria, llicenciatura o superior)

B.9) Indiqui, aproximadament, quins són els ingressos nets mensuals de la seva llar (aportació de tots els membres de la llar):

- ☐ Menys de 900 €
- ☐ Entre 900 € i menys de 1.500 €
- ☐ Entre 1.500 € i menys de 2.500 €
- ☐ Entre 2.500 € i menys de 3.500 €
- ☐ Entre 3.500 € i menys de 5.000 €
- ☐ Més de 5.000 €

C. Característiques i gestió del jardí

C.1) Durant quant de temps han existit, en l'estat actual, la majoria d'elements del seu jardí?

- ☐ Des de la seva construcció
- ☐ Des de fa 10 anys, o més
- ☐ Entre 5 anys i menys de 10
- ☐ Entre 2 anys i menys de 5
- ☐ Menys de 2 anys
- ☐ NS/NC

C.2) S'ha fet algun canvi significatiu en el jardí del vostre habitatge en els darrers 5 anys?

☐Sí ☐No

Si la resposta anterior és "SÍ", de la llista de canvis que segueix marqui amb una **X** tots els que corresponguin, indicant alhora quin és el principal motiu:

(a) estalviar aigua / (b) estalviar diners / (c) estalviar temps / (d) fer més bonic i agradable aquest espai exterior / (e) millorar l'espai d'oci de l'exterior.

	Tipus de canvis realitzats	Motius del canvi
	Posar gespa	a ( ), b ( ), c ( ), d ( ), e ( ), Altres: ....
	Pavimentar una part o tot el terra	a ( ), b ( ), c ( ), d ( ), e ( ), Altres: ....
	Retirar plantes	a ( ), b ( ), c ( ), d ( ), e ( ), Altres/quines: ....
	Fer un hort	a ( ), b ( ), c ( ), d ( ), e ( ), Altres: ....
	Posar/treure una piscina	a ( ), b ( ), c ( ), d ( ), e ( ), Altres: ....
	Altres:..	a ( ), b ( ), c ( ), d ( ), e ( ), Altres: ....
	Altres:..	a ( ), b ( ), c ( ), d ( ), e ( ), Altres: ....
	Altres:..	a ( ), b ( ), c ( ), d ( ), e ( ), Altres: ....

C.3) Ha considerat recentment realitzar canvis importants en l'estructura del seu jardí (ex: pavimentar-lo, plantar-hi un hort, construir/retirar una piscina, etc.)? En cas afirmatiu, quins canvis faria?

- ☐ Ns/Nc
- ☐ No, m'agrada el meu jardí i no tinc intenció de canviar-lo.
- ☐ Sí, si tingués els recursos o el temps per fer-ho.

Canvis: ....

C.4) Qui té cura generalment del jardí? Marqui amb una **X** tantes caselles com procedeixi.

	Ns/Nc	Ningú	Jo mateix	Altres familiars	Empresa jardineria	Altres
Qui va dissenyar el jardí?						
Qui selecciona les plantes?						
Qui poda o sega el jardí?						
Qui rega el jardí?						
Qui mena el jardí?						

C.5) Amb quina freqüència utilitza les següents fonts d'obtenció de plantes per al seu jardí? (**0=NS/NC; 1- Mai o gairebé mai; 5 – Sempre**)

a. Centres de jardineria/vivers/floristeries 0 - 1 - 2 - 3 - 4 - 5
b. Regals d'amics/veïns 0 - 1 - 2 - 3 - 4 - 5
c. Mercat/Supermercat 0 - 1 - 2 - 3 - 4 - 5
d. Paisatgistes 0 - 1 - 2 - 3 - 4 - 5
e. Esqueixo propis 0 - 1 - 2 - 3 - 4 - 5
f. Silvestres, agafades de la natura 0 - 1 - 2 - 3 - 4 - 5
g. Altres:........................... 0 - 1 - 2 - 3 - 4 – 5

C.6) Si és vostè qui adquireix les plantes per al seu jardí, què li **INFLUEIX** per escollir-les? Marqui, per a cada criteri suggerit, el grau d'influència considerant que: **0 = NS/NC; 1= gens influent, 5 = molt influent**.

a. Els meus coneixements i preferències 0 - 1 - 2 - 3 - 4 - 5
b. La oferta de plantes i el seu preu 0 - 1 - 2 - 3 - 4 - 5
c. El consell dels experts 0 - 1 - 2 - 3 - 4 - 5
d. El què veig en altres jardins 0 - 1 - 2 - 3 - 4 - 5
e. Informació recollida en llibres/Internet/etc. 0 - 1 - 2 - 3 - 4 - 5
f. Altres: .... 0 - 1 - 2 - 3 - 4 - 5

C.7) Amb quina freqüència mínima, aproximadament, incorpora **noves** plantes al seu jardí?

	Mai o gairebé mai	**Cada mes**	**Cada mig any**	**Cada any**	**Cada dos anys**	**Cada cinc anys, o més**
Gespa						
Plantes de temporada, anuals i vivaces						
Plantes aromàtiques, medicinals i culinàries						
Plantes arbustives ornamentals i enfiladisses						
Cactus i plantes crasses						
Arbres ornamentals, palmeres i coníferes						
Arbres fruiters i hortícoles						

C.8) De quina manera rega vostè el seu jardí? Marqui amb una **X** el mètode emprat per regar **cada part** del seu jardí (ex: hort, bancals de flors, arbustos, gespa, tot, etc.).

☐ **No rego el jardí**	**Gespa**	**Flors**	**Arbustos**	**Arbres**	**Altres**
Manual, amb mànega					
Manual, amb regadora					
Aspersió. Activació manual					
Aspersió. Activació automàtica					
Degoteig. Activació manual					
Degoteig. Activació automàtica					

C.9) Amb quina freqüència rega vostè el seu jardí durant les dues estacions de l'any? En quin moment del dia acostuma a fer-ho?

	Cada dia	**Dies alterns**	**Cada 3 dies**	**Cada setmana**	**No rego**	**Moment dia**
Hivern						
Estiu						

D. Variables culturals i de comportament

D.1) Respongui a les següents preguntes:

Quin percentatge de plantes del seu jardí es troben adaptades al clima mediterrani?	0%	25%	50%	75%	100%	NS/NC
Quin percentatge de plantes del seu jardí són originàries de la regió mediterrània?	0%	25%	50%	75%	100%	NS/NC

D.2) Indiqui el seu grau d'acord (5) o desacord (1) amb cadascuna de les **preferències** i **raons** de cultiu de plantes al seu jardí.

Molt en desacord	En desacord	Neutral	D'acord	Molt d'acord
1	**2**	**3**	**4**	**5**

PREFERÈNCIES que vostè busca en l'ús del seu jardí.

Per donar valor estètic a casa meva (colors, formes, varietats de plantes, etc.)	1	2	3	4	5
Per tenir cert contacte amb la natura	1	2	3	4	5
Per entretenir-m'hi com una distracció i hobby	1	2	3	4	5
Per obtenir aliments i altres productes per la llar	1	2	3	4	5
Per tenir un espai de relaxació (llegir, seure, prendre el sol, etc.)	1	2	3	4	5
Per realitzar-hi activitats domèstiques com menjar, estendre la roba, etc.	1	2	3	4	5
Per desenvolupar-hi activitats d'oci i lleure	1	2	3	4	5
Per donar més valor econòmic a casa meva	1	2	3	4	5
Altres:	1	2	3	4	5

RAONS que vostè té per cultivar les plantes del seu jardí

Perquè fan més maco el meu jardí	1	2	3	4	5
Perquè són fàcils de mantenir i necessiten poca aigua	1	2	3	4	5
Perquè mes les van recomanar	1	2	3	4	5
Perquè floreixen tot l'any	1	2	3	4	5
Perquè són plantes que s'adapten bé	1	2	3	4	5
Perquè són útils i en trec profit	1	2	3	4	5
Perquè ja estaven al jardí	1	2	3	4	5
Per raons històriques o circumstàncies personals	1	2	3	4	5
Altres:	1	2	3	4	5

Factura aigua: Si/No
Font d'obtenció d'aigua:

GRÀCIES PER LA SEVA COL·LABORACIÓ

Aquesta enquesta forma part del projecte "Noves pautes de consum i gestió de l'aigua en espais urbanoturístics de baixa densitat" realitzat per la Universitat de Girona i la Universitat Autònoma de Barcelona. Els seus resultats seran emprats amb finalitats exclusivament científiques. Es garanteix l'anonimat dels participants i que aquestes dades seran tractades i custodiades amb respecte per a la intimitat i amb les garanties de la Llei 15/1999 de 13 de desembre, de Protecció de Dades de Caràcter Personal.

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ENCUESTA SOBRE LA COMPOSICION FLORÍSTICA DELOS JARDINES

A. Características de la vivienda

A.1) ¿Es esta vivienda de propiedad?
□ Sí □ No

A.2) En caso que sea de propiedad, ¿de qué manera adquirió su casa?
□ Autopromoción (compra de parcela y posterior construcción)
□ Promotor inmobiliario, primera mano.
□ Particular o contratista, primera mano.
□ Promotor inmobiliario, segunda mano.
□ Particular o contratista, segunda mano

A.3) Tipo de ocupación de la vivienda:
□ Residencia principal □ Residencia secundaria

A.4) En caso de ser una residencia secundaria de propiedad, marque con una **X** con qué frecuencia acostumbra a ocupar la vivienda:
Fines de semana: □ Uno por mes □ Dos por mes □ Tres por mes □ Prácticamente todos □ Ninguno
Días festivos: □ Ninguno □ Pocos □ La mitad □ La mayoría □ Todos
Durante el período de vacaciones:
Período del año, aproximadamente **(meses del año)**: ....

A.5) En caso de ser una residencia secundaria propia, ¿Dónde se encuentra su residencia principal?
Localidad:........................... País:...........................

A.6) Edad de la vivienda:
□ Menos de 5 años □ De 11 a 20 años □ De 31 a 50 años
□ De 6 a 10 años □ De 21 a 30 años □ 51 años, o más

B. Aspectos socioeconómicos

B.1) Sexo: □ Mujer □ Hombre

B.2) País de nacimiento: ....

B.3) Edad: .... B.4) Edad otros miembros del hogar: ....

B.5) Indique, utilizando un círculo, el nombre de personas, incluyéndose usted, que viven en su casa y se encuentran en la situación siguiente:

a. Estudiante: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
b. Trabajando: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
c. En paro: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
d. Jubilado: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
e. Otras situaciones: ....

B.6) Sectores profesionales (núm. personas).
a. Agricultura/ganadería (....)
b. Industria (....)
c. Servicios (....)
d. Construcción (....)

B.7) ¿Cuántos años hace que vive en esta vivienda?
□ Menos de 2 años □ de 2 a 4 años □ de 5 a 9 años
□ de10 a 14 años □ de 15 a 20 años □ 21 años o más

B.8) ¿Cuál es su formación académica?
□ Ha ido menos de 5 años a la escuela.
□ Ha cursado estudios de primaria o cinco cursos aprobados de EGB, o equivalente.
□ Ha cursado estudios de segundo ciclo (BUP, COU, FP, LOGSE, ESO y BAT).
□ Ha cursado estudios universitarios (diplomatura, ingeniería, licenciatura o superior).

A.10) Indique, aproximadamente, cuales son los ingresos netos mensuales de su hogar (aportación de todos los miembros del hogar):

- ☐ Menos de 900 €
- ☐ Entre 900 € y menos de 1.500 €
- ☐ Entre 1.500 € y menos de 2.500 €
- ☐ Entre 2.500 € y menos de 3.500 €
- ☐ Entre 3.500 € y menos de 5.000 €
- ☐ Más de 5.000 €

C. Características i gestión del jardín

C.1) ¿Durante cuánto tiempo han existido, en el estado actual, la mayoría de elementos de su jardín?

- ☐ Desde su construcción
- ☐ Desde hace 10 años, o más
- ☐ Entre 5 años y menos de 10
- ☐ Entre 2 años y menos de 5
- ☐ Menos de 2 años
- ☐ NS/NC

C.2) ¿Se ha realizado algún cambio significativo en el jardín de su vivienda en los últimos 5 años?

☐Sí ☐No

Si la respuesta anterior es "SÍ", de la lista de cambio s que siguen marque con una **X** todos los que correspondan, indicando simultáneamente cuál es el principal motivo de cambio:

(a) ahorrar agua / (b) ahorrar dinero / (c) ahorrar tiempo / (d) embellecer y hacer más agradable este espacio exterior / (e) mejorar el espacio de ocio del exterior.

	Tipos de cambio realizados	Motivos del cambio
	Poner césped	a ( ), b ( ), c( ), d ( ), e ( ), Otros: ....
	Pavimentar una parte, o todo	a ( ), b ( ), c( ), d ( ), e ( ), Otros: ....
	Retirar plantas	a ( ), b ( ), c( ), d ( ), e ( ), Otros/cuáles: ....
	Hacer un huerto	a ( ), b ( ), c(), d ( ), e ( ), Otros: ....
	Poner/quitar una piscina	a ( ), b ( ), c( ), d ( ), e ( ), Otros: ....
	Otros:..	a ( ), b ( ), c( ), d ( ), e ( ), Otros: ....
	Otros:..	a ( ), b ( ), c( ), d ( ), e ( ), Otros: ....
	Otros:..	a ( ), b ( ), c( ), d ( ), e ( ), Otros: ....

C.3) ¿Ha considerado recientemente realizar cambios importantes en la estructura de su jardín (ex: pavimentarlo, hacer un huerto, construir/retirar una piscina, etc.)? En caso afirmativo, ¿qué cambios haría?

- ☐ Ns/Nc
- ☐No, me gusta mi jardín y no tengo intención de cambiarlo.
- ☐ Sí, si tuviera los recursos o el tiempo para hacerlo.

Cambios: ....

C.4) ¿Quién cuida generalmente del jardín? Marque con una **X** tantas casillas como proceda.

	Ns/Nc	Nadie	Yo mismo	Otros familiares	Empresa jardinería	Otros
¿Quién diseñó el jardín?						
¿Quién selecciona las plantas?						
¿Quién poda o sega el jardín?						
¿Quién riega el jardín?						
¿Quién mena el jardín?						

C.5) ¿Con qué frecuencia utiliza la siguientes fuentes para la obtención de plantas de su jardín? (**0=NS/NC; 1- Nunca o casi nunca; 5 – Siempre**)

a. Centros de jardinería/viveros/floristerías	0 - 1 - 2 - 3 - 4 - 5
b. Regalos de amigos/vecinos	0 - 1 - 2 - 3 - 4 - 5
c. Mercado/Supermercado	0 - 1 - 2 - 3 - 4 - 5
d. Paisajistas	0 - 1 - 2 - 3 - 4 - 5
e. Esquejes propios	0 - 1 - 2 - 3 - 4 - 5
f. Silvestres, recogidas en la naturaleza	0 - 1 - 2 - 3 - 4 - 5
g. Altres:...........................	0 - 1 - 2 - 3 - 4 – 5

C.6) Si es usted quién adquiere las plantas para su jardín, ¿qué le **INFLUYE** para escogerlas? (Marque, para cada criterio sugerido, el grado de influencia considerando que: **0 = NS/NC; 1= nada influyente, 5 = muy influyente**.

a. Mis conocimientos y preferencias	0 - 1 - 2 - 3 - 4 - 5
b. La oferta de plantas y su precio	0 - 1 - 2 - 3 - 4 - 5
c. El consejo de los expertos	0 - 1 - 2 - 3 - 4 - 5
d. Lo qué veo en otros jardines	0 - 1 - 2 - 3 - 4 - 5
e. Información recogida en libros/Internet/etc.	0 - 1 - 2 - 3 - 4 - 5
f. Otros:	0 - 1 - 2 - 3 - 4 – 5

C.7) ¿Con qué frecuencia mínima, aproximadamente, incorpora **nuevas** plantas a su jardín?

	Nunca o casi nunca	Cada mes	Cada medio año	Cada año	Cada dos años	Cada cinco años, o más
Césped						
Plantas de temporada, anuales y vivaces						
Plantas aromáticas, medicinales y culinarias						
Plantas arbustivas ornamentales y trepadoras						
Cactus y plantas crasas						
Árboles ornamentales, palmeras y coníferas						
Árboles fruteros y hortícolas						

C.8) ¿De qué manera riega usted su jardín? Marque con una **X** el método emprado para regar cada parte de su jardín (ex: huerto, bancales de flores, arbustos, césped, todo, etc.):

☐ **No riego el jardín**

	Césped	Flores	Arbustos	Árboles	Otros
Manual, con manguera					
Manual, con regadora					
Aspersión. Activación manual					
Aspersión. Activación automática					
Goteo. Activación manual					
Goteo. Activación automática					

C.9) ¿Con que frecuencia riega usted su jardín durante las dos estaciones del año? ¿En qué momento del día acostumbra a hacerlo?

	Cada día	Días alternos	Cada 3 días	Cada semana	No riego	Momento día
Invierno						
Verano						

D. Variables culturales i de comportamiento

D.1) Responda a las siguientes preguntas:

¿Qué porcentaje de plantas de su jardín se hallan adaptadas al clima mediterráneo?	0%	25%	50%	75%	100%	NS/NC
¿Qué porcentaje de plantas de su jardín son nativas del área mediterránea?	0%	25%	50%	75%	100%	NS/NC

D.2) Indique su grado de acuerdo (5) o desacuerdo (1) con cada una de las **preferencias** y **razones** de cultivo de plantas en su jardín:

Muy en desacuerdo	Desacuerdo	Neutral	De acuerdo	Muy de acuerdo
1	**2**	**3**	**4**	**5**

PREFERÉNCIAS que usted busca en el uso de su jardín.

Para dar valor estético a mi casa (colores, formas, variedades de plantas, etc.)	1	2	3	4	5
Para tener cierto contacto con la natura	1	2	3	4	5
Para entretener-me como distracción y hobby	1	2	3	4	5
Para obtener alimentos y otros productos para el hogar	1	2	3	4	5
Para tener un espacio de relajación (leer, sentarse, tomar el sol, etc.)	1	2	3	4	5
Para realizar en él actividades domésticas como comer, tender la ropa, etc.	1	2	3	4	5
Para desarrollar en él actividades de ocio	1	2	3	4	5
Para dar más valor económico a mi casa	1	2	3	4	5
Otros:	1	2	3	4	5

RAZONES que usted tiene para cultivar las plantas de su jardín

Porque hacen más bonito mi jardín	1	2	3	4	5
Porque son fáciles de mantener y necesitan poca agua	1	2	3	4	5
Porque me las recomendaron	1	2	3	4	5
Porque florecen todo el año	1	2	3	4	5
Porque son plantas que se adaptan bien	1	2	3	4	5
Porque son útiles y saco provecho	1	2	3	4	5
Porque ya estaban en el jardín	1	2	3	4	5
Por razones históricas o circunstancias personales	1	2	3	4	5
Otros:	1	2	3	4	5

Factura aigua: Si/No
Font d'obtenció d'aigua:

GRÁCIAS POR SU COLABORACIÓN

Esta encuesta forma parte del proyecto "Nuevas pautas de consumo y gestión del agua en espacios urbanoturísticos de baja densidad" realizado por la Universidad de Girona i la Universidad Autónoma de Barcelona. Sus resultados serán utilizados con finalidades exclusivamente científicas. Se garantiza el anonimato delos participantes y que estos datos serán tratados y custodiados con respecte per a la intimidad y con las garantías de la Ley 15/1999 de 13 de diciembre, de Protección de Datos de Carácter Personal.

