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Agri-environmental Indicators: Land use, Pesticides and Biodiversity in Farmland

This document presents a summary of trends and main drivers of land use, pesticides and biodiversity OECD Agri-environmental Indicators.

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Key messages

This report analyses recent trends in agricultural land use, farmland bird biodiversity and pesticide sales indicators in OECD countries, considering some their linkages and the role of specific agri-environmental policies.

The key findings of the report are:

- The area of land used for agriculture has continued to decline in the majority of OECD countries, particularly in Western Europe, over the period 2002-14. The rate of decline has accelerated during this period compared to the previous decade. Despite this, agricultural output has increased 0.5% in the OECD region on average over the same period, signalling an increase in land productivity.
- In countries where permanent cropland makes up a significant share of total agricultural land, pesticide sales per hectare were significantly higher than the OECD average. Fungicides are the commonest pesticides sold in OECD countries (37% of all pesticides), followed by herbicides (32%).
- Farmland bird populations, an indicator for biodiversity in farmland, continued to decline over the most recent period of analysis (2002-14) in almost all OECD countries that monitor them. Moreover, the rate at which farmland bird populations declined has accelerated in the most recent decade.
- Key factors explaining declining farmland birds trends are: increased use of insecticides per hectare, the loss of landscape heterogeneity, particularly extent of crop fields without trees, bushes and other woody elements, as well as hotter temperatures.
- At the country level, agri-environmental support policies that tend to improve farmland bird populations are those that decouple support from production, such as those that provide payments for areas set aside or those that specifically target the conservation of high ecological value areas, wildlife or biodiversity. An econometric analysis focusing on 22 countries suggests that agri-environmental support policies are less effective at improving biodiversity when they are coupled with input use or production, such as those that impose environmental constraints or environmentally friendly practices on the production of a particular commodity or the use of specific inputs.
- The net impacts on biodiversity of agri-environmental policies that tend to improve biodiversity in one area are not clear. The reason is that such policies can decrease yields and production in the country in which they are adopted, which can stimulate land conversion to agricultural uses and higher production in other countries, potentially affecting areas with high biodiversity.
- The example of Switzerland illustrates that not only the quantity of set-aside areas but also the ecological quality is important in improving biodiversity promotion effectiveness. In particular, improving the quality of set aside can have large benefits for biodiversity, especially for farmland birds. The amount of high-quality set-aside areas on farms (6.3% of agricultural land) in Switzerland still needs to be

increased in order to maximise the effect of set-aside areas on the farmland bird population, particularly of those species that are at risk and have very specific needs in terms of habitats. In the coming years, increasing the quality of set-aside area will be fundamental to reverse or at least limit at-risk farmland birds decline.

1. Interactions between land use, pesticide use and biodiversity

There is widespread evidence that biodiversity in farmland is declining globally (Landis, 2017[1]). Declines in the diversity of plants (Kleijn et al., 2012[2]; José-María et al., 2011[3]), birds (Landis, 2017[1]; Donald, Green and Heath, 2001[4]; Donald et al., 2006[5]; Stanton, Morrissey and Clark, 2018[6]; Chamberlain et al., 2000[7]) and pollinators (Potts et al., 2010[8]; Bartomeus et al., 2013[9]) and of insects in general (Sánchez-Bayo and Wyckhuys, 2019[10]) have been documented, mainly in North America and Europe.

Multiple ecosystem services are potentially affected by biodiversity loss, many of them relevant to agriculture (Díaz et al., 2006[11]; Mace, Norris and Fitter, 2012[12]). These include regulating services such as nutrient cycle regulation, pollination, pest control, climate regulation and seed dispersal; provisioning services such as crop, livestock and medicine production; and cultural services such as landscape amenities for recreation or contemplation (Mace, Norris and Fitter, 2012[12]; Hardelin and Lankoski, 2018[13]). For example, notwithstanding there are different approaches to measure pollinator dependency of crops, pollinators are estimated to contribute to the pollination of three-quarters of the main cultivated crops worldwide (Hardelin and Lankoski, 2018[13]), mainly sustaining the production of diverse fruits, vegetables and seeds. Soil biodiversity – bacteria, fungi and earthworms – can improve the efficiency of water and nitrogen use (de Ruiter and Brown, 2007[14]). Insects can also provide biological pest control (Hardelin and Lankoski, 2018[13]). These ecosystem services are relevant at different scales: field, farm, landscape, regional and global (Hardelin and Lankoski, 2018[13]).

Changes in land and pesticide use are key drivers of change in farmland biodiversity, particularly farmland birds (Stanton, Morrissey and Clark, 2018[6]; OECD, 2018[15]). Excess nutrient applications can negatively impact biodiversity due to increased toxicity in the environment and nutrient enrichment, oxygen depletion in aquatic ecosystems, soil or water acidification or intensifying the impact of other stressors such as pathogens, invasive species and climate change (OECD, 2018[15]). Declines in agricultural land area, the loss of crop diversity, landscape heterogeneity (the combination of different land uses in a given space), and greater use of chemical inputs – all symptoms of the intensification of agriculture – are some of the main pressures faced by farmland birds in most OECD countries (Firbank et al., 2008[16]; Tilman et al., 2001[17]). The habitat quality for biodiversity in farmland also depends on the type of crops grown (Jerrentrup et al., 2017[18]; Turley, 2006[19]).

The intensification of agricultural activities can reduce biodiversity but so does the expansion of the agriculture frontier, which has mainly occurred in tropical countries in the last 30 years. More than 80% of forest clearing in tropical countries is attributed to agriculture, both for subsistence and for commercial purposes (Hosonuma et al., 2012[20]). While this expansion has made a minimal contribution to global production due to low yields, its environmental impact on biodiversity loss, greenhouse gas emissions and soil degradation has been large (Foley et al., 2011[21]).

By the end of 2027, biodiversity both within farmland and in natural areas will continue to be at risk from increased food production to satisfy increasing global demand for crops and food. Global demand for food is expected to grow at 1% per year in the coming decade mainly due to population growth (OECD/FAO, 2018[22]). To satisfy global demand, arable lands are likely to expand in South America, sub-Saharan Africa and South East Asia, increasing pressure on natural habitats and ecosystems, while the intensification process of agriculture is expected to keep increasing, mainly in Europe (OECD/FAO, 2018[22]), exacerbating environmental challenges.

2. Trends in land use, pesticides and biodiversity indicators

Due to the connection between biodiversity in farmland, land use and pesticides, this report mainly focuses on these three agri-environmental indicators.[1] Box 2.1 clarifies the nature of the data available before the rest of this section analyses recent trends.

[1] While other factors such as nutrient surpluses may also play an important role on biodiversity in farmland, nutrient balances were separately analysed in a dedicated chapter (OECD, 2018[65]).

Box 2.1. Indicators and data used

Area of agricultural land

This indicator covers four types of land use: total agricultural land, arable crops, permanent crops and pasture. In principle, total agricultural land is the sum of the area of arable crops, permanent crops and pasture but due to differences in the accuracy of the measurement of different land uses within countries, the sum of the components of agricultural land is not equal to the reported total agricultural land in some countries. This makes it difficult to assess changes in the components of agricultural land.

Pesticide sales per hectare of agriculture land (kg of active ingredients/ha)

This indicator is expressed as the ratio of total pesticide sales in a given country to agricultural land. It is important to bear in mind that this indicator is a proxy of environmental pressure at the national level, and does not consider sub-national heterogeneity. The national figure can mask important within-country heterogeneity. Care is required when comparing pesticide sales per unit of land across countries, because of differences in crop composition, climatic conditions and farming systems, which affect the composition and intensity of usage (OECD, 2013[23]).

Additionally, pesticide sales data do not convey information on the real levels of risk for ecosystems and human health, which depend on other factors including toxicity, mobility (how quickly the substances travel through air or water) and persistence (the time chemicals remain in the air, water and food) (OECD, 2013[23]). Pesticide sales might be different from pesticide use because pesticides are sometimes stored rather than used. For some countries, pesticide sales could also include sales for urban uses (e.g. road and rail verges), private gardens, golf courses and forestry land. Most OECD countries do not have readily available indicators for risk of exposure to pesticides.

Due to changes in the methodology for collecting pesticide sales in EU countries since 2009, trends in pesticide sales could not be produced and the report will only focus on average sales levels in the period 2011-15.

