The potential impact of the pesticide-free buffer zones in agriculture – a French case study

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Abstract: The use of pesticides around built-up areas has become an issue of concern both for local populations and for policy makers. Attempts to regulate the use of phytoproducts around built-up areas, such as pesticide-free zones in France, have been met with complaints from farmers about the loss of production. However, there is currently no clear estimation of the real size of the surface areas concerned by this regulation. In this work, we assess, at regional and farm level, the agricultural land uses impacted by the 2019 French regulation banning the use of pesticides on agricultural land located in proximity to residential areas and areas hosting vulnerable people (e.g. hospital or schools). We identify the farms that are the most likely to be significantly impacted by the regulation, considering their location and production characteristics. Based on our results, less than 1% of the regional agricultural area is impacted by the regulation, and on 90% of farms, less than 2% of the total utilized agricultural area (UAA) is concerned (less than one 1% if we exclude no or less pesticide-dependent areas). Special attention should nevertheless be paid to the impact of this regulation on some farms such as small non-organic fruit/permanents crops or market gardening/horticulture specialized farms, especially when located in large urban areas. Those farms are indeed both the most impacted and the ones for which our results are the most likely to underestimate the share of UAA concerned by the regulation. Economic and public policy implications for farms and territories are then discussed, as well as further research-related challenges.

Keywords: phytoproducts, pesticides, LPIS, land use, agriculture, organic farming, urban fringe, Nord-Pas-de-Calais, no-spray zones.

Classification JEL : Q15 (Q18, Q12, R52)

1. Introduction

Extensive pesticide use in agriculture has become an issue of concern in terms of the population's exposure and health. Whereas initially, most concern was to have pesticide-free areas near water courses and water bodies, for ecological reasons (Reichenberger et al., 2007; Felsot et al., 2010), scientists and governments are now turning their attention to residential exposure to agricultural phytoproducts (e.g. Dereumeaux et al., 2020; Sinfort and Bonicelli, 2011; Boudet et al, 2006; Gunier et al., 2017 ; OECD 2021). The growing interest in this regard can be explained both by the increasing concerns and awareness in the population at large, as to the health impacts of pesticides (Remoundou et al., 2014; Levi and Sperry, 2007), and by the increasing size of contact areas between residential and agricultural land uses, due to urbanization patterns (Antrop, 2004 ; York et al., 2011; Irwin and Bockstael, 2007; EEA-FOEN, 2016). In many cities and countries, the use of pesticides is banned or is becoming more tightly regulated in public greenspaces (Heinrich-Böll-Stiftung, 2022). However, in most countries, agricultural pesticide use around residential zones and places hosting vulnerable people (such as schools or hospitals) is not subject to any specific regulation. Only recommendations are issued, such as those reported on product labels (see e.g. OECD 2021).

In France, the decree of December 27, 2019, established "*safety distances in the proximity of residential areas and areas hosting vulnerable groups of persons*" (Légifrance, 2020) when plant protection products are used. This distance is 10 m for "*arboriculture, viticulture, trees and shrubs, forests, berries and ornamental crops over 50 cm in height, bananas and hops*" (hereafter indicated as high agricultural uses, "high" referring to the height of the vegetation), and 5 m for "*all others agricultural and non-agricultural covers*" (hereafter indicated as low agricultural uses, "low" referring to the height of the vegetation). These restrictions only partially apply to organic farming, as most of the products used in pest control in organic farming are not concerned by the law (Produire-bio.fr, 2020).

The potential impacts put forward in terms of areas, public health, or economic activity vary widely, depending on the different stakeholders concerned by this regulation. Thus, despite recommendation from the French Agency for Food, Environmental and Occupational Health and Safety (ANSES, 2019), residents, environmentalists and some policy makers consider the stipulated distances to be insufficient to protect populations living nearby (e.g. Prudent, 2019, Delbecque 2019, Générations Futures, 2022). At the same time, farmers and farmer unions are also dissatisfied with the regulation. They argue that it implies a large loss of farmland and consequently a loss of income. For instance, the main French agricultural trade union, the FNSEA, estimated that this regulation would affect from 2 to 5% of farms' agricultural area (Francetvinfo, 2020), with a loss of approximatively €1500/ha impacted but that could rise to tens of thousands of euros per hectare in vineyards (Feldman, 2019). This impact has been analyzed mainly in wine-growing areas. Some wine-grower associations and trade unions claimed that the 10 m restriction would affect 1000 ha out of 30,000 in Burgundy (LAVRF, 2019), 800 ha in the Champagne vineyard region, at least 85 ha in the Bourgeuil region (Gerbod, 2019), and between 2% and over 10% of the Val-de-Loire wine-growing area (Lecocq, 2020). Some also argued that not preventing weed growth on the borders of their fields would require more intensive use of pesticides in the fields themselves (Prudent, 2019).

To our knowledge, the only previous research that has assessed the area impacted on a large scale and not only in wine-growing regions is that of Guilpart et al. (2022). One of the reasons for this paucity of research, in addition to the relative recency of the regulation, is probably the need for very accurate land-use data (not always available on a large scale) that locate with precision all the residential areas and areas hosting vulnerable groups of persons (hereafter indicated as "sensitive areas"). Guilpart et al. (2022) assessed the areas impacted by 10 m to 150 m buffers around (mainly) residential buildings across the entire French territory for 23 crop types, and found that around 0.2% of all French agricultural areas were concerned by 10 m buffers.

In this paper, we propose an assessment on a regional case study using a geographical database that allowed us both to overcome some of the methodological issues encountered by Guilpart et al. (2022) and to include a farm-level analysis. We also considered types of territories (along the urban-rural gradient) and types of production (main types of agricultural production, organic or not, farm size and specializations). We applied the proposed methodology to a study area located in the extreme north of France where the urbanization patterns and farm specialization make this contact between sensitive and agricultural areas very likely. This analysis allows us to identify the characteristics of the farms that are likely to be the most impacted by the regulation.

2. Material and methods

2.1 Case study description

The study was carried out on the Nord-Pas-de-Calais region (hereafter NPdC), located in the extreme north of France. In 2016, around 18% of the region was artificialized (vs 10% for Metropolitan France as a whole, SRISE Hauts-de-France, 2017) and from 2009 to 2020, 1.5% of the area became artificialized (vs 0.05% of France as a whole, CEREMA, 2021). It is also the second most densely populated of the 22 former administrative regions, after the Paris region, with a density of a 328 inhab/km² (vs 117 inhab/km² in metropolitan France, according to the 2017 INSEE Census). The INSEE typology in urban areas[1] indicated that municipalities belonging to an urban center hosted 77.6% of the region's population in 2017, on 29.8% of the region's surface area (vs 64.9% and 13.6% respectively, at national level). Peri-urban municipalities hosted 21.5% of the region's population on 64.5% of the region's surface area (vs 30.6 and 59.9% respectively, at national level), and areas beyond the sphere of an urban center hosted only 0.8% of the region's population on 5.6% of its surface area (vs 4.5% and 26.5% respectively, at national level). As shown in Figure 1, most of the region is thus within the economic sphere of urban centers.

