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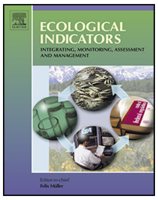

Strong observer effect on tree microhabitats inventories: A case study in a French lowland forest

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ABSTRACT

Validating biodiversity indicators requires an analysis of their applicability, their range of validity and their degree of correlation with the biodiversity they are supposed to represent. In this process, assessing the magnitude of observer effect is an essential step, especially if non-specialist observers are involved. Tree microhabitats – woodpecker cavities, cracks and bark characteristics – are reputed to be easily detected by non-specialists as microhabitat observation does not require prior forestry or ecology knowledge. We therefore quantified the probabilities of true and false positive detections made by observers during inventories.

Within two 0.5 ha plots in a forest reserve that has not been harvested for at least 150 years, 14 observers with various backgrounds visually inventoried microhabitats on 106 oak (*Quercus petraea* and *Quercus robur*) and beech (*Fagus sylvatica*) trees. We used parametric and Bayesian statistics to compare these observers' recorded observations with results from an independent census.

The mean number of microhabitats per tree varied widely among observers – from 1.4 to over 3. Only five observers reported a mean number of microhabitats per tree that was statistically equivalent to the reference census. The probability of true detection also varied among observers for each microhabitat (from to 0 to 1) as did the probability of false positive detection (from 0 to 0.7). These results show that microhabitat inventories are particularly prone to observer effects.

Such strong observer effects weaken the usefulness of microhabitats as biodiversity indicators. If microhabitat inventories are to be developed, we recommend controlling for observer effects by (i) defining standard operating procedures and multiplying the number of observer training sessions and of consensual standardization censuses; (ii) using pairs of observers to record microhabitats whenever possible (though the efficiency of this method remains to be tested); (iii) planning fieldwork so that the factors of interest are not confused with observer effects; and (iv) integrating observer profiles into the statistical models used to analyze the data.

1. Introduction

Quality assurance is an integral part of the production process in most companies. Through the quality control process, the company insures that its products consistently fulfil a standardized set of quality and safety requirements, notably by establishing standard operating procedures. In ecology, such processes are rarely mentioned, except in long-term monitoring networks where high standards of quality assurance are applied (e.g. Allegrini et al., 2009; Ferretti, 2013 for forest monitoring). However, high-quality data is crucial to minimizing noise and avoiding biases such as over- or under-estimations of species richness (Allegrini et al., 2009; Archaux et al., 2006). Among the possible sources of noise, observer effect has frequently been pinpointed, especially for data that rely on observation (Ahrends et al., 2011; Larjavaara and Muller-Landau, 2013). Indeed, observer effect has been identified as an important source of variation in ground flora surveys (Archaux et al., 2006; Gotfryd and Hansell, 1985) and bird censuses (Manu and Cresswell, 2007; Riffell and Riffell, 2002; Venier et al., 2012), but also in forest health assessment (Innes, 1988; Strand, 1996; Vales and Bunnell, 1988) or for estimations of classical forest measurements such as tree height (Ferretti et al., 2013; Larjavaara and Muller-Landau, 2013).

Even if observer effect can – and most of the time should – be included in statistical models explaining ecological patterns and processes, measures to limit it should first be taken before conducting any assessment. To be validated as relevant, an ecological indicator should have a limited observer effect, i.e. repeatability and

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solid confidence in estimations are mandatory (Sutherland et al., 2004). Several authors have recently proposed using tree microhabitats to explain biodiversity differences between managed and unmanaged forests (Michel and Winter, 2009; Vuidot et al., 2011) since these microhabitats appear to correlate with at least some components of biodiversity (Regnery et al., 2013a; Winter and Möller, 2008). In addition, microhabitat inventories are reputed to be easily performed by non-specialists as microhabitat observation does not require prior forestry or ecology knowledge (Regnery et al., 2013a). Yet as the quality of ecological data has been shown to depend on former field experience of the observers, a formal field test is warranted to validate the assertion that microhabitats can be monitored by the general public, e.g. through citizen science programmes (see e.g. Butt et al., 2013; Kendall et al., 1996; Scott and Hallam, 2003).

In a broad sense, microhabitats are defined as small substrates used by certain species or groups of species to grow, nest or forage (e.g. numerous bryophytes preferentially grow on deadwood logs, Fenton and Bergeron, 2008). The term “microhabitat” hence encompasses various forest features and authors often differ in what they include in this category. Here, we have adopted a more restrictive definition which includes only microhabitats linked to living trees and snags (cavities, cracks and bark characteristics).

To validate tree microhabitats (hereafter referred to as “microhabitats”) as indicators of biodiversity, one of the first steps is to assess the potential observer effect associated to their identification (Regnery et al., 2013b; Vuidot et al., 2011). Observer effect can vary according to observer skill or observation conditions. Several authors have pointed out the importance of training and observer experience as well as census duration (Ahrends et al., 2011; Archaux et al., 2006; Chen et al., 2009).

