THE DEFINITION OF OLIGOTROPHIC GRASSLANDS

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Abstract

In the 25 years since the Convention on Biological Diversity was signed, the idea of biodiversity has spread well into science and popular culture and is often portrayed by images of rich rainforests. In this paper we try to define a less popular instance of biodiversity, oligotrophic grasslands, by describing what they mean and what the context is for understanding them in terms of ecology and management applications. We look at the oligotrophic grasslands of Europe as a case for understanding these habitats, protecting them, researching them and managing them, and we present a meaningful context in which to understand and consider oligotrophic grasslands.

Keywords: oligotrophic grasslands, biodiversity, high nature value, oligohemerobic

DEFINING GRASSLANDS

From an agronomic point of view, grasslands are areas of land used for the production of animal feed consumed by means of pasturing and/or mowing, or for the production of biomass for use as a biofuel. Grassland vegetation consists mostly of grass, along with legumes and various forb and occasional woody plants. Grasslands can be temporary or permanent (Peeters *et al.*, 2014).

From the ecological point of view, grasslands are communities dominated by species from the grass families, *Poaceae*, *Cyperaceae*, *Juncaceae*, along which live various other herbaceous species from families like *Fabaceae* or *Asteraceae* i.e. Encroachment from woody species is usually a sign of disturbance.

A grassland habitat also includes the micro-flora, fauna and micro-fauna; and between all the individuals, species, biotope and geophysical environmental factors there form complex specific interconnections, building up to a functional ecosystem we call "a grassland" (Puia *et al.*, 1984; Rotar and Carlier, 2010).

THE MEANING OF OLIGOTROPHY IN THE CONTEXT OF GRASSLANDS

Oligotrophic, with the root "trophic" meaning food or nourishment and the suffix "oligo" meaning little or a small quantity, is a characteristic of an individual organism or of a habitat which exists and even thrives on a low nutrient level. Because individual species and habitats evolved together, this characteristic is shared between them. Grassland plant species that have this oligotrophic characteristic become a determining factor in the type of grassland. Due to the variety of low nutrient soils on Earth, oligotrophic grasslands (OG) do not describe a specific assembly of species or families, but a type of grassland dominated by native plants which are often endemic, plants which are adapted to survive and to thrive in more severe conditions, plants which have managed to colonize more extreme biotopes to bring life to new areas or to amplify biodiversity.

THE ECOLOGY OF OLIGOTROPHIC GRASSLANDS

The degree of naturalness is an indicator which provides nuance to ecological analysis of habitats by allowing us to describe and measure areas which are under anthropic influence, especially where this influence has been exerted for a long time, but the anthropic factor is not dominant.

E.g. the case of grasslands in Central and Eastern Europe where we have cultural landscapes with grasslands. Naturalness is the quality of being natural. This seems a bit circular and, for contrast, we have another indicator which is complementary, "hemeroby" – from the Greek "to tame" meaning the degree of tamed nature. Oligotrophic grasslands are mostly part of habitats with 1st and 2nd degree of naturalness (table 1).

Table 1

Degrees of naturalness

	Type of habitat	Formations	Definition
1	Natural	Unchanged remnants of natural vegetation	No management. Natural habitat dynamics (oligohemerobic)
2	Semi-natural	Changed remnants of natural vegetation	Use without direct impact and without nutrient replacement (oligo-mezohemerobic)
3	Pre-industrial anthropogenic	Controlled vegetation originating in pre-industrial times	Use with impact, occasional nutrient replacement (mezohemerobic)
4	Industrial anthropogenic	Controlled vegetation originating from the industrial era	Powerful human impact (euhemerobic)

	Type of habitat	Formations	Definition
5	Artificial	Vegetation controlled largely by humans	Total conversion of habitat, chemical treatments, exotic plant cover (polyhemerobic)

(Source: Christian *et al.*, 2018)

BIODIVERSITY OF OLIGOTROPHIC GRASSLANDS

If we view plants' access to nutrients as an equation in which all environmental characteristics are parameters, it will become apparent that there are many combinations between the parameters that can result in a low value, in a low level of nutrition.

