Conservation Biology

Contributed Paper

Offsets and Conservation of the Species of the EU Habitats and Birds Directives

BAPTISTE REGNERY, DENIS COUVET, AND CHRISTIAN KERBIRIOU

Muséum National d'Histoire Naturelle, UMR 7204, Conservation des Espèces, Restauration et Suivi des Populations, 55 Rue Buffon, 75005 Paris, France, email regnery@mnhn.fr

Abstract: *Biodiversity offsets are intended to achieve no net loss of biodiversity due to economic and human development. A variety of biodiversity components are addressed by offset policies. It is required that loss of protected species due to development be offset under the EU Habitats and Birds Directives in Europe. We call this type of offset a species-equality offset because the offset pertains to the same species affected by the development project. Whether species equality can be achieved by offset design is unknown. We addressed this gap by reviewing derogation files (i.e., specific files that describe mitigation measures to ensure no net loss under the EU Habitats and Birds Directives) from 85 development projects in France (2009–2010). We collected information on type of effect (reversible vs. irreversible) and characteristics of affected and offset sites (i.e., types of species, total area). We analyzed how the type of effect and the affected-site characteristics influenced the occurrence of offset measures. The proportion of species targeted by offset measures (i.e., offset species) increased with the irreversibility of the effect of development and the conservation status of the species affected by development (i.e., affected species). Not all effects on endangered species (International Union for Conservation of Nature Red List) were offset; on average, 82% of affected species would be offset. Twenty-six percent of species of least concern were offset species. Thirty-five percent of development projects considered all affected species in their offset measures. Species richness was much lower in offset sites than in developed sites even after offset proposals. For developed areas where species richness was relatively high before development, species richness at offset sites was 5–10 times lower. The species-equality principle appears to have been applied only partially in offset policies, as in the EU directives. We suggest the application of this principle through offsets is highly important for the long-term conservation of biodiversity in Europe.*

Keywords: conservation status, offset policies, biodiversity offset, species equality

Compensaciones y Conservación de las Especies de las Directivas de Hábitats y Aves de la UE

Resumen: *Las compensaciones de biodiversidad tienen la intención de alcanzar la no-pérdida neta de la biodiversidad debido al desarrollo humano y económico. Una variedad de componentes de la biodiversidad están señalados por políticas de compensación. Se requiere que la pérdida de especies protegidas debido al desarrollo sea compensada bajo las Directivas de Hábitats y Aves de la Unión Europea. Llamamos a este tipo de compensación una compensación de igualdad de especies porque pertenece a las mismas especies afectadas por el proyecto de desarrollo. Se desconoce si la igualdad de especies se puede obtener mediante el diseño de compensaciones. Nos dirigimos a este vacío al revisar archivos de derogación (p. ej.: archivos específicos que describen las medidas de mitigación para asegurar la no-pérdida bajo las Directivas de Hábitats y Aves de la UE) de 85 proyectos de desarrollo en Francia (2009–2010). Colectamos información sobre el tipo de efecto (reversible vs. irreversible) y sobre las características de los sitios afectados y de compensación (p. ej.: tipos de especies, área total). Analizamos como el tipo de efecto y las características del sitio afectado influenciaron la ocurrencia de las medidas de compensación. La proporción de especies enfocadas por las medidas de compensación (p. ej.: especies afectadas). No todos los efectos sobre las especies en peligro (Lista Roja de la Unión Internacional para la Conservación de la Naturaleza) fueron compensaciones; en promedio el 82% de las especies afectadas serían compensaciones. El 26% de las especies de menor preocupación fueron especies de compensación. El 35% de los proyectos de desarrollo consideraban a todas las especies afectadas*

Paper submitted May 23, 2012; revised manuscript accepted April 4, 2013.

Conservation Biology, Volume 00, No. 0, 1–9

DOI: 10.1111/cobi.12123

en sus medidas de compensación. La riqueza de especies fue mucho más baja en los sitios de compensación que en sitios desarrollados, aún después de las propuestas de compensación. Para las áreas desarrolladas donde la riqueza de especies fue relativamente alta antes del desarrollo, la riqueza de especies en sitios de compensación fue entre 5 – 10 veces más baja. El principio de igualdad de especies parece haber sido aplicado parcialmente en políticas de compensación, como en las directivas de la UE. Sugerimos que la aplicación de este principio a través de compensaciones es muy importante para la conservación a largo plazo de la biodiversidad en Europa.

Palabras Clave: compensación de biodiversidad, estado de conservación, igualdad de especies, políticas de compensación

Introduction

Habitat destruction and transformation of land through development (e.g., roads, commercial centers, sandpits) is currently one of the greatest threats to biodiversity (Balmford & Bond 2005), and this threat is likely to continue (Giam et al. 2010). In addition to habitat loss, development leads to the fragmentation of species' habitats, land-use changes, and pollution (Davenport & Davenport 2006; Quintero & Mathur 2011). However, there are strong political and economic pressures to build new development projects (MEA 2005; World Bank 2007; Quintero & Mathur 2011).

