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# Strategic Environmental Assessment of Plans and Programs: A Methodology for Estimating Effects on Biodiversity

**MARIO DÍAZ***
Departamento de Ecología, Facultad de Biología
Universidad Complutense
E-28040 Madrid, Spain

**JUAN CARLOS ILLERA**[1]
C/ Seseña, 31
E-28024, Madrid, Spain

**DOLORES HEDO**
Sociedad Española de Ornitología (SEO/BirdLife International)
C/ Melquiades Biencinto, 34
E-28053 Madrid, Spain

ABSTRACT / We developed a methodology for biodiversity evaluations within the process of Strategic Environmental Assessment and we applied it to the estimation of the effect of two Regional Plans of Development on all bird species inhabiting the Castilla y León region (northwestern Spain). The methodology is based on the evaluation of the effects of main development actions on the habitat requirements of species. From these evaluations, and from data on the current distribution and population size (number of individuals) of each species, we estimated the most likely pattern of distribution and population size after the full implementation of the plans for each species. The impacts of the plans were quantified as the differences between the pre- and postproject patterns after codifying them to compensate for differences in the quality of the information available among species. Overall, we conclude that the proposed methodology fulfills the requirements for its use within the SEA process as it allows for the assessment of cumulative impacts on every species, highlighting the development directions and the habitat types with major impacts, and ascertaining whether impacts affect species with either low or high conservation and/or economic value. Generalization of the proposed methodology to other regions or species will require wildlife-habitat models adequate for SEA analyses, so that we also propose guidelines for the development and validation of these models.

Current planning demands the implementation of integrated plans of development that should harmonize the variety of objectives to be achieved and the policies to be complied within each particular territory, be it at the local, regional, national, or even international level. Such harmonization is ultimately aimed at securing the sustainability of the proposed development plans so that resource use should meet the needs of the present without compromising the ability of future generations to meet their needs (Goodland and others 1991). This goal is explicitly stated within the main principles of both the European and North American policies, i.e., the Amsterdam Treaty of the European Union and the US National Environmental Protection Act.

KEY WORDS: Bird species; European Dispersed Species Project; Methodology; Regional scale; Strategic environmental assessment (SEA); Wildlife–habitat relationships

[1]Present address: Departamento de Biología Animal (Zoología), Facultad de Biología, Universidad de La Laguna, E-38206 La Laguna, Tenerife, Spain.

*Author to whom correspondence should be addressed at present address: Departamento de Ciencias Ambientales, Facultad de Ciencias del Medio Ambiente, Universidad de Castilla-La Mancha, E-45071 Toledo, Spain. e-mail: mariod@amb-to.uclm.es.

Strategic environmental assessment (SEA), the systematic assessment of the environmental implications of policies, plans, and programs, shows several features that contribute to direct development planning towards sustainability. SEA starts at the very beginning of the process of producing planning documents, which should include explicit environmental goals. The draft plan is then evaluated to determine whether such goals could be reached through the implementation of its proposals. If not, the proposals are redefined in order to maximize the performance of the plan against the variety of objectives it has been drafted for (Therivel and others 1992; Therivel and Partidario 1996). To reach these goals, the expected changes in the environmental factors that would be derived from each development action are quantified at the scale of the planning region. This quantification allow for the comparison of alternative draft plans containing different combinations of development actions. In this way, SEA: (1) helps to give similar importance to every aspect of development, be it environmental, economic, financial or other, and hence to integrate the environment in the decision-making process; (2) facilitates the formulation of alternative plans; (3) allows for the assessment of cumulative impacts arising from the variety of projects under the plans; (4) reduces the need for case-by-case environmental impact assessments (EIA) of the projects included in the plan; (5) enhances transparency on environmental issues both between the various organizations involved in the planning process and the general public; and (6) allows for consistency in considering the environment throughout planning processes across different levels of government (Therivel and others 1992; Therivel and Partidario 1996). SEA therefore contributes to the incorporation of environmental concerns within the planning process as well as to the clarification of the "environment" as comprising physical, biological, social and economic factors.

Within biological factors, biodiversity issues are crucial because of the variety of relationships between biodiversity and sustainability, as endorsed by the conclusions of the Earth Summit in Rio de Janeiro in 1992 and the resulting Convention on Biological Diversity. However, the incorporation of biodiversity issues within the SEA process is frequently regarded either as an impossible task or as a burden that would hamper the achievement of objectives of a different nature (e.g., generation of employment and enhancement of local income). This impossibility has been attributed to the lack of detailed information on the patterns of distribution of most organisms. Even for birds, whose patterns of distribution and whose population sizes are best known (see Tucker and Heath 1996, Hagemeijer and Blair 1997, Cramp and others 1977—1994; Glutz von Blotzheim and others 1966–1997 for Europe; and Robbins and others 1986, Root 1988 for the United States), the information available appears to be inappropriate even to evaluate the effects of small-scale projects due to the lack of detailed information at the local level (see, e.g., Treweek 1996). Widening the scale of the assessment to development plans for whole regions or countries would seem impossible until our level of knowledge has been considerably improved.

An alternative to the analyses of the direct effects of development actions on organisms is the analysis of the dependency of the distribution of species on selected characteristics of their habitat (the so-called wildlife–habitat relationships) (Morrison and others 1998). Wildlife–habitat models that quantify such dependence allow an assessment of the effects of development actions on species through the effect of such actions on the habitat characteristics each species depends on (see Verner and others 1988, Morrison and others 1998 for reviews). This habitat-focused approach is rooted on habitat selection theory, which states that individuals should select the habitats where their fitness is maximal within the limits imposed by their morphofunctional and physiological designs, by competition with other individuals and by their predators, parasites, and pathogens (Fretwell and Lucas 1970, see Cody 1985, Wiens 1989a for bird reviews). Apart from providing a solid theoretical basis for the wildlife–habitat relationship approach, results from habitat selection studies are the best guide for the selection of the habitat characteristics needed to develop predictive models useful for environmental assessment (Morrison and others 1998 and references therein).

