ENVIRONMENTAL COMPONENTS OF AGRICULTURAL SUPPORT POLICY: HOW DOES CANADA COMPARE WITH OTHER OECD MEMBERS?

by

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Executive Summary

As an avid consumer of natural resources, agriculture is a major source of environmental harm, but it is also seen as a potential contributor to its mitigation, indicating that environmental measures on agriculture could have positive impacts.

In this work we categorize the environmental components of agricultural policies reported by each country to the OECD's Producer Support Estimate database and develop variables that calculate five ratios that are used to compare the measures for Canada and three other developed OECD countries.

The results show that the performance of Canada is lower than expected given its commitments to action in the international scene, and that there is a lot to be done from an agricultural policy perspective to protect the environment and mitigate the impacts of agricultural activity.

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1. Introduction

Wealthier people have a higher demand for environmental quality (Day & Grafton, 2003) and are willing to make personal sacrifices to improve environmental conditions (Nevitte & Kanji, 1995) as they become more concerned about the environment. However, the position of Canada, a country with high GDP per capita, is not clear. Assessing the Canadian response to the Kyoto Protocol, Bernstein (2002) discussed a paradox regarding the country's stance on climate change policy; on one side promoting mechanisms that its own domestic policy and economic interests allow, while at the same time committing to actions beyond those constraints. Canada has intensified its ecological footprint but below the global average (Sarkodie 2021), requiring policies and incentives to solve environmental problems that it does not seem to have the luxury to solve on its own (Day & Grafton, 2003). These issues are expected to be accelerated by growing concerns about environmental impacts (Mamun et. al, 2019), and the needs to provide strong incentives for nations to consider adopting policies to develop rapid responses (Wang et al., 2018). These are reflected in international instances from the United Nations Framework Convention on Climate Change to the Kyoto Protocol and the Paris Agreement,

Agriculture, being an avid consumer of natural resources and a major emitter in terms of ammonia and greenhouse gases (Lankoski & Thiem, 2020), is recognized as a major source of environmental harm (Ruhl, 2002). Liu et al. (2017) cite other authors (Chel and Kaushik, 2011; Vermeulen et al., 2012) that state that agricultural activity and its production processes rely heavily on fossil fuels, accelerating global warming as a main source of direct and indirect greenhouse gases (GHG), and contributing between 19% to 29% of the global anthropogenic emissions. Therefore, the emissions derived from the agricultural activity are expected to have important implications on the design on environmental policies (Lichtenberg, 2002).

On the other hand, agriculture is also suggested as a potential contributor to GHG and other pollutant reductions (Goddard, 2021) through the implementation of measures such as using renewable energy, converting crops and residues to energy, and avoiding the use of artificial inputs using instead more natural ones. These activities can do a lot to mitigate climate change with a potential of reducing emissions up to 80% by 2030 (Liu et al., 2017). It looks like, then, that policies and incentives could be used to transform the agricultural production from a detrimental activity to a more beneficial one for the environment.

Most agri-environmental policies compensate farmers for the loss of income and the additional costs (Galati et al., 2015) resulting from deviating away from their most lucrative, and potentially harmful, practices (Baylis et al., 2008). Many of these policies encourage activities that produce environmental protection (Ferraro & Simpson, 2002), and in many nations these approaches have been recognized to mitigate harmful environmental impacts (Galati et al., 2015) that would otherwise be ignored if farmers were not compensated accordingly (Zhang et al., 2013).

Previous research (Eagle et al., 2016; Henderson & Lankoski, 2020) has also used the OECD Producer Support Estimate (PSE) database indicators to address factors such as the environmental consequences and impacts of agricultural policies in OECD countries, nevertheless this work follows a different approach by answering the question: To what level **do Canadian agricultural policy measures positively impact the environment and how do these measures compare to those of other OECD members**.

In this document we classify each of the policies that make up the PSE information into categories based on their expected environmental outcomes to produce an agri-environmental policy indicator that contains the aggregated values of the agricultural policies aimed to improve the environment either by generating environmental benefits or mitigating the environmental impact of the agricultural activity. This new agri-environmental indicator is then associated with five variables to assess the level in which the Canadian agricultural policy has intended to positively impact the environment over a 34-year span (from 1986 to 2019). We also compare these indicators with those from comparable OECD countries. The results provide objective insights into the relative position of Canada's agri-environmental policy investment level against its peers (developed OECD countries). The hope is that this comparison can serve as an incentive for the country to increase the inclusion of the environment as a key element of future agricultural policy development.

2. Literature Review

2.1 Agri-Environmental Measures

Most agri-environmental policies are measures that compensate farmers for the provision of environmental services targeted at reducing negative environmental externalities and increase the positive ones (Baylis et al., 2008). These payments are an aggregation of the loss of income and the additional costs incurred by the farmers in performing the incentivised measures (Galati et al., 2015). These policies address a market failure, as it implies that the farmer is compensated for deviating from other more lucrative agricultural practices (Baylis et al., 2008).

The concept has been addressed by many authors and perspectives as, beyond its role as a food and fibre producer, agriculture can also produce environmental outcomes such as renewable natural resources management and landscape and biodiversity conservation (Renting et al., 2009). Dupras et al., (2017) measured the value of landscape aesthetics and other ecosystem services to find the willingness to pay for an improvement of the environmental situation in agricultural areas, confirming the existence of demand for agri-environmental policies. Rodríguez-Ortega et al. (2018) developed and applied a framework to quantify the effect of beneficial agricultural practices on environmental services delivery, stating that improved tools are needed to set objective environmental targets and recognize farmers for delivering ecosystem services through agricultural policy.

Galati et al. (2015) suggested that agri-environmental measures have been recognized as an effective strategy for mitigating harmful impacts, citing other authors when pointing out that if land managers were not compensated for providing beneficial ecosystem services, they would ignore such services leading to decisions that are not optimal for the environment (Zhang et al., 2013). Direct payments to key farmers can encourage activities that produce environmental protection as a by-product (Ferraro & Simpson, 2002).

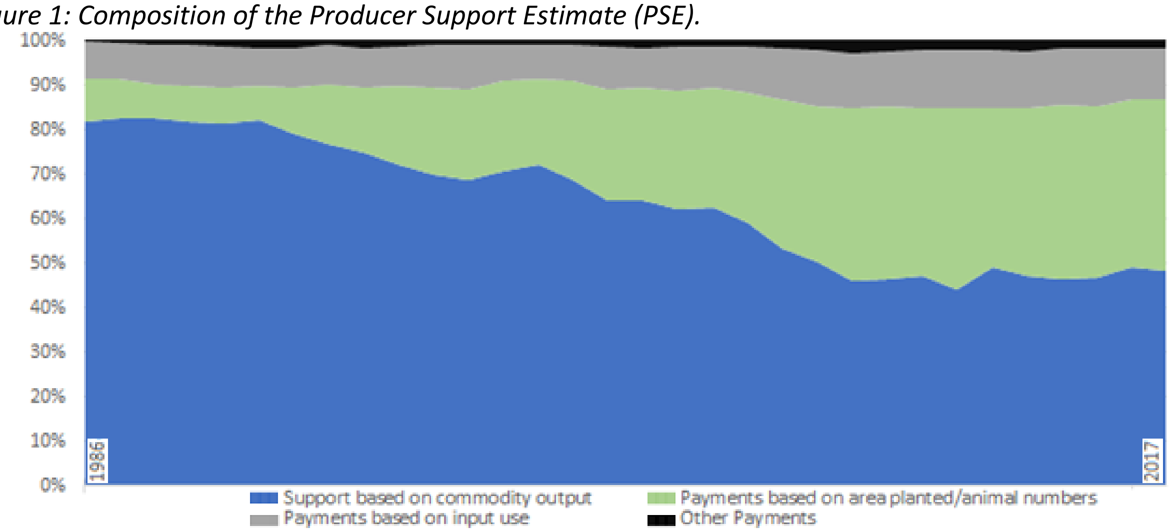
Baylis et al. (2008), suggested that producers should be required to meet certain minimum environmental standards to be eligible for any kind of agri-environmental financial support. This would ensure an efficient delivery of the expenditures. Baylis et al. conclude that this lack of requirement is one of the reasons why these policies are frequently not well defined.

2.2 OECD's Producer Support Estimate (PSE)

The agricultural support measures implemented by each country are compiled by the OECD to a Producer Support Estimate (PSE) indicator, formerly called the Producer Subsidy Equivalent (also PSE). The producer support estimate is a highly visible result of OECD work on agriculture (Tangermann, 2005), defined as "The annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures that support agriculture, regardless of their nature, objectives or impacts on farm production or income" (OECD, 2021).

The PSE measures support arising from policies targeted to agriculture, indicating contributions to help finance the policy measure providing implicit and explicit transfers to producers (OECD, 2021). Its value is obtained by calculating Market Price Support (MPS) for individual commodities and aggregating them into a national MPS, the main component of PSE (Oskam & Meester, 2006), that is then combined with other policy transfers that support individual producers. (OECD, 2016).

Figure 1: Composition of the Producer Support Estimate (PSE).



Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

The Producer Support Estimate is one of the best-known measures used all over the globe. (Oskam & Meester, 2006). Even when the OECD's approach has been criticized and questioned, it is the only available source of internationally comparable information of agricultural support levels and attracts much attention in agricultural policy reports (Tangermann, 2005). Therefore, the concept has been widely used as a base for policy related research such as evaluating environmental impacts (Henderson & Lankoski, 2020), elaborating the effects of policy on producers in the European Union (Anders et al., 2004) or using a PSE approach to conduct economic analysis (Lema & Gallacher, 2015; Đurić et al., 2019).

The PSE uses highest analytical standards to monitor the nature, evolution, and impact that the policies have on agricultural production, trade, and the environment (Tangermann, 2005), but it is no more and no less than one summary indicator conceived to measure policy efforts, not policy effects, as payments made to producers do not always produce the environmental objectives they aim (Baylis et al., 2008). Consequently, the analysis of ratios obtained from the values of the Producer Support Estimates and other variables in this document, will not reflect the actual environmental impacts of the policies. Instead, it will reflect the intention of the legislators and the commitment of each country's administration towards the environment.

The PSE concept provides a structure to examine all the policies affecting agricultural production, consumption, and trade (Cahill & Legg, 1990), and as the goal of this study is to compare the environmental components of the agricultural support policy, the PSE provides a framework to extract those environmentally related policies in, as stated by Cahill & Legg (1990), a rigorous and disciplined comparative assessment.

2.3 Agricultural Land Use and Emissions

One of the most important drivers of land use are economical outcomes. Hence, it is no surprise that the most important function for agricultural land are its outputs, as stated by Li et al., (2020). However, these authors also point out the increasing risks caused by the use of excessive inputs, such as chemical fertilizers and pesticides, and inappropriate behaviour of farmers who seek economic outcomes from the lands they manage. Therefore, the expectation of higher economic outcomes incentivizes potentially harmful agricultural practices that, in our assessment should be a driver of agri-environmental policies to mitigate those negative impacts.

Lankoski & Thiem (2020), point to ammonia and greenhouse gas emissions as two negative outputs of agriculture. These are the same emissions that Wang et al. (2018) address as major issues for human development and environmental impacts. The negative effects of these emissions derived from the use of fertilizers are pointed to as a main issue for the sustainability of agriculture (Verdi et al., 2018) and several studies have addressed methods of mitigation (Newell-Price et al., 2011; Wang et al., 2018; Wei et al., 2018)

3. Data

3.1 Overview

Because of the differences in factors such as economy, size, population, policies, among many other characteristics, comparison between countries may require analysis deeper than straight contrasts. We believe that a better approach would be to compare the performance of the countries based on indicators and ratios created by introducing other variables to examine possible differences. In this document we compare the environmental components of agricultural support policy in of Canada and four other OECD members for a period of 34 years, by calculating ratios from five variables that have also been reported to the OECD.

The objective of this study is to compare the environmental components of agricultural support policy, which we call agri-environmental support, and indicators regarding this subject can be found in plenty of sources varying from government websites to academic journals. However, since every author presents the data depending on their own approach, we collect data that is found in the excel spreadsheets published in both in the agricultural policy monitoring and evaluation and the PSE database sections of the OECD website (OECD, 2021). These spreadsheets compile information reported directly by each country. This data is accompanied with a definitions and sources document that provides brief insights about most of the policies reported that we will review and categorize. The details and methods of this categorization are explained in the Agricultural Policy Monitoring sub-section of this document.

Two other variables are extracted from the same spreadsheets, the Producer Support Estimate, and the Total Value of Production. Both variables along with agricultural land area, total greenhouse gas emissions and total ammonia emissions, extracted from the Agriculture and Fisheries section of the OECD statistics website OECD.stat. (OECD, 2021) will be reviewed and explained in the independent variables sub-section of this document.

Table 1: Variable overview and definition

Variable	Unit	Description	Source	Period
Agri-environmental policy*	Local currency and USD$	Expenditures in agricultural policies aimed to generate environmental improvements and/or mitigate the environmental impacts of the agricultural activity.	OECD	1986 - 2019
Producer Support Estimate	Local currency	Value of gross transfers to agricultural producers, measured at the farm-gate level, arising from policy measures that support agriculture.	OECD	1986 - 2019
Value of production	Local currency	Total value of agricultural production measured at farm-gate.	OECD	1986 - 2019
Agricultural land area	Thousand of hectares	Total area of land associated to agricultural use per country.	OECD	1991 - 2019
Greenhouse Gas Emissions	Thousand of tonnes CO2 equivalent	Total greenhouse gas (GHG) emissions per country.	OECD	1991 - 2019
Ammonia Emissions	Tonnes	Total ammonia emissions per country.	OECD	1991 - 2019

Source: Prepared by the authors.

3.2 Country Selection

The agricultural policies listed in the spreadsheets of nine other countries, including Canada, were reviewed to search for suitable subjects for comparison. Six countries were discarded (Argentina, Brazil, Chile, China, Iceland, and South Africa) either because there was not enough information to assess the components of each policy or simply because there were no policies with any environmental component reported. Three countries reported policies with environmental components and enough information to assess its components: Australia, the United States, and the European Union, whose 28 members report most of its data to the OECD as a single “country”.

3.3 Period of Evaluation

The study uses data for a 34-year period, from 1986 to 2019 which was all the available data reported on the OECD websites (OECD, 2021). The non-currency variables (Agricultural land area, Greenhouse Gas Emissions and Ammonia emissions) are only available since 1991; therefore, these variables, along with the ratios associated with them, are reported for a shorter period, from 1991 to 2019. The period in which the variables and its associated ratios are reported can be seen in the last row of table 1.

4. Methods

In this section we first categorize all the policies included in the Producer Support Estimator for each country to define the agri-environmental policy indicator, our measure of the environmental components of the agricultural support policy, as the dependant variable. After a dependant variable is defined, we select five other variables to calculate ratios that will be analyzed to compare the environmental components of agricultural support policies of the four countries during the period of evaluation described in section 3.3, as well as a contrast of the current situation, represented by the year 2019 which is the last year reported by the OECD.

4.1 Policy Categorization

The data contained in the OECD PSE excel spreadsheets of each country contains the yearly expenditures in each of the agricultural support policies reported, as well as information about sources, units of measure, eligibility, exceptions, etc., but there is no information or classification regarding the environmental outcomes of each policy. Therefore, to use this data to compare the environmental components of agricultural support policy we need to start by classifying the possible environmental impacts of the data.

Table 2: Categorization of agricultural support policies.

Step	Source	Description
Step 1	OECD Data	Review the definitions and sources document, known as cookbooks, for each country.
Step 2	External Data	Review external sources, official government websites, documents and publications available online.
Step 3	Expert advice	In the case of Australia, agricultural policy experts were contacted to assess certain policies.

Source: Prepared by the authors.

Each policy was individually reviewed based on the information presented on the respective definitions and sources document (OECD, 2018) and, when the information in those documents was not available or not described in enough detail, review of additional sources took place. This included web searches of official government websites, official government documents available online, and in some cases, contacting agricultural policy experts, the process is summarized in table 2.

Table 3: Categorization of agricultural support policies.

Category	Definition
Green	• Policies whose primary goal is to generate environmental improvements. • Policies whose primary goal is to mitigate the environmental impacts of the agricultural activity. • i.e. Environment Services and Initiatives, Farm Stewardship, Agricultural GHG programs.
Yellow	• Policies whose primary objective is not generating environmental benefits, but do generate collateral benefits. • Policies in which only a lesser portion may produce environmental benefits. • i.e. Manure Management, Forage restoration assistance programs.
Red	• Policies where there are no environmental improvements or impact at all. • Policies where its implementation generates negative impacts on the environment. • i.e. Stability, Crop Insurance, Farm Income and Market Development Programs.

Source: Prepared by the authors.

After a comprehensive review, each of the 1978 reported policies were assigned to one of three categories depending on the level in which environmental benefits were outcomes of each policy as shown in table 3, while the numbers of policies classified on each category, per country, is shown in table 4.

Table 4: Number of agricultural policies per country, classified.

