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ENVIRONMENTAL OBJECTIVES OF SPANISH AGRICULTURE: SCIENTIFIC GUIDELINES FOR THEIR EFFECTIVE IMPLEMENTATION UNDER THE COMMON AGRICULTURAL POLICY 2023-2030

OBJETIVOS AMBIENTALES DE LA AGRICULTURA ESPAÑOLA: RECOMENDACIONES CIENTÍFICAS PARA SU IMPLEMENTACION EFECTIVA SEGÚN LA NUEVA POLÍTICA AGRARIA COMÚN 2023-2030

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SUMMARY.—The next reform of the EU Common Agricultural Policy (CAP) for the period 2021-2027 (currently extended to 2023-2030) requires the approval by the European Commission of a Strategic Plan with environmental objectives for each Member State. Here we use the best available scientific evidence on the relationships between agricultural practices and biodiversity to delineate specific recommendations for the development of the Spanish Strategic Plan. Scientific evidence shows that Spain should (1) identify clear regional biodiversity targets and the landscape-level measures needed to achieve them; (2) define ambitious and complementary criteria across the three environmental instruments (enhanced conditionality, eco-schemes, and agri-environmental and climate measures) of the CAP's Green Architecture, especially in simple and complex landscapes; (3) ensure that other CAP instruments (areas of nature constraints, organic farming and protection of endangered livestock breeds and crop varieties) really support biodiversity; (4) improve farmers' knowledge and adjust measures to real world constraints; and (5) invest in biodiversity and ecosystem service monitoring in order to evaluate how the Plan achieves regional and national targets and to improve measures if targets are not met. We conclude that direct assessments of environmental objectives are technically and economically feasible, can be attractive to farmers, and are socially fair and of great interest for improving the environmental effectiveness of CAP measures. The explicit and rigorous association of assessments and monitoring, relating specific environmental indicators to regional objectives, should be the main

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criterion for the approval of the Strategic Plan in an environmentally-focused CAP 2023-2030.—Díaz, M. *et al*. (2021). Environmental objectives of Spanish agriculture: scientific guidelines for their effective implementation under the Common Agricultural Policy 2023-2030. *Ardeola*, 68: 445-460.
Key words: biodiversity, CAP reform, ecosystem services, scientific guidelines, Strategic Plan.

RESUMEN.—La reforma de la Política Agraria Común (PAC) para el periodo 2021-2027 (extendido en la actualidad a 2023-2030) exige que la Comisión Europea apruebe un Plan Estratégico por cada Estado Miembro con claros objetivos ambientales. En este trabajo desarrollamos recomendaciones específicas para la elaboración del Plan Estratégico para los sistemas agrícolas españoles, basadas en la mejor evidencia científica disponible sobre las relaciones entre la gestión agrícola y los componentes de la biodiversidad. La evidencia científica muestra que España debe 1) identificar objetivos regionales claros relativos a la biodiversidad de los medios agrarios y las medidas a nivel paisajístico necesarias para alcanzarlas; 2) definir criterios ambiciosos y complementarios para los tres instrumentos ambientales (condicionalidad extendida, eco-esquemas y medidas agroambientales y climáticas) de la Arquitectura Verde de la PAC, especialmente en paisajes sencillos y complejos; 3) garantizar que otros instrumentos de la PAC (zonas desfavorecidas, agricultura ecológica y protección de razas ganaderas y variedades de cultivos en peligro de extinción) favorecen realmente la diversidad biológica; 4) mejorar el conocimiento de los agricultores y ajustar las medidas a las limitaciones del mundo real; y 5) invertir en seguimiento de la biodiversidad y sus servicios ecosistémicos asociados con el fin de evaluar si el Plan alcanza los objetivos regionales y nacionales y mejorarlos adaptativamente si no lo consigue. Concluimos que la evaluación directa de los objetivos ambientales es técnica y económicamente viable, puede ser atractiva para los agricultores, es socialmente justa y de gran utilidad en la mejora de la efectividad de las medidas de la PAC. Una combinación rigurosa de seguimiento y evaluación de medidas y objetivos adaptados regionalmente mediante indicadores ambientales directos y claros debería ser el criterio que guíe la aprobación del Plan Estratégico para una PAC 2023-2030 centrada en el medio ambiente y orientada a la conservación de la biodiversidad.—Díaz, M. *et al*. (2021). Objetivos ambientales de la agricultura española: recomendaciones científicas para su implementación efectiva según la nueva Política Agraria Común 2023-2030. *Ardeola*, 68: 445-460.
Palabras clave: biodiversidad, Plan Estratégico, recomendaciones científicas, reforma de la PAC, servicios ecosistémicos.