Populations of a selected group of breeding bird species that are dependent on agricultural land for nesting or breeding (index, 2000=100)

While there are several biodiversity indicators for farmland that could potentially be tracked (OECD, 2013[23]),[a] very few of them are consistently collected for multiple countries. One indicator that is available for multiple countries is the farmland bird index,[b] which tracks the population of a selected group of breeding bird species that are dependent on agricultural land for nesting or breeding. Indicators based on bird populations tend to be good indicators since, given their position in the food chain, they reflect the general health and changed of ecosystems (OECD, 2013[23]). In general, a decrease in the index means that the population abundance of bird species is declining, representing biodiversity loss. If it is constant, there is no overall change. An increase implies an increase in the farmland bird population. Note that a trend in the composite index of farmland birds can hide significant changes for individual species. An increase in the index could reflect an increase in abundance of some bird species at the expense of others. The index can also be quite volatile over time which could affect the assessment of its trends.

The farmland bird indicator used here mainly draws on Birdlife International's (BI) Pan European Common Bird Monitoring Scheme of the European Bird Census Council (European Birds Census Council, n.d.[24]), as well as national bird monitoring programmes. These national indices vary significantly in the number and type of species they include (ranging from 8 to

39 bird species, to reflect varying national situations), and the variety of methods used to derive the indices (see the detailed notes on OECD (2018[25]).[2]

Expanding biodiversity indicators to cover land use and habitat are needed to further strengthen the analysis and understanding of biodiversity in farmland and its interaction with other land uses. In terms of developing biodiversity indicators in farmland, some of the main conclusions of the OECD Workshop on the Use of New Technologies for Agri-environmental Indicators to Support Effective Policy Monitoring, Evaluation and Design indicators were: data from new technologies cannot fully replace data from the field, but it can help to augment the cost-effectiveness of biodiversity monitoring on farmland and data from satellite imagery can be used to create proxy biodiversity indicators based on land cover (OECD, 2018[26]). The advantage of such an indicator is that it can be readily available and easy to standardise; an example is the Wildlife Habitat Availability indicator calculated in Canada using Earth Observations or the High Nature Value farmland for the EU which uses CORINE data from the Copernicus programme.

a. Examples include biodiversity of pollinators, habitat quality indicators for biodiversity, and the genetic resources of plants and livestock.
b. In general, indices are first calculated for each species independently at the national level using sampling results from the field, then national-level species indices are aggregated to generate a single index.

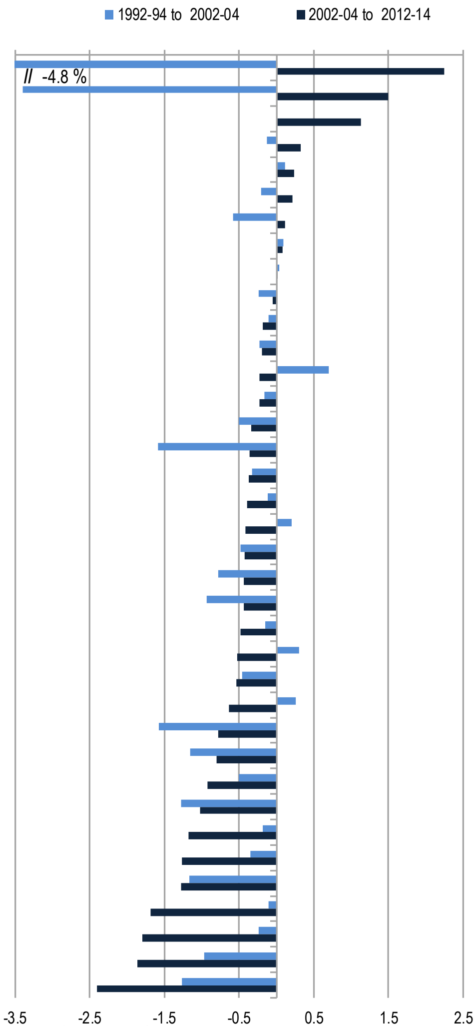
2.1. Agricultural land area continues to shrink in OECD countries while agricultural production increases

Agricultural land is declining in OECD countries and the rate of decline accelerated over the 2002-14 period. The majority of OECD countries experienced a decline in agricultural land during this period, except for Chile, Estonia, Finland, Greece, Ireland, Latvia, Luxembourg, Mexico and the United States (Figure 2.1). Moreover, in most of the countries where agricultural land has been shrinking, the rate of decline was faster during 2002-14 than during 1992-2004. From 2004 to 2015, lost cropland in OECD countries has mainly been converted to tree-covered areas (51% of the total) and artificial surfaces such as buildings and roads (37% of the total) (Figure 2.2), while 49% of the grassland lost was converted to sparse vegetation areas and 28% to tree-covered areas (Figure 2.3). There are regional variations in land conversion: in European OECD countries, cropland and grassland have been mainly converted to tree cover, while in the Asian and Oceanian OECD countries, cropland conversion has been dominated by artificial surfaces and grassland by sparse vegetation. In most OECD countries, this decline in agricultural land has not affected agriculture production, which has continued to increase.

Variation in the area of permanent pasture land drove most of the changes in the use of agricultural land in OECD countries during the period 2002-14. In Chile, Estonia, Greece, Luxembourg and the United States, the expansion of permanent pasture explains most of the changes those countries experienced, while in countries such as Austria, Iceland and New Zealand, which saw sharp declines in their agricultural land, permanent pasture shrank faster than arable land and permanent cropland.

[2] As of 2018, the OECD Secretariat started collecting the farmland birds indicators directly from OECD countries via a questionnaire. In 2019, the data collection will include more details about the species and the methods used to create the indicators to ensure comparability in terms of the definition of species and methodologies used across countries.

Figure 2.1. Agricultural land area is decreasing in the majority of OECD countries