Category	Country				Total
	European Union	United States	Canada	Australia	
Green	64	55	11	43	173
Yellow	26	7	9	7	49
Red	638	407	447	264	1756
Total	**728**	**469**	**467**	**314**	**1978**

Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

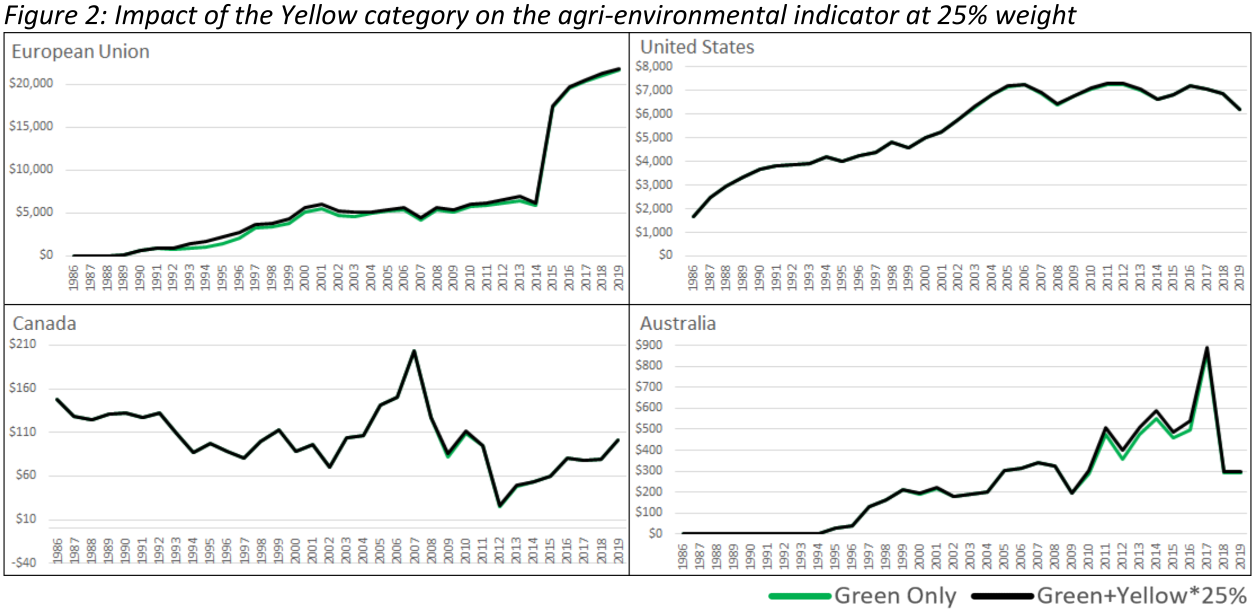
4.2 The agri-environmental policy indicator

Once the policies were categorized it becomes clear that the primary component of the agri-environmental indicator that will be used to compare among countries is the green category that contains those policies that either generated environmental improvements or mitigated the environmental impacts of the agricultural activity. While the assessment revealed that some of the policies may have non-environmental components, those are also deemed necessary for the environmental outcome to be reached, such as technical support policies for the implementation of other support policies. Therefore, this category will be included in its entirety to the agri-environmental policy variable.

Unfortunately, the policies in the yellow category only have partial or collateral environmental benefits and the associated environmental components are more complex to measure. Thus, this category was thought to be problematic as it was more difficult to detect the magnitude to which the policy would benefit the environment.

In this section, we weight and aggregate the yellow category with the green category to assess the agri-environmental policy indicator. The set of graphs shown in figure 2 provide a comparison of an agri-environmental policy indicator across the 4 countries that contains the expenditures of the policies in the green category, and the addition of expenditures in the yellow category weighted at 25% of the expenditure associated with beneficial environmental effects. In our assessment, 25% would be a relatively high weight considering the information available for the policies in that category.

Figure 2: Impact of the Yellow category on the agri-environmental indicator at 25% weight



Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).
Note 1: Each graph can be seen in detail in annex 1.
Note 2: Vertical axis stands for expenditures.

As can be seen in the graphs, aggregating the yellow category weighted at 25% with the green category in developing our agri-environmental indicator does not appear to be significant for Canada or the United States as the impact of the yellow category over the indicator does not exceed the 5% of change on the whole period examined. In the case of Australia, the impact is not significant for most of the years examined, except for an impact of 10% in 2012. Conversely, the graph of the European Union shows a higher impact of the yellow category on the agri-environmental indicator in 1994.

A detailed review of European Union's yellow category policies reveals that there is one policy that stands out over the others. The national expenditures associated to set aside lands related to per hectare aid program accounts for 77% of the expenditures classified as yellow during the period it was implemented (1993 to 2003) but, unfortunately, the definitions and sources document of the European Union (OECD, 2018) does not provide enough data to assess whether the set aside land considered in this policy was associated with environmental objectives and it was not possible to gather information from other sources.

Considering that adding and weighting the policies on the yellow category with the green one to our indicator has significant impacts on one country because of a single policy that we have been unable to assess in detail, the yellow category is not included in our agri-environmental indicator for comparisons. However, it should be noted that there are policies under this category that could be studied in detail if more information about them becomes available.

Consequently, after discarding the yellow category, the agri-environmental indicator contains exclusively those expenditures based the policies classified as green, as summarized in table 4, This category of expenditure comprises the aggregated values of yearly expenditures agricultural policies with a clear environmental component that each country reported to the OECD for the period of 34 years. The values are displayed both in the local currency of each country and converted to USD$ using the exchange rated reported by the OECD for each year as both values will be used depending on each ratio. This is addressed in detail in the ratios sub-section.

Table 5: Agri-environmental indicator. (millions).

Year	Local Currency				USD Conversion			
	European Union	United States	Canada	Australia	European Union	United States	Canada	Australia
	EURO €	USD $	CAD $	AUD $	USD $	USD $	USD $	USD $
1986	0	1,676	148	0	0	1,676	107	0
1987	36	2,463	128	0	48	2,463	97	0
1988	38	2,936	124	0	49	2,936	101	0
1989	143	3,358	131	0	186	3,358	111	0
1990	653	3,689	132	0	854	3,689	113	0
1991	886	3,835	127	0	1,159	3,835	111	0
1992	749	3,872	133	0	979	3,872	110	0
1993	902	3,905	109	1	1,180	3,905	85	1
1994	1,059	4,185	87	1	1,386	4,185	64	1
1995	1,466	4,027	97	28	1,917	4,027	71	21
1996	2,104	4,266	88	40	2,672	4,266	65	31
1997	3,236	4,378	81	131	3,669	4,378	58	97
1998	3,353	4,803	100	164	3,759	4,803	67	103
1999	3,752	4,588	113	210	3,999	4,588	76	135
2000	5,112	5,012	89	193	4,721	5,012	60	112
2001	5,447	5,253	96	219	4,879	5,253	62	113
2002	4,740	5,758	70	182	4,482	5,758	45	99
2003	4,604	6,316	104	189	5,208	6,316	74	122
2004	4,938	6,815	106	202	6,143	6,815	82	148
2005	5,190	7,159	141	303	6,457	7,159	116	232
2006	5,380	7,248	150	313	6,756	7,248	133	236
2007	4,209	6,891	203	340	5,769	6,891	189	284
2008	5,405	6,414	127	327	7,949	6,414	119	274
2009	5,115	6,765	82	195	7,135	6,765	71	152
2010	5,824	7,070	108	287	7,721	7,070	105	264
2011	5,867	7,253	95	474	8,166	7,253	96	489
2012	6,173	7,244	25	357	7,931	7,244	25	370
2013	6,488	7,033	48	478	8,617	7,033	47	461
2014	5,958	6,637	53	551	7,916	6,637	48	496
2015	17,362	6,813	60	459	19,263	6,813	47	345
2016	19,562	7,207	80	499	21,653	7,207	60	371
2017	20,414	7,064	77	869	23,061	7,064	60	666
2018	21,043	6,870	79	293	24,851	6,870	61	219
2019	21,625	6,193	101	292	24,208	6,193	76	203
Total	**198,834**	**184,995**	**3,493**	**7,598**	**234,744**	**184,995**	**2,810**	**6,047**

Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).
Note: Values do not consider inflation.

4.3 Independent Variables

Once the dependant variable, the agri-environmental policy indicator, has been defined five other variables were selected to calculate ratios that allow a better comparison of the environmental components of agricultural support policy.

The two independent variables that were extracted from the OECD PSE excel spreadsheet are reported in the local currency of each country, therefore the calculation of ratios and the analysis involving these variables will also remain in terms of local currency. The Producer support estimate (PSE) indicates the annual value of gross transfers from taxpayers to agricultural producers that arises from agricultural support policies (Womach, 2005) and the value of production stands for total agricultural production valued at wholesale prices (OECD, 2018).

Both monetary values are used with the dependent variable to develop a ratio that provides a measure of expenditures that each country invests on agri-environmental polices as a function of the total support to agriculture, and the outcomes the agricultural activity.

The other three independent variables were extracted from the Agriculture and Fisheries section of the OECD statistics website (OECD, 2021) and two adjustments were made. The first one considers the assumption that governments budget their expenditures using the available information at the time of the decision, therefore a 1-year adjustment is made to these variables, and each value is associated with the agri-environmental policy expenditures of the following year. The second adjustment is related to missing values in the data that, given the nature of the variables it is not possible that the values are zero and it is assumed that the data is either lost of the country failed to report that year, in these cases the missing values were estimated using linear regression functions.

To calculate the ratios of agri-environmental policy expenditures as a function of these variables, that are not measured in terms of currency, local currencies are not suitable as we would be comparing different units, therefore it becomes necessary to convert the values to a common currency and, given that the United States Dollar (USD$) is the base exchange rate used by the OECD, it is also the currency that will be used as a base to calculate these ratios.

The first non-currency independent variable is the agricultural land area measured in thousands of hectares. Considering that the total area, the land use distribution, and the relative size of the agricultural activity may considerably differ from one country to another, this variable provides a measure of the agri-environmental policy expenditures as a function of the actual land area that is destinated to agricultural uses.

The other two non-currency variables are directly related to environmentally detrimental by-products of the agriculture industry which are ammonia and greenhouse gases (Lankoski & Thiem, 2020). As described above these are two major pollution issues that influence human health and the global environment (Wang et al., 2018).