To limit the negative effects of project development on biodiversity, many countries consider biodiversity offsets in the context of the mitigation hierarchy (Fox & Nino-Murcia 2005; McKenney & Kiesecker 2010; BBOP 2012). This hierarchy includes a 4-step procedure. First, avoid effects of development on biodiversity (e.g., avoid development in areas where threatened species occur). Second, reduce the size of the affected area or reduce fragmentation of native vegetation (e.g., through the construction of wildlife crossings). Third, conduct on-site restoration or rehabilitation to correct the effects of the project (e.g., restoration of a sandpit after development). Fourth, implement offset measures to compensate for residual effects (i.e., effects that could not be suppressed by the first 3 steps). Mitigation hierarchy (avoiding, reducing, restoring, and offsetting effects) is intended to achieve a no net loss of biodiversity or a net environmental benefit, and both of these require a so-called ecological equivalence between biodiversity losses (i.e., residual effects) and biodiversity gains through offset measures implemented outside the development site (Quétier & Lavorel 2011). Offsets are supposed to generate gains in biodiversity through management measures (e.g., restoration or creation of habitat on offset sites) (Maron et al. 2012). Measures to reduce the negative effect of other anthropogenic pressures on offset sites are also considered. For example, land acquisition and the legal protection of areas to reduce certain threats (e.g., disturbance from tourists or intensive agriculture) are considered.

Assessing ecological equivalence requires comparing biodiversity losses and gains on affected and offset sites. To do this, offsets often aim to compensate for the same types of biodiversity found in the affected sites in terms of species, habitats, and ecosystem functions (BBOP 2012). When the types of biodiversity are the same between affected and offset sites, biodiversity offset is termed "in-kind" or "like for like" (Hayes & Morrison-Saunders 2007; McKenney & Kiesecker 2010; BBOP 2012). This type of offset is highly accepted in the development of offset policy frameworks, especially for conserving protected species. Examples include the U.S. Endangered Species Act (since 1973) (Fox & Nino-Murcia 2005), the management policy of fish habitats in Canada (since 1986) (Harper & Quigley 2005), and the Australian Environment Protection and Biodiversity Conservation Act (since 1999) (Australian Government 2007). In the European Union, offsets to protect species are strictly regulated by the EU Habitats and Birds Directives (EEC 1992, 2009 [articles 16 and 9, respectively]), which are the most influential policy frameworks in European nature conservation (Fontaine et al. 2007). All these policies assume effective species-by-species offsets that we call species equality (i.e., the species affected by development projects are affected by offset projects). Species equality is a key step in the goal of no net loss of biodiversity. However, the achievement of species equality in offset design remains poorly known, especially in Europe.

We explored how the principle of species equality is enforced in France, an EU member, under the EU Habitats and Birds Directives. We investigated how many development projects in France included offsets and upheld species-equality principles; the factors that most affected the achievement of species equality; and the relation between richness of affected species and richness of offset species (i.e., species targeted by offset measures).

Methods

Species Protection Status and the European Legal Framework

Species protection in Europe is based on the EU Habitats Directive and the EU Birds Directive. Over 900 animal and plant species are protected under Annex IV of the EU Habitats Directive 92/43/EEC (EEC 1992), and all wild birds are protected under Article 1 of the EU Birds Directive 2009/147/EC (codified version of

Table 1. Information extracted from the derogation files of the 85 development projects.

Criteria	*Description*	*Variable*
Type of project	transport (e.g., road, railway), commercial (e.g., shop, shopping center), housing, sandpit, waste landfill, tourism (e.g., tourist park, ski trail), other (e.g., water project, maintenance of electric lines)	category of project
Type of effect	duration of the effects	reversible or irreversible
Affected site	species present at the affected site	name of species
	taxonomic group of affected species	plant, insect, mammal, amphibian, reptile, bird
	French Red List of affected species	
	legal protection status of the affected species	Annexes of EU Birds (I) and Habitats Directives (IV, II, II*—species of "priority interest")
	affected area	total affected area
Offset site(s)	affected species targeted but not present on the offset site(s)	name of species
	affected species targeted and present on the offset site(s)	name of species
	other species targeted by offset measures but not affected by development project	yes or no
	offset area	total offset area

Directive 79/409/EEC as amended) (EEC 2009). The protection of these species prohibits the destruction or alteration of their habitats and aims to maintain or restore a favorable conservation status to these species (EEC 1992, 2009). When developers cannot avoid negatively affecting a species (considering the economic and social issues of development projects), strict protection may be bypassed through derogations under articles 16 and 9 of EU Habitats and Birds Directives. According to these articles, development projects are allowed under the condition that they do not detrimentally affect the maintenance of a favorable conservation status of the populations of the species concerned (EEC 1992, 2009). To achieve these objectives, European countries must achieve species equality to demonstrate that derogations are "neutral or positive for a species" (EC 2007). This requirement drives the need to provide effective avoidance, reduction, on-site restoration, and offset measures (EC 2007).