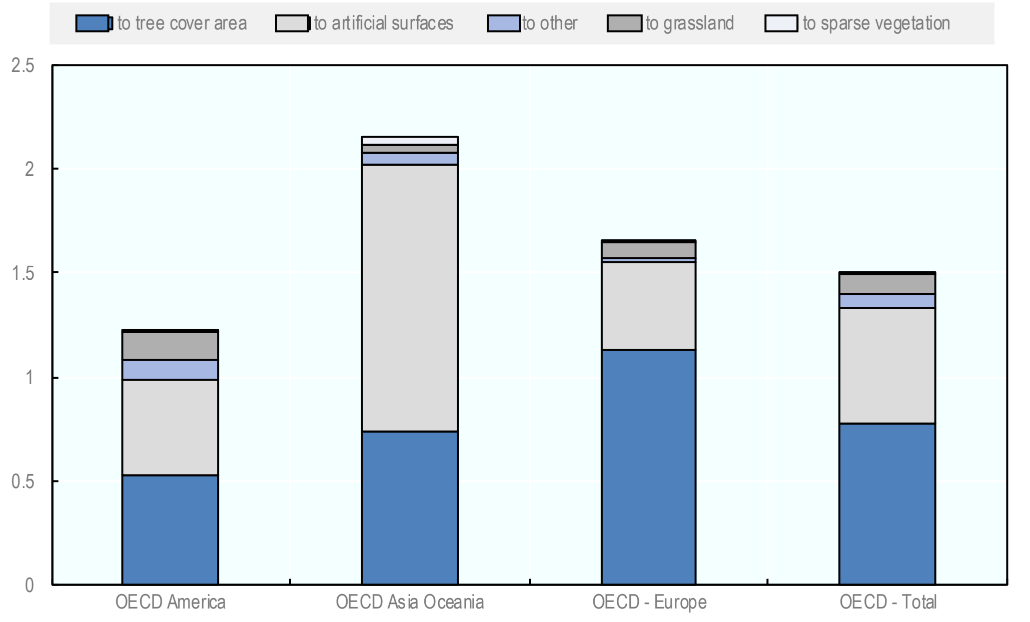


	Average (thousand hectares)			Average annual % change	
	1992-94	2002-04	2012-14	1992-94 to 2002-04	2002-04 to 2012-14
Estonia	1 265.13	773.13	965.53	-4.8	2.2
Latvia	2 270.30	1 606.47	1 863.70	-3.4	1.5
Greece	n.a.	4 783.71	5 350.40	n.a.	1.1
Ireland	4 404.73	4 349.30	4 492.09	-0.1	0.3
Luxembourg	126.60	128.10	131.18	0.1	0.2
United States	423 172.00	414 631.00	423 568.12	-0.2	0.2
Finland	2 379.80	2 245.00	2 270.33	-0.6	0.1
Chile	15 494.33	15 641.67	15 765.73	0.1	0.1
Mexico	106 182.33	106 556.67	106 705.00	0.0	0.0
Denmark	2 726.27	2 660.40	2 647.80	-0.2	0.0
Germany	17 174.63	17 000.87	16 697.23	-0.1	-0.2
Switzerland	1 591.46	1 556.30	1 525.63	-0.2	-0.2
United Kingdom	16 461.40	17 650.40	17 260.33	0.7	-0.2
France	30 129.90	29 644.33	28 968.87	-0.2	-0.2
Sweden	3 302.60	3 140.60	3 034.55	-0.5	-0.3
Czech Republic	4 282.00	3 650.61	3 520.82	-1.6	-0.4
OECD	1 306 346.29	1 264 323.55	1 217 572.29	-0.3	-0.4
Canada	61 772.18	61 050.12	58 660.60	-0.1	-0.4
Belgium	1 364.93	1 392.87	1 335.29	0.2	-0.4
Portugal	4 044.17	3 853.71	3 694.02	-0.5	-0.4
Japan	5 123.67	4 737.53	4 535.03	-0.8	-0.4
Slovenia	551.53	501.90	480.25	-0.9	-0.4
Netherlands	1 963.93	1 933.63	1 842.73	-0.2	-0.5
Norway	1 010.93	1 042.23	988.92	0.3	-0.5
EU15	134 022.93	127 954.14	121 263.07	-0.5	-0.5
Turkey	39 970.67	41 016.69	38 460.02	0.3	-0.6
Spain	29 784.47	25 421.93	23 509.82	-1.6	-0.8
Korea	2 129.33	1 894.67	1 748.04	-1.2	-0.8
Australia	465 032.79	442 216.12	402 785.98	-0.5	-0.9
Slovak Republic	2 428.50	2 135.70	1 926.90	-1.3	-1.0
Hungary	6 128.93	6 015.80	5 341.28	-0.2	-1.2
New Zealand	13 088.60	12 631.67	11 122.00	-0.4	-1.3
Poland	18 487.20	16 442.80	14 454.50	-1.2	-1.3
Iceland	1 906.47	1 885.33	1 591.03	-0.1	-1.7
Austria	3 455.13	3 372.17	2 814.06	-0.2	-1.8
Italy	16 704.37	15 160.83	12 564.75	-1.0	-1.9
Israel	434.99	383.00	300.12	-1.3	-2.4

Note: Countries are ranked from highest to lowest % annual growth rate 2002-04 to 2012-14. The annual growth rate was calculated using geometric growth rate. Agricultural land is defined as arable and permanent cropland plus permanent and temporary pasture. The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law. Data for Chile are not official and were obtained from FAO (FAOSTAT, 2018[27]).
Source: (OECD, 2018[25]).

Figure 2.2. Cropland in OECD countries has been converted to tree cover and artificial surfaces

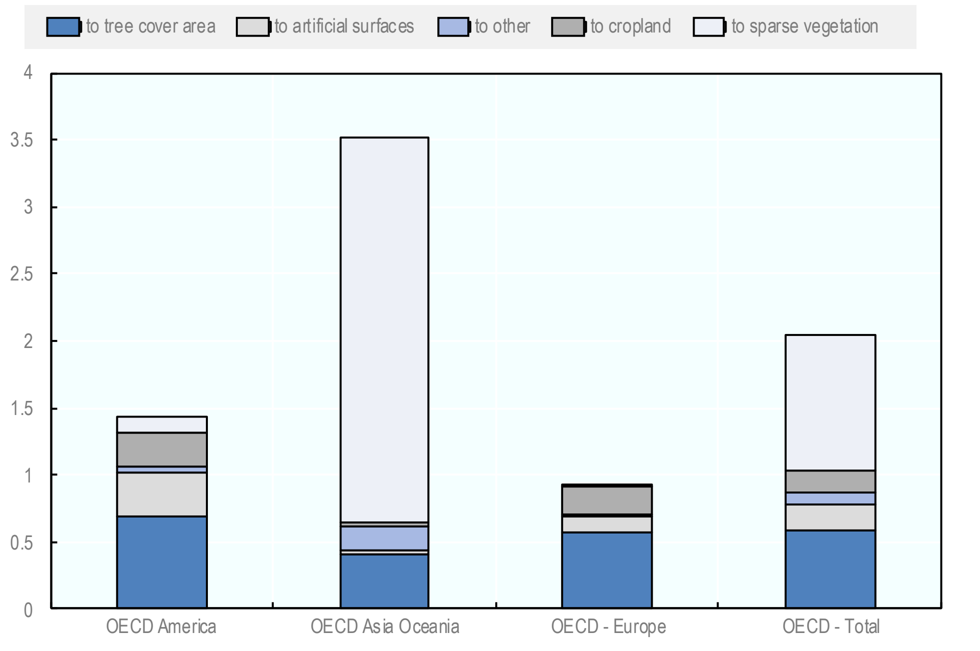
% change of cropland area in 2004 converted to other land cover types in 2015



Source: (OECD, 2018[28]).

Figure 2.3. Grassland in OECD countries has been converted to sparse vegetation and tree cover

% change of grassland area in 2004 converted to other land cover types in 2015



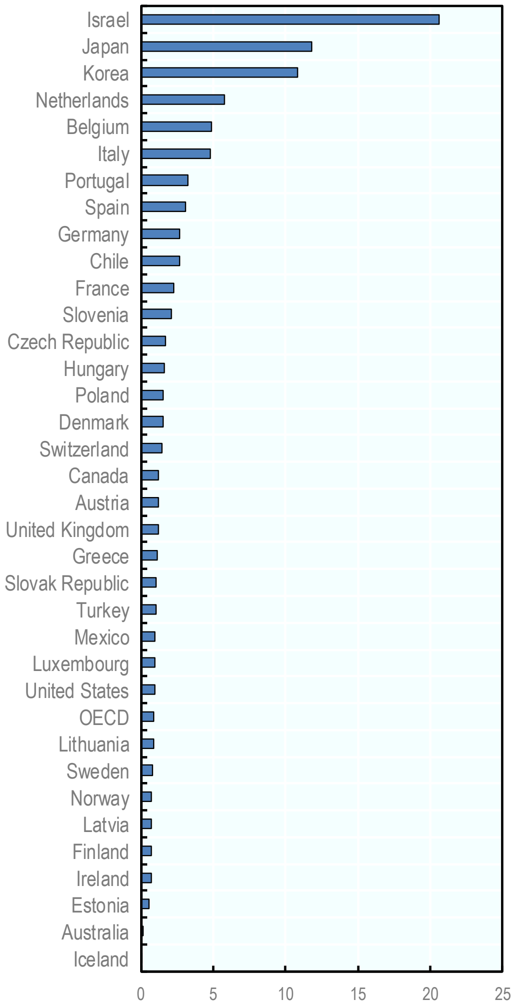
Source: (OECD, 2018[28]).

Pesticide sales in OECD countries averaged 0.93 kg/ha of agricultural land in the period 2011-15 (Figure 2.4). In countries like Italy, Portugal and Spain, that have relatively large pesticide sales per unit of land, permanent cropland makes up nearly 20% of all agricultural land, a share that is four times the average share in OECD countries. Permanent cropland is planted with permanent crops such as fruit and berry trees, bushes, vines and olive trees. On the other hand, in countries with low levels of pesticide use per unit of land, such as Australia, Iceland and Ireland, pasture makes up more than 80% of agricultural land, a figure that is twice the average share in OECD countries.

Fungicides are the most widely used pesticides in OECD countries (37% of all pesticides), followed by herbicides (32%) and insecticides (13%) (Figure 2.5). In Italy, Portugal and Slovenia, fungicides account for more than 60% of total pesticide sales, while in Australia, Canada, Denmark, Estonia, Finland, Iceland, Ireland, Latvia, Lithuania, Norway, Sweden and the United States, herbicides represent at least 60% of all pesticides sold. The type of pesticide used is associated with the level of usage per unit of land (using sales as a proxy for use): in countries where use (pesticide sales per hectare) is high, fungicides also make up a large share of total pesticide sales, while in countries where the use of pesticide per hectare is low, the share of herbicides tends to be high. In European countries, fungicide use is highly associated with the cultivation of grapes (EUROSTAT, 2007[29]).