INTRODUCTION

The Common Agricultural Policy (CAP) was the first common policy of the European Union (EU). It was implemented in 1957, takes a large share of the EU budgets (37% for the period 2014-2020), and impacts a high proportion of European landscapes (ca. 40% of terrestrial land; Navarro & López-Bao, 2018; Pe'er *et al*., 2020a; 2020b). The initial goal of the CAP was to maintain a self-sufficient agriculture that guaranteed food provision for European citizens at reasonable prices, an objective now considered as fulfilled (references in Pe'er *et al*., 2020a, 2020b). In fact, the successive reforms of the CAP ever since the 1992 MacSharry reform have moderated the EU's agricultural production, as food is produced in Europe generally in excess of needs. Schemes have been developed to subsidise the environmental benefits associated with extensive agriculture, aiming to ensure farmers' incomes and preventing rural abandonment. In fact, the current priority of the CAP is to overcome the serious environmental problems raised by intensive agriculture (pollution, biodiversity loss, climate change, and the abandonment of extensive systems of high natural value, among others), as well as socioeconomic problems also linked to agricultural intensification (mainly rural depopulation, increased regional inequalities and speculation with agricultural products and land).

Currently, the EU is discussing a new reform of the CAP for 2023-2027 (Pe'er *et al*., 2020a). The future CAP requires Member States to develop a country-level Strategic Plan including specific actions, funding allocated and evaluation protocols, that will then be implemented by competent authorities (Regional ones in Spain, mostly). This approach is in line with current knowledge on ways to design and evaluate effective and efficient measures to promote the environmental and social sustainability of farming systems (Díaz & Concepción, 2016). The need to design and implement CAP actions at the regional level is particularly relevant in the Spanish case, according to the latest analysis of the European Commission (EU, 2020). Strategic Plans must take into account regional variations of farming systems and be accountable, in order to be approved by the Commission (EU, 2020).

In late 2020 the main research groups that have been working on the conservation of biodiversity and its associated services in Spanish agricultural environments formed a working group. Our goal was to collate and synthesise the best scientific evidence available on the topic and to make it available to Spanish policymakers. A significant share of this evidence comes from studies on birds but results from a much larger array of other taxa and services have also been examined. In November 2020 this group conducted a workshop whose results, together with those of parallel workshops held in 13 other European countries, were published in early December 2020 (Pe'er *et al*., 2020b). The synthesis at the European level concluded that it is urgent to increase the protected area of grasslands, to increase funding to mitigate the negative effects of agriculture on biodiversity and climate, and to redistribute funds in order to finance explicit environmental and socio-economic objectives, which should be evaluated routinely. Furthermore, reports of the 13 workshops and additional enquiries to over 300 European scientists were presented to the Commissioner for Agriculture in a public event held on May 19th 2021 (Pe'er *et al*., 2021). Here, we offer specific recommendations for the development of the Spanish Strategic Plan based on scientific evidence available for Spanish agricultural systems.

Why should the Spanish Strategic Plan prioritise biodiversity goals?