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SURVEY ABOUT GARDEN PLANT COMPOSITION

A. Housing characteristics

A.1) Do you own this house?
- ☐ Yes ☐ No

A.2) If you own this house, who did you get it from?
- ☐ Self-promotion
- ☐ Property developer, second hand.
- ☐ Property developer, first hand.
- ☐ Individual or contractor, second hand.
- ☐ Individual or contractor, first hand.

A.3) Kind of residence:
- ☐ Main residence ☐ Secondary residence

A.4) In the case of being a secondary residence of your own, mark with an **X** how often you occupy this house:

Weekends: ☐ Once a month ☐ Twice a month ☐ Three times a month ☐ Almost all weekends ☐ None

Public holidays: ☐ None ☐ Few of them ☐ Half of them ☐ Most of them ☐ All

Being on labour vacations:

Periods of the year, approximately **(months of the year)**: ....

A.5) In the case of being a secondary residence of your own, where is your main residence?

Locality:........................... Country:...........................

A.6) Age of building:
- ☐ Less than 5 years ☐ 11 to 20 years ☐ 31 to 50 years
- ☐ 6 to 10 years ☐ 21 to 30 years ☐ More than 51 years

B. General aspects

B.1) Gender: ☐ Female ☐ Male

B.2) Country of birth: ....

B.3) Age: .... B.4) Age of all other members of the house: ……………….

B.5) Please indicate by circling how many residents in this house are ion one of the following situations:

a. Studying: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
b. Working: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
c. Unemployed: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
d. Retired: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
e. Other situations:...

B.6) Professional dedication (num. people).
a. Agriculture/livestock (....)
b. Industry (....)
c. Services (....)
d. Construction (....)

B.7) Please indicate the number of years that you have been living in this house?
- ☐ Less than 2 years ☐ 2 to 4 years ☐ 5 to 9 years
- ☐ 10 to 14 years ☐ 15 to 20 years ☐ 21 years and over

B.8) Please indicate which is your level of education.
- ☐ I have gone to school less than 5 years.
- ☐ First grade: Primary school.
- ☐ Second grade: Secondary school and/or technical school.
- ☐ Third grade: Graduated from university, post-degree or PhD.

B.9) Please indicate which income range describes your household's total gross income per month in the last financial year.

- ☐ Less than 900 €
- ☐ 901 € to 1.500 €
- ☐ 1.501 € to 2.500 €
- ☐ 2.501 € to 3.500 €
- ☐ 3.501 € to 5.000 €
- ☐ Over 5.001 €

C. Features and management of the garden

C.1) How long have existed, in its current state, most of the elements in your garden?

- ☐ Since it was built
- ☐ For 10 years or more
- ☐ Between 5 years and less than 10
- ☐ Between 2 years and less than 5
- ☐ Less than 2 years
- ☐ NS/NC

C.2) Have you done some meaningful change in your yard in the last 5 years?

☐Yes ☐No

If the answer is "yes", from de following list of changes, mark with an "X" the ones that match, marking also which the main reason is:

(a) concern to preserve water / (b) save money / (c) spending less time / (d) increase the aesthetic value of my home / (e) make the outdoor of my house more enjoyable

	Kind of change	Change reasons
	Plant lawn	a ( ), b ( ), c ( ), d ( ), e ( ), Others: ....
	Paveall or part ofthegarden land	a ( ), b ( ), c ( ), d ( ), e ( ), Others: ....
	Remove plants	a ( ), b ( ), c ( ), d ( ), e ( ), Others/Which: ....
	Plantar new plants	a ( ), b ( ), c ( ), d ( ), e ( ), Others: ....
	Plant more Mediterranean plants	a ( ), b ( ), c ( ), d ( ), e ( ), Others: ....
	Make vegetable garden	a ( ), b ( ), c ( ), d ( ), e ( ), Others: ....
	Make a swimming pool	a ( ), b ( ), c ( ), d ( ), e ( ), Others: ....
	Others:..	a ( ), b ( ), c ( ), d ( ), e ( ), Others: ....
	Others:..	a ( ), b ( ), c ( ), d ( ), e ( ), Others: ....
	Others:..	a ( ), b ( ), c ( ), d ( ), e ( ), Others: ....

C.3) Have you recently considered to make significant changes in the structure of your garden (e.g., pave it, planting a vegetable garden, building/removing a swimming pool, etc.)? If so, what changes would you do?

- ☐ DK/NA
- ☐ Yes, if I had the money or the time to do so.
- ☐ No, I like my garden and I have no intention of changing it.

Changes to do: ....

C.4) Who usually takes care of the garden? Mark with an "X" as many answers you consider appropriate.

	DK/ NA	Nobody	Me	Other relatives	Landscaping company	Others
Who designed the garden?						
Who selects the plants?						
Who prunes and mows the garden?						
Who waters the garden?						
Who manages the garden?						

C.5) What is the **main source** for obtaining plants for your garden? Mark each of the proposed sources according to the frequency you visit them: **0 = DK/NA; 1= Never o hardly ever, 5 = always**.

a. Garden centre/nursery/florists 0 - 1 - 2 - 3 - 4 - 5
b. Presents from friends/neighbours 0 - 1 - 2 - 3 - 4 - 5
c. Market/Supermarket 0 - 1 - 2 - 3 - 4 - 5
d. Landscape company 0 - 1 - 2 - 3 - 4 - 5
e. Own cuttings 0 - 1 - 2 - 3 - 4 - 5
f. Wild, taken from nature 0 - 1 - 2 - 3 - 4 - 5
g. Others:........................... 0 - 1 - 2 - 3 - 4 – 5

C.6) If you select the plants in your garden, which is the main criterion for choosing them? Mark, for each of the proposed criteria, the degree of influence they have on you considering that: **0 = DK/NA; 1= not at all influential, 5 = very influential**.

a. My knowledge and preferences in gardening 0 - 1 - 2 - 3 - 4 - 5
b. The range of plants sold and their prices 0 - 1 - 2 - 3 - 4 - 5
c. The expert advices 0 - 1 - 2 - 3 - 4 - 5
d. What I see in other gardens 0 - 1 - 2 - 3 - 4 - 5
e. The information found in books/Internet/etc. 0 - 1 - 2 - 3 - 4 - 5
f. Others: .... 0 - 1 - 2 - 3 - 4 - 5

C.7) How often minimal, approximately, do you include new plants into your garden?

	Never or hardly never	**Every month**	**Every half a year**	**Every year**	**Every two years**	**Every five years, or more**
Lawn						
Seasonal plants, annuals and perennials						
Aromatic, medicinal and culinary plants						
Ornamental shrubs and vines						
Cactus and succulent plants						
Ornamental trees, palms and conifers						
Fruit trees and vegetables						

C.8) How do you water your garden? Mark with an **"X"** the way of water with the corresponding element of the garden watered. If your garden does not have any of the parts described below, leave it **blank**.

☐ **I never water my garden**

	Lawn	**Flower terrace**	**Ornamental shrubs**	**Trees**	**Others: ....**
I do not water this part					
Hand watering with hose					
Hand watering with watering can					
Sprinkling. Manual activation					
Sprinkling. Automatic activation					
Drip irrigation. Manual activation					
Drip irrigation. Automatic activation					

C.9) How often do you water your garden during the two seasons? At what time of day usually do you water your garden?

	Every day	**Alternate days**	**Every 3 days**	**Every week**	**No irrigation**	**Moment day**
Winter						
Summer						

D. Cultural and behaviour variables

D.1) Answer the following questions (blank = DK/NA):

Which percentage of plants in your garden do you think are well adapted to the Mediterranean climate?	0%	25%	50%	75%	100%
Which percentage of plants in your garden do you think are autochthonous from this Mediterranean region?	0%	25%	50%	75%	100%

D.2) Following the next scale, please indicate your level of agreement (5) or disagreement (1) to each of the **preferences** and **reasons** for cultivating plants in your garden (blank = DK/NA):

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	**2**	**3**	**4**	**5**

PREFERENCES you look into the use of your garden.

To provide aesthetic value to my house (colour, shapes, varieties of plants, etc.)	1	2	3	4	5
To have some contact with nature	1	2	3	4	5
To entertain me as a hobby	1	2	3	4	5
To obtain food and other household products	1	2	3	4	5
To have a place to relax (reading, setting, sunbathing, etc.)	1	2	3	4	5
To make domestic activities such as eating, drying, etc.	1	2	3	4	5
To be used for recreational and leisure activities	1	2	3	4	5
To give a higher economic value to my home	1	2	3	4	5
Others:	1	2	3	4	5

REASONS you have to cultivate your plants in the garden

Because they make my garden more beautiful	1	2	3	4	5
Because they are easy to maintain and need little water	1	2	3	4	5
Because someone recommended them to me	1	2	3	4	5
Because they bloom all year	1	2	3	4	5
Because they are adapted to the place and the climate	1	2	3	4	5
Because they are useful and I take profit of them	1	2	3	4	5
Because they were already in the garden when I arrived	1	2	3	4	5
Because of historical reasons or personal circumstances	1	2	3	4	5
Others:	1	2	3	4	5

Factura aigua: Si/No
Font d'obtenció d'aigua:

THANS FOR YOUR COLLABORATION

This survey is part of the project "New consumption patterns and water management in low density urban-tourist spaces" carried out by the University of Girona and the Autonomous University of Barcelona. Its results will be used exclusively for scientific purposes. The anonymity of the participants is guaranteed and these data will be treated and will be guarded with respect for the privacy and with the guarantees of the Law 15/1999 of 13 December, of Protection of Personal Data.

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SONDAGE SUR LA COMPOSITION FLORISTIQUE DES JARDINS

A. Caractéristiques de l'habitation

A.1) Vous en êtes le propriétaire?
□ Oui □ Non

A.2) Dans le cas que vous en soyez le propriétaire, de quel façon vous avez acquis cette habitation?
□ Autopromotion (achat de parcelle et postérieur construction)
□ Promoteur immobilier, à neuf.
□ Particulier, maison neuve.
□ Promoteur immobilier, occasion.
□ Particulier, occasion.

A.3) Type de résidence :
□ Résidence principal □ Résidence secondaire

A.4) Dans de lac d'une propre résidence secondaire, cochez avec une **<u>X</u>** avec quel fréquence vous occupez la maison :

Weekends: □ Un pour moi □ Deux pour moi □ Trois pour moi □ Presque tous les weekends □ Aucun

Jours fériés: □ Aucun □ Peut □ La moitié □ La majorité □ Tous

Pendant le période des vacances:

Période de l'année, approximativement **(mois de l'année)**: ....

A.5) Dans le cas d'une propre résidence secondaire, ou se trouve votre résidence principale?
Ville:.......................... Pays:..........................

A.6) Age du bâtiment:
□ Moins de 5 ans □ De 11 à 20 ans □ De 31 à 50 ans
□ De 6 à 10 ans □ De 21 à 30 ans □ 51 ans, ou plus

B. Aspects socioéconomiques

B.1) Sexe: □ Femme □ Homme

B.2) Pays de naissance: ....

B.3) Âge: .... B.4) âges des personnes qui habitent dans votre maison? ....

B.5) Signaler avec un cercle le numéro de personnes, vous comprise, qui habitent dans votre maison et qui se trouvent dans la situation ci-dessous :

a. étudiant: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
b. travailler: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
c. chômage: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
d. retraité 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
e. autres situations: ....

B.6)Secteurs professionnels (núm. personnes).
a. Agriculture/ élevage (….)
b. Industrie (....)
c. Services publics (....)
d. Construction (....)

B.7) Combien d'années ça fait que vous occupez la maison?
□ Moins de 2 ans □ de 2 à 4 ans □ de 5 à 9 ans
□ De 10 à 14 ans □ de 15 à 20 ans □ 21 ans ou plus

B.8) Quel est votre formation académique?
□ J'ai fait moins de 5 ans d'école
□ J'ai fait l'école élémentaire ou équivalente.
□ J'ai fait études d'enseignement secondaire.
□ J'ai fait des études supérieures.

B.9) Signaler de façon approximative les revenus imposables de votre famille (somme de toutes les personnes qui habitent la maison)

☐ Moins de 900 €	☐ Entre 2.500 € et moins de 3.500 €
☐ Entre 900 € et moins de 1.500 €	☐ Entre 3.500 € et moins de 5.000 €
☐ Entre 1.500 € et moins de 2.500 €	☐ Plus de 5.000 €

C. Caractéristiques et gestion du jardin :

C.1) Pendant combien du temps ont existé, dans l'état actuel, la majorité des éléments du jardin?

☐ Depuis sa construction ☐ Entre 5 ans et moins de 10 ☐ Moins de 2 ans
☐ Depuis 10 ans, ou plus ☐ Entre 2 ans et moins de 5 ☐ NSP

C.2) Il y a ù un changement significatif dans votre jardin les dernières 5 ans?

☐Oui ☐ Non

Si la réponse antérieure est "OUI", dans la liste a continuation cochez avec une **X** tous qu'ils correspondent, indiquant au même temps quel est le motif principale:
(a) Economiser de l'eau / (b) faire des économies / (c) gain du temps / (d) faire plus jolie et agréable l'espace extérieur / (e)améliorer l'espace récréatif extérieur.

	Type de changement fait	Motif du changement
	Planter du gazon	a ( ), b ( ), c ( ), d ( ), e ( ), Autres: ....
	Bétonner une partie ou tout le sol	a ( ), b ( ), c ( ), d ( ), e ( ), Autres: ....
	Sortir plantes	a ( ), b ( ), c ( ), d ( ), e ( ), Autres/quels: ....
	Faire un potager	a ( ), b ( ), c ( ), d ( ), e ( ), Autres: ....
	Faire/supprimer une piscine	a ( ), b ( ), c ( ), d ( ), e ( ), Autres: ....
	Autres:..	a ( ), b ( ), c ( ), d ( ), e ( ), Autres: ....
	Autres:..	a ( ), b ( ), c ( ), d ( ), e ( ), Autres: ....
	Autres:..	a ( ), b ( ), c ( ), d ( ), e ( ), Autres: ....

C.3) Serais vous disponible a fer des changements importantes dans l'structure de votre jardin (bétonner, faire un potager, construire/enlever une piscine, etc.)? Si c'est oui, quels changements vous feraient?

☐ NSP ☐ Non, j'aime mon jardin et je ne veux pas le changer ☐Oui, si j'aurais des possibilités économiques ou le temps.

Changements: ....

C.4) Qui sent charge généralement du jardin? Cochez avec une **X** plusieurs options s'il faut.

	NSP	Personne	Moi	Autres familiers	Enterprise paysagiste	Autres
Qui a designer le jardin ?						
Qui choisit les plantes ?						
Qui taille ou coupe le jardin ?						
Qui arrose le jardin ?						
Qui prend soin du jardin?						

C.5) Quel est le **principal** moyenne d'obtention de plantes pour votre jardin? Avec quelle fréquence vous utilisez les suivantes sources d'obtention de plantes pour votre jardin? (**0=NSP; 1- Jamais ou presque jamais; 5 – Toujours**)

a. Centre de jardinerie/pépinière/fleuriste	0 - 1 - 2 - 3 - 4 - 5
b. Cadeaux d'amis/voisins	0 - 1 - 2 - 3 - 4 - 5
c. Marché/Supermarché	0 - 1 - 2 - 3 - 4 - 5
d. Enterprise paysagiste	0 - 1 - 2 - 3 - 4 - 5
e. Boutures	0 - 1 - 2 - 3 - 4 - 5
f. Sauvages, récoltes en nature	0 - 1 - 2 - 3 - 4 - 5
g. Autres:...........................	0 - 1 - 2 - 3 - 4 – 5

C.6) Si vous qui choisit les plantes pour le jardin, quel est les critères que suivez-vous pour les choisir? Encercle, pour chaque critère proposé, le dégrée d'importance que ont sur vous, sachant que: **0 = peu influent, 5 = très influent.**

a. Mes compétences et préférences en jardinerie	0 - 1 - 2 - 3 - 4 - 5
b. L'offre de plantes et son prix	0 - 1 - 2 - 3 - 4 - 5
c. Les conseils des experts	0 - 1 - 2 - 3 - 4 - 5
d. Des choses que je voie dans des autres jardins	0 - 1 - 2 - 3 - 4 - 5
e. Des informations sur livres/Internet/etc.	0 - 1 - 2 - 3 - 4 - 5
f. Autres:	0 - 1 - 2 - 3 - 4 - 5

C.7) Avec quel fréquence, approximativement, vous introduisez des nouvelles plantes dans votre jardin?

	Jamais ou presque jamais	Chaque mois	Chaque six mois	Chaque année	Chaque deux an	Chaque cinq an, où plus
Gazon						
Plantes de saison, annuelles et vivaces						
Plantes aromatiques, médicinales et culinaires						
Arbustes d'ornement et plantes grimpantes						
Cactus et plantes succulentes						
Arbres ornementales, palmiers et conifères						
Arbres fruitiers et espèces horticoles						

C.8) De quel façon vous arrosez votre jardin? Cochez avec <u>**X**</u> comment vous arrosez **chaque partie** de votre jardin.

☐ **N'arrose pas**

	Pelouse	Fleurs	Arbustes	Arbres	Autres
N'arrose pas cette partie					
Manuel, avec tuyau d'arrosage					
Manuel, avec arrosoir					
Aspersion. Activation manuel					
Aspersion. Activation automatique					
Goutte à goutte. Activation manuel					
Goutte à goutte. Activation automatique					

C.9) Avec quelle fréquence vous arrosez votre jardin pendant les deux saisons de l'année? Dans quel moment de la journée vous avec l'habitude de le faire?

	chaque jour	chaque Deux jours	Tous les 3 jours	Chaque semaine	Pas d'irrig.	heure de la journée
Hiver						
Été						

D. Variabilités culturales et de comportement

D.1) Répondez à la question suivante:

Quel pourcentage de plantes de votre jardin sont-elles adaptées au climat méditerranéen?	0%	25%	50%	75%	100%	NS/NC
Quel pourcentage des plantes de votre jardin sont-elles originaires de la région méditerranéenne?	0%	25%	50%	75%	100%	NS/NC

D.2) Répondez à la question suivante en fonction de l'échelle de ponctuations ci-dessous:

Fortement en désaccord	En désaccord	Neutre	D'accord	Fortement d'accord
1	**2**	**3**	**4**	**5**

PREFERENCES: Pourquoi avez-vous un jardin ?

