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What is unmanaged forest and how does it sustain biodiversity in landscapes with a long history of intensive forestry?

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Abstract

1. A recent paper by Schall et al. (2020) concluded that beech forests managed in even-aged (EA) rotation systems were more efficient than unmanaged (UNM) forest and forest managed in uneven-aged (UEA) selective cutting systems in supporting landscape-scale biodiversity in Germany.
2. The authors based their conclusion on a comprehensive multitaxon survey and a promising resampling model for assessing gamma diversity at landscape scale. Here, we challenge their conclusions and evaluate the importance of UNM forests for conservation of forest biodiversity.
3. The average amount of deadwood reported from EA stands (27.8 m^3/ha) was almost 30% higher than reported from UNM stands (21.6 m^3/ha) in the study. Averages from long UNM temperate forests in Europe are typically six to seven times higher (131–157 m^3/ha). We therefore conclude the UNM studied stands to reflect legacies of former management, and to be poorly representative of UNM forests. Data from our own studies, including long UNM beech stands in Denmark, demonstrate how this shortcoming seriously undermines the general validity of the presented results to conservation of forest biodiversity.
4. *Synthesis and applications*. Preservation and restoration of intact forest ecosystems remains essential to biodiversity conservation. We show that the findings of Schall et al. (2020) do not contradict this important notion. Schall and colleagues identified UEA management systems as potentially inferior to more traditional EA management systems for conserving forest biodiversity at the landscape scale. The paper also provides insight into the limited short-term conservation value of simply abandoning forest management in intensively managed landscapes. Based on this, we call for discarding the current orthodox view of non-intervention when new forest reserves are created in temperate Europe. Active reinforcement of natural disturbance regimes and active habitat creation may lead to faster recovery of natural stand structure and forest biodiversity.

KEYWORDS

deadwood, disturbance, ecological legacies, *Fagus sylvatica*, forest management, habitat creation, oldgrowth forest, restoration

1 | INTRODUCTION

We read the recent paper by Schall et al. (2020) with great interest, but are concerned that their conclusion that even-aged forestry may support forest biodiversity just as well or even better than unmanaged (UNM) forest reserves is unsupported. We credit the authors for a comprehensive survey of multiple taxa and a promising analytical resampling model, which appears to be a very useful framework for analyses of gamma diversity in heterogeneous landscapes. Second, some of the conclusions regarding differences between even-aged (EA) and uneven-aged (UEA) forest landscapes seem reasonably well-supported.

However, our criticism focusses on their synthesis—'Our study shows that combining fine-grained forest management and management abandonment at the landscape scale will rather reduce than enhance regional forest biodiversity'. We find this to be far too general, neglecting fundamental limitations in their study system with regard to assessing the conservation value of UNM forests. This weakness may seem of only academic interest, were it not for the fact that forestry and conservation of forest biodiversity are high on the current public agenda. European forests are among the most degraded globally, with only very small fragments remaining in close to virgin conditions (Sabatini et al., 2018). As a result, most landscapes have lost major aspects of their native biodiversity, and actions to restore more natural conditions and associated biodiversity are urgent. On top of historical exploitation of European forest, the current demand for bioenergy and other wood-based products is putting forests under increased pressure for wood extraction (Ceccherini et al., 2020). The conclusion of Schall and colleagues is poised to transform into weakened political support for conservation of forest reserves or even abolishment of existing reserves. Such actions would have wide-ranging and long-lasting consequences and, therefore, must be underpinned by solid science. The paper by Schall et al. (2020) does not provide such support.

2 | REPRESENTATIVITY OF UNMANAGED FORESTS IN THE STUDY

The most fundamental problem in the study by Schall et al. (2020) is that the UNM forest stands included are not representative. Because of the rather short time since cessation of forestry, they provide little of the conditions that characterise long UNM old-growth stands (e.g. Burrascano, Keeton, Sabatini, & Blasi, 2013). Rather, they represent the legacy of forest management in the recent past and do not really represent a management class distinct from EA and UEA. Thus, the study cannot teach us much about the contribution of truly UNM forest stands to gamma diversity. In the discussion section, the authors partly recognise this limitation, but do still draw their main conclusion for UNM forest as such. They write: 'A likely reason (that UNM forest do not complement managed forests) may be that UNM forests are still developing old-growth stand structures as forest management ceased only 20 (five stands) to 70 (eight stands) years ago. With around 160 years they are *far from senescence* and still show impressive growth (Schall et al., 2018). This leads to *closed canopies* … and *low amounts of total deadwood*… Habitat heterogeneity and deadwood availability of UNM forests were thus probably also not high enough yet to substantially contribute to higher multidiversity at the landscape scale' [our emphasis]. The dissimilarity between their UNM class and genuine UNM forest is very clearly expressed in the deadwood amount, which is indicated to be 21.6 m^3/ha for UNM. This corresponds to only *c*. 15% of the averages of 131–157 m^3/ha reported from long UNM temperate forests in Europe and beyond (Burrascano et al., 2013; Christensen et al., 2005). The same is probably true also for other crucial habitats typical of old-growth forest stands, such as tree cavities and sap flows (cf. Winter & Möller, 2008). But the problem is worse, because the UNM stands included in the study actually contain lower levels of deadwood and possibly other important habitat features than the EA managed stands, presenting an average of 27.8 m^3 of deadwood per ha. That is almost 30% more than the UNM average, and well above the European averages for deadwood amounts across all forests, managed or UNM (FOREST EUROPE, 2015). Thus, not only are both UNM and managed stands quantitatively atypical in a broader context, their deadwood levels are qualitatively reversed.