National Strategic Plans should consider environmental objectives, which are a priority due to the current climate and biodiversity crisis but have scarcely been considered by public administrations so far (Pe'er *et al*., 2014, 2020a; Baur *et al*., 2016; Navarro & López-Bao, 2018, 2019). The European Commission advises specifically to focus on the conservation of biodiversity associated with Spanish agricultural environments (EU, 2020). Spain is the European country with the highest levels of biodiversity in its agricultural environments (Kleijn *et al*., 2006; Emmerson *et al*., 2016). Furthermore, of the total terrestrial species and habitats included in the Birds and Habitats Directives and present in Spain, 511 species (40%) and 111 habitats (48%) are linked to agricultural landscapes; 38% of these species and 23% of these habitats are of priority conservation concern under these Directives (Díaz *et al*., 2006). The mandatory protection of these species and habitats stems from the designation of Natura 2000 Network sites, which cover 27.4% of Spain's land area. Given that most Natura 2000 sites are agricultural land and their natural value depends on agricultural use, CAP measures are the main financial instrument for ensuring the conservation of biodiversity within the Natura 2000 network (EU, 2018).

The Spanish government has recently published three Spanish Strategies aimed at protecting ecosystem services associated with biodiversity in agricultural environments: the National Strategy for the Conservation of Pollinators (MITECO, 2020a), the National Strategy for Green Infrastructure and Ecological Connectivity and Restoration (MITECO, 2020b), and the National Strategy for the Conservation and Use of Wild Relatives of Crops and Wild Plants for Food Use (MAPA, 2020). Management of agricultural landscapes is key to achieving the objectives of these Strategies (Martin *et al.*, 2019). These Strategies mention the role of the CAP in funding the management actions needed to achieve their objectives, although they provide no details on how this will be done. Finally, biodiversity conservation greatly contributes to mitigation of, and adaptation to, climate change (Kremen and Merenlender, 2018), the other major objective of the CAP reform along with biodiversity conservation. Particular attention should be paid to synergies and possible trade-offs between these two major objectives (Ortiz *et al.*, 2021).

In conclusion, the Strategic Plan to be developed under the CAP reform should focus on explicit objectives referring to biodiversity in agricultural systems and its associated ecosystem services. These objectives should be the conservation, or increase as necessary, of both the species' populations of ecosystem service providers (number of individuals and area of distribution), the ecological communities in which they thrive (species diversity and their network of interactions), and the threatened habitats that are protected under biodiversity conservation regulations. Special attention should be paid to key ecosystem services associated with biodiversity, such as pollination, biological pest control, carbon storage, cultural services or reservoirs of genetic resources.

Identifying regional targets and designing a landscape-scale policy

Current scientific consensus establishes that effective conservation measures for agricultural environments must be based on the definition of explicit and quantifiable objectives at a regional scale, designed at the scale of agricultural landscapes, and their impact must be monitored and evaluated (Díaz & Concepción, 2016; Pe'er *et al.*, 2014, 2020a). Spain is a large and diverse country, with multiple types of farming systems of varying extent, problems and conservation needs. Each system is occupied by different species and habitats, and even different regions within each system harbour different species and habitats (Díaz e*t al.*, 2006). Different objectives should therefore be developed for each of the main agricultural and livestock systems present in Spain, taking into account regional biodiversity variations. Eight main agricultural systems have been identified in Spain based on their biological and agricultural characteristics (Supplementary Material, Appendix 2, Figure A1): 1) Mediterranean arable crops; 2) agro-silvo-pastoral systems (dehesas); 3) olive groves; 4) vineyards; 5) mixed Euro-Siberian systems; 6) extensive and transhumant grazing systems; 7) fruit orchards; and 8) rice fields.