Theoretical studies on habitat selection can rarely be applied directly for SEA analyses since they are usually carried out at spatial scales much smaller than the scales of development planning (local versus regional or even continental; see, e.g., Bina and others 1995) and habitat selection patterns and processes are scale-dependent (Wiens and others 1987, Wiens 1989b). Fortunately, a wide-scale project aimed at applying the information available on habitat selection and wildlife–habitat relationships to the conservation of birds in Europe has been developed in the last years: the European Dispersed Species Project (Tucker and Evans 1997). The main goal of this project is to complement a conservation policy based on protected areas by promoting land uses throughout Europe that enhance habitats for birds. This approach stems from the facts that most land in Europe is currently under a variety of human uses and that most bird species depend on habitats that are managed in a certain way. After reviewing the information available on the distribution, population size, and recent population trends of all bird species in all countries, European bird species were classified according to their conservation status (summarized in Tucker and Heath 1994). Then, all European habitats were classified into eight major habitat types according to the international policies that influence its management (e.g., agricultural and grassland, influenced by the Common Agricultural Policy; forests, influenced by the European forest policy; and so on; see Tucker and Evans 1997 for details) and all bird species were assigned to the habitat types they occupy preferentially. The available (mostly qualitative) information on the main habitat characteristics required by each species in each major habitat type, as well as on the way management policies could affect such characteristics, was collected and reviewed during workshops of experts at the spatial scale relevant for each habitat (e.g., wide for agricultural habitats and forests and narrow for wetlands). From this information, a number of suggestions for management were derived for every major habitat type, and these suggestions were prioritized according to the conservation status of the bird species benefited from their implementation (Tucker and Evans 1997).

In this paper we will be the first to use the information summarized by the Dispersed Species Project to quantify the effects of two complementary regional plans of development on birds. Our main aim is to develop a methodology that can allow for the incorporation of biodiversity issues within the SEA process, as the proposed methodology can be extended to any other group of organisms as long as the information available on their habitat requirements are formalized properly. In addition, we will also evaluate the effects of the two plans on the important bird areas (IBAs) identified in this region (Viada 1998). IBAs are a network of sites whose boundaries were designed to enclose within them most of the populations of the bird species that depend on conservation measures at an European scale (Grimmett and Jones 1989). This later evaluation can only be carried out site by site at local scales and can only evaluate the effects of plans on threatened species, so that a comparison of the results of both evaluations will show whether the regional-scale approach developed here is consistent with the sum of local-scale, species-specific evaluations for the purposes of SEA analyses.

## Materials and Methods

### Study area

The Castilla y León region extends over 94146 km$^2$, i.e., 19% of Spain (Figure 1). It roughly coincides with the Spanish basin of the Duero River, that crosses the highland plain from east to west (600–800 m asl) forming most of the central part of the region. Four main European habitat types (as established by the Dispersed Species Project) can be found in Castilla y León: (1) agricultural and grassland habitats that include annual crops, pastoral woodlands or "dehesas" (seminatural open holm oak, *Quercus ilex*, woodlands) and perennial crops (Junta de Castilla y León 1997a); (2) inland wetlands that include riparian forest, lagoons, and reservoirs (Ibero 1996, Casado and Montes 1995); (3) temperate and mediterranean forests, including pine, *Pinus* spp., and poplar, *Populus* sp., plantations (Blanco and others 1997, Junta de Castilla y León 1997b, Santos and Tellería 1998); and (4) open areas with scrub or scattered bushes, as well as rocky outcrops and inland riverside cliffs.

### Strategic Environmental Assessment Process

For best efficiency, the assessment of the environmental consequences of plans and programs should start at the very beginning of the planning process (see Introduction). However, we had to evaluate plans that were nearly completed, as one of them had passed two of three approval stages, whereas the other was an advanced draft (see Hedo and Bina 1999 for details). The plans also did not include any explicit statement about maintaining or enhancing biological diversity (Junta de Castilla y León 1997a, Confederación Hidrográfica del Duero 1994). We were then forced to adopt a working approach that resembled a environmental impact assessment of a single project but for the larger spatial scale of the assessment and the variety of actions considered.

*Selection of indicators.* The first step to tackle a SEA is to describe the state of the environment in the plan area using indicators (Therivel and others 1992, Therivel and Partidario 1996). These indicators should include information of both the environmental significance and sensitivity of the environment to the projected actions, so that the environmental implications of proposed plans of development can be clearly identified and evaluated (Therivel and Thompson 1996). Although appealing, the indicator approach is currently under close scrutiny for biodiversity assessments due to the fact that organism responses to the environment tend to be species-specific (see, e.g., Prendergast and others 1993, Prendergast 1997, Morrison and others 1998). We then tried to evaluate the effects of the plans on the distribution and population size of all species present in the plan area instead of selecting indicators. We focused on birds since: (1) there is information available on the current distribution and population size of most species in the region of interest (reviewed in Díaz and others 1996, Purroy 1997, Tellería and others 1999); (2) the information available on bird–habitat relationships and on the way management could affect the habitat requirements of each European bird species has been recently reviewed (Tucker and Evans 1997); and (3) there is no comparable database for any other group of organisms for the region of interest.