Agriculture is a non-negligible sector in the region. According to the French Ministry of Agriculture (Agreste Nord-Pas-de-Calais, 2015), in 2013 the Utilized Agricultural Area (UAA) covered 66% of the region's surface area (827,280 ha out of a total of 1,245,080 ha). Agriculture

[1] This zoning distinguishes large (respectively medium or small) urban areas as "a set of municipalities, in one piece and without enclaves, consisting of an urban center of more than 10,000 [respectively 5000 or 1500] jobs, and rural and urban municipalities of which at least 40% of the resident population with a job works in the center or in municipalities attracted by it" (INSEE, 2020)

also employed 27,250 people in 2010 (0.7% of the region's population but around 2.8% of the population working in agriculture in France, according to the 2010 INSEE Census). Farms are mainly specialized in field crops, polyculture and mixed livestock farming (Agreste Nord-Pas-de-Calais, 2015). The main agricultural productions are wheat, sugar beet, fresh vegetables, and potatoes. The livestock farms that still exist are growing fast in terms of surface area (due to concentration) and poultry farming is developing alongside dairy cattle and pig breeding (Agreste, 2020). Figure 2 shows the main type of farming per municipality in the study area. As outlined by Guilpart et al. (2022), NPdC is one of the French regions where the crops located near built-up areas are quite pesticide intensive.

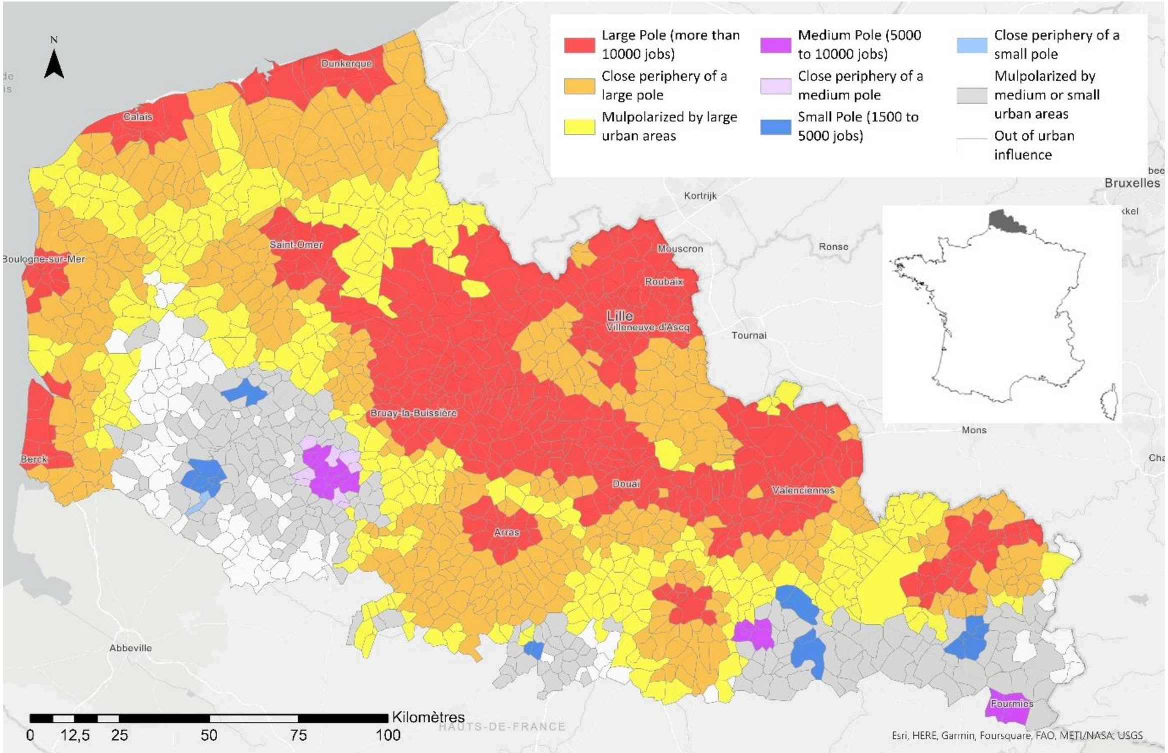

Figure 1 Location of the study area and typology of urban areas

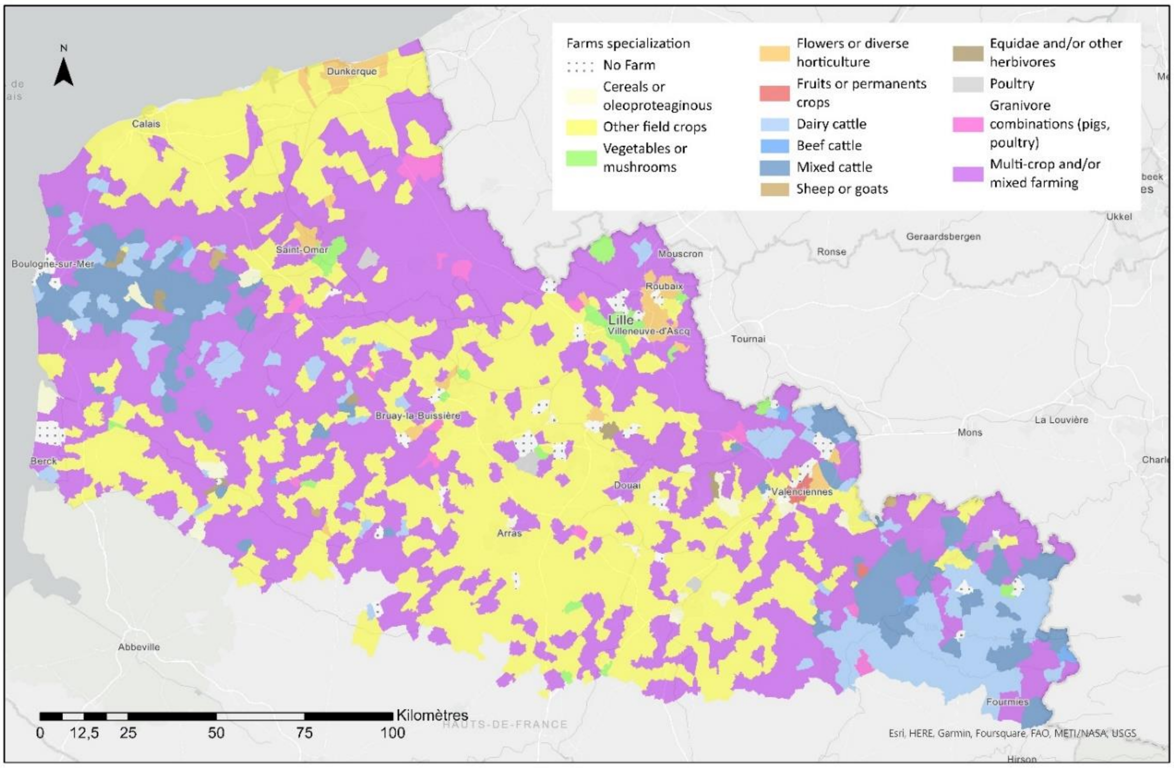

Figure 2 Main type of farming per municipality in the study area (according to 2010 Agricultural Census)