Deadwood is one of the several key structural attributes crucial for sustaining specialised forest biota and typical of old-growth forests (e.g. Brunet, Fritz, & Richnau, 2010). Analyses of own data from a study very similar to that of Schall et al., but in contrast including long UNM forest reserves, have shown these to be clearly differentiated from managed forests and young reserves in terms of forest structures related to deadwood and tree microhabitats. These stands were found to support many more old-growth indicators of lichens, fungi and bryophytes, but not vascular plants, compared to stands showing few old-growth structural features (Lelli et al., 2019).

3 | CONCEPTUAL FRAMING OF UNMANAGED FORESTS

From a more general perspective, we miss ecological and evolutionary perspectives on nature conservation in the conceptual framework of Schall and colleagues. In general, we find it inconceivable that biomass extraction from ecosystems, be it hay, wood or meat, should promote increased niche space and hence biodiversity. In intact ecosystems, there would almost certainly be organisms living from the resources, which are extracted in the managed counterpart. This basic law is obscured in the study system of Schall and colleagues. It is impossible to comprehend a long-term steady state, in which forest managed for timber extraction would contain higher amounts of deadwood than comparable UNM stands without timber extraction.

Taken at face value, the conclusion of Schall et al. (2020) means that biodiversity conservation is worse off in more natural ecosystems than in managed ones. This raises the question where all the inhabitant species lived before systematic forestry was put in action

a few centuries ago, given that their evolutionary history in general spans the entire Pleistocene or beyond. It also raises the question of the ultimate purpose of nature conservation: Is the aim to secure natural ecosystems with whatever levels of species diversity that entails. Or is it optimising species diversity by all sorts of management interventions? We believe the purpose of setting aside UNM forest should be to restore self-sustaining, fully functional forest ecosystems. Schall and colleagues seem to define UNM forest simply as production forest, in which logging has been halted. They seem not to consider if the legacy of other aspects of forestry are still in action, such as drainage, fencing out large mammals or keeping their population densities low, or if the imprint of past forest operations (tree species selection, planting, coppicing, thinning etc.) are still effective. An orthodox hands-off definition of UNM forest may be counterproductive for short-term conservation of threatened species. Some of the forest operations effective in Schall and colleagues' EA and UEA classes may in fact mimic natural disturbances, which are absent in modern production forests, even after being left UNM for several decades. But, there are in fact ways to reintroduce disturbances in UNM stands shaped by former management, in order to promote the formation of tree microhabitats, deadwood and—importantly—the heterogeneity in light and microclimate typical of long UNM forests after local stand senescence and breakdown. In the boreal zone, such interventions have been developed and scientifically tested over the last decades and are now regularly applied to conservation areas (e.g. Halme et al., 2013), while a comprehensive perspective for restoration of biodiversity in temperate forests is still lacking. Targeted management—with conservation purpose—could be prescribed to young forest stands designated for nature in its own right and without extraction of timber. From the point of view of red-listed species, it is of no importance whether their specific habitat is created by natural processes, which demands great patience in newly designated UNM stands (von Oheimb, Westphal, Tempel, & Härdtle, 2005) or by targeted actions, such as induced wind-throw, re-established natural hydrology, re-established near-natural grazing regimes, deadwood enrichment and veteranisation of single trees. However, such active restoration actions should be well-founded in an ecological understanding of natural processes shaping biodiversity in target ecosystems over evolutionary time (Attiwill, 1994; Fløjgaard et al., 2018).

4 | DIFFERENCES BETWEEN EVEN-AGED AND UNEVEN-AGED MANAGEMENT SYSTEMS

On a second line, regarding the differences between EA and UEA forest stands, we have reservations on two important accounts. First, the application of a stratified sampling design only in the EA forests may have secured a better representation of overall variation than the non-stratified sampling of UEA and UNM forests. Second, it appears from the supplementary data, that EA forests had a 3.7 times higher proportion of other tree species than beech, compared to the UEA stands. While the authors correctly emphasise that the even higher proportion of intermixed tree species recorded in the UNM stands may potentially 'overestimate biodiversity of UNM in comparison to other natural beech forests … with a higher share or total dominance of European beech', they fail to highlight that the substantial difference in proportions of intermixed tree species between EA and UEA stands may be a main explanation for the recorded differences in gamma diversity between these systems. We do not doubt that the difference in proportions of intermixed tree species is true for the study landscape, but we doubt whether this difference generally apply to EA and UEA management systems across Europe.

