FLORISTIC AND ECOLOGICAL CHARACTERISTICS OF PEDUNCULATE OAK (Quercus robur L.) FOREST

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PROJECT: Phenotypic and Epigenetic Response to Drought Stress and Adaptability of Quercus robur L. Populations along a Latitudinal Gradient
INTRODUCTION

Pedunculate oak (*Quercus robur* L.) – one of the most economically valuable European tree species and the main component of temperate deciduous mixed forests.

- a key climatogenic species in forests of high biodiversity and consequently it has invaluable ecological and social value
• naturally widely distributed throughout Europe
• spreading from north Scotland, southern Norway and Sweden in the north to the Iberian, Apenine and Balkan peninsula in the south and to the central Russia and Ural in the east
Even though pedunculate oak can survive on nutrient poor soils, it prefers fertile and moist soils, where it is able to dominate forests in number and size at low-mid elevations.

It is often stated that pedunculate oak is locally limited to strictly defined ecological conditions, but at the same time, at European level it is described as a species with a very wide ecological niche (xerophilic to humid conditions, wide range of soil types and acidity karst, peat, sand, clay, alluvial soil, ...).
Due to this wide ecological niche *Q. robur* forms different types of forests widespread in Europe.

In northern Europe are present mostly small (<2 ha) and highly fragmented oak wooded pastures or pine-oak communities, where dominates moraine relief with sandy clays and clay sands.

In central Europe it forms
- oak-hornbeam forests on nutrient-rich soils.
- communities on extreme (moist and wet or dry) habitats where forced out into sites that are too moist or too dry for the natural regeneration of *Fagus sylvatica*.

In temperate atlantic and subatlantic region of Western Europe – acidophilous forests on nutrient-poor soils, even on higher altitudes than in S-E EU.

In Poland and Russia – mixed woods with a closed canopy, where other tree species differ depending on the growth conditions.

In the S and S-E Europe, where under the influence of the Mediterranean and Pannonian region, it forms termophilous communities on nutrient poor soils dry calcareous or loess parent.

In the whole region of temporal and boreal Europe – azonal forests in humid valleys and floodplains on deep clayed or sandy soils with sufficient groundwater level, where occasional floods are no rarity.
THE AIM

The oak dominated forests in Europe are well documented within local and regional phytosociological studies, but a critical revision of their principal ecological-floristic components based on a comprehensive global data set is missing.

The aim of this study is to give an insight in the floristic and ecological characteristics of the pedunculate oak forests in Europe. It is not properly syntaxonomical, but it could provide feedbacks that can be of relevance to better define/validate a more comprehensive syntaxonomical position of some forest types.
MATERIALS AND METHODS

• A selected data set of 14.745 phytosociological relevés with pedunculate oak cover value >3 according to Br.-Bl. scale was used, obtained from the European phytosociological database (EVA - http://euroveg.org/eva-database) and the literature (for areas that were not included in the European database).

• Species nomenclature was made according to EuroVegChecklist, EVC (Mucina et al. 2016). Taxa treated at different taxonomic levels (e.g. subspecies, variety) were aggregated to the upper level. Records of species determined to genus level were deleted from the data set. Moss and lichen species were excluded.

• Heterogenity-constrained random resampling method (based on species composition) was used. In order to avoid oversampling, maximum 200 relevés were chosen for each strata.
MATERIALS AND METHODS

- After the stratification, the resulting subset was conducted on 3594 phytosociological relevés, which was numerically classified by hierarchical cluster analysis in PC-ORD 5 using relative Sorensen (Rel. Manh.) as a distance measure and Ward’s algorithm for dendrogram construction.

- DCA ordination analysis of relevés based on floristic composition with passive projection of syntaxonomic affiliation of species was performed using CANOCO 5.

- Diagnostic species of each cluster were calculated in JUICE 7.0 by calculating the fidelity of each species to each cluster using the phi-coefficient as a fidelity measure.

- Ecological conditions, estimated using species Ellenberg indicator values (EIV) for continentality (C), light (L), nutrients (N) and soil reaction (S) (Pignatti et al. 2005) and chorological analysis (Pignatti) were performed using Juice Header Dana Analysis v.2.2 in R.

- Bioclimatic variable (Worldclim) analysis was performed using CANOCO 5.
RESULTS

Based on the hierarchical cluster analysis, five basic types of pedunculate oak forests were defined, which differ in their floristic, ecological and geographical characteristics. On fine-scale division they could be further divided into 17 different subtypes, so the data was observed and analyzed on two levels.
DCA ordination analysis of relevés with passive projection of syntaxonomic affiliation of species.
For each of these five forest types, the area of distribution and diagnostic plant species were determined.
The results show clear differences in floristic (and later in ecological) features among the groups obtained from the cluster analysis.
Cluster 1 (Atlantic forest type):

Acidophilous oak forests on nutrient-poor soils of Northern Iberian Peninsula and temperate atlantic and subatlantic Western Europe

(All. *Quercion pyrenaicae* and *Quercion roboris* Order *Quercetalia roboris*, Class *Quercetea robori-petraeae*)

**Countries:** Spain, France, Ireland, UK
Cluster 1 (Atlantic forest type):

Acidophilous oak forests on nutrient-poor soils of Northern Iberian Peninsula and temperate atlantic and subatlantic Western Europe

(All. *Quercion pyrenaicae* and *Quercion roboris* Order *Quercetalia roboris*, Class *Quercetea robori-petraeae*)

**Countries:** Spain, France, Ireland, UK
Cluster 2 (Acidophilous forest type):

Temperate subatlantic acidophilous oak forests on nutrient-poor soils of Western and Central Europe.

