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ASSOCIATION BETWEEN FOREST TYPE AND FOREST HISTORY NEAR BARCELONA (CATALONIA) – A GIS APPROACH

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Abstract: The distribution of forest types in the fragmented landscape of the Vallès Plain (NE Spain) was analysed in relation to recent (1956-1993) changes in forest patches, using MiraMon, an in-house developed GIS. Forest type was determined in 252 field plots chosen at random within forest islands of 1993. Changes in forest patches were determined by combining forest boundaries of 1956 and 1993, both obtained from photo-interpretation of orthophotomaps. Two approaches to forest change were considered: presence of absence in 1956 and the degree of change in patch area. Contingency tables were then constructed to analyse the distribution of the main forest types (pine forests with *Rosmarino-Ericion* and *Brachypodion phoenicoidis* understorey, pine forests with *Quercion ilicis* understorey, and mixed forests of *Quercion ilicis*) in relation to (i) the presence or absence of forest in 1956 and (ii) the change in patch area. Both the presence of forest in 1956 and the degree of change in patch area had significant effects on the distribution of forest types. In general, the more late-succession the forest type, the more over-represented in patches already existing in 1956. Mixed forests were, in addition, concentrated in patches resulting from fragmentation of large forest areas, thus suggesting some relict situation of these forests, traditionally considered near the climax.

Introduction

Landscape dynamics throughout time is a graphic expression of a successional mosaic: although landscape might appear in equilibrium, individual patches can remain in steady state, or they can appear and disappear, thus conforming a shifting mosaic of successional stages and histories [4]. Landscape dynamics appears to be particularly complex in metropolitan areas, which undergo intense urbanisation and simultaneous crop abandonment and intensification. This probably affects patches of natural vegetation in a complex way, with a coexistence of recovering, reduction, and fragmentation processes.

Stability of patches over time can be, in turn, associated with the successional status of their corresponding plant communities. Later-successional communities are expected to be concentrated in relatively stable patches, whereas earlier-successional ones would dominate in more dynamic patches [15]. The present study was aimed at analysing this hypothesis for the case of forests in the metropolitan area of Barcelona (NE of Iberian Peninsula), where long and intense interaction with man activities determined a complex landscape dynamics, with coexisting processes of forest recovering and fragmentation. A GIS-based approach was performed in order to combine data on forest patch change, obtained from photo-interpretation, and forest typology following traditional phytocoenological schemes, determined by means of a field survey.

Area of study

The study was carried out in the fragmented landscape of the Vallès Plain, in the metropolitan area of Barcelona (Catalonia, NE Spain, 35.478 ha, Fig. 1). The climate is typically Mediterranean, with soft winters and hot summers (mean temperature 16ºC), and moderate annual precipitation (600-700 mm). Forests covers 36% of the study area (Fig. 1). As in the rest of lowland areas of northern Mediterranean, evergreen forests of *Quercion ilicis* potentially constitute the late successional stage in lowland areas [2, 14]. Current forest vegetation is, however, integrated by a mosaic of remaining forests of *Quercus ilex,* mixed forests of *Q. ilex* and *Pinus halepensis* (or *P. pinea*), or pine forests with diverse undergrowth communities (belonging to *Quercion ilicis, Rosmarino-Ericion,* and *Brachypodion phoenicoidis*). Land abandonment during the XXth Century favoured forest recovering and succession mainly in mountain areas, whereas lowland areas and plateaus are mainly affected by urbanisation and industrialisation that determined forest fragmentation and holm oak substitution by early succesional pine [1, 14].

Methodology

Forest changes between 1956 and 1993 were inferred from the comparison of two digital layers containing the corresponding forest boundaries of 1956 and 1993. Boundaries of 1993 were directly obtained from the Land Cover Map of Catalonia, (www.creaf.uab.es/mcsc), which was generated by on-screen digitising of the orthophotomaps at 1:5.000 scale. Boundaries of 1956 were photo interpreted at the same scale on another orthophotomap, generated *ad hoc* by geometric correction, geo-referring, and mosaicking of 1956 aerial photographs. Overlaying of 1956 and 1993 forest boundaries was finally performed to create a boundary change map (Fig. 2). Othophotomap generation, and boundary photo interpreting and overlaying were performed using MiraMon, an in-house developed GIS [12, www.creaf.uab.es/miramon].

