

**DIVERSITY PATTERNS OF THE ALPINE FLORA AND VEGETATION IN
SOUTH-EASTERN CARPATHIANS: FROM GENES TO
ECOSYSTEMS**

HABILITATION THESIS

-Abstract-

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In this habilitation thesis, I present the main results of my research work beginning with the completion of the Ph.D. thesis (2008) until present (2016). Most studies were conducted in the field of **biogeography** and **alpine ecology**, with special focus on structure, functioning and dynamic of alpine herbaceous ecosystems. The results of research in this period have been published in 23 scientific articles and a chapter in a book; these publications have been cited over 800 times. Of the 23 articles, 14 are published in scientific peer-reviewed journals (indexed in *Web of Science*), three of which are, respectively, *Science*, *Nature Climate Change* and *Ecology Letters*. Three articles are included in the *Web of Science' Highly Cited Paper* category (they received enough citations to place them in the top 1% of the academic field *Environment/Ecology*). Additionally, I was the director of three research grants won by competition and member of the research team in other 11 projects (with national or international funding).

The habilitation thesis is divided into seven chapters, the first of which is **introductory**, presenting brief **the study system (South-Eastern Carpathians)**.

The **chapter 2** presents the contributions to the **chorology of a set of plant species** in South-Eastern Carpathians and to the issue of **conservation of high mountain flora** of this region. Within the framework of a European project, it was conducted the first comprehensive database on the distribution of subalpine - alpine taxa occurring in the Romanian Carpathians, which could allow the first concrete quantitative assessment on the rarity and vulnerability of these taxa, based on objective and quantifiable criteria. Based on this, we can draw a more effective biodiversity conservation policies. These results were reported in articles published in international journals with impact factor:

- ❖ Coldea G, Stoica IA, Puşcaş M, Ursu T, Oprea A, IntraBioDiv-Consortium (2009). Alpine-subalpine species richness of the Romanian Carpathians et the current conservation status of rare species. *Biodiversity et Conservation* **18**: 1441-1458.
- ❖ Jimenez-Mejias P, Hilpold A, Frajman B, Puşcaş M, Koop-Man J, Mesterhazy A *et al* (2014). *Carex cespitosa*: reappraisal of its distribution in Europe. *Willdenowia* **44**: 327-343.
- ❖ Pachschwöll C, Puşcaş M, Schönswetter P (2011). Distribution of *Doronicum clusii* et *D. stiriacum* (Asteraceae) in the Alps et Carpathians. *Biologia* **66**: 977-987.
- ❖ Puşcaş M (2012). Distribution et phytocoenotic context of *Kobresia simpliciuscula* (Wahlenb.) Mack. in South-Eastern Carpathians. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* **40**: 29.

Chapter 3 focuses on **biogeography of the alpine belt** in the high mountains of temperate Europe. It is the first detailed study of the spatial patterns of species distribution within the European Alpine System, based on a comprehensive analysis of species diversity (intra- and inter communities). The results were published in:

- ❖ Puşcaş M, Choler P (2012). A biogeographic delineation of the European Alpine System based on a cluster analysis of *Carex curvula*-dominated grasslets. *Flora (Jena)* **207**: 168-178

Chapter 4 presents the results of a continuous work within the dynamic research field related to the **impact of climate change in the structure of natural vegetation**. The studies have been integrated into international research networks and represent the first evaluation of this type that includes the Romanian Carpathians as well. This is achieved through two complementary methods, **species distribution modelling** and **in situ monitoring**. The writing of this chapter is based on our research results published in:

- ❖ Engler R, Retin CF, Thuiller W, Dullinger S, Zimmermann NE, Araujo MB, Pearman PB, Le Lay G, Piedallu C, Albert CH, Choler P, Coldea G, De Lamo X, Dirnbock T, Gegout J-C, Gomez-Garcia D, Grytnes J-A, Heegaard E, Hoistad F, Nogues-Bravo D, Normet S, Puşcaş M, Sebastia M-T, Stanisci A, Theurillat J-P, Trivedi MR, Vittoz P, Guisan A (2011) 21st century climate change threatens mountain flora unequally across Europe, *Global Change Biology*, **17**: 2330-2341.
- ❖ Gottfried M, Pauli H, Futschik A, Akhalkatsi M, Barancok P, Alonso JLB, Coldea G, Dick J, Erschbamer B, Calzado MRF, Kazakis G, Krajci J, Larsson P, Mallaun M,