The important bird areas (IBAs) network aims at preserving bird diversity by protecting the populations of species that are declining or threatened. The state of the bird populations within IBAs is then considered as an indicator of overall bird diversity at an European scale (Grimmett and Jones 1989). We evaluated the cumulative effects of plans on the subset of bird species protected by the IBAs identified for the region in order

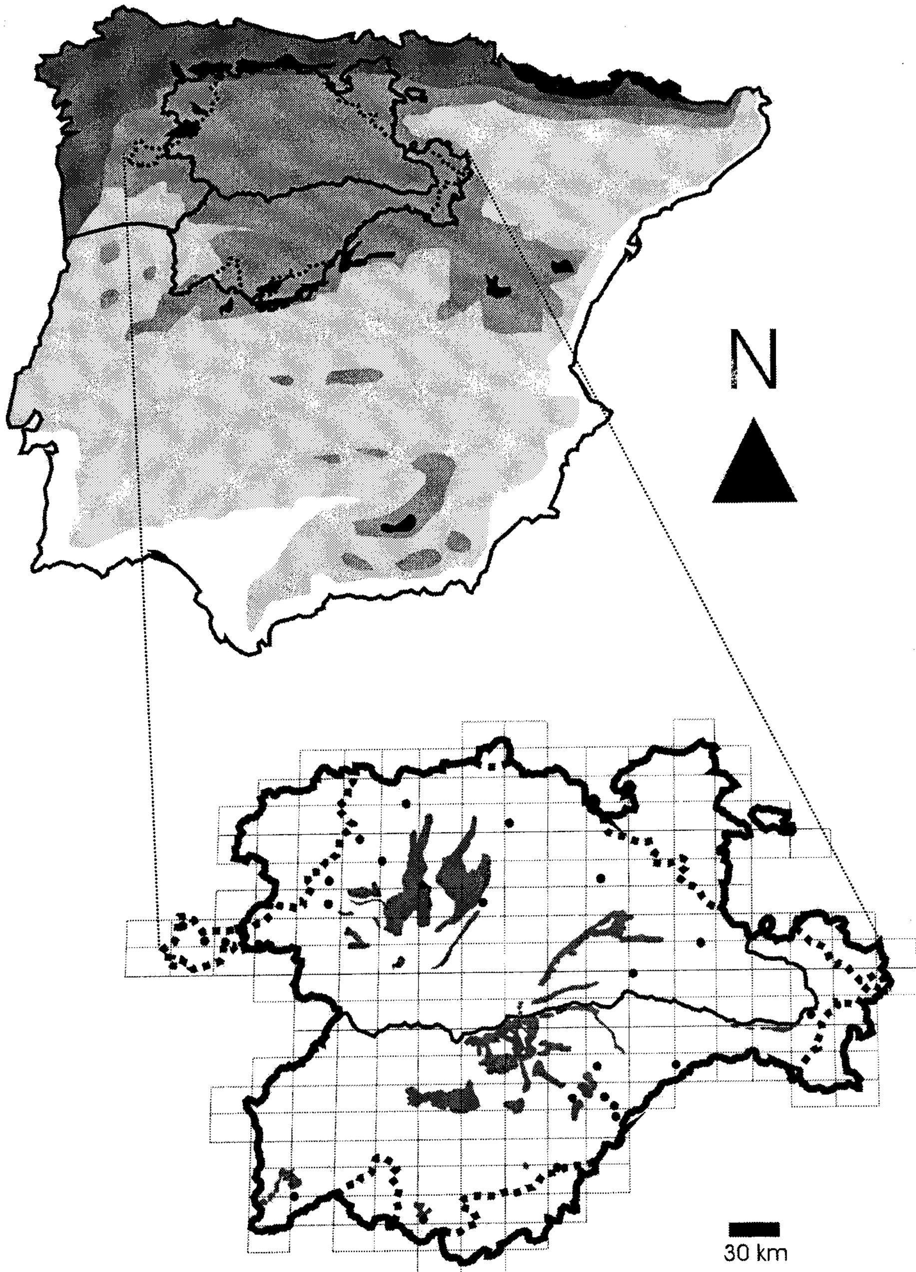


**Figure 1.** Study area, aims of the plans and proposed development actions. Black areas in the upper map indicate mountain ranges, whereas shading indicates the biogeographical regions of the Iberian Peninsula (Eurosiberian, Supramediterranean, Mesomediterranean and Thermomediterranean from north to south) (Rivas-Martínez 1981). The closed boundary in the lower map encompasses the Castilla y León region and the dashed line the Spanish basin of the Duero River. Shaded areas indicate new irrigations areas and dots new reservoirs. The grid of 1:50,000 topographic maps (Lambert projection) to which the presence/absence of each bird species in the study area was refered is superimposed on the lower map.

to compare the results obtained with the evaluation of the effects on all bird species in the whole region. The exact boundaries of these IBAs, the habitat types they include, and the number of individuals of the species protected by each IBA are detailed in Viada (1998).

*Current distribution and population size of bird species.* Data on each species' distribution and population size in the plan region were obtained from three recent reviews (Díaz and others 1996, Purroy 1997, Tellería and others 1999) after excluding some species: (1)

whose presence was uncertain or irregular; (2) that were introduced recently; (3) whose presence was marginal within their European range; or (4) that are linked to habitats not affected by the plans such as high mountains or cities. The distribution of breeding birds was taken from the Spanish ornithological atlas (Purroy 1997), which reviews the presence/absence of all species between 1975 and 1995 in a grid of ca. 500 $km^2$ (Figure 1). The information available on the winter distribution of birds (reviewed in Díaz and others 1996, Tellería and others 1999) was also refered to this grid. Patterns of bird distribution were classified and scored according to the extent and fragmentation of distribution areas in the plan region, as these characteristics are related to the vulnerability of the pattern of distribution to local extinction (Dytham 1995, Simberloff 1995, Bascompte and Solé 1996). Such scores were: (1) local-continuous—the current distribution area is small (1–6 grid cells) and continuous; (2) local-fragmented—the overall size of the distribution area is as in category 1 but the occupied cells are scattered across the region; (3) regional-fragmented—species distributed across the region but in noncontiguous cell grids; and (4) regional-continuous—populations are continuously distributed across the region. Low scores indicate high vulnerability and high scores low vulnerability.