Figure 2.4. Pesticide sales per unit of land vary significantly across OECD countries

Average annual pesticide sales, kg/ha (2011-15)



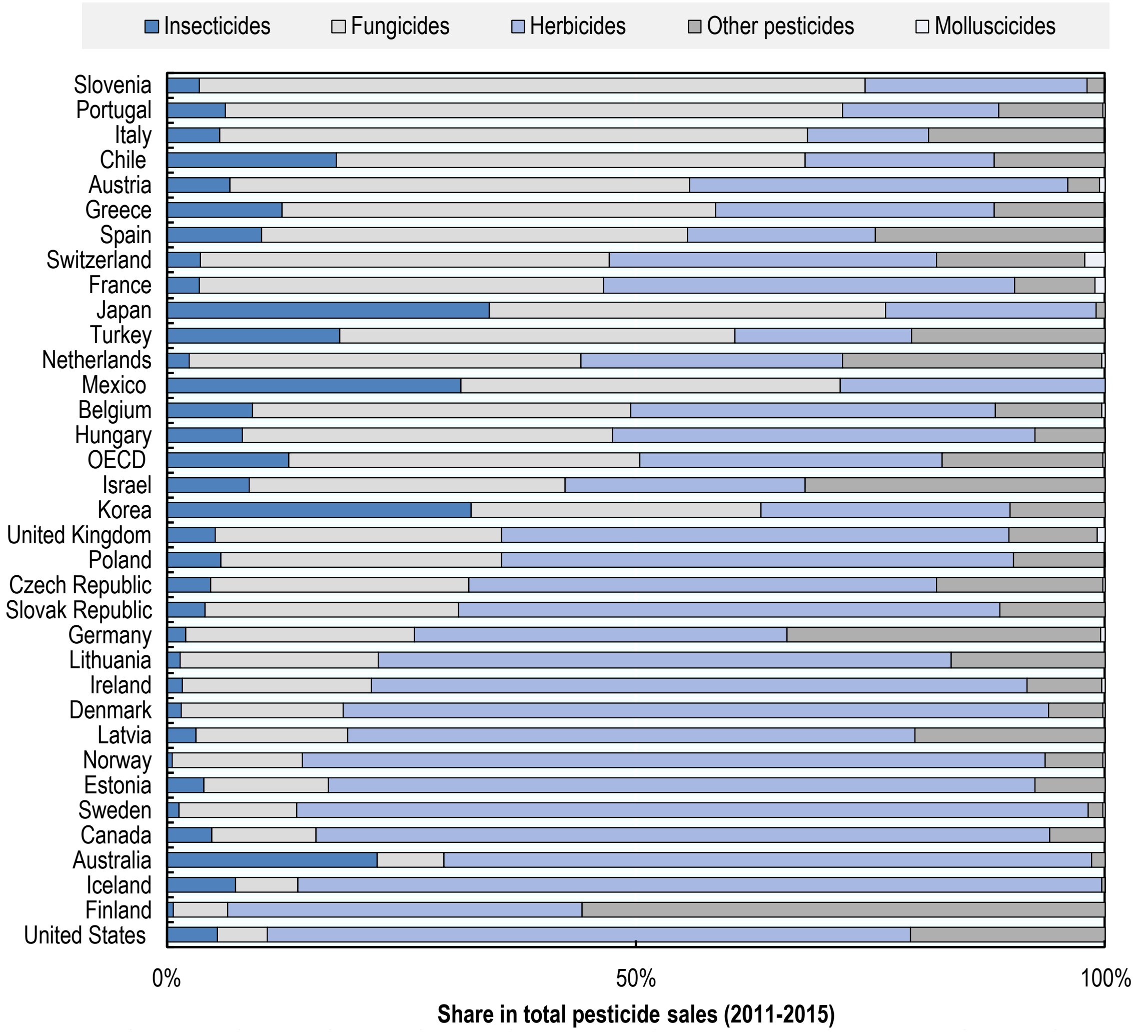
Country	Pesticide Sales (Tn)	Agricultural land (1000 ha)	Pesticide sales kg/ha
Israel	6046	293	20.6
Japan	53404	4532	11.8
Korea	18909	1739	10.9
Netherlands	10738	1846	5.8
Belgium	6490	1335	4.9
Italy	60748	12605	4.8
Portugal	11897	3686	3.2
Spain	72818	23664	3.1
Germany	45 560	16 709	2.7
Chile	42316	15772	2.7
France	66798	28975	2.3
Slovenia	1022	475	2.2
Czech Republic	6016	3512	1.7
Hungary	8588	5342	1.6
Poland	22678	14508	1.6
Denmark	4008	2650	1.5
Switzerland	2192	1526	1.4
Canada	72881	58605	1.2
Austria	3451	2806	1.2
United Kingdom	21050	17220	1.2
Greece	5862	5324	1.1
Slovak Republic	2056	1926	1.1
Turkey	40066	38432	1.0
Mexico	107440	106705	1.0
Luxembourg	132	131	1.0
United States	403932	420040	1.0
OECD	1 004 957 031	1 079 879 858	0.9
Lithuania	2487	2900	0.9
Sweden	2353	3039	0.8
Norway	746	986	0.8
Latvia	1307	1858	0.7
Finland	1591	2273	0.7
Ireland	3140	4492	0.7
Estonia	557	967	0.6
Australia	48455	396920	0.1
Iceland	3	1591	0.002

Notes:
1. Data for 2011-15 average refer to 2011-13 for Israel.
2. Pesticide sales in non- active ingredients for Mexico and Chile.
3. OECD average excludes Chile and Mexico as units are not in active ingredients.
4. Agricultural land area data for Chile are not official and were obtained from FAO (FAOSTAT, 2018[27]).

Source: (OECD, 2018[25]).

Figure 2.5. Fungicides and herbicides are the main pesticides sold in OECD countries

Average % of pesticides sales (active or chemical ingredients) by type (2011-15)



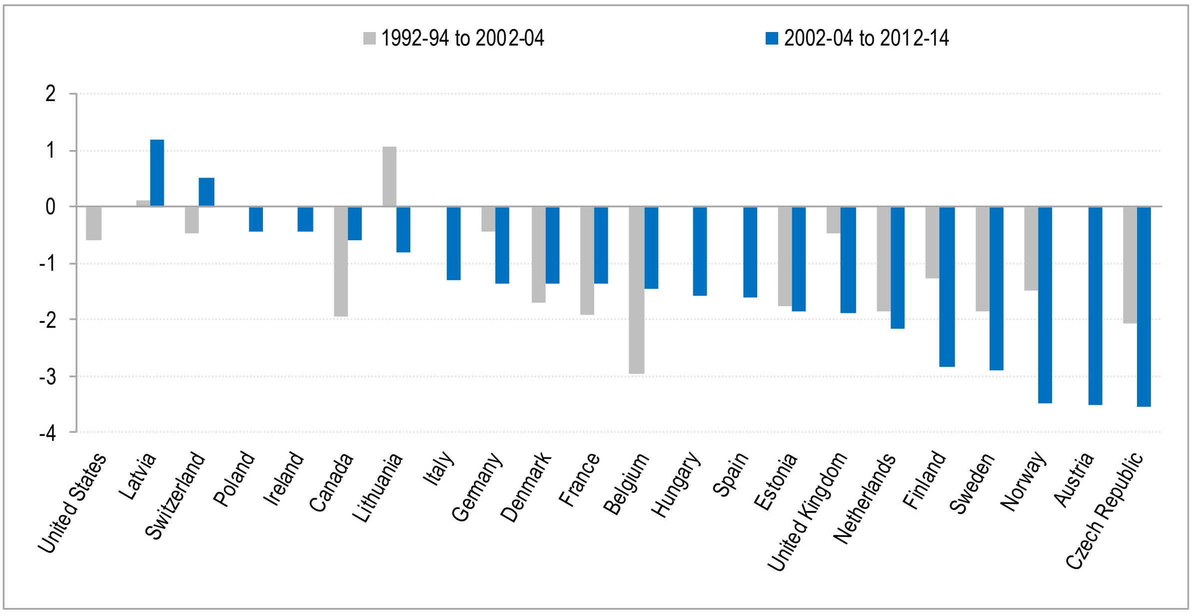
Note: Countries are ranked in descending order of average fungicide share.
1. Data for 2011-15 refer to 2011-13 for Israel.
2. Pesticide sales not in active ingredients for Mexico and Chile.
3. OECD average excludes Chile, Mexico as units are not in active ingredients.
Source: (OECD, 2018[25]).

2.2. Farmland bird populations continue to decline in OECD countries

The indicator of farmland birds continued to decline in the period 2002-14 in almost all OECD countries that monitor them (Figure 2.6). The exceptions were Switzerland, which reversed a decline in the farmland bird indicator in the period 1992-2004, and Latvia, where the slightly positive trends observed in the period 1992-2004 increased in the period 2002-14. Some countries, such as Belgium, Canada, Denmark and France were able to slow the rate of decline; in countries such as the Czech Republic, Estonia, Finland, the Netherlands, Norway and Sweden, the rate of decline became more pronounced during the period 2002-14.

Figure 2.6. Farmland bird indicators continue to decline in the majority of OECD countries

Average annual % change in farmland bird index (2000=100)



Note: Aggregated index of population trend estimates of a selected group of breeding bird species that are dependent on agricultural land for nesting or breeding. Annual growth rate was calculated using geometric growth rate. For Canada and the United States these are only grassland breeding birds. Countries are ranked in descending order according to average percentage change 2002-04 to 2012-14.