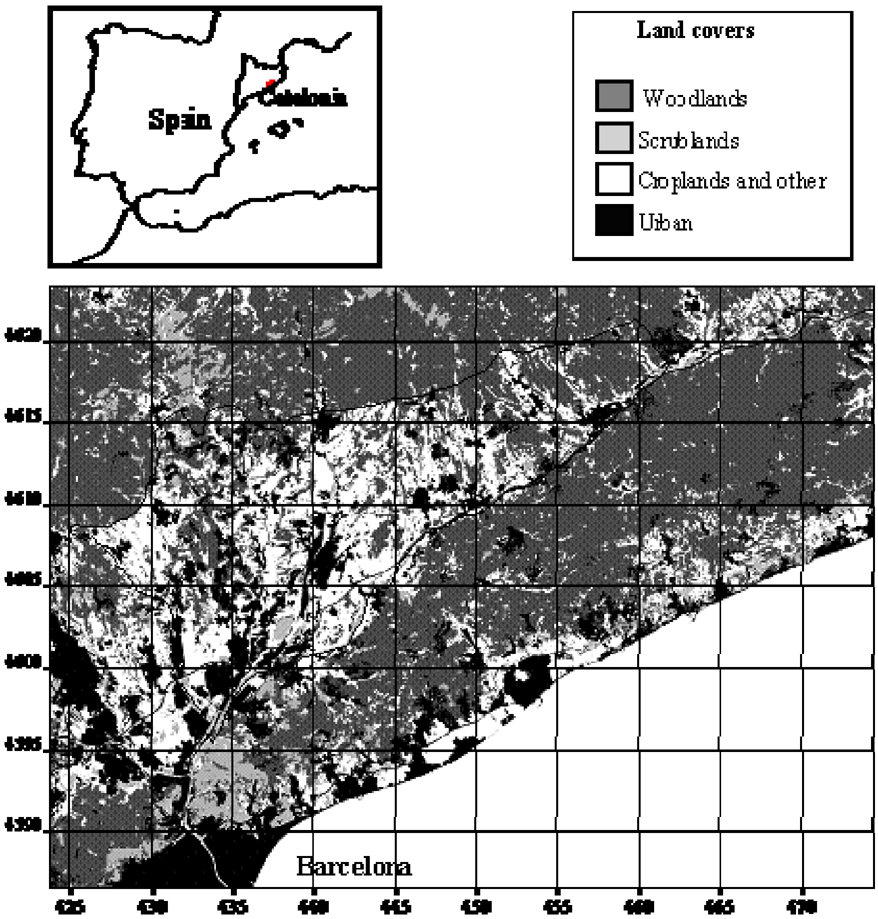


Fig. 1: Study area showing the main land covers. Grid corresponds to the UTM 5x5 km. Source: LandCover Map of Catalonia (CREAF-DMA 1993, www.creaf.uab.es/mcsc)

Two different approaches to forest patch change were performed:

1. Qualitative: Presence (F) or absence (NF) of current forest patches in 1956.
2. Quantitative: Changes in patch area from 1956 to 1993 according the following categories:
   - 2.1. Patches resulting from the fragmentation of large forests existing in 1956 (loosing at least 50% of their 1956 area).
   - 2.2. Patches already existing in 1956 with moderate area changes (reductions or increases of, at most, 50% of their 1956 area).
   - 2.3. New patches in 1993 (non-existing in 1956).

