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A Woodland Management Protocol for the Conservation of a Locally Endangered Raptor Breeding in Timber Plantations

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ABSTRACT.—Woodlands subjected to commercial exploitation can play an important role in the conservation of forest-dwelling birds, whether these species breed, forage, or spend all or part of their annual cycle in this habitat. Since 2016, the Administration of Gipuzkoa Province, Spain, has implemented a new protocol designed to preserve the nesting habitat of the Red Kite (*Milvus milvus*) population breeding within the region. This species is locally classified as endangered and therefore has conservation priority. The aim of our study was to evaluate the efficacy, demographic impact, and cost of this protocol. Over a period of 7 yr (2016–2022), implementation of the protocol preserved 23 nests (i.e., 15.2% of the total 151 nests). From these protected nests, 37 young fledged, which was 16% of all the young fledged within the region in this period. Relative to the financial cost of protecting nature in Gipuzkoa, implementation of this protocol was inexpensive, totalling <0.1% of the administration's budget for managing natural habitats within the province.

KEY WORDS: *biological conservation*; *Gipuzkoa*; *Monterey pine*; Pinus radiata; *sustainable forest exploitation*.

PROTOCOLO DE GESTIÓN FORESTAL PARA LA CONSERVACIÓN DE UN AVE RAPAZ LOCALMENTE EN PELIGRO DE EXTINCIÓN QUE SE REPRODUCE EN PLANTACIONES FORESTALES

RESUMEN.—Los bosques sometidos a explotación comercial pueden desempeñar un papel importante en la conservación de aves que habitan en ellos y se reproducen, forrajean o pasan todo o parte de su ciclo anual allí. Desde 2016, la Administración de la Provincia de Gipuzkoa, España, ha diseñado e implementado un nuevo protocolo con el fin de preservar el hábitat de nidificación de la población de *Milvus milvus* que se reproduce en la región, ya que esta especie está clasificada como localmente en peligro de extinción y, por lo tanto, tiene prioridad de conservación. El objetivo de nuestro estudio fue evaluar la eficacia, el impacto demográfico y el costo de este protocolo. Durante un período de siete años (2016–2022), la implementación del protocolo preservó 23 nidos (es decir, el 15.2% del total de 151 nidos). De estos nidos protegidos, 37 crías emplumaron, lo que representó el 16% de todas las crías emplumadas en la región en este período. En relación con el costo financiero de proteger la naturaleza en Gipuzkoa, la implementación de este protocolo fue económica, totalizando <0.1% del presupuesto del departamento para la gestión de hábitats naturales en la provincia.

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INTRODUCTION

Woodlands subjected to commercial exploitation can play an important role in the conservation of forest-dwelling birds, whether these species breed, forage, or spend all or part of their annual cycle in this habitat (Saurola and Björklund 2004, Zuberogoitia et al. 2006, García-Salgado et al. 2018, Rodríguez et al. 2021). This is particularly relevant in regions where a significant part of the woodlands are dedicated to such economic use, as is the case in vast areas throughout Europe (Zuberogoitia and Martínez 2011). From an ecological standpoint, proper management is crucial to make commercial exploitation of woodlands compatible with wildlife conservation (García-Dios and Viñuela 2000, Gibbons et al. 2002, Lõhmus 2005, Pasinelli 2007, Björklund et al. 2015).

Today, many forest-dwelling raptors worldwide nest in woodlands dedicated to commercial exploitation, with many of these being plantations of exotic tree species (Ferguson-Lees and Christie 2001, Zuberogoitia and Martínez 2011). In regions where significant parcels of the landscape are designated for such economic use, the majority of forest-dwelling raptor populations of the region may depend on managed woodland patches (e.g., Olano et al. 2016b). Effective protocols for making logging compatible with raptor conservation are critical for management of species of concern.