- Alpine OG, where plants grow on levigated soils with thin top layers
- Halophyte OG, where the plants grow on soils with a high salt load, usually near seashores, mangroves, marshes
- Xerophyte OG, where plants are well adapted to dryness (e.g. grasslands in the Mediterranean area)
- Hydrophyte OG, where the plants grow in temporary or permanent swamps.
- Arctic OG, where plants can tolerate extreme cold (e.g. tundra)

And many others.

In Europe, over 1320 endemic plant species belong to grasslands – areas which occupy a small slice of the total European landmass. The importance of these grasslands is strongly underestimated (Bruchmann *et al.*, 2010). The pool of European plant species tends towards species adapted to oligotrophic habitats; from 7394 species, 49.9% prefer soils that are oligotrophic or very oligotrophic (Chalmandrier *et al.*, 2017). Europe's story is a strong example of underestimation of biodiversity; although the overall flora of Europe is lacking in variety, there are habitats in Europe which have some of highest levels of biodiversity density – especially at the level of semi-natural grasslands (Habel *et al.*, 2013).

In figure 1 the results are more precise for Western Europe, while in Eastern Europe there is less data, less power and more errors, and it does not account sufficiently, for example, for the flora of the Carpathian Mountains and their basin (shown as nitrophilous). In the chart next to the map we can see the large number of species in the 2nd category and in the 3rd category, representing plants that are oligotrophic or semi-oligotrophic.

The widespread distribution of grasslands in Europe has also increased the vulnerability to poor management due to national limitations and a lack of cooperation between countries relative to the need for conservation of endemic plants, leading to loss in both quality and quantity (Bruchmann and Hobohm, 2010).

