PAPER PROJECT

Preliminary title:

Habitat thresholds for the conservation of multiple taxa in European temperate forests

Target journals:

Journal of Applied Ecology or Ecological indicators

Outline:

Old-growth forests share an important part of biodiversity in temperate ecosystems (Christensen & Emborg 1996; Lassauce *et al.* 2011). However, past deforestations and modern forestry have changed the distribution of forests as well as their appearance and biodiversity substantially (Majka *et al.* 2009; Paillet *et al.* 2010).

Sustainable forestry aims to implement management strategies (MCPFE 2002; European Commission 2015) that consider biodiversity and allow for the conservation or recolonization of species in managed forests. Therefore, it should guarantee the establishment and improvement of connectivity between high value forest habitats such as deadwood or cavities in trees, which represent habitats used by a high number of species, including a high percentage of rare ones. Due to the importance of protecting biodiversity, the term sustainable forestry found its way into several recommendations for practitioners, e.g. developed by Forest Europe (European Commission 2021), the European Commission for the Natura 2000 network (European Commission 2015), or national biodiversity plans (e.g. Bayerische Staatsforsten AöR 2007).

The large number of recommendations results into a variety of aspects that should be considered by practitioners but are often rather unspecific. The indicators for the 'biodiversity' criterion by Forest Europe (C4: Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems) for example covers tree species composition, regeneration, naturalness, introduced tree species, deadwood, genetic resources, forest landscape pattern threatened forest species and protected forests. Although these indicators are correct in themselves, they provide no specific guidelines or threshold values for managers. Scientists have provided clear recommendations e.g. for deadwood (Müller & Bütler 2010), but no thresholds have been specified in Forest Europe or Natura 2000 so far. Furthermore, science recommends even more indicators for biodiversity, e.g. in relationship to management (Oettel & Lapin 2021). The work by Oettel and Lapin (2021) also shows that currently known thresholds are rare and based on single species from a few taxonomic groups or umbrella species linked to single management indicators. These are, for example lichens with forest age (Moning & Müller 2009), woodpeckers (i.e. *Picoides dorsalis* and *Dendrocopos leucotos*) or saproxylic beetles with deadwood (Bütler *et al.* 2004; Della Rocca *et al.* 2014; Lešo, Kropil & Kajtoch 2019) or other individual forest bird species, including cavity breeding species, with forest age, tree species composition and trees with cavities (Moning & Müller 2008).

This work aims at identifying thresholds where the presence or abundance of a management indicator, as defined by Oettel and Lapin (2021) has an exceeding high effect on biodiversity. Determining these more general thresholds can help to define management recommendations and thus allow foresters to improve sustainable forest management.

Within this work we want to use the large dataset the COST Action provides to:

1. Link biodiversity (separated into multidiversity, diversity of single taxa and of functional groups) with management indicators, e.g. forest habitats like deadwood.
2. Define habitat thresholds for biodiversity in European temperate forests and distinguish different thresholds for different taxa.
3. Clarify whether thresholds differ between larger biogeographical regions (i.e. EUNIS terrestrial habitat classification).
4. Clarify whether the protection or management has an influence on thresholds.

We will use a recursive partitioning approach (Hothorn, Hornik & Zeileis 2006), used by studies testing the thresholds of environmental factors for single species groups (Müller & Hothorn 2004; Zielewska-Büttner *et al.* 2018). Specifically, we would undertake the following steps:

- Modeling the species occurrences and biodiversity as a function of management indicators using General Additive Models. Biodiversity is calculated as a multidiversity index proposed by Allan *et al.* (2014).
- Testing for the significance of the smooth terms using chi-square test statistics.
- Calculating thresholds using conditional inference trees with multivariate trees for all variables which show significant fitting in the GAM and univariate trees with significant splits in the multivariate trees.