Effective conservation of populations, communities and habitats needs to involve spatial scales larger than individual farms. Most species use several types of land cover, agricultural or semi-natural, during their daily or annual cycles, commonly spanning areas much larger than single fields or farms (Díaz *et al.*, 2013; Chapron *et al.*, 2014; García-Fernández *et al.*, 2019). For this and other reasons, levels of biological diversity at the field level, and responses of biodiversity to in-field management, are related to the structure of the surrounding landscape (Concepción *et al.*, 2008, 2012; Rey *et al.*, 2019; Guiralt *et al.*, 2021). A minimum level of landscape complexity is required for local diversity to increase, until a maximum threshold is reached in very complex landscapes, beyond which local diversity does not increase further (Concepción *et al.*, 2008, 2012). Landscape characteristics that influence complexity (presence of herbaceous or woody field margins, field size, intercropping, crop diversity and semi-natural habitats, among others), as well as the minimum and maximum complexity thresholds, vary among organisms depending on their requirements and mobility (Concepción *et al.*, 2008, 2012, 2020; Concepción & Díaz, 2011, 2019; Rey *et al.*, 2019; Martínez-Sastre *et al.*, 2020). Likewise, ecosystem services provided by biodiversity within individual fields or farms depend on the surrounding landscape, and that landscape may be key for the provision of services to these farms. Farms and their features can therefore be viewed as islands connected to each other and to the surrounding landscape through ecological processes delivered by animals; such as pollination, seed dispersal, predation or herbivory (Martin *et al.*, 2019). Ensuring the connection of these islands with each other and with other landscape elements is key to the maintenance of ecosystem services. Therefore, any policy instrument aimed at maintaining ecosystem services must consider the interactions of farms with the surrounding landscape at relevant spatial scales (García & Martínez, 2012; Alvarez-Martínez *et al.*, 2014; García *et al.*, 2018; Rey *et al.*, 2019; Martínez-Sastre *et al.*, 2020), as is indeed recognised in the National Pollination and Ecological Connectivity Strategies (MITECO, 2020a, 2020b).

In conclusion, the National Strategic Plan to implement the new CAP should (1) define specific biodiversity conservation objectives for each of the major farming systems in Spain, (2) adapt them regionally to the organisms and the threats to them present in each region, and (3) define actions at both the farm and the agricultural landscape scales. This general approach of regionalisation of objectives and mechanisms is in line with the recommendations of the European Commission for Spain (EU, 2020), as well as with current approaches to improve the environmental effectiveness of the CAP (Díaz & Concepción, 2016).

Using the complementarity of the CAP conservation instruments to achieve regional goals at landscape scales

The CAP 2023-2030 reform includes a Green Architecture composed by three instruments directly related to biodiversity conservation: 1) enhanced conditionality: mandatory for all farmers receiving CAP funds; 2) eco-schemes: mandatory for Member States but voluntary for farmers; and 3) Agri-Environment-Climate Measures (AECM): also voluntary for farmers and mandatory for countries as part of their Strategic Plans. AECM should be ambitious and specific, e.g. aimed at recovering populations of endangered species. Eco-schemes should be more general in their goals, e.g. enhancing biodiversity levels or restoring landscape complexity, and hence of much wider application. AECM are expected to be as effective as in the past (Batáry *et al.*, 2015) but it is foreseeable that the effectiveness of eco-schemes can be constrained by landscape-scale limitations unless adopted by a majority of farmers, as happened with greening of the current CAP. Mandatory measures, such as enhanced conditionality or measures that ensure wide-scale adoption, are thus needed, especially in areas of low landscape complexity (Díaz & Concepción, 2016).

In general terms, the proposal by scientists at the European level involves reducing production-linked payments (direct payments and coupled payments for industrial products such as cotton, wool or oils) and increasing eco-scheme and AECM payments. Indeed, it has been proposed that up to 30% of Pillar I of the CAP should be devoted to eco-schemes at the EU level, to the detriment of direct payments and the removal of limitations to allocate funds to AECM (Pe'er *et al*., 2020). For Spain we recommend that the distribution of specific actions between instruments and their funding should be based on three main criteria. Firstly, relevant environmental objectives for the eight main Spanish agricultural systems should be derived from European and national biodiversity and ecosystem service strategies, specifically the Birds, Habitats, Water and Soils Directives, the European Green Deal, the National List of Threatened Species and of Species of Special Interest, and the Pollinator, Green Infrastructure and Wild Relatives Strategies. Secondly, measures should be based on the specific requirements of the target species, communities or ecosystem services established as relevant regional objectives. And, thirdly, measures should be distributed between conditionality, eco-schemes and AECM in a way that mutually enhances their effects, taking into account landscape-scale constraints (Díaz & Concepción, 2016). For instance, conditionality would ensure minimum levels of landscape complexity by maintaining current non-productive landscape elements, eco-schemes to restore this complexity at landscape and farm scales, and AECM to design landscape configurations and management strategies for endangered species.