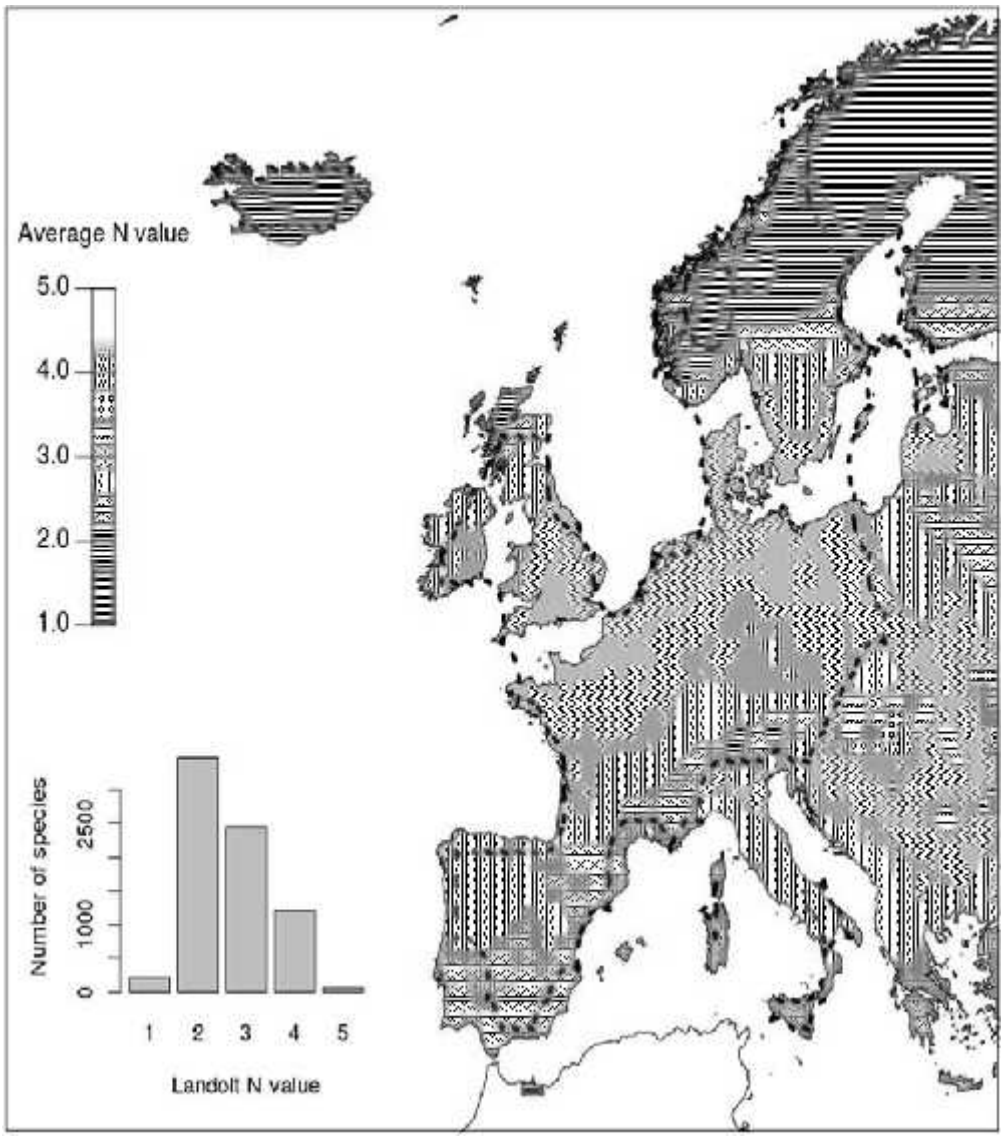

Fig. 1. An incomplete map of European flora, converted to grayscale, indicating trophic preferences based on the Landolt indicator for Nitrogen; low Landolt N values indicate species with preferences for oligotrophy. The dashed line marks the area where this map is low in errors due to the inclusion of over 50% of the species (Western and Northern Europe)

(Source: Chalmandrier *et al.*, 2017, https://www.nature.com/articles/s41598-017-15334-4/figures/5)