Pour lui donner de valeur esthétique à maison (couleurs, formes, variétés de plantes, etc.)	1	2	3	4	5
Pour avoir du contact avec la nature	1	2	3	4	5
Pour avoir une distraction au hobby	1	2	3	4	5
Pour obtenir des aliments et des autres produits pour la maison	1	2	3	4	5
Pour avoir un espace de relaxation (lire, s'assoir, prendre le soleil, etc.)	1	2	3	4	5
Pour faire des activités domestiques comment des repas, étendre le linge, etc.	1	2	3	4	5
Pour faire des loisirs	1	2	3	4	5
Pour lui donner plus de valeur économique a la maison	1	2	3	4	5
Autres:	1	2	3	4	5

RAISONS que vous avez pour cultiver les plantes de votre jardin

Parce que mon jardin est plus joli	1	2	3	4	5
Parce que sont faciles d'entretenir et elles ont besoin de pas trop d'eau	1	2	3	4	5
Parce que me les ont recommandés	1	2	3	4	5
Parce qu'els fleurissent toute l'année	1	2	3	4	5
Parce que sont des plantes que s'adaptent bien	1	2	3	4	5
Parce que sont utiles et j'ai en profite	1	2	3	4	5
Parce que elles été déjà au jardin	1	2	3	4	5
Pour des raisons historiques ou circonstances personnelles	1	2	3	4	5
Autres:	1	2	3	4	5

Factura aigua: Si/No
Font d'obtenció d'aigua:

MERCI POUR SA COLLABORATION

Ce sondage fait partie du projet "Nouveaux modes de consommation et gestion de l'eau dans les zones de faible densités urbano-touristiques" réalisé par l'Université de Gérone et l'Université Autonome de Barcelone. Ses résultats seront utilisés à des fins scientifiques. Il se garantie l'anonymat des participants et que ces données seront gardées dans le respect de la vie privée avec les garanties de la Loi 15/1999 du 13 décembre, de la Protection des Données Personnelles.

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UMFRAGE ÜBER DIE VERWALTUNG VON HAUSGÄRTEN

Abschnitt A: ***In diesem Abschnitt werden die sozialen Aspekte der Bewohner der Anwesen analysiert, um diese mit der Art des Gartens zu verknüpfen. Sie können Fragen, auf die Sie die Antwort nicht kennen, unbeantwortet lassen.***

A.1) Geschlecht: ☐ Frau ☐Mann

A.2) Welches ist Ihr Geburtsland? ....

A.3) Was ist Ihr Alter? ....

A.4) Welches Alter haben die anderen Mitbewohner? ....

A.5) Geben Sie mithilfe eines Kreises an, die Anzahl der Bewohner, einschließlich sich selbst, die sich den folgenden Situation wiederfinden:
a. Student: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
b. Beschäftigt: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
c. Beschäftigungssuchend: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
d. Rentner: 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
e. Andere Situationen: ....

A.6) Geben Sie mit Hilfe eines Kreises die Anzahl der Bewohner, einschließlich sich selbst, an, die in den folgenden Bereichen arbeiten:
a. Landwirtschaft 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
b. Industrie 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
c. Serviceleistungen 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
d. Bau 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10
e. Andere Bereiche: ....

A.7) Wie viele Jahre bewohnen Sie das Anwesen?
☐ Weniger als 2 Jahre ☐ 2 bis 4 Jahre ☐5 bis 9 Jahre
☐ 10 bis 14 Jahre ☐ 15 bis 20 Jahre ☐21 oder mehr Jahre

A.8) Welche Ausbildung haben Sie?
☐ Ich war weniger als 4 Jahre in der Schule.
☐ Ich war in der Grundschule/Gymnasium.
☐ Ich war im Realschulabschluss / Hauptschulabschluss / Abitur.
☐ Ich habe ein abgeschlossenes Studium (Diplom, Master, Magister, oder höher).

B.9) Bitte kreuzen Sie die Einkommenspanne an, die das Bruttoeinkommen pro Monat Ihres Haushaltes im letzten Jahr wiedergibt.
☐ weniger als 900 €
☐ 901 € bis 1500 €
☐ 1501 € bis 2500 €
☐ 2501 € bis 3500 €
☐ 3501 € bis 5000 €
☐ mehr als 5001 €

Abschnitt B: ***Ziel von diesem Abschnitt ist es Daten über die Merkmale Ihres Hauses zu sammeln, um diese auf die Art der Anlage der Pflanzen in Ihrem Garten zurück zu führen. Sie können Fragen, auf die Sie die Antwort nicht kennen, unbeantwortet lassen.***

B.1) Ist das Anwesen Ihr Eigentum? ☐Ja ☐ Nein

B.2) Falls sie Frage B.1 mit „Ja" beantwortet haben: Wie haben Sie Ihr Anwesen gekauft?
☐ Hausbau (Grundstückskauf mit anschließendem Bau)
☐ Immbolienentwickler, aus 1. Hand.
☐ Privatperson oder Auftragsnehmer, aus 1. Hand.
☐ Immobilienmakler aus 2. Hand.
☐ Privatperson oder Auftragsnehmer, aus 2. Hand

B.3) Ist dieses Ihr Hauptwohnsitz oder Zweitwohnsitz?
☐ Hauptwohnsitz ☐ Zweitwohnsitz
**Hinweis: Wenn Sie nicht der Eigentümer sind und das Anwesen Zweitwohnsitz ist, stoppen Sie bitte mit der Umfrage.*

B.4) Im Falle eines Zweitwohnsitzes, markieren Sie mit einem ***X***, wie oft Sie diesen Wohnsitz benutzen:

Wochenende: ☐Niemals ☐ 1 mal pro Monat ☐ 2 mal pro Monat ☐ 3 mal pro Monat ☐ Fast jedes Wochenende

Feiertage: ☐ Keine ☐ Wenige ☐ Die Hälfte ☐ Fast alle ☐ Alle

Während der Urlaubszeit:

Jahreszeitraum, in etwa **(Monate im Jahr)**: ....

B.5) Im Falle eines Zweitwohnsitzes, wo befindet sich Ihr Hauptwohnsitz?
Land:..........................

B.6) Wie alt ist das Anwesen?

☐ Weniger als 5 Jahre ☐11 bis 20 Jahre ☐31 bis 50 Jahre
☐6 bis Jahre ☐21 bis 30 Jahre ☐51 Jahre oder älter

Abschnitt C. ***In diesem Abschnitt werden Informationen über die Merkmale und Verwaltung vom Garten gesammelt. Sie können Fragen, auf die Sie die Antwort nicht kennen, unbeantwortet lassen.***

C.1) Wie lange existieren, im heutigen Zustand, die Mehrheit der Elemente in Ihrem Garten?

☐ Seit der Erbauung ☐ Zwischen 5, weniger als 10 ☐Weniger als 2 Jahre
☐ 10 Jahre oder mehr ☐ Zwischen 2, weniger als 5 Jahre ☐Weiß ich nicht

C.2) Gab es wesentliche Änderungen in den letzten **5 Jahren**?

☐Ja ☐Nein

Falls die Antwort "JA" ist, markieren Sie mit einem **X** alle wesentlichen Änderungen und geben Sie gleichzeitig die Hauptgründe für diese an:

(a) Wasser sparen / (b) Geld sparen / (c) Zeit sparen / (d) Verschönerung und Außenbereich dekorieren / (e) den Außenbereich zu verbessern.

	Vorgenommene Änderungen	Änderungsgründe
	Rasen setzen	a ( ), b ( ), c ( ), d ( ), e ( ), Andere: ....
	Einen Teil oder ganz betonieren	a ( ), b ( ), c ( ), d ( ), e ( ), Andere: ....
	Pflanzen entfernen	a ( ), b ( ), c ( ), d ( ), e ( ), Andere/welche: ....
	Anlegung eines Gemüsegartens	a ( ), b ( ), c (), d ( ), e ( ), Andere: ....
	Bau/Abbau eines Schwimmbads	a ( ), b ( ), c ( ), d ( ), e ( ), Andere: ....
	Sonstiges......................................	a ( ), b ( ), c ( ), d ( ), e ( ), Andere: ....
	Sonstiges:....................................	a ( ), b ( ), c ( ), d ( ), e ( ), Andere: ....
	Sonstiges:....................................	a ( ), b ( ), c ( ), d ( ), e ( ), Andere: …......................................

C.3) Erwägen Sie wesentlichen Änderungen in naher Zukunft in Ihrem Garten durchzuführen (zum Beispiel Betonierung, Gemüsegarten anlegen, Bau/Abbau Schwimmbad, etc.)? Falls Ja, welchen Änderungen? Markieren Sie mit, einen **X** Ihre Antwort:

☐ Nein, Ich mag meinen Garten und habe nicht die Absicht ihn zu ändern. ☐ Ja, wenn Ich die Ressourcen und die Zeit dafür hätte ☐Keine Antwort

Änderungen: ....

C.4) Wer kümmert sich in der Regel um den Garten? Markieren Sie mit einem **X**.

	Weiß nicht	Keiner	Ich	Familie	Gärtnerei	Andere
Wer hat den Garten gestaltet?						
Wer hat die Pflanzen ausgesucht?						
Wer beschneidet den Garten?						
Wer bewässert den Garten?						

C.5) Woher kommen oder erwerben Sie Ihre Pflanzen. Welche Quellen benutzen Sie? Kreuzen sie die entsprechende Quelle je nach Häufigkeit des Besuchs an. **0 = WN/KA; 1 = niemals/kaum; 5 = immer**

a. Gartencenter/Baumschule/Gärtnerei 0 - 1 - 2 - 3 - 4 - 5
b. Geschenke von Freunden/Nachbarn 0 - 1 - 2 - 3 - 4 - 5
c. Markt/Supermarkt 0 - 1 - 2 - 3 - 4 - 5
d. Gärtnerei 0 - 1 - 2 - 3 - 4 - 5
e. Stecklinge 0 - 1 - 2 - 3 - 4 - 5
f. Wilde Pflanzen, selbst gepflügt 0 - 1 - 2 - 3 - 4 - 5
g. Andere:............................ 0 - 1 - 2 - 3 - 4 – 5

C.6) Falls Sie selbst Ihre Pflanzen kaufen, was **beeinflusst** Sie beim Kauf? Kreuzen Sie die entsprechenden Kriterien je nach Beeinflussungsgrad an. **0 = WN/KA; 1 = Keine Beeinflussung; 5 = starke Beeinflussung**

a. Mein Wissen und Geschmack 0 - 1 - 2 - 3 - 4 - 5
b. der Preis und das Angebot 0 - 1 - 2 - 3 - 4 - 5
c. Rat von Experten 0 - 1 - 2 - 3 - 4 - 5
d. Was ich in anderen Gärten sehe 0 - 1 - 2 - 3 - 4 - 5
e. Was ich in Bücher oder Internet lese. 0 - 1 - 2 - 3 - 4 - 5
f. Andere: .... 0 - 1 - 2 - 3 - 4 - 5

C.7) Wie häufig pflanzen Sie **neue** Pflanzen im Garten? (ungefähre Angabe)

	Fast nie	Jeden Monat	Jedes halbe Jahr	Jedes Jahr	Alle 2 Jahre	Alle 5 oder mehr Jahre
Rasen						
Saison Pflanzen, Stauden und Einjährige						
Heil-, Duft-und Kulinarische Pflanzen						
Ziersträucher und Kletterpflanzen						
Kakteen und Sukkulenten						
Ornamental Bäume, Palmen und Koniferen						
Obstbäume und Gemüse						

C.8) Welche Bewässerungsart benutzen Sie? Markieren Sie mit einem X wie Sie jeden Teil des Garten bewässern (zum Beispiel Gemüsegarten, Terrassen mit Blumen, Sträucher, Rasen, etc.):

☐ **Ich bewässere nicht**

	Rasen	Blumen	Sträucher	Bäume	Andere: .....
Manuell mit Gartenschlauch					
Manuell mit Gießkanne					
Sprühen. Manuelle Einstellung					
Sprühen. Automatische Einstellung					
Tropf. Manuelle Einstellung					
Tropf. Automatische Einstellung					

C.9) Wie oft bewässern Sie ihren Garten? Zu welcher Tageszeit?

	Jeden Tag	Alle 2 Tage	Alle 3 Tage	Jede Woche	Ich gieße nicht	Tageszeit
Winter						
Sommer						

Abschnitt D: ***In diesem Abschnitt werden Ihre Vorlieben im Garten gesammelt. Sie können Fragen, auf die Sie die Antwort nicht kennen, unbeantwortet lassen.***

D.1) Bitte beantworten Sie folgende Fragen:

Wie viel Prozent Ihrer Pflanzen sind dem mediterranen Klima angepasst?	0%	25%	50%	75%	100%	WN/KA
Wie viel Prozent Ihrer Pflanzen stammen aus der Mittelmeerregion?	0%	25%	50%	75%	100%	WN/KA

D.2) Bitte beantworten Sie folgende Fragen:

Starke Ablehnung	Ablehnung	Neutral	Zustimmung	starke Zustimmung
1	**2**	**3**	**4**	**5**

VORLIEBEN: Warum haben Sie einen Garten?

Einen ästhetischen Wert dem Anwesen geben	1	2	3	4	5
Einen Kontakt zur Natur haben	1	2	3	4	5
Als Hobby / Unterhaltung	1	2	3	4	5
Der Anbau von Nahrungsmittel	1	2	3	4	5
Einen Platz zum Entspannen	1	2	3	4	5
Als häusliche Tätigkeiten	1	2	3	4	5
Als Freizeitaktivität	1	2	3	4	5
Um den wirtschaftlichen Wert meines Heims zu steigern	1	2	3	4	5
Andere:	1	2	3	4	5

Ernennen Sie die GRÜNDE warum Sie Pflanzen in Ihrem Garten anbauen oder pflegen.

Weil sie meinen Garten verschönern	1	2	3	4	5
Weil sie sich gut anpassen und wenig Wasser brauchen	1	2	3	4	5
Jemand hat sie mir empfohlen	1	2	3	4	5
Weil sie das ganze Jahr über blühen	1	2	3	4	5
Weil sie an das Klima und die Gegend angepasst sind	1	2	3	4	5
Weil sie nützlich sind	1	2	3	4	5
Weil sie schon vorher im Garten waren	1	2	3	4	5
Persönliche Gründe	1	2	3	4	5
Andere:	1	2	3	4	5

Aus welcher Quelle beziehen Sie ihr Bewässerungswasser? (Öffentliches Netz, Brunnen/Zisterne, Wassertanks):

VIELEN DANK FÜR IHRE ZUSAMMENARBEIT

Diese Umfrage ist Teil des Projektes “Nuevas pautas de consumo y gestión del agua en espacios urbano-turísticos de baja densidad” (Neue Konsummuster und Wasserwirtschaft in gering besiedelten urbaner-tourismus Gebiete) durchgeführt von der Universität Girona und der Autonomen Universität Barcelona. Die Ergebnisse werden für rein wissenschaftliche Zwecke verwendet. Die Anonymität der Teilnehmer wird garantiert und die Daten werden mit dem größten Respekt für die Privatsphäre bearbeitet unter der Garantie des Gesetzes Ley 15/1999 de 13 de diciembre, de Protección de Datos de Carácter Personal (zum Schutz personenbezogener Daten).

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Annex 5/Appendix 5: List of the 635 species identified in domestic gardens of the Costa Brava (Catalonia, Spain) and their characteristics. Frequency (Freq.); Family; Raunkiaer life form (LF): therophytes (Th), chamaephytes (Ch), geophytes (G), hemicryptophytes (H), phanerophyes (Ph); Natural distribution (ND): Africa (Af), Asia (As), Australia & New Zealand (AusNZ), North America (N Am), South America (S Am), Europe, Eurasia, Europe, Africa & Asia, Mediterranean (Med), Cosmopolitan (Cos), Hybrids (Hort) and Unknown (Un); Use: Ornamental (Or), Edible (Ed), Weed (We), Medicinal (Me); and native species (x).

Taxa	Frequency (%)	Family	LF	Distrib.	Use	Native
Abelia × grandiflora (Rovelli ex André) Rehder	12,40	Caprifoliaceae	Ph	Hort	Or	
Abies alba Mill.	3,86	Pinaceae	Ph	Eur	Or	x
Abutilon × hybridum Voss	1,16	Malvaceae	Ph	Hort	Or	
Acacia dealbata Link	5,02	Mimosaceae	Ph	AusNZ	Or	
Acacia retinodes Schltdl.	1,16	Mimosaceae	Ph	AusNZ	Or	
Acanthus mollis L.	1,54	Acanthaceae	H	Med	Or	x
Acca sellowiana (O.Berg) Burret	0,39	Myrtaceae	Ph	S Am	Or	
Acer negundo L.	1,16	Aceraceae	Ph	N Am	Or	
Acer palmatum Thunb.	3,47	Aceraceae	Ph	As	Or	
Acer platanoides L.	0,39	Aceraceae	Ph	Euras	Or	x
Acer pseudoplatanus L.	0,39	Aceraceae	Ph	Eur	Or	x
Actinidia deliciosa (A.Chev.) C.F.Liang & A.R.Ferguson	1,93	Actinidiaceae	Ph	As	Or	
Aeonium arboreum Webb & Berthel.	18,15	Crassulaceae	Ch	Af	Or	
Aesculus hippocastanum L.	0,77	Hippocastanaceae	Ph	Eur	Or	
Agapanthus praecox Willd.	20,46	Amaryllidaceae	G	Af	Or	
Agave americana L.	10,42	Agavaceae	H	S Am	Or	
Agave attenuata Salm-Dyck	1,16	Agavaceae	H	S Am	Or	
Agave filamentosa Salm-Dyck	0,39	Agavaceae	H	S Am	Or	
Agave salmiana Otto ex Salm-Dyck	0,39	Agavaceae	H	S Am	Or	
Agave victoriae-reginae T.Moore	1,93	Agavaceae	H	S Am	Or	
Agrostemma githago L.	0,39	Caryophyllaceae	Th	Eur	Or	
Agrostis sp.	6,56	Poaceae	H	Cos	Or, We	x
Ajuga reptans L.	1,54	Lamiaceae	H	Eur-Af-As	Or	x
Albizia julibrissin Durazz.	0,77	Mimosaceae	Ph	As	Or	
Alcea rosea L.	2,70	Malvaceae	H	As	Or	
Allium cepa L.	9,27	Liliaceae	G	As	Ed	
Allium sativum L.	2,32	Liliaceae	G	As	Ed	
Allium schoenoprasum L.	13,51	Liliaceae	G	As	Ed	
Allium sp.	11,58	Amaryllidaceae	G	Cos	We	x
Alocasia macrorrhizos (L.) G.Don	3,47	Araceae	G	As	Or	
Aloe arborescens Mill.	11,97	Xanthorrhoeaceae	Ph	Af	Or	
Aloe distans Haw.	5,02	Xanthorrhoeaceae	Ph	Af	Or	
Aloe juvenna Brandham & S.Carter	1,54	Xanthorrhoeaceae	Ph	Af	Or	