The greenhouse gas emissions impact to the environment is recognized as a major harm in international instances as the United Nations Framework Convention on Climate Change to the Kyoto Protocol and the Paris Agreement (Wang et al., 2018). The ammonia emission stimulates the formation of secondary particulate matter and contributes to problems such as odor emanation, water eutrophication, soil acidification, and GHG emissions (Wang et al., 2018). Both have been recognized as environmental issues since the 80's (Kirchmann et al., 1998). Therefore, these variables were selected to calculate ratios that provide insights on how much the countries invest in agri-environmental policies as a function of those negative effects. The logic behind the ratio is that low level of expenditures in agri-environmental policies is not necessarily a bad indicator if it is related to low levels of emissions, in the sense that there is not much of a need to spend to develop new policies if the environmental issues related to the agriculture have already been addressed and/or solved.

The comprehensive tables containing the data of each of the variables listed in this subsection are presented in the annex 2.

5. Analysis

5.1 Ratios

In this section we calculate five ratios, all of them based on our agri-environmental policy indicator as a function of one of the independent variables introduced on the independent variables sub-section, as seen in table 6.

The measures obtained are compiled in graphs, each one containing the values of the four countries. These comparisons are then used to assess how Canada compares with the other countries regarding their environmental components of agricultural support policies from five different perspectives.

Table 6: Agri-environmental policy ratios.

Ratio	Unit	Description	Period
Agri-environmental expenditures over PSE.	-	Measures of how much of the expenditures aimed to support agriculture, also aim to promote benefits to the environments.	1986 - 2019
Agri-environmental expenditures over Value of Production.	-	Measures the level of expenditures in agri-environmental policy as a function of the outcomes of the agricultural activity represented by VP.	1986 - 2019
Agri-environmental expenditures per area.	USD$ per thousand of hectares	Measures the how many dollars are spent per hectare of agricultural land.	1991 - 2019
Agri-environmental expenditures per ammonia emissions.	USD$ per Kg of ammonia	Measures the expenditures in agri-environmental policies as a function of the negative impacts of the agricultural activity.	1991 - 2019
Agri-environmental expenditures per GHG emissions.	USD$ per Tonne of CO2 equivalent	Measures the expenditures in agri-environmental policies as a function of the negative impacts of the agricultural activity and its mitigation.	1991 - 2019

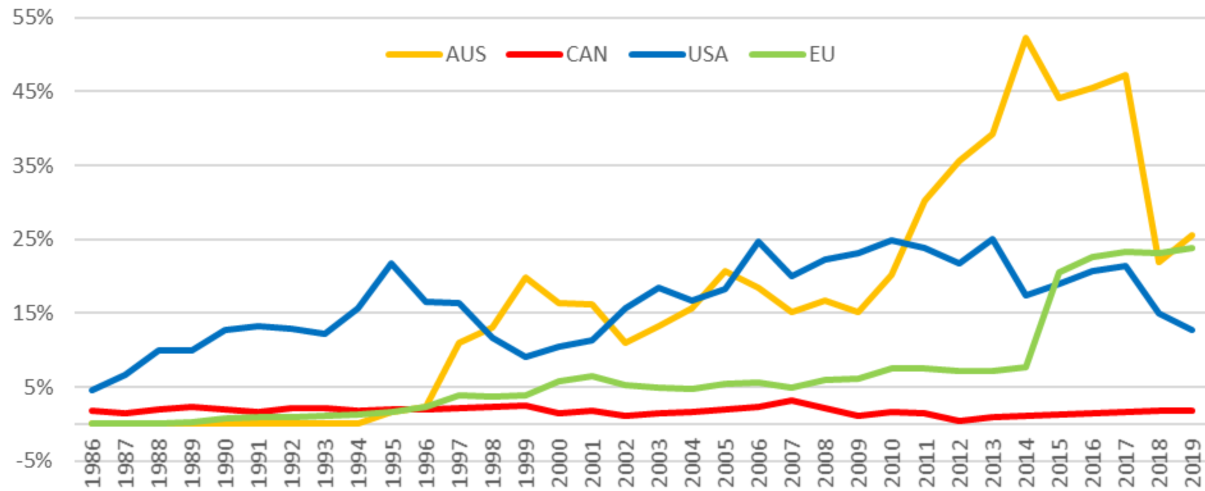
Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

5.2 Contrasting Over Time

The ratio of agri-environmental policy as a function of the Producer Support Estimate (PSE) is, in our assessment, one of the strongest of this document as it provides a measure of how much of the expenditures are aimed to support agriculture, as well as how much promotes benefits to the environment.

The measure for Canada at the beginning of the period is 1.8%. This is low, but not relatively speaking, considering that the leader in that year was the United States with 4.6% while the European Union and Australia have values of zero until 1990 and 1995 respectively.

Figure 3: Agri-environmental policy as a percentage of the Producer Support Estimate (PSE).

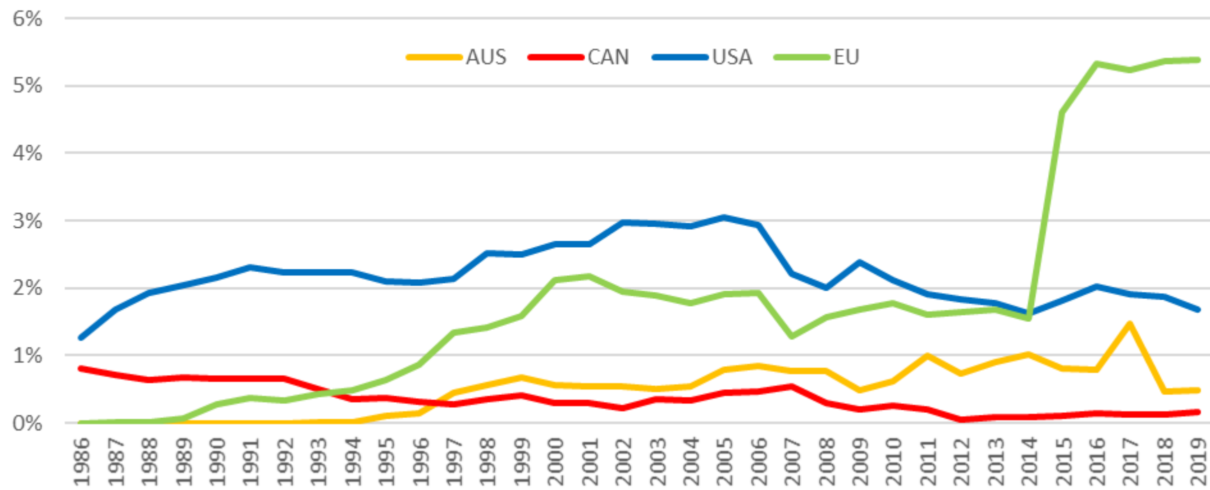


Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).
Note: Calculated using domestic currencies.

Adversely, while the performance of the other three countries increases considerably over time, the ratio for Canada remains low, only exceeding the 3% threshold in 2007, and then declining to 1.8% in the last evaluated year, compared to 25.5%, 12.9% and 12.7% for Australia, the European Union, and the United States respectively. This suggests that while the other OECD members are making their environmental concerns a larger portion of their agricultural support policies, Canada does not seem to take as much action on this issue.

The agri-environmental policy expenditures as a percentage of the Total Value of Production ratio gives us a measure of how much the economic outcome of agriculture reflects governmental efforts for reducing or mitigating the environmental impacts of that production. While a different magnitude than the ratios in figure 3, the results for this second ratio are similar across the countries and each line roughly resembles the trends in the previous graph (fig. 3). In the same way, Canada starts the period second only because the European Union and Australia have not started to implement environmental measures in their agricultural support policies yet. However, these countries surpass Canada in 1994 and 1997 respectively, and Canada continues to show a downward slope until the end of the period in 2019.

Figure 4: Agri-environmental policy as a function of the Total Value of Production.



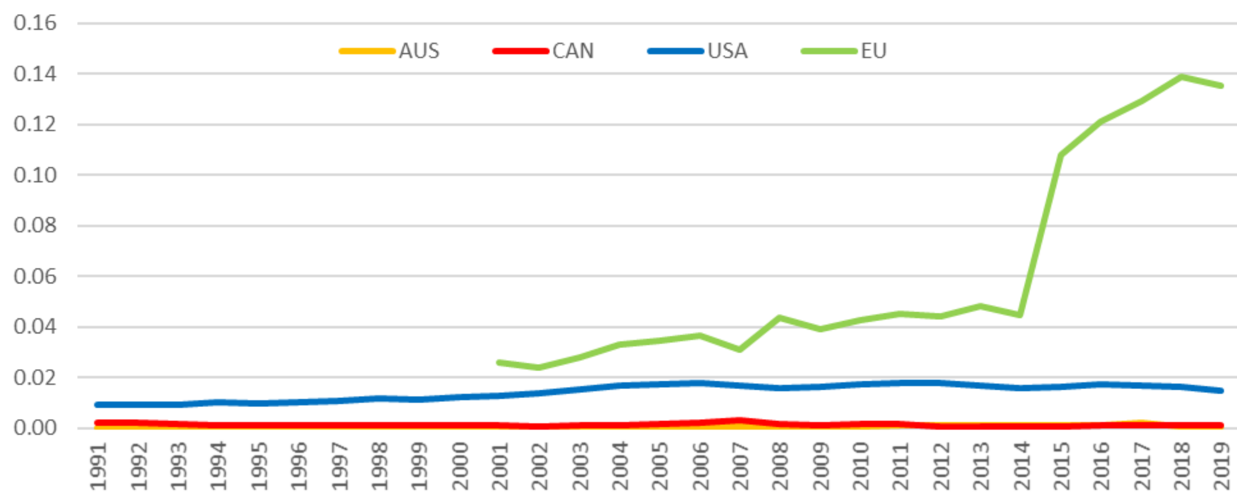
Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).
Note: Calculated using domestic currencies.