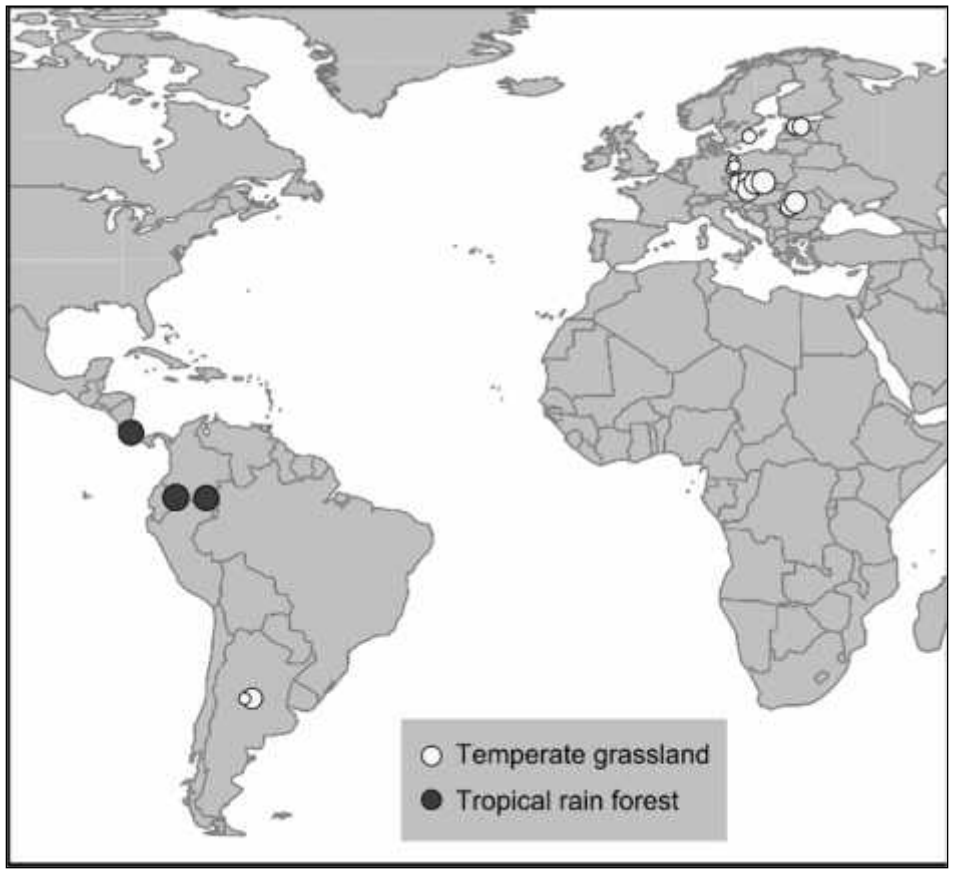

Fig. 2. The land areas of the World with the highest species richness. The size of the circles is logarithmically scaled to the studied area and some circles are slightly displaced for visibility. Light – temperate grasslands; dark – tropical forest

(Source: Wilson *et al.*, 2012)

On the figure 2 map we can see the richness of grasslands in Central and Eastern Europe. A grassland in Romania holds the record for species richness per unit of area: a semi-xerophyte basiphile grassland with a record number of plant species at the scale 0.1-10 m^2.

In Transylvania, the highest density of species in a grassland was found in mezoxerice meadows of the type *Brachypodietalia pinnati* (Rusina and Kuzemko, 2009).

The correlation between biodiversity and productivity, the way in which assemblies of species in oligotrophic grasslands manage to prosper in difficult trophic conditions is a good example of the success of diversity: while similarity of niche specialization causes more intense intraspecific competition, interspecific

competition is reduced, thus fostering a more varied community that occupies niches more efficiently and leading to higher productivity in the context of oligotrophic conditions (François *et al.*, 2016; Chalmandrier *et al.*, 2017). This effect also hints at the problem of biodiversity loss due to application of fertilizers.

THE INFLUENCE OF NITROGEN ON BIODIVERSITY

The main pathways by which the addition of Nitrogen to a habitat can lead to a reduction in the number of species and to the simplification of community structure and composition (Bobbink and Hicks, 2014):

- Increase in disturbance and stress
- Direct toxicity from NO_2, NH_3, NH_4
- Increase in N accessibility:
  - Increased sensibility to diseases and pests
  - Increased competition for light and resources
  - Imbalance in the N-P nutrient balance
  - Nitrogen Cycle amplification (more productivity - more biomass - more mineralization)
- Soil acidification:
  - Inhibiting nitrification and accumulation of NH_4+
  - Decrease in the quantity of basic cations and increase in metal ones (Al_3+)

As management involves directly or indirectly altering soil nutrient levels, it is very relevant in the quest to protect biodiversity.

In oligotrophic grassland communities, the effects of management may be masked by edaphic and climatic factors, leading to an underestimation of the results of management (Barbaro *et al*., 2004).

The influence of Phosphorus in these grasslands also needs to be considered more, since it may be a decisive trophic parameter, as evidenced by the Rengen grassland experiments (Milan *et al*., 2014).

DISCUSSION

The idea of oligotrophic grasslands should be understood within 3 dimensions: the evolution of species and natural or semi-natural habitats under limited trophic conditions, the importance of OG to biodiversity and conservation, and their connection to human influence, especially in the case of semi-natural grasslands that depend on extensive and traditional management. Romania's situation is special, but not unique, as the challenge of protecting OG is shared with the rest of Europe.

Management at the national level is behind Western Europe due to the lack of a coherent application of tools and resources and due to the lack of investment in data and

research, information being essential to good planning.

Figure 1 shows the spread of oligotrophic plants, but Romania is covered by a fog of errors due to the information deficit.

In Romania, in 2007, there were approximatively 4.8 million ha of agricultural land with high nature value (HNV), mostly oligotrophic and oligo-mesotrophic grasslands (figure 3).