1. Data for 1992-94 refer to 1995-97 for Latvia, Lithuania and Norway.
2. Data for 2012-2014 refer to 2008-10 for Canada and 2006-08 for Spain.

Source: (OECD, 2018[25]).

3. The impact of agricultural intensification and agri-environmental policies on farmland birds

While agricultural intensification has resulted in increasing yields and has sustained food production for a growing population, it has also adversely affected biodiversity, particularly the population of farmland birds (Landis, 2017[1]; Donald, Green and Heath, 2001[4]; Donald et al., 2006[5]; Stanton, Morrissey and Clark, 2018[6]; Chamberlain et al., 2000[7]). Agricultural intensification can be broadly defined as a process which increases agricultural input use per hectare of land, usually leading to an increase in the level of production per unit of land, livestock unit and agricultural working unit (European Commission, 1999[30]). It comes in the form of increased chemical inputs and use of machinery, as well as the simplification of the agricultural landscape (Firbank et al., 2008[16]). Agricultural activities affect farmland birds in diverse and often interconnected ways (Chamberlain et al., 2000[7]): 1) reducing their food supplies; 2) providing less suitable nesting habitats; and 3) direct mortality caused by farming operations. Declines in bird populations could be the result of reduced breeding productivity or reduced survival outside the breeding season. Such declines usually observed with some lag following agricultural intensification (mainly by increasing the use of chemicals per unit of land, mechanisation and landscape simplification) (Chamberlain et al., 2000[7]).

OECD countries have adopted several types of policy instruments to counter the environmental impact of agriculture intensification. One of these is the use of agri-environmental payments – voluntary programmes that offer monetary incentives to farmers to implement environmentally friendly farming measures that go beyond those required by regulations (OECD, 2010[31]). These policies promote a wide range of practices, such as reduced chemical inputs, crop rotation, enhancement and improvement of habitats for wildlife, land retirement and conversion, buffer strips, field margins, and conservation of genetic resources (Science for Environment Policy, 2017[32]).

Agricultural practices that increase the ecological quality of uncultivated areas and that optimise and minimise the use of pesticides can be particularly beneficial for farmland biodiversity. Management and preservation of uncultivated areas in farmland such as field margins and buffers, grassland strips or patches can provide forage and nesting benefits for farmland birds (Stanton, Morrissey and Clark, 2018[6]; Aebischer et al., 2016[33]). Since the use of pesticides can negatively impact the population of farmland birds via direct poisoning or, indirectly, by affecting food availability (seeds and insects) and habitat for breeding and foraging (Chiron et al., 2014[34]), practices that support integrated pest management and that minimise pesticide applications can potentially reduce those negative impacts (Stanton, Morrissey and Clark, 2018[6]). The impact of organic farming is generally positive supporting biodiversity but the magnitude of the impact varies with organism groups (arthropods, plants, birds, etc.) and crop (Tuck et al., 2014[35]).

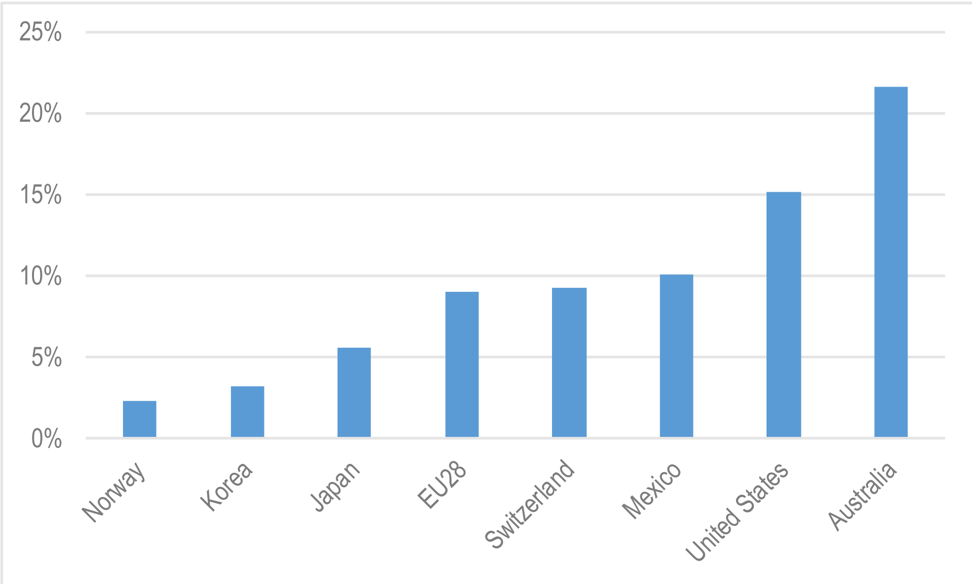
Agri-environmental payments are monitored by the OECD by measuring how much of the average Producer Support Estimate (PSE) comes with environmental constraints.[3] Environmental constraints can be mandatory or voluntary. Payments conditional on compliance with basic environmental practices are considered mandatory as those practices are a prerequisite for farmers to obtain direct payments. Payments with mandatory environmental constraints are also called "cross-compliance". Payments requiring specific practices going beyond basic requirements are voluntary as they are not a prerequisite for accessing direct payments. The latter include agri-environmental payments or schemes. The percentage of total PSE which has voluntary environmental constraints differs widely across countries (Figure 3.1). Among the countries that have PSE with voluntary environmental constraints in the PSE database, Australia has the highest share (22%) followed by the United States (15%), while Korea (3%) and Norway (2%) have the smallest. The distribution of support per hectare also differs widely. Over the period 2012-15, annual support with environmental constraints averaged EUR 428/ha in Japan, EUR 340/ha in Korea and EUR 285/ha in Switzerland, while the lowest support was in Mexico (EUR 4/ha) and Australia (EUR 0.4/ha).[4]

[3] The PSE refers to the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm gate level. In some countries, some transfers are conditional on farmers adopting pro-environmental practices or producing environmental goods and, therefore, are subject to environmental constraints.

[4] Payments per hectare were calculated by dividing the total support with voluntary environmental constraints by total agricultural land.

Figure 3.1. The share of the Producer Support Estimate which comes with environmental constraints varies widely across OECD countries

Average PSE with environmental constraints as % of total PSE (2012-17)



Source: (OECD, 2018[36]).

Agricultural support can be either coupled – linked to production or based on input use – or decoupled from production or input use, commonly based on non-commodity criteria. Most agricultural support with voluntary environmental constraints is coupled (72% (OECD, 2018[36])); of the remaining 28%, the majority is for long-term resource retirement (set aside) (OECD, 2018[36]). From the data available, it is possible to examine the impact of agricultural land use, the intensity of pesticide use and agri-environmental payments on farmland biodiversity by conducting an econometric analysis to test the effect on farmland bird indices of cropland, pesticide sales intensity and PSEs with environmental constraints (Annex A). The results of this econometric regression analysis are presented in Table 3.1 and show a negative relationship between coupled support with environmental constraints and farmland bird populations, and a positive relationship between decoupled support with environmental constraints and farmland bird indices.

The database used for the econometric regression is an unbalanced panel of 22 countries[5] over 24 years (1990-2014), which was constructed using several data sources (see Annex A). Using a fixed effects model to control for country characteristics, four models were estimated: Model (1) includes only land use variables (the land area used for fruits and vegetables, oil crops, cereals, and permanent pasture as a share of total agricultural area). Model (2) adds pesticide intensity of use by type (insecticides, herbicides, fungicides

[5] Farmland bird indices are mainly available for Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, the Netherlands, Norway, Poland, Spain, Sweden, Switzerland, the United Kingdom and the United States. For the United States and Canada, the data series are incomplete.

and bactericides and other pesticides) and nutrient balances. Model (3) includes temperature variables over 4 seasons: March-May, June-August, September-November and December-February. Model (4) is the most comprehensive specification, which also adds gross domestic product (GDP) per capita and PSE-related variables with environmental constraints. Based on the PSE classification, three PSE-related variables with voluntary environmental constraints were constructed: 1) coupled support with voluntary environmental constraints; 2) decoupled support with voluntary environmental constraints for the long-term retirement of factors of production; and 3) decoupled support with voluntary environmental constraints for the use of farm resources to produce specific non-commodity outputs of goods and services.[6] While voluntary environmental constraints can lower the environmental impact of coupled support, they may still not be as effective at improving environmental conditions as decoupled agri-environmental payments.