Aloe maculata All.	18,53	Xanthorrhoeaceae	Ph	Af	Or	
Aloe variegata L.	2,32	Xanthorrhoeaceae	Ph	Af	Or	
Aloe vera (L) Burm.f.	22,39	Xanthorrhoeaceae	Ph	Af	Or, Me	
Aloysia tryphilla Britton	11,58	Verbenaceae	Ph	S Am	Or, Me	
Alstroemeria sp.	0,39	Alstroemeriaceae	G	S Am	Or	
Alyssum maritimum (L.) Lam.	9,27	Brassicaceae	Ch	Med	Or, We	x
Amaranthus sp.	3,09	Amaranthaceae	Th	S Am	We	
Anagallis arvensis L.	11,58	Primulaceae	Th	Eur	We	x
Annona cherimola Miller	0,77	Annonaceae	Ph	S Am	Ed	
Anthurium sp.	1,16	Araceae	Ep	S Am	Or	
Antirrhinum majus L.	2,70	Plantaginaceae	Ch	Med	Or	x
Apium graveolens L.	5,79	Apiaceae	G	Euras	Ed	x
Aptenia cordifolia (L.f.) Schwantes	15,06	Aizoaceae	Ch	Af	Or	
Aquilegia flabellata Siebold & Zucc.	0,39	Ranunculaceae	H	As	Or	
Araucaria heterophylla (Salisb.) Franco	1,16	Araucaliaceae	Ph	AusNZ	Or	
Arbutus unedo L.	4,25	Ericaceae	Ph	Med	Or	x
Arctotis × hybrida Hort.	1,16	Asteraceae	Ch	Hort	Or	
Ardisia crenata Roxb.	0,39	Myrsinaceae	Ch	As	Or	
Armeria maritima Willd.	0,39	Plumbaginaceae	H	Eur	Or	x
Armoracia rusticana P. Gaertn.	0,77	Brassicaceae	G	Euras	Or	x
Artemisia arborescens L.	0,39	Asteraceae	Ph	Med	Or	x
Arum italicum Mill.	10,42	Araceae	G	Euras	We	x
Arundo donax L.	0,77	Poaceae	G	Med	Or	
Asparagus acutifolius L.	2,32	Liliaceae	Ch	Med	We	x
Asparagus densiflorus (Kunth) Jessop	24,71	Asparagaceae	Ch	S Am	Or	
Asphodelus fistulosus L.	0,39	Xanthorrhoeaceae	G	Med	We	x
Aspidistra elatior Blume	6,95	Convallariaceae	G	As	Or	
Asteriscus maritimus (L.) Less.	2,70	Asteraceae	Ch	Med	Or	x
Asteriscus spinosus Sch.Bip.	0,39	Asteraceae	H	Med	We	x
Astilbe sp.	0,39	Saxifragaceae	H	As	Or	
Aucuba japonica Thunb.	6,56	Aucubaceae	Ph	As	Or	
Austrocylindropuntia sp.	6,56	Cactaceae	Ph	S Am	Or	
Avena barbata Pott ex Link in Schrad.	3,47	Poaceae	Th	Euras	We	x
Beaucarnea recurvata Lem.	0,77	Nolinaceae	Ph	S Am	Or	
Begonia sp.	16,99	Begoniaceae	Ch	Hort	Or	
Begonia tiger Hort.	0,39	Begoniaceae	Ch	Hort	Or	
Bellis perennis L.	17,37	Asteraceae	H	Eur-Af-As	We	x
Berberis thunbergii DC.	1,16	Berberidaceae	Ph	As	Or	
Bergenia crassifolia (L.) Fritsch	7,72	Saxifragaceae	G	As	Or	
Beta vulgaris L.	1,54	Amaranthaceae	H	Eur-Af-As	Ed	x
Betula pubescens Ehrh.	0,39	Betulaceae	Ph	Euras	Or	x
Bidens ferulifolia (Jacq.) Sweet	0,77	Asteraceae	Th	S Am	Or	
Borago officinalis L.	0,39	Boraginaceae	Th	Med	We	x
Boswellia sacra Flueck.	0,77	Burseraceae	Ph	Af	Or	

Bougainvillea sp.	30,12	Nyctaginaceae	Ph	S Am	Or	
Brachychiton populneus R.Br.	0,39	Sterculiaceae	Ph	AusNZ	Or	
Brahea edulis H.Wendl. Ex S.Watson	0,77	Arecaceae	Ph	S Am	Or	
Brassica oleracea L.	2,70	Brassicaceae	Ch	Euras	Ed	x
Bromus diandrus Roth	5,41	Poaceae	Th	Eur-Af-As	We	x
Broussonetia papyrifera (L.) Vent.	0,77	Moraceae	Ph	As	Or	
Brugmansia chlorantha (Hook.) Melliss	0,39	Solanaceae	Ph	S Am	Or	
Brugmansia x candida Pers.	3,09	Solanaceae	Ph	S Am	Or	
Bulbine frutescens Willd.	1,16	Asphodelaceae	Ch	Af	Or	
Bulnesia sarmientoi Lorentz ex Griseb.	0,39	Zygophyllaceae	Ph	S Am	Or	
Bupleurum fruticosum L.	0,39	Apiaceae	Ph	Med	Or	x
Butia capitata Becc.	0,77	Arecaceae	Ph	S Am	Or	
Buxus microphylla Siebold & Zucc.	0,77	Buxaceae	Ph	As	Or	
Buxus sempervirens L.	16,22	Buxaceae	Ph	Eur	Or	x
Caesalpinia gilliesii Wall. Ex Hook.	3,09	Fabaceae	Ph	S Am	Or	
Calathea sp.	0,39	Maranthaceae	G	S Am	Or	
Calendula arvensis L.	1,93	Asteraceae	Th	Eur-Af-As	Or	x
Calendula officinalis L.	7,34	Asteraceae	Ch	Med	Or	x
Calibrachoa × hybrida Hort.	0,77	Solanaceae	Ch	Hort	Or	
Callistemon citrinus (Curtis) Skeels	25,48	Myrtaceae	Ph	AusNZ	Or	
Callistemon viminalis (Gaertn.) G.Don	1,54	Myrtaceae	Ch	AusNZ	Or	
Callistephus chinensis Nees	1,16	Asteraceae	Th	As	Or	
Calluna vulgaris (L.) Hull	1,93	Ericaceae	Ch	Eur	Or	x
Calocedrus decurrens (Torr.) Florin	1,54	Cupressaceae	Ph	N Am	Or	
Camellia japonica L.	10,42	Theaceae	Ph	As	Or	
Campanula poscharskyana Degen	6,18	Campanulaceae	H	Hort	Or	
Campsis grandiflora K. Schum.	0,39	Bignoniaceae	Ph	As	Or	
Campsis radicans (L.) Bureau	14,67	Bignoniaceae	Ph	N Am	Or	
Canna × generalis L.H.Bailey.	19,69	Cannaceae	H	S Am	Or	
Cannabis sativa L.	0,77	Cannabaceae	Th	As	Me	
Capsella bursa-pastoris (L.) Medik.	2,70	Brassicaceae	Th	Euras	We	x
Capsicum annuum L.	5,02	Solanaceae	Th	S Am	Ed	
Cardamine hirsuta L.	4,25	Brassicaceae	Th	Euras	We	x
Carex sp.	0,77	Cyperaceae	H	Cos	Or	x
Carpobrotus sp.	9,27	Aizoaceae	Ch	Af	Or	
Castanea sativa Mill.	1,16	Fagaceae	Ph	Euras	Or, Ed	x
Catapodium rigidum (L.) F.T.Hubbard	1,16	Poaceae	Th	Med	We	
Catharanthus roseus (L.) G.Don	2,32	Apocynaceae	Ch	Af	Or	
Ceanothus thyrsiflorus Eschsch.	0,39	Rhamnaceae	Ph	N Am	Or	
Cedrus deodara (D. Don) G.Don.	0,77	Pinaceae	Ph	As	Or	
Celosia argentea L.	0,77	Amaranthaceae	Th	As	Or	
Celtis australis L.	0,39	Ulmaceae	Ph	Med	Or	x
Centaurea cyanus L.	0,39	Asteraceae	Th	Eur	Or	
Centranthus ruber (L.) Dc.	1,16	Valerianaceae	Ch	Med	Or	x

Cerastium glomeratum Thuill.	8,49	Caryophyllaceae	Th	Euras	We	x
Ceratostigma plumbaginoides Bunge	0,77	Plumbaginaceae	Ch	As	Or	
Cercis siliquastrum L.	3,09	Caesalpiniaceae	Ph	Euras	Or	
Cereus peruvianus (L.) Mill.	4,25	Cactaceae	Ph	S Am	Or	
Cestrum nocturnum L.	2,32	Solanaceae	Ph	S Am	Or	
Chamaecereus sp.	2,32	Cactaceae	Ph	S Am	Or	
Chamaecyparis lawsoniana (A.Murray bis) Parl.	0,77	Cupressaceae	Ph	N Am	Or	
Chamaedorea elegans Mart.	1,54	Arecaceae	Ph	S Am	Or	
Chamaerops excelsa Thunb.	12,36	Arecaceae	Ph	As	Or	
Chamaerops humilis L.	20,08	Arecaceae	Ph	Med	Or	x
Chamaesyce prostrata (Aiton) Small	1,54	Euphorbiaceae	Th	S Am	We	
Chamelaucium uncinatum Schauer	1,16	Myrtaceae	Ph	AusNZ	Or	
Cheiranthus cheiri L.	0,39	Brassicaceae	Ch	Med	Or	x
Chenopodium sp.	5,41	Chenopodiaceae	Th	Cos	We	x
Chlorophytum comosum (Thunb.) Jacques	19,69	Asparagaceae	H	Af	Or	
Chrysanthemum sp.	21,62	Asteraceae	Th	Euras	Or	x
Cichorium endivia L.	0,77	Asteraceae	Th	Med	Ed	x
Cichorium intybus L.	0,77	Asteraceae	Ch	Euras	We	x
Cinnamomum camphora (L.) T.Nees & C.H.Eberm.	0,39	Lauraceae	Ph	As	Or	
Cirsium sp.	1,54	Asteraceae	H	Euras	We	x
Citrus aurantiifolia (Christm.) Swingle	0,39	Rutaceae	Ph	As	Or, Ed	
Citrus limon (L.) Osbeck	43,24	Rutaceae	Ph	As	Or, Ed	
Citrus nobilis Lour.	6,18	Rutaceae	Ph	As	Or, Ed	
Citrus paradisi Macfad.	1,16	Rutaceae	Ph	As	Or, Ed	
Citrus sinensis Osbeck	28,19	Rutaceae	Ph	As	Or, Ed	
Cleistocactus jujuyensis Backeb.	1,54	Cactaceae	Ph	S Am	Or	
Cleistocactus sp.	2,70	Cactaceae	Ph	S Am	Or	
Clematis sp.	4,25	Ranunculaceae	Ph	Med	Or	x
Clivia miniata (Lindl.) Bosse	12,36	Amaryllidaceae	Ch	Af	Or	
Codiaeum variegatum (L.) A.Juss.	0,39	Euphorbiaceae	Ph	As	Or	
Convallaria majalis L.	1,54	Liliaceae	G	Eur	Or	x
Convolvulus arvensis L.	1,16	Convolvulaceae	G	Euras	We	x
Convolvulus cneorum L.	1,16	Convolvulaceae	G	Med	Or	
Convolvulus tricolor L.	0,39	Convolvulaceae	G	Med	Or	x
Conyza sp.	19,31	Asteraceae	Th	N Am	We	
Cordyline australis (G.Forst.) Endl.	4,63	Agavaceae	Ph	AusNZ	Or	
Cordyline indivisa (G.Forst.) Endl.	14,67	Agavaceae	Ph	AusNZ	Or	
Coreopsis grandiflora Hogg ex Sweet	0,39	Asteraceae	Th	N Am	Or	
Coronilla glauca L.	5,79	Fabaceae	Ph	Med	Or	x
Cortaderia selloana Asch. & Graebn.	5,41	Poaceae	H	S Am	Or	
Corylus avellana L.	1,16	Betulaceae	Ph	Euras	Ed	x
Cotinus coggygria Scop.	0,77	Anacardiaceae	Ph	Euras	Or	
Cotoneaster horizontalis Decne.	3,47	Rosaceae	Ph	As	Or	
Cotoneaster lacteus W.W.Sm.	6,18	Rosaceae	Ph	As	Or	

Cotoneaster pannosus Franch.	0,77	Rosaceae	Ph	As	Or	
Crassula pellucida L.	0,39	Crassulaceae	Th	Af	Or	
Crassula perforata Thunb.	0,39	Crassulaceae	Th	Af	Or	
Crassula sp.	40,54	Crassulaceae	Th	Af	Or	
Crassula tetragona L.	1,93	Crassulaceae	Th	Af	Or	
Crepis sancta (L.) Babc.	5,41	Asteraceae	Th	Eur	We	
Cucumis melo L.	1,16	Cucurbitaceae	Th	As	Ed	
Cucumis sativus L.	1,93	Cucurbitaceae	Th	As	Ed	
Cucurbita pepo L.	3,09	Cucurbitaceae	Th	As	Ed	
Cuphea hyssopifolia Kunth	1,93	Lythraceae	Ch	S Am	Or	
Cupressucyparis × leylandii (A.B.Jacks. & Dallim.) Dallim.	3,86	Cupressaceae	Ph	Hort	Or	
Cupressus arizonica Greene	1,54	Cupressaceae	Ph	N Am	Or	
Cupressus macrocarpa (Vent.) A.Cunn.	4,25	Cupressaceae	Ph	N Am	Or	
Cupressus sempervirens L.	27,41	Cupressaceae	Ph	Med	Or	
Cycas revoluta Thunb.	38,22	Cycadaceae	Ph	As	Or	
Cyclamen persicum Mill.	14,67	Primulaceae	G	Med	Or	
Cydonia oblonga Mill.	1,54	Rosaceae	Ph	As	Or, Ed	
Cymbalaria muralis Gaertn. B.Mey et Sherb	2,32	Plantaginaceae	Ch	Eur	We	
Cymbidium sp.	1,54	Orchidaceae	G	As	Or	
Cymbopogon citratus Stapf	1,54	Poaceae	H	As	Or, Me	
Cynara scolymus L.	0,77	Asteraceae	H	Med	Ed	
Cynodon dactylon (L.) Pers.	11,58	Poaceae	H	Af	Or	
Cyperus alternifolius L.	6,56	Cyperaceae	H	Af	Or	
Cyperus eragrostis Vahl	0,39	Cyperaceae	H	N Am	We	
Cyrtomium falcatum (L.f.) C.Presl	0,77	Dryopteridaceae	H	As	Or	
Cytisus racemosus Hort.	3,09	Fabaceae	Ph	Med	Or	
Dactylis glomerata L.	16,60	Poaceae	H	Euras	We	x
Dahlia sp.	0,39	Asteraceae	Ch	S Am	Or	
Dasylirion wheeleri S.Watson	3,47	Nolinaceae	Ph	S Am	Or	
Daucus carota L.	4,25	Apiaceae	G	Euras	Ed	x
Delosperma lehmannii Graessner	1,16	Aizoaceae	Ch	Af	Or	
Delphinium ajacis L.	1,54	Ranunculaceae	Th	Euras	Or	x
Dianthus sp.	19,69	Caryophyllaceae	Ch	As	Or	
Dichondra repens J.R.Forst. & G.Forst.	3,09	Convolvulaceae	Ch	S Am	Or	
Dicliptera suberecta (André) Bremek.	0,39	Acanthaceae	H	S Am	Or	
Diospyros kaki Thunb.	1,16	Ebenaceae	Ph	As	Or, Ed	
Dipsacus fullonum L.	0,77	Dipsacaceae	H	Eur-Af-As	We	x
Dodonaea viscosa Jacq.	0,39	Sapindaceae	Ph	N Am	Or	
Dracaena draco L.	0,77	Dracaenaceae	Ph	Af	Or	
Echeveria sp.	23,94	Crassulaceae	Ch	S Am	Or	
Echinocactus grusonii Hildm.	4,63	Cactaceae	Ch	S Am	Or	
Echinopsis chamaecereus Friedrich & Glaetzle	0,77	Cactaceae	Ch	S Am	Or	
Echinopsis eyriesii Pfeiff. & Otto	7,72	Cactaceae	Ch	S Am	Or	
Elaeagnus angustifolia L.	0,39	Elaegnaceae	Ph	Euras	Or	

Eleagnus × *ebbingei* Door.	5,02	Elaegnaceae	Ph	Hort	Or	
Eleusine tristachya (Lam.) Lam.	0,77	Poaceae	H	S Am	We	
Elymus repens (L.) Gould.	0,39	Poaceae	H	Eur-Af-As	We	x
Epilobium hirsutum L.	0,39	Onagraceae	H	Eur	We	x
Epiphyllum oxypetalum Haw.	0,77	Cactaceae	Ep	S Am	Or	
Epipremnum aureum (Linden ex André) G.S.Bunting	0,77	Araceae	Ph	As	Or	
Equisetum ramosissimum Desf.	6,95	Equisetaceae	Ph	Med	We	x
Erica arborea L.	1,16	Ericaceae	Ph	Eur-Af-As	Or	x
Erigeron karvinskianus DC.	1,16	Asteraceae	Ch	S Am	Or	
Eriobotrya japonica (Thunb.) Lindl.	14,67	Rosaceae	Ph	As	Or, Ed	
Erodium moschatum (L.) Aiton	3,47	Geraniaceae	Th	Med	We	x
Eruca vesicaria (L.) Cav.	0,39	Brassicaceae	Th	Med	We	x
Eryngium campestre L.	0,39	Apiaceae	G	Eur	We	x
Escallonia rubra (Ruiz & Pav.) Pers.	8,11	Escalloniaceae	Ph	S Am	Or	
Eschsholzia californica Cham.	0,39	Papaveraceae	Th	N Am	Or	
Espostoa sp.	2,32	Cactaceae	Ch	S Am	Or	
Eucalyptus globulus Labill.	1,16	Myrtaceae	Ph	AusNZ	Or	
Eugenia myrtifolia Sims	0,77	Myrtaceae	Ph	S Am	Or	
Euonymus japonicus Wall.	44,02	Celastraceae	Ph	Hort	Or	
Euphorbia avasmontana Dinter	1,93	Euphorbiaceae	Ph	Af	Or	
Euphorbia canariensis L.	2,70	Euphorbiaceae	Ph	Af	Or	
Euphorbia candelabrum Tremaut ex Kotschy	0,77	Euphorbiaceae	Ph	Af	Or	
Euphorbia characias L.	0,77	Euphorbiaceae	Ph	Med	We	x
Euphorbia enopla Boiss.	0,77	Euphorbiaceae	Ch	Af	Or	
Euphorbia helioscopia L.	17,76	Euphorbiaceae	Th	Eur	We	x
Euphorbia milii Des Moul.	4,25	Euphorbiaceae	Ch	Af	Or	
Euphorbia pseudocactus A. Berger	1,54	Euphorbiaceae	Ph	Af	Or	
Euphorbia sp. (cactus)	0,77	Euphorbiaceae	Ph	Cos	Or	
Euryops pectinatus Cass.	19,69	Asteraceae	Ph	Af	Or	
Euryops virgineus Less.	0,39	Asteraceae	Ph	Af	Or	
Farfugium japonicum (L.) Kitam.	0,39	Asteraceae	H	As	Or	
Fatsia japonica Decne. & Planch.	3,47	Araliaceae	Ch	As	Or	
Felicia amelloides (L.) Voss	7,34	Asteraceae	Ch	Af	Or	
Ferocactus sp.	5,41	Cactaceae	Ch	N Am	Or	
Festuca glauca Vill.	2,32	Poaceae	H	Med	Or	x
Festuca sp.	26,64	Poaceae	H	Cos	Or	x
Ficus benjamina L.	3,09	Moraceae	Ph	As	Or	
Ficus carica L.	16,22	Moraceae	Ph	As	Or, Ed	
Ficus lyrata Warb	0,39	Moraceae	Ph	Af	Or	
Ficus macrophylla Pers.	5,79	Moraceae	Ph	AusNZ	Or	
Ficus pumila L.	1,16	Moraceae	Ph	As	Or	
Foeniculum vulgare Mill.	5,41	Apiaceae	Ch	Med	We	x
Forsythia × *intermedia* Zabel	0,39	Oleaceae	Ph	Hort	Or	
Fortunella margarita Swingle	7,34	Rutaceae	Ph	As	Or	