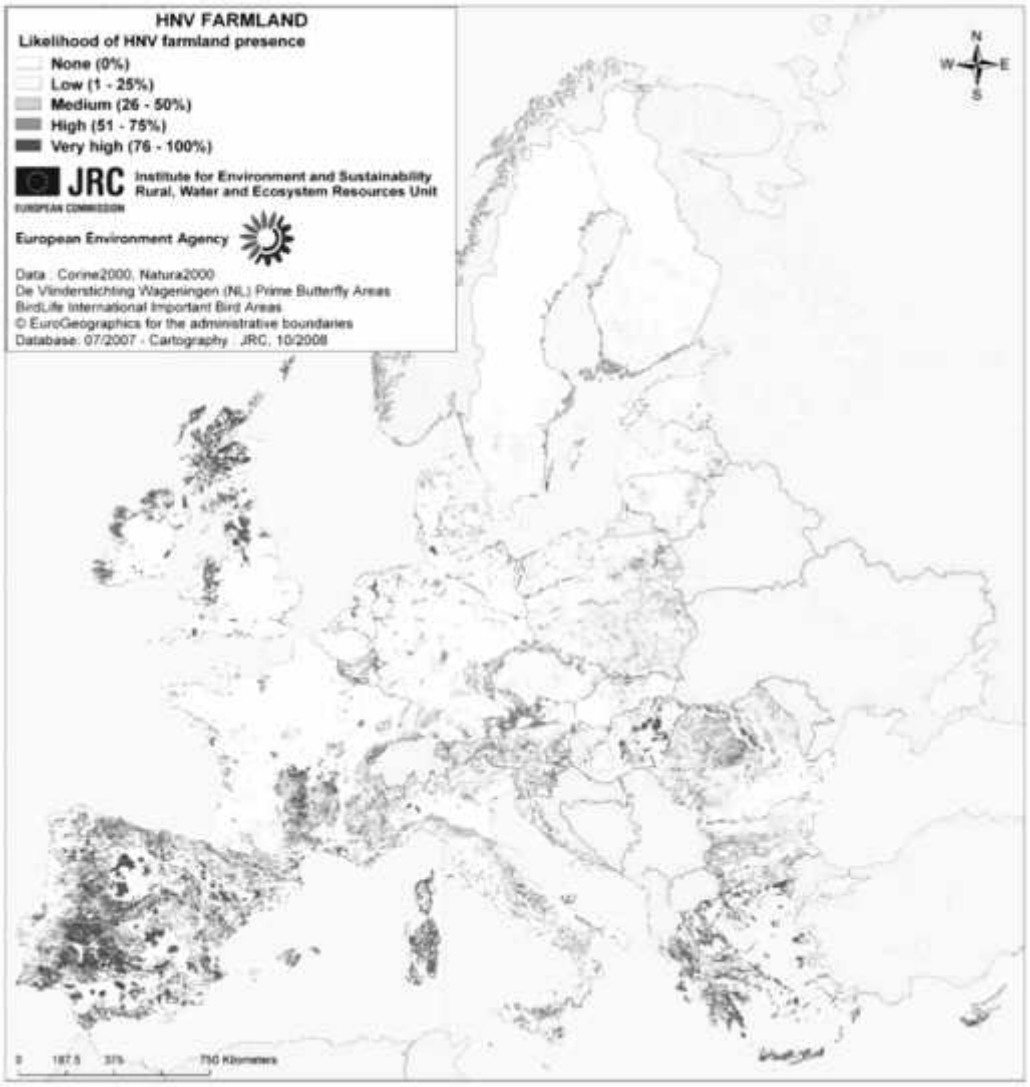

Fig. 3. The likelihood of HNV flora in agricultural lands

(Source: Paracchini *et al*., 2008)

Two relevant cases in Romania portray the spectrum of HNV habitats: Sarbu *et al*. presented, in 2009, the high botanical value of 2 unprotected areas in the SE of the Dobrogea region, Coroana and Vânători. These areas had inaccessible calciphile OG with over 35 rare species that had significant populations. Brinkmann *et al*., in 2009, explored the value of OG with *Arnica montana* in the Apuseni Mountains near the village Gârda de Sus; a project that continues today with research on those OG communities and the influence of local management styles on them (Rotar *et al*., 2018). We hope that this framing of what oligotrophic grasslands are can help in future discussion and can increase support for conservation, management and research where it is needed most.

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