The findings show that an increase of 10% in coupled support with environmental constraints is associated with a 1% *reduction* in the farmland bird index (Table 3.1). A similar increase in decoupled support with environmental constraints on the use of farm resources to produce specific non-commodity outputs of goods and services is associated with a 6% *increase* in the farmland bird index. The coefficient of decoupled support with voluntary environmental constraints for the long-term retirement of factors of production is positive, but it is not statistically significant. Comprehensive reviews of the impact of agri-environmental schemes support these results and show that decoupled payments are more effective at improving biodiversity than coupled payments related to production (Batáry et al., 2015[37]; OECD, 2019[38]). While this evidence draws mostly from farm-level studies in specific regions within a given country, policies that promote land sparing (long-retirement) in one country can have unintended consequences. The reason is that land sparing policies can decrease yields and production in the country in which they are adopted, which can stimulate land conversion to agricultural uses and higher production in other countries, potentially affecting areas with high biodiversity (Green et al., 2005[39]; Fischer et al., 2008[40]; Balmford, Green and Phalan, 2012[41]).

Additional results show that the farmland bird index is positively associated with oil crops. A 10% increase in the land under oil crops as a share of total agricultural land is associated with a 0.6% increase in the farmland bird index (Table 3.1). The main oilseed crops produced in OECD countries are soybeans, rapeseed (canola) and sunflower. Rape crops can provide feeding and nesting resources for a range of farmland bird species (OECD, 2004[42]) and have been shown to be positively associated with farmland bird populations (Green, Osborne and Sears, 1994[43]), but less suitable for bird nesting and breeding than other types of crops, such as sugar beet (Glemnitz, Zander and Stachow, 2015[44]). In general, farmland bird diversity and density tend to be lower in maize cultivated lands (Jerrentrup et al., 2017[18]; Turley, 2006[19]). In the empirical analysis performed, the share of pasture area was not statistically significant, but several studies have reported the

[6] Support to agriculture in the European Union is either entirely financed by the EU or co-financed by the EU and member countries. Unfortunately, from the underlying databases for constructing the EU PSE it was not possible to recover all national-level PSE with environmental constraints measures, mainly because the EU-funded share is not available by country for the years before 2012. Another drawback of the EU-funded share is that, for the period that is available, it is not divided by type of support (coupled or decoupled). Hence, for EU countries the PSE variables with environmental constraints mainly represent the nationally funded shares of PSE with environmental constraints. Robustness checks of the econometric exercise included adding the EU-funded share; results of such exercise indicate that coupled support is negative and statistically significant although the number of observations sharply decrease.

importance of pasture for bird diversity (Cerezo, Conde and Poggio, 2011[45]; Hartel et al., 2014[46]). Additional factors that enhance the diversity of bird species are landscape heterogeneity, represented by a combination of crop fields and perennial features, such as trees, bushes and other woody elements, (Redlich et al., 2018[47]; Pickett and Siriwardena, 2011[48]; Cerezo, Conde and Poggio, 2011[45]) and small fields (Zellweger-Fischer et al., 2018[49]). There could be differences between low-ranging and wide-ranging species, with the former preferring more homogeneous landscapes (Katayama et al., 2014[50]).

Warmer temperatures in the summer negatively affect farmland bird indices. A 10% increase in summer temperatures reduces the index by 0.04% (Table 3.1). This finding is in line with research results that point at the impacts of long term climate trends on abundance and richness of birds (Stephens et al., 2016[51]; Pearce-Higgins et al., 2015[52]; Both et al., 2006[53]). One way in which climate change affects bird populations is that organisms in a lower position in the food chain (insects, flowering plants, etc.) are adapting to a hotter climate by bringing forward their seasonal activities, while birds are responding at a slower pace to a changing climate, generating misalignments between breeding time and food supply abundance (Both et al., 2006[53]).

The use of pesticides is considered a key driver of farmland bird declines (Stanton, Morrissey and Clark, 2018[6]; OECD, 2018[15]). Pesticides can directly impact birds by poisoning or indirectly by affecting habitat and disrupting food web chains due to removal of insect and seed food sources (BirdLife International, 2015[54]). The results of the econometric exercise show that a 10% increase in insecticide intensity (sales per hectare) is associated with a 0.4% decline in the farmland bird index (Table 3.1). Of particular concern for invertebrates such as pollinator colonies, and also for insectivorous birds, is the application of certain neonicotinoid insecticides (Hallmann et al., 2014[55]; Gill, Ramos-Rodriguez and Raine, 2012[56]). Since 2013, the EU has severely restricted the use of three neonicotinoids (clothianidin, imidacloprid and thiamethoxam) due to their potentially negative impacts on bee populations (European Food Safety Authority, 2018[57]). Some countries, like Denmark, France, Italy, Mexico, Norway and Sweden have implemented wider pesticide taxes to reduce pesticide risks (OECD, 2018[15]). While instruments targeted at single substances can reduce risks in the short-term, a proper evaluation of the unintended effects from these instruments, such as induced land use changes and potentially increased application rates of substitute substances, should be properly accounted for.

Table 3.1. Farmland birds may benefit from decoupled agricultural support with environmental constraints

	(1)	(2)	(3)	(4)
Share of fruits and vegetables in total agriculture land	-0.069	-0.085	-0.086	-0.086
	[(0.063)]	[(0.062)]	[(0.060)]	[(0.059)]
Share of oil crops in total agriculture land	0.053***	0.068***	0.065***	0.059***
	[(0.017)]	[(0.016)]	[(0.015)]	[(0.015)]
Share of cereals in total agriculture land	0.055	0.021	0.026	0.107
	[(0.088)]	[(0.115)]	[(0.114)]	[(0.096)]
Share of permanent pasture in total agriculture land	-0.037	-0.086	-0.076	-0.037
	[(0.027)]	[(0.060)]	[(0.060)]	[(0.058)]
Insecticides per hectare		-0.036*	-0.034*	-0.042**
		[(0.018)]	[(0.018)]	[(0.018)]
Herbicides per hectare		0.040	0.044	0.034
		[(0.032)]	[(0.032)]	[(0.030)]
Other pesticides per hectare		-0.009	-0.013	-0.005
		[(0.017)]	[(0.017)]	[(0.016)]
Fungicides per hectare		0.027	0.027	0.022
		[(0.017)]	[(0.017)]	[(0.018)]
GDP per capita				0.063
				[(0.122)]
Coupled support per hectare				-0.107***
				[0.027]
Decoupled support per hectare: long-term resource retirement				0.104
				[0.16]
Decoupled support per hectare: specific non-commodity output				0.602***
				[0.178]
Temperature Mar-May			-0.001	-0.0005
			[0.0012]	[0.001]
Temperature Jun-Aug			-0.004**	-0.004**
			[0.002]	[0.001]
Temperature Sep-Nov			-0.002*	-0.001
			[0.001]	[0.001]
Temperature Dec-Feb			0.0005	0.0003
			[0.001]	[0.001]
Nitrogen balance per hectare		-0.00001	9.80E-06	-9.25E-06
		[0.0001]	[0.0001]	[0.0001]
Phosphorus balance per hectare		0.0003	0.0003	0.0003
		[0.0007]	[0.0007]	[0.0006]
Constant	16.939***	17.193***	14.746**	32.012***
	[(2.640)]	[(5.789)]	[(5.859)]	[(8.865)]
Observations	453	404	404	404
R-squared	0.631	0.662	0.670	0.687

Note: Coefficients expressed in elasticities. The PSE variables reflect nationally funded measures, which means that for EU countries EU-funded measures are excluded. Coefficients were estimated using a fixed-effect model and robust standard errors are presented in parenthesis. *, ** and *** represent statistically significant coefficients at the 10%, 5% and 1% levels, respectively. All models include year dummies and a trend. Due to lack of data availability, the sample covers 1990-2014 for 22 countries. The models were estimated using STATA 15.