Fragaria vesca L.	18,92	Rosaceae	Ch	Eur	Ed	x
Fraxinus excelsior L.	0,39	Oleaceae	Ph	Euras	Or	x
Fuchsia sp.	9,65	Onagraceae	Ch	S Am	Or	
Fumaria capreolata L.	0,77	Papaveraceae	Th	Eur	We	x
Fumaria officinalis L.	0,39	Papaveraceae	Th	Eur	We	x
Galium aparine L.	2,32	Rubiaceae	Th	Euras	We	x
Gardenia sp.	4,25	Rubiaceae	Ph	As	Or	
Gaura lindheimeri Engelm. & Gray	1,54	Onagraceae	Ch	N Am	Or	
Gazania sp.	15,83	Asteraceae	Ch	Af	Or	
Geranium dissectum L.	7,34	Geraniaceae	Th	Eur	We	x
Geranium molle L.	3,09	Geraniaceae	Th	Med	We	x
Geranium robertianum L.	3,09	Geraniaceae	Th	Eur-Af-As	We	x
Gerbera sp.	0,77	Asteraceae	Ch	Af	Or	
Gladiolus sp.	8,11	Iridaceae	G	Af	Or	
Glaucium flavum Crantz	0,39	Papaveraceae	H	Med	Or	x
Grevillea juniperina R.Br.	4,25	Proteaceae	Ph	AusNZ	Or	
Grevillea lanigera A.Cunn. ex R.Br.	0,77	Proteaceae	Ph	AusNZ	Or	
Guzmania sp.	0,39	Bromeliaceae	Ep	S Am	Or	
Gypsophila paniculata L.	0,39	Caryophyllaceae	Ch	Euras	Or	
Hardenbergia violacea (Schneev.) Stearn	1,16	Fabaceae	Ph	AusNZ	Or	
Hatiora gaertneri (Regel) Barthlott	8,88	Cactaceae	Ch	S Am	Or	
Hatiora salicornioides Britton & Rose	0,39	Cactaceae	Ch	S Am	Or	
Haworthia reinwardtii Haw.	5,41	Xanthorrhoeaceae	Ch	Af	Or	
Hebe sp.	8,49	Scrophulariaceae	Ph	Hort	Or	
Hedera algeriensis Hibberd	3,47	Araliaceae	Ph	Af	Or	
Hedera helix L.	36,68	Araliaceae	Ph	Eur	Or, We	x
Helianthus annuus L.	1,54	Asteraceae	Th	N Am	Or, Ed	
Helianthus tuberosus L.	0,77	Asteraceae	Th	N Am	Or	
Helichrysum italicum (Roth) G. Don f. In Loudon	0,39	Asteraceae	Ch	Med	We	x
Hemerocallis sp.	9,65	Xanthorrhoeaceae	G	Af	Or	
Hibiscus rosa-sinensis L.	16,22	Malvaceae	Ph	As	Or	
Hibiscus syriacus L.	16,99	Malvaceae	Ph	As	Or	
Hippeastrum sp.	6,18	Amaryllidaceae	H	S Am	Or	
Hordeum murinum L.	9,65	Poaceae	H	Euras	We	x
Hosta sp.	0,77	Asparagaceae	H	As	Or	
Hoya carnosa (L.) R.Br.	0,39	Apocynaceae	Ch	As	Or	
Hyacinthus sp.	0,77	Asparagaceae	G	Eur-Af-As	Or	
Hydrangea macrophylla (Thunb.) Ser.	33,59	Hydrangeaceae	Ph	As	Or	
Hypericum calycinum L.	0,77	Hypericaceae	Ph	Euras	Or	
Iberis sempervirens L.	1,16	Brassicaceae	Ch	Eur	Or	x
Ilex aquifolium L.	3,09	Aquifoliaceae	Ph	Euras	Or	x
Imperata cylindrica (L.) Raeuschel	0,77	Poaceae	H	As	Or	
Inula crithmoides L.	0,39	Asteraceae	Ch	Euras	We	x
Ipomoea indica (Burm.) Merr.	6,95	Convolvulaceae	Th	S Am	Or	

Iris sp.	18,92	Iridaceae	G	Hort	Or	
Isotoma axillaris Lindl.	0,77	Campanulaceae	H	AusNZ	Or	
Jacaranda mimosifolia D.Don	0,77	Bignoniaceae	Ph	S Am	Or	
Jacobaea maritima (L.) Pelser & Meijden	4,25	Asteraceae	Ch	Med	Or	x
Jasminum mesnyi Hance	2,70	Oleaceae	Ph	As	Or	
Jasminum officinale L.	1,54	Oleaceae	Ph	As	Or	
Jasminum polyanthum Franch.	11,20	Oleaceae	Ph	As	Or	
Jasminum sambac (L.) Aiton	0,39	Oleaceae	Ph	As	Or	
Jasminum sp.	2,32	Oleaceae	Ph	As	Or	
Juglans regia L.	1,54	Juglandaceae	Ph	Euras	Or	x
Juniperus × media Melle	3,09	Cupressaceae	Ph	Hort	Or	
Juniperus chinensis L.	3,47	Cupressaceae	Ph	Hort	Or	
Juniperus communis L.	1,54	Cupressaceae	Ph	Eur	Or	x
Juniperus horizontalis Moench	0,39	Cupressaceae	Ph	N Am	Or	
Justicia brandegeeana Wassh. & L.B.Sm.	1,54	Acanthaceae	Ph	S Am	Or	
Kalanchoe × houghtonii D.B.Ward	2,32	Crassulaceae	Ch	Hort	Or	
Kalanchoe blossfeldiana Poelln.	9,27	Crassulaceae	Ch	Af	Or	
Kalanchoe daigremontiana Raym.-Hamet & H.Perrier	0,39	Crassulaceae	Ch	Af	Or	
Kalanchoe laxiflora Baker	1,16	Crassulaceae	Ch	Af	Or	
Kalanchoe tomentosa Baker	0,39	Crassulaceae	Ch	Af	Or	
Kniphofia uvaria (L.) Hook.	1,93	Asphodelaceae	G	Af	Or	
Lactuca sativa L.	7,34	Asteraceae	Ch	As	Ed	
Lactuca serriola L.	1,93	Asteraceae	Th	Eur	We	x
Lagerstroemia indica L.	3,47	Lythraceae	Ph	As	Or	
Lamium amplexicaule L.	4,63	Labiaceae	Th	Euras	We	x
Lamium galeobdolon (L.) L.	1,54	Labiaceae	Th	Eur	Or	x
Lampranthus sp.	33,20	Aizoaceae	H	Af	Or	
Lantana camara L.	18,92	Verbenaceae	Ph	S Am	Or	
Lantana montevidensis (Spreng.) Briq.	8,49	Verbenaceae	Ch	S Am	Or	
Laurus nobilis L.	24,71	Lauraceae	Ph	Med	Or	x
Lavandula × intermedia Emeric ex Loisel.	0,39	Lamiaceae	Ch	Eur	Or	x
Lavandula angustifolia Mill.	28,19	Lamiaceae	Ch	Med	Or	x
Lavandula dentata L.	6,18	Lamiaceae	Ch	Med	Or	x
Lavandula stoechas L.	1,16	Lamiaceae	Ch	Med	Or	x
Ledebouria socialis (Baker) Jessop	0,39	Asparagaceae	G	Af	Or	
Leontopodium alpinum Cass.	0,77	Asteraceae	H	Eur	Or	x
Leptospermum scoparium J.R.Forst. & G.Forst.	0,77	Myrtaceae	Ph	AusNZ	Or	
Leucanthemum maximum DC.	3,09	Asteraceae	H	Med	Or	
Ligustrum ionandrum Diels	0,39	Oleaceae	Ph	AS	Or	
Ligustrum japonicum Thunb.	1,54	Oleaceae	Ph	As	Or	
Ligustrum lucidum Aiton f.	2,32	Oleaceae	Ph	As	Or	
Ligustrum sinense Lour.	0,77	Oleaceae	Ph	As	Or	
Lilium sp.	11,20	Liliaceae	G	Cos	Or	
Linum grandiflorum Desf.	0,39	Linaceae	H	Af	Or	

Linum usitatissimum L.	0,39	Linaceae	H	Af	Or	
Lippia nodiflora (L.) Rich. In Michx.	0,77	Verbenaceae	H	S Am	Or	
Liriope muscari L.H.Bailey.	1,16	Convallariaceae	G	As	Or	
Lithodora diffusa (Lag.) I.M.Johnst.	1,93	Boraginaceae	Ch	Eur	Or	
Lithops sp.	0,39	Aizoaceae	H	Af	Or	
Lobelia erinus L.	3,09	Campanulaceae	Th	Af	Or	
Lobelia laxiflora Kunth	0,39	Campanulaceae	Th	N Am	Or	
Lobivia sp.	0,39	Cactaceae	Ch	S Am	Or	
Lolium perenne L.	17,76	Poaceae	H	Eur-Af-As	Or, We	x
Lonicera japonica Thunb.	7,34	Caprifoliaceae	Ch	As	Or	
Lonicera nitida E.H.Wilson	6,95	Caprifoliaceae	Ph	As	Or	
Lotus corniculatus L.	6,18	Fabaceae	H	Eur-Af-As	We	x
Lychnis coronaria (L.) Desr.	0,39	Caryophyllaceae	H	Euras	Or	x
Lythrum salicaria L.	0,39	Lythraceae	H	Euras	Or	x
Magnolia grandiflora L.	7,72	Magnoliaceae	Ph	N Am	Or	
Magnolia stellata (Siebold & Zucc.) Maxim.	0,77	Magnoliaceae	Ph	As	Or	
Malus domestica Borkh.	5,41	Rosaceae	Ph	Hort	Or, Ed	
Malva sylvestris L.	3,47	Malvaceae	H	Eur	We	x
Mammillaria sp.	5,41	Cactaceae	H	S Am	Or	
Mandevilla laxa (Ruiz & Pav.) Woodson	18,15	Apocynaceae	Ph	S Am	Or	
Matricaria recutita L.	1,16	Asteraceae	Th	Euras	Or	x
Matthiola incana (L.) R.Br.	1,16	Brassicaceae	Ch	Euras	Or	x
Matthiola sinuata (L.) R.Br.	0,39	Brassicaceae	H	Eur	Or	x
Medicago lupulina L.	10,81	Fabaceae	H	Eur-Af-As	We	x
Medicago sativa L.	1,93	Fabaceae	H	Euras	We	
Melia azedarach L.	1,16	Meliaceae	Ph	As	Or	
Melisa officinalis L.	0,39	Lamiaceae	H	Eur	Or, Me	x
Mentha sp.	38,61	Lamiaceae	H	Cos	Or, Me	x
Mespilus germanica L.	0,39	Rosaceae	Ph	Eur	Or	x
Mirabilis jalapa L.	9,65	Nyctaginaceae	G	S Am	Or	
Miscanthus sinensis Andersson	0,39	Poaceae	H	As	Or	
Morus alba L.	14,29	Moraceae	Ph	As	Or	
Musa × paradisica L.	2,70	Musaceae	G	As	Or	
Muscari aucheri Baker	0,39	Asparagaceae	G	As	Or	
Muscari botryoides (L.) Mill.	0,77	Asparagaceae	G	Euras	Or	
Muscari neglectum Guss. ex Ten.	0,39	Asparagaceae	G	Eur-Af-As	Or	x
Myrtus communis L.	1,54	Myrtaceae	Ph	Med	Or	x
Nandina domestica Thunb.	1,93	Berberidaceae	Ch	As	Or	
Narcissus sp.	6,56	Amaryllidaceae	G	Euras	Or	x
Nepeta × faassenii Bergmans	0,77	Lamiaceae	Ch	Hort	Or	
Nephrolepis cordifolia (L.) C.Presl.	8,49	Davalliaceae	G	As	Or	
Nerium oleander L.	35,91	Apocynaceae	Ph	Euras	Or	x
Nicotiana tabacum L.	0,39	Solanaceae	Th	S Am	Or	
Nigella damascena L.	3,47	Ranunculaceae	Th	Med	Or	x

Ocimum basilicum L.	9,27	Lamiaceae	Th	Af	Ed	
Oenothera rosea L'Hér. ex Aiton	1,16	Onagraceae	H	S Am	Or	
Olea europaea L.	45,56	Oleaceae	Ph	Med	Or	x
Ophiopogon japonicus (L.f.) Ker Gawl	3,09	Convallariaceae	G	As	Or	
Opuntia ficus-indica (L.) Mill.	8,49	Cactaceae	Ph	S Am	Or	
Opuntia microdasys (Lehm.) Pfeiff.	7,34	Cactaceae	Ph	S Am	Or	
Opuntia monacantha Haw.	0,77	Cactaceae	Ph	S Am	Or	
Orbea variegata Haw.	1,93	Apocynaceae	Ch	Af	Or	
Oreocereus sp.	0,39	Cactaceae	Ch	S Am	Or	
Origanum majorana L.	4,63	Lamiaceae	Ch	Med	Or, Ed	x
Origanum vulgare L.	2,70	Lamiaceae	Ch	Euras	Or, Ed	x
Ornithogalum dubium Houtt.	0,77	Liliaceae	Ch	Af	Or	
Oryzopsis miliacea (L.) Beck	2,32	Poaceae	Ch	Med	We	x
Osteospermum sp.	37,84	Asteraceae	Ch	Af	Or	
Oxalis articulata Lam.	4,63	Oxalidaceae	G	S Am	Or	
Oxalis corniculata L.	27,80	Oxalidaceae	Th	Un	We	x
Oxalis debilis Kunth	1,93	Oxalidaceae	Th	S Am	Or	
Oxalis sp.	1,93	Oxalidaceae	Th	Un	We	x
Pachycereus sp.	5,02	Cactaceae	Ph	N Am	Or	
Pachyveria sp.	1,54	Crassulaceae	Ch	Hort	Or	
Paeonia suffruticosa Andrews	1,16	Ranunculaceae	G	As	Or	
Pandorea jasminoides (Lindl.) K.Schum.	1,16	Bignoniaceae	Ph	AusNZ	Or	
Papaver orientale L.	0,77	Papaveraceae	Th	As	Or	
Papaver rhoeas L.	1,16	Papaveraceae	Th	Eur-Af-As	We	x
Parietaria judaica L.	7,34	Urticaceae	Ch	Med	We	x
Parodia leninghausii (Haage) F.H.Brandt	0,77	Cactaceae	Ch	S Am	Or	
Parthenocissus quinquefolia (L.) Planch.	1,54	Vitaceae	Ph	N Am	Or	
Parthenocissus tricuspidata Planch.	3,09	Vitaceae	Ph	As	Or	
Paspalum sp.	5,41	Poaceae	Ch	S Am	We	
Passiflora caerulea L.	7,34	Passifloraceae	Ph	S Am	Or	
Pelargonium grandiflorum Willd.	1,16	Geraniaceae	Ch	Af	Or	
Pelargonium graveolens L'Hér.	16,60	Geraniaceae	Ch	Af	Or	
Pelargonium peltatum (L.) L'Hér	10,42	Geraniaceae	Ch	Af	Or	
Pelargonium zonale (L.) L'Hér	38,61	Geraniaceae	Ch	Af	Or	
Pentas lanceolata (Forssk.) Deflers	0,77	Rubiaceae	Ch	Af	Or	
Peperomia verticillata Sessé & Moc.	0,39	Piperaceae	Th	S Am	Or	
Pericallis × hybrida B.Nord.	0,77	Asteraceae	Ch	Hort	Or	
Perovskia sp.	0,77	Lamiaceae	Ch	As	Or	
Persea americana Mill.	4,63	Lauraceae	Ph	S Am	Ed	
Petroselinum crispum (Mill.) Nyman	22,78	Apiaceae	H	Euras	Ed	x
Petunia sp.	22,78	Solanaceae	Th	S Am	Or	
Phalaenopsis sp.	0,39	Orchidaceae	Ep	As	Or	
Phaseolus vulgaris L.	2,70	Fabaceae	Th	S Am	Ed	
Philadelphus coronarius L.	1,16	Hydrangeaceae	Ph	Eur	Or	

Phillyrea angustifolia L.	0,39	Oleaceae	Ph	Med	Or	
Phillyrea media L.	0,39	Oleaceae	Ph	Med	Or	
Philodendron pertusum Kunth & C.D.Bouché	0,77	Araceae	Ph	S Am	Or	
Phlomis purpurea L.	0,39	Lamiaceae	Ch	Med	Or	x
Phlomis viscosa Poir.	0,39	Lamiaceae	Ch	Med	Or	
Phlox sp.	0,39	Polimoneaceae	H	N Am	Or	
Phoenix canariensis Hort. Ex Chabaud	42,08	Arecaceae	Ph	Af	Or	
Phoenix roebelenii O'Brien	0,39	Arecaceae	Ph	Af	Or	
Phormium tenax J.R.Forst. & G.Forst.	3,09	Phormiaceae	Ph	AusNZ	Or	
Photinia × fraseri Dress	8,11	Rosaceae	Ph	Hort	Or	
Phyllostachys aurea Riviere & C.Riviere	6,56	Poaceae	Ph	As	Or	
Picea abies (L.) Karsten	3,09	Pinaceae	Ph	Eur	Or	x
Picea glauca (Moench) Voss	1,16	Pinaceae	Ph	N Am	Or	
Picea pungens Engelm.	2,32	Pinaceae	Ph	N Am	Or	
Picea smithiana Boiss.	0,39	Pinaceae	Ph	As	Or	
Picris echioides L.	5,41	Asteraceae	Th	Med	We	x
Pieris japonica D.Don ex G.Don	0,39	Ericaceae	Ph	As	Or	
Pinus halepensis Mill.	3,09	Pinaceae	Ph	Med	Or	x
Pinus mugo Turra	1,16	Pinaceae	Ph	Eur	Or	x
Pinus pinea L.	4,25	Pinaceae	Ph	Med	Or	x
Pistacia lentiscus L.	1,16	Anacardiaceae	Ph	Med	Or	x
Pittosporum tenuifolium Gaertn.	3,47	Pittosporaceae	Ph	AusNZ	Or	
Pittosporum tobira [Dryand.]	30,12	Pittosporaceae	Ph	As	Or	
Plantago coronopus L.	1,54	Plantaginaceae	Th	Euras	We	x
Plantago lagopus L.	6,56	Plantaginaceae	Th	Med	We	x
Plantago lanceolata L.	5,02	Plantaginaceae	H	Euras	We	x
Plantago major L.	1,16	Plantaginaceae	H	Euras	We	x
Platycodon grandiflorus A.DC.	8,11	Campanulaceae	H	As	Or	
Plectranthus australis R.Br.	5,02	Lamiaceae	Ch	Af	Or	
Plumbago auriculata Lam.	12,36	Plumbaginaceae	Ph	Af	Or	
Poa annua L.	34,36	Poaceae	Th	Euras	We	x
Poa pratensis L.	10,42	Poaceae	H	Eur-Af-As	Or	x
Poa trivialis L.	1,54	Poaceae	H	N Am	Or	x
Podocarpus neriifolius D.Don	1,16	Podocarpaceae	Ph	As	Or	
Polygala myrtifolia L.	16,22	Polygalaceae	Ph	Af	Or	
Polygonatum sp.	1,54	Ruscaceae	G	Euras	Or	x
Polygonum aviculare L.	0,39	Polygonaceae	Th	Euras	We	x
Polypogon monspeliensis (L.) Desf.	1,16	Poaceae	Th	Med	We	x
Populus alba L.	0,39	Salicaceae	Ph	Eur-Af-As	Or	x
Portulaca grandiflora Hook.	1,16	Portulacaceae	Th	S Am	Or	
Portulaca oleracea L.	4,25	Portulacaceae	Th	Euras	Or, We	x
Portulacaria afra Jacq.	5,41	Portulacaceae	Ch	Af	Or	
Potentilla reptans L.	4,25	Rosaceae	H	Eur-Af-As	We	x
Primula acaulis (L.) L.	8,49	Primulaceae	H	Euras	Or	x