The protection of species listed in EU directives applies to all European countries. Furthermore, in many European countries, the initial lists of protected species were defined prior to the application of the Habitats Directive (1992); hence, the national protected species lists often contain species in addition to those listed in the Habitats Directive (mostly endemic species and species in decline at a national scale). In France, the derogations in the EU directives are included in the Ministerial decree of 19 February 2007, and they apply to all protected species, irrespective of the protection extent.

Development Projects

We reviewed the derogation files of 85 development projects (e.g., roads, sandpits, commercial centers). Each file related to the derogation of strict species protection under the EU Habitats and Birds Directives. They contained impact assessments and accounts of measures taken to mitigate residual effects on protected species (see Supporting Information for details about the content of derogation files). We selected the most recent files available at the French Ministry of Ecology. They included 73 files transmitted in 2010 and the last 12 files transmitted in 2009. The files from 2010 represented 95% of the annual derogation files. We could not analyze other 2010 derogation files because they were still being evaluated by the Ministry or were being litigated.

There were 7 types of projects and 2 types of effects with regard to duration of the project (Table 1). Reversible effects corresponded to projects with operating times of <30 years that could be ecologically restored after operation (e.g., sandpits, landfill sites, hydraulic maintenance operations). Irreversible effects were associated with projects that had operating times >30 years or that could not be restored (e.g., road construction, shopping centers).

In total, 253 species were affected by all development projects: 161 were protected at continental and national extents (i.e., species listed in Annex IV of the EU Habitats Directive, species listed in the EU Birds Directive) and 92 were protected nationally.

Evaluation Criteria of Offset Proposals

We assessed offset proposals from technical and biological criteria contained in the derogation files (Table 1). To examine the use of the species-equality principle, we determined which species were specifically targeted by offset measures (i.e., among the affected species, the species for which the offset measures [ecological engineering, land acquisition, or protection] were devised).

We added 2 criteria that were not mentioned in the derogation files: legal protection status of the species and conservation status (Table 1). We considered the legal protection status at the European scale (Appendices II and II* of the Habitats Directive and Appendix I of the

Birds Directive confer a priority value for such species [see Supporting Information]). The legal protection status is currently used for conservation purposes (Donald et al. 2007; Pullin et al. 2009); however, there may be differences between legal protection and conservation status (Fontaine et al. 2007). Therefore, we also used the National Red List for France (IUCN 2011), which was prepared according to International Union for Conservation of Nature (IUCN) Red List Categories and Criteria. Species on the National Red List of France accounted for 89% of the species included in the database (some species, such as some plants and invertebrates, were not on the national list). Files contained species from 4 red-list categories: least concern, near threatened, vulnerable, and endangered (IUCN). We did not evaluate species in the unknown red-list category (equivalent to the IUCN data deficient or not evaluated).

Offset policies may have different requirements on the time lag between project effects and offset measures (McKenney & Kiesecker 2010). We referred to the Guidance document of article 16 of the Habitats Directive (EEC 2007) to avoid possible biases due to the interpretation of terms sometimes used in derogation files. The European Commission specifies "that offsets would have to be effective before or at the latest when deterioration or destruction of a breeding site or resting place starts to take place" because temporary losses need to be offset (Bekessy et al. 2010; BBOP 2012). Thus, we did not consider offset measures implemented after development, especially on-site restoration or rehabilitation measures that are sometimes proposed several years after effects have occurred (e.g., rehabilitation of a mine after development).

Statistical Analyses

We used linear discriminant analyses (R package MASS) to differentiate the projects that contain no offsets, partial offsets, or uphold the species-equality principle. Explanatory variables were the main types of projects (transport, sandpit, commercial), type of effects (irreversible versus reversible), and affected site characteristics (site area, species richness, mean conservation status). To determine mean conservation status, we averaged the national red-list category of the species present at each site (Supporting Information). We tested the significance of the discriminant analysis with a multivariate analysis of variance (MANOVA) (R package stat) that allowed treating the group of response variables as one multivariate response (Hand & Taylor 1987). To determine the occurrence of offset measures in the derogation files, we used a generalized linear model (GLM) in which presence or absence of offset measures was the binary dependent variable. Explanatory variables were type of effect, mean conservation status, and the affected species richness. Total species richness was not available in the derogation files; therefore, species richness refers to the richness of the protected species, that is for each derogation file, the number of protected species listed as present at the affected site (hereinafter affected species richness) and the number of protected species targeted by offset measures (hereafter offset species richness).

