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Letter to the Editor

Extrapolation and biodiversity indicators: Handle with caution!

In recent years, there has been growing interest among researchers, governmental agencies, resource managers and environmental conservation groups in elaborating and testing synthetic indicators of biodiversity in both terrestrial and aquatic ecosystems. Such indicators are designed as surrogates for species richness and are often intended to evaluate the outcome of conservation actions. Indicators may be based on "indicator species", *i.e.* species whose presence and abundance are related to global biodiversity (Lindenmayer et al., 2000), or based on the species richness of one or several groups of organisms. These indicators are referred to as "species" or "direct" indicators (Maes and Van Dyck, 2005). Alternative or complementary biodiversity indicators are structure-based indices that rely on local and/or landscape-level features of ecosystems deemed correlated with overall species richness (Dauber et al., 2003; Lindenmayer et al., 2000). They are also referred to as "habitat" or "indirect" indicators. "Species" indicators highly depend on the taxonomic groups considered and on the taxonomic resolution. They have led to contrasted results (Prendergast and Eversham, 1997; Similä et al., 2006). "Habitat" indicators are highly sensitive to the spatial scales at which habitat is described as well as to the habitat or landscape descriptors themselves (Rossi and van Halder, 2010). Finally, the performances of "species" indicators are severely limited by a general lack of covariation between species richness among different taxa (Heino, 2010; Wolters et al., 2006), whereas those of "habitat" indicators are impeded by the great variability of species responses to environmental heterogeneity (Araújo et al., 2001; Similä et al., 2006). Because predicting the richness of a large range of different taxonomic groups (*e.g.* vascular plants, birds, butterflies. . .) has proven very difficult (if ever possible), a more pragmatic approach often prevails: biodiversity indicators often deal with a single or a very limited number of taxa. Another important point is that historical information about species often lack. This impedes the establishment of indicator baselines and the interpretation of the condition and changes of biodiversity (Niemelä, 2000).

The present letter focuses on the domain of application of indicators of biodiversity based on one or a few taxa and is illustrated by a recent paper dealing with indicators of biodiversity in a plantation forest (Brin et al., 2009). Emphasis is given to the risk of using such indicators to predict general levels of biodiversity. Plantation forests are highly managed systems and there is a need for indicators that may help monitoring biodiversity and defining sustainable management options. Brin et al. (2009) surveyed the relationship between saproxylic beetle species richness and deadwood volume or diversity in a maritime pine plantation. The work was intentionally limited to specialist saproxylic species of coleoptera associated with pine wood despite the fact that data comprised many more taxa (Section 2.3 and 3.1 in Brin et al., 2009). Although demonstrating the value of deadwood as an indicator of saproxylic species richness may sound like a truism, Brin et al. (2009) showed the cost effectiveness of a "habitat" over a "species" indicator.

The main point is that such indicators have a narrow scope. In the example, deadwood can only provide information on saproxylic species and extrapolating this relationship to other elements of biological diversity is, at the very least, misleading. Problems arise when authors suggest that their "habitat" indicator provides a suitable sustainable forest management indicator allowing to evaluate new management options (Section 4.3 in Brin et al., 2009). Such conclusions are probably true with regard to saproxylic beetles but are risky extrapolations regarding all other taxa. Consequently, any generalisation would be simplistic and any application might be erroneous. Indicators based on a limited number of taxa cannot be interpreted or used as biodiversity indicators as long as their correlation to general levels of diversity is not properly demonstrated and documented. Not only semantic, these considerations have both fundamental and practical implications. A single taxon based indicator may be a very useful management tool for that taxon but its value as an indicator is restricted to the taxon for which it has been elaborated and should not be extrapolated.

Since the relationships between the diversity of different taxa often appear idiosyncratic, extreme caution is needed when indicators based on a limited number of taxa are intended to appraise the success or failure of management regimes to sustain biological diversity.

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J.-P. Rossi*
INRA, UMR1202 BIOGECO, 69 Route d'Arcachon, F-33612 Cestas, France

* Present address: INRA, UMR CBGP (INRA/IRD/Cirad/Montpellier SupAgro), Campus International de Baillarguet, CS 30016, F-34988 Montferrier-sur-Lez cedex, France.
Tel.: +33 04 30 63 04 30; fax: +33 04 99 62 33 45.
*E-mail address:*Jean-Pierre.Rossi@supagro.inra.fr

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