2.2 Data and methods.

We used two different databases – each with different characteristics and associated advantages and drawbacks – to analyze the areas impacted by the regulation:

- the Ocs2d database, produced by the Nord-Pas-de Calais Public platform for geographic information (PPIGE[2]);
- the Land Parcel Identification System (LPIS), used to process and record the declaration files submitted for subsidies under the Common Agricultural Policy (CAP), and managed in France by the ASP, a service and payment agency.

2.2.1. Ocs2d database

Ocs2d was used to assess the pesticide-free areas at regional scale for different types of agricultural uses. The geographical database represents local land use for the year 2015 and covers around 13,736 km (geo2france, 2019). The spatial scale ranges from 1/2000 (or even 1/1500) in urban environments to 1/3000 in natural or agricultural environments (PPIGE, 2018). Not only the built-up areas are represented but also the associated spaces such gardens, car parks and green spaces. Contrary to Guilpart et al. 2022, we therefore consider distances to the

[2] Now called Geo2france

outside limit of the unbuilt amenity space surrounding buildings (where the regulation actually applies), rather than distances to buildings.

To measure and describe the size and type of agricultural areas potentially impacted by the regulation, we needed to define the land use categories corresponding to sensitive areas, defined in Article L. 253-7-1 and in Section III of Article L. 253-8 of the rural and fisheries code as: 1) "*playgrounds and spaces usually frequented by pupils within the confines of educational establishments; spaces usually frequented by children within the confines of crèches, day nurseries and leisure centers, as well as in play areas intended for children in parks, in gardens and in green spaces open to the public*"; 2) "*hospitals, private health facilities, nursing homes, functional rehabilitation homes, facilities that welcome or accommodate the elderly and facilities that accommodate disabled adults or people with serious illnesses*"; and 3) "*areas adjoining inhabited buildings and undeveloped areas for recreational use adjoining these buildings*".

For our purposes, we considered the category "urban area devoted primarily to housing" (that includes 4 sub-categories: continuous, discontinuous, multifamily housing estate and isolated housing) and the classes "schools and universities" and "hospitals" as sensitive areas. We do not consider classes such as "cultural and leisure complexes", "sport facilities" or "parks and green spaces" as part of the "sensitives areas" because they include lots of many land uses that show none of the characteristics mentioned above.

After selecting classes corresponding to sensitive areas, we built 5 m and 10 m buffers around them. Sensitives areas located nearby but outside the boundaries of the NPdC Region are available in the Ocs2d database and were also buffered in case their buffer would cover agricultural areas within the boundaries of the region. We then calculated the area of the intersection between the 5 m buffers and the low agricultural uses, corresponding to arable lands and grasslands, as well as the area of the intersection between the 10 m buffers and the high agricultural uses, corresponding to permanent crops.

Apart from calculating the surface area, we use specific indexes to assess if some uses (types of crops, organic production, etc.) are concentrated or not in buffers:

$$S_{\text{use\_i, buffer}} = \frac{\text{Area of use i in buffer}/\text{Toral area in buffer}}{\text{Total area in use i}/\text{Total agri. area}} = \frac{\text{Area of use i in buffer}/\text{Total area in use i}}{\text{Toral area in buffer}/\text{Total agri. area}}$$

$$= \frac{\text{Buferred area in use i in \% of total buffered agri area}}{\text{Total area in use i in \% of total agri area}} = \frac{\text{Buferred area in use i in \% of total area in use i}}{\text{Total agri area in buffer in \% of total agri area}}.$$

The higher S is compared to 1, the more use i will be concentrated in the buffer area, the more the buffer area will be specialized in use i. In other words, if S>1, use i is relatively more present in the buffer area that in agricultural areas in general.

2.2.2. LPIS database

To study the impact of the regulation at farm level, we relied on the Land Parcel Identification System (LPIS). This system is informed by farmers' declarations of their parcel contours that are eligible for Common Agricultural Policy (CAP) subsidies. The input scale is 1:5000, and the minimum and maximum scales of use are 1:2500 and 1:10,000. The LPIS thus provides yearly updated information on the location and characteristics (namely type of production, organic or not) of the parcels managed by farmers who have filed an application for CAP aid P. Areas that are not eligible for CAP aid are not included in this database. According to Cantelaube and Carles (2014), for metropolitan France, LPIS comprises approximately 6 million plots (approximately 26 million hectares) distributed between just over 400,000 agricultural holdings, while the 2010 agricultural census lists around 490,000 farms in metropolitan France on a UAA of 27 million hectares. Cantelaube and Carles (2014) explain this difference by the absence in the LPIS of areas belonging to farms not subsidized by the CAP and point out that the total area covered by the LPIS is 2 to 3% lower than the holding's utilized agricultural area (UAA). When they distinguish the types of crops, the difference is less than 1% for cereal, oil and protein crops surfaces, 12 to 14% for the meadows and about 60% for permanent crops (on average, over the period 2006-2009). According to the agricultural characteristics of the study area, we thus do not expect a big difference between the area obtained with the Ocs2d and the LPIS databases.

In this study, we use a 2015 version of the LPIS provided by the Regional Department of Food, Agriculture and Forestry (DRAAF Hauts-de-France) that is more detailed than the publicly available one. This version allows us to group the plots together by farm (with an anonymized identifier) and includes farms' total UAA.

To evaluate the representativeness of this database, we selected all the LPIS areas within the NPdC boundaries and compared them to the agricultural areas in the Ocs2d database. We performed this comparison in general, by main types of crops (crops, horticulture, vegetables, permanent crops, grasslands, fodder, set-aside, rangelands, borders and strips and diverse) and by types of area according to the INSEE typology in urban areas. We also made this comparison within the buffered areas. In particular, we compared the number of farms and their surface area in the LPIS to: i) those reported in the 2010 and 2020 agricultural census; ii) data provided by *Agence bio* (a public interest group in charge of the development, promotion and structuring of French organic agriculture); and iii) data provided by DRAAF Hauts-de-France. We expected to find differences, due to the time lag (for comparison with the 2010 and 2020 census) and to the fact that some farms or parcels do not appear in the LPIS if they are not concerned by the CAP. The purpose was to understand how representative the LPIS data was of the actual agricultural uses and structures in general, as well as in the buffer areas and for each kind of agricultural use, farms type (size, production) and territory (urban, peri-urban, rural).

