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**Review of the doctoral dissertation of Hassanali Mollashahi entitled "Management of urban grasslands in the context of green infrastructure ecosystem services"**

## 1. Basic information about the candidate

Mr. Hassanali Mollashahi studied Agricultural Engineering in Iran and Sustainable Agriculture at Padova University, Italy. He was graduated on July 19th 2019 based on his Master thesis "Genetic variability of olive fly populations and its co-evolved symbiont Candidatus *Erwinia dacicola* in Iran" (grade 90/110). To the best of my knowledge, he has not previously applied for a doctoral degree. After his B. Sc. and M. Sc. in Agricultural Engineering in 2010 at Zabol University, Iran, Mr. Mollashahi came to Italy to participate in the Master program Sustainable Agriculture. During his professional life, he worked as a lecturer and teaching assistant at Zabol University, Wrocław University of Environmental and Life Science, and University of Applied Sciences (HTW) Dresden - often in courses related to urban ecology. Regarding his scientific age, he counts on a relatively high record of conference contributions and scientific publications (four articles published), of which two are included in the present dissertation. During his stay as guest scientist at HTW Dresden, I have known Mr. Mollashahi as internationally experienced and hard-working scientist with broad scientific skills in different disciplines. This includes population genetics of urban grassland species, GIS analyses on connectivity of grasslands in the urban matrix, and experimental approaches for increasing urban grassland biodiversity.

## 2. Information about the evaluated doctoral thesis

Mr. Mollashahi dedicated his doctoral dissertation entitled "Management of urban grasslands in the context of green infrastructure ecosystem services" to urban grassland vegetation and its ecosystem services. In particular, the thesis deals with 1) the connectivity of urban grassland patches regarding the species' dispersal potential and proposed a prioritization of grassland

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patches in the city of Wrocław; 2) The possible relation of a huge array of soil and vegetation parameters with urban grassland type and location within the city. The dissertation comprises two published articles on these topics along with a summary in English and Polish, as well as a description of the dissertation highlighting the most important findings. The work significantly contributes to the current knowledge of urban grassland dynamics and is clearly of general interest in urban ecology. The prioritization of grassland patches based on a connectivity analysis using GIS tools is innovative as is deepens our understanding on urban matrix impacts on biodiversity and is a straight-forward method for biodiversity-friendly city planning. However, the approach has been similarly been explored by Hejkal et al (2017) in the city of Münster. The second part of the dissertation may be considered a base-line study on environmental conditions of urban grassland in the city of Wrocław, which adds evidence to findings from other cities of the world. The study relies on an impressive field analysis on a high number of grassland patches in the center and periphery of Wrocław. The overall not significant patterns of soil and vegetation parameters in mostly management-related grassland types such a lawn, parks, and road verges is not particularly surprising. However, the high degree of heavy metal contamination in the city center is an important finding that may similarly apply to many other European cities. Overall, the thesis demonstrates both the candidate's general theoretical knowledge in the diverging disciplines of urban ecology and the capability to independently conduct scientific work.

The thesis description is a 16-pages short version of the two publications. It highlights the main hypotheses, findings and conclusions of the dissertation. The description is overall well-written. The importance of urban grasslands in comparison to other types of urban green infrastructure is properly addressed and justified based on current literature. Mr. Mollashahi also provides a convincing rationale for the hypothesis on connectivity. In contrast, the research gap for the second hypothesis on differences in soil and vegetation of four types of urban grasslands remains less clear. In particular, it is not understandable why the grassland types, that are a consequence of management, should have a direct impact on the selected soil properties. The methods section comprises all necessary information to understand the chapter. The approach to use empirical dispersal classes and three connectivity measures has, as stated above, already been tested elsewhere, but it is the first time that it has been used in Poland. The statistical methods are adequate, although for the multivariate analysis, non-parametric methods such as NMDS may have been more robust. The results section showcases the most important results of the studies, that are mostly properly addressed in the discussion. Nevertheless, it remains unclear why potassium content should not be related to fertilization when NPK fertilizers are used on lawns, which show the highest potassium content. Furthermore, the negative correlation of N and P with species richness, albeit often

reported in literature, cannot be seen in the PCA, as the arrows point to the same but not in opposite direction. The candidate may have better provided the correlation results from the second article. The conclusions section addresses correctly the practical implications of the findings along with challenges in implementation. In summary, the thesis description indicates a sound understanding of the candidate in urban ecology and his capacity to contextualize the core findings of his work.

The English summary provides nearly the same information as the thesis description. The methods description remains too concise to be understandable to the reader. Also the links to the articles within the methods paragraph are formally awkward as the summary should be readable without further information. In addition, it is rather unusual to add references in the summary. Despite this criticism, the summary properly displays the aims, the main findings, and conclusions. The Polish summary seems equivalent but for language reasons I am not able to assess this part.

