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Being efficient and green by rethinking the urban-rural divide—Combining urban expansion and food production by integrating an ecosystem service perspective into urban planning

Åsa Gren[a,*], Erik Andersson[b]

[a] The Beijer Institute of Ecological Economics, The Royal Swedish Academy of Sciences, Lilla Frescativägen 4a, 104 05, Stockholm, Sweden
[b] Stockholm Resilience Centre, Stockholm University, Sweden

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ABSTRACT

A pressing issue for mankind is how to combine urban expansion and food production for present and future generations. Using a case study example –the Stockholm County in Sweden- we illustrate how incorporating an ecosystem service perspective into urban planning may help us rethink the urban-rural divide in order to facilitate a sustainable development of the urban agricultural landscape of Stockholm. In our case study we show that semi-natural pollinator habitats will be 12 times as affected by the planned urban expansion than farmland. Hence, the fate and management of semi-natural pollinator habitats need to be prioritized at least as much as saving productive areas for farming in the urban expansion process. We also show that urban green areas, through their potential to act as semi-natural habitats, provide a tangible link between the pollination service and the urban planning process, contributing to a better grounding of the urban expansion in an ecosystem service reality. Also, acknowledging that land use types typically classified as "urban", such as urban green areas, can ecologically support many "rural" ecosystem services, like pollination and food production, contributes to overcoming the, often unconstructive, urban-rural divide.

We conclude that beneath the apparent direct trade-offs between finding suitable land for urban expansion and preserving land for food production, there is potential for compromises, opportunities and synergies.

1. Introduction

The world is experiencing urbanisation at a rate unprecedented on the planet. The proportion of people living in urban areas is projected to increase to 70% by 2050, which means an additional 2.5 billion urbanites on the planet in the next 35 years (United Nations, 2014) and that 60% of the land that will be urban in 2030 has yet to be built (Elmqvist et al., 2013). At the same time, another global issue is how not to undermine the capacity of Earth to provide food for present and future generations (FAO, 2016; Rockström et al., 2009). In many parts of the world, urban expansion has taken place almost exclusively at the expense of farmland (see e.g. Munton, 2009; Russell, 2006). So, how do we combine urban expansion and food production? Although this offers an enormous challenge, it also provides a great opportunity to shift the development of cities towards a more sustainable and regionally embedded path (see Elmqvist et al., 2013). Beneath the apparent direct trade-offs between finding suitable land for projected urban development and preserving agricultural land (e.g. EEA, 2006; KSLAT, 2012; Seto, Güneralp, & Hutyra, 2012), there is potential for compromises, opportunities and synergies. The impact of future expansion of cities on agricultural production is, in part, a question of cross-land use linkages. For example, the homogenization of agricultural landscapes has reduced the extent of semi-natural, non-crop habitats (Tilman, Cassman, Matson, Naylor, & Polasky, 2001). These types of habitats are of great value for pollinators, seed dispersers and pest control agents, as nesting locations and additional food sources. Presence of pollinators, such as bees, birds and bats, have a strong effect on 35% of the world's crop production, e.g. by increasing outputs of 87 of the leading food crops (FAO, 2017). Several studies have shown how pollinator densities and the pollination service itself varies with both the distance to and the amount of semi-natural grasslands (Kremen, Williams, Bugg, Fay, & Thorp, 2004; Öckinger & Smith, 2006; Steffan-Dewenter, Münzenberg, Bürger, Thiers, & Tschrntke, 2002). The long- term stability of pollination has been shown to be related to both increased proportional area of semi-natural land (Kremen et al., 2004) and the presence of mass flowering crops (Thom, Eberle, Forcella, & Lundgren, 2016; Westphal, Steffan-Dewenter, & Tscharntke, 2013). Also, effective pollination often depends on the interspersion or juxtaposition of agricultural fields with

* Corresponding author.
E-mail address: asa.gren@beijer.kva.se (Å. Gren).

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pollinator nesting habitats (Kremen, Williams, & Thorp, 2002; Tscharntke & Kruess, 1999).

Landscape restoration needs to be revisited − new circumstances need new strategies for strengthening the pollination potential in our production landscapes. Can urbanisation have something to offer? Resent research indeed show that cities can provide refuge for pollinators, presenting evidence that the biological value and ecological importance of cities, e.g. in the context of abundance and diversity of native bee species in urban landscapes that are absent in nearby rural lands, have implications for biodiversity conservation (Hall et al., 2016).

Studies have shown that many urban green areas, such as allotment gardens and private urban gardens, provide excellent pollinator habitats and so can be important source areas for pollinators in the surrounding landscape (Andersson, Barthel, & Ahrné, 2007; Ahrné, Bengtsson & Elmqvist, 2009). Certain kinds of urbanisation, if located close to crop fields, could thus potentially bring back some of the lost qualities to agricultural landscapes by reinforcing the ecological interactions needed for some types of food production (see e.g. Andersson et al., 2007; Ahrné et al., 2009; Baldock et al., 2015; Niemelä 2014).

In general, an ecosystem service (ES) approach can inform and guide strategic planning e.g. by identifying the spatial and temporal scales of operation of different services and benefits (Jansson & Polasky, 2012) and how they relate to administrative boundaries (Ernstson, Barthel, Andersson, & Borgström, 2010). Furthermore, the implicit need to assess multiple scales simultaneously (Carpenter et al., 2009) emphasize the need for collaboration and alignment of planning processes taking place at different scales in society (Ernstson et al., 2010). Incorporating ES into urban planning can hence potentially contribute to mitigating the negative effects of urban expansion and maybe even provide opportunities for strengthening the production capacity of the urban agricultural landscape.