The estimates of the current population size (number of individuals) of each bird species in the region were derived from Díaz and others (1996), Purroy (1997), and Tellería and others (1999). Direct censuses for the large and/or scarce species are available. However, for some species (i.e., most small passerines), only measurements of their population densities in the variety of habitats they occupy can be used to estimate population size (see Tellería and others 1999 for a discussion). This was done by multiplying average densities in each habitat by the approximate extent of such habitat (taken from Junta de Castilla y León 1997a,b), then summing up across habitat types. The figures obtained by these two methods are hardly comparable directly due to a number of methodological artifacts associated with density estimates and extrapolations to larger areas (see Blackburn and Gaston 1996, Smallwood 1997 for reviews). To avoid this bias, estimates of the number of individuals for the plan region were transformed to orders of magnitude following a decimal logarithm scale as 1, $1–10^2$ individuals; 2, $10^2–10^3$; 3, $10^3–10^4$; and 4, $>10^4$. Distribution and population size scores for al the species considered are available upon request.

*Assessment of impact of plans on birds.*

*Description of plans in terms of regional-scale development directions.* The two plans assessed are closely linked. The Duero Basin Hydrological Plan allocates over 75% of the budget to irrigation-related actions (Confederación Hidrográfica del Duero 1994). The regional irrigation plan, in turn, assumes the provisions of the hydrological plan and proposes irrigation schemes as the means to overcoming the region's main structural problems, namely low income, aging population, and abandonment of rural areas (Junta de Castilla y León 1997a). The plans also give some consideration to the potential of recreation as a source of income. The joined core objectives of both plans are thus to promote agriculture and, to a lesser extent, to promote tourism and recreation.

The development actions described in the plans to achieve their core objectives were classified into four main types of development directions. The classification of development actions into development directions was an attempt to reflect the strategic and regional (rather than action by action and site by site) scale of the SEA evaluations (Therivel and Thompson 1996), as well as the potential effects of these actions on the habitat traits bird species depend on (see below). Such directions were:

1. Creation of new irrigated lands. Some 300,000 ha of the region's lowlands will be irrigated by the year 2010 (Figure 1) under the assumption that irrigated crops are more profitable that current land uses. New irrigated lands will produce reductions in the area of dry croplands, pastoral woodlands, shrublands and lowland forests, as well as alterations in the neighboring habitat types (e.g., alteration of water levels and eutrophication of inland wetlands).

2. Construction of new reservoirs. The construction of 26 new reservoirs by the year 2010 is planned (Figure 1). Reservoirs will flood habitats in places where they are built. The extent of nine of the 26 reservoirs projected was detailed in the plans (961 ha on average; range: 5–5392 ha) (Confederación Hidrográfica del Duero 1994). We used the average extent of these nine reservoirs as the best estimate available for the extent of the remaining.

3. Riverside alteration, which derives from the development of irrigation and the construction of reservoirs. Expected alterations include widespread degradation of the riverside vegetation and riverbed deviations both within irrigated areas and downstream of new reservoirs.

4. Human disturbance. The human presence in the developed areas of the region will increase due to the explicit intention of exploiting the new reservoirs and

the existing riversides for recreational purposes. In addition, a sprawling growth of settlements, roads, power lines, etc., will follow the increased availability of water.

Other actions described in the plans, such as the development of piping structures both for irrigation and for water supply to human settlements, were not considered because of the local scale of their effects on bird habitats.

*Effects of development directions on distribution and numbers of bird species.* Relevant habitat requirements of each bird species in each main habitat type found in the plan region were taken from Tucker and Evans (1997). Species were first classified according to the main habitat type they occupy, i.e., agricultural and grassland habitats, inland wetlands, forests (both Mediterranean and temperate) and shrublands and rocky habitats. We pooled Mediterranean and temperate forest bird species and separated species of Mediterranean shrublands and rocky habitats from Mediterranean forest species (see Tucker and Evans 1997). Data on habitat requirements were updated using the recent reviews by Díaz and others (1996), Purroy (1997), and Tellería and others (1999). The updated habitat requirements of each bird species within each major habitat type are available upon request. Then, we evaluated whether each of the four development directions will have negative, positive, or no effect on the habitat requirements of each bird species following Tucker and Evans (1997) and estimated the proportion of the current distribution area of the species (i.e., the number of occupied cells of the grid of 1:50,000 topographic maps) affected by each direction. If the direction will produce an increase of suitable habitat for the species, we estimated the proportion of new habitat in relation with the current size of the distribution area in the region of interest. Proportions were scored as: A, <10%, B, 10%–20%; C, 20%–50%, and D, 50%–100%.

On the basis of these evaluations, as well as on the geographical distribution of each species and each development direction, we estimated the most likely pattern of distribution and the population size for each species after the full implementation of the plans, and scored patterns in the same way as current patterns of distribution and abundance. The species-specific impact of both plans was quantified as the pre- and post-plan difference between the scores of the distribution patterns and of the orders of magnitude of population sizes. Negative values indicate decreases in the distribution area and/or population sizes while positive values show the opposite and zero values indicate no change. Codification of changes allows adding them to obtain a global index of impact of both plans for all species. Furthermore, species scores for each main habitat type could be added to obtain an index of the impact of plans on each major habitat type.

Changes in the distribution area may arise if habitat modifications are likely to cause the local extinction (or the local colonization) of the species in one or more grid cells. For simplicity, we assumed that the habitat requirements of each species were uniformly distributed across each grid cell and that negative effects on habitat requirements will produce local (cell) extinction if they affect more than 20% of the cell grid in the case of large-sized species (e.g., large eagles, vultures, bustards), more than 40% in the case of medium-sized birds (e.g., ducks, falcons, partridges, corvids), or more than 60% in the case of small-sized species (e.g., most passerines). The same was assumed for local (cell) colonization. This semiquantitative procedure was inspired in the results obtained when analyzing the effects of the plans on the Spanish imperial eagle *Aquila adalberti*, the only species for which an adequate quantitative model was available (González and others 1990). This model states that a given 500-$km^2$ cell in Spain can be occupied by this species if it has less than 10% of irrigated lands and more than 10% of open forests (see González and others 1990 for details). Threshold values of habitat alteration for the remaining species were derived from these values, on similar models developed for other bird species in other Spanish regions (Carrascal and others 1993, Donázar and others 1993, Bustamante 1996, 1997, Blanco and others 1998, Gil-Sánchez 1999) and on information available on the relationships between forest patch size and bird communities in the region's lowland forests (Tellería and Santos 1995, 1997, Díaz and others 1998, Santos and Tellería 1998).