Specific actions with positive effects on biodiversity in relation to agricultural practices for each farming systems defined above are listed in the Appendix 1 (Supplementary Material). The Appendix 1 also indicates in which CAP instrument each action should be included to maximise its positive effect, providing specifications on implementation details at field and landscape scales in the many cases where they are known (e.g. minimum, general optimum, and specific optima for seminatural habitats at landscape and field scales, or specific fallow management schedules to enhance populations of endangered steppe birds). Among these actions, conditionality measures (enhanced conditionality in the future CAP) should be based on maintaining the minimum amounts of productive (e.g. agroforestry) and non-productive (e.g. field borders) areas that will comply with the European Birds, Habitats, Water and Soils Directives. The conservation of unique landscape elements such as isolated trees, stone walls, streams or ponds; field margin management and thus adjustment of field sizes; water management; and agrochemical use are common to all farming systems, but minimum amounts to ensure minimum landscape complexity differ between systems and, geographically, within systems (details in Díaz *et al*., 2006; Concepción & Díaz, 2019; Concepción *et al*., 2020). Several eco-schemes should include elements already addressed by the enhanced conditionality (see above), and should aim at promoting the restoration of these elements at landscape scales when insufficient, improving semi-natural elements and habitats to cover up to 10-20% of both farms and landscapes (Concepción & Díaz, 2019; Concepción *et al*., 2020; BioGEA project, 2020; Garibaldi *et al*., 2020). Other eco-schemes should be specific to particular systems, such as fallow management in arable crops, maintenance of grass cover in woody and mixed crops, management of stocking rates in extensive grazing systems and pastures or flood control in rice fields. Finally, AECM should target more specific conservation objectives. Their widespread success for increasing biodiversity in Spanish herbaceous systems (Kleijn *et al*., 2006; Concepción & Díaz, 2011; Concepción *et al*., 2012) would encourage promoting their implementation as eco-schemes to increase adoption by farmers. This has been done successfully in

Switzerland with the old agri-environmental measures, which were included in conditionality given their effectiveness and high adoption levels by farmers (Aviron *et al*., 2009). Further improvements of a more local nature can be the basis for new, more effective AECM, by adapting specific measures within schemes to the needs of regional targets. For instance, Tarjuelo *et al*. (2021) found that an increase of measures aimed at improving food availability (e.g. reduced pesticide applications) enhanced diversity of farmland birds at field scales, whereas balanced food- and shelter-measures (e.g. delaying harvest) enhanced bird abundance. Finally, basic research is still needed in the case of poorly known but very important systems, such as vineyards, intensive olive groves, several rain-fed and irrigated fruit-orchard systems (e.g. almond and pistachio groves), and rice fields. Urgent research is also needed to adjust local livestock loads, avoiding both abandonment and overgrazing, through specific eco-schemes integrated with other tools for assessing the effects of extensive livestock farming on biodiversity (Velado-Alonso *et al*., 2020).

Using other CAP instruments for the conservation of agricultural biodiversity

Some CAP instruments are not designed directly for biodiversity purposes but may however help conservation and its associated services if used appropriately. Areas of natural or other specific constraints (ANC) include funds that compensate for limitations on production due to climatic or edaphic factors. These constraints have often prevented the intensification of agriculture so that ANC are often home to endangered species or highly diverse communities. Compensation funds can be used to maintain biodiversity only if they are applied in areas with high levels of biodiversity and are sufficiently attractive to prevent land abandonment (Oñate *et al*., 2007) or the substitution of agricultural usage by infrastructures such as airports (López-Jamar *et al*., 2011), wind-farms (Gómez-Catasús *et al*., 2018) or solar power plants (Serrano *et al*., 2020). The best tool for locating ANC with high levels of biodiversity is High Nature Value Farmland (HNVF) mapping (Lomba *et al*., 2017). We therefore propose prioritising ANC that coincide with HNVF as recipients of payments (Navarro & López-Bao, 2018, 2019).