The Red Kite (*Milvus milvus*) is a medium-size raptor endemic to western Europe; it breeds in woodlands ranging from narrow riparian edges along small streams to large intact forests (Newton et al. 1996, Viñuela et al. 1999, Seoane et al. 2003), including exotic tree plantations (Olano et al. 2016b). Woodlands are used not only to nest but also to roost communally during the winter (Heredia et al. 1991, Sergio et al. 2005, Arizaga et al. 2022, García-Macía et al. 2022b, Panter et al. 2022); thus woodlands are also important outside of the breeding season. Populations vary from migratory to sedentary, with an increasing proportion of resident birds in the southern and western parts of their range (Carter 2007). In winter, Spain hosts approximately 50,000 individuals (Molina 2015), roughly 80% of the European population (BirdLife International 2021). Although the species has recovered relatively well overall (Tucker and Heath 2004) with increasing populations in many countries (BirdLife International 2021), populations are still declining in some regions, especially in southern Europe. For this reason the Red Kite has been classified as endangered on the Red List of Spanish birds (López-Jiménez 2021), and on the Spanish Catalogue of Species of Concern (Real Decreto 139/2011, referred as BOE-A-2011-3582; for details see www.boe.es). The main threats for the species' conservation in Spain include poisoning (Villafuerte et al. 1998, Tavecchia et al. 2012, Mateo-Tomás et al. 2020), collisions with power lines or electrocution (Viñuela et al. 1999, Crespo-Luengo et al. 2020), collisions with vehicles (Viñuela et al. 2021), illegal killing (Hiraldo et al. 1995, Viñuela et al. 1999, Balmori 2019), habitat loss and degradation (Viñuela et al. 1999, Mougeot et al. 2011, Sergio et al. 2019), predation (Seoane et al. 2003, Sergio et al. 2019), decreasing food availability (Mougeot et al. 2011, Blanco et al. 2017, Pitarch et al. 2017), and climate change (Seoane et al. 2003, Sergio et al. 2019, Godino et al. 2020). Because the Red Kite is a priority species of concern, public agencies are required to take measures to guarantee its conservation and promote improvement of its habitat and, if possible, its population (Viñuela et al. 2021).

Since 2016, the Administration of Gipuzkoa Province, Spain (www.gipuzkoa.eus), has implemented a protocol designed to preserve the nesting habitat of the Red Kite population breeding within the region. This was done because of the species' conservation classification in Spain and because, in Gipuzkoa, it breeds mostly in private timber patches. Commercial logging, therefore, represents a real threat to the conservation of the Red Kite within this region. Compared to other nearby areas in Spain, the Red Kite population of Gipuzkoa is increasing and has an apparently favorable conservation status, as indicated by the high breeding site fidelity of adult territorial pairs and high recruitment rate due to small natal dispersal distances, low mortality, and high productivity (Olano et al. 2016a, 2022, Urios and García-Macía 2022). One of the most challenging issues for the conservation of the Red Kite in Gipuzkoa is the fact that the majority of the pairs breed in private exotic pine plantations (Olano et al. 2016b).

The aim of our study was to evaluate the efficacy, demographic impact, and cost of this protocol. Additionally, we documented rates of between-year nest switching (i.e., abandonment) at sites where the management protocol was implemented and at undisturbed forests (where no exploitation or logging occurred).

METHODS

Study Area. The province of Gipuzkoa (centroid: 43°06′N, 02°15′W) in northern Spain (Fig. 1) is a mountainous region with a significant amount of

