



Bridging the research implementation gap – Identifying cost-effective protection measures for Montagu's harrier nests in Spanish farmlands



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ABSTRACT

Expensive active management programs are increasing worldwide, while resources for conservation remain scarce. There is a need to evaluate management actions, so that scarce resources are used more cost-effectively. We evaluate the effectiveness of alternative protection measures for Montagu's harrier nests in Spanish farmlands. The species is focus of extensive protection measures across Europe owing to high rates of nest destruction during mechanical harvesting operations. We use a novel approach, combining Latin hypercube sampling and population viability analysis in order to explore the impact of alternative protection measures on populations' persistence across a whole range of resource allocation scenarios. We also report estimates of financial costs for different protection measures. Our results show that, in absence of nest protection, Spanish harrier populations would most likely decrease during the next 20 years. The most cost-effective protection measures, among those evaluated, were the relocation or removal of the chicks and harvest delay, although this varied according to region and context. Interestingly, retention of a small un-harvested buffer around the nest, despite being widely implemented across Spain, was less cost-effective than the other two protection measures. Overall, the cost-effectiveness of each protection measure varied widely by region and by local agronomic context. We ultimately explore what proportion of nests could be protected with the most effective measure in each studied region, and estimate how much this effort would cost to local administrations. This is a clear example of conservation science producing outcomes relevant to action.

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1. Introduction

Evaluating the effectiveness of conservation measures is crucial because resources to tackle the current biodiversity crisis are insufficient (Ferraro and Pattanayak, 2006; McCarthy et al., 2012). Knowing which measure provides the best outcome at the lowest cost is fundamental in order to take appropriate evidence-based decisions (Sutherland et al., 2004). Despite their immense importance, evaluations of effectiveness are still insufficiently undertaken in conservation (Ferraro and Pattanayak, 2006). As a consequence, the field of conservation biology lags far behind other disciplines, like medical science, which develops through the practice of systematic review of the evidence (Sutherland et al., 2004).

Throughout Europe, traditional farm management practices have created and shaped novel agricultural landscapes over recent millennia. A community of open grassland taxa has progressively adapted and expanded into these new habitats (Tucker and Evans, 1997). This community is now under severe threats due to the recent intensification of agricultural practices (Donald et al., 2001). Such intensification is mostly achieved through increased mechanization, use of new crop varieties, and widespread use of inorganic inputs aimed at increasing production (Pain and Pienkowski, 1997).

Ground-nesting birds breeding in intensive farmland may be particularly impacted by harvesting operations which cause nest destruction, and active management schemes are necessary to address this problem (Gruebler et al., 2012). One of such actively managed species is the Montagu's harrier (*Circus pygargus*), a ground-nesting raptor that nowadays mostly breeds in cropland across Europe (Arroyo et al., 2003). In western Europe, an average of 60% of nestlings of this species are unfledged at harvest time,

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thus being at high risk of being killed by mechanical harvesting in absence of nest protection measures. Such losses would have strong detrimental consequences at the population level (Arroyo et al., 2002). Different protection measures to reduce nestling loss have been adopted since the late 20th century in many Western European countries including Spain (Arroyo et al., 2003), which holds ca. 25% of the European population of the species excluding Russia (Arroyo and García, 2007).

To date, a thorough assessment of the effectiveness, relative to the costs, of adopted protection measures is still lacking. It is therefore timely and relevant to fill this gap. Such assessment is critically needed, particularly in light of conservation resource cuts under current economic crisis in Europe, whereas conservation needs steadily increase.

In this study, we evaluate the effectiveness of different measures to protect Montagu's harrier nests from destruction due to mechanical harvesting in Spain. Specifically, we compare productivity at nests under three protection measures (nestlings' relocation or temporary removal during harvest; harvest delay following negotiation with farmers; retention of an un-harvested buffer around the nest) with that of unprotected nests. We also test for an interaction between protection measure and the harvest-laying date difference, in order to assess whether the relative effect of certain protection measures on productivity varied according to when harvest occurs in relation to the harriers' breeding cycle. We hypothesize that buffers, which remain rather conspicuous after harvest, could be less effective than harvest delay when harvest occurs very early in the breeding cycle. Alternatively, if harvest occurs close to fledging time, we would expect the two protection measures to be similarly effective. We then quantify the costs of each protection measure and use them to present a cost-effectiveness analysis for the alternative protection measures. Finally, we use Latin hypercube sampling in combination with population viability analysis (PVA) to explore the effectiveness of protection

measures along a continuous gradient of resource allocation scenarios at the regional scale. Latin hypercube sampling is a method that allows to randomly sample values so as to cover the entire parameter space within a realistic range of values (Iman et al., 1981). In population demography, this method has been so far used only for sensitivity analyses (e.g. Fordham et al., 2012), while we here explicitly incorporate it into a PVA process.

2. Methods

2.1. Study areas

The study was conducted in Spain, within the regions of Andalusia, Aragon, Catalunya, Extremadura and Madrid (Fig. 1).

The Montagu's harrier is a common breeder throughout Andalusia, Extremadura and Madrid (Arroyo and García, 2007), where over 95% of the nests are in cereal fields. In Aragon and Catalunya, the breeding distribution is less homogeneous, and more than 25% of birds breed in natural vegetation (Arroyo and García, 2007). Only data from birds breeding in farmland are included in this study. In Catalunya, data are limited to one province (Lleida); here, an important proportion of birds breed in irrigated cereal and fodder crops since 2005, in addition to dry cereal (Catalan Wildlife Service unpubl. data).

Within these regions, study sites were selected opportunistically, based on the availability of information (see below and Table S1). The average size of each site was highly variable, from ca. 200 km² to more than 2000 km².

2.2. Adopted protection measures

The adopted protection measures for Montagu's harrier nests were: (1) temporary removal of nestlings during harvesting and subsequent relocation to the same place, by building a nest-like structure with straw and other material; (2) nestlings' relocation



Fig. 1. Map with location of the ten study sites within five regions of Spain. Letters refer to codes indicated in Table S1.

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