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Review

Set-aside management: How do succession, sowing patterns and landscape context affect biodiversity?

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ABSTRACT

European Union (EU) member states set aside between 5 and 15% of arable land during the last two decades, but abolition of the set-aside scheme in 2008 caused a sudden loss in habitat availability and biodiversity in agricultural landscapes. Management of set-aside has many facets and in this perspective paper we focus on the biodiversity effects of successional age, sowing strategies and landscape context. Young, 1–2-year-old set-asides have been initially considered to be too ephemeral to have any conservation value. However, when a rich seed and bud bank is available, a species-rich natural (secondary) succession can be observed. Arable (annual) weed communities in the first two years of succession can even include endangered plant species with associated rare insect consumers. Furthermore, many bird species benefit from early-successional habitats, whereas small mammal communities are richer in older habitats. If the local plant species pool is poor, sowings of diverse mixtures from regional seed collections can be recommended. Set-aside managers using species-rich sowings often experience that dominant weeds suppress the less competitive annual species. This trend to species-poor communities can be avoided by intraspecific aggregation of competitively weak species. Broadening the spatial scale from the plot to the landscape, efficiency of set-aside is highest in simple landscapes, where set-aside exhibits greatest effect in enhancement of biodiversity and associated services such as pollination and biological control. In complex landscapes, however, additional set-aside does not add much to the high level of biodiversity and ecological processes already present. Twenty percent of semi-natural, non-crop habitat appears to be a rough threshold for enhancing biodiversity and sustaining services such as pollination and biological control, but improved set-aside management should have the potential to reduce the percentage of semi-natural non-crop habitat needed. EU policy should tailor set-aside schemes for the maintenance of biodiversity and also consider that management efficiency is higher in simple than complex landscapes.

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1. Introduction

1.1. Set-aside and agricultural policy changes

Agricultural set-aside schemes were introduced by the Common Agricultural Policy (CAP) of the European Union (EU) in the late 1980s to reduce overproduction and soil erosion, but also to protect farmland biodiversity (ENCA, 2008). In the beginning of the set-aside scheme, the contribution to nature protection was sometimes questioned by conservationists, because of the ephemeral nature of rotational set-aside, which was regarded as an ecological trap without long-term biodiversity benefit. Increasing research on this issue has shown, however, that rotational set-aside contributes to population density of many valuable early successional species in agricultural landscapes (Clarke, 1992; Corbet, 1995; Sotherton, 1998).

Set-aside schemes changed over the decades. In 1988, when the first set-aside scheme was introduced by the EU, most arable land set-aside was left to natural succession. Hence, in the following years, landscapes were characterized by a mosaic of successional stages, including young, 1–2-year old plots dominated by arable weeds, while older stages were dominated by perennial plants (Clarke, 1992; Corbet, 1995). In 1993, set-aside became an obligation for any farmer receiving EU subsidies. Roughly 5–15% of arable land was expected to become rotational set-aside. In contrast to set-aside practices in the early years, farmers in some countries were advised to sow these fallows, thereby avoiding increased weed pressure and facilitating re-cultivation. During this period, landscapes were often colourful, due to set-aside sowings of *Phacelia*, *Trifolium*, *Sinapis* and other plants. From 1995 onwards, farmers increasingly dedicated set-aside to non-food plant production, in particular renewable resources (ENCA, 2008).

After 2006 energy crops (such as oilseed rape) were increasingly sown. In 2008, the abolition of set-aside as an EU-wide instrument to control supply and the rising commodity prices for food and energy crops have led to a widespread loss of set-aside in Europe, with the exception of Switzerland, where farmers are still obliged to set-aside at least 7% of their farmland as ecological compensation areas (ENCA, 2008; Albrecht et al., 2007; Oppermann et al., 2008; Aviron et al., 2009).

1.2. Set-aside and biodiversity conservation

After two decades of set-aside schemes, the political change has led to a sudden decline in fallow land since 2006. The consequences of these changes in set-aside area are pronounced and although there are no published data summarising any biodiversity losses in EU landscapes, there is little doubt about the generally negative effects of set-aside loss on biodiversity (Van Buskirk and Willi, 2004). However, the relative importance of different types of set-aside management, the different responses of species groups and the role of the landscape context for conservation of biodiversity and associated services is still a matter of debate. In this perspective paper, the adverse impact of giving up set-aside on plant, vertebrate and invertebrate communities and associated ecosystem services will be explored, which are in stark contrast to the political objective to halt the decline of biodiversity by 2010 (UNEP, 2002). The review is guided by three hypotheses on the management of set-aside–biodiversity relationships covering less studied aspects on different temporal to spatial scales integrating local and landscape scale management:

(1) From early to late succession, biodiversity displays a hump-shaped pattern from early stages dominated by annual vegetation to perennial stages (e.g., Steffan-Dewenter and Tscharntke, 1997, 2001; Kovács et al., submitted for publication).
(2) Sowing of intraspecifically aggregated wild plants improves conservation value of set-aside (Wassmuth et al., 2009).
(3) Landscape context influences the biodiversity value and ecosystem services of set-aside (Thies and Tscharntke, 1999; Wretenberg et al., 2010).

We conclude with recommendations for improved set-aside management on local and landscape scales.

2. Successional change in naturally developing set-aside fallows

Secondary succession on fallow arable land (old fields) is a subject dominated by plant studies (Glenn-Lewin et al., 1992; Pickett et al., 2009). Also a number of animal studies have accumulated data, and in their meta-analysis Van Buskirk and Willi (2004) showed that age of set-aside generally increases richness of plants and insects, but not birds. However, secondary succession of naturally developed set-aside does not necessarily exhibit steadily increasing species richness with successional age, although this is often expected (Brown and Southwood, 1987).

2.1. Plant and insect diversity through succession

Plant species richness is often closely related to insect richness (Tscharntke and Greiler, 1995). For example, species richness of flowering plants is a good predictor of species richness of bees, whereas the cover of flowering plants is a good predictor of bee abundance (Steffan-Dewenter and Tscharntke, 2001; Batáry et al., 2009). More diverse vegetation supports more diverse insect communities (Strong et al., 1984; Andow, 1991; Siemann et al., 1999), as has also been shown for butterflies (Steffan-Dewenter and Tscharntke, 1997) and trap-nesting bees (Gathmann et al., 1994) on set-aside in Germany.

In a set-aside project located in Germany, species richness of plants, butterflies, beetles, true bugs, parasitoids and bees was highest on 2-year-old set-aside fields in a sequence from 1- to 3-year-old set-aside, in a hump-shaped relationship (Gathmann et al., 1994; Greiler, 1994; Steffan-Dewenter and Tscharntke, 1997, 2001). The most striking pattern was the rapid change from annual vegetation in the first two years of succession to perennial vegetation from the third year onwards. These studies found that in intermediate succession, when annuals were still and perennials already present, species richness of flowering plants was as high as on old low-intensity orchard meadows. Abundance of parasitoids in 2-year-old successional fields, but not of 1-year old or 3-year old fields (Fig. 1), was higher than in crop and *Phacelia* fields, which does not support the hypothesis that the impact of biological control continuously increases with age of succession (Southwood, 1988). These results provide evidence that even young stages of set-aside can serve as significant reservoirs of parasitoids that potentially play a role as biocontrol agents of many plant-feeding insects.