



Doctoral Thesis Review Report

Title of the thesis: Carbon exchange between soil, vegetation and atmosphere in ecosystems under anthropogenic pressure

Author: Aysan Badraghi

Supervisor: Prof. Mgr. Ing. Jan Frouz, CSc.

Study programme: Environmental Science

Reviewer: Ing. Jakub Černý, Ph.D.

Overall Assessment

Aysan Badraghi's doctoral thesis addresses a highly relevant and important topic; namely the restoration of ecosystems after mining and their ability to act as carbon sinks. The main focus of the thesis is on comparing different approaches to restoring disturbed areas—specifically spontaneous succession and technical reclamation—and their impact on the carbon balance between soil, vegetation, and the atmosphere. Combining detailed experimental research with long-term monitoring, the work utilizes advanced measurement techniques (eddy covariance) to allow precise analysis of ecological processes and their influence on ecosystems' carbon sequestration capacity. Overall, the thesis concludes that spontaneous succession can be an effective and efficient restoration strategy, leading to stronger carbon sink capacity compared to traditional reclamation methods, especially in the mid-succession stages. This finding highlights the potential for more sustainable and cost-effective ecosystem recovery practices.

Strengths of the Thesis

1. **Relevance and Originality:** The topic of the thesis is highly timely, given global efforts to mitigate climate change and promote sustainable land use. Research on post-mining ecosystem recovery is crucial both ecologically and socio-economically. The thesis addresses this subject innovatively, utilizing advanced techniques for measuring carbon fluxes that provide new insights into the effectiveness of different reclamation approaches.
2. **Methodological Rigor:** The use of the eddy covariance technique to measure CO₂ fluxes during different stages of succession is one of the strongest aspects of the thesis. This method ensures highly accurate data and enables long-term monitoring of carbon flux dynamics. The author also processed the data thoroughly, employing robust statistical and analytical tools.
3. **Comprehensive Approach:** The thesis not only focuses on carbon exchange between soil, vegetation, and the atmosphere but also on broader ecological questions related to ecosystem restoration, including the impact of different reclamation practices on vegetation structure and development. This multidisciplinary approach provides valuable insight into the restoration process.
4. **Practical Applicability of Conclusions:** The results of the thesis have significant practical implications for the management of post-mining areas, not only in the Czech Republic but also in other regions with similar conditions. The finding that spontaneous succession can be an



effective restoration strategy is relevant to both ecosystem restoration practitioners and policymakers.

Weaknesses of the Thesis

1. **Regional Focus:** While the thesis examines a highly interesting and important region (Sokolov coal basin), some conclusions may be limited to the specific regional conditions. Climatic and soil factors in other parts of the world may lead to different results, so it would be useful if the thesis included a discussion of how its conclusions could be applied in other climate zones.
2. **Socio-Economic Context:** Although the thesis thoroughly analyses the ecological aspects of restoration, it would benefit from more attention to the socio-economic impacts of different reclamation approaches. For example, a discussion of the costs and benefits of each method could enhance the practical value of the work.
3. **Limited Analysis of Biodiversity:** While the thesis mentions the impact of reclamation practices on vegetation, it devotes less attention to soil microorganisms and fauna, which are key components influencing the long-term stability of ecosystems. A more detailed analysis of these factors could provide a more holistic view of ecosystem restoration.
4. **Long-Term Environmental Risks:** Although the thesis emphasizes carbon balance restoration, it gives less attention to long-term environmental risks, such as soil and water contamination or changes in climate conditions, which can affect restoration processes.

Questions

1. Why an assessment of eddy covariance and microclimatic data from 2022 was omitted from study of early-stage stands? Were alder seedling somehow protected against game damage and forest weed competition?
2. How did you quantify canopy cover in mid-stage stands (35-year-old)? Were these stands somehow managed after their planting (e.g. forest tending, thinning) or they were let for spontaneous development?
3. In your thesis, you mention that alder, a nitrogen-fixing species, was planted on reclaimed areas. In your opinion, what role do nitrogen-fixing trees play in restoring soil fertility and carbon balance in post-mining sites? Is this approach sufficiently effective in the long term perspective, or would you recommend combining it with other tree species?

Conclusion

Aysan Badraghi's doctoral thesis significantly contributes to post-mining ecosystem restoration and the role of these ecosystems as carbon sinks. The thesis is methodologically sound, provides innovative and relevant conclusions, and has high practical value. The thesis poses clearly formulated scientific questions that are highly relevant to the study of carbon balance and ecosystem restoration after mining. The author has successfully answered all the proposed scientific questions based on the collected data, using methodologically sound approaches. Each question was thoroughly analysed, and the responses are well-supported by experimental data.



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Given that majority of thesis results has already been published or submitted to worthy scientific journals, **I recommend the thesis for defence and propose that the Ph.D. degree be awarded.**

In Platěnsko on 16/09/2024

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Jakub Černý
Reviewer