We examined the effect of the species' characteristics variables (National Red List of France, legal protection status, and taxonomic group), species richness, and the type of effects on the probability that the effects of development on a species would be offset. We used a GLM with a mixed effect on species names (GLMM) (R package lme4) and the presence or absence of offset measures per species as the binary dependent variables. Species' characteristics were not all independent; they were not included in our models so we could avoid multicollinearity (Crawley 2009). For each species characteristic, we compared Akaike's information criterion (AIC) of simple models (each species characteristic was modeled as a unique explanatory variable) and selected the best model as that with the lowest AIC value (Crawley 2009). Then, we used the variable selected in the GLMM (species characteristic + species richness + type of effect).

We compared affected and offset species richness with a GLM with a Poisson error distribution (species richness was considered count data) (Crawley 2009). We also compared affected and offset log-transformed areas with a GLM with a normal error distribution. We then studied the relation of affected species richness to offset species richness with a GLM and a GLM with a broken-line relation (both models had a Poisson error distribution) to detect a possible threshold value in the offsets (R package segmented) (Muggeo 2008).

Independencies among the explanatory variables were systematically checked when multiple regressions were performed (Supporting Information). We analyzed data with R statistical software (R Development Core Team 2011). Data were deemed significant if $\alpha < 0.05$.

Results

Offset Application

Project offsets fell into 3 categories: no offset, partial offset, and species equality. No-offset projects did not mention any offset measures nor did they include projects that confused offset measures with reducing or accompanying measures (e.g., financial aid provided to research programs). Partial offset projects offset effects on some of the affected species but not all affected species. Species-equality projects offset effects on all affected species. Six of these projects provided a net positive effect (i.e., projects offset every affected species plus other unaffected protected species). Of the 85 development projects, 19 had no offset measures (8 of the 19 had

Table 2. Occurrence of offset measures as a function of different species' characteristic variables.

Explanatory variable	Effect size (SE)[a]	AIC[b]	p
All species			
French National Red List category[c]	EN 3.57 (1.07) > VU 2.4 (0.61) > NT 0.65 (0.36) > LC[d] –1.49 (0.15)	552.5[e]	<0.001
Taxonomic group	insect 2.53 (0.48) > plant 2.34 (0.39) > reptile 1.74 (0.43) > amphibian 1.45 (0.4) > mammal 0.57 (0.45) > bird[d] –2.72 (0.26)	672.6	<0.001
Nonbird species			
French National Red List category[c]	EN 3.57 (1.07) > VU 2.4 (0.61) > NT 0.65 (0.36) > LC[d] –1.49 (0.15)	363.4[e]	<0.001
European protection	Nat. prot. 0.33 (0.32) > Eur. prot.[d] -1.25 (0.23)	508.0	=0.30
Annex IV of Habitats Directive	not Ann. IV 0.47 (0.32) > Ann. IV[d] –1.33 (0.24)	507.0	=0.15
Annex II of Habitats Directive	Ann. II 0.35 (0.2) > not Ann. II[d] –1.12 (0.17)	508.3	=0.39
Annex II* of Habitats Directive species of priority interest)	Ann. II* 2.07 (1.52) > not Ann. II*[d] –1.09 (0.16)	507.2	=0.17
Birds			
French National Red List category[c]	EN 3.10 (1.64) > VU 2.07 (0.8)> NT 1.06 (0.85) > LC[d] –3.10 (0.31)	173.2[e]	=0.001
Annex I of Birds Directive	Ann. I 1.39 (0.6) > not Ann. I[d] –3.13 (0.33)	177.2	=0.02

[a] *Estimate of the generalized linear models with a binomial distribution and a mixed effect on species, names.*
[b] *Akaike information criterion.*
[c] *LC, least concern; NT, near threatened; VU, vulnerable; EN, endangered.*
[d] *Intercept of the model.*
[e] *The AIC of the selected models.*

confused offset) and 66 included offset measures. Of the 66 projects with offset measures, 36 partially offset effects and 30 offset 100% of effects.

These categories could not be differentiated by type of development, type of effect, or site characteristics (MANOVA, Wilks' $\lambda = 0.76$, $F_{2,62} = 1.15$, $p = 0.32$). The probability of presence of offset measures was positively affected by mean conservation status (GLM, $F_{1,62} = 15.50$, slope estimate [SE] = 3.51 [1.8]; $p < 0.001$), whereas no significant effect of the type of effect ($F_{1,62} = 2.04$; slope estimates: irreversible effects [intercept] = –2.88 [2], reversible effects = –0.93 [0.75]; $p = 0.16$) or species richness ($F_{1,62} = 1.23$; slope estimate = 0.03 [0.03]; $p = 0.21$) was detected. Thus, effects had a lower probability of being offset in communities where the mean conservation status of species was low than where species had a high mean conservation status. The same pattern occurred with or without the projects that did not contain offset measures.

