Box C6

The conservation of forest biodiversity in multiple-use landscapes of central Europe based on tree-related microhabitats

T. Asbeck[1], M. Basile[2], J. Bauhus[1]

[1] Chair of Silviculture, University of Freiburg, Freiburg, Germany

[2] Chair of Wildlife Ecology and Management, University of Freiburg, Freiburg, Germany

Integrative conservation practices that include the retention of structural elements such as habitat trees are used in managed temperate forests to conserve forest biodiversity (Gustafsson *et al.* 2019). Such practices are often called variable retention forestry or retention forestry (Martínez Pastur *et al.* 2020). The search for such integrative solutions has led to an increased attention in recent scientific projects, including several large-scale projects that focus on the retention of structural elements. One of these recent large projects is 'Conservation of forest biodiversity in multiple-use landscapes of Central Europe' (ConFoBi) (Storch *et al.* 2020). The research design of ConFoBi comprises 135 one-hectare plots in mountain forests (≥500 m a.s.l.) along two environmental gradients in the southern Black Forest in southwest Germany: (1) fragmentation (measured as the percentage of forest in the surrounding 25 km²); and (2) stand structural diversity (measured as the amount of standing deadwood visible in aerial images). Determination of the gradients for each plot is based on GIS data. Within the project, plot-based information on bats, birds, insects, epiphytes, and ground vegetation has been collected. The interdisciplinary project also investigated economic and social aspects related to retention forestry. One of the approaches that has been used in close-to-nature forest management to value and select habitat trees for retention are tree-related microhabitats (TreMs) (e.g. Forstamt Thurgau 2017; ForstBW 2015). Larrieu *et al.* (2018) define a TreM as "a distinct, well delineated structure occurring on living or standing dead trees, that constitute a particular and essential substrate or life site for species or species communities during at least a part of their life cycle to develop, feed, shelter or breed".

Within the framework of the ConFoBi project, it has become clear that forests at higher altitudes provide a greater abundance of TreMs in central European mountains compared to those at lower altitudes (Asbeck *et al.* 2019). This might be related to factors such as increasing rock fall or soil movement or other factors such as tree swaying that may lead to stronger development of buttresses at higher altitudes. Other factors that might contribute to this finding is a difference in management regimes at lower altitudes compared to higher altitudes. The results imply that neither tree size nor forest type show a significant interaction with altitude.

A second interesting result is related to forest management intensity. In the plots of the ConFoBi project, management type (uneven-aged or even-aged) did not influence TreM abundance and diversity (Asbeck *et al.* 2019). Other predictors besides management categories could provide more information on the influence of forest management on TreMs. Therefore, a preliminary analysis of the relationship between forest management intensity, expressed as a continuous index (ForMI) (Kahl and Bauhus 2014), and TreMs was carried out. The ForMI index includes three single indicators: (a) the proportion of harvested tree volume to the theoretical maximum; (b) the proportion of tree species that are not part of the natural forest community compared to the potential natural vegetation; and (c) the proportion of deadwood showing signs of saw cuts versus deadwood without these signs (Kahl and Bauhus 2014). For each of these parts a value between 0 (no management influence) and 1 (strong management intensity) was assigned; the sum of values for each indicator presents a single index value between 0 and 3. The explorative analysis on this issue showed a close and significant correlation between forest management intensity and TreM abundance and richness per plot (fig. 1). In this analysis, the richness was based on the occurrence of groups of TreMs (out of 15 possible groups) as described in Larrieu *et al.* (2018).

TreMs were more abundant in the less intensively managed areas, indicating that the concept of TreMs as biodiversity indicators might have some relevance for the conservation of forest biodiversity in integrative approaches. Considering these preliminary results, it is obvious that the value for biodiversity conservation of forest stands strongly depends on the management history. In an earlier