Primula obconica Hance	1,54	Primulaceae	H	As	Or	
Prunus armeniaca L.	9,65	Rosaceae	Ph	As	Or, Ed	
Prunus avium (L.) L.	11,58	Rosaceae	Ph	Euras	Or, Ed	x
Prunus cerasifera Ehrh.	5,79	Rosaceae	Ph	Euras	Or	
Prunus domestica L.	4,25	Rosaceae	Ph	Euras	Or, Ed	
Prunus dulcis (Mill.) D.A.Webb	5,41	Rosaceae	Ph	As	Or, Ed	
Prunus laurocerasus L.	3,86	Rosaceae	Ph	Euras	Or	
Prunus persica (L.) Batsch	7,72	Rosaceae	Ph	As	Or, Ed	
Pseuderanthemum atropurpureum L.H.Bailey.	0,39	Acanthaceae	Ph	S Am	Or	
Punica granatum L.	15,83	Lythraceae	Ph	As	Or, Ed	
Pyracantha coccinea M. Roem.	1,54	Rosaceae	Ph	Euras	Or	x
Pyracantha sp.	1,54	Rosaceae	Ph	Euras	Or	x
Pyrus communis L.	2,70	Rosaceae	Ph	Euras	Or, Ed	
Quercus coccifera L.	0,39	Fagaceae	Ph	Med	Or	x
Quercus ilex L.	1,16	Fagaceae	Ph	Med	Or	x
Quercus suber L.	0,77	Fagaceae	Ph	Med	Or	x
Ranunculus ficaria L.	0,77	Ranunculaceae	G	Euras	Or	x
Ranunculus sp.	0,39	Ranunculaceae	G	Euras	Or	x
Raphanus raphanistrum L.	0,77	Brassicaceae	Th	Med	Ed	x
Raphanus sativus L.	0,77	Brassicaceae	Ch	As	Ed	
Rebutia sp.	0,39	Cactaceae	Ch	S Am	Or	
Rhamnus alaternus L.	0,39	Rhamnaceae	Ph	Med	Or	x
Rhododendron sp.	16,60	Ericaceae	Ph	Cos	Or	
Ribes sp.	1,54	Grossulariaceae	Ph	Eur	Or, Ed	x
Ricinus communis L.	0,77	Euphorbiaceae	Ph	Af	Or	
Robinia pseudoacacia L.	1,16	Fabaceae	Ph	N Am	Or	
Rosa sp.	58,30	Rosaceae	Ph	As	Or	
Rosmarinus officinalis L.	41,31	Lamiaceae	Ch	Med	Or, Me	x
Rubia peregrina L.	0,39	Rubiaceae	Ph	Med	We	x
Rubus idaeus L.	1,54	Rosaceae	Ph	Euras	Or, Ed	x
Rubus ulmifolius Schott	0,77	Rosaceae	Ph	Eur-Af-As	We	x
Rumex acetosa L.	1,54	Polygonaceae	H	Eur	Or, Ed	x
Rumex crispus L.	3,47	Polygonaceae	H	Eur-Af-As	We	x
Ruscus aculeatus L.	3,86	Ruscaceae	Ch	Euras	Or	x
Ruscus hypoglossum L.	0,39	Ruscaceae	Ch	Med	Or	
Russelia equisetiformis Schltdl. & Cham.	0,77	Plantaginaceae	Ch	S Am	Or	
Ruta graveolens L.	2,32	Rutaceae	Ch	Eur	Or, Ed	
Sagina apetala Ard.	7,34	Caryophyllaceae	Th	Euras	We	x
Salix alba L.	2,70	Salicaceae	Ph	Euras	Or	x
Salix caprea L.	0,39	Salicaceae	Ph	Euras	Or	x
Salvia greggii A.Gray	1,54	Lamiaceae	Ch	N Am	Or	
Salvia microphylla Sessé & Moc.	4,25	Lamiaceae	Ch	N Am	Or	
Salvia officinalis L.	11,97	Lamiaceae	Ch	Eur	Or	x
Salvia splendens Ker Gawl.	0,77	Lamiaceae	Ch	S Am	Or	

Sambucus nigra L.	0,39	Caprifoliaceae	Ph	Eur-Af-As	Or, Ed	x
Sansevieria sp.	0,39	Asparagaceae	Ch	Af	Or	
Santolina chamaecyparissus L.	3,86	Asteraceae	Ch	Eur	Or	x
Sarcococca sp.	0,39	Buxaceae	Ph	As	Or	
Sarracenia purpurea L.	0,39	Sarraceniaceae	Ch	N Am	Or	
Satureja hortensis L.	0,39	Lamiaceae	Th	Med	Ed	x
Scaevola aemula R.Br.	0,39	Goodeniaceae	H	AusNZ	Or	
Schefflera arboricola Hayata	12,36	Araliaceae	Ph	As	Or	
Schinus molle L.	2,32	Anacardiaceae	Ph	S Am	Or	
Sciadopitys verticillata Siebold & Zucc.	0,39	Sciadopityaceae	Ph	As	Or	
Scilla campanulata Aiton	0,39	Liliaceae	G	Eur	Or	
Scirpus maritimus L.	0,39	Cyperaceae	G	Cos	We	x
Sclerocactus sp.	0,39	Cactaceae	Ch	N Am	Or	
Sedum dasyphyllum L.	1,93	Crassulaceae	Ch	Eur	Or	x
Sedum lineare Thunb.	0,77	Crassulaceae	Ch	As	Or	
Sedum mexicanum Britton	0,39	Crassulaceae	Ch	N Am	Or	
Sedum morganianum E.Walther	0,39	Crassulaceae	Ch	S Am	Or	
Sedum pachyphyllum Rose	16,22	Crassulaceae	Ch	N Am	Or	
Sedum palmeri S.Watson	27,03	Crassulaceae	Ch	N Am	Or	
Sedum rupestre L.	6,56	Crassulaceae	Ch	Eur	Or	x
Sedum sieboldii Hort. ex G.Don	0,39	Crassulaceae	Ch	As	Or	
Sempervivum sp.	3,47	Crassulaceae	Ch	Eur-Af-As	Or	x
Senecio barbertonicus Klatt	0,39	Asteraceae	Ch	Af	Or	
Senecio inaequidens DC.	0,39	Asteraceae	Ch	Af	We	
Senecio mikanioides Walp.	0,77	Asteraceae	Ch	Af	Or	
Senecio serpens G.D.Rowley	1,54	Asteraceae	Ch	Af	Or	
Senecio vulgaris L.	3,47	Asteraceae	Th	Eur-Af-As	We	x
Senna corymbosa (Lam.) H.S.Irwin & Barneby	0,77	Caesalpiniaceae	Ph	S Am	Or	
Setaria sp.	1,93	Poaceae	Th	Cos	We	x
Sherardia arvensis L.	3,86	Rubiaceae	Th	Euras	We	x
Silene pseudoatocion Desf.	4,25	Caryophyllaceae	Th	Med	Or	x
Silybum marianum (L.) Gaertn.	0,77	Asteraceae	H	Med	We	x
Sinapis arvensis L.	0,39	Brassicaceae	Th	Eur	We	x
Smilax aspera L.	0,39	Smilacaceae	Ph	Eur-Af-As	We	x
Solanum jasminoides Paxton	7,72	Solanaceae	Ph	S Am	Or	
Solanum lycopersicum L.	21,62	Solanaceae	Th	S Am	Ed	
Solanum melongea L.	1,93	Solanaceae	Ch	As	Ed	
Solanum pseudocapsicum L.	0,39	Solanaceae	Th	S Am	Or	
Solanum rantonnetii Carriere	12,74	Solanaceae	Ph	S Am	Or	
Solanum tuberosum L.	2,32	Solanaceae	G	S Am	Ed	
Sonchus oleraceus L.	23,17	Asteraceae	Th	Euras	We	x
Sonchus tenerrimus L.	8,49	Asteraceae	Th	Med	We	x
Sophora microphylla Aiton	0,39	Fabaceae	Ph	AusNZ	Or	
Spartium junceum L.	1,16	Fabaceae	Ph	Med	Or	x

Spathiphyllum sp.	0,77	Araceae	Ch	S Am	Or	
Spinacia oleracea L.	0,39	Chenopodiaceae	Ch	As	Ed	
Spiraea × vanhouttei (Briot) Carrière	0,39	Rosaceae	Ph	Hort	Or	
Spiraea cantoniensis Lour.	0,39	Rosaceae	Ph	As	Or	
Spiraea japonica L.f.	1,54	Rosaceae	Ph	As	Or	
Sporobolus indicus (L.) R.Br.	0,77	Poaceae	H	S Am	We	
Stapelia grandiflora Jacq.	0,77	Apocynaceae	Ch	Af	Or	
Stellaria media Cirillo	9,27	Caryophyllaceae	Th	Eur	We	x
Stenocereus eruca (Brandegee) A.C.Gibson & K.E. Horak	0,39	Cactaceae	Ch	N Am	Or	
Stenotaphrum secundatum (Walter) Kunzte	4,63	Poaceae	H	S Am	Or	
Stevia sp.	0,39	Asteraceae	Ch	S Am	Me	
Strelitzia alba Skeels	0,39	Strelitziaceae	G	Af	Or	
Strelitzia reginae Banks	15,44	Strelitziaceae	G	Af	Or	
Syagrus romanzoffiana (Cham.) Glassman	3,47	Araceae	Ph	S Am	Or	
Syngonium sp.	0,39	Araceae	Ph	S Am	Or	
Syringa vulgaris L.	6,56	Oleaceae	Ph	Eur	Or	
Syzygium aromaticum (L.) Merr. & L.M.Perry	0,39	Myrtaceae	Ph	As	Or, Ed	
Syzygium australe (Link) B.Hyland	0,39	Myrtaceae	Ph	AusNZ	Or	
Tagetes sp.	6,56	Asteraceae	Th	S Am	Or	
Tamarix gallica L.	3,09	Tamaricaceae	Ph	Eur	Or	x
Taraxacum officinale F.H.Wigg.	10,04	Asteraceae	H	Euras	We	x
Taxus baccata L.	3,09	Taxaceae	Ph	Eur	Or	x
Tetrastigma voinierianum Pierre ex Gagnep.	0,39	Vitaceae	Ph	As	Or	
Teucrium fruticans L.	7,34	Lamiaceae	Ph	Med	Or	x
Thelocactus sp.	0,39	Cactaceae	Ch	N Am	Or	
Thuja occidentalis L.	18,92	Cupressaceae	Ph	N Am	Or	
Thuja orientalis L.	8,11	Cupressaceae	Ph	As	Or	
Thymbra capitata Griseb.	0,39	Lamiaceae	Ch	Med	Or	
Thymus × citriodorus (Pers.) Schreb.	4,25	Lamiaceae	Ch	Hort	Or, Me	
Thymus vulgaris L.	22,78	Lamiaceae	Ch	Med	Or, Me	x
Tilia sp.	0,39	Tiliaceae	Ph	Euras	Or	x
Tillandsia recurvata L.	5,79	Bromeliaceae	Ep	S Am	Or	
Trachelospermum jasminoides Lem.	9,65	Apocynaceae	Ph	As	Or	
Tradescantia cerinthoides Kunth	1,16	Commelinaceae	Ch	S Am	Or	
Tradescantia fluminensis Vell.	6,18	Commelinaceae	Ch	S Am	Or	
Tradescantia pallida (Rose) D.R.Hunt	6,95	Commelinaceae	Ch	S Am	Or	
Tradescantia sillamontana Matuda	3,86	Commelinaceae	Ch	S Am	Or	
Tradescantia zebrina Bosse	0,39	Commelinaceae	Ch	S Am	Or	
Trifolium sp.	8,49	Fabaceae	H	Eur	We	x
Tropaeolum majus L.	6,18	Tropaeolaceae	Th	S Am	Or	
Tulbaghia violacea Harv.	0,77	Amaryllidaceae	H	Af	Or	
Tulipa sp.	2,32	Liliaceae	G	Eur-Af-As	Or	x
Urospermum dalechampii (L.) F.W.Schmidt	2,32	Asteraceae	H	Med	We	x
Urtica dioica L.	0,77	Urticaceae	H	Euras	We	x

Vaccinium corymbosum L.	0,39	Ericaceae	Ph	N Am	Or, Ed	
Valeriana officinalis L.	0,77	Valerianaceae	H	Euras	Me	x
Verbascum sinuatum L.	0,77	Scrophulariaceae	H	Eur-Af-As	We	x
Verbena × hybrida Hort. Ex Vilm.	3,86	Verbenaceae	H	Hort	Or	
Veronica persica Poir.	8,11	Scrophulariaceae	Th	Euras	We	x
Viburnum opulus L.	0,39	Caprifoliaceae	Ph	As	Or	
Viburnum suspensum Lindl.	0,39	Caprifoliaceae	Ph	As	Or	
Viburnum tinus L.	13,90	Caprifoliaceae	Ph	Med	Or	x
Vicia faba L.	1,16	Fabaceae	Th	Euras	Ed	x
Vicia sativa L.	1,16	Fabaceae	Th	Eur-Af-As	We	x
Vinca major L.	3,86	Apocynaceae	Ch	Eur	Or	x
Viola × wittrockiana Gams	8,88	Violaceae	H	Hort	Or	
Viola alba Besser	0,77	Violaceae	H	Eur	Or	x
Viola odorata L.	9,65	Violaceae	H	Euras	Or	x
Viola tricolor L.	6,56	Violaceae	H	Eur	Or	x
Vitis vinifera L.	16,99	Vitaceae	Ph	Euras	Or, Ed	x
Vriesea splendens (Brongn.) Lem.	0,39	Bromeliaceae	Ep	S Am	Or	
Washingtonia filifera (Linden ex André) H.Wendl.	3,47	Arecaceae	Ph	S Am	Or	
Washingtonia robusta H.Wendl.	8,11	Arecaceae	Ph	S Am	Or	
Weigela florida A.DC.	1,93	Caprifoliaceae	Ph	As	Or	
Wisteria sinensis (Sims) DC.	8,88	Fabaceae	Ph	As	Or	
Yucca aloifolia L.	13,90	Asparagaceae	Ph	N Am	Or	
Yucca filamentosa L.	1,16	Asparagaceae	Ph	N Am	Or	
Yucca gloriosa L.	0,39	Asparagaceae	Ph	N Am	Or	
Yucca guatemalensis Baker.	16,22	Asparagaceae	Ph	N Am	Or	
Yucca rostrata Engelm.	0,39	Asparagaceae	Ph	N Am	Or	
Zantedeschia aethiopica (L.) Spreng.	20,08	Araceae	G	Af	Or	
Zea mays L.	0,39	Poaceae	Th	S Am	Ed	
Zinnia elegans Jacq.	0,39	Asteraceae	Th	S Am	Or	
Zoysia japonica Steud.	0,77	Poaceae	H	As	Or	

Annex 6: Còpies de les publicacions derivades de la tesis.

1. PADULLÉS, J., VILA, J. & BARRIOCANAL, C. (2014). "Examining boundaries between garden types at the global scale". *Investigaciones geográficas*, 61 (1), 71-86.

   FI IN-RECS: 0,192. Posició 7/39.

2. PADULLÉS, J., VILA, J. & BARRIOCANAL, C. (2014). "Maintenance, Modifications, and Water Use in Private Gardens of Alt Empordà, Spain". *HortTechnology*, 24 (3), 374-383.

   FI SCI: 0,600. Posició 19/32 (Q3) de la categoria *Horticulture*.

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EXAMINING FLORISTIC BOUNDARIES BETWEEN GARDEN TYPES AT THE GLOBAL SCALE[1]

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ABSTRACT

Gardens represent important sources of goods and services for their owners. This functionality translates directly into the types of plants cultivated in a given garden, and terminology has been developed to distinguish each category of garden according to its purpose. The factors explaining the differentiation and distribution of gardens have not previously been explored at the global scale. In this study, the plant lists for 44 sets of gardens from around the world were analyzed to explore their taxonomic similarities and the factors shaping each garden. Several biophysical and socioeconomic variables were examined at the appropriate scale for their roles in garden species distribution. Physical and climatic factors (temperature, rainfall, potential evapotranspiration and distance between settlements) were found to be significantly related with species makeup; all of these factors were less important than GDP per person, a proxy for household income, which was determined to be the primary driver of garden composition. All of the studied socioeconomic factors, such as language similarity among settlements and population density, were significant drivers of species distribution. However, the present analysis omits a number of variables due to data unavailability, such as garden size and owner gender, which have been previously recognized as influences on garden plant composition. The genera cultivated in different gardens were found to be very different from each other, and the definitions of each type are hard to establish from these data alone. Finally, the implications of likely future income variations, such those caused by severe economic crisis, and global climate change on bio-cultural diversity and food security are discussed.

Keywords: Gardens, homegardens, biodiversity, ethnobotany, food security.

RESUMEN

Examinando las fronteras florísticas entre tipologias de jardín a escala global

Los jardines son una importante fuente de bienes y servicios para los residentes de un hogar. Su función se traduce directamente en el tipo de plantas que en ellos se cultiva. Por otro lado, la terminología usada para denominar los distintos tipos de jardín en inglés (*garden*, *homegarden*, *forest garden*, etc.) varía según su función y propósito. Los factores que explican la diferenciación y distribución de los jardines a escala global no habían sido previamente explorados hasta ahora. En este estudio se han analizado los inventarios florísticos de 44 conjuntos de jardines de to do el mundo para explorar sus similitudes taxonómicas y los factores que configuran la distribución de su flora. Para ello, se escogieron distintas variables biofísicas y socioeconómicas a una escala apropiada de trabajo. Como resultado, los factores biofísicos y climáticos (temperatura, precipitación, evapotranspiración potencial y distancia entre asentamientos) se hallaron significativamente relacionados con la distribución de las especies; no obstante, todos estos factores resultaron ser menos importantes que el GDP (PIB) *per cápita*, utilizado aquí

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como indicador de los ingresos del hogar, y que se obtuvo como el principal impulsor de la composición de los jardines. También el resto de factores sociales y culturales incluidos en el análisis, como son la similitud entre las lenguas de los distintos asentamientos o la densidad de población, se encontraron como variables significativas. Cabe señalar que el presente análisis omite cierto número de variables debido a la no disponibilidad de datos. Algunas de estas variables son el tamaño del jardín o el género de su dueño, las cuales han sido reconocidas previamente como agentes influyentes en la composición vegetal de los jardines. El estudio concluye que los géneros vegetales cultivados en los conjuntos de jardines son muy diferentes entre sí y que, por lo tanto, las distinciones entre tipologías de jardín son difíciles de establecer a partir de tan solo datos florísticos. Por último, se discuten también las implicaciones que podrían tener posibles futuras fluctuaciones en el nivel de la renta (causadas por una severa crisis económica) o el cambio climático, sobre la diversidad bio-cultural y la seguridad alimentaria.

