Supporting Information for: "Decaying trees improve nesting opportunities for cavity-nesting birds in temperate and boreal forests: A meta-analysis and implications for retention forestry"

List S1: Study Inclusion Criteria sorted by relevance:

- (1) Studies that provided information about the amount of nest and available trees with broken/intact crown were included.
- (2) Studies that provided information about the amount of nest and available trees that were dead/alive were included.
- (3) Studies that reported the diameter at breast height (DBH) of trees that hosted an active cavity and random trees as numerical data (e.g. mean DBH) in the text/supplementary data/appendix or a figure were included.
 - (3a) Studies that reported DBH measurements taken from trees with active *and* inactive nests were included in the literature review.
 - (3b) Studies that included nest trees in the "random" tree DBH value were included if less than 25% of "random" trees were nest trees.
 - (3c) Studies were included only if DBH data for non-nest trees were measured on trees that could be considered as being selected randomly (i.e. not based on several selection criteria such as presence of cavities or stick nests, minimum cavity entrance) from the available trees.
- (4) Studies about primary (excavators, e.g. white-headed woodpecker, *Picoides albolarvatus*) cavitynesting birds were included.
- (5) Studies about secondary (non-excavators, e.g. mountain chickadee, *Poecile gambeli*) cavity-nesting birds were included.
- (6) Studies carried out in forests of the boreal and temperate regions were included (Def. boreal and temperate region based on study area description and complemented by the World Biomes Map, http://www.worldbiomes.com/biomes_map.htm).
- (7) Only studies published in peer-reviewed journals were included.
- (8) If it was stated that trees hosting different nest types (e.g. top cavities, platforms, stick nests) were studied information to distinguish from side-cavities had to be included. If just one nest-tree DBH was reported for different nest types the study was included if more than 90% of total cavities were side-cavities.
- (9) We included observational studies (Level of Evidence 3 of the evidence hierarchy, Mupepele et al. 2016) if data measured in the field were reported that also fulfilled our other inclusion criteria.

Table S1: Search strings used for the meta-analysis. In November 2017 the search wasupdated with search string two.

Database	Search String				
1. WoS	TS=(("avian" OR "avifauna" OR "aves" OR "ornithology" OR "bird" OR "woodpecker"				
	OR "chickadee" OR "picidae" OR "poecile" OR "picoides" OR "strigidae" OR "strigi-				
	forme" OR "cavity nester" OR "nest" OR "excavator") AND ("habitat requirement" OR				
	"old-growth" OR "snag") AND ("dbh" OR "threshold")) Refined by: Research Areas: (En-				
	vironmental Sciences Ecology OR Forestry OR Biodiversity Conservation OR Zoology				
	OR Reproductive Biology OR Evolutionary Biology OR Developmental Biology)				
2. WoS	TS=("woodpecker" AND "nest") Refined by: Document Types: (article OR review OF				
	abstract) and Research Areas: (Environmental Sciences Ecology OR Forestry OR Bio-				
	diversity Conservation OR Zoology OR Reproductive Biology OR Evolutionary Biology				
	OR Developmental Biology)				
3. GS	((avian OR avifauna OR aves OR bird OR woodpecker OR picidae OR poecile OR cavity				
	nester OR nest OR excavator) AND (habitat-requirement OR old-growth OR snag OR				
	silviculture) AND (dbh OR basal OR threshold))				
4. Cab	((avian or avifauna or aves or ornithology or bird or woodpecker or chickadee or picidae				
	or poecile or picoides or strigidae or strigiforme or cavity nester or nest or excavator) and				
	(habitat requirement or old growth or snag or silviculture) and (dbh or height or basal				
	or density or threshold)) .mp. [mp=abstract, author, book author, book title, corporate				
	author, collection authors, collection title, corporate author word, heading word, subject				
	heading, title, year]				
5. GeoRef	((avian OR avifauna OR aves OR ornithology OR bird OR woodpecker OR chickadee OR				
	picidae OR poecile OR cavity nester OR nest OR excavator OR picoides OR strigidae				
	OR strigiforme) AND (habitat requirement OR old growth OR snag OR silviculture)				
	AND (dbh OR height OR basal OR density OR threshold))				
6. DOAJ	((avian OR avifauna OR aves OR ornithology OR bird OR woodpecker OR chickadee OR				
	picidae OR poecile OR cavity nester OR nest OR excavator OR picoides OR strigidae				
	OR strigiforme) AND (habitat requirement OR old growth OR snag OR silviculture)				
	AND (dbh OR height OR basal OR density OR threshold))				