Organic farming regulations implement limits on the application of synthetic chemicals but do not guarantee high levels of biodiversity and ecosystem services. For example, the benefits of the absence of chemicals may be outweighed by the negative effects of increased mechanical tillage or irrigation to increase production (Hole *et al*., 2005; Ponce *et al*., 2011; Schneider *et al*., 2014; Clark, 2020). The area under organic cultivation cannot be considered as devoted to biodiversity conservation unless direct evidence of net positive effects is provided (Schneider *et al*., 2014). We therefore propose to establish monitoring indicators on farms with and without organic management that assess the impacts of these practices on biodiversity and its services. Monitoring would help ensure biodiversity benefits of organic farming, especially if combined with eco-schemes with explicit biodiversity goals.

Funding aimed to protect threatened livestock breeds and crop varieties may also be used for biodiversity conservation. Spatial correlations between presence and abundance of threatened breeds and/or varieties of crops and livestock, and biodiversity, have been documented, but in most cases it is impossible to establish whether there is a causal relationship between breed protection and biodiversity conservation (Velado-Alonso *et al*., 2020). Direct evidence of such positive effects on biodiversity is thus needed. Examples include the role of several free-ranging livestock breeds for the maintenance of large carnivores or scavengers (Bautista *et al*., 2019), the dependence of fruit-eating overwintering bird communities on mixtures of olive varieties of different phenology (Rey, 1995) or the role of some livestock breeds in the maintenance of local diversity of grassland communities (Rook *et al*., 2004). In the absence of such direct evidence, protection of the genetic diversity of livestock breeds and crop varieties should not be allowed to compete for funds with the conservation of wild biodiversity.

Increasing farmers' involvement in CAP biodiversity goals

One of the main challenges of CAP conservation measures is the low levels of adoption by farmers (Herzon *et al*., 2018; Pardo *et al*., 2020). Limited adoption of voluntary measures compromises the achievement of the minimum thresholds of complexity in the agricultural landscape that constrain the effectiveness of local actions (Concepción *et al*., 2008, 2012; Díaz & Concepción, 2016). Compulsory enhanced conditionality, complemented with attractive eco-schemes, is needed to build up a minimum green and blue infrastructure of semi-natural habitats in the simpler landscapes. The best option in very complex landscapes is to develop attractive compensation funds to avoid land abandonment or switching to non-agricultural usage, using either properly-funded ANC or AECM whose prescriptions match existing practices that maintain high biodiversity levels. AECM and more complex eco-schemes should be reserved and developed for landscapes of intermediate complexity (Concepción & Díaz, 2019; Concepción *et al*., 2020; Rey *et al*., 2019).

Improvement of take-up by farmers can be obtained by implementing the following four recommendations. First of all, simplification of paperwork is essential, especially for measures to be applied in the simpler landscapes (e.g. conditionality) and more complex ones (e.g. ANC). Disproportionate bureaucratic complexities relative to the economic benefit of environmental measures usually demotivate farmers, who tend to choose conservative options even if they imply lower economic and environmental benefits (Rook *et al*., 2004; Pe'er *et al*., 2017). A second factor is that training and advice to farmers for the application and management of CAP funds is usually led by professionals from the agricultural and financial sectors, with little or no participation of professionals from the environmental sector. This partly explains the low relative importance of environmental factors in farmers' decision-making (Kazakova *et al*., 2019a, 2019b; Pardo *et al*., 2020). Administrations should therefore support and advise farmers in their transition towards a more environmentally sustainable agriculture, that will also play an active role in biodiversity conservation (Gaba & Bretagnolle, 2020). Thus, advice to farmers should be extended to include professionals with environmental expertise (Navarro & López-Bao, 2018).