In order to estimate changes in the number of individuals, we assumed, for simplicity, that populations are uniformly distributed across their distribution areas. Under this assumption, percent changes in the number of individuals will be the same as the percent changes in the size of the distribution area, except when habitat modifications reduce or increase population densities without producing local extinction or colonization [see Díaz and others (1993) for an example involving dry *vs* irrigated croplands and Díaz and others (1996) and Tellería and others (1999) for reviews]. In these cases we estimate changes in population size from the differences in densities in the current and new habitats.

*Importance of each bird species for conservation and regional income.* Codification of distribution and population size changes allow weighting them according to the conservation status and economic importance of each species. The Spanish conservation status of each species was taken from Blanco and González (1992) and scored as

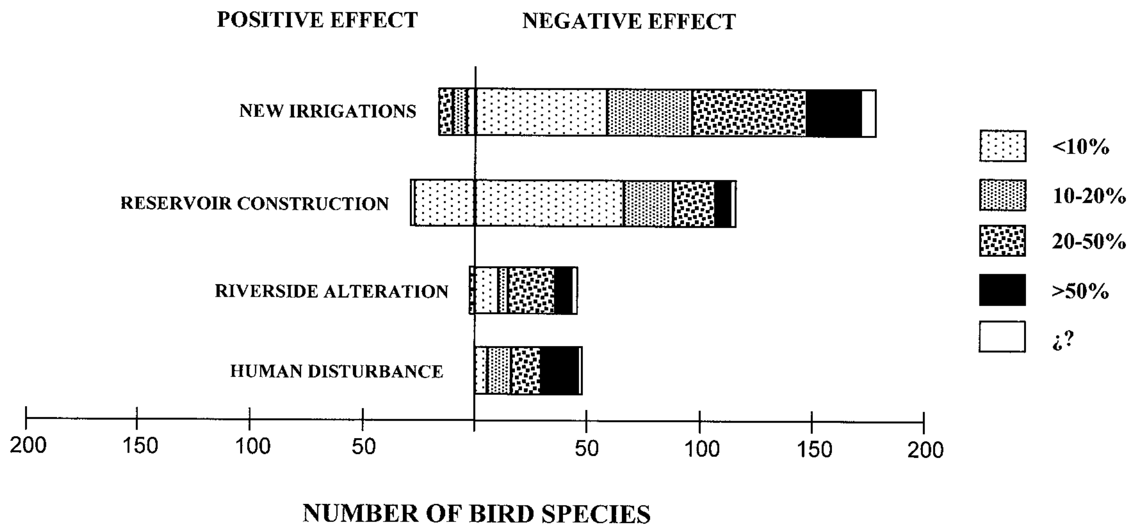


**Figure 2.** Number of bird species whose habitat requirements will be affected by each development direction included in the Hydrological Plan of the Spanish River Duero Basin and the Irrigation Plan of Castilla y León. The direction (positive or negative) of effects on each species, as well as the proportion of the current distribution area of each species that will be affected, is also indicated (¿?: no estimation could be made because of lack of detailed information in the plans). The cumulative number of bird species' evaluations is larger than the number of bird species evaluated (194) since most species will be affected by more than one development action. Details on the evaluations in which this figure is based on are available upon request.

(1) secure; (2) insufficiently known or indeterminate; (3) rare; (4) vulnerable; and (5) endangered. The European conservation status was scored as (1) no SPEC; (2) SPEC 4; (3) SPEC 3; (4) SPEC 2; (5) SPEC 1. SPEC categories indicate the importance of conservation measures to ensure the long-term persistence in Europe of each bird species (see Tucker and Heath 1994 for details). No official data on the conservation status of each species at the level of the plan region was available.

The economic importance of each species was scored as their importance as game birds. Hunting is a recreational activity of high economic importance in the plan region. It produced direct incomes of 11,000 million pesetas (ca. US$73 million) in 1984, a figure that is estimated to have doubled by now (Junta de Castilla y León 1997b). We scored as 0 the species that are not listed in the region's annual hunting orders (Boletín Oficial de Castilla y León 1996), as 1 the species listed but not of value by hunters [e.g., corvids, lapwings (*Vanellus vanellus*), blackbirds (*Turdus merula*)], as 2 the species valued by hunters but whose hunting provides only moderate income (e.g., ducks, coots, thrushes), and as 3 the species whose hunting provides the largest economic profitability within the region [e.g., quails (*Coturnix coturnix*), red-legged partridges (*Alectoris rufa*), wood pigeons (*Columba palumbus*)] (Junta de Castilla y León 1997b).

*Assessment of impact of plans on important bird areas.* We measured the percentage of the surface of each IBA affected by plans by comparing the geographical distribution of both IBAs (taken from Viada 1998) and development directions (Figure 1). To estimate the most likely change in the absolute population size of each of the bird species protected by each IBA (Viada 1998), we assumed that both the habitat requirements of each species and its populations were uniformly distributed throughout the IBA for consistency with the approach followed in the regional-scale assessments described above. In this way, the percent of each habitat type affected was translated to percent changes in bird populations. The figures obtained were summed for each species across IBAs to obtain a regional estimate of population change for the subset of species protected by IBAs.