Palabras clave: Jardines, huertos familiares, biodiversidad, etnobotánica, seguridad alimentaria.

1. INTRODUCTION

Humans have cultivated their immediate living environments since the Neolithic (Brownrigg 1985), and some of these cultivated areas, particularly those adjacent with or close to the homes of their owners and smaller than the average size of an agricultural plot, are commonly classified as gardens (Vogl *et al.* 2004). The exact definition of “garden” depends heavily on context, and according to Vogl *et al.* (2004), an ethnoecological approach to garden classification might include a generic category for “garden” along with several specific subcategories (e.g., “coffee garden”, “field garden”, “home garden”, “cocoa garden”). Therefore, classifying gardens at the regional scale is not always straightforward, and any labeling effort should be accompanied by the precise definitions of the variables and gradients used to distinguish between types. At the global scale, many types of gardens, each with different plant composition and purpose, have been described. However, most scientific literature has classified gardens into only two groups: domestic gardens (e.g., Daniels, Kirkpatrick 2006; Loram *et al.* 2008, Bigirimana *et al.* 2012), and homegardens (e.g., Kumar, Nair 2004; Blanckaert *et al.* 2004; Das, Das 2005). The key element linking all types of gardens is that local residents have autonomy over the space, although they may delegate this responsibility to others, such as professional designers or hired gardeners (Cameron *et al.* 2012).

Domestic gardens have been defined by Gaston *et al.* (2005) as the private spaces adjacent to or surrounding dwellings and they may be composed of lawns, ornamental and vegetable plots, ponds, paths, patios or temporary buildings such as sheds and greenhouses. In the same way, Bhatti and Church (2000) describe a domestic garden as an area of enclosed ground, cultivated or not, within the boundaries of an owned or rented dwelling, where plants are grown and other materials are arranged spatially. Depending on the characteristics of the cities and towns in which they are located, domestic gardens can contribute nearly one third of the total urban area (Domene, Saurí 2003; Gaston *et al.* 2005; Mathieu *et al.* 2007). Therefore, studies regarding domestic gardens have traditionally focused on urban biodiversity (Smith *et al.* 2006; Davies *et al.* 2009; Doody *et al.* 2010), ecosystem services (Tratalos *et al.* 2007; Cameron *et al.* 2012), socio-economic patterns for greening, (Luck *et al.* 2009; Hunter, Brown 2012), water consumption (Syme *et al.* 2004; Hurd 2006) and even psychology and well-being (Clayton 2007; Freeman *et al.* 2012).

The term “homegarden”, also known as the “kitchen garden”, “dooryard garden”, or “agroforestry homegarden” (among many other variations), has received several definitions, although none has gained universally acceptance (Kumar, Nair 2004). Homegardens have been primarily described as social and economic units of rural households, in which crops, trees, shrubs, herbs and livestock are managed to provide food, medicine, shade, cash, poles and socio-cultural functions (Christanty 1990; Campbell *et al.* 1991; Shackleton *et al.* 2008). Fernandes and Nair (1986) reported that homegardens should therefore be considered as intensively cultivated agroforestry systems managed within the compounds of each household. In a predominantly subsistence-oriented economy, homegardens provide an array of outputs (Jose, Shanmugaratnam 1993), but although many are used for food and commercial production, others contain only lawn and ornamental species (Vogl *et al.* 2004). This broad definition of the term has led to the characterization of homegardens as a category with indeterminate boundaries. The existing scientific research regarding homegardens has mostly been conducted in tropical areas and is oriented towards ethnobotany (Agelet *et al.* 2000; Eichemberg *et al.* 2009), agroforestry production and food security (Wezel, Bender 2003; Kumari *et al.* 2009), ecology (Gajaseni, Gajaseni 1999; Kumar 2011) or biodiversity issues (Kabir, Webb 2008; Akinnifesi *et al.* 2010).

The precise differences between these two garden categories are still unclear, and their characteristic features are often mixed in practice. Generally, "domestic gardens" are associated with urban environments, while "homegardens" are mainly considered as rural agroforestry systems (Vogl *et al.* 2004). Furthermore, homegardens are associated with a more utilitarian perspective, while domestic gardens are mainly cultivated for recreational and aesthetic value. However, many other types of garden have been described, and others remain unexplored. The processes of global change and the specific characteristics of each region blur the boundaries of garden types, and the classification of gardens is not always easy.

The distribution of cultivated plants, unlike that of native vegetation, is influenced by many factors beyond biophysical variables such as temperature, precipitation and the movement of land masses (Kendal *et al.* 2012). Indeed, socio-economic variables (e.g., population and housing density, education, age, home ownership, income) have been described as better predictors of the vegetation cover in private gardens than biophysical variables (Hope *et al.* 2003; Luck *et al.* 2009; Marco *et al.* 2010). In the same way, colonialism has resulted in widely dispersed cities with similar cultivated landscapes, which mimic those of their shared colonial homeland (Reichard, White 2001; Ignatieva, Stewart 2009). Therefore, the cultural background and behavior of residents can partly overcome the natural tendencies of plant dispersal (Head *et al.* 2004).

There has been almost no attempt to describe the composition and distribution of the flora of gardens at the global scale (Thompson *et al.* 2003). The number of studies that document the differences in species composition between gardens is also limited (Cameron *et al.* 2012), but floristic surveys and plant inventories of these ecosystems have increased in recent years (e.g., Albuquerque *et al.* 2005; Daniels, Kirkpatrick 2006; Tynsong, Tiwari 2010), providing the opportunity to analyze them at the global scale. Kendal *et al.* (2012) explored the distribution patterns for all types of cultivated urban flora at the global scale and concluded that physical variables, especially mean annual temperature, were the most important to species composition. However, the importance of social factors on the distribution of cultivated plants was also documented. In the present study, a similar methodology with a focus on private gardens and accurate data at the appropriate scale is used.

This study aims to refine the classification gardens described in the scientific literature and to assess the factors determining their plant composition. Plant inventories for 44 sets of gardens from around the world are compared according to their previous classification (e.g., "domestic gardens", "homegardens", and "mixed gardens"). A comparison of global garden vegetation may provide clues about the structure, cultivation and use of these spaces in different societies around the world. Moreover, a better understanding of the distribution of cultivated vegetation in urban and rural gardens will contribute towards the better management of natural resources, conservation of biodiversity in anthropogenic environments and enhancement of food security worldwide.

2. MATERIAL AND METHODS

2.1. Selection of plant inventories

Publications containing plant garden inventories were obtained by searching titles, abstracts and keywords within Web of Science, Scopus, Google Scholar, and other relevant journals not included in these databases. Several key terms were searched (e.g., garden*, yard, lawn, plant*, flor*, vegetat*), both alone and in multiple combinations, until no new relevant publications were found. The keywords were also searched in several combinations using "AND" and "OR" statements to generate more accurate results. Further studies were obtained from the references of previously located studies. The term "garden", for the purpose of this study, is defined as the private area around a home used for the planting of ornamental plants as well as for the production of food and other agricultural products. Furthermore, a garden must be cultivated for leisure, home consumption or as a means of generating income. Garden studies without plant inventories, along with those in which plant inventories were mixed with other environments or garden types, were excluded. Floristic surveys which could not be assigned to a specific location with precise coordinates were also discarded. Finally, the garden typology, main research question(s), key words, and type of plants inventoried for each study were also recorded.

2.2. Selection of variables

Several physical and socioeconomic variables were collected to analyze the distribution patterns of garden flora at the global scale. Accurate data were selected at the appropriate scale to describe particular locations within countries. The climatic data included mean annual temperature (°C), mean annual rainfall (mm), and monthly potential evapotranspiration (mm). Mean annual temperature and rainfall were obtained from each study or, when not reported by the authors, from the World Meteorological Organization (2013). Potential evapotranspiration was calculated using the methods of Willmott and Kenji (2001) with a gridded raster of a 50x50 km cell. Distances in kilometers between each location were calculated using the great-circle method.

The socioeconomic data presented in the literature differed for each study; therefore, different sources were examined to obtain proxy data for multiple variables. The selected variables were chosen according to those considered significantly influential in Kendal *et al*. (2012) and other scientific publications (e.g., Hope *et al*. 2003; Marco *et al*. 2008; Luck *et al*. 2009; Bigirimana *et al*. 2012). Population density (persons/ km^2) in the year 2000 was used as a proxy for the urban to rural gradient and was obtained using the gridded raster method (25x25 km) of CIESIN and CIAT (2005). Gross Domestic Product (GPD; millions of US $), obtained from CIESIN (2002), was used as a proxy for household income. In this case, more recent data were unavailable, values for the year 1990 were taken from a gridded raster (25x25 km) based on the SRES B2 Scenario. Dominant language family, obtained from the map in Goode (2006), was chosen as a proxy for the influence of cultural background. As the specific language of each community was not reported in all of the articles, a broader scale was selected, reducing the number of categories and amplifying the influences of cultural background and colonialism. When more than one location was used in a study, average values were generated for each variable and the plant inventory; the centroid between all points was used for great circle distances.

The uses of a given garden are reflected by its plants. Therefore, different types of gardens are associated with different cultivated plants. Each paper reviewed categorizes its surveyed gardens in a distinct way. The descriptions and categorizations given by the authors are reported in the classification of each inventory. However, no distinction has been made between "homegarden", "home garden", house garden" and "home-garden". All of these terms have been included in the same category as "homegarden".

2.3. Data analysis

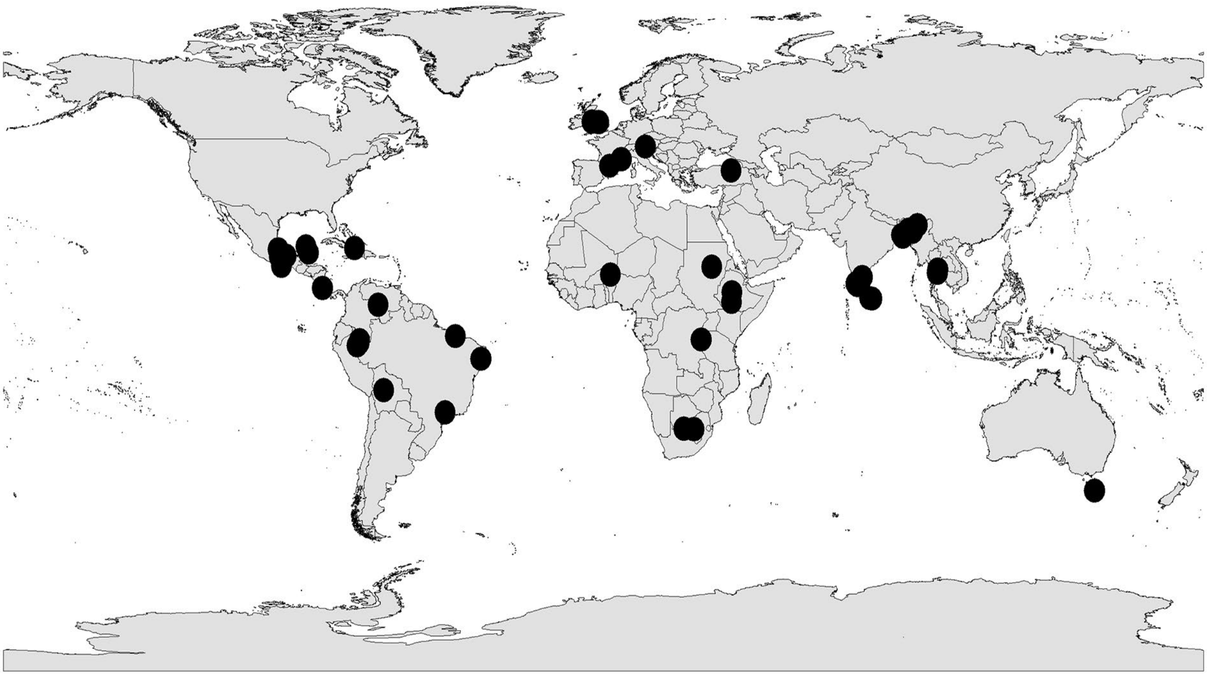
The plant inventories were examined for orthographic mistakes and standardized according to The International Plant Name Index database (IPNI 2013). Genus was selected as an appropriate taxonomic category for meaningful statistical analysis (Krebs 1999; Kendal *et al*. 2012). To reduce the stochastic noise, those genera present at relative frequencies of less than 6.82% were excluded from the study. For the same reasons, plant inventories containing less than 20 genera were also discarded. The variables obtained through Geographical Information Systems (potential evapotranspiration, GDP and population density) were processed with ArcGis v10 (ESRI 2012). Non-metric Multidimensional Scaling (NMDS) with the Bray-Curtis dissimilarity index (Faith *et al*. 1987) was run with the *vegan* package in R 2.15.2 (Team 2012) and used to investigate the relative taxonomic similarities between garden flora.

A standard linear regression model was applied to test the significance of different environmental, socioeconomic and cultural variables against the dissimilarity level of the different inventories. The Bray-Curtis dissimilarity index was set as the dependent variable and was transformed by squaring to improve the normality of residuals. The independent variables selected for the model were pairwise differences in mean annual temperature, mean annual rainfall, mean annual potential evapotranspiration, GDP per person, population density and distance between settlements. All of these variables were transformed by taking the square root to improve the normality of the residuals. Coded dummy variables for the differences between garden types and dominant language families were also included in the model (0=same, 1=different). A stepwise procedure using the Akaike Information Criterion (AIC) was conducted to obtain the most adjusted linear regression model, and multicollinearity was measured using the Variance Inflation Factor (VIF). The spatial correlation between the environmental data and the distances between each settlement was tested using the Mantel test with the package *ade4*. Because no significant result was observed (P=0.078) for this test, spatially weighted regression was not conducted (Lichstein *et al*. 2002; Kendal *et al*. 2012).

3. RESULTS AND DISCUSSION

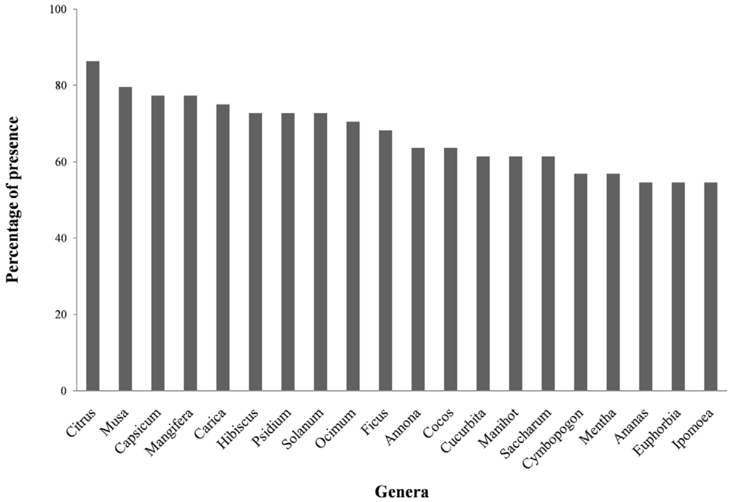
A total of 44 plant lists from different studies covering a global distribution were selected to analyze the floristic dissimilarities between gardens (Figure 1). The main research questions, key words and interests for all of the studies were examined to analyze their research purposes and to classify them into synthetic research categories. Five main categories were established: biodiversity, ethnobotany, agroforestry production, ecology and landscaping. Each study could be classified into one or more of these categories. Biodiversity issues (65.9%) were the most prevalent among the research, but ethnobotany (31.82%) and agroforestry production (27.27%) were also of significant importance to garden research. Plant uses were recorded in more than 75% of the studies, most of them studies of homegardens. Because many categories were applied to describe plant uses (e.g., timber, medicinal, food, fruit, fencing, construction), only those coincident for all plant inventories were selected for the present study. Using this approach, plants used for food supply were the most important category (57.97%), followed by medicinal (30.19%) and ornamental species (26.7%). A single plant may have multiple uses and can be classified into several categories simultaneously.

Figure 1. Locations of the 44 plant inventories compiled for this study. Those inventories representing more than one settlement are located using their geographical centroids.



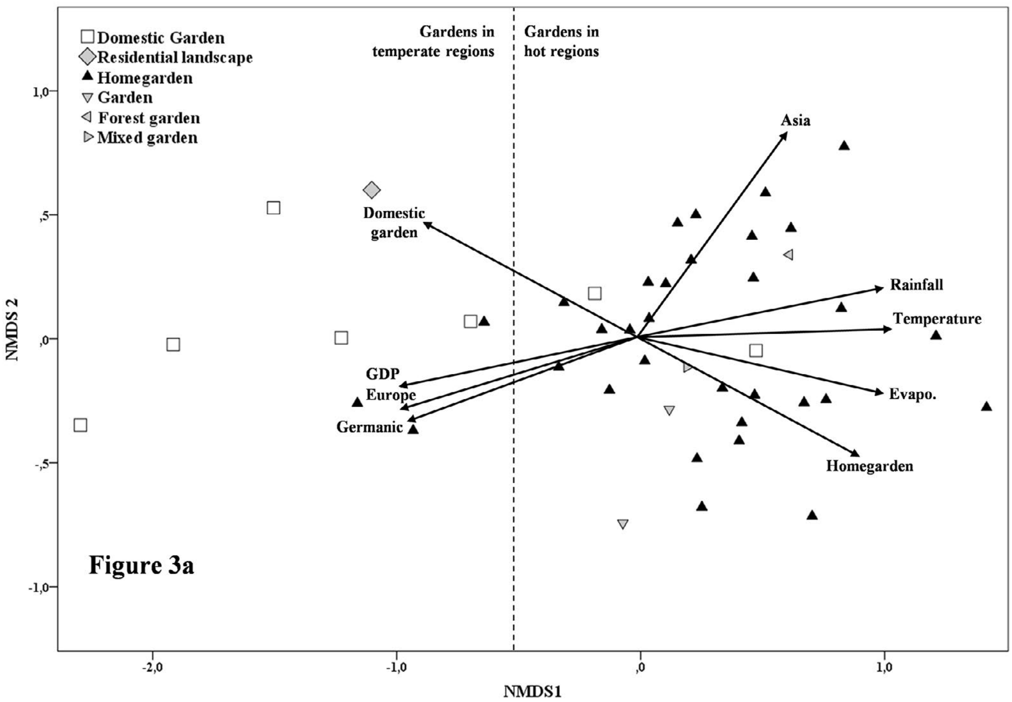
A set of 688 genera was included in the meta-analysis. The most frequent cultivated genera among the inventories were *Citrus* (86.36%), *Musa* (79.55%), *Capsicum* (77.27%), *Mangifera* (77.27%) and *Carica* (75%) (Figure 2). Only 3.17% of the studies had no genera in common. However, 96.41% of the inventories had a Bray-Curtis dissimilarity index of over 0.5, suggesting that the plants grown in gardens around the world are substantially different.

Figure 2. The 20 most representative genera across all inventories and their relative frequencies.