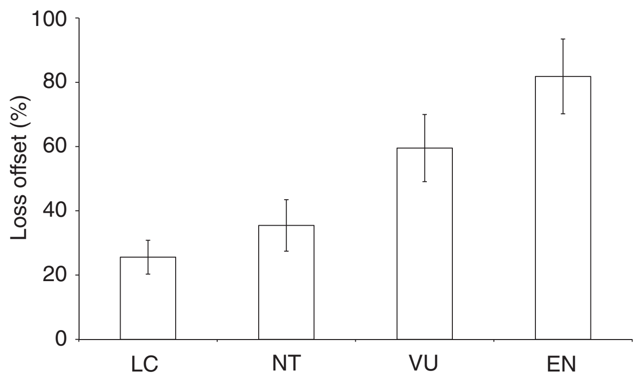

Figure 1. Species loss offset as a function of conservation status (French National Red List) (LC, least concern; NT, near threatened; VU, vulnerable; EN, endangered).

Species Equality, Species Status, and Effect Type

National red-list category explained the presence of offset measures better than legal-protection status or taxonomic group (Table 2). Legal protection had no significant effect, except for birds (Table 2). However, national red-list category was the best explanatory variable for birds (Table 2).

National red-list category had a positive effect on the choices of offset species (GLMM, $z = 5.568$, estimates [SE]: least concern [intercept] = –0.39 [0.24], near threatened = 0.99 [0.36], vulnerable = 1.78 [0.47], endangered = 3.47 [0.99]; $p < 0.001$). For species with a highconservation status, effects had a higher probability of being offset than for species with a low conservation status. On average, the proportion of offset species (the number of offset species divided by the number of affected species) was 3 times higher for endangered species than for species of least concern (proportion of offset species: least concern = 26% [5]; endangered = 82% [12]) (Fig. 1). However, the proportion of offset species was <100%, even for endangered species (Fig. 1).

Affected species were offset less when effects of development were reversible than when effects were irreversible (GLMM, $z = -3.839$, estimates [SE]: irreversible effects [intercept] = –1.41 [0.33], reversible effects = –1.07 [0.28]; $p < 0.001$) (proportion of offset species

(SE): irreversible = 54% [6%], reversible = 29% [6%]). Affected species were significantly less offset where species richness was high than where species richness was low ($z = -6.437$, slope estimate = –0.05 [0.008]; $p < 0.001$).

Species Equality and Species Richness at Affected sites

The offset sites had 5 times less species richness than the affected sites (mean species richness [SE]: affected sites = 8.9 [1.38], offset sites = 1.74 [0.21]; GLM, $F_{1,168} = 43.521$; $p < 0.001$). The total offset area (sometimes distributed in several offset sites close to each other) were smaller than the affected area (total area per project: affected sites = 34.64 ha [5.98], offset sites = 22.12 ha [6.27]; GLM, $F_{1,166} = 30.983$; $p < 0.001$).

There was a positive relation between affected species richness and the offset species richness (slope β [SE] = 0.027 [0.005]; $p < 0.001$). However, a segmented model with a break point at affected species richness of 8 better explained the offset species richness than the linear model (AIC for linear model = 307.73, AIC for segmented model = 295.54). Thus, the segmented model helped distinguish 2 different categories of offset projects with regard to affected species richness: <8 affected species, where the relation between affected species richness and offset species richness was significant and positive (slope $\beta = 0.125$ [0.030]; $p < 0.001$), and >8 affected species, where there was no significant relation between the affected species richness and offset species richness ($p = 1$). Thus, the percentage of offset species was higher in the <8 affected species category (56% [6]) than in the >8 affected species category (= 17% [3]).

Discussion

Offsets for protected species are intended to ensure that there is "no net loss" of species by improving the ecological conditions outside the affected site. Our analysis of the derogation files subjected to the EU Habitats and Birds Directives highlighted that this type of offset is moderately enforced in practice.

Offset Application

All development projects had residual effects on protected species before offset proposals. However, in 11 projects offset measures were not devised. Avoidance, reduction, and on-site restoration or rehabilitation were the only measures implemented to counterbalance development effects, and the measures did not achieve the no-net-loss objective. Indeed, offset measures are the only measures that specifically aim to offset residual effects of development projects (Quétier & Lavorel 2011; Quintero & Mathur 2011; BBOP 2012). In 8 other projects, offsets were confused with reduction, on-site restoration, or accompanying measures that did not match the project's effects (e.g., financial aid to research programs). Such confusion in mitigation interpretation was recently highlighted by Villarroya and Puig (2010), and our results show that confusion by developers and regulators can lead to no offset measures implemented in development projects.