## Results

### Effects of plans on bird species

*Number of species affected by each development direction.* We were able to evaluate the effects of development directions on the habitat requirements of the 194 bird species affected by plans. These effects will be negative in most cases (Figure 2). New irrigation will affect the habitat requirements of the largest number of species,

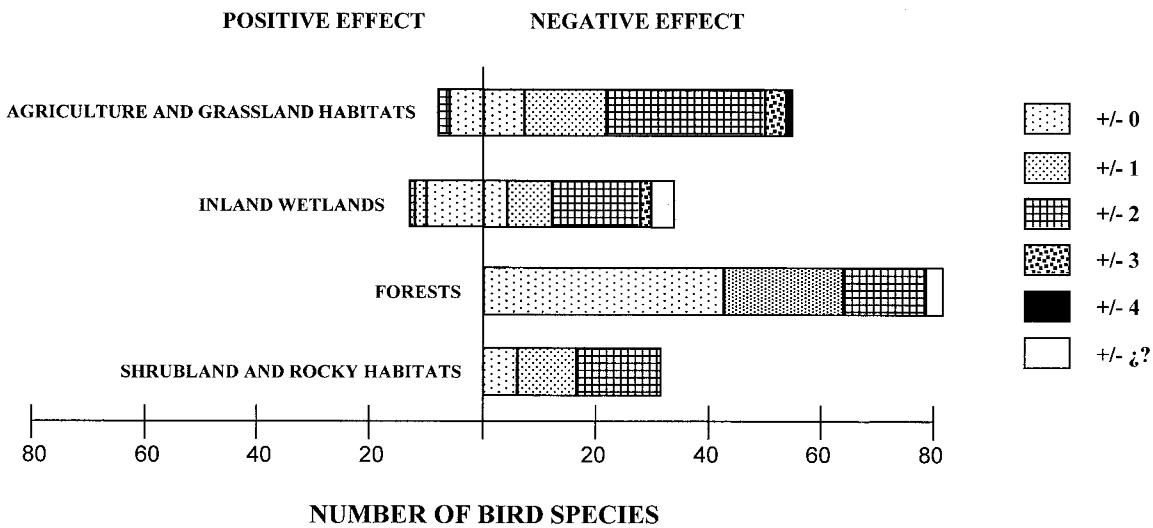


**Figure 3.** Number of bird species in each of the four main habitat types found in Castilla y León whose habitat requirements will be affected by the development actions proposed in the hydrological plan of the Spanish River Duero basin and the irrigation plan of Castilla y León. Also indicated is whether the effect will be positive or negative for the involved species, as well as the global impact factor of the plans on its distribution and abundance. (¿?: no estimation could be made because of lack of information). Details on the evaluations in which this figure is based on are available upon request.

followed by new reservoirs (44.7 and 33.4%; $N = 434$ evaluations; details on such evaluations are available upon request). Riverside alteration and human disturbance will each affect the habitat of only 11% of bird species. The proportion of the current distribution area that will be affected by each development direction was generally small (less than 10% in 39% of evaluations, 20%–50% in 26% of evaluations; Figure 2), although all directions will affect more than 50% of the distribution area of some species. The effects of new reservoirs will generally be local while irrigation, riverside alteration, and, especially, human disturbance will produce widespread effects (Figure 2).

*Changes in distribution and numbers of bird species.* Most of the effects of plans on the habitat requirements of bird species will produce strong changes in their patterns of distribution and population size (Figure 3). In all, 122 species (62.8%) will experience regional declines in their distribution (at the spatial scale of 500-$km^2$ grid cells) and/or in the order of magnitude of their population size. Alteration of forest habitats will negatively affect more than 80 species. These negative effects, however, did not translate into mensurable changes in patterns of distribution or in order of magnitude of population sizes in most cases (Figure 3). On the other hand, alteration of agricultural and grassland habitats will harm 55 species and benefit eight. For this habitat type, changes in the patterns of distribution and abundance will be strong enough to be detected at the spatial scale of the assessment in most cases (79%). In fact, changes will be severe in the case of the great bustard (*Otis tarda*), an endangered species that is expected to reach a global impact of −4 due to the reduction and fragmentation of its distribution area and a change of two orders of magnitude in its population size. Overall global impacts were −41 for shrubland and rocky habitats, −42 for inland wetlands, −51 for forests, and −83 for agricultural and grassland habitats. Average per species impacts were −1.3 ($N = 64$), −0.9 ($N = 79$), −0.6 ($N = 45$), and −1.3 ($N = 32$), respectively. Average per species impacts will thus be more severe in agricultural and grassland habitats and in shrubland and rocky habitats than in wetlands and forests (Kruskal-Wallis test: $H_3 = 21.4$, $P = 0.0001$).

*Effects of plans on conservation and economic value of birds.* The global impact on agricultural and grassland habitats was doubled when considering the Spanish status of species and was increased by a factor of 2.8 when considering their European status. The global impact on shrubland and rocky habitats was increased by factors of 1.8 and 2.6, respectively, the impact on inland wetlands by 2.5 and 1.9, and the impact on forests by 1.7 and 2.4. Finally, the consideration of the economic importance of birds as game species also increased the negative impact of the evaluated plans, since 74% of the 35 game birds found in the region were negatively affected. Further, these effects will be strong enough to translate into measurable changes in

