For more than two decades, ecologists have investigated potential links between biodiversity and the functioning of ecosystems. This research, which was first triggered by societal concerns about human-driven species losses (Bradley J. Cardinale et al., 2012), led to theoretical controversies and advances in the study of ecological communities. Community ecology traditionally focuses, among others, on the causes of species diversity at a given spatial scale, and thus sees local biodiversity as a consequence of ecological processes (Vellend, 2010). The focus on the effects of biodiversity on ecosystem functioning resulted in a shift of perspective, because it considered biodiversity as a cause as much as a consequence (Loreau, 2010). The central question of this research program was: *is biodiversity positively correlated to the functioning of ecosystems*? A lot of experimental studies were performed, mostly manipulating species richness at a local scale, and several synthesis papers, either qualitative (Hooper et al., 2005) or quantitative (Balvanera et al., 2006), ranging from terrestrial to marine ecology (Bradley J. Cardinale et al., 2011; Stachowicz, Bruno, & Duffy, 2007; Worm et al., 2006), reported their overall results. In these experiments, biodiversity, measured as species richness, evenness, or the number of functional groups, appeared to positively impact measures of ecosystem performance (e.g. biomass production) and stability (Bradley J. Cardinale et al., 2006; Tilman et al., 2014). These studies first raised concerns about their external validity, because they were performed in controlled, and thus extremely simplified, systems (Hillebrand & Matthiessen, 2009; Naeem et al., 2012). However, further studies incorporating complexity, for instance considering several ecosystem functions at a time (i.e. multifunctionnality) tend to reinforce the conclusions of these studies (Lefcheck et al., 2015; Naeem et al., 2012). In addition, niche theory predicts that more species are necessary to support ecosystem functioning when environmental heterogeneity (and thus complexity) is high (Turnbull, Isbell, Purves, Loreau, & Hector, 2016), which is empirically supported (Hooper et al., 2005). All of this leads to a growing confidence that biodiversity positively affects ecosystem functioning at local to regional scales.

A central question to the BEF (biodiversity and ecosystem functioning) field is to identify the mechanisms responsible for the positive effects of diversity on ecosystem functioning. Why do species mixture generally perform better than the monocultures of their component species? Does richness have a positive effect *by itself,* or is it a consequence of the functional properties of the organisms present in a community (Garnier & Navas, 2011)? A review of the literature reveals that all the explanations for the links between biodiversity and ecosystem performance (i.e. ecosystem rates: productivity, decomposition, element cycling...) require functional differences between the species (Hillebrand & Matthiessen, 2009), and there is a consensus that the magnitude of ecosystem function depends on the functional characteristics of the species (Bradley J. Cardinale et al., 2012; Hooper et al., 2005). These explanations fall into two main categories, respectively termed selection and complementarity effects (Loreau & Hector, 2001). First, selection (also called sampling) effect occurs because increasing the number of species in a community increases the probability of retaining a highly performant species in that community (Hooper et al., 2005; Loreau & Hector, 2001). If species are functionally heterogeneous, we can indeed expect that the more species we sample, the more likely it is that one of them is a good performer. Second, complementarity effect answers the question: *Do species,* *functional groups, or genotypes, perform better in a mixture than in a monoculture* (Barry et al., 2019)*?* Indeed, the association between different species may enhance ecosystem functioning because of either: i) resource partitioning between species, leading to a better overall use of the resources in the community; ii) abiotic facilitation, whereby species alter their environment in a way that favors other species; or iii) positive biotic interactions (Barry et al., 2019).

However general these relations may be, it has been repeatedly emphasized that they are expected to be context-dependent. For instance, an early theoretical study predicted that spatial heterogeneity and disturbance are likely to drive the shape of BEF curves (Brad J. Cardinale, Nelson, & Palmer, 2000). In line with these predictions, a recent study showed that climate indirectly affects ecosystem multifunctionnality by altering the composition of above- and below-ground plant and microbial communities (Jing et al., 2015). More fundamentally, if ecosystem functioning is dependent on the species richness, any driver of species richness should affect it. Because studying the determinants of species richness has been one major focus of community ecology (Loreau, 2010), classical niche theory could be used to indirectly predict ecosystem functioning by focusing on the determinants of species coexistence (Turnbull et al., 2016). For instance, aquatic detritivore interactions were shown to change along environmental stress gradients, which was proposed as a likely explanation for the context-dependence of BEF relationships (Fugère et al., 2012). Even in environment with similar climates, the availability of resources is expected to determine the number of coexisting species by shaping the niche dimensionality (Harpole & Tilman, 2007): increasing the number of limiting resources is then likely to allow more complementary species to coexist because each of them specializes on a different subset of all the resources. BEF relationships thus seem to depend on environmental variables at large spatial scales as well as locally.

Trait-based approaches provide a useful was to capture both the dependence of BEF

With the dichotomy effect traits/response traits.

Since the functional characteristics of the species are responsible for their effect on ecosystem functioning, and the

A unifying framework for considering these relationships stems from trait-based ecology.

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