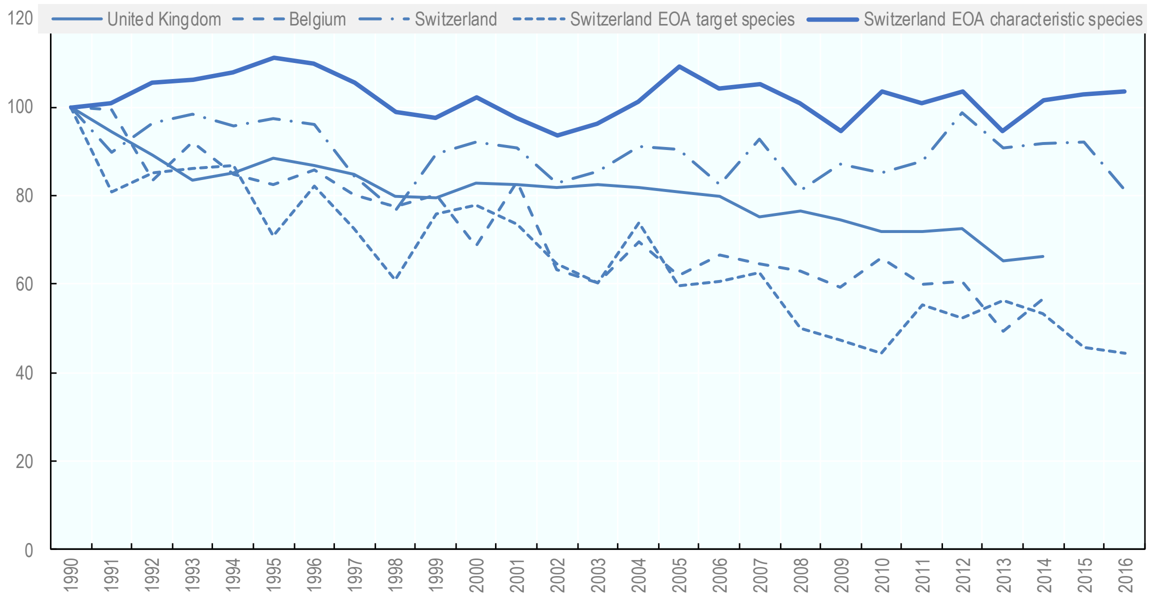
Sources: Data for pesticides were obtained from FAOSTAT (FAOSTAT, 2018[27]); land use data were extracted from FAOSTAT (FAOSTAT, 2018[27]) and OECD AEIs (OECD, 2018[25]); GDP per capita data were obtained from World Bank Development Indicators Database (World Bank, 2018[58]); PSE variables were constructed from PSE database (OECD, 2018[36]) and temperature data were obtained from the Climatic Research Unit (Climatic Research Unit, 2019[59]). Nutrient balances were obtained from OECD AEIs (OECD, 2018[25]).

4. Policy responses to farmland bird declines in Switzerland

The Swiss farmland bird index has remained stable since 2000. This indicator is composed of 38 bird species which are commonly found on farmland. An alternative index focusing on targeted farmland bird species, The Environmental Objectives of Agriculture (EOA) targeted species index, tells a less favourable story, however (Figure 4.1). The EOA index was created after the publication of the Environmental Targets for Agriculture by the Swiss Federal Office for the Environment and the Federal Office for Agriculture in 2008 and updated in 2016 (OECD, 2017[60]). The Environmental Targets for Agriculture set specific goals related to thematic areas, including biodiversity and landscape, climate and air, water, and soil (OECD, 2017[60]); it prompted a revision of the farmland birds indicator and proposed a more accurate methodology and definition of species to render the indicator more sensitive to policy changes and more linked to specific environmental goals.

Figure 4.1. Declines in farmland bird populations in selected European countries (1990-2016)

Farmland bird index (1990=100)



Source: Indices for the UK, Belgium and Switzerland were obtained from the OECD Agri-environmental Indicators database (OECD, 2018[25]). Switzerland EOA indices were obtained from Swiss Bird Index®, https://www.vogelwarte.ch/en/projects/population-trends/sbi-state/.

The Environmental Targets for Agriculture policy imposed specific targets for conserving and favouring indigenous species. In accordance with these objectives, the Swiss Ornithological Institute defined two lists of “targeted” and “characteristic” species from which two indices were derived. The EOA target species index is composed of 28 species, all of them facing different degrees of risk according to national assessments, as they are further classified as critically endangered, endangered, vulnerable or near threatened. Currently, four species (10% of the total list) are critically endangered. The characteristics species index is composed of 17 species, which are commonly found in specific habitats, such as hedgerows. Characteristic species have been relatively stable since 1990 (Figure 4.1), while the EOA targeted species index has been declining.

One of the most important agri-environmental measures for biodiversity conservation in Switzerland has been the creation of Biodiversity Promotion Areas (BPAs), previously called Ecological Compensation Areas.[7] The objective of the BPA measure is to create habitats for plants and wildlife. In order for farmers to be eligible for direct payments, they need to set aside 7% of their agricultural land as BPAs. Farmers can decide among 16 options for these areas with varying ecological qualities, including wildflower strips, meadows, extensively used pasture, hedgerows and other traditional farmland habitat. Additionally, in BPAs, input use is constraint; in particular, fertiliser use is prohibited, chemical controls and mulching are not allowed and grass must be cut and discharged at specific dates. Since 2000, farmers can claim additional quality-based payments for BPAs on which plants of particularly high ecological relevance grow (QII BPAs). To be eligible for QII BPA payments, in addition to fulfilling the aforementioned input constraints, the area subject for payment must prove its botanical quality or have specific structures for the promotion of biodiversity.

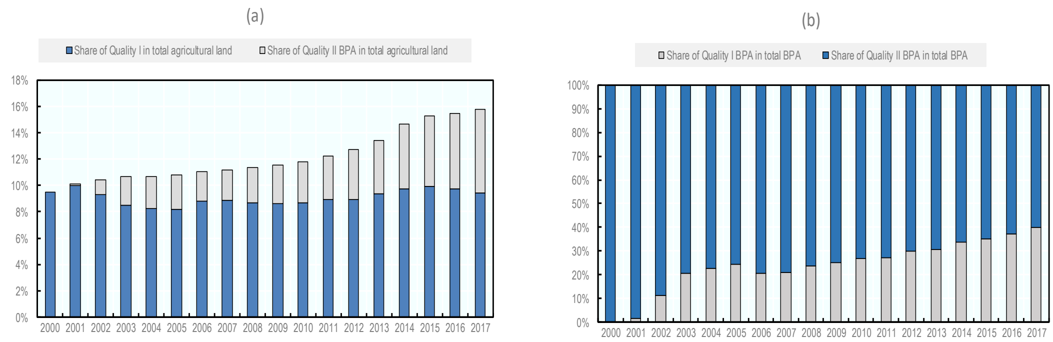
Overall, BPAs have had a moderate effect on supporting farmland bird populations at the landscape level (Birrer et al., 2007[61]; Herzog et al., 2005[62]), mainly improving bird populations that are not at risk without successfully halting the decline of at-risk and targeted species. A frequently cited reason for the limited effectiveness of this measure is that most BPAs are of relatively low ecological quality (Birrer et al., 2007[61]). Evidence shows that BPAs tend to be particularly successful at supporting biodiversity when they are of high ecological quality, such as wildflower strips or high ecological quality meadows (Meichtry-Stier et al., 2014[63]) and when they are established in ecologically suitable areas. When evaluated at the landscape level, species richness of birds and butterflies tends to decrease with lower BPA area in the landscape (Zingg, Grenz and Humbert, 2018[64]).

Subsequent agricultural reforms over the past two decades in Switzerland made the preservation, conservation and promotion of biodiversity one of the key objectives. As a consequence, direct payments to livestock farmers were removed and farmers received increased payments for meeting biodiversity goals such as devoting larger areas to extensive upland grazing, building ecological networks and increasing the share of high-quality BPAs. In 2002, high-quality BPAs accounted for 1% of total agricultural land and 11% of total BPAs (Figure 4.2). By 2017, this had risen to 6.3% of agricultural land and 40% of total BPAs. After 2014, following the latest reform in agricultural policies, high-quality BPAs increased by 20% and Switzerland became one of the OECD countries that spends more on agri-environmental payments per hectare (PSE support with environmental constraints) relative to other OECD countries (Figure 4.3). More importantly, nearly 90%

[7] The term Ecological Compensation Area was changed to Biodiversity Promotion Area in the 2014-17 agriculture reform.

of Switzerland's support with environmental constraints is now decoupled from production.