5 | CONCLUSIONS

Overall, we find the conclusions of Schall et al. (2020) ill-founded in their data and cast in a conceptual framework of forestry, rather than of ecology and evolution. Taken very strictly, their conclusions may apply to their specific study system and potentially for assessing short-term conservation impact of young, orthodox UNM beech forests reserves on the wider scale. Their management recommendations, however, are addressed to an international audience, and not just for the forest managers of the study area. Therefore, they should have been phrased to apply in general. As the recommendations read now, they will be taken to mean that conservation authorities should stop creating new forest reserves in heavily managed forest landscapes with the purpose to halt the global loss of biodiversity. The conclusion could even be taken to imply that remaining virgin forests can be converted into managed forest ecosystems without substantial loss of biodiversity. Surely, that cannot be considered sound science-based advice to societies around the planet.

AUTHORS' CONTRIBUTIONS

J.H.-C. initiated and framed the manuscript with input from H.H.B. Both authors contributed equally to manuscript writing.

DATA AVAILABILITY STATEMENT

Data have not been archived because no primary data are associated with this paper.

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REFERENCES

Attiwill, P. M. (1994). The disturbance of forest ecosystems: The ecological basis for conservative management. *Forest Ecology and Management*, *63*, 247–300. https://doi.org/10.1016/0378-1127(94)90114-7

Brunet, J., Fritz, Ö., & Richnau, G. (2010). Biodiversity in European beech forests-a review with recommendations for sustainable forest management. *Ecological Bulletins*, *53*, 77–94.

Burrascano, S., Keeton, W. S., Sabatini, F. M., & Blasi, C. (2013). Commonality and variability in the structural attributes of moist

temperate old-growth forests: A global review. *Forest Ecology and Management*, *291*, 458–479. https://doi.org/10.1016/j.foreco.2012.11.020

Ceccherini, G., Duveiller, G., Grassi, G., Lemoine, G., Avitabile, V., Pilli, R., & Cescatti, A. (2020). Abrupt increase in harvested forest area over Europe after 2015. *Nature*, *583*, 72–77. https://doi.org/10.1038/s41586-020-2438-y

Christensen, M., Hahn, K., Mountford, E. P., Ódor, P., Standovár, T., Rozenbergar, D., … Vrska, T. (2005). Dead wood in European beech (*Fagus sylvatica*) forest reserves. *Forest Ecology and Management*, *210*, 267–282. https://doi.org/10.1016/j.foreco.2005.02.032

Fløjgaard, C., Bruun, H. H., Hansen, M. D., Heilmann-Clausen, J., Svenning, J. C., & Ejrnæs, R. (2018). Are ungulates in forests concerns or key species for conservation and biodiversity? Reply to Boulanger et al. (DOI: 10.1111/gcb.13899). *Global Change Biology*, *24*, 869–871. https://doi.org/10.1111/gcb.14029

FOREST EUROPE. (2015). *State of Europe's forests 2015*. Retrieved from https://www.foresteurope.org/docs/fullsoef2015.pdf

Halme, P., Allen, K. A., Auniņš, A., Bradshaw, R. H. W., Brūmelis, G., Čada, V., … Zin, E. (2013). Challenges of ecological restoration: Lessons from forests in northern Europe. *Biological Conservation*, *167*, 248–256. https://doi.org/10.1016/j.biocon.2013.08.029

Lelli, C., Bruun, H. H., Chiarucci, A., Donati, D., Frascaroli, F., Fritz, Ö., … Heilmann-Clausen, J. (2019). Biodiversity response to forest structure and management: Comparing species richness, conservation relevant species and functional diversity as metrics in forest conservation. *Forest Ecology and Management*, *432*, 707–717. https://doi.org/10.1016/j.foreco.2018.09.057

Sabatini, F. M., Burrascano, S., Keeton, W. S., Levers, C., Lindner, M., Pötzschner, F., … Kuemmerle, T. (2018). Where are Europe's last primary forests? *Diversity and Distributions*, *24*, 1426–1439. https://doi.org/10.1111/ddi.12778

Schall, P., Gossner, M. M., Heinrichs, S., Fischer, M., Boch, S., Prati, D., … Ammer, C. (2018). The impact of even-aged and uneven-aged forest management on regional biodiversity of multiple taxa in European beech forests. *Journal of Applied Ecology*, *55*, 267–278. https://doi.org/10.1111/1365-2664.12950

Schall, P., Heinrichs, S., Ammer, C., Ayasse, M., Boch, S., Buscot, F., … Gossner, M. M. (2020). Can multi-taxa diversity in European beech forest landscapes be increased by combining different management systems? *Journal of Applied Ecology*, *57*, 1363–1375. https://doi.org/10.1111/1365-2664.13635

von Oheimb, G., Westphal, C., Tempel, H., & Härdtle, W. (2005). Structural pattern of a near-natural beech forest (*Fagus sylvatica*) (Serrahn, North-east Germany). *Forest Ecology and Management*, *212*, 253–263. https://doi.org/10.1016/j.foreco.2005.03.033

Winter, S., & Möller, G. C. (2008). Microhabitats in lowland beech forests as monitoring tool for nature conservation. *Forest Ecology and Management*, *255*, 1251–1261. https://doi.org/10.1016/j.foreco.2007.10.029

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