Species Equality, Species Conservation Status, and Type of Effects

The probability of a species being offset depended on the national red-list categories, not on legal protection. Offset measures were absent for many species, but vulnerable and endangered species were more often considered for offset measures than nonthreatened species, especially species of least concern (Fig. 1). A possible compensatory effect for the latter species is that they may ultimately be present in some offset sites but not noted because they may be searched for less than more threatened species. Although this possibility cannot be eliminated, our data do not support this interpretation because total offset area was 37% smaller than the affected area, and there should be a corresponding decrease of species richness in these communities (Rosenzweig 1995). Furthermore, because some ecological processes depend on the amount of habitat (e.g., immigration, extinction; Rosenzweig 1995), small offset areas introduce an uncertainty in efficient offset of species over time.

A lower proportion of affected species was offset when there were reversible effects than when there were irreversible effects. A possible explanation for this is that projects involving reversible effects tend to have reduction or on-site restoration measures rather than offset measures (proportion of projects without offset measures: irreversible = 16%; reversible = 50%). On-site restoration may offer interesting conservation benefits (e.g., restoration of sandpits may occasionally create habitats and pioneer vegetation for rare and specialist species; Yuan et al. 2006). However, we found that even in these cases, the offset remained incomplete. After temporary development, landscapes and ecosystems often differed from the initial landscape and ecosystems; therefore, restoration measures did not consider the same biodiversity components. Furthermore, on-site restoration does not allow offsetting of the temporary losses due to the development projects because restoration measures only occur after the effects have ceased and recovery may not be achieved until long after the start of effects.

Species Equality and Species Richness at Affected Sites

Affected species richness and offset species richness were positively related at sites with low-species richness (<8 affected species) but not at sites with high-species richness (>8 affected species). Consequently, species at sites with a large number of protected species were less offset than species at sites that had lower protected species richness (proportion of offset species was 3 times higher when projects affected <8 species than when they affected >8 species). This result reveals the limits in the achievement of the species-equality principle for rich-species communities. Most offset measures (52%) aimed to increase habitat area or to improve habitat quality for species already present on offset sites and hence would not increase species richness on offset sites. Significant gains in species richness might rather be achieved by creating or recreating conditions for additional species (i.e., for affected species not present on offset sites but likely to benefit from offset measures) and thus turning offset sites of low-species richness into sites of higher species richness.

Consequences for Biodiversity of Current Offset Practices

The EU directives aim to maintain the species conservation status when it is favorable and to improve this status when it is unfavorable. This is important because all species in Europe are exposed to threats such as climate change, pollution, or habitat fragmentation (Conrad et al. 2006; Devictor et al. 2012), and this latter pressure is partially driven by project development. Our results show that current offset practices do not completely compensate for the effects of development. However, the most important biodiversity consequences may vary depending on a species' conservation status.

For vulnerable and endangered species, incomplete offsets put them at high risk given the vulnerability of their populations. We observed that these species were mostly flying animals (birds, butterflies, and one bat). Although such mobile species can move from affected areas to other areas, they are less likely to be effectively protected by the existing matrix of protected areas across a landscape. To protect these species one would need dynamic approaches that consider their life cycles (e.g., mobile protected areas; Bull et al. 2013) or large protected areas, especially in highly altered landscapes, where habitats of high quality may be rare. An additional reason to pay special attention to mobile species is that they more often cross roads than less-mobile species (Rytwinski & Fahrig 2012) and are thus highly susceptible to negative effects of new development.

For nonthreatened species, especially species of least concern, the low proportion of offset species will also have a negative effect on conservation status if no change is made in offset practices. Although these species are more abundant and widely distributed, they are not spared from global threats. Among common birds, a significant proportion of least-concern species (53%) show long-term population declines in Europe, despite their current abundance and large distribution (data from 1980 to 2009; European Bird Census Council 2011). Although the effects of development on ecosystems may be marginal when considering common species individually, when all species of least concern are considered, low offset levels for these species could have marked effects on biodiversity because common species play an important role in the structure of communities and ecosystem functions (Sekercioglu 2006; Devictor et al. 2007). Although EU directives do not specifically aim to maintain ecosystem functions, the possible effect of development on ecosystem functions is one reason to be particularly vigilant in the offset for such species. Thus, for all species, there is an urgent need to improve species conservation efforts through offset measures.

Future Perspectives

Designing and determining the extent of offsets requires extensive planning. Many developers maintain a last-minute approach to biodiversity issues and offsets (Söderman 2006), and this often does not allow much time to plant for species equality and social contexts of offset measures. In Europe, where human population density is high, offset possibilities through partnerships or land acquisitions are rare. In particular, a major impediment to the purchase of land could be the difficulty in finding offset sites that offer the opportunity to create gains for all affected species. In this context, proactive approaches that assess ecological possibilities very far upstream of the development projects and the time and money needed to negotiate with local stakeholders are needed to better adapt development projects to the species-equality principle. Proactive approaches would offer opportunities for solutions acceptable to all stakeholders (Rosenzweig 2003). For developers, proactive approaches could lead to a more cost-efficient project and, most importantly, to greater political and social legitimacy. For regulators (i.e., agencies in charge of biodiversity conservation), effective planning should reduce effects on species, allow for the selection of the best offset sites, ensure implementation of offset measures before development, and improve ecological efficiency by mutualizing offsets in landscapes concerned with cumulative effects (e.g., offsets to reconnect fragmented areas).