Figure 4.2. High quality BPAs have been growing over time but still represent a low share in total agricultural land



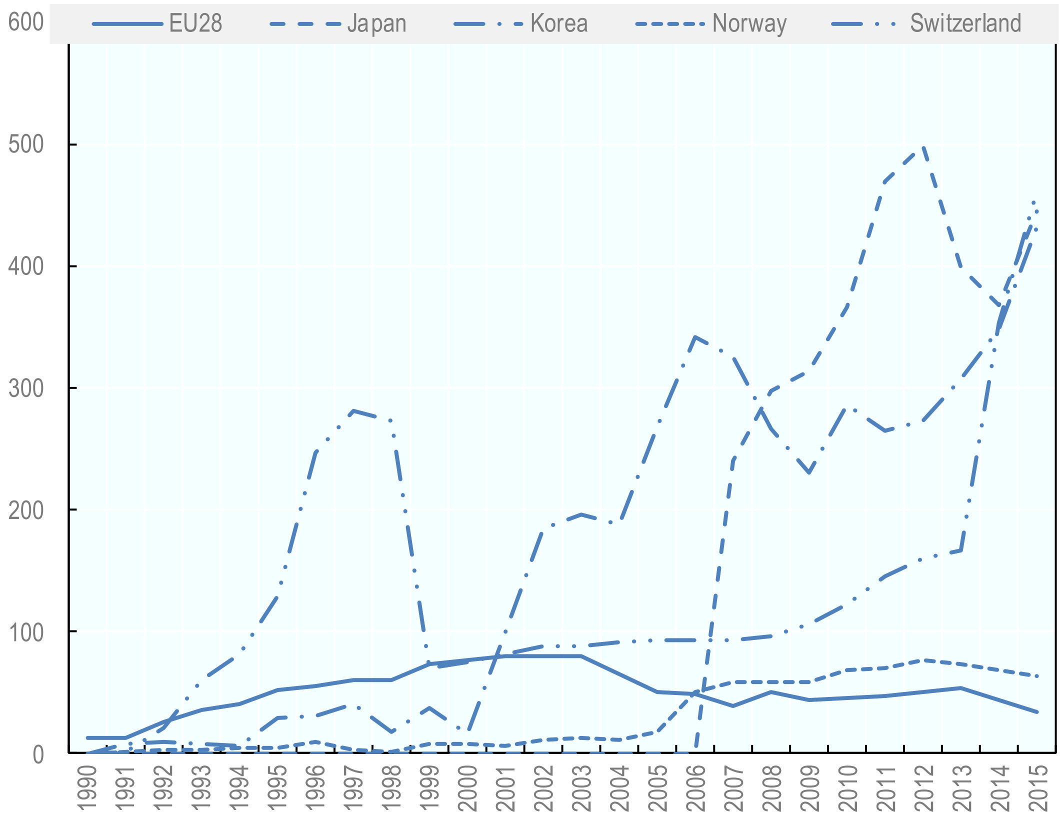
Note: Total agricultural land is total utilized agricultural area and does not include summer pasture.
Source: Swiss Federal Office of Agriculture (FOAG).

To improve biodiversity, the government has also promoted the establishment of ecological networks by linking biodiverse areas. Farmers participating in BPAs can also receive additional payments if they belong to a regional network of BPAs, which has to be developed and operated according to the guidelines of a regional networking project approved by a canton (local government). A networking project lasts eight years. As of 2017, 75% of BPAs belonged to a network.

While it is still too early to evaluate the environmental impact of the recent reforms on agricultural policies, including those of 2014, they have improved the targeting and decoupling of support for farmers which could have a positive impact on biodiversity in the medium and long term. The decline of at-risk species still represents a key challenge in Switzerland. Increasing the geographical coverage of high-quality BPAs could help to improve biodiversity in Swiss farmland. To completely reverse the negative trends observed for some species, and considering that other factors such as land-use change, climate change and crop mix, among others, impact farmland bird populations, Switzerland still needs to make increased efforts. It is estimated that high-quality BPAs should make up 14% of total farmland to support farmland bird populations (Meichtry-Stier et al., 2014[63]), particularly those at risk. At the same time, it is important to evaluate the potential impacts on yields and productivity of policies that aim at improving biodiversity on farmland to minimise their unintended effects such as the clearance of remote and highly valuable ecosystems for agriculture (Green et al., 2005[39]; Fischer et al., 2008[40]; Balmford, Green and Phalan, 2012[41]).

Figure 4.3. Agri-environmental payments increased sharply in Switzerland

PSE with environmental constraints (EUR/ha)



Sources: PSE data were obtained from the OECD Producer and Consumer Support Estimates database (OECD, 2018[36]), while land use data were retrieved from the OECD Agri-environmental Indicators database (OECD, 2018[25]).

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Annex A.

This Annex provides details about the econometric estimation performed to produce results reported in Table 3.1. The following fixed effects model was fit:

$$\log(Bird)_{ct} = \log(FrutVeg)_{ct} + \log(OilCrop)_{ct} + \log(Cereal)_{ct} + \log(Pasture)_{ct} + \log(Insec/ha)_{ct} + \log(Herb/ha)_{ct} + \log(OtherPest/ha)_{ct} + \log(Fung/ha)_{ct} + \log(GDPpercap)_{ct} + Coupled_{ct} + Decoupled\_Long\_Ret_{ct} + Decoupled\_Non\_Comm_{ct} + \sum_{i=1}^{4} Temp_{ict} + NBalance_{ct} + PBalance_{ct} + C + T + PestDumm + trend + \mathrm{e}_{ct}$$

Where variables $FrutVeg$, $OilCrop$, $Cereal$ and $Pasture$ refer to the share of fruits and vegetables, oil crops, cereals and pasture cultivated area to total cultivated area, respectively; pesticides sales are included separately by type and relative to unit of land (hectares): $\frac{Insec}{ha}$, $\frac{Herb}{ha}$, $\frac{OtherPest}{ha}$ and $\frac{Fung}{ha}$ denote insecticides, herbicides, other pesticides and fungicides, respectively. The variable $GDPpercap$ refers to per capita Gross Domestic Product. The main policy variables of interest are $Coupled$, $Decoupled\_Non\_Comm$ and $Decoupled\_Long\_Ret$. Agri-environmental support coupled with either input use or output is represented by the variable $Coupled$; decoupled forms of agri-environmental support are divided into two: based on long-term resource retirement,[8] $Decoupled\_Long\_Ret$, or based on specific non-commodity output,[9] $Decoupled\_Non\_Comm$. Four country average temperature variables ($\sum_{i=1}^{4} Temp_{ict}$) were included: March-May, June-August, September-November and December-February. Nitrogen and phosphorus balances are represented by variables $NBalance$ and $PBalance$. Country and year dummies were also included, C and T, to control for time-invariant country-specific elements (such as geographic characteristics) and time varying shocks, such as global market swings, weather shocks, etc. A trend variable, $trend$, and a dummy ($PestDumm$) that takes a value of one for European countries after 2010 were also added. The latter controls for changes in the methodology for measuring pesticides in European countries after 2010.

The data come from different sources. Cultivated area by crop type and pesticides sales come from FAOSTAT. GDP per capita from World Bank Indicators and coupled and decoupled support come from OECD PSE database. The database is an unbalanced panel with 22 countries spanning the period 1990-2014. Table A A.1 presents summary statistics of the data used for the analysis.

[8] These transfers are for the long-term retirement of factors of production from commodity production.

[9] These transfers are for the use of farm resources to produce specific non-commodity outputs of goods and services, which are not required by regulations.

Table A A.1. Summary statistics

Variable	Units	Mean	Std. Dev.	Min	Max
Farmland bird index	(2000=100)	95.302	14.186	58.200	157.400
Share of fruits and vegetables in total agriculture land	%	2.749	2.764	0.182	14.202
Share of oil crops in total agriculture land	%	5.396	4.071	0.050	16.518
Share of cereals in total agriculture land	%	30.696	14.030	5.999	58.503
Share of permanent pasture in total agriculture land	%	34.256	21.172	0.586	90.331
Coupled support with environmental constraints	1 000 EUR /ha	0.021	0.032	0.000	0.254
Decoupled support per hectare: long-term resource retirement	1 000 EUR /ha	0.002	0.007	0	0.086
Decoupled support per hectare: specific non-commodity output	1 000 EUR /ha	0.005	0.014	0	0.119
N balance per hectare	Kg/ha	75.562	59.232	6.661	321.000
P balance per hectare	Kg/ha	6.066	7.306	-8.000	38.000
Temperature Mar-May	°C	7.145	4.099	-9.300	13.500
Temperature Jun-Aug	°C	16.730	2.796	10.200	24.100
Temperature Sep-Nov	°C	8.458	3.764	-3.900	16.700
Temperature Dec-Feb	°C	-0.693	5.588	-21.900	8.400
Insecticides per hectare	Kg/ha	0.155	0.235	0.001	1.014
Herbicides per hectare	Kg/ha	0.798	0.637	0.087	4.009
Other pesticides per hectare	Kg/ha	0.212	0.267	0.001	1.829
Fungicides per hectare	Kg/ha	0.648	0.839	0.027	4.078
GDP per capita	US$/capita	38268.670	18081.230	5140.528	91617.280

Note: Total observations: 405.
Source: Farmland bird index, pesticides and nutrient balance per hectare were obtained from the OECD Agri-environmental Indicators database (OECD, 2018[25]); share of cultivated land by crop type to total land variables were calculated from FAOSTAT (FAOSTAT, 2018[27]); temperature data was obtained from the Climate Research Unit of the University of East Anglia dataset consisting of country averages at a seasonal frequency, where spatial averages are calculated using area-weighted means (Climatic Research Unit, 2019[59])