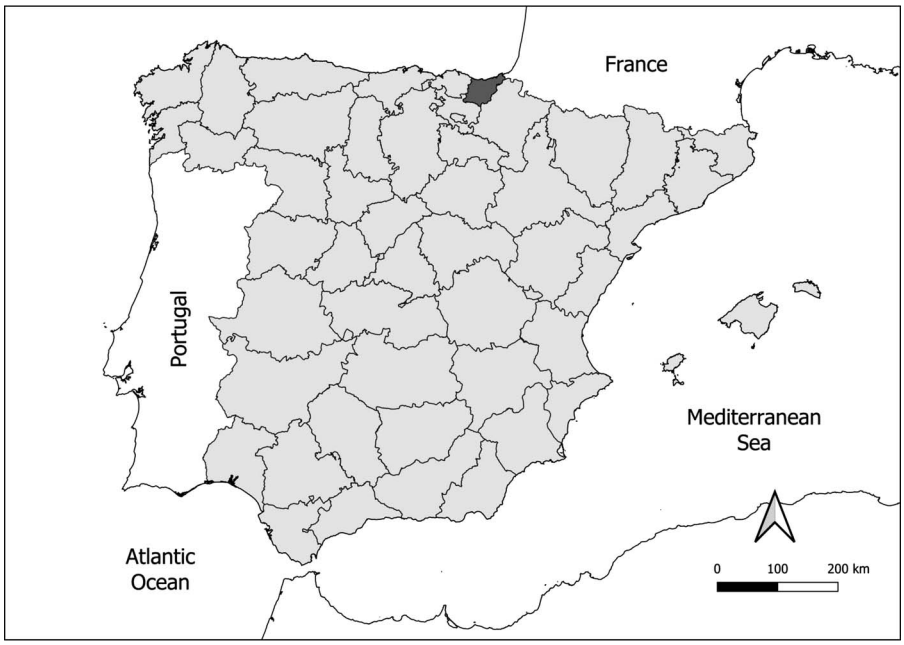

Figure 1. Location of the Gipuzkoa province in northern Spain (dark-grey shaded area); the rest of provinces of Spain are shown in pale grey.

forest exploitation (i.e., logging; Loidi et al. 2011). Of the province's approximately 2000 km^2, 61.5% is forest. The forested regions are about half conifers and half broad-leaved species, including some *Eucalyptus* plantations; 2020 Basque forest inventory, www.euskadi.eus). Today, the main, most important forest patches within the region are Monterey pine (*Pinus radiata*), an exotic North American species that was intensively planted during the second half of the 20th century (Rodríguez 2006); of these pine plantations, most (84%) are privately owned. Due to the intensification of commercial logging activities through the province, patches of native forest are small and scarce. Many raptors nest in commercial forest plantations, including Red Kites, Black Kites (*Milvus migrans*), Eurasian Goshawks (*Accipiter gentilis*), Eurasian Sparrowhawks (*A. nisus*), Booted Eagles (*Hieraaetus pennatus*), Eurasian Buzzards (*Buteo buteo*), and European Honey-Buzzards (*Pernis apivorus*; Aierbe et al. 2001). This nesting behavior increases the probability of human-wildlife conflict within the region. Due to the conservation challenge posed by this potential conflict, a protocol was established with the aim of protecting the nests of Red Kites in Gipuzkoa.

Pine Plantation Conservation Management Protocol. The protocol for Gipuzkoa evaluated here consists of the following procedures. (1) When a pine plantation owner wants to cut the plantation, they must send an application to the Gipuzkoa Regional Council (officially, Diputación Foral de Gipuzkoa). (2) The Council examines the application and uses data from the Red Kite survey (see Red Kite Surveys below) to determine if there is a Red Kite nest within the parcel. (3) If there is no nest, the cut is authorized. (4) If there is a nest, the cut is temporarily prohibited during the breeding period for Red Kites (from March to July). After August, the cut is authorized with the exception of a circular buffer around the nest (buffer contains the nearest 20 trees, the size of which equates to approximately 1000 m^2; i.e., 0.1 ha).

Monetary compensation to the plantation owner is calculated based on the following: (1) For limiting the cut to a period of the year when the logging is more difficult due to adverse weather conditions (from August to February): €1.50/m^3 of timber at 400 m^3 of timber/ha, depending on the volume of timber within the parcel. (2) For the uncut trees (up to a maximum of 20 trees): €40.00/m^3 of timber (2016 valuation), based on a volume of 1.5 m^3/tree (with valuation updated annually based on market value; valuation for 2023 was €80.00/m^3 of timber). (3) For not cutting the preserved parcel of 20 trees (maximum) during the next 5 yr: €200.00/ha/year.

Table 1. Number of occupied territories of breeding Red Kites in pine plantations in Gipuzkoa, Spain, where a conservation management protocol was implemented and trees were left undisturbed. Also shown is the compensation paid to the landowner, the number of young fledged from the nests, and the number of pairs that nested in the same pine patches one year later.