We hypothesized that observer identity, experience and training, as well as census duration, would all have an effect on the accuracy of microhabitat inventories. In other words, we aimed at testing whether microhabitat inventories done by either experienced or non-experienced observers were sensitive to observer effect. We quantified these effects and provided recommendations to help researchers and practitioners reduce observer effect in future studies.

2. Materials and methods

2.1. Study site descriptions and plot selection

We selected two 0.5 ha (100 m × 50 m) plots located inside strict forest reserves near Fontainebleau, France (48°24′ N, 2°42′ E). These forest reserves have not been managed for at least 150 years and present certain characteristics of old-growth forests (Koop and Hilgen, 1987; Pontailler et al., 1997), particularly different tree microhabitat types. The stands are composed of two oak species (*Quercus robur* L. and *Quercus petraea* Liebl.) and beech (*Fagus sylvatica* L.). Both plots have similar topographic and stand structure characteristics: they are both flat, high forest stands with large (mean diameter at breast height ± SD = 70 ± 44 cm) and tall trees (dominant height = 30 m), and low density (100 stems per hectare). Understory vegetation was absent from the plots, so that all observers had clear views of the trees. For these reasons, we assumed that plot effect was negligible.

In the two plots, the microhabitats present on all trees with a Diameter at Breast Height (DBH) >30 cm (50 and 56 trees for plots 1 and 2 respectively) were inventoried. We used a list of 28 microhabitats adapted from Vuidot et al. (2011, Table 1). The trees differed considerably in terms of the types and number of microhabitats they hosted.

Table 1
List of the 28 tree microhabitats used for the observer effect test and proportion of trees occupied by each microhabitat (based on the reference census). Microhabitats 1–7 represent general tree features while microhabitats 8–28 describe more specific tree structures.

Microhabitat type	Proportion microhabitat bearing trees (%)
1. Presence of a crown skeleton (snags only)	3.8
2. Between 10% and 25% of dead crown: one or more main branches are dead. The living crown represents 75% of the former total crown	12.3
3. Between 25% and 50% of dead crown: one or more main branches are dead. The living crown represents between 50 and 75% of the former total crown	0.9
4. >50% of dead crown: one or more main branches are dead. The living crown seems to be <50% of the former total crown	0.0
5. Broken stem: the primary crown is totally absent with or without the presence of a secondary crown. Main parts of the tree stem are already dead and decomposing	2.8
6. Broken fork: complete fracture of one of the two forking branches; the loss of one forking branch has resulted in severe damage to the main stem	2.8
7. Splintered stem: splitting-has resulted in numerous slabs (minimum 5) of wood >50 cm long	0.0
8. Conks of fungi. Fruiting bodies, diameter >5 cm	6.6
9. Conks of fungi. Equal to or more than 3 fruiting bodies >5 cm in diameter	0.9
10. Conks of fungi occurring in 10 cm long cascades of small fruiting bodies	4.7
11. Woodpecker cavities with >2 cm aperture	7.5
12. Non-woodpecker cavities with >5 cm aperture: formed after injury, branch fall	53.8
13. Cavity string: at least three woodpecker cavities on a same stem with a maximum distance of 2 m between two cavity entrances	3.8
14. Deep stem cavities: a tubular cavity in the base of the tree	7.5
15. Deep stem cavities: a tubular cavity in the base of the tree with mould	0.9
16. Lightning scar: a crack caused by lightning; at least 3 m long and reaching the sapwood	0.0
17. Cracks: cleft in the sapwood >25 cm long along the stem and at least 2 cm deep in the sapwood	34.9
18. Bark pocket: space between loose bark and the sapwood with a minimum extension of 5 cm × 5 cm × 2 cm	42.5
19. Bark pocket with mould: same structure and size as 17, but with mould	5.7
20. Bark loss: patches with bark loss of at least 5 cm × 5 cm mainly caused by injuries sustained from felling or natural falling of other trees	84.0
21. Bark burst: black burst of bark often with resin indicating injury/disease	0.9
22. Recent wood injury	2.8
23. Canker: proliferation of cell growth; irregular cellular growth on stems or branches, caused by bark-inhabiting fungi, viruses and bacteria. Areas of canker >10 cm in diameter were recorded	8.5
24. Witch broom: dense agglomeration of branches from a parasite or epicormic branching	5.3
25. Heavy sap or resin: fresh, heavy flow of sap or resin at least 30 cm long or >5 flows of sap or resin of smaller size	0.9
26. Sap or resin drop: only a few sap or resin drops indicating a minor injury	0.9
27. Bryophytes developed on >50% of the base, trunk or branch area (noted separately)	Base: 37.7; trunk: 12.3; branches: 8.5
28. Ivy growing on >50% of the base, trunk or branch area (noted separately)	Base: 0.0; trunk: 0.9; branches: 0.9