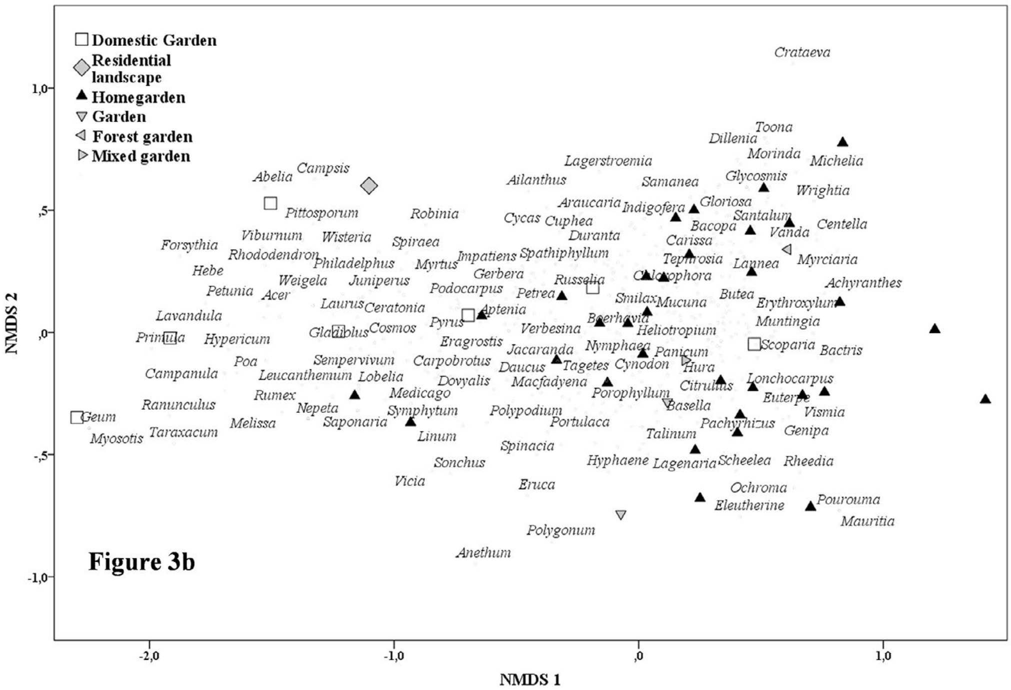
The NMDS ordination (Figure 3a) represents the taxonomic dissimilarities between all of the samples according to their categories. Temperature was calculated to be the strongest environmental gradient (R^2=0.61), but many other physical and social environmental gradients, including potential evapotranspiration (R^2=0.50), GDP per person (R^2=0.47) and Germanic spoken languages (R^2=0.47), were also significantly related to plant type (p<0.005). Two main clusters were identified, separating those gardens grown in temperate regions from those grown in hot regions. No clear differentiation was found between arid, tropical and subtropical gardens.

Figure 3a. Non-metric Multidimensional Scaling Analysis (NMDS) ordination plot of the Bray-Curtis distance between each garden's cultivated flora (Stress=0.152). Each symbol represents a different garden type according to the classifications of the authors. Grey symbols indicate categories that were also classified as homegardens or domestic gardens in the scientific literature. Physical and social environmental gradients calculated as significant (P<0.01) are represented as vectors indicating the direction of the environmental gradient (Germanic=Languages with the same Germanic origin; Evapo.=Potential Evapotranspiration; GDP=Gross Domestic Product per person).



Genera were mapped on the ordination to clarify which scored highly for each NMDS axis (Figure 3b). For the first NMDS axis, *Digitalis*, *Geum* and *Myosotis* scored positively, while *Centella*, *Areca*, *Achyranthes* scored negatively. Genera that scored highly on the second NMDS axis included *Crataeva*, *Adenanthera* and *Alstonia* in the positive direction and *Anethum*, *Polygonum* and *Scheelea* in the negative direction.

Figure 3b. Genera with a frequency of greater than 9.09% are shown in the ordination. To avoid label overlapping, only the most common genera are represented.



Multiple linear regression (Table 1) shows that all of the significant variables included in the model explain more than 50% of the total dissimilarity variation with the adjusted R^2. Difference in GDP is the strongest significant variable explaining taxonomic dissimilarity. Other physical and social variables, such as difference in mean annual temperature and distance between settlements, were also determined to be important significant co-variables. To a lesser extent, differences in potential evapotranspiration, family language, garden typology, and mean annual rainfall were found to be moderately but significantly related with taxonomic dissimilarity. Population density, intended as a proxy for the urban-to-rural gradient, was also found to be a significant variable in the model. The VIF values indicate a slight but acceptable multicollinearity between differences in mean annual temperature and potential evapotranspiration.

Table 1. Results from the multiple linear regression of selected variables on the Bray-Curtis dissimilarity matrix (Adjusted R-squared: 0.5361). All selected variables were included in the final model (AIC=-1037.605). VIF values are included to interpret multicollinearity. P-value defined as *P<0.01. **P<0.001.

	Coefficient	VIF
Constant	0.2336**	
Square root of difference in GDP per person (millions of US $)	0.0133**	1.7
Square root of difference in mean annual temperature (°C)	0.0527**	2.3
Square root of distance between study sites (km)	0.0000**	1.2
Square root of difference in potential evapotranspiration (mm)	0.0090**	2.1
Settlements with different dominant language family	0.0504*	1.3
Studies of different garden type	0.0323*	1.4
Square root of difference in mean annual rainfall (mm)	0.0010*	1.1
Square root of population density (persons/km²)	-0.0014*	1.2

3.1. Boundaries between "domestic gardens" and "homegardens"

The results of the present study indicate that many gardens have been inventoried from different regions and territorial contexts around the world. Each author applies the most appropriate descriptive label for his or her study garden according the research interests of the work. Globally, but especially in tropical areas, homegardens have attracted more scientific attention due to their roles in food production and agrobiodiversity conservation. In contrast, garden studies of developed countries in temperate areas have mainly focused on domestic gardens to analyze issues related to urban biodiversity, such as biological invasions, or other matters like garden water consumption. The dissimilarities between garden floristic compositions suggest that there is a slight distinction between domestic gardens and homegardens, although the boundaries between the categories are not distinct, especially in warmer regions. Many taxa are present in all types of gardens regardless of classification, confirming that the differences of garden types are subtle and dependent on their purposes and particular characteristics. In agreement with this view, homegardens located in temperate areas have more genera in common with nearby domestic gardens than with other homegardens in warmer regions. Regarding taxonomic dissimilarities within the categories, domestic gardens are significantly more different from each other than are homegardens. However, the latter gardens also differ depending on multiple biophysical, socioeconomic and cultural factors. In this respect, homegardens have been impacted by "acculturation", the process through which a culture is transformed by the widespread adoption of cultural traits from another society. This process has direct consequences on the plant species grown in gardens and the extent to which they are used (Caballero 1992). Thus, traditionally managed homegardens are under the threat of transformation into more homogeneous gardens.

3.2. Factors correlated to plant diversity in gardens

The present study suggests that plant diversity in selected gardens from around the world is significantly related to many physical, socioeconomic and cultural variables. The results suggest that temperature, which has been long been considered as the primary driver of plant distribution, is less important than differences in GDP per person. However, temperature, distance between settlements and potential evapotranspiration remain very important significant variables in the explanation of the taxonomic dissimilarity between gardens. To a lesser extent, cultural background (settlements sharing the same language family), garden type, mean annual rainfall and population density also contribute positively to differences in cultivated genera.

Physical and climatic variables, specifically temperature, act as important filters of plant distribution. Kendal *et al.* (2012), using similar methodology, concluded that the main driver of global distribution for plants cultivated in green urban areas was temperature. In the current study, difference in mean annual temperature was an important factor in plant distribution but was not the main predictor. Distance between settlements was also a significant influential variable. The distribution of plants cultivated in gardens, unlike that of native flora, does not necessarily follow spatial correlation patterns, because their dispersion is caused by both natural and anthropogenic processes. According to the inventories analyzed in the present study, homegardens have similar percentages of native and alien plants. In domestic gardens, an average of three quarters of the species are alien. Therefore, distance between settlements has a powerful effect on the former type. Differences in mean annual potential evapotranspiration and in mean annual rainfall were both included in the model, although the latter variable had limited explanatory power. This result can be explained by the manipulation of climate through human activities such as irrigation whereby the contribution of extra water compensates for the lack of rain. In contrast, temperature is difficult to alter in outdoor gardens without the construction of greenhouses or similar structures.

Among the socioeconomic and cultural variables considered in the analysis, the explanatory power of GDP per person is most significant. A relationship between human resource abundance and plant diversity in urban ecosystems has been observed in many cities and is named the "luxury effect" (Hope *et al.* 2003). Social scientists also call this phenomenon the "prestige effect", and it involves the symbolic display of identity and social status beyond economic ability (Martin *et al.* 2004; Kinzig *et al.* 2005; Grove *et al.* 2006; Troy *et al.* 2007). For example, Lubbe *et al.* (2010) reported that garden plants in high-class neighborhoods have mainly ornamental functions, while those of lower-class neighborhoods have more utilitarian functions. According to the present study, gardens in regions with low GDP per person are typically classified as homegardens and contain more utilitarian plants, such as fruit, vegetables, or timber plants, which are nearly absent from gardens in wealthier areas. Ornamental woody plants are characteristic of urban domestic gardens in temperate regions. Because private management is the most common management style among the analyzed gardens, a great range of goods and services could be obtained from them by their owners. Conversely, public gardens handled by governments fulfill other functions and are not as closely linked to the income and personal preferences of local people.

Regions sharing the same dominant language family have a lower taxonomic dissimilarity index, confirming the significant role of cultural background on the distribution of garden species at the global scale. This influence has been reported to be especially prevalent in colonized areas (Crosby 1996; Ignatieva, Stewart 2009; Kendal *et al*. 2012). In terms of garden type, a taxonomically justifiable distinction does exist between the two main categories. The predominant species in domestic gardens include *Hedera helix*, *Lonicera sp*., *Hydrangea macrophylla*, *Lavandula sp*., *Rosa sp*., and *Rosmarinus officinalis*, while the most prevalent plants in homegardens include *Citrus sp*., *Mangifera indica*, *Musa paradisiaca*, *Capsicum anuum* and *Carica papaya*. However, taxonomic matches between these two groups are still abundant, and the classification of gardens must depend on variables beyond floristic composition. Population density was shown to be negatively related with taxonomic dissimilarity. Therefore, gardens in densely populated areas are much more similar than are gardens in sparsely populated regions. Previous research has documented that people tend to prefer plants for their own gardens that are growing in nearby gardens (Zmyslony, Gagnon 1998; Nassauer *et al*. 2009), and this effect may be amplified in urban areas.

Many other factors not included in the present analysis have been shown to influence the floristic composition of gardens at different scales and with different effects. Several studies have indicated that housing or farming age and size can positively contribute to the greater biodiversity of homegardens (Kumar *et al*. 1994; Larsen, Harlan 2006; Eichemberg *et al*. 2009). Education, gender, median house value and even home ownership are also influential factors in determining the types of plants grown by people in their gardens (Yabiku *et al*. 2008; Larson *et al*. 2009; Zhou *et al*. 2009). Especially in domestic gardens, preferences linked to aesthetic value have also been described as important drivers of plant choices (Martin *et al*. 2003; Spinti *et al*. 2004; Nielson, Smith 2005). On a broader scale, political legacy, as measured through a steep socio-economic gradient, was found to be a relevant explanatory variable for plant diversity in the city of Tlokwe in South Africa (Lubbe *et al*. 2010).

3.3. Gardens flora and biodiversity conservation

Gardens from around the world host a wide range of species incorporated from many sources, both natural and artificial. This elevated species richness, combined with the large area that gardens occupy at the global scale, provides many opportunities for conservation. Several studies have recognized the potential value of horticultural flora to biological diversity and their role in providing resources to wildlife (Owen 1991; Kendle, Forbes 1997; Smith *et al*. 2006; Davies *et al*. 2009). Tropical homegardens preserve a number of landraces and cultivars, as well as rare and endangered species (Watson, Eyzaguirre 2002). However, the future transformation of these ecosystems may be determined by social trends (Wiersum 2006). The taxonomic comparison of selected plant inventories indicates that a substantial percentage of gardens have high levels of taxonomic dissimilarity despite their relative closeness. Therefore, gardens may be considered heterogeneous habitats, with distinct territorial idiosyncrasies that result in a great variety of species. In rural environments, protecting the identity of a territory entails preserving the natural values of its gardens. Small variations in several socioeconomic variables, such as income level or population density, may affect biodiversity patterns. Furthermore, ornamental horticulture has been recognized as the main route by which invasive plant species are introduced into developed countries (Dehnen-Schmutz *et al*. 2007; Sanz-Elorza *et al*. 2008), and the uncontrolled management of garden wastes can act as a source for the establishment of these non-native plants (Batianoff, Franks 1998; Sullivan *et al*. 2005; Rusterholz *et al*. 2012). In urban areas, the focus of conservation should also consider the quality of life of the inhabitants (Miller 2005). Environmental education, the use of a common language for communication with decision makers and planners, the involvement of different stakeholders, and even the inclusion of experts from different scientific disciplines can offer a wider perspective on terms such as "diversity" or "conservation" (Miller, Hobbs 2002; Cilliers *et al.* 2004). Gardens can serve as an interface between the natural and the urban and can contribute to the incorporation of ecological values into society. Therefore, the importance of gardens should encourage global awareness of environmental protection.

3.4. Food security, economic crisis and their likely impact on garden floras

The main reason for gardening is the satisfaction of the needs and requirements of the garden's owners. However, these needs are not always the same in all places and at all times. For example, the food security guaranteed through urban and peri-urban agriculture (UPA) has long been considered a significant component of the livelihood strategies for many households (Frankenberger, McCaston 1998; Marsh 1998; Bernholt *et al.* 2009; Thompson *et al.* 2009). Approximately one-seventh of the total world food production is obtained through UPA, which includes the contributions of gardens (Olivier 1999). In tropical developing countries, homegardens may contribute over one third of the total calories and protein consumed (Torquebiau 1992). This production may be obtained directly through the harvest of edible fruit, vegetables, nuts and other products, or it may be obtained indirectly by selling the enhanced and sustained production. For this reason, homegarden production is worthy of recognition as a source of "health" food, which offers many important intangible benefits (Kumar, Nair 2004). Because gardens are dynamic environments, they are relatively sensitive to changes in environmental and socioeconomic conditions. Therefore, a severe economic situation may cause changes in the way garden plants are grown in developed countries. Social groups and families that are closer to poverty thresholds may change the structure and functionality of their gardens to readapt them for food production. In other areas, gardeners may alter their production focus from subsistence to semi-commercial or commercial production according to market forces (Peyre *et al.* 2006). These changes may alter the vegetation structures of gardens, resulting in the dominance of exotic crops and plants instead of traditional production systems and their associated ecosystem services. However, more research is needed to clarify how gardens evolve and which factors cause change. This knowledge, combined with research conducted in other disciplines, would help in establishing viable strategies for the improvement of household nutritional security.

3.5. Limitations of available data

An exhaustive literature review was conducted to find inventories of garden plants from around the world. However, data were not available from all geographical and climatic areas, with a particular lack of research in North America and Northern Asia. Therefore, more research on garden plants is necessary, especially in temperate areas. Additionally, the criteria of the selected inventories varied widely between studies. Several of the selected plant lists were incomplete, including only the most representative species or those considered useful or cultivated, which may have biased the results, although the main conclusions remain robust. Regarding the variables used in the meta-analysis, data were selected to match the appropriate working scale. However, these data may not be sufficiently precise or detailed for some regions.

The socioeconomic dataset was obtained completely from external sources and was less detailed than the physical and climatic data. Moreover, these data were used as proxies for income or cultural background. Any analysis that combines these data is inherently complex and should be assessed carefully. Many other data were not included in the analysis due to unavailability, including education level, gender, age soil type, and these factors have been previously described as important influences on garden floristic composition (see, for example, Cook *et al.* 2012). Much about the global distribution of garden plants remains to be explored, and the present results should be interpreted in light of the existing scientific literature on these issues (Hope *et al.* 2003; Ignatieva, Stewart 2009; Kendal *et al.* 2012).

4. CONCLUSIONS

The analysis of taxonomic dissimilarities between the 44 plant lists from gardens around the world revealed conclusive information about the key factors determining their floristic differences. Unexpectedly, climatic and physical factors, particularly temperature, were not the main drivers of garden species distribution, although they were significantly related. Difference in GDP per person, used here as a proxy for household income, was instead the most important factor. The urban and rural green spaces of private property are usually exploited by their owners to obtain goods and services. This situation creates interests, benefits and opportunities that do not exist in public cultivated areas. Therefore, income level was able to exceed the significance of the physical and climatic variables that explain the botanical distribution for most of Earth's ecosystems. Other socio-economic variables, such as urban density (used as a proxy for the urban-to-rural gradient) and regions sharing the same language family, also shape the composition of garden flora at the global scale.

Many garden types have been described in the scientific literature in a variety of territorial and ethnoecological contexts, although "domestic gardens" and "homegardens" are the most used labels. Urban domestic gardens are associated with high rent residential urban areas in developed countries with temperate environments. In contrast, homegardens are typically associated with rural sites in hot and tropical environments with lower income levels and a predominantly subsistence economy. The present analysis provides significant insight into the differentiation of these two categories. However, boundaries between the types based on taxonomic similarities are still difficult to establish, and no precise criteria have been obtained. Furthermore, not all types of gardens have been studied and inventoried for all regions, and further research is necessary to analyze the biological structure of gardens and their species distribution at the global scale. Gathering information about the owners of these gardens is also essential for establishing strong comparisons. Further research should focus on determining the differences between gardens according to the variables used in a particular analysis.

Gardens are dynamic ecosystems that evolve over time and face the challenge of constantly adapting to current societal pressures. Alterations in socioeconomic dynamics can cause changes in the structure of gardens and their biodiversity. Moreover, severe economic crisis or situations resulting from global climate change may lead to significant changes in the uses of gardens. In near future, gardens currently for leisure in some areas may be converted into gardens for food production, and those already cultivated for subsistence may become more market-oriented. Future research should be concerned with exploring the factors that cause these changes in each territorial context. Knowledge of the trends that determine plant garden composition, and of the ways economic and climate change may affect them, will provide information about how to manage the bio-cultural diversity of gardens.

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Abstract

Water scarcity in developed countries along the Mediterranean coast may be aggravated in the near future due to rising water demand. The recent growth of low-density urban developments in these regions has led to an increase in the number of private domestic gardens. These particular landscapes may account for a large proportion of total domestic water use. This article examines the features and management practices of private gardens in relation to their relative water requirements. To calculate this variable, we use a method based on the relative water needs of garden species and the area of vegetation cover. In addition, transformations in the layouts of the gardens over the last 5 years, as well as various expected changes, are assessed. In total, 258 domestic gardens along the coast of Catalonia were investigated and their owners interviewed. A list of all plants growing in the gardens was recorded. The results indicate that the presence of turf is related to professional landscaping design, property age, and swimming pool presence. Moreover, gardens with greater landscape water requirements have more efficient watering systems. We present a progressive strategy for garden restructuring that may reduce water use while increasing the number of orchards and fruit trees.

Keywords

Costa Brava; domestic gardens; irrigation; low-density; urbanism; water management