We present here the main observations resulting from this assessment, that should guide the interpretation of our results in the following section. More details can be found in Appendices 1, 2 and 3. We found a 5.8% difference in the total UAA, between LPIS and Ocs2d: the ratio of agricultural area according to LPIS, over the same area according to Ocs2d, is equal to 0.94. That ratio is respectively equal to 0.94 for low uses (that represent more than 99.9% of NPdC agricultural land) and 0.82 for permanent crops. Among low uses, the ratio for arable land (that includes annual crops, borders and strips, and horticulture, and accounts for more than 77% of agricultural land) is 0.96 while that for grasslands is lower (0.82). In line with Cantalaube and Carles (2014), we found that in LPIS, arable land is registered better than grasslands. However, within arable areas, what the Ocs2d classify as annual crops are considered as horticultural crops in the LPIS (horticultural areas are 40 times larger in LPIS than in Ocs2d). If we spatially intersect the two databases, we find that 92.7% of the agricultural areas according to Ocs2d is present in LPIS. If we evaluate the difference in agricultural areas according to the urban-rural gradient, the largest differences are observed in large urban centers (9.1%) and the smallest in close suburbs of middle-sized UA (5.5%). Lastly, according to LPIS, the area under organic farming amounts to 7258 ha, i.e. 94.7% of the area certified as organic in 2015, indicated by Agence Bio (Agreste Haut-de-France 2016).

In the buffered areas, there is a 41.7% difference between the two databases. This means that a large part of the data in the Ocs2d database that is not covered by the LPIS is likely to be located near sensitive areas, and that consequently we under-estimate the impact of the buffers when we use the LPIS database to assess them. The figures (comparison of areas and a percentage of land under this use that is buffered) indicates that for arable land, the coverage of LPIS database is quite satisfactory (ratios>0.7). For grasslands and set aside, the ratios are not as good (0.50 for areas and 0.59 for percentages). Despite limitations, using LPIS data to analyze the impact of 5 m buffers is then more convenient to study impact on arable land than on grasslands, mainly because most of arable lands are annual crops in the region, and because annual crops are correctly represented in the LPIS database. The impact on grasslands is underestimated, probably because grasslands is not covered so well by LPIS and because part of grasslands not covered should be located near sensitive areas (as Guilbert et al., 2022 also observed at national level and for buffers of at least a 10m width). However, considering that the aim of the work is to capture the buffered area where pesticides are likely to be intensively used, we are particularly interested in arable and permanent crops, more than grasslands. In fact, we observe that 0.09 km² (out of 4.77, i.e. 1.89%) of permanents crops are impacted by 10 m buffers while calculations with Ocs2d give 0.07 km² (out of 5.79 i.e. 1.25%) of permanents crop areas impacted, which is in the same order of magnitude. If we take the urban-rural gradient into account, we observe the largest difference in suburbs of small UA (54.7%) and the smallest in suburbs of middle-sized UA (36.5%).

We also found that the UAA of 10,345 farms (83% of average 2010-2020 number of farms in NPdC according to the agricultural census) was correctly described. Most of the farms with the three most common specializations in the area (crops, dairy cattle, polyculture and/or mixed farming) are quite well covered, and farms specialized in other kinds of livestock breeding that are present in the database are also rather well represented in terms of UAA (but some are probably in the “unclassified” category of specialization). Farms specialized in market gardening or horticulture, fruits or permanent crops are the least well covered (probably also because many of them are unclassified in LPIS), while field crops and mixed cropping and/or mixed livestock are those that are covered the most fully. Lastly, 192 farms were declared to be under organic farming (with organic areas accounting for more than 75% of the area declared for 120 of them). According to 2015 register from Agence Bio, there were 340 farms doing organic farming. As the areas under organic farming seem to be rather well covered in LPIS, there is a huge difference in the number of organic farms between the two sources of information. A possible explanation is that those farms that are not present in LPIS would be small farms, non-CAP subsided for their organic production. But again, the most important objective is to capture farms for which the regulation may imply changes in practices, which is not the case for organic ones.

Lastly, using correlation matrices and with statistical (linear) regressions, we observed the relationships between the percentage of UAA affected (and that consisted of non-organic areas under annual crops, permanents crops, horticulture and fodder) and the characteristics of farms.

3. Results

3.1 Impact of buffers at the study area level

Sensitive areas represent around 8.6% of the total study area according to Ocs2d. Most of them are discontinuous (66% of the sensitive areas) and continuous (21%) urban areas devoted primarily to housing (see Appendix 4 for more details). Agricultural areas account for 8589 km², that is 69% of the total study area (12,482 km²). As expected, given the agricultural specialization of the region, permanent crops cover a very small share of the total agricultural area (0.07%) of the region. Most of the low agricultural uses are arable land (around 77% of total agricultural area) followed by grasslands (22.7%) (Table 1).

The surface impacted by buffers is 74 km² i.e. 0.9% of the agricultural area. Concerning low uses, 0.4% of arable land and 2.3% of grasslands are buffered. While grasslands account for less than one third of the arable land in the study area, the buffered grassland area is larger (around 44 km²) than the buffered arable land area (around 29 km²). This gives an indication of the proximity of grasslands to sensitive areas and confirms at a regional scale the observations of Guilpart, 2022. Moreover, 1.3% of the permanents crops area is impacted by the 10 m buffer which totals around 0.07 km². The most over-represented use in the buffers is horticulture, as shown by the specificity index (last column of Table 1). As every use except annual crops presents a specificity index higher than one, those uses are concentrated in buffers.