(All. *Quercion roboris*, Order *Quercetalia roboris*, Class *Quercetea robori-petraeae*)

Countries: Netherlands, Belgium, Germany, Poland, Czech Rep., France
Cluster 2 (Acidophilous forest type):

Temperate subatlantic acidophilous oak forests on nutrient-poor soils of Western and Central Europe.

(All. *Quercion roboris*, Order *Quercetalia roboris*, Class *Quercetea robori-petraeae*)

Countries: Netherlands, Belgium, Germany, Poland, Czech Rep., France
Cluster 3 (Termophilous forest type): Thermophilous calciphilous oak forests on shallow to deep soils in Central, Southern Europe and forest-steppe zone of the Pontic-Pannonian region (Order *Quercetalia pubescenti-petraeae*, Class *Quercetea pubescentis*)

**Countries:** Czech Rep., Poland, Hungary, Romania, Russia
Cluster 3 (Termophilous forest type):
Thermophilous calciphilous oak forests on shallow to deep soils in Central, Southern Europe and forest-steppe zone of the Pontic-Pannonian region

(Order Quercetalia pubescenti-petraeae, Class Quercetea pubescentis)

Countries: Czech Rep., Poland, Hungary, Romania, Russia
Cluster 4 (Alluvial forest type):
Azonal elm-ash-oak and alder-oak riparian floodplain forests on nutrient-rich brown and alluvial soils in the temperate and nemoral zone of Europe

(All. Fraxino-Quercion roboris and Alno-Quercion roboris, Order Alno-Fraxinetalia excelsioris, Class Alno glutinosae-Populetea albae)

Countries: Czech Rep., Poland, Hungary, Romania, Russia
Cluster 4 (Alluvial forest type):
Azonal elm-ash-oak and alder-oak riparian floodplain forests on nutrient-rich brown and alluvial soils in the temperate and nemoral zone of Europe

(All. *Fraxino-Quercion roboris* and *Alno-Fraxinetalia excelsioris*, Class *Alno glutinosae-Populetea albae*)

**Countries:** Czech Rep., Poland, Hungary, Romania, Russia
Cluster 5 (Mesic forest type):
Oak-hornbeam and mesic oak forests on deep nutrient-rich soils of the temperate Europe.

(All. CENTRAL EUROPEAN – *Carpinion betuli*, and SUB-CONTINENTAL – *Querco roboris-Tilion cordatae, Scillo sibericae-Quercion roboris*, Order *Carpinetalia betuli*, Class *Carpino-Fagetea sylvaticae*)

**Countries:** Netherlands, Belgium, Poland, Czech Rep., Ukraine, Croatia
Cluster 5 (Mesic forest type): Oak-hornbeam and mesic oak forests on deep nutrient-rich soils of the temperate Europe.

(All. CENTRAL EUROPEAN – Carpinion betuli, and SUB-CONTINENTAL – Querco roboris-Tilion cordatae, Scillo sibericae-Quercion roboris, Order Carpinetalia betuli, Class Carpino-Fagetea sylvaticae)

Countries: Netherlands, Belgium, Poland, Czech Rep., Ukraine, Croatia
EIV ANALYSIS

At fine-scale of 17 different forest subtypes, the differentiation is based on ecological differences of site conditions evaluated by Ellenberg indicator values and distribution reflected in change of chorological spectrum.
LIGHT

(1) Atlantic
(2) Acidophilous
(3) Termophilous
(4) Alluvial (Azonal)
(5) Mesian
SOIL REACTION

(1) Atlantic
(2) Acidophilous
(3) Termophilous
(4) Alluvial (Azonal)
(5) Mesic
CHOROLOGICAL ANALYSIS

ATLANTIC SPECIES

Cluster:
- (1) Atlantic
- (2) Acidophilous
- (3) Termophilous
- (4) Alluvial (Azonal)
- (5) Mesic
EUROASIATIC SPECIES

1. Atlantic
2. Acidophilous
3. Termophilous
4. Alluvial (Azonal)
5. Mesic
MEDITERRANEAN SPECIES

(1) Atlantic
(2) Acidophilous
(3) Termophilous
(4) Alluvial (Azonal)
(5) Mesic
BIOCLIMATIC ANALYSIS

Two bioclimatic variables express the most of the variability between the groups.

**BIO 11 – Mean Temperature of Coldest Quarter**

1. Atlantic
2. Acidophilous
3. Termophilous
4. Alluvial (Azonal)
5. Mesic
BIO 12 – Annual Precipitation

(1) Atlantic
(2) Acidophilous
(3) Termophilous
(4) Alluvial (Azonal)
(5) Mesic
CONCLUSION

• The results show clear differences in floristic and ecological features among the groups obtained from the cluster analysis.

• Modern climate changes cause shifts in the current distribution of numerous taxa, communities and ecosystems towards poles globally. It is considered that tree species are particularly endangered by climate change due to the limitations in their spread, long life span and slow evolution. Pedunculate oak is no exception and it is feared that in the future it will not be able to follow these ecological niche shifts or changes in habitat preference quickly enough.

• The assumptions and predictions on the impact of environmental factors and the influence of climate change on habitats are usually carried out by modeling of ecological niches. This study could serve as a good knowledge base in the process of developing a reliable ecological niche model.
Thank you!