One interesting feature of the comparison is the sudden increase in the percentage for the European Union in 2015 that, after a review of its components, can be explained by expenditures related to “Payments for agricultural practices beneficial for the climate and the environment – greening”. This is a huge program whose impact on the expenditures for agri-environmental policies increased the category by 143% with expenditures that covered 78% of the utilized agricultural area in 2015 (Hart, et al. 2017).

The ratio of agri-environmental policy expenditures per thousand hectares provides an indicator of expenditures based on the amount of land used for agricultural production. This indicator involves land that can considered susceptible of being used for environmentally harmful practices but can also be lands targeted with agri-environmental measures.

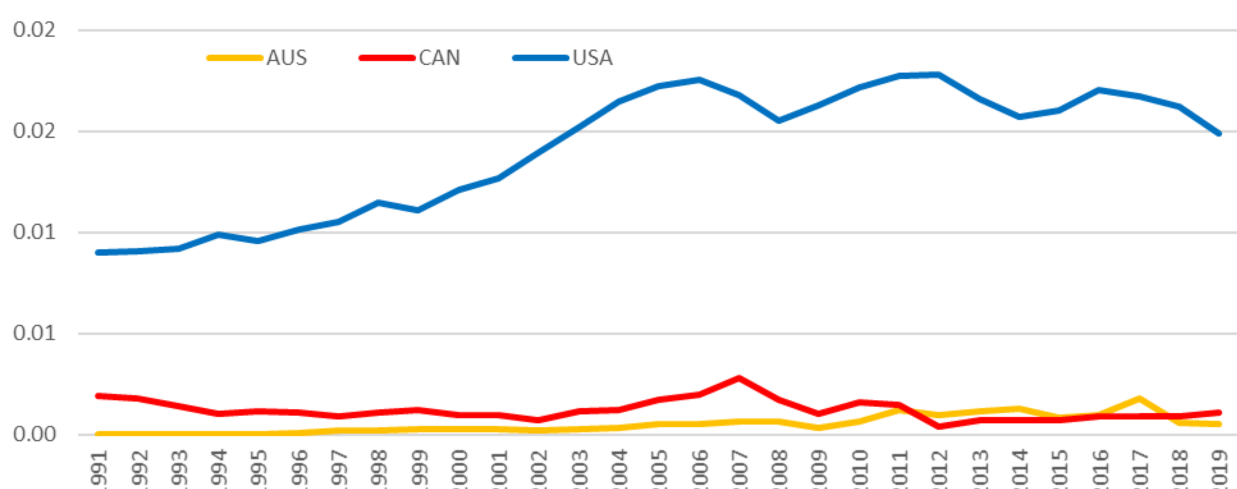
Figure 5 shows agri-expenditures per 1000 ha for the four countries over the period. The results suggest that Canada's performance along with Australia, is low compared to the European Union. However, the missing data for the EU in the early part of the period lead us to remove the EU and rescale the graph to highlight differences between the three remaining countries. This is shown in figure 5.b.

Figure 5: Expenditures in Agri-environmental policy per thousand of hectare (USD$).



Source: Prepared by the authors based on the OECD PSE Database and on the OECD statistics website (OECD, 2021).

Figure 5.b: Expenditures in Agri-environmental policy per thousand of hectare (USD$). Excludes EU.



Source: Prepared by the authors based on the OECD PSE Database and on the OECD statistics website (OECD, 2021).

Deeper research would be required to explain the big differences on the performances of each country for this ratio, especially for the European Union but, in our assessment, there are a few factors that are more likely to be the reason behind the trends shown.

The first, and simpler one would be population densities. The measure of total population over agricultural land (Annex 4) shows that there are considerably more people per 1000 hectare of agricultural land use in the European Union than in any other of the countries in the study and, as explained earlier, as citizens become more concerned about the environment, they are more likely to put pressure on the authorities to take measures to protect the environment.

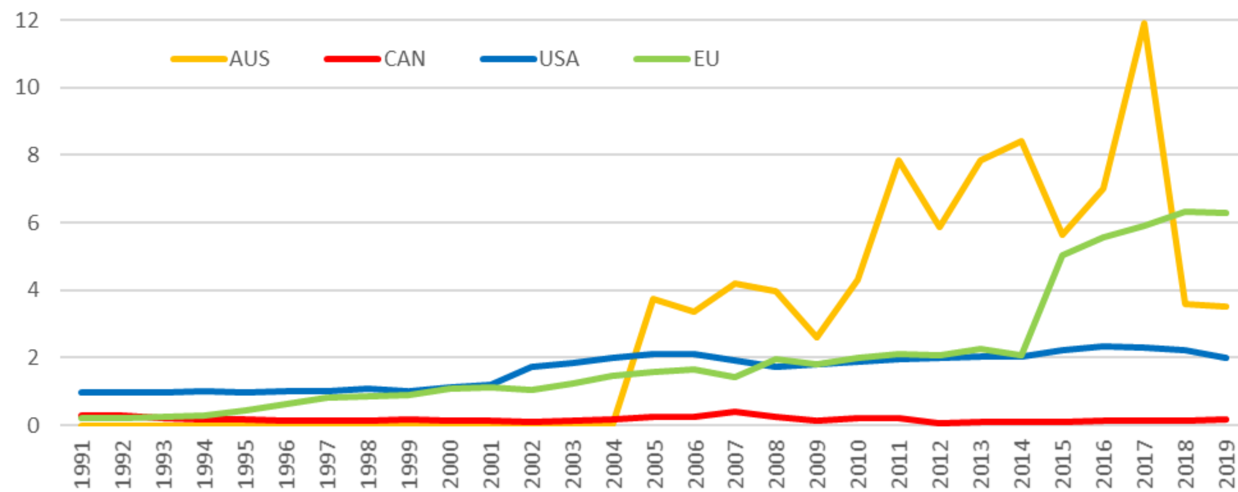
A second factor would be the fact that, as opposed to the other countries in the study, the European Union is not a country itself, but a community of different countries each with their own political agenda. Thus, the measures taken by one of the country members may also pressure their neighbors to act.

The third factor is that the European Union, and the United States to a certain extent, tend to use intensive production practices that on one hand might increase agricultural support measures, while on the other, worsen environmental impacts for the years to come (Hunter & Nyssens, 2021).

To partially address this concern, ratios of expenditures in agri-environmental policies to ammonia and GHG emissions were developed. These ratios aim to measure the levels with which countries attempt to correct, through policies, the negative impacts to environment produced by agricultural activities. The results are shown in figures 6 and 7.

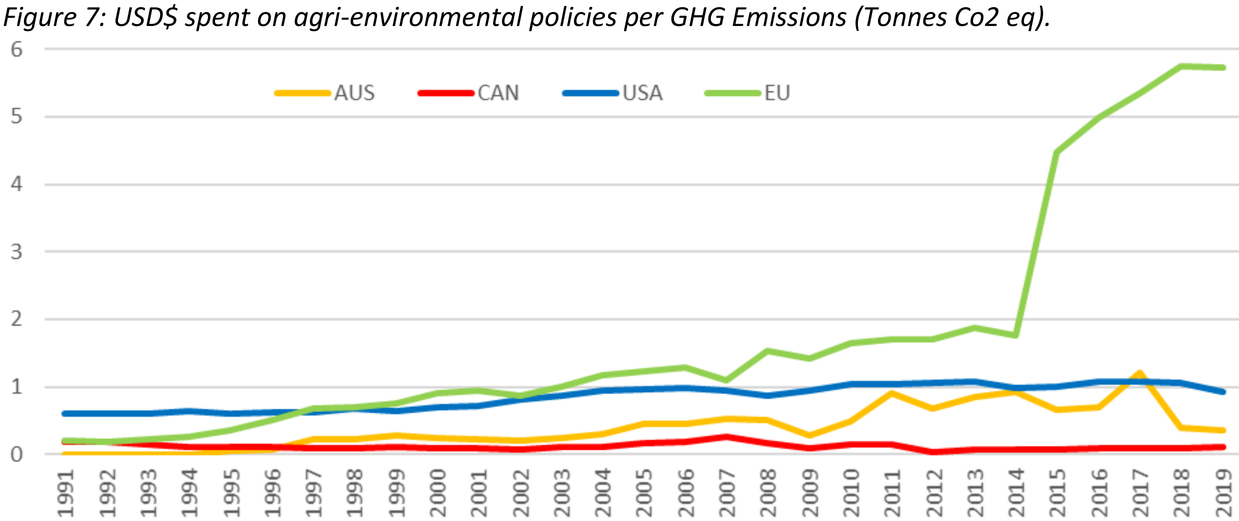
The graphs show that the other OECD countries perform very differently for each indicator. However, for either ammonia or GHG emissions, the results for Canada show low levels of expenditures. These results suggest that the level of emissions does not incentivize environmental measures in Canadian agricultural policy and has not led to measures to mitigate the environmental effects of agriculture, at least not in the formulation of agricultural policies to incentivize farmers to follow more environmentally friendly methods.