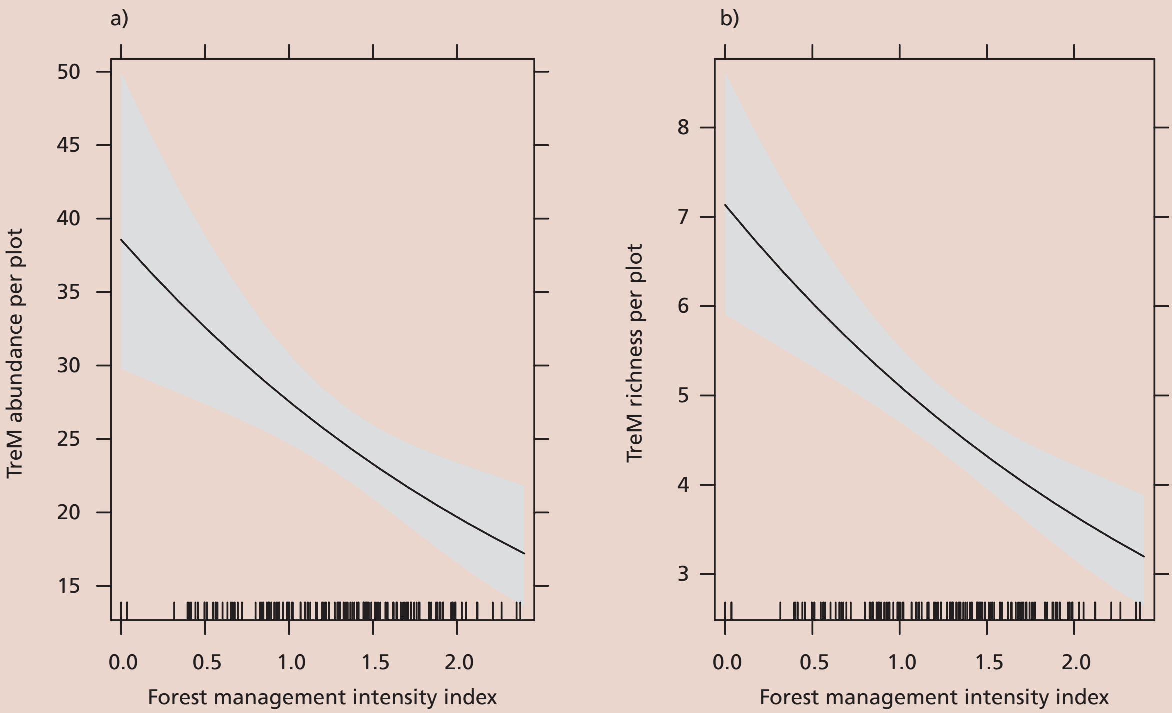

Fig. 1. Effect plots from a generalised linear model for the predicted abundance (a) and richness (b) per plot of TreMs that responded significantly to forest management intensity. The grey area indicates the 95 % confidence interval and the rug plot at the bottom the marginal distribution of the numeric predictor. From Asbeck (2019).

study, TreMs were more abundant in small-scale private forests than in municipal or state-owned forests (Johann and Schaich 2016). This is reflected by different approaches towards retention forestry as described for private and public landowners for different regions of Europe, where continuous-cover forestry is practised (Gustafsson *et al.* 2019). Motivations for different types of owners differ. For instance, private forest owners might be compensated for retention of structural elements on their lands by the private sector as compensation measures for larger projects such as windmills for energy production (cf. Gustafsson *et al.* 2019). On the other hand, state foresters might be obliged to retain structural elements in their forests to fulfil legal requirements of habitat and species conservation (e.g. ForstBW 2015).

In addition to these results with a focus towards site conditions and management, it has become clear that the concept of TreMs is especially beneficial for the conservation of three species groups in temperate mountain forests of central Europe (Basile *et al.* 2020). The abundance of certain taxonomic groups (particularly bats and insects, and to a lesser extent birds) is positively correlated with the abundance of specific TreMs (fig. 2). For instance, rot holes were identified as key structures for the conservation of bats and insects, and fresh exudates (i.e. sap runs or heavy resinosis), which are often caused by bark beetle outbreaks that provide additional food sources for birds, are positively correlated with bird abundance. Hence, managers could address this in the selection of habitat trees that provide these features in case their goal is the conservation of one of these taxonomic groups.

The results of ConFoBi indicate that flexible approaches to the retention of structural elements are needed based on the diversity of requirements of species from different taxonomic groups. While some TreMs are more important than others, a certain diversity of TreMs needs to be provided to support a wide range of taxa. The relationship between