Database	Search String				
7. BioOne	(("avian" OR "avifauna" OR "aves" OR "ornithology" OR "bird" OR "woodpecker" OR				
	"chickadee" OR "picidae" OR "poecile" OR "picoides" OR "strigidae" OR "strigiforme" OR				
	"cavity nester" OR "nest" OR "excavator") AND ("habitat requirement" OR "old-growth"				
	OR "snag" OR "silviculture") AND ("dbh" OR "height" OR "basal" OR "density" OR				
	"threshold"))				
8. Springer	(("avian" OR "avifauna" OR "aves" OR "ornithology" OR "bird" OR "woodpecker" OR				
	"chickadee" OR "picidae" OR "poecile" OR "picoides" OR "strigidae" OR "strigiforme" OR				
	"cavity nester" OR "nest" OR "excavator") AND ("habitat requirement" OR "old-growth"				
	OR "snag" OR "silviculture") AND ("dbh" OR "height" OR "basal" OR "density" OR				
	"threshold")) within Forestry AND Ecology				
9. ScienceDi-	tak(("avian" OR "avifauna" OR "aves" OR "ornithology" OR "bird" OR "woodpecker" OR				
rect	"chickadee" OR "picidae" OR "poecile" OR "picoides" OR "strigidae" OR "strigiforme" OR				
	"cavity nester" OR "nest" OR "excavator") AND ("habitat requirement" OR "old-growth"				
	OR "snag" OR "silviculture") AND ("dbh" OR "height" OR "basal" OR "density" OR				
	"threshold")				
10. JSTOR	(("avian" OR "avifauna" OR "aves" OR "bird" OR "woodpecker" OR "picidae" OR "poe-				
	cile" OR "cavity nester" OR "nest" OR "excavator") AND ("habitat requirement" OR				
	"old-growth" OR "snag" OR "silviculture") AND ("dbh" OR "basal" OR "threshold"))				
	AND disc:(biologicalsciences-discipline OR ecology-discipline OR botany-discipline OR				
	environmentalscience-discipline OR zoology-discipline)				

Bird Species			ES [95% CI]
Acorn woodpecker (Melanerpes formicivorus)			1.31 [0.82, 2.11]
American kestrel (Falco sparverius)			1.51 [1.00, 2.29]
American three-toed woodpecker (Picoides dorsalis)		<u></u>	1.12 [1.01, 1.25]
Barrow's goldeneye (Bucephala islandica)			2.15 [1.97, 2.35]
Black-backed woodpecker (Picoides arcticus)			1.27 [1.04, 1.55]
Black-capped chickadee (Poecile atricapillus))		0.91 [0.80, 1.03]
Brown creeper (Certhia americana)		· · · ·	1.33 [1.19, 1.48]
Brown-headed nuthatch (Sitta pusilla)			0.76 [0.50, 1.14]
Bufflehead (Bucephala albeola)			1.63 [1.42, 1.88]
Cordilleran flycatcher (Empidonax difficilis)			1.07 [0.49, 2.37]
Downy woodpecker (Picoides pubescens)			1.10 [1.01, 1.20]
European starling (Sturnus vulgaris)			1 47 [1 12, 1 94]
Great spotted woodpecker (Dendrocopos major)			1.09 [1.00, 1.19]
Hairy woodpecker (Picoides villosus)			1 27 [1 07, 1 52]
Hooded merganser (Lophodytes cucullatus)			2 21 [1 68 2 89]
House wren (Troglodytes aedon)			1 20 [1 11 1 30]
Japanese pygmy woodpecker (Dendrocopos kizuki)			1.06 [0.86, 1.30]
Lewis's woodpecker (Melanerpes lewis)			1.57 [1.31, 1.90]
Mountain bluebird (Sialia currucoides)			1.32 [1.17, 1.49]
Mountain chickadee (Poecile gambeli)	L		1 00 [0 77 1 29]
Northern flicker (Colaptes auratus)	1		1 38 [1 21 1 58]
Northern hawk-owl (Sumia ulula)		•	1 84 [1 84 1 84]
Northern saw-whet owl (Aegolius acadicus)			1 70 [1.46, 1.98]
Pileated woodpecker (Dryocopus pileatus)			2.09 [1.59, 2.75]
Pygmy puthatch (Sitta pygmaea)			0.93 [0.54, 1.59]
Red-breasted nutbatch (Sitta canadensis)	I		1 21 [0 86 1 71]
Red-beaded woodpecker (Melaneroes eru/brocenhalus)			1 20 [1 02 1 62]
Red-naned sansucker (Sobvranicus nuchalis)			1.29 [1.02, 1.63]
Thorn-tailed rayadito (Anbrastura spinicauda)			1.42 [1.03, 1.34]
Tree swallow (Tachycineta bicolor)			1.42 [1.00, 1.07]
Unspecified			1.06 [0.63, 1.40]
Violet-green swallow (Tachwineta thalassina)			1.26 [0.90, 1.05]
Western bluebird (Sialia maxicana)			1.26 [0.90, 1.76]
White-backed woodnecker (Dendroconos leucotos)			1.21 [1.03, 1.41]
White-breasted nuthatch (Sitta carolinensis)			0.94 [0.61, 1.16]
White-beaded woodnecker (<i>Bicoides albolanatus</i>)			0.84 [0.61, 1.16]
Williameon's concuctor (Soluranicus thursideus)			1.14 [0.89, 1.47]
Weed duels (Aix energe)			1.39 [0.94, 2.03]
Overall effect			2.03 [2.03, 2.03]
Overall energy		•	1.30 [1.13, 1.43]
	0.5	1 2 3	
		Response ratio of	