Figure 6: USD$ spent on agri-environmental policies per Ammonia emissions (Kilo).



Source: Prepared by the authors based on the OECD PSE Database and on the OECD statistics website (OECD, 2021).

Figure 7: USD$ spent on agri-environmental policies per GHG Emissions (Tonnes Co2 eq).



Source: Prepared by the authors based on the OECD PSE Database and on the OECD statistics website (OECD, 2021).

5.3 Assessment of Agri-environmental Policy Expenditures in 2019

Finally, for a summary review of the most recent period in the data series, the results obtained for each country on each measure in 2019 were compiled and assigned a value, from one to zero, depending on how the country compares to the country that is the leader in that particular measure. This is shown in table 7 using a colour value given from green being a high and therefore more environmentally friendly value, to red for the lowest value meaning a lesser environmentally friendly measure. Here the performance for Canada is a strong red in every measure. This means that its performance in comparison to the other three countries is not only low as observed for each of the indicators described above, but also low on a relative measure, especially compared to the European Union that, except for one ratio, leads the ranking.

Table 7: Ranking of Ratios in 2019

Ratio	Country			
	European Union	United States	Canada	Australia
Agri-environmental expenditures over PSE.	0.94	0.50	0.07	1
Agri-environmental expenditures over Value of Production.	1	0.31	0.03	0.09
Agri-environmental expenditures per area.	1	0.11	0.01	0.00
Agri-environmental expenditures per amonia emissions.	1	0.32	0.03	0.56
Agri-environmental expenditures per GHG emissions.	1	0.16	0.02	0.06

Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

The European Union comes second, only in the ratio measuring the environmental expenditures over all the support policies related to agriculture, the United States follows from afar with relatively low values, while Australia's performance ranges from being a leader in one ratio to being the last with a 0.4% of the European Union ratio of agri-environmental expenditures per thousand of hectares.

But the overall results show that, in comparison with other OECD members included in the study, the environmental components of the Canadian agricultural support policy are low for every of the five ratios presented. Canada's best performance is in the agri-environmental expenditures over PSE ratio, the measure that most directly relates to the objectives of this research that achieving just a 7% of the European Union's measure.

6. Conclusions

After having compared Canada with three other developed OECD countries in five different environmentally related measures, it appears that there is still a lot to be done from an agricultural point of view and that, the proposed paradox between the promotion of constrained environmental mechanisms to protect its economy and the commitment to action beyond these constraints suggested by Bernstein (2002), appears to be not the way environmentalists would expect.

From analyzing the ratios calculated we can suggest that in comparison with the other OECD members in the study:

- The environment does not seem to be an important factor in the development of the Canadian agricultural support policies. As reflected in the Producer Support Estimate, only a small proportion of the support is aimed at incentivizing environmentally friendly measures or the mitigation of harmful outputs from agricultural practices.
- The environment does not receive a large share of economic attention in the outputs from agriculture, reflected in the Total Value of Production. The low expenditures on environmental policies in agriculture can be seen as a low reinvestment to recover the

environment which could be a source of the natural resources that the industry needs to thrive.

- Whether because of low human population density, political composition, or the intensity of practices, Canadian agricultural policy expenditures on environmental issues per area used for agricultural land is low. The issue grows when it is considered that even when Canada, the largest of the countries analyzed, has the lowest agricultural land use, around 40% of the European union and less than 20% of Australia and the United States (OECD, 2021).
- The environmentally detrimental outcomes of agricultural activity, reflected in the level of two emissions, do not seem to have incentivized policies in agriculture to mitigate them. Even when the issues related to GHG and ammonia emissions have been addressed in international instances, the expenditures per measure of emissions in Canada is low.

Apart from, these results demonstrating that the environmental components of the agricultural support policy are lower for Canada than any other OECD country, the historical trends also suggests that this is not likely to change.

This research is not intended to be seen as criticism of Canada's agricultural policy implementation. Instead, it is an invitation to review the impacts of its agricultural measures and to introduce the environment as a key factor of their future development. The Canadian performance in environmentally aimed agricultural policies is low in every measure addressed in this study, but also reveal that significant opportunities to grow by either following successful measures implemented by other OECD members or through developing its own policies to help the agricultural industry evolve from a source of environmental harm, into a powerful mitigator of environmental threats.

While this work manages to show the relative position of Canada among its OECD peers in terms of agri-environmental policy expenditures, it also reveals limitations that, if addressed, might open the door for future challenges and research on the topic.

The first limitation, as already mentioned on the document, is that the information about each policy collected by the OECD in the definitions and sources documents is not completely accurate as some policies do not contain enough data, or no data at all, to assess information on possible environmental components, goals, or intentions of the measure. This weakness is reflected is the yellow category as an example of how better access to data about every policy could lead to a more detailed comparison.

Another limitation is that the document attempts to compare the agri-environmental policies by measuring each country expenditures on agricultural support policies. But this comparison does not include other kinds of agri-environmental expenditures that are not related to PSE, but still aim to protect or benefit the environment in agriculture. For example, one of them could be Environment and Climate Change Canada's Habitat Stewardship Program for Species at Risk that addresses habitats on private lands. Many of these lands are farms. Such program expenditures are missing from the OECD data, but it should be noted that they are missing for each of the four countries, not just Canada.

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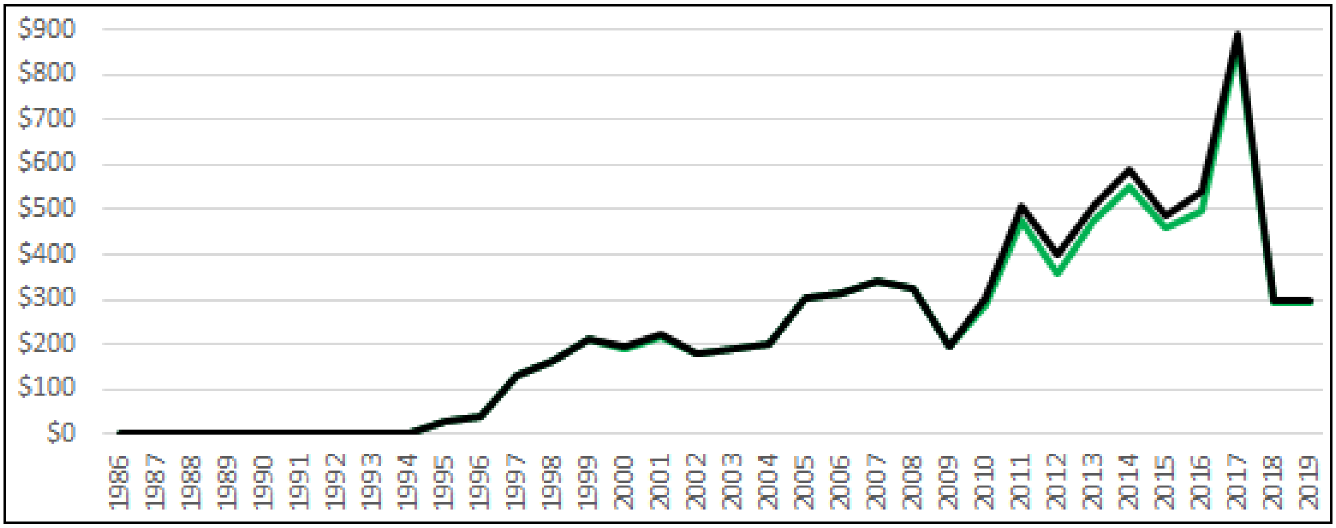
Annexes