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Core authors outside BOTTOMS-UP: none yet

Further opt-in authors:

Data to be used:

We would like to calculate habitat thresholds based on the indicators for management by Oettel and Lapin (2021), which include living trees and their features, lying and standing deadwood as well as metadata, e.g. for protection status (Table 1). Species groups included in this analysis should be available in most of the datasets, especially in the datasets which include microhabitats. This would be (to our knowledge):

Raw_data_taxa (estimates on what is available based on the handbook for sampling): Plants, Bryophytes, Lichen, Fungi, Beetles (including Carabidae and Staphilinidae), True Bugs, Hymenoptera, Diptera, Gastropoda, Birds, Bats (and other Mammals if available).

Table 1: Data for habitat structure to be included in the analysis, based on the indicators for management by Oettel and Lapin (2021). Data present in the database are marked by an X. Data need to be checked for their distribution to determine whether they can be used in threshold analysis.

IM group	No.	Indicator for management	Present in the database	Dataset	Variable
(Oettel & Lapin 2021)	Database COST Action				
Regeneration	1	litter cover natural	No		
	2	regeneration ground	X	Raw_data_taxa = 'Plants'	
	3	vegetation cover	X	Raw_data_taxa = 'Plants'	
	4	vegetation diversity	X	Raw_data_taxa = 'Plants'	
Tree species composition and diversity	5	soil disturbance	No		
	6	share of alien species	X	output_standing_trees	treesp
	7	share of broadleaves	X	output_standing_trees	treesp
	8	share of native species	X	output_standing_trees	treesp
	9	share of coniferous	X	output_standing_trees	treesp
	10	tree species composition	X	output_standing_trees	treesp
	11	tree species diversity	X	output_standing_trees	treesp
Deadwood	12	deadwood decomposition	No		
	13	deadwood dimension	X	output_standing_trees; alive = '0' + output_lyng_deadwood	treedb + diam01
	14	deadwood diversity	(x)		
	15	deadwood amount	X	output_standing_trees; alive = '0' + output_lyng_deadwood	treedb, tree ht or treevol + diam01, lenhei, volume
	16	lying deadwood	X	output_lyng_deadwood	
	17	standing deadwood	X	output_standing_trees	
Habitat provisioning	18	branchiness	No		

	19	cavities	X	output_standing_trees	No name yet
	20	characteristic species	No		
	21	microhabitats	X	output_standing_trees	No name yet
	22	old/veteran/ habitat trees	X	output_standing_trees	No name yet
	23	protected species	X	Raw_data_taxa	Red list?
	24	waterbodies	No		
Canopy structure	25	canopy cover	X	??	Maybe 'crownrad'?
	26	canopy diversity	No	??	
	27	tree height	X	output_standing_trees; alive = '1'	treeht
Stand structure and stand size	28	basal area	X	output_standing_trees; alive = '1'	treedb
	29	diameter diversity	X	output_standing_trees; alive = '1'	treedb
	30	distance to forest edge	No		
	31	forest/tree age	(x)		
	32	forest area	No		
	33	growing stock	X	output_standing_trees; alive = '1'	treevol
	34	stand diversity	X	output_standing_trees; alive = '1' or Raw_data_taxa = Plants (if they included shrubs)	treeht
Management intensity	35	area-no/low management	X	Plot_Stand_description	Manarea, noint, typint
	36	distance to forest road	No		
	37	forest road width	No		
	38	harvesting method	No		
	39	management history	X	Time since last harvest	
	40	management intensity	No		
	41	management type	X	Silvicultural treatment	
	42	nr of visitors	No		

43	harvesting intensity	X	output_lyng_deadwood = 'stumps' etc.
44	long-term changes	No	

Time line:

	From	Until
Deadline for permission of data usage from custodians:		25.02.2022
Extraction of data from BOTTOMS-UP:	26.02.2022	11.03.2022
Data preparation and analysis:	14.03.2022	30.06.2022
Raw results to be sent to the wider author team:		01.07.2022
Writing up of the paper (including preparation/optimization of figures):		16.09.2022
Final feedback round of co-authors to MS:		30.09.2022
Submission:		14.10.2022

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Confirmation:

I confirm that I will adhere to the BOTTOMS-UP Bylaws.

Date

01.09.2021

Signature