Year	No. Occupied Territories where Conservation Management Protocol Was Implemented	Compensation Paid to Landowner (€)	No. Young Fledged	No. of Pairs that Nested in the Same Pine Patches 1 yr Later
2016	2	6350	4	2
2017	2	4400	1	1
2018	0	—	—	—
2019	3	13427	8	1
2020	4	10250	3	3
2021	4	15400	8	4
2022	8	14811	13	

In this valuation, the minimum awarded is always for an area of 0.5 ha, even though the uncut stands typically occupy less land (~0.1 ha). Thus, for compensation for 1 ha, based on the 2016 valuation and retaining 20 trees without cutting for 5 yr, we obtain: (1 ha $\times$ 400 m^3/ha $\times$ €1.50/m^3) + (20 trees $\times$ 1.5 m^3 $\times$ €40.00/m^3) + (0.5 ha $\times$ 5 yr $\times$ €200.00/ha) = €2300.00. Compensation for implementation of the conservation management protocol expires after 5 yr, or sooner if the Red Kites leave the parcel.

Red Kite Surveys. For this protocol to be operate successfully, a team of forest rangers annually surveyed the Red Kite population of Gipuzkoa (Supplemental Material Fig. S1). In brief, the survey was used to detect as many breeding pairs as possible, by surveying for at least 5 hr per 5-km $\times$ 5-km (=25 km^2) plot. Surveys were conducted in March, which is during the kites' courtship period. After a pair was detected and the nest located, it was surveyed on a regular basis until the young fledged or the nest failed. For more details, see Olano et al. (2016a, 2022).

In Gipuzkoa, with approximately 2000 km^2 and a Red Kite population exceeding 40 pairs, the survey cost involves a team of approximately 12 people (in Gipuzkoa made up mainly of forest rangers employed by the department), working 5 h/wk/person, with the exception of one person who worked 25 h/wk from March to July to coordinate surveys and ensure coverage of all territories and nests.

For each breeding season, the forest rangers collected the following data: (1) number of territorial pairs, (2) number of these territorial pairs that build a nest, (3) number of successful nests (defined as a nest where at least one young fledged) and failed nests, and (4) number of fledged young per successful nest. We defined breeding success as the percentage of egg-laying pairs that fledged at least one young. We defined productivity as the number of fledglings per territorial pair (Olano et al. 2016a). Additionally, we determined which (presumed) pairs remained in the same breeding site from one year to the next and which ones moved to a new breeding site in the following year. These new breeding sites were often situated close to the previous one, due to high breeding site fidelity and relatively small home ranges (Urios and García-Macía 2022), and may represent an alternate nest location within the same territory or a new territory. In either case, we termed this "nest abandonment."

Statistical Analyses. We used a Pearson χ^2 test to compare whether the rate of between-year nest abandonment (kites leaving a forest patch to breed in another one in the next year) in pine patches where the conservation management protocol was implemented differed from that at undisturbed sites where the no cutting occurred and the protocol was not implemented. We used the software R (R Core Team 2023) for statistical analyses.

RESULTS

Overall, from 2016 to 2022, the conservation management protocol was implemented at 23 pine parcels with a nesting pair. The monetary compensation to landowners across the entire period was 64,638 €(range: 4400–15,400 €, $n = 7$ yr; Table 1). Because 37 young fledged from those 23 nests, the implementation of the protocol had a direct mean cost of 1746 €/young.

In the entire Gipuzkoa Province (regardless of whether or not the conservation management protocol was implemented), the number of occupied

territories (pairs) increased from 18 in 2016 to 43 in 2022. In this same period, the number of pairs that built a nest increased from 15 in 2016 to 37 in 2022; thus, 78% (range = 68–86%) of occupying pairs built a nest. Across this study period, pairs at 117 out of 151 nests successfully fledged at least one young, giving rise to an annual mean breeding success of 76.4% (range: 53.8–86.6%). The number of young fledged during this period was 233 and the mean annual productivity was 1.2 young per territorial pair (range: 0.94–1.41 young per territorial pair).