1.1. The Stockholm County case

In its long-term strategy for a sustainable and competitive Swedish food system, the Swedish government expresses an expectation that the food production potential in the country will increase (Swedish government, 2016). This expectation is partly founded on predictions of temperature increase and precipitation patterns, which may indeed support increased crop production in Scandinavia (IPCC, 2007), and the maintenance and effective use of agricultural land. However, the area of farmland in Sweden has over a long period of time been decreasing. Between 1995 and 2015 it decreased by 6.3% and it has been predicted that the production will be reduced by 35% by 2030, if this trend holds (SOU, 2014). Farmland in Sweden appropriates about 7% of the total land area, while the average within the EU is above 40% (Swedish government, 2016). Hence, although Sweden's strategy for a sustainable and competitive food system heavily relies on more effective production systems, Sweden will, most likely, also have to use more lands area for farming purposes than at present.

At the same time, Sweden is committed to building houses at an unprecedented rate. Out of a total of 700 000 homes to be built in Sweden, in the near future (Boverket, 2016), over 300 000 are to be built in the Stockholm area alone 2030 (SLL, 2016). Stockholm County, with over 2 million inhabitants, generates one-third of the economic growth of Sweden. The county covers about 6500 km^2 and it has comparatively large agricultural and forest sectors (845 km^2 arable land, 112 km^2 pasture and 360 km^2 forest land (SCB, 2015)). The current use of land for agriculture in the Stockholm County is thus about 13% at present, which, although more than the Swedish average of about 7%, is still far from the average of 40% in the EU. The population is expected to increase by 17% between 2014 and 2024 (RUFS, 2015), the spatial consequences of this growth have been projected in the Regional Urban Development Plan (RUDP)(RUFS, 2010).

We will use the Stockholm County case to illustrate how an ES perspective may influence how we think about, and plan, the urban-rural interface to better support food production in the city region and meet the demand for urban expansion. Although such a perspective ultimately covers multiple ES, the case here is to serve as an illustration of applied general theory, rather than an in-depth, stand-alone case study. Therefore the ES in focus here is pollination, since this service, beyond its relevance for food production, also serves to functionally bridge the often-perceived divide between the urban and the rural (cf. Lundberg & Moberg, 2003). About 45% of the crops grown in the Stockholm County require or are enhanced through pollination (SCB, 2015). Much of the pollination in the Stockholm region, within the agricultural- as well as the forest landscape, is still provided by wild pollinators, most importantly wild bees (Hymenoptera, Apidae, *Bombus* spp.) (Pettersson, Cederberg, & Nilsson, 2004), although many of these are declining (Linkowski, Cederberg, & Nilsson, 2004). The pollinators that provide the majority of the pollination service within this group, at present, are short- tongued generalist bumblebees (Linkowski et al., 2004; Steffan-Dewenter et al., 2002; Walter-Hellvig & Frankl, 2000).

More specifically, we will use the Stockholm County case to address the question "how can we combine urban expansion and food production?". This we do, *firstly*, by quantifying the percentage of the planned urban expansion, through the RUDP, that will affect farmland and semi-natural areas. This information provides a proxy for predicting the impact of urbanisation on future direct food production potential via the planned areal transformation of farmland to urban land, as well as the pollination potential of the urban agricultural landscape via the planned transformation of semi-natural areas to urban land. *Secondly*, we will quantify the percentage of semi-natural areas close to farmland that will be affected by the urban expansion. This information provides a proxy for predicting the effective impact on the pollination potential of the urban expansion, since there is a limit to how far away pollinators can live from a crop in order to effectively perform the pollination service. *Thirdly*, we will complement estimate in the first task with field assessments of pollinator habitats in the Stockholm County, using three different landscape types: urban, peri-urban and rural. Through the addition of local scale inventories we try to compensate for the fact that regional land use classifications of Stockholm County are crude in their representation of pollinator needs. *Finally*, we will discussing the results in the context of rethinking urban planning and the urban-rural interface using an ES perspective.

2. Materials and methods

2.1. Quantifying the amount of farmland and semi-natural areas affected by urban expansion

To capture the order of magnitude of the RUDP expansion on the different land use classes, we quantified the percentage of farmland and different types of semi-natural areas that will be affected by the future urban development plan of Stockholm to 2030. We used a more inclusive interpretation of semi-natural habitats, expanding on the most commonly used ones − hedgerows, woodland and grassland (Holland et al., 2017) –, to also capture the potential of urban green areas to act as semi-natural habitats, hence including the following classes: discontinuous urban fabric with more than 200 inhabitants and major areas of gardens and greenery, discontinuous urban fabric with less than 200 inhabitants, urban green areas, solitary houses with property, road and rail networks and associated land, airfields, golf courses, non-urban parks, camping sites and holiday cottage sites and pastures (Colding & Folke, 2009; Jansson & Polasky 2010). We used ArcMAP GIS (version10.0) and an overlay function to assess how much of the different land use classes that potentially will be affected by the regional urban development plan for Stockholm County by 2030 (RUDP)(RUFS, 2010). The analysis was based on GDS-Marktäckedata (25 m pixels; resolution 1–25 ha; classification: artificial areas, agricultural land, forests and natural areas, wetlands and water), a Swedish land-cover