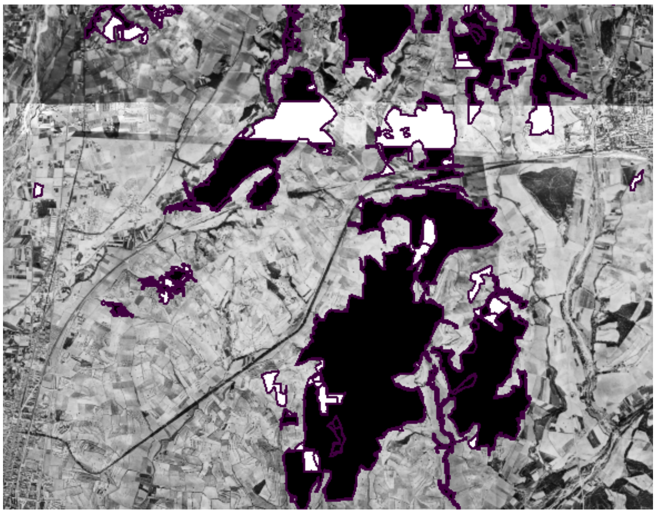


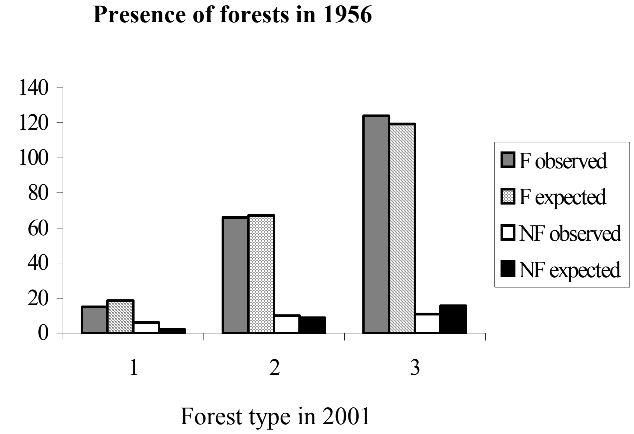
Fig. 2: A fragment from the Boundary Change Map (1956-1993) of Valles Plain (*black*: 1956 forest patches, *white*: 1993 patches with changes in patch area – reductions, increases or new patches)

Forest type was determined in 2001 in 252 field plots chosen at random within forest islands of 1993, separated from the continuous forests occupying the adjacent ranges. Plots were located using the global positioning system (GPS) and by consulting 1:5.000 ortophotomaps from ICC (Cartographic Institute of Catalonia). In each plot, a forest inventory was performed in a 10x10 m area in order to score forest community into (1) pine (*Pinus halepensis* or *P. pinea*) forests with *Rosmarino-Ericion* or *Brachypodion phoenicoidis* understorey, (2) pine forests with *Quercion ilicis* understorey, and (3) mixed forests of *Quercion ilicis* (Guirado, 2002). These forest types reflect a gradient from early (1) to late (3) successional stages.

A point layer containing forest plots was overlayed with the boundary change map in order to score each plot into the forest change categories previously described. Contingency tables were generated in order to analyse the distribution of forest types in relation to the presence (F) or absence (NF) of forests in 1956 and to changes in patch area. The statistic computed was the Pearson chi-square statistic, which evaluates the differences between the observed and the expected values. The analyses were performed using Statistica software.

Results

Forest islands of the study area are dominated by type 3 (mixed forest of *Quercion ilicis,* 58.18% of plots), followed by type 2 (pine forests with *Quercion ilicis* understorey, 32.75%) and type 1 (pine forests without *Quercion ilicis* understorey, 9.05%). The analysis of observed and expected frequencies of forest types (Fig. 2) indicates that type 1 is under-represented in forest patches already existing in 1956, whereas type 3 exhibited the opposite situation. Type 2 shows an intermediate situation with almost coincidence of expected and observed values. Concerning changes in patch area, type 3 forests showed a marked over-representation in patches recently fragmented from large forests adjacent to the study area (area change class A), whereas type 2 are more frequent than expected in patches already existing in 1956 (class B). Type 1 forests are the only over-represented in patches non-existing in 1956 (class C). Contingency tables proved to be significant in both cases, that is, the presence of forest in 1956 and the change of its area exhibited significant association with forest typology (Tab. 1).



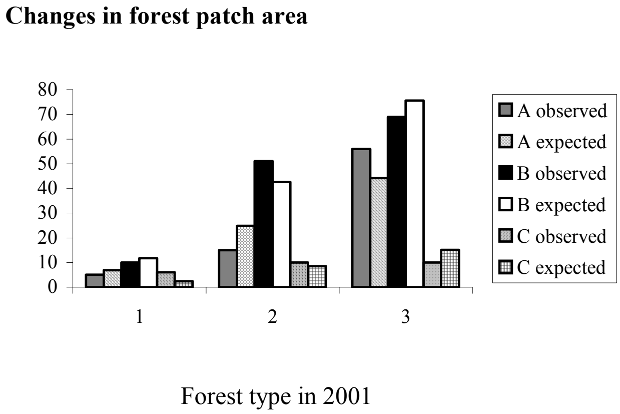


Fig. 3: Observed and expected frequencies of 1993 forest types in relation to the presence (F) or absence of forest (NF) in 1956, and to changes in forest patch size from 1956 to 1993 (A, patches fragmented from large forests; B, patches already existing in 1956 showing moderate size changes; C, non existing patches in 1956). Forest types: 1, pine forests with *Rosmarino-Ericion* or *Brachypodion phoenicoidis* understorey; 2, pine forests with *Quercion ilicis* understorey; 3, mixed forests of *Quercion ilicis.*

Table 1: Significance of the contingency tables applied on presence or absence of 1956 forests and changes in forest area

Presence or absence of 1956 forest			
	Value	**df**	**p**
Pearson's Chi Square	7.625	2	0.022
Likelihood ratio	6.323	2	0.042
N	232		
Changes in patch area from 1956 to 1993			
	Value	**Df**	**p**
Pearson's Chi Square	17.741	4	0.001
Likelihood ratio	16.653	4	0.002
N	232		