Assessing species equality is a first step in offset efficiency because no net loss ought to be considered in a temporal dimension. To be completely effective, offsets should be maintained as long as the effects last to achieve species equality through time (McKenney & Kiesecker 2010). Maintaining habitats and ecological conditions for affected species involves monitoring and effective adaptive management given the uncertainty associated with offsets, such as restoration measures (Maron et al. 2012), especially in a context of land-use changes and climate change. We suggest monitoring the efficiency of offsets on the ground and to examine whether the offsets really conserve the species and for how long.

An important point in the efficacy of offsets is the protection status bestowed on offset sites in France. Only 16% of the projects we examined proposed legal protection of offset sites, and among these, no protection statuses were directly contracted by the French government (regional entities only). The low proportion of protected offset sites is a major difference with other offset schemes, such as those of the U.S. conservation-banking policy (U.S. DOI 2003), where offset sites are systematically protected through conservation banks. The legal protections in the development projects we examined might be easily changed. Conservation banks ensure permanent protection with habitat-management obligations in perpetuity (U.S. DOI 2003), but there are currently no equivalent tools to protect offset sites and species in Europe.

Species offsets were strongly correlated with the characteristics of affected sites (type of species present, the type of effects, and species richness), and this correlation suggests variable but overall poor outcomes with regard to species conservation. We suggest it is vital to improve the design of offset measures to ensure the no net loss of species by 2020 that is expected by the EU Biodiversity Strategy (EC 2011).

Acknowledgments

We are grateful to F. Quétier and 4 anonymous reviewers for their constructive comments on previous versions of this paper. We thank the French Ministry of Ecology and the Conseil National de Protection de la Nature for providing the derogation files. We also thank M. Perret and J. Wintergerst for their helpful discussions on European legal frameworks and M. Brun and E. Beck for help in analyzing the derogation files. Funding was provided by the Commissariat à l'Energie Atomique (prefectorial decree n° 200863-5 of 3 March 2008). We certify that the funding agency was not involved in the collection, analysis, or interpretation of the data.

Supporting Information

Descriptions of derogation files (Appendix S1), European legal framework (Appendix S2), calculation of mean conservation status (Appendix S3), and tests of independence among variables (Appendix S4) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than for an absence of the material) should be directed to the corresponding author.

Literature Cited

Australian Government. 2007. Use of environmental offsets under the Environment Protection and Biodiversity Conservation Act 1999. Australian Government, Canberra, Australia. Available from http://www.environment.gov.au/archive/epbc (accessed May 2013).

Balmford, A., and W. Bond. 2005. Trends in the state of nature and their implications for human well-being. Ecology Letters **8:**1218–1234.

BBOP (Business and Biodiversity Offsets Programme). 2012. Biodiversity offset design handbook-updated. BBOP, Washington, D.C. Available from http://bbop.forest-trends.org/guidelines/odh.pdf (accessed May 2013).

Bekessy, S., B. A. Wintle, D. B. Lindenmayer, M. McCarthy, M. Colyvan, and M. Burgman. 2010. The biodiversity bank cannot be a lending bank. Conservation Letters **3:**151–158.

Bull, J. W., K. B. Suttle, N. J. Singh, and E. J. Milner-Gulland. 2013. Conservation when nothing stands still: moving targets and biodiversity offsets. Frontiers in Ecology and the Environment **11:**203–210.

Conrad, K. F., M. S. Warren, R. Fox, M. S. Parsons, and I. P. Woiwod. 2006. Rapid declines of common, widespread British moths provide evidence of an insect biodiversity crisis. Biological Conservation **132:**279–291.

Crawley, M. J. 2009. The R book. John Wiley & Sons, Chicago.

Davenport, J., and J. L. Davenport, editors. 2006. The ecology of transportation: managing mobility for the environment. Springer, Dordrecht, the Netherlands.

Devictor, V., et al. 2012. Differences in the climatic debts of birds and butterflies at a continental scale. Nature Climate Change **2:**121–124.

Devictor, V., L. Godet, R. Julliard, D. Couvet, and F. Jiguet. 2007. Can common species benefit from protected areas? Biological Conservation **139:**29–36.

Donald, P. F., F. J. Sanderson, I. J. Burfield, S. M. Bierman, R. D. Gregory, and Z. Waliczky. 2007. International conservation policy delivers benefits for birds in Europe. Science **317:**810–813.

European Bird Census Council. 2011. Trends of common birds in Europe, 2011 update. Available from http://www.ebcc.info/index.php?ID=457 (accessed April 2103).