	Total area		**Buffered area**		**Specificity index S**
	in km²	**in % (aa)**	**in km²**	**as a % of use of each area**	
Agricultural Area (aa)	8589	100.0%	74	0.86%	1
Agricultural "low" uses (includes:)	8583	99.9%	74	0.86%	1
Arable lands (includes:)	**6628**	**77.2%**	**29**	**0.44%**	**0.5**
Annual crops	6566	76.4%	28	0.33%	0.5
horticulture	20.6	0.24%	0.70	1.7%	4.0
Grasstrip	41	0.48%	0.62	3.0%	1.8
Grasslands	**1955**	**22.8%**	**44**	**2.3%**	2.6
Permanent crops	**5.8**	**0.07%**	**0.07**	**1.3%**	**1.5**

Table 1 Total and buffered area according to Ocs2d

As presented in Table 2, most of the NPdC (79%) consists of large urban areas (UAs), with only 6% of the region lying beyond the urban sphere. Most agricultural areas (76%) are located within the sphere of those large UAs, especially on the periphery of large urban centers (56% of NPdC agricultural area). In large UAs, agricultural uses cover 66% of the land (up to 76% in the periphery of large centers). In areas beyond the urban sphere, agricultural uses cover 78% of the land. This is also the case in medium and small UAs, where agriculture accounts for 85% of the land use in the close periphery of large and medium-sized towns. Consequently, and

given urbanization patterns in the different kinds of territories, most of the buffered areas are located in larges urban areas (83%, with 51% of NPdC buffered areas in the periphery of large centers), whereas 13% are located in small and medium-sized UAs, almost all of which are in multipolarized areas. Only 4% of buffered areas are located in areas beyond an urban sphere.
In each kind of territory, buffered areas account for around 1% of all agricultural areas (from 0.50% in areas beyond an urban sphere to 1.44% of agricultural areas in large centers).
As a result, we observe that buffered areas are concentrated in larges centers (the specificity index is higher than 1 for large UAs, all centers, and all areas within an urban sphere only because of this concentration in large centers).

	Total area		**Agricultural area**			**Buffered area**			**specificity index**
	in km²	**in % of NPdC area**	**in km²**	**in % of NPdC agri. area**	**in % of this territory area**	**in km²**	**in % of NPdC buffered area**	**in % of the agri. area of this kind of territ.**	
Large UAs	**9812**	**78.6%**	**6500**	**75.7%**	**66.2%**	**61**	**83.2%**	**0.94%**	**1.1**
Includes ***Large centers***	***3425***	***27.4%***	***1655***	***19.3%***	***48.3%***	***24***	***32.2%***	***1.4%***	***1.7***
Periphery of large centers	***6386***	***51.2%***	***4845***	***56.4%***	***75.9%***	***38***	***51%***	***0.78%***	***0.9***
inc. Close periph of large urban centers	3754	30.1%	2879	33.5%	76.7%	22	30.4%	0,78%	0.9
Areas multi-polarized by large UAs	2632	21.1 %	1965	22.9%	74.7%	15	20.5%	0,77%	0.9
Medium and small UAs	**1965**	**15.7%**	**1536**	**17.9%**	**78.2%**	**9.7**	**13.1%**	**0.63%**	**0.7**
Includes ***Medium-sized or small urban centers***	***289***	***2.3%***	***200***	***2.3%***	***69.2%***	***1.4***	***1.9%***	***0.71%***	***0.8***
inc. Medium-sized urban centers	123	0.99%	79	0.92%	64.0%	0.65	0.9%	0,83%	0.97
Small urban centers	165	1.3%	121	1.4%	73.0%	0.76	1.0%	0,63%	0.7
Periph. of medium and small urban centers	***1677***	***13.4%***	***1337***	***15.6%***	***79.7%***	***8.3***	***11.2%***	***0.62%***	***0.7***
includes Close periph. of medium-sized and small urban centers	48	0.38%	41	0.47%	85.3%	0.22	0.29%	0,53%	0.6
inc. Close periph. of medium-sized urban centers	41	0.33%	35	0.41%	85.4%	0.18	0,24%	0,51%	0.6

Close periph. of small urban centers	6.6	0.05%	5.6	0.07%	84.2%	0.04	0,05%	0,67%	0.8
Area multi-pol. by medium or small UA	1629	13.05%	1296	15.1%	79.6%	8.0	10.9%	0,62%	0.7
Areas beyond urban sphere	705	5.7%	552	6.4%	78.3%	2.8	3.7%	0.50%	0.6
Total	**12,482**	**100.00%**	**8589**	**100.0%**	**68.8%**	**74**	**100.0%**	**0.86%**	**1**
All centers	**3714**	**29.8%**	**1855**	**21.6%**	**50.0%**	**25**	**34.12%**	**1.36%**	**1.6**
All periph.	**8063**	**64.6%**	**6182**	**72.0%**	**76.7%**	**46**	**62.15%**	**0.74%**	**0.9**
inc. ***All close periph.***	3803	30.5%	2921	34.0%	76.8%	23	30.71%	0.78%	0.9
inc. ***all multi-pol. areas***	4261	34.1%	3261	38.0%	76.5%	23	31.44%	0.71%	0.8
All areas within urb. sphere	**11778**	**94.4%**	**8037**	**93.6%**	**68.2%**	**71**	**96.27%**	**0.88%**	**1.03**

Table 2 Total agricultural and buffered areas according to Ocs2d database and urban-rural gradient

3.2. Impact of buffers at the farm level

3.2.1. *Impact of buffers on organic farming*

Organic pest control practices are not concerned by the regulation. Therefore, the adaptation cost for regional agriculture will be lower when there are organic areas in buffers. Location of organic farming near built-up areas can be expected, as the demand for organic production is higher among urban consumers, and organic farming can be a way to extract more value per hectare in places where land is expensive (see e.g. Allaire et al., 2015). It might also be a way for farmers to avoid conflicts regarding chemical spraying with neighboring uses, especially residential ones (although it is rarely the main reason why farmers adopt organic farming, see e.g. Hermelin-Burnol and Preux, 2021). Agreste Haut-de-France (2016) figures show that organic area accounts for only 0.9% of NPdC's total UAA (and 2.7% the NPdC's 2010-2020 average number of holdings). In LPIS, organic areas cover more than 72 km² (i.e. 0.9 % of agricultural areas in LPIS). However, organic areas account for only 0.5% of the buffered areas (the highest percentages are observed for permanents crops and grasslands: respectively 9.4% and 0.7% of their buffered areas are organic). As shown by the specificity index in last column of **Erreur ! Source du renvoi introuvable.**, organic areas are not concentrated in buffers, irrespective of the agricultural use (even permanents crops), except for horticulture.