The first article entitled „ Connectivity assessment and prioritization of urban grasslands as a helpful tool for effective management of urban ecosystem services" was published in 2020 in PLOS one (Impact Factor 2022: 3.7). It elaborates on the connectivity of grassland patches in the city of Wrocław. The candidate and co-authors constructed a model for several dispersal distance thresholds (2, 20, 44, 100, and 1000 m), according to Hejkal et al. (2017). The study shows that connectivity of grassland patches is low in the city, in particular for low dispersal distance up to 20 m. Large patches, that are mainly located in the periphery of the city, play the most important role for connectivity. Moreover, inhabitant density was negatively correlated with connectivity. The study mainly relies on the above-mentioned study from Münster, Germany. It therefore is not outstanding in terms of methods development. Both dispersal distance classes and connectivity indices were used exactly as in Hejkal et al. (2017). However, the article clearly addresses the general challenge of gene and propagule exchange in urban environments and provides an important practical tool for city planners of Wrocław by prioritizing those patches that are particularly important for connectivity. The authors furthermore discuss the importance of increasing the quality of grasslands in terms of biodiversity to optimize ecosystem service provision of this important part of the urban green infrastructure in the city center. The candidate took the main responsibility in conducting the study and writing the manuscript together with the co-authors. However, he was not included in the conceptualization phase, albeit the methods were taken from literature. Consequently, I assess the independent contribution of Mr. Mollashahi as moderate. The literature used is adequate with well-known contribution on urban grassland biodiversity (e.g., Fischer at al. 2013a, b; Buchholz et al. 2018).

The second article was published in 2022 in Environmental Monitoring and Assessment (Impact Factor 2022: 3.0). It is entitled "The effect of grassland type and proximity to the city center on urban soil and vegetation coverage". The article relies on the comparison of four grassland types with pronounced differences in management intensity concerning soil and vegetation parameters. The comparison of managed lawns, park meadows, riparian (semi-)natural grasslands and roadside herbaceous vegetation seems difficult as they represent totally different urban grassland classes with different origin and species assemblage. Even meadows are known to be differentiated according to soil humidity, cutting frequency and fertilization. It is therefore surprising that the authors did not include these well-documented environmental parameters but instead a huge compilation of soil chemical measures. However, the hypotheses (that nutrient content of soil decreases and pH increases towards the city center, that lawn shows higher soil nutrient content due to fertilization, and that in the city center, contamination with heavy metals is higher) seem reasonable and interesting. The study is based on a huge number of study plots. It remains unclear if the candidate conducted this tremendous field work alone or with the help of field assistants, who are then unfortunately not mentioned in the dissertation. Lab work and statistics are adequate to test the hypotheses. On page 5 of the article, there is an incomplete sentence. The study shows that soil pH is not different in the city center, but heavy metal concentration is higher, which also applies to road edges. Despite tentative fertilization of lawns, only potassium is higher than in other grassland soils, whereas N and P show no difference. The authors argue that, owing to missing correlation of K, N and P, high K values cannot be attributed to fertilization. However, the fate of the elements in grassland soils may differ concerning the uptake of elements through plants. Overall, the study is a valuable base-line study on soil conditions in urban grasslands. The patterns along the rural-urban gradient revealed better results than the, rather artificial grassland categorization. The inclusion of soil humidity and management may have yielded clearer results. The candidate's contribution to the article was high. Again, the cited literature is adequate and contains well-known contributions (e.g.; McKinney 2006, Wessolek et al. 2011).

In summary, the articles along with the description and summaries clearly show the strong scientific qualification of the candidate in different fields of ecology (GIS, vegetation and soil analyses). He furthermore transfers the findings of his individual studies to major issues of urban ecology, such as habitat connectivity, biodiversity, and heavy metal contamination. In the course of his doctoral thesis, Mr. Mollashahi independently conducted field campaigns, lab work and statistical analyses. In the case of the second paper, he also strongly contributed the study design. Thereby, he made a decisive contribution to urban ecology in the city of Wrocław and provided practical solutions to current challenges. Overall, Mr. Mollashahi proved his skills as

scientist who can work on complex issues at a scientifically high level. The quality of his work has been repeatedly proven by the published articles. However, due to the mostly well-established methods used and the low number of articles included into the thesis, I do not believe that the doctoral thesis deserves distinction.

Based on the above, I conclude that the doctoral dissertation meets the requirements specified in Article 187, paragraphs 1-4 of the Act of July 20, 2018, the Law on Higher Education and Science (Journal of Laws of 2018, item 1668, as amended). Therefore, I propose to the Discipline Council of Agriculture and Horticulture at the University of Life Sciences in Wrocław to admit the doctoral candidate to the next stages of the doctoral procedure.

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