Legend: df - degree of freedom; p – probability; n – number of observations

Conclusions

Bearing in mind that the study is based on qualitative or semiquantitative data, it gives a preliminary evidence for association of forest typology with the historical presence and dynamics of forests patches in the Vallès plain. Historical presence of forest at landscape scale is related to forest successional status, as the more late-successional the forest type, the more over-represented in patches already existing in 1956. The study also indicates that the extent of changes in forest patches is also relevant to determine forest type. Indeed, recent changes belonging to large forest patches seems to be a guarantee for the persistence of later successional forests, of *Quercion ilicis*. Forest fragmentation is, in most cases, a direct or indirect consequence of human activity that determines both a reduction of forest area and a split up in small patches [4, 5]. Ecological consequences of forest fragmentation have been largely described [3, 6, 9, 10, 16]. Fragmentation causes loss of species diversity [4, 13], and reduces the population size, which become more sensitive to perturbations [8].

Generally speaking, large forests provide the most stable conditions because of their reduced perimeter/area ratio, and this probably determines appropriate condition for communities growing in long-term stable areas, as it was also suggested for rare tree species in southern Catalonian forests [11]. It is possible that the historical changes occurred within the metropolitan forests also affected their floristical richness and composition, as can be observed in relation to recent human activity [7]. More detailed studies will be neccesary in the future, in order to analyze the developmemt of the vascular flora of the understorey according to the forest history and topology.

From a conservation point of view, the study suggests that *Quercion ilicis* forests might have difficulties in colonising new or isolated forest patches, thus indicating the vulnerability of these forest communities in fragmented landscapes in the metropolitan area of Barcelona. A good management of metropolitan forest in Brcelona probably required the promoting of linkages between the remaining patches and the adjacent large forests, in order to facillitate patch colonisation by species of *Quercion ilicis*. Promoting large forests is also a way to ensure forest integrity against plant invasions [7].

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ASOCIEREA DINTRE TIPUL ŞI ISTORIA PĂDURILOR DIN APROPIERE DE BARCELONA (CATALUNIA) – PRIN ABORDAREA GIS

(Rezumat)

Această lucrare analizează distribuția tipurilor de pădure în funcție de schimbările recente (1956-1993) care au avut loc în "petele" (*patches*) de pădure. Studiul a fost realizat cu ajutorul GIS-ului MiraMon, creat în cadrul *Centrului de Cercetări Ecologice şi Aplicații Silvice* (*Centre de Recerca Ecològica i Aplicacions Forestals*, CREAF) din Barcelona.

Tipurile de vegetație forestieră au fost determinate în urma datelor obținute din analiza a 252 de eşantioane aleatorii efectuate în anul 2001 în zona Vallès (Catalunia, Spania). Tabelele de contingență au fost efectuate pe baza unei hărți finale, care a rezultat din suprapunerea harților din 1956 şi 1993. Harta finală din anul 1956 s-a obținut în urma georeferiențierii şi mozaicării imaginilor aeriene corespunzătoare zonei de studiu, iar pentru harta din 1993 s-a folosit un fragment din harta tip *Land Cover* a Cataluniei. S-a analizat distribuția celor trei tipuri de vegetație forestieră (1. păduri de *Pinus halepensis* cu *Pinus pinea*, în care vegetația ierboasă aparține alianțelor *Rosmarino-Ericion* şi *Brachypodion phoenicoidis*; 2. păduri mixte de *Pinus halepensis* şi *Quercus ilex*; 3. păduri de *Quercus ilex*), în funcție de prezența sau absența petelor de pădure în 1956 şi schimbarea suprafeței petelor. Atât prezența pădurii în 1956, cât şi schimbarea suprafeței petelor în timp au efecte semnificative asupra distribuției vegetației forestiere. Pădurile mixte de *Quercus ilex* şi pin, precum şi pădurile de *Quercus ilex*, provin din fragmentarea unor mase mari de padure şi au un caracter relictar, pe când petele noi de pădure sunt formate din *Pinus halepensis* şi *Pinus pinea*.

Acest studiu demonstrează că pădurea de stejar de stâncă întâmpină dificultăți în colonizarea de noi teritorii, ceea ce indică vulnerabilitatea acestei comunități în peisajul fragmentat din zona metropolitană a Barcelonei, implicit disfuncționalități în refacerea acestor formații de tip climax. De asemenea, se evidențiază importanța pe care o au studiile de istorie a vegetației în ecologia peisajului.