Thirty-seven young were produced in nests that were protected due to implementation of the conservation management protocol, which was 16% of the total number of young fledged during the entire study. Without the intervention, therefore, the local productivity would likely have declined to a mean of 1.0 young per territorial pair ($1.2 - [1.2 \times 0.16]$).

Although the pairs are rather faithful to their breeding sites, nest abandonments from one year to the next were not exceptional ($n = 15$ pairs, out of 114 pairs). Between-year nest abandonment in pine patches where the protocol was implemented was 26.6%, compared to 11% in pine plantations where there was no intervention ($\chi^2 = 1.926$, df = 1, $P = 0.236$).

Apparent proximal causes of nest abandonment ($n = 9$) were: competition with other species (Black Kites, three nests; Common Ravens [*Corvus corax*], two nests; Booted Eagles, one nest); and anthropogenic disturbances, three nests. Prior to egg-laying, competition with other species for nest platforms was especially present in old pine patches with large nests where Red Kites had been breeding for several years.

DISCUSSION

Active raptor conservation often requires intervention from public-private agreements in order to preserve the most important habitat patches, such as in the case of the Red Kite, which nests in pine plantations in our study area (Olano et al. 2016b). To the best of our knowledge, this is the first case in Spain in which a management protocol designed to conserve the nesting habitat of a locally endangered forest-dwelling raptor has been described and evaluated. Regulations limiting woodland exploitation were invoked in a nearby area to avoid disturbance of cliff-nesting raptors, but not forest-dwelling raptors (Zuberogoitia et al. 2021).

In the particular case of Gipuzkoa, the public-private agreements are important because most of the native forests (76%) and pine plantations (84%) within the region are privately owned (Basque Government 2021). This reality underscores the need for collaboration with private landowners, including agreements and compensation, for habitat management within the region. Although this is challenging, as it often demands great efforts to negotiate, this collaboration also offers an opportunity to promote a society more involved in the conservation of its natural heritage.

During a period of 7 yr, implementation of the protocol saved 23 nests (15% of the total nests) and 37 young (16% of all young fledged in the region). The cost of this implementation, in terms of economic compensation to pine plantation owners, made up 0.068% of the budget (€95,604,200 for the period 2016–2022) of the Department of the Gipuzkoa administration with the responsibility of protecting nature and managing the natural habitat (www.gipuzkoa.eus). Thus with a relatively small financial investment, it was possible to implement a conservation measure that allowed maintenance or even growth of the Red Kite population within the region (Olano et al. 2022). For this protocol to be effective, however, it is mandatory to invest human resources (and thus salaries) prior to intervention, because managers need to know nest locations and these locations must be updated annually.

Although the protocol seemed effective, its implementation may have affected breeding site fidelity (García-Dios and Viñuela 2000). For example, among Booted Eagles breeding in places with forest management activities near nests, nest abandonment was 54.5%, compared to 10.8% in undisturbed patches (García-Dios and Viñuela 2000). The between-year nest abandonment in Gipuzkoa did not differ between sites where the protocol was implemented and undisturbed sites; however the statistical comparison may have been hindered by small sample size. We recommend future analyses with larger sample sizes. Considering larger buffers around nests could also be helpful to evaluate how this assumption affects estimated breeding site fidelity.

Beyond implementation of this protocol, conservation efforts for the Red Kite in Gipuzkoa should also consider the landscape/habitats used for foraging and outside the breeding season by this resident species (Arizaga et al. 2022, García-Macía et al. 2022a, García-Macía et al. 2022b, Urios and García-Macía 2022), as the quality of these areas also affects breeding performance and survival. We also note that this protocol, either as presented here or modified, could also be used to protect other raptors, either forest-dwellers (e.g., Booted Eagles,

goshawks) or those associated with open landscapes (e.g., harriers).

SUPPLEMENTAL MATERIAL (available online). Figure S1: Schedule of the protocol used in Gipuzkoa to protect the nesting habitat of the Red Kite.

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