Estimation of a sunflower pollination buffer

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http://pollolegi.eu

Introduction

Sunflower is the most important oilseed crop in Castilla y León and other Spanish regions. This crop is highly dependent on insect pollination, having a direct impact on yields. In some areas of Spain, the highly fragmented landscape without natural green infrastructure (GI) poses a significant barrier to the pollination ecosystem service. Quantification of the efficacy of natural green infrastructure on pollination efficiency will help inform policy and land use decisions.

There are key, unanswer questions about the influence of existing natural green infrastructures: **to what spatial extent do these landscape structures have an influence on pollination-dependent crops? And, what is the economic benefit of this ecosystem service owing to landscape structure?** In this study, we make a first attempt to answering such questions in a quantitative manner, using field data from 10 experimental plots.

Methodology

Fields and sunflowers

In 2017, ten sunflower fields adjacent to two different landscape structures - with (NGI) and without (NON) natural green infrastructure - were monitored in 5 different municipalities in the province of Burgos, Spain (one field of each type per municipality). In each field, the proportion of viable seed development was assessed on eight sunflower heads at four distances from field edge: 0, 15, 30, and 60 m. The effects of distance and landscape structure on seed set were evaluated and quantified in a mixed model, with plot type (NGI or NON) and distance as fixed factors, and zone and plot as random factors. Data were power-transformed, and interpretation was subsequently made on the original scale (untransformed). Following estimation of maximum pollination rate (78% viable seeds at 0 meters from NGI) and minimum pollination rate (66% at 60 meters inside a NON plot), the effect distance was calculated by simple algeba by solving for *x* (meters; see Equation 1), resulting in a buffer distance of 138.82 meters.

Spatial modeling of a pollination buffer

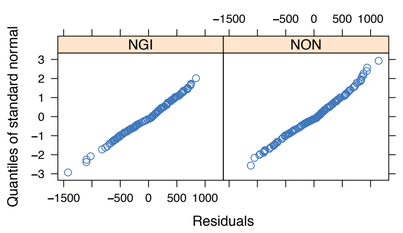
Spatial analysis was done in qGIS. This analysis, conducted on one study municipality, utilized SIGPAC parcel polygons and the 2017 landcover raster from the Castile and Leon crops and natural land map project (http://mcsncyl.itacyl.es/) to establish natural areas and sunflower crops. The 138 m buffer was established around natural areas, and the areas of sunflower crops falling inside and outside of the buffer were calculated. To calculate the economic value of the pollination service, we used the average yields for the Burgos provice for 2016 (MAPAMA), and grain price was set at the 2017 market price.

Figure: *The pollination buffer calculated over the Villafruela study zone.*

Model estimates and calculations (transformed data)			
Estimate	Value	Std. Error	p-value
Intercept	1447.2	52.6	0.000
Distance	-3.0	1.1	0.006
NGI	221.1	48.7	0.000

Equation 1

$$66.81 = -0.085 * x + 78.61$$



Results and discussion

The effect of natural green infrastructure on pollination was significant, on average 6% greater in NGI plots. Distance from field edge significantly negatively affected pollination at an estimated rate of approximately -0.085% per meter. When assuming that all area within the projected buffer results in a 6% increase, it is estimated that the proximity of 137 Ha of sunflower fields to natural landscape structures increased economic gains in that particular locality by € 3,128 in 2017. On the other hand, 85 Ha of sunflower fields were not covered by the estimated buffer; had these fields been closer to green infrastructure, gains might have been increased by another € 2,072.

	Ha	Kg Ha^{-1}	Euros Kg^{-1}	Income (€)	Pollination benefit (€)	Pollination opportunity cost (€)
In buffer	137.05	1120	0.36	55,259	3,128	NA
Not in buffer	85.64	1120	0.36	34,530	NA	2,072

The modeling exercise shows that it may be beneficial for farmers to take landscape structure into account when planning where to plant pollination-dependent oilseed crops. Also, benefits may be increased by implementing “rural GI” such as flower patches, whereas implementation costs would be offset by the estimated productivity gains.

Rural green infrastructure promoting pollination