Table 1. Impact of evaluated regional plans on bird species protected within IBAs

| Bird species | Population size in affected IBAs[a] | Affected (cumulative %) | Estimated population size in affected IBAs after development of evaluated plans | Population size within IBA network | Overall change (%) |
|---|---|---|---|---|---|
| *Ardea purpurea* | 60 | −60 | 24 | 60 | −60.0 |
| *Anser anser* | 35663 (winter) | −60 | 14265 (winter) | 35683 (winter) | −60.0 |
| *Anas platyrhynchos* | 11867 (winter) | −60 | 4747 (winter) | 11867 (winter) | −60.0 |
| *Milvus migrans* | 100 | −60 | 40 | 484 | −12.4 |
| *Grus grus* | 811 | −60 | 324 | 2811 | −17.3 |
| *Recurvirostra avosetta* | 82 | −60 | 33 | 82 | −59.8 |
| *Melanocorypha calandra* | 9000 | −60 | 3600 | 9000 | −60.0 |
| *Falco naumanni* | 1248 | −59 | 514 | 1248 | −58.8 |
| *Circus aeruginosus* | 92 | −58 | 39 | 106 | −50.0 |
| *Circus cyaneus* | 12 | −58 | 5 | 112 | −6.3 |
| *Pterocles alchata* | 240 | −55 | 108 | 240 | −55.0 |
| *Ciconia ciconia* | 772 | −53 | 359 | 1793 | −23.0 |
| *Pterocles orientalis* | 740 | −51 | 364 | 1080 | −34.8 |
| *Nycticorax nycticorax* | 502 | −50 | 252 | 624 | −40.1 |
| *Otis tarda* | 5819 | −49 | 2939 | 6159 | −46.8 |
| *Circus pygargus* | 740 | −48 | 387 | 906 | −39.0 |
| *Milvus milvus* | 1560 | −40 | 930 | 2369 | −26.6 |
| *Tetrax tetrax* | 1880 | −39 | 1140 | 2060 | −35.9 |
| *Burhinus oedicnemus* | 560 | −35 | 364 | 760 | −25.8 |
| *Bubo bubo* | 16 | −12 | 14 | 130 | −1.5 |
| *Gyps fulvus* | 296 | −10 | 266 | 3880 | −0.8 |
| *Neophron percnopterus* | 24 | −8 | 22 | 572 | −0.3 |
| *Hieraaetus pennatus* | 80 | −8 | 74 | 215 | −2.8 |
| *Falco peregrinus* | 52 | −6 | 49 | 165 | −1.8 |
| *Pernis apivorus* | 50 | −4 | 48 | 186 | −1.1 |
| *Perdix perdix* | 100 | −3 | 97 | 1189 | −0.3 |
| *Monticola saxatilis* | 100 | −3 | 97 | 454 | −0.7 |
| *Pyrrhocorax pyrrhocorax* | 200 | −3 | 193 | 3383 | −0.2 |
| *Circaetus gallicus* | 50 | −2 | 49 | 243 | −0.4 |
| *Aquila chrysaetos* | 7 | −0 | 7 | 147 | −0.0 |
| *Ciconia nigra* | 36 | ?[b] | ? | 87 | ? |
| *Aegypius monachus* | 18 | ? | ? | 352 | ? |
| *Aquila adalberti* | 36 | ? | ? | 36 | ? |
| *Hieraaetus fasciatus* | 2 | ? | ? | 50 | ? |

[a]Minimum number of individuals. IBAs: Important Bird Areas identified for Castilla y León (Viada 1998).

[b]?: no assessment was possible due to incomplete information on the location of development directions.

the distribution and population size of 14 game species, including the red-legged partridge (*Alectoris rufa*), one of the most important game birds in the region (Junta de Castilla y León 1997b).

### Effects of Plans on Birds Protected by IBAs

The development actions described in the plans will affect 16 of the 59 IBAs identified in the region (Viada 1998). The proportion of each IBA affected by such directions will vary between 2% and 80% (details on these evaluations are available upon request). Development directions will negatively affect the habitat requirements of all bird species protected by the affected IBAs. The cumulative percent changes in the population size of these species was estimated to vary between −2% and −60% of the former populations within the affected IBAs (Table 1). Estimates of overall population change only decreased by 3.2% on average (range: 0–21.9%) when considering the effect of the plans on the whole population inhabiting all IBAs, thus indicating that most of the populations of the involved species were concentrated in the IBAs affected by the plans (Table 1).

### Comparison of Estimated Effects on Regional Populations and IBA Populations

The order of magnitude of the decreases in the population size of birds protected by IBAs was significantly correlated across species with the changes in their regional population size ($r = 0.34$, $P = 0.04$).

However, the parameters of the linear regression model relating the $\log_{10}$-scored changes in regional population size (dependent variable) with the decimal logarithm of the expected absolute decreases of IBA populations (independent variable) showed that regional estimates of change tended to be consistently larger than the estimates based on IBA populations only [$a = 0.52$ (SE = 0.19), $P = 0.01$; $b = 0.18$ (SE = 0.08), $P < 0.001$; $t$ test for the null hypotheses of $a = 0$ and $b = 1$, respectively]. Part of these discrepancies could have been due to the fact that IBAs do not protect the whole regional population of these species. In fact, the linear regression model relating the $\log_{10}$-scored current population size in the region and the decimal logarithm of the population inhabiting the whole IBA network (Table 1) showed that the estimated population size for the whole region doubled, on average, the size of IBA populations for the 34 bird species listed in Table 1 [$b = 0.57$ (SE = 0.10), $P = 0.0001$; $a = -0.22$ (SE = 0.28), $P = 0.43$; $t$ test for the null hypotheses of $a = 0$ and $b = 1$, respectively].

## Discussion

### Use of Proposed Methodology in SEA Process

The integration of the information available on the habitat requirements of all bird species found in Europe, as well as on the effects of a wide range of management practices on such requirements, allowed the Dispersed Species Project to develop broad policy recommendations aimed at preserving and enhancing the diversity of European birds (Tucker and Evans 1997). The combination of this information with the available data on the distribution and population of birds at a regional scale, as well as with the spatial projection of the development actions included in two complementary regional plans of development, allowed us to go one step further by developing methods for the semiquantitative assessment of the effects of such plans on all bird species found in the plan region. Three main factors made this quantification possible: (1) the spatially explicit comparison of the distribution of both bird species and development directions; (2) the coarse-grained, regional scale of the assessment; and (3) the codification of the patterns of distribution and population size of birds.