	Total LPIS area	**LPIS buffered area**	**LPIS organic area**	**LPIS organic area in buffer**	**Specificity index**

		in km²	in % of total LPIS area	in km²	in % of LPIS area in this use	in km²	in % of LPIS area in this use	in km²	in % of LPIS organic area in this use	in % of buffered area in this use	
Arable land		**6392**	**79.0%**	**21**	**0.33%**	**25**	**0.39%**	**0.05**	**0.21%**	**0.25%**	**0.6**
Includes	Annual crops	5430	67.1%	17	0.31%	14	0.26%	0.02	**0.12%**	0.10%	0.4
	Horticulture	859	10.6%	3	0.35%	4.4	0.51%	0.02	**0.49%**	0.71%	1.4
	Borders and strips	22	0.28%	0.31	1.4%	0.00	0.00%	0.00	--	0.00%	--
	Fodder	81	1.0%	0.60	0.74%	6.6	8.2%	0.01	**0.21%**	2.34%	0.3
Grasslands		**1659**	**20.5%**	**22**	**1.3%**	**46**	**2.8%**	**0.16**	**0.35%**	**0.72%**	**0.3**
Inc.	Grasslands	1608	19.9%	21	1.3%	46	2.8%	0.16	**0.34%**	0.76%	0.3
	Set-aside	51	0.63%	1.3	2.5%	0.22	0.43%	0.00	**0.98%**	0.17%	0.4
Classic low uses		**8052**	**99.6%**	**43**	**0.5%**	**71**	**0.88%**	**0.21**	**0.30%**	**0.49%**	**0.6**
Permanent crops		**4.8**	**0.06%**	**0.09**	**1.9%**	**1.3**	**28.12%**	**0.01**	**0.63%**	**9.4%**	**0.3**
Classic uses		***8057***	***99.6%***	***43***	***0.53%***	***72***	***0.90%***	***0.22***	**0.30%**	***0.51%***	***0.6***
Others (if 5m buffered)		**32**	**0.39%**	**0.45**	**1.4%**	**0.25**	**0.78%**	**0.00**	**0.73%**	**0.40%**	**0.5**
Inc.	Diverse	29	0.36%	0.44	1.5%	0.18	0.63%	0.00	**0.99%**	0.42%	0.7
	Rangelands	2.8	0.03%	0.02	0.58%	0.07	2.4%	0.00	**0.00%**	0.00%	0.0
Others (if 10m buffered)		**32**	**0.39%**	**0.94**	**3.0%**	**0.25**	**0.78%**	**0.00**	**1.4%**	**0.38%**	**0.5**
Inc.	Diverse	29	0.36%	0.91	3.1%	0.18	0.63%	0.00	**2.0%**	0.40%	0.6
	Rangelands	2.8	0.03%	0.04	1.3%	0.07	2.4%	0.00	**0.00%**	0.00%	0.0

Table 3 Agricultural, organic and buffered areas according to LPIS database

3.2.2. Impact of buffers on farms

The average percentage of farms' UAA impacted by buffers is 0.9% and the median percentage is 0.5% (Table 4**Erreur ! Source du renvoi introuvable.**). Dispersion around those average and median values is huge, although for 90% of holdings, this does not exceed 1.8% of the total UAA.

	mean	sd	IQR	Min.	25%	50%	75%	90%	max	n
"Classic uses" impacted by buffers in % of total UAA	0.85	1.3	0.74	0.00	0.24	0.51	0.98	1.8	31.1	10,345
% of UAA impacted if other uses are subject to a 5m buffer	0.86	1.3	0.75	0.00	0.24	0.52	0.99	1.8	31.1	10,345
% of UAA impacted if other uses are subject to a 10 m buffer	0.91	1.7	0.79	0.00	0.25	0.54	1.04	1.8	91.0	10345

Table 4 Farms' UAA buffered (in % of farm's UAA): descriptive statistics

Table 5 shows how farms are impacted, according to their specialization. The highest averages (>1%) are observed for ovine and/or caprine and/or others grazing livestock, fruits and/or permanent crops, cattle, and market gardening and/or horticulture. The highest median values (>1%) are observed for ovine and/or caprine and/or other grazing livestock and for beef cattle. Lastly, on most (90%) of farms specialized in crops, dairy cattle and polyculture and/or mixed farming (the most common specializations in our study area), the impacted areas account for less than 2% of the UAA. This is also the case for farms specialized in mixed cattle, pig and/or poultry, or for which the specialization is not provided. The highest value of the ninth decile is observed for farms specialized in ovine and/or caprine and/or other herbivores, mixed cattle, fruit and/or permanent crops, and in market gardening and/or horticulture.

	Mean	SD	IQR	Min	Median	3rd quart	90th percentile	Max	Nber of obs.
field crops	**0.83**	1.4	0.78	0.00	**0.47**	0.97	**1.8**	24.4	5279
market gardening or horticulture	**1.0**	1.5	1.04	0.00	**0.54**	1.2	**2.3**	9.5	129
fruit or other perm. crops	**1.8**	2.5	2.5	0.00	**0.95**	2.5	**3.3**	8.8	12
cattle - milk production	**0.72**	0.74	0.57	0.00	**0.55**	0.89	**1.4**	10.1	1439
cattle - livestock and meat	**1.6**	2.1	1.5	0.00	**1.0**	1.9	**4.0**	18.4	327
cattle - milk, livestock and meat combined	**0.98**	2.2	0.64	0.00	**0.56**	0.99	**1.6**	31.1	277
sheep and/or goats, and/or other herbivores	**1.92**	2.1	1.9	0.00	**1.2**	2.4	**5.0**	11.3	160
pigs and/or poultry	**0.92**	1.6	0.78	0.00	**0.63**	1.1	**1.7**	22.8	340
mixed farming and/or mixed livestock	**0.79**	1.0	0.64	0.00	**0.52**	0.93	**1.6**	14.7	2221
not classified	**0.94**	1.6	0.84	0.00	**0.50**	0.99	**1.8**	13.4	161
no organic area	**0.86**	1.3	0.75	0.00	**0.52**	0.99	**1.8**	31.1	10153
>75% organic	**0.95**	1.4	0.87	0.00	**0.50**	1.0	**2.3**	9.5	120
less than 75% organic	**1.1**	1.7	0.75	0.00	**0.47**	1.0	**2.6**	8.8	72

Table 5 Descriptive statistics of the share of farms' UAA impacted by buffers (when a 5m buffer is applied to rangeland and "diverse" uses) according to specialization (more details in Appendix 5)

If we group farms together according on how much they are impacted and their production characteristics (specialization, organic farming), we obtain Table 6. We observe that around 25% of farms have more than 1% of their UAA impacted. The largest proportion of farms with more than 1% of their UAA buffered are those specialized in ovine and/or caprine and/or other herbivores, beef cattle, and fruits and/or permanent crops. This percentage is similar for conventional and organic farms.

