Highly productive sown biodiverse pastures with low invasion risk

Driscoll et al. (1) have recently drawn attention to the risk of new pasture plants becoming invasive, because the same biological traits that promote pasture productivity may also facilitate the invasion of natural areas. The authors indicate some aspects that could mitigate the risk of invasion: namely, the use of native species to develop new pasture plants, the avoidance of new characteristics associated with environmental weeds, and the selection of new characteristics that limit invasion risk. Here we describe a system that meets the above criteria—specifically, the last one—through the existence of a mismatch between the environmental conditions found in managed and in natural areas, such that improved pasture plants face environmental limitations in natural areas while keeping a high performance in managed ones.

The system of sown biodiverse permanent pastures rich in legumes (SBPPRL) has been successfully implemented in Portugal on farms in Mediterranean climate areas (2, 3). SBPPRL were developed by Portuguese agronomists, namely David Crespo, as a response to the low levels of productivity and feed quality obtained in seminatural pastures. The pastures' low performance results from endogenous low soil fertility and historical land use practices that depleted soil nutrients, disrupted soil structure, and caused plant community impoverishment, especially the decline of legume species (4). SBPPRL consist in mixtures of up to 20 taxa of grasses and legumes, each mixture tailored to local environmental conditions (e.g., precipitation and soil texture) to best cover the available environmental niches. Seed mixtures include autochthonous (the majority) and exotic species (all native to the Mediterranean basin) selected to achieve the best performance in soils with enhanced fertility. Legumes and associated *Rhizobium* fix atmospheric nitrogen, making the system self-sufficient in nitrogen, but require an external input of phosphorus (a limiting nutrient in Mediterranean soils) and the correction of soil acidity for optimal legume growth (5). As result, improved cultivars are not competitive in oligotrophic environments with acidic soils (i.e., natural environments) but outcompete spontaneous pasture plants in managed systems. This aspect not only contributes to the long-term persistence of SBPPRL but also to reducing their invasive risk. In fact, the older SBPPRL are now over 30 y old, and there are no reports of exotic pasture species establishment outside ruderal or managed pasture habitats (i.e., in natural ecosystems).

Moreover, SBPPRL offer an alternative for sustainable intensification by combining higher pasture productivity (i.e., socio-economic benefits) with environmental benefits that emerge as positive externalities, such as soil carbon sequestration and soil restoration, both associated with the absence of tillage in SBPPRL and the accumulation of soil organic matter (3, 4). Additionally, the use of phosphorus fertilization is more than compensated by the avoided impacts of using nitrogen fertilizers (otherwise required either to produce concentrate feed or fertilize pastures), and potential leaching of phosphorus is mitigated by increased soil organic matter (4). The opportunities for society of SBPPRL were acknowledged by the Portuguese Carbon Fund* through the payment of soil carbon sequestration (2009–2014) in around 50,000 ha, in an estimated total of 1 million tons of CO_2 (2).

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*An outreach video on the payment of soil carbon sequestration project is available at https://www.youtube.com/watch?v=WR4tINbSXp4.