<u>Annex 1: Impact of the yellow category per country</u>

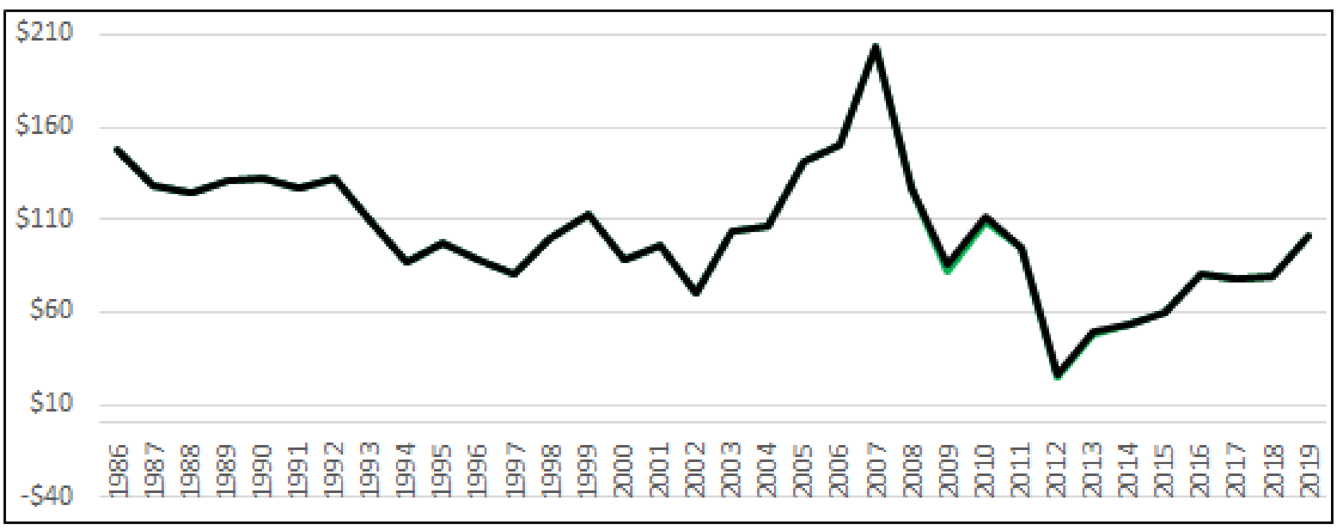
a.1.1 Australia



Green Only   Green+Yellow*25%

Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

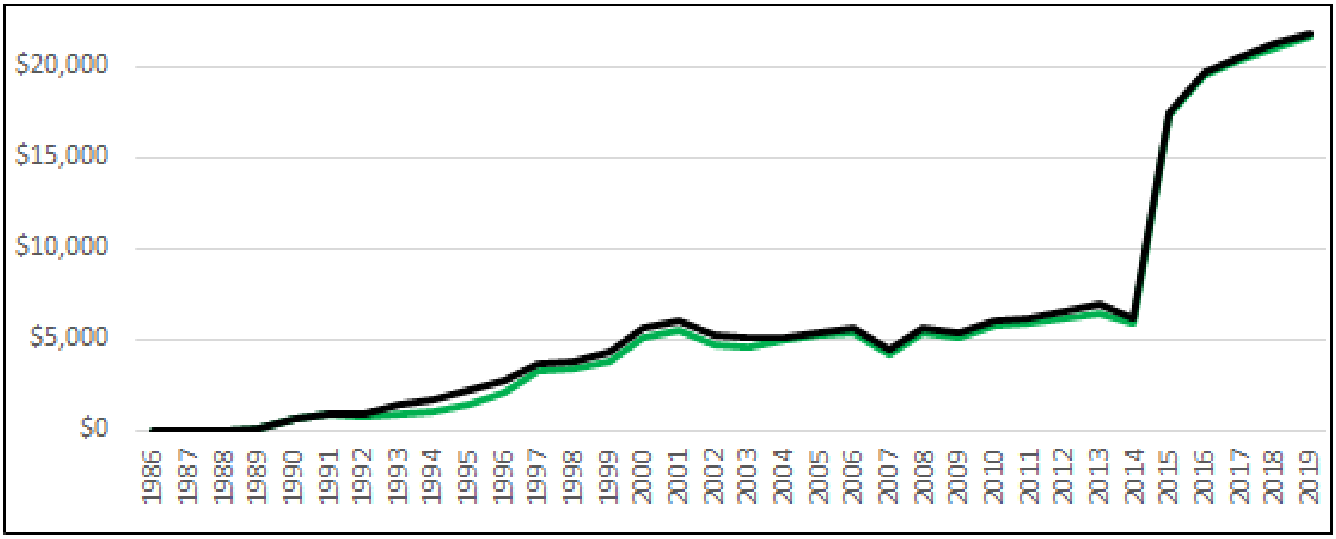
a.1.2 Canada



Green Only   Green+Yellow*25%

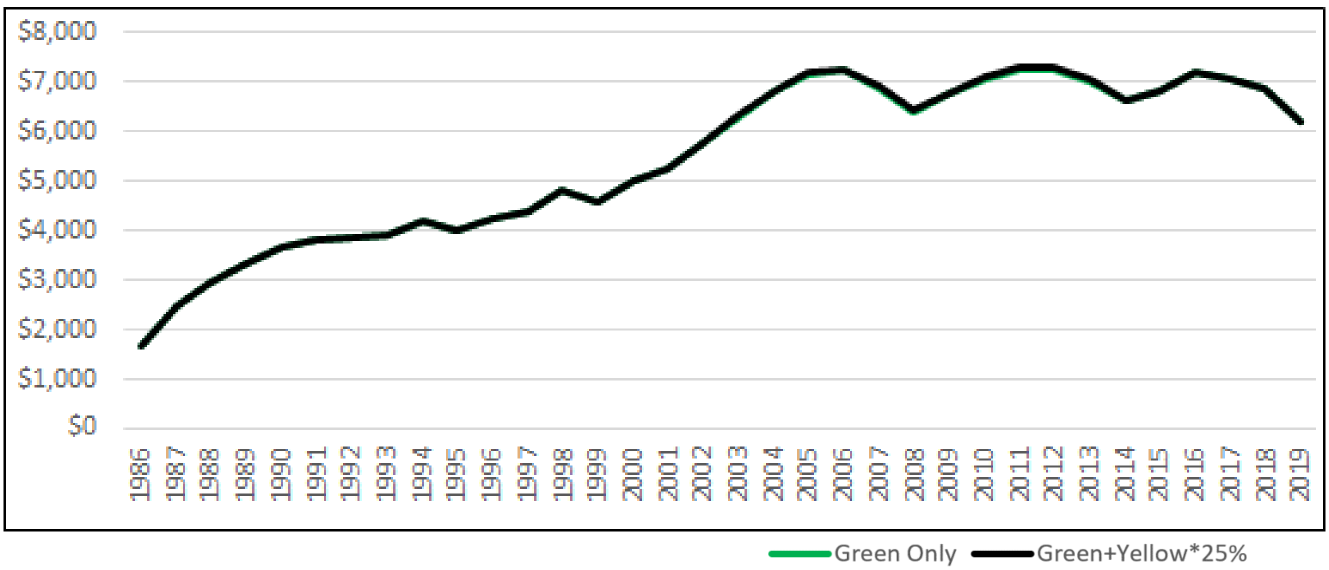
Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

a.1.3 European Union



Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

a.1.4 United States



Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

Annex 2: Detail of variables

a.2.1 Total: Producer Support Estimate (Local currency).

Year	Country			
	European Union	United States	Canada	Australia
	EURO €	USD $	CAD $	AUD $
1986	85,787	36,391	8,196	2,244
1987	90,834	36,900	8,439	1,744
1988	82,319	29,469	6,556	1,937
1989	68,520	33,632	5,743	1,842
1990	80,653	28,903	6,977	1,895
1991	96,801	29,107	7,950	1,638
1992	86,312	29,997	6,260	2,016
1993	87,654	31,912	5,156	1,998
1994	87,385	26,694	4,805	1,972
1995	90,717	18,550	5,125	1,727
1996	88,366	25,758	4,551	1,755
1997	84,907	26,873	3,765	1,183
1998	92,195	41,249	4,436	1,260
1999	98,353	50,808	4,694	1,060
2000	87,796	48,004	5,884	1,185
2001	85,194	46,657	5,249	1,353
2002	90,763	36,707	6,784	1,654
2003	92,108	34,311	7,520	1,433
2004	104,026	40,913	6,632	1,289
2005	96,363	39,028	7,056	1,467
2006	94,831	29,430	6,701	1,706
2007	86,917	34,342	6,505	2,237
2008	90,566	28,717	5,753	1,957
2009	84,234	29,242	6,926	1,283
2010	77,022	28,468	6,627	1,421
2011	78,107	30,501	6,777	1,566
2012	85,760	33,449	6,725	1,005
2013	90,117	28,185	5,039	1,219
2014	77,952	38,113	4,703	1,054
2015	84,292	36,078	4,641	1,041
2016	86,740	34,884	5,687	1,098
2017	87,600	33,041	4,680	1,840
2018	91,044	45,863	4,634	1,337
2019	90,453	48,927	5,692	1,145
Total	**2,982,684**	**1,171,102**	**202,868**	**52,562**

Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

a.2.2 Total: Value of production (Local currency).

Year	Country			
	European Union	United States	Canada	Australia
	EURO €	USD $	CAD $	AUD $
1986	212,795	132,583	18,107	16,965
1987	207,729	146,066	18,029	19,852
1988	213,615	151,757	19,237	22,846
1989	231,548	164,026	19,568	23,591
1990	231,568	170,243	20,071	21,207
1991	235,124	166,002	19,530	21,168
1992	227,401	173,960	19,930	22,709
1993	213,236	174,820	21,385	24,516
1994	216,311	186,808	24,473	24,035
1995	232,302	191,088	25,889	27,785
1996	242,921	204,808	28,066	28,718
1997	242,468	205,080	28,691	28,820
1998	237,058	190,082	28,035	29,159
1999	234,927	183,777	27,928	30,775
2000	241,703	189,318	30,003	34,779
2001	249,966	197,892	32,761	39,906
2002	242,638	193,151	32,542	33,235
2003	243,283	214,023	29,397	37,371
2004	278,451	234,094	31,476	36,537
2005	271,481	234,652	31,995	38,696
2006	279,199	246,198	32,505	36,663
2007	326,343	311,268	36,776	43,752
2008	344,323	318,311	41,927	41,964
2009	302,616	284,502	41,269	39,697
2010	326,267	334,931	41,317	46,375
2011	364,601	379,486	46,410	47,432
2012	376,186	396,606	50,823	48,501
2013	386,583	394,251	52,942	53,355
2014	383,256	406,355	56,165	54,451
2015	376,565	376,171	57,887	56,741
2016	366,516	355,467	58,173	63,416
2017	390,229	370,604	59,765	59,134
2018	392,000	368,197	60,199	62,239
2019	400,948	367,576	61,623	60,664
Total	**9,722,155**	**8,614,155**	**1,204,894**	**1,277,054**