		0%	0-1%	1-2%	2-5%	5-10%	>10%	>1%	Total
All (number of farms)		595	7197	1745	635	137	36	2553	10345
All (in % of the total number of farms)		5.8	69.6	16.9	6.1	1.3	0.35	24.9	100.0
By specia...	**field crops**	7.9	68.3	16.1	6.1	1.3	0.40	23.9	100

	market gardening or horticulture	8.5	63.6	14	10.9	3.1	0.0	28.0	100
	fruit or other perm. crops	25.0	25.0	16.7	25	8.3	0.0	50.0	100
	cattle - milk production	1.7	78,0	16.3	3.7	0.30	0.10	20.4	100
	cattle - livestock and meat	8.3	41.0	27.2	18	4.3	1.2	50.7	100
	cattle - milk, livestock and meat combined	1.4	74.0	17.7	5.1	1.1	0.70	24.6	100
	sheep and/or goats, and/or other herbivores	9.4	36.2	21.2	23.1	9.4	0.60	54.3	100
	pigs and/or poultry	4.7	67.6	20.6	5.3	1.2	0.60	27.7	100
	mixed farming and/or mixed livestock	2.3	75.1	16.8	4.8	0.90	0.20	22.7	100
	not classified	17.4	57.8	16.1	5.6	2.5	0.60	24.8	100
Organic farming*	no organic farming	5.7	69.7	16.9	6.1	1.3	0.40	24.7	100
	>75 % organic	12.5	60.8	15	9.2	2.5	0.0	26.7	100
	less than 75% organic	2.8	72.2	9.7	11.1	4.2	0.0	25.0	100

Table 6 Number of farms according to percentage of UAA buffered, expressed in % of the total number of farms (by production type). *% of the total number of farms having this share of organic areas

As some uses are usually more pesticide-intensive than others (Butault et al., 2011), we considered only the buffered non-organic areas of annual crops, permanent crops, horticulture and fodder as a percentage of the total UAA. Table 7 and Table 8 present the same analysis as the previous ones, but exclude organic areas, grasslands, set aside, borders and strips, and "rangeland and diverse". The mean, median and 9th decile values (Table 7) are respectively 0.4%, 0.1% and 0.9% of the UAA. Average value is over 1% for fruits and/or permanent crops only, median value is always below 1%, and 9th decile value is above 2% for fruit and/or permanent crops and for market gardening and/or horticulture (and over 1% for crops and for pigs and/or poultry). Less than 9% of the farms (Table 8) have more than 1% of their UAA that is both buffered and under non-organic annual crops, permanent crops, horticulture or fodder (most of the buffered areas devoted to ovine and/or caprine and/or others herbivores and beef cattle farms are probably grasslands or rangelands). The largest shares of farms with more than 1% of UAA buffered are those specialized in fruit and/or permanent crops (50%), followed by market gardening and/or horticulture (23%), field crops (12%) and pig and/or poultry (10,6%). This share is the lowest (as expected) for farms with over 75% of their UAA devoted to organic farming, but highest for farms that are only partially organic.

		Mean	SD	IQR	Min	Median	3rd quart	90th percentile	Max	No. of obs.
All		0.38	0.79	0.46	0.00	0.14	0.46	0.93	22.8	10345
	field crops	0.48	0.94	0.57	0.00	0.21	0.59	**1.1**	17.5	5279
	market gardening or horticulture	0.74	1.1	0.89	0.00	0.36	0.94	**2.1**	6.4	129
	fruit or other perm. crops	**1.9**	1.6	2.4	0.00	0.83	2.4	**3.1**	5.0	12

	cattle - milk production	0.16	0.27	0.20	0.00	0.05	0.20	0.48	3.4	1439
	cattle - livestock and meat	0.07	0.25	0.00	0.00	0.00	0.00	0.18	2.4	327
	cattle - milk, livestock and meat combined	0.12	0.21	0.15	0.00	0.03	0.15	0.34	2.2	277
	sheep and/or goats, and/or other herbivores	0.16	0.47	0.01	0.00	0.00	0.01	0.53	3.5	160
	pigs and/or poultry	0.48	1.3	0.57	0.00	0.27	0.61	**1.0**	22.8	340
	mixed farming and/or mixed livestock	0.32	0.52	0.42	0.00	0.15	0.43	0.81	8.3	2221
	not classified	0.39	0.71	0.54	0.00	0.12	0.54	0.98	5.5	161
Organic farming*	**no organic farming**	0.38	0.79	0.47	0.00	0.15	0.47	0.93	22.8	10153
	>75 % organic	0.20	0.59	0.06	0.00	0.00	0.06	0.58	3.7	120
	less than 75% organic	0.57	1.1	0.63	0.00	0.12	0.63	1.5	5.2	72

Table 7 Descriptive statistics of the share of farms' UAA impacted by buffers that are in non-organic areas of either annual crops, permanents crops, horticulture or fodder (when a 5m buffer is applied to rangeland and "diverse" uses) according to specialization

		0%	**0-1%**	**1-2%**	**2-5%**	**5-10%**	**>10%**	**>1%**
	All (number of farms)	2759	6668	654	220	35	9	918
	All (in % of the total number of farms)	26.7	64.5	6.3	2.1	0.34	0.09	8.84
By specialization (% of the total number of farms having the specialization)	**field crops**	20.8	67.1	8.4	3	0.5	0.2	12.1
	market gardening or horticulture	18.6	58.1	11.6	**10.1**	**1.6**	0	23.3
	fruit or other perm. crops	33.3	16.7	16.7	**33.3**	**0**	0	50
	cattle - milk production	35.4	62.3	2.2	0.1	0	0	2.3
	cattle - livestock and meat	80.1	18.3	1.2	0.3	0	0	1.5
	cattle - milk, livestock and meat combined	40.4	59.2	0	0.4	0	0	0.4
	sheep and/or goats, and/or other herbivores	73.8	21.2	3.8	1.2	0	0	5
	pigs and/or poultry	20.3	69.1	9.1	1.2	0	0.3	10.6
	mixed farming and/or mixed livestock	22.7	70.8	5	1.4	0.2	0	6.6
	not classified	36	54	6.8	2.5	0.6	0	9.9
Organic farming*	**no organic farming**	26.3	64.9	6.4	2.1	0.3	0.1	8.9
	>75 % organic	63.3	31.7	1.7	3.3	0	0	5
	less than 75% organic	23.6	59.7	9.7	5.6	1.4	0	16.7

Table 8 Number of farms according to percentage of UAA buffered and non-organic areas of annual crops, permanents crops, horticulture and fodder, expressed in % of the total number of farms (by production type) . *% of the total number of farms having this share of organic areas

3.2.3. Relation between affected agricultural areas and farm characteristics

In this section, we call "dependent variable", the percentage of UAA that is both in buffers and under non-organic annual crops, permanents crops, horticulture and fodder. We consider the relationships between the dependent variable and the characteristics of farms, by means of the correlation and statistical linear regressions.

The dependent variable is negatively correlated (see correlation table in appendix 6) with the total UAA and the annual crop area (both, if expressed in ha and in % of the UAA), and with the area under horticulture (when expressed in ha). Conversely, the dependent variable is positively correlated with the area under grasslands (when expressed in % of the UAA but negatively and to a lesser extent when expressed in ha) and, to a lesser extent, with the area located in large urban centers.