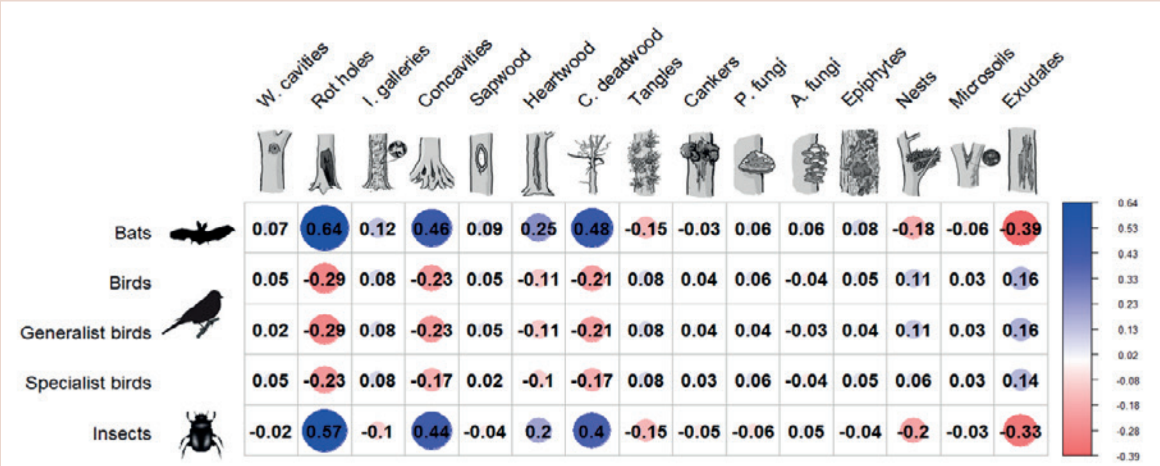

Fig. 2. Correlation matrix between different taxonomic groups and different types of TreMs. W. cavities=woodpecker cavities; I. galleries=insect galleries; C. deadwood=crown deadwood; P. fungi=perennial fungi; and A. fungi=annual fungi. Blue circles show positive correlations while red circles show negative correlations. The number in the circles indicates the correlation coefficient. From Basile *et al.* (2020).

forest management intensity and the occurrence of TreMs suggests that retention forestry approaches are a useful tool to buffer the impact of past and current forest management.

References

Asbeck, T., 2019: Tree-related microhabitats as selection criteria for habitat trees in close-to-nature forest management in the Black Forest. PhD Thesis, University of Freiburg, Freiburg im Breisgau, Germany. 161 p.

Asbeck, T.; Pyttel, P.; Frey, J.; Bauhus, J., 2019: Predicting abundance and diversity of tree-related microhabitats in Central European montane forests from common forest attributes. Forest Ecology and Management 432: 400–408. https://doi.org/10.1016/j.foreco.2018.09.043

Basile, M.; Asbeck, T.; Jonker, M.; Knuff, A.K.; Bauhus, J.; Braunisch, V.; Mikusiński, G.; Storch, I., 2020: What do tree-related microhabitats tell us about the abundance of forest-dwelling bats, birds, and insects? Journal of Environmental Management 264: 110401. https://doi.org/10.1016/j.jenvman.2020.110401

Forstamt Thurgau, 2017: Wegleitung "Habitatbaumgruppen". https://forstamt.tg.ch/public/upload/assets/58527/Wegleitung_Habitatbaumgruppen_2017-11-30.pdf (last accessed 24.11.2020).

ForstBW, 2015. Alt und Totholzkonzept Baden-Württemberg.

Gustafsson, L.; Bauhus, J.; Asbeck, T.; Augustynczik, A.L.D.; Basile, M.; Frey, J.; Gutzat, F.; Hanewinkel, M.; Helbach, J.; Jonker, M.; Knuff, A.; Messier, C.; Penner, J.; Pyttel, P.; Reif, A.; Storch, F.; Winiger, N.; Winkel, G.; Yousefpour, R.; Storch, I., 2019: Retention as an integrated biodiversity conservation approach for continuous-cover forestry in Europe. Ambio 49: 85–97. https://doi.org/10.1007/s13280-019-01190-1

Johann, F.; Schaich, H., 2016: Land ownership affects diversity and abundance of tree microhabitats in deciduous temperate forests. Forest Ecology and Management 380: 70–81. https://doi.org/10.1016/j.foreco.2016.08.037

Larrieu, L.; Paillet, Y.; Winter, S.; Bütler, R.; Kraus, D.; Krumm, F.; Lachat, T.; Michel, A.K.; Regnery, B.; Vandekerkhove, K., 2018: Tree related microhabitats in temperate and Mediterranean European forests: A hierarchical typology for inventory standardization. Ecological Indicators 84: 194–207. https://doi.org/10.1016/j.ecolind.2017.08.051

Martínez Pastur, G.J.; Vanha-Majamaa, I.; Franklin, J.F. 2020: Ecological perspectives on variable retention forestry. Ecological Processes 9, 12: s13717-020-0215–3. https://doi.org/10.1186/s13717-020-0215-3

Storch, I.; Penner, J.; Asbeck, T.; Basile, M.; Bauhus, J.; Braunisch, V.; Dormann, C.F.; Frey, J.; Gärtner, S.; Hanewinkel, M.; Koch, B.; Klein, A.; Kuss, T.; Pregernig, M.; Pyttel, P.; Reif, A.; Scherer-Lorenzen, M.; Segelbacher, G.; Schraml, U.; Staab, M.; Winkel, G.; Yousefpour, R., 2020: Evaluating the effectiveness of retention forestry to enhance biodiversity in production forests of Central Europe using an interdisciplinary, multi-scale approach. Ecology and Evolution 10: 1489–1509. https://doi.org/10.1002/ece3.6003

Fig. 3. Habitat tree providing a multitude of tree microhabitats (TREMs) at Mt. Schauinsland in the southern Black Forest (Photo: Andreas Rigling).