Source: Prepared by the authors based on the OECD PSE Database (OECD, 2021).

a.2.3 Agricultural land area (Thousand of hectares)

Year	Country			
	European Union	United States	Canada	Australia
1991	464,027	58,581	426,948	-
1992	462,763	60,891	426,948	-
1993	465,953	60,207	425,429	-
1994	460,097	60,762	422,948	-
1995	469,048	61,399	421,139	-
1996	463,347	60,801	420,139	-
1997	465,220	63,182	416,306	-
1998	466,152	63,415	418,932	-
1999	463,786	63,323	414,588	-
2000	453,729	62,730	414,292	-
2001	455,516	63,375	415,208	190,301
2002	455,723	62,715	413,293	189,953
2003	447,007	62,392	416,067	187,830
2004	439,531	67,440	413,152	186,472
2005	440,110	66,564	414,674	186,339
2006	445,149	66,393	412,878	185,390
2007	434,925	66,858	411,030	185,819
2008	425,449	68,457	413,537	183,069
2009	417,288	67,994	415,311	182,808
2010	409,029	66,227	412,415	181,566
2011	397,451	64,627	408,426	180,137
2012	391,686	65,067	406,928	179,365
2013	405,474	68,418	423,893	178,198
2014	396,615	68,037	422,481	178,099
2015	406,269	67,517	424,330	178,393
2016	384,558	67,552	422,568	178,996
2017	371,078	68,141	422,826	178,751
2018	393,797	69,855	422,826	178,822
2019	383,176	68,117	415,916	179,145

Source: Prepared by the authors based on the OECD statistics website (OECD, 2021).

a.2.4 Greenhouse Gas Emissions (Thousand of Tonnes of CO2 equivalent)

Year	Country			
	European Union	United States	Canada	Australia
1991	424,998	603,222	6,437,000	5,647,955
1992	426,015	594,873	6,373,260	5,553,233
1993	430,216	612,471	6,480,087	5,380,781
1994	430,613	615,049	6,596,775	5,280,942
1995	430,653	636,374	6,685,730	5,255,169
1996	439,005	653,058	6,771,016	5,305,289
1997	446,682	674,575	6,974,407	5,417,760
1998	458,842	686,115	7,028,805	5,323,930
1999	472,630	693,059	7,077,750	5,283,301
2000	478,200	707,364	7,125,609	5,174,379
2001	489,374	730,682	7,275,397	5,167,526
2002	496,982	719,697	7,172,475	5,216,693
2003	500,808	723,948	7,214,461	5,183,908
2004	502,302	740,246	7,255,112	5,272,805
2005	520,315	741,584	7,381,669	5,275,528
2006	526,207	729,747	7,391,771	5,240,044
2007	530,788	720,516	7,314,389	5,226,844
2008	536,889	742,314	7,416,454	5,178,377
2009	540,669	722,568	7,210,129	5,062,456
2010	544,285	680,494	6,753,906	4,691,786
2011	540,571	690,531	6,981,613	4,796,604
2012	542,512	702,413	6,820,533	4,636,541
2013	544,733	710,108	6,580,675	4,574,655
2014	535,007	720,877	6,769,551	4,477,092
2015	530,411	721,354	6,829,017	4,300,748
2016	538,619	720,380	6,676,371	4,335,347
2017	548,863	706,196	6,524,080	4,308,422
2018	556,612	713,838	6,488,235	4,323,067
2019	558,047	729,349	6,676,650	4,224,358

Source: Prepared by the authors based on the OECD statistics website (OECD, 2021 *a.2.5 Ammonia Emissions (Tonnes)*

Year	Country			
	European Union	United States	Canada	Australia
1991	-	401,648	3,918,000	5,183,557
1992	-	397,750	3,975,000	4,940,315
1993	-	409,680	4,031,000	4,676,773
1994	-	413,027	4,099,000	4,555,533
1995	-	427,601	4,163,000	4,446,846
1996	-	454,453	4,227,000	4,378,391
1997	-	470,795	4,289,000	4,430,556
1998	-	476,330	4,372,000	4,408,140
1999	-	477,905	4,481,000	4,411,457
2000	-	473,994	4,406,000	4,381,122
2001	-	483,737	4,453,000	4,301,113
2002	-	483,764	3,348,000	4,278,342
2003	-	493,897	3,417,852	4,209,358
2004	-	488,776	3,398,869	4,173,086
2005	61,887	502,698	3,379,886	4,140,134
2006	70,211	498,236	3,446,754	4,080,454
2007	67,697	487,265	3,578,477	4,057,251
2008	69,175	491,128	3,710,200	4,064,054
2009	58,380	480,555	3,772,611	3,956,177
2010	61,069	465,879	3,735,000	3,889,794
2011	62,364	458,770	3,695,000	3,844,102
2012	62,893	456,103	3,655,000	3,845,500
2013	58,703	472,030	3,465,000	3,806,622
2014	59,007	485,363	3,275,000	3,814,158
2015	61,177	476,772	3,085,000	3,839,232
2016	52,887	479,073	3,082,000	3,887,048
2017	56,028	480,130	3,079,000	3,900,696
2018	60,819	469,637	3,076,000	3,919,805
2019	57,876	484,205	3,123,987	3,858,921

Source: Prepared by the authors based on the OECD statistics website (OECD, 2021

Annex 3: Population

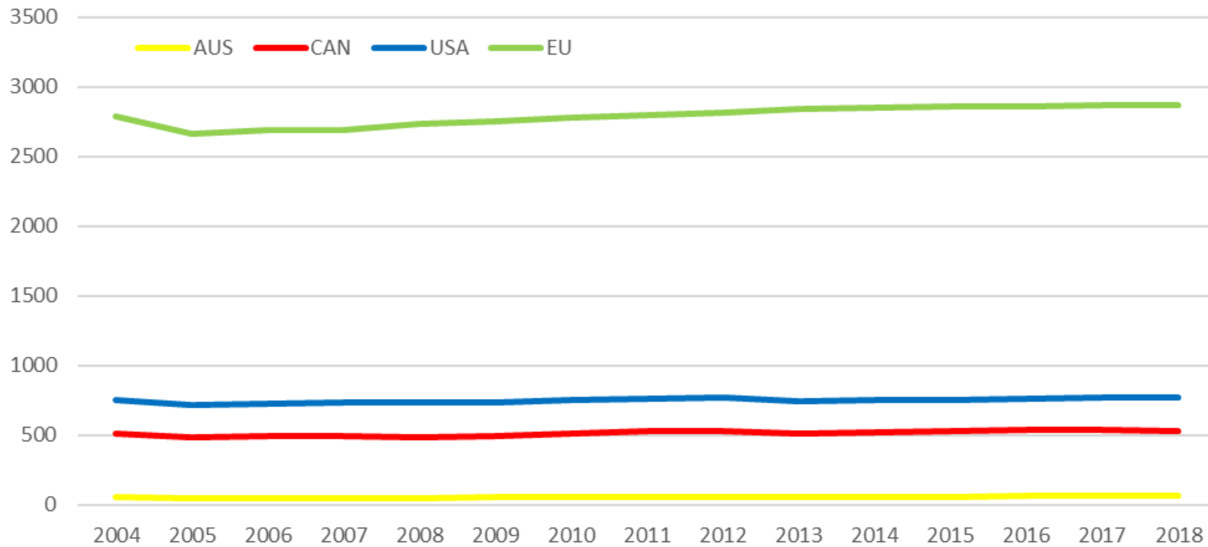
a.3.1 Exchange rates from local currency to USD$.

Year	Country			
	European Union	United States	Canada	Australia
	EURO €	USD $	CAD $	AUD $
1986	0.76	1	1.39	1.50
1987	0.76	1	1.33	1.43
1988	0.76	1	1.23	1.28
1989	0.76	1	1.18	1.26
1990	0.76	1	1.17	1.28
1991	0.76	1	1.15	1.28
1992	0.76	1	1.21	1.36
1993	0.76	1	1.29	1.47
1994	0.76	1	1.37	1.37
1995	0.76	1	1.37	1.35
1996	0.79	1	1.36	1.28
1997	0.88	1	1.38	1.35
1998	0.89	1	1.48	1.59
1999	0.94	1	1.49	1.55
2000	1.08	1	1.49	1.72
2001	1.12	1	1.55	1.93
2002	1.06	1	1.57	1.84
2003	0.88	1	1.40	1.54
2004	0.80	1	1.30	1.36
2005	0.80	1	1.21	1.31
2006	0.80	1	1.13	1.33
2007	0.73	1	1.07	1.20
2008	0.68	1	1.07	1.19
2009	0.72	1	1.14	1.28
2010	0.75	1	1.03	1.09
2011	0.72	1	0.99	0.97
2012	0.78	1	1.00	0.97
2013	0.75	1	1.03	1.04
2014	0.75	1	1.10	1.11
2015	0.90	1	1.28	1.33
2016	0.90	1	1.33	1.35
2017	0.89	1	1.30	1.30
2018	0.85	1	1.30	1.34
2019	0.89	1	1.33	1.44

Source: Prepared by the authors based on the OECD exchange rates website (OECD, 2021)

Annex 4: Population

a.4.1 Population per thousand of hectare of agricultural land.



Source: Prepared by the authors based on the OECD statistics website (OECD, 2021).