Recognising the value of insects in providing ecosystem services

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The concept that biodiversity and healthy functioning ecosystems provide goods and services of benefit and value to human wellbeing has been accepted for decades, but it was the Millennium Ecosystem Assessment (2005), which cemented the concept of 'ecosystem services' into today's environmental policies and management. The concept is a useful tool for linking ecosystem functions with human wellbeing in a range of decision-making contexts, although it can over-simplify the complexity of ecological systems (Norgaard, 2010). For insects, their role in regulating pest populations in agriculture and plant pollination has been recognised for many years, but in Schulze and Mooney's (1994) seminal book *Biodiversity and Ecosystem Function*, it is notable and surprising that the contribution of insects to ecosystem services barely received a mention. A decade later, *Insects and Ecosystem Function* appeared (Weisser & Siemann, 2004), which opened with the following statement: 'In contrast [to plants], our understanding of the role of insects in ecosystem processes is relatively primitive. Because insects are a dominant component of biodiversity in terrestrial ecosystems, this state of knowledge is unsatisfactory'. In the last decade, since the publication of this book, there has been a notable increase in articles on insect ecosystem service provision published (Fig. 1), and the concept is clearly gaining traction as a useful mechanism to illustrate the ecological and economic value of insects.

In particular, the role of insects in providing ecosystem services in agricultural contexts has been recognised, largely in terms of their influence on provisioning services, such as crop yields. Herbivorous insects and the damage they inflict both directly through consumption of plant material, and indirectly through the transmission of plant pathogens, have attracted the majority of research attention from ecological entomologists. However, at all trophic levels, insects provide services which can be fundamental to crop production, including pollination of entomophilous crops to ensure seed and/or fruit production, population regulation of pests by natural enemies (biocontrol) to prevent crop damage/loss, and the decomposition of dead and waste material to recycle nutrients required for crop growth. This focus on services that contribute to yield, however, has meant that the contribution of these services to the wider agricultural ecosystem has been largely ignored. For example, insects are important pollinators of wild hedgerow plants and rare agricultural weeds (Jacobs *et al.*, 2009), which not only provide seeds and berries for farmland birds and other wildlife, but also other supporting, regulating, and cultural services (Hinsley & Bellamy, 2000). Thus, perturbations to insect populations in agricultural systems can affect rates of herbivory, pollination, predation, and decomposition. In turn, such perturbations could have profound consequences for the structure and composition of biological communities, and thus knock-on impacts on the delivery of a whole host of services from the agricultural ecosystem.

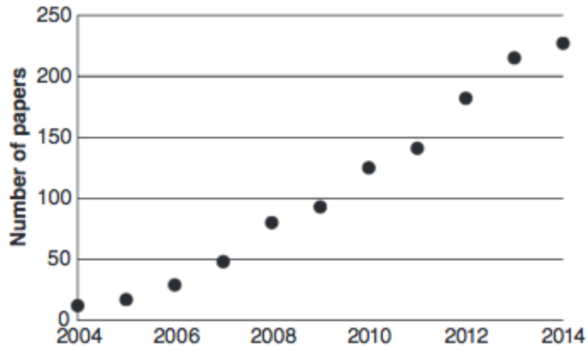

Fig. 1. The number of published papers with 'ecosystem service* insect*' included as 'topic' (from Web of Science) from 2004 to 2014.

Beyond agricultural systems, insects also provide other, largely overlooked, services. For example, insects deliver provisioning services directly, and there is increasing recognition that eating insects as an alternative protein source could aid their conservation (Yen, 2009) and counteract climate change (Premalatha *et al.*, 2011). Although recently, crickets have been shown not to have such efficient conversion rates as previously claimed (Lundy & Parrella, 2015). In addition, by burying dung, insects contribute to not only to its decomposition, a key supporting service, but also to regulating services via the suppression of pathogens of both livestock and humans (Ryan *et al.*, 2011). Insects can also provide services to commercial waste treatment, through the conversion of organic waste into nutrient-rich humus, and their larvae can provide protein-rich animal feed for chickens, pigs, and aquaculture (Diener *et al.*, 2009). Finally, insects can also provide cultural services and non-material benefits, such as recreation and education benefits, and act as flagships for conservation. In the case of the latter, bees have become the invertebrate equivalent to the giant panda or tiger in terms of stimulating people to support and implement conservation.

All of these services are valuable, and for some of them we can calculate an economic value (Losey & Vaughan, 2006). This can be controversial, however, with some people arguing that economic valuations are over-simplified and thus flawed and that we should not even attempt to put a value on something as priceless as natural ecosystems and their component parts. Others argue that putting an economic value on services is the only way to make sure they are accounted for, and incorporated into decision-making. Certainly, much of the focus on the bee conservation policy and practice uses the argument that bees provide economic benefits to farmers in terms of crop yields.

In this Special Issue, arising from a Royal Entomological Society International Symposium at Trinity College Dublin in September 2015, a total of 11 reviews and original research articles address the broad issue of ecosystem service provision by insects. These articles address agricultural services, including pest management (Midega *et al.*, 2015; Bengtsson, 2015; Schäckermann *et al.*, 2015; Macfadyen *et al.*, 2015), pollination (Dicks *et al.*, 2015; Birkin & Goulson, 2015), and waste decomposition (Beynon *et al.*, 2015; Ulyshen *et al.*, 2015), as well as cultural services (Leather, 2015), and service provision in specific systems (Cross *et al.*, 2015; Macadam *et al.*, 2015). Furthermore, this issue addresses key contemporary issues of economic value of services (Cross *et al.*, 2015; Beynon *et al.*, 2015), how science can inform policy to enhance service providers (Dicks *et al.*, 2015), and the use of citizen science to measure service provision (Birkin & Goulson, 2015). Additionally, two papers emphasise the importance of taking a landscape-scale approach when assessing services in agroecosystems (Schäckermann *et al.*, 2015; Macfadyen *et al.*, 2015). Judging by the trajectory of Fig. 1, we can all look forward to the continued development of research on the effects of insects on ecosystem function and the delivery of services. We hope that this Special Issue contributes to this effort.

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