Thirdly, training and bureaucratic simplification should be reinforced by fair and attractive lost-profit compensations. Traditionally, low value-added alternatives of subsidised management options have been used for the calculation of income foregone, especially in marginal areas supporting high environmental values, making subsidies in these areas scarcely attractive economically. Two main alternatives to this calculation model have been proposed. The first consists in assessing profit loss based on more realistic alternatives than local agricultural intensification, such as the construction of large housing, transport or energy infrastructures that are increasingly occupying former marginal agricultural land (López-Jamar *et* *al*., 2011; Gómez-Catasús *et al*., 2018; Serrano *et al*., 2020). The second alternative consists in estimating the values of ecosystem services associated with biodiversity using economic tools based on simulated markets, whose development and official implementation will soon be mandatory (Rodríguez-Ortega *et al*., 2018; Campos *et al*., 2019). Transference of these values to farmer's accounts can be done through quality markets (Catarino *et al*., 2019a, 2019b; Olivares Vivos, 2021), payment for environmental services or land stewardship agreements (Miñarro & García, 2020), either included in the future CAP as criteria for subsidies or developed outside the CAP in the wider market. Rigorous demonstration of the environmental value of the farming practices involved is obviously required to avoid abuse of 'eco-labels' (e.g. Asensio *et al*., 2016). Finally, adoption of measures by farmers can be increased by direct assessments of the environmental and ecosystem services derived from CAP subsidies, especially if payments are partly or totally dependent on reaching biodiversity goals. The environmental effectiveness of subsidised actions is rarely assessed directly, by measuring the response of environmental variables such as diversity or associated ecosystem services (Kleijn *et al*., 2006; Batáry *et al*., 2015). Instead, management or agronomic indicators that may not be related to the environmental objectives of the actions are regularly used. Monitoring programmes of biodiversity targets are thus needed, designed in such a way that results of the assessments can be used to improve farmers' actions, policy designs, or both (Díaz & Concepción, 2016). Direct biodiversity monitoring and result-based payments would also provide greater credibility to the environmental objectives of CAP measures, encouraging their implementation by farmers (Pardo *et al*., 2020).

Closing the loop to improve CAP goals: direct monitoring of environmental targets

Available studies indicate that the costs of direct assessments of biodiversity responses and ecosystem services amount to a very low proportion of CAP budgets (Díaz *et al*., 2006; Geijzendorffer *et al*., 2016), which would make their routine implementation affordable. Standardised, cost-effective methods for the efficient measurement of direct indicators have been developed in the context of recent European research projects (Dennis *et al*., 2012; Herzog *et al*., 2012; Lüscher *et al*., 2016; Oppermann *et al*., 2017). Finally, certification systems aimed at incorporating the added value of biodiversity recovery in some agricultural systems (Valera *et al*., 2019) and activities, such as hunting, that exploit recreation ecosystems services (Linares & Carranza, 2012) are currently being developed. Adaptation of these certification systems for the evaluation of the performance of CAP tools seems promising.

Currently, the only official indicator of the environmental value of European agricultural systems is the Farmland Bird Index (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_bio2&lang=en). This indicator is based on a large-scale citizen science programme coordinated by a NGO, BirdLife International. Volunteer work implies that the spatial and temporal coverage of sampling is heterogeneous and, usually, too sparse to allow for monitoring at scales smaller than Member States (Díaz *et al*., unpublished). Bird monitoring methods can however be adapted to obtain indices that measure changes in the bird communities of an agricultural system due to changes in land use (e.g. caused by the expansion of irrigation in rainfed cereal systems; Giralt *et al*., 2021), although this adaptation usually implies professional resources to supplement volunteer work. Indicators based on other biological groups, such as weeds or pollinating insects, are already available (e.g. Herzog *et al.*, 2012; Lüscher *et al.*, 2016; Oppermann *et al.*, 2017), and should be incorporated into the monitoring of the effectiveness of CAP measures when regional objectives are based on these target groups (e.g. when measures seek to improve pollination services or overall biodiversity).