European Commission (EC). 2007. Guidance on Habitats Directive Articles 12 and 16. Available from http://ec.europa.eu/environment/nature/conservation (accessed April 2103).

European Commission (EC). 2011. EU Biodiversity Strategy to 2020. Available from ec.europa.eu/environment/nature/biodiversity (accessed April 2103).

European Economic Community (EEC). 2009. Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds on the conservation of wild birds (codified version). Official Journal **L20:**7–25.

European Economic Community (EEC). 1992. Council directive 92/43EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal **L206:**7–50.

Fontaine, B., et al. 2007. The European union's 2010 target: putting rare species in focus. Biological Conservation **139:**167–185.

Fox, J., and A. Nino-Murcia. 2005. Status of species conservation banking in the United States. Conservation Biology **19:**996–1007.

Giam, X., C. J. A. Bradshaw, H. T. W. Tan, and N. S. Sodhi. 2010. Future habitat loss and the conservation of plant biodiversity. Biological Conservation **143:**1594–1602.

Hand, D. J., and C. C. Taylor. 1987. Multivariate analysis of variance and repeated measures. Chapman and Hall, London.

Harper, D. J., and J. T. Quigley. 2005. 'No net loss' of fish habitat: a review and analysis of habitat compensation in Canada. Environmental Management **36:**343–355.

Hayes, N., and A. Morrison-Saunders. 2007. Effectiveness of environmental offsets in environmental impact assessment: practitioner perspectives from Western Australia. Impact Assessment and Project Appraisal **25:**209–218.

International Union for Conservation of Nature (IUCN). 2011. IUCN national red list categories and criteria. IUCN, Gland, Switzerland. Available from http://www.uicn.fr/Liste-rouge-France.html (accessed May 2013).

Maron, M., R. J. Hobbs, A. Moilanen, J. W. Matthews, K. Christie, T. A. Gardner, D. A. Keith, D. B. Lindenmayer, and C. A. McAlpine. 2012. Faustian bargains? Restoration realities in the context of biodiversity offset policies. Biological Conservation **155:**141–148.

McKenney, B. A., and J. M. Kiesecker. 2010. Policy development for biodiversity offsets: a review of offset frameworks. Environmental Management **45:**165–176.

MEA (Millennium Ecosystem AssessmentMEA). 2005. Ecosystems and human well-being: scenarios. Island Press, Washington, D.C.

Ministerial decree, 2007. Arrêté du 19 février 2007 fixant les conditions de demande et d'instruction des dérogations portant sur des espèces de faune et de flore sauvages protégées. Available from http://www.legifrance.gouv.fr (accessed April 2013).

Muggeo, V. M. R. 2008. Segmented: an R package to fit regression models with broken-line relationships. R News **8/1:**20–25.

Pullin, A. S., et al., 2009. Conservation focus on Europe: major conservation policy issues that need to be informed by conservation science. Conservation Biology **23:**818–824.

Quétier, F., and S. Lavorel. 2011. Assessing ecological equivalence in biodiversity offset schemes: key issues and solutions. Biological Conservation **144:**2991–2999.

Quintero, J. D., and A. Mathur. 2011. Biodiversity offsets and infrastructure. Conservation Biology **25:**1121–1123.

Rosenzweig, M. L. 2003. Win-win ecology: how the earth species can survive in the midst of human enterprise. Oxford University Press, Oxford, New York.

Rosenzweig, M. L. 1995. Species diversity in space and time. Cambridge University Press, Cambridge, United Kingdom.

Rytwinski, T., and Fahrig, L. 2012. Do species life history traits explain population responses to roads? A meta-analysis. Biological Conservation **147**:87–98.

Sekercioglu, C. H. 2006. Increasing awareness of avian ecological function. Trends in Ecology & Evolution **21:**464–471.

Söderman, T. 2006. Treatment of biodiversity issues in impact assessment of electricity power transmission lines: a Finnish case review. environmental impact assessment Review **26:**319–338.

U.S. DOI (Department of the Interior). 2003. Guidance for the establishment, use and operation of conservation banks. DOI, Washington, D.C. Available from http://www.fws.gov/endangered/esa-library/pdf/Conservation_Banking_Guidance.pdf (accessed May 2013).

Villarroya, A., and J. Puig. 2010. Ecological compensation and environmental impact assessment in Spain. Environmental Impact Assessment Review **30:**357–362.

World Bank. 2007. The nexus between infrastructure and environment. Evaluation brief 5. Independent Evaluation Group, Washington, D.C.

Yuan, J. G., W. Fang, L. Fan, Y. Chen, D. Q. Wang, and Z. Y. Yang. 2006. Soil formation and vegetation establishment on the cliff face of abandoned quarries in the early stages of natural colonization. Restoration Ecology **14:**349–356.