Spatially explicit comparisons at a coarse-grained scale allowed us to estimate whether development directions will affect almost every bird species, as well as the proportion of their current distribution area to be modified. This permitted the evaluation of the relative effects of each development direction in terms of the changes in the pattern of distribution and in the order of magnitude of the population size of each species after the development of the plans. Codification of the patterns of distribution and population size of all species and of their conservation and economic value allowed us to compensate for interspecies differences in the quality of the information available, to weight expected changes according to the conservation status and the estimated economic importance of species, and to add up changes both within species and across habitats. These proprieties of the proposed methodology allow for the assessment of cumulative impacts on every bird species, highlighting the development directions and the habitat types with major impacts, and ascertaining whether impacts affect species with either low or high conservation and economic value.

### Regional Assessment for All Species vs Local-Scale Assessments for Indicator Species

The proposed methodology in based on the evaluation of the regional changes in distribution and population size of all species in a given group of organisms, so that these changes measure directly changes in the taxonomic diversity of that group (e.g., Ricklefs and Schluter 1993). Further, the comparison of our approach with an approach based on indicators (i.e., the threatened species protected by IBAs) show consistent results. Both analyses coincided in the main direction of the expected effects of plans on birds, in the relative importance of the proposed development directions, and even in the relative decreases expected for the subset of bird species that IBAs try to safeguard. This result is likely to be general as the evaluation of the effects on bird populations located within IBAs is necessarily included in the regional evaluation of all bird populations. On the other hand, estimates of losses based on the assessment of effects on the IBA network only were consistently lower than estimates for the whole region, both in terms of the number of bird species whose expected changes could be assessed and on the magnitude of such changes. Our regional-scale approach thus captured the main results of an assessment based on indicator species and provided further results on the remaining species of the same group. This fact overcomes the potential biases arising from the degree of representativity of indicators (see, e.g., Morrison and others 1998).

### Usefulness of Semiquantitative Estimates at Regional Scales for SEA Analyses

The semiquantitative approach developed here produces synthetic measures of the impact of each development action included in the plans on the overall diversity and on the conservation and economic value of the group of species analyzed. For instance, the case study presented here shows that new irrigations and reservoirs will have widespread harmful effects on birds (Figure 2), that these negative effects will be concentrated in agricultural habitats and forests (Figure 3), and that they will affect preferentially species of high conservation value and economic importance as game birds. These results indicate that the core objective of the plans evaluated (i.e., the promotion of irrigated agriculture) will have negative effects on birds. As these negative effects are measured, explicit comparisons of alternative plans would have been done if such plans had been developed by the corresponding authorities. For instance, it has been proposed that the widespread application of the European Agri-environmental Regulation (which promotes extensive agriculture) and the Afforestation Regulation (which promotes reafforestations on former arable land) will enhance bird diversity in agricultural areas (Tucker and Dixon 1997). This proposal can be evaluated with the methodology proposed here as far as concrete plans based on it are developed by the planning authorities.

Negative effects of plans on some aspects of the environment can be assumed by the planning authorities if they are somewhat compensated by other environmental, social, economic, or financial goals. Direct comparisons of the relative importance of these goals are difficult as they are measured in different units. However, the proposed quantification of the effects of plans on organisms will help to enhance the transparency of the environmental evaluation. Further, the consistency of its results with results from the evaluation of other goals (economic, financial) of the plans will be also enhanced as they are referenced to the same regional scale (Russell 1996) and permit explicit evaluations of the social and economic values of the species involved. For instance, we found that the evaluated plans will not reach the socioeconomic goals they have been drafted for, namely solving the regional problems of low income, aging population, and abandonment of rural areas (Hedo and Bina 1999). In addition, the conservation and economic value of the region's birds will decrease, thus reducing important sources of income based on recreational activities. Overall, we can conclude that the methodology developed here fulfills the requirements for its use within the SEA process to evaluate the consequences of policies, plans, and programs on the diversity of birds (see Introduction and Therivel and others 1992, Therivel and Partidario 1996, Therivel and Thompson 1996).

## Generalization of the Methodology

The proposed methodology can be extended to any other group of organisms as long as there is information available on its regional pattern of distribution, population size, habitat requirements, and the ways development actions could affect such requirements. However, it should be borne in mind that our methodology should have been validated by means of independent tests of its predictions and/or the premises it is based on (Morrison and others 1998) before extending it to other regions or other groups of organisms.

A direct test of the predictions will be done by measuring the distribution and population size of all bird species over the whole region after the full implementation of the analyzed plans. A more cost-effective alternative might have been to perform sensitivity analyses of critical parameters of the proposed methodology such as local extinction thresholds or to develop explicit comparisons of the evaluations of alternative plans (see, e.g., Brown and Rothery 1993). Finally, testing the premises of the evaluation (i.e., validating the wildlife-habitat models applied) is a much more promising alternative, as it would help solve a major drawback of the proposed methodology, i.e., the deficiencies in the information available on bird distributions, bird–habitat relationships, and the spatial scale of the bird responses to changes in habitat characteristics. In fact, most of the models summarized by the European Dispersed Species Project have not been validated and are in part based on agreements between bird experts rather than on sound field data (Tucker and Evans 1997). Validation of these models should include: (1) the development of quantitative models for the relationships between the presence/absence of species in grid cells and the habitat features of such cells (e.g., González and others 1990, Bustamante 1996, 1997); (2) the selection of grid sizes adjusted to the spatial scales relevant for each bird species (e.g. Edwards and others 1996, Lavers and Haines-Young 1996); (3) the calibration of presence/absence models to predict densities in reference areas (see Boyce and McDonald 1999, Díaz and others in preparation for a review).

Summarizing, proper development of wildlife–habitat models for the presence–absence and population size of organisms at relevant spatial scales will enhance the usefulness of the proposed methodology for SEA analysis. For best performance, these models should combine the criteria for the selection of independent variables followed by the Dispersed Species Project (i.e., should be based on expected land-use changes) and a modeling approach based on the explicit use of habitat selection theory, quantitative modeling, and model validations. This general approach will allow the application of knowledge on wildlife–habitat relationships to the conservation of biodiversity.

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