Concluding remarks

The current CAP reform will require the approval by the European Commission of a Strategic Plan with environmental objectives, since the main current goal of European agriculture is to reverse biodiversity loss and environmental damage, in order to become truly sustainable and socially fair (Pe'er *et al.*, 2014, 2020a; Baur *et al.*, 2016; Navarro & López-Bao, 2018, 2019). There is strong scientific consensus that effective conservation actions for agricultural environments should state, monitor and evaluate explicit region-specific targets for biodiversity in agricultural systems and their associated ecosystem services (Díaz & Concepción, 2016). Our review of the information available for the Spanish agricultural systems has shown that our level of knowledge is sufficient to develop effective measures, funded by the instruments available in the future CAP 2023-2030. The necessary increase in the adoption by farmers of effective measures can be achieved by tools included in the CAP framework if complementarity between Green Architecture measures is properly designed and funded. We also conclude that direct assessments of environmental objectives are technically and economically feasible, can be attractive to farmers, socially fair and of great interest for improving the environmental effectiveness of the CAP measures. The explicit and rigorous association of evaluations and monitoring with regionalised objectives of the measures through direct and clear environmental indicators should then be the main criterion for the approval of the Spanish Strategic Plan for the CAP 2023-2030, given its fundamental environmental character and focus (Díaz & Concepción, 2016; Pe'er *et al.*, 2020a, 2020b).

Acknowledgements.—This paper comes from results and discussion of an online workshop held on November 2020, organised by M. Díaz, E.D. Concepción and M.B. Morales under the EU-level coordination of Guy Pe'er. The workshop formed part of a set of scientists' workshops across the EU, coordinated by Guy Pe'er, Maren Birkenstock, Sebastian Lakner and Norbert Röder as part of the iDiv strategic project "iCAP-BES: Impacts of the Common Agricultural Policy on Biodiversity, Ecosystem Services and people". Francisco M. Azcárate, Gérard Bota, Lluis Brotons, Santiago Mañosa, Pedro J. Rey, José Eugenio Gutiérrez, Daniel García, Alberto Navarro, Rocío Tarjuelo, Fabián Casas, Ignacio Bartomeus, Carolina Puerta, Ana Carricondo, Irene Guerrero, Georgina Álvarez, Pedro P. Olea, José Vicente López-Bao, Carlos Palacín, Juan Carlos Alonso, Luis Miguel Bautista, José A. Sánchez-Zapata, Federico Fernández, Irene Guerrero, Begoña Peco, Marcos Miñarro, Javier Seoane, Susana Suárez-Seoane, Juan Traba, Francisco Valera, Elena Velando-Alonso and Gerardo Moreno attended the meeting and/or completed the templates used to organise and collate the information gathered. Out of these, this paper was written by MD, EDC, MBM, JCA, FMA, LMB, IB, GB, LlB, FC, DG, DGi, JEG, JVLB, SM, RM, MM, GM, AN, PPO, CP, BP, PJR, ChS, JS, SSS, RT, JT, FV and EVA and supported by Beatriz Arroyo, Juan Carlos Illera, Federico Fernández, François Mougeot, José Antonio Sánchez-Zapata and David Serrano, for presentation to the Spanish Ministries of Agriculture and Ecologic Transition. MD warmly thanks Asunción Ruiz (SEO/BirdLife) for her help and support along the whole process, and Clelia Sirami for her helpful and keen suggestions during revision. This work has been done without any financial support.

Author contributions.—MD, EDC and MBM organised the collation of information and coordinated the writing of the manuscript, led by MD. All authors collated and summarised the information requested and contributed to writing drafts and to the critical review, commentary and revision of the final manuscript, which was approved by all authors.

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Infographics / Infografía

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Supplementary Electronic Material

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Appendix 1:
Effective conservation measures for the eight main Spanish farming systems, with details of their major environmental effects, their regional variation, the spatial scale of their effects (farms, landscapes, or both,) and the CAP instruments into which they can be integrated (C: enhanced conditionality; EC: eco-schemes; AECM: agri-environmental and climate measures).
[Medidas de conservación eficaces en los ocho grandes sistemas agropecuarios españoles, detallando sus principales efectos ambientales, su variación regional, su escala espacial actuación (parcelas, paisajes o ambas) y los instrumentos de la PAC en los que se integrarían (C: condicionalidad reforzada; EC: eco-esquemas; AECM: medidas agroambientales y climáticas).]

Appendix 2:
Figure A1. Geographical distribution of the eight main Spanish agricultural systems.
[Distribución geográfica de los ocho principales sistemas españoles de cultivo.]

Submitted: March 30, 2021
Minor revision: May 10, 2021
Second version arrived: May 26, 2021
Accepted: May 27, 2021

Editor: J.A. Masero