

## **Dissertation review for Ph.D. candidate Aysan Badraghi**

Review carried out by: Mgr. Ladislav Šigut, Ph.D.

The main focus of the presented work is the evaluation of the reclamation strategies of spoil heaps after brown coal mining at the Sokolov basin. The study asks several research questions:

Q1: Does the early stage of post-mining succession act as a carbon sink or source?

Q2: Do carbon sequestration and emissions, and energy flux (LE and H) differ between reclaimed and unreclaimed sites in the early stage of succession?

Q3: Whether relatively young developing forests in the mid-stage of post-coal mining sites, either reclaimed with alder or naturally colonized, function as carbon sinks?

Q4: Which restoration practices—reclaimed or unreclaimed—have a stronger potential for carbon sequestration in the mid-stage of succession? Is this higher potential due to greater assimilation through photosynthesis or reduced emissions?

Since the reclamation of the land after finishing of mining operations is required by law, it is even more important to understand the impacts of the site management and find the most efficient way to assist restoration of the sites, e.g. find optimal soil and vegetation management that will support high carbon uptake. Therefore, the research questions are up-to-date and have the potential of practical application. The research questions are well posed, and the Ph.D. candidate answers them all in five papers (two published, 2 submitted and one prepared). It is shown that even during the early stages of reclamation, the C uptake can outbalance C losses during the most productive months, suggesting a fast recovery of the sites. The reclamation management appears to have a negative impact on the vegetation development, also from a long-term perspective, likely due to the soil compaction connected with levelling of the heaps. While the planted alder is a nitrogen-fixing species, the benefits of the added available nitrogen within the reclamation treatment did not seem to outweigh the negative effects of soil compaction. In summary, based on the presented results it appears that natural succession on the sites would be preferred to the reclamation strategy in the way it is currently applied. The findings are further supported by a forest structure and diversity evaluation on a chronosequence of unreclaimed post-mining sites. Here it is shown that even as soon as 90 years after the mining operations, the site restoration can lead to an establishment of a climax forest with strong C uptake.

I find the overall work well structured, each presented study supporting the next and building the whole story using the space-for-time substitution approach. Regarding the actual text of the dissertation, the thesis formal requirements including the formatting were met, although the clarity of the text could be improved. This contrasts with the higher quality of English and scientific language in the actual publications. I particularly enjoyed reading the last chapters Ch. 7 – Major finding of the study and Ch. 8 – Conclusion, where the candidate well summarized the findings in relation to individual papers and picked the most important aspects.

Considering the writing skills, I would suggest paying more attention when constructing Abstract. The thesis Abstract should be stand-alone and guide the reader, but the actual one was not much understandable without knowing the whole content (e.g. hypotheses were referenced but not stated). Although soil properties appeared to have important role in the presented research, I missed more comprehensive introduction to this topic in relation with spoil heaps. Also Ch. 4.1 is missing any mention about the important difference between Lignite (brown coal) opencast mining and Anthracite (black coal) deep mining; though a mention is included in the first paper. I

would also appreciate more general background to be included considering fixing environmental problems after coal mining using vegetation. It appears that it can include multiple steps with different motivation. I am not an expert in this field, but could you explain difference in the terms: Remediation, Reclamation, Restoration, Rehabilitation and include some examples? To clearly explain the treatment applied at the site, I would prefer term natural succession over unreclaimed as that would be self-explanatory. While I think that the dissertation is a valuable contribution to the topic of soil reclamation after mining, it appears that the candidate did not develop extended understanding of plant ecophysiology and these aspects were analyzed and interpreted in limited extent. Particularly, it is surprising to see quadratic fits of Reco in the submitted papers when the actual methods suggest exponential fit; also Reco response to  $R_g$ . Measurements from outside of growing season were included and they confound the actual relationships relevant to the vegetation. It is unclear whether the candidate knows what are the main drivers of NEE components (GPP and Reco). On pages 18,19 it is stated: "Previous research has indicated that temperature and water availability are the primary factors affecting carbon cycling processes". Can you explain why this statement can indeed be valid though GPP is primarily dependent on incoming photosynthetic active radiation? On page 19 it is stated: "NEE represents the net balance of CO<sub>2</sub> exchange, reflecting whether the ecosystem is acting as a source (positive NEE) or a sink (negative NEE) for atmospheric CO<sub>2</sub>. It is calculated as the difference between gross GPP and Reco (Equation 1)". This statement is either quite unfortunate or suggests a misunderstanding of the method. While Equation 1 indeed suggests this mathematically, I consider important to acknowledge that NEE is the actual measured variable and GPP and Reco are estimated using simple models. Since we are deriving variables (GPP and Reco) which have approximately one order of magnitude higher rates than original variable (NEE), the results carry also much higher uncertainty. The role of footprint is not explained, why is it integral to the EC method? What is the difference between LE and ET? How were the reclaimed sites established if they are not allowed by legislation?

I state that despite the mentioned shortcomings, the dissertation thesis fulfils the requirements, and I recommend it for the defence and awarding the Ph.D. title.