Michelsen O, Moiseev D, Moiseev P, Molau U, Merzouki A, Nagy L, Nakhutsrishvili, G, Pedersen B, Pelino G, Puşcaş M, Rossi G, Stanisci A, Theurillat JP, Tomaselli M, Villar L, Vittoz P, Vogiatzakis I, Grabherr G (2012) Continent-wide response of mountain vegetation to climate change, *Nature Climate Change*, **2**: 111-115.

- ❖ Pauli H, Gottfried M, Dullinger S, Abdaladze O, Akhalkatsi M, Alonso JLB, Coldea G, Dick J, Erschbamer B, Calzado RF, Ghosn D, Holten JJ, Kanka R, Kazakis G, Kollar J, Larsson P, Moiseev P, Moiseev D, Molau U, Mesa J M, Nagy L, Pelino G, Puşcaş M, Rossi G, Stanisci A, Syverhuset AO, Theurillat JP, Tomaselli M, Unterluggauer P, Villar L, Vittoz P, Grabherr G (2012) Recent Plant Diversity Changes on Europe's Mountain Summits, *Science*, **336**: 353-355.

In **chapter 5**, I present another area of interest in which I was active, i.e. **relationships between ecosystems and genetic diversity of species**. The hypothesis of covariance between the two levels of diversity was tested for the first time at biogeographical scale and the results have been published in:

- ❖ Taberlet P, Zimmermann NE, Englisch T, Tribsch A, Holderegger R, Alvarez N, Niklfeld H, Coldea G, Mirek Z, Moilanen A, Ahlmer W, Marsan PA, Bona E, Bovio M, Choler P, Cieslak E, Colli L, Cristea V, Dalmas J-P, Frajman B, Garraud L, Gaudeul M, Gielly L, Gutermann W, Jogan N, Kagalo AA, Korbecka G, Kupfer P, Lequette B, Letz DR, Manel S, Mansion G, Marhold K, Martini F, Negrini R, Nino F, Păun O, Pellecchia M, Perico G, Piekos-Mirkowa H, Prosser F, Puşcaş M, Ronikier M, Scheuerer M, Schneeweiss GM, Schonswetter P, Schrott-Ehrendorfer L, Schupfer F, Selvaggi A, Steinmann K, Thiel-Egenter C, van Loo M, Winkler M, Wohlgemuth T, Wraber T, Gugerli F, IntraBioDiv C (2012) Genetic diversity in widespread species is not congruent with species richness in alpine plant communities, *Ecology Letters*, **15**: 1439-48

Another line of research is described in **chapter 6**, represented by the link between biogeography and ecology of communities. The new axis of research that I started in recent years involved the analysis of soil microbial communities using molecular methods (*Next Generation Sequencing* coupled with *DNA metabarcoding*). These new methods opened new frontiers in biogeography still unexplored, namely the microbial biogeography. Writing of this chapter was based on our research findings published in:

- ❖ Geremia RA, Puşcaş M, Zinger L, Bonneville J-M, Choler P (2016). Contrasting microbial biogeographical patterns between anthropogenic subalpine grasslets et natural alpine grasslets. *The New Phytologist* **209**: 1196-1207.

The **future scientific development plans** are presented in the last part of habilitation thesis. Further, I would like to extend the fields of research initiated already, by adding new directions. Thus, the recent massive sequencing techniques made possible by the new platforms for *Next Generation Sequencing* offer highly promising avenues in assessing biodiversity at multiple levels. I would like to use new types of molecular markers for further studies on spatial structure of genetic diversity in plants (**phylogeographical, taxonomical** and **molecular ecology** approaches). I would also like to continue the studies initiated in **biogeography of Carpathians, microbial biogeography, functional ecology** and **monitoring of the impact of climate change on vegetation structure**.