tree selection

Figure S1: Forest plot for effect size DBH on log-scaled x-axis. The vertical line is the line of no effect. A response ratio >1 indicates that large-diameter trees were preferred for nesting by cavity-nesting birds. The figure indicates that most bird species selected for large nest trees.

Bird Species

ES [95% CI]





Figure S2: Forest plot for effect size vital status (dead/living tree) on log-scaled xaxis. The vertical line is the line of no effect. Relative probabilities >1 indicate that the probability of being selected as nest tree was higher for dead trees than for live trees. The figure indicates that most bird species selected for dead nest trees.

Bird Species

ES [95% CI]



Relative probability of tree selection

Figure S3: Forest plot for effect size crown status (broken/unbroken crown) on log-scaled x-axis. The vertical line is the line of no effect. Relative probabilities >1 indicate that the probability of being selected as nest tree was higher for broken-crown trees than for intact-crown trees. The figure indicates that most bird species selected for broken-crown nest trees.



Figure S4: Contour-enhanced funnel plot for effect size DBH. To indicate nonindependence same numbers were used if several effect sizes were derived from the same study. In the top-left corner a magnification of clustered effect sizes is provided. Shading indicates the p-value (white: >.10, grey: from .10 to .05, dark grey: from .05 to .01, area outside the triangle: <.01). Intercept of Egger's regression indicated asymmetry (publication bias): a = 0.27 (p-value: <0.001). The figure indicates that publication bias was present for the effect size DBH. Please note that funnel plots do not account for the multi-level structure of our data and Egger's regression may therefore detect publication bias that in fact is accounted for in our mixed-model analysis (Egger *et al.* 1997; Koricheva *et al.* 2013, pp. 218).



Figure S5: Contour-enhanced funnel plot for effect size vital status. To indicate nonindependence same numbers were used if several effect sizes were derived from the same study. Shading indicates the p-value (white: >.10, grey: from .10 to .05, dark grey: from .05 to .01, area outside the triangle: <.01). Intercept of Egger's regression indicated asymmetry (publication bias): a = 1.34 (p-value <0.001). The figure indicates that publication bias was present for the effect size DBH. Please note that funnel plots do not account for the multi-level structure of our data and Egger's regression may therefore detect publication bias that in fact is accounted for in our mixed-model analysis (Egger *et al.* 1997; Koricheva *et al.* 2013, pp. 218).



Figure S6: Contour-enhanced funnel plot for effect size crown status. To indicate nonindependence same numbers were used if several effect sizes were derived from the same study. Shading indicates the p-value (white: >.10, grey: from .10 to .05, dark grey: from .05 to .01, area outside the triangle: <.01). Intercept of Egger's regression indicated asymmetry (publication bias): a = 0.91 (p-value: <0.001). The figure indicates that publication bias was present for the effect size DBH. Please note that funnel plots do not account for the multi-level structure of our data and Egger's regression may therefore detect publication bias that in fact is accounted for in our mixed-model analysis (Egger *et al.* 1997; Koricheva *et al.* 2013, pp. 218).



Figure S7: Forest plot showing subgroups of all three effect sizes (DBH, vital status, crown status) for explanatory variables (biom, forest type, naturalness) on log-scaled x-axis. The vertical line is the line of no effect. Effect sizes are only slightly different between subgroups for all three effect sizes. This indicates that large-diameter trees, dead trees and broken-crown trees were preferred for nesting by cavity-nesting birds across bioms, forest types and management regimes. Numbers in parenthesis refer to number of studies/bird species contributing to this category. Unspecified bird species are counted as one single species because only one overall effect size could be estimated for these species.

Authors who provided data

Besides contacting authors of studies to which we had no access we also requested data. In several cases these data were no longer available. This was not the case for the study of Renken & Wiggers (1989). We appreciate very much the efforts made by Ms Rochelle Renken to locate and sending us data.

References

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