Even if the explanatory power of the linear regressions presented in Table 9 (more details in Appendix 7) is weak (see "R-squared": only around 10% of the dependent variable's variance is explained), such regression highlights some interesting relationships. When introduced as explanatory variable, the share of UAA located in the urban centers, in the close periphery or in multi-polarized municipalities of large UAs, showed a positive effect on the dependent variable. However, given the correlation between those variables, this introduction creates high collinearity. Therefore, we merged them into a single variable (% of UAA in a large UA) and observed a positive relationship between the dependent variable and the share of UAA located in large UAs, in small urban centers, and in municipalities multi-polarized by median or small centers.

The regressions also show positive relationships with the share of UAA in fodder, permanent crops, horticulture or annual crops (while the correlation, i.e. when not controlling for the effect of other variables, between the latter three crops and the dependent variable is negative). The effect of the total UAA is negative (as is the effect of the share of grasslands, when introduced in the regression[3]). Lastly, if we consider farms' specialization (rather than share of UAA in different crops), we observe that farms specialized in market gardening or horticulture and fruit or other permanent crops are impacted significantly more than field crop farms. Other farms are affected significantly less by the regulation than are field crops farms, except for farms specialized in pigs and/or poultry (for which the impact is not significantly different than for field crop farms).

Dependent variable = non-organic areas of annual crops, permanents crops, horticulture and fodder buffered areas (in % of total UAA)	**reg1**		**reg2**		**reg3**	
(Intercept)	-0.120	**	0.402	***	0,323	***
% of UAA in a large UA	0.003	***	0.003	***	0,004	***
% of UAA in medium-sized center	0.001		0.001		0,001	
% of UAA in periphery of a medium-sized center	-0.001		-0.001		-0,000	
% of UAA in a small center	0.002	.	0.002	.	0.001	
% of UAA in periphery of a small center	0.001		0.001		0.000	
% of UAA in *municipalities muti-polarized by medium-sized or small centers*	0.001	.	0.001	.	0.001	
UAA (ha)	-0.003	***	-0.003	***	-0.002	***

[3] This is due to the fact that the dependent variable excludes grassland.

% of UAA organic	-0.000		-0.000		-0.001	
% of UAA in annual crops	0.005	***	--		--	
% of UAA in grasslands	--		-0.005	***	--	
% of UAA in borders and strips	0.080	***	0.075	***	--	
% of UAA "diverse"	0.005		0.001		--	
% of UAA in rangeland	-0.001		-0.007		--	
% of UAA in set-aside	0.004		-0.001		--	
% of UAA in fodder	0.006	***	0.001		--	
% of UAA in horticulture	0.008	***	0.003		--	
% of UAA in permanent crops	0.016	***	0.011		--	
market gardening or horticulture	--		--		0.201	**
fruit or other perm. crops	--		--		0.839	***
cattle - milk production	--		--		-0.226	***
cattle - livestock and meat	--		--		-0.430	***
cattle - milk, livestock and meat combined	--		--		-0.257	***
sheep and/or goats, and/or other herbivores	--		--		-0.398	***
pigs and/or poultry	--		--		-0.030	
mixed farming and/or mixed livestock	--		--		-0.106	***
not classified	--		--		-0.145	*
adjusted R-squared:	0.1103		0.1100		0.081	
F-statistic's p-value:	< 2.2e-16		< 2.2e-16		< 2.2e-16	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 9 Relationships between the area buffered in non-organic areas of annual crops, permanents crops, horticulture and fodder (in % of total UAA) and available farm characteristics.

4. Discussion

4.1 Further research and policy implications

The obtained results suggest that special attention should be paid to the impact of the pesticide regulation on some farms such as small non-organic fruit/permanent crops or market gardening/horticulture specialized farms, especially when located in large urban areas. Those farms appears to be both the most impacted by the regulation and the ones for which the results are the most likely to underestimate the share of utilized agricultural area actually concerned by the regulation. They are the most affected farms since these productions are usually located near cities (high value added per unit of land, as land is increasingly expensive the closer one gets to the cities) and because they are usually among the most dependent on the use of phytoproducts. These productions are prone to pest attacks, yet, given land rent levels near cities, production must be secured. Thus, in the context of urban expansion or sprawl, policies to support these most impacted farms both locally (e.g. land use policy) and on a wider scale (e.g. national or regional equivalents to the Common Agricultural Policy) seems particularly relevant.

Further analysis can also focus on the share of land that is directly affected at plot level (rather than at farm level). For a given percentage of UAA affected, and depending on farm specialization, farmers' decisions might not be the same if some plots are heavily affected or if the impact is more dispersed among plots. In the first case, farmers might change the use on the entire area of affected plots, opting rather for pesticide-free uses or even giving up cultivating them. Moreover, as plots near artificialized areas are usually smaller, heavily impacted plots are expected to be more likely to be found near or in urban areas.

While studies such as this one or that of Guilpart et al. 2022 are necessary steps to assess the potential impacts of such a regulation, its actual economic impacts will depend on the production (value-added per hectare, how they are compatible with pesticide-free practices or can be distributed differently among the farm's plots) and on the geographical characteristics of farms' plots (location and fragmentation). It will also depend on how the regulation is actually enforced and evolves. For instance, in many cases, according to local charters resulting from the consultations between inhabitants, elected officials and farmers (and approved before July 2021) the width of the non-treatment zone can be reduced, for instance if farmers use special machinery (such as anti-drift devices). However, in July 2021, the Conseil d'État prohibited the development and approval of new charters (Vie Publique, 2022, Escoffier, 2021). Even if we consider that the data quality is sufficient and the regulation is not subject to local alteration or weak enforcement, this economic impact evaluation is still challenging. The literature assessing the output elasticity of land reveals a wide diversity of results, depending on the context, methodology and data used (see e.g. Zhengfei et al., 2005; Gardebroeck et al., 2010; Kumbahar et al., 2009; Lakner and Breustedt, 2017; Petrick and Kloss, 2013; Tiedemann and Latacz-Lohmann, 2013; Madau 2007). The same goes for the literature on the output elasticity of pesticides (see e.g. Karagiannis and Tzouvelekas, 2012; Skevas et al. 2012; Zhengfei et al., 2005; Gardebroeck et al., 2010). Moreover, these works consider the reduction of pesticides at the farm (or more aggregated) level and not on specific areas only. The 1992 CAP reform introduced a 15% compulsory set-aside rate applied to the combined area of cereals, fodder maize, oilseeds, and protein crops. One can also draw inspiration from works assessing the impact of the 1992 reform on agricultural practices and output (e.g. Falconer and Oskam, 2000; Abler and Shortle, 1992; Serra et al., 2005; Boussard et al., 1997). However, compulsory set-aside concerns only field crops, and farmers are able to choose where to locate the set aside, while they cannot do so for non-treatment buffers, which concern all kinds of productions. Considering this, the risk of more intensive use of pesticides in areas outside of buffers (to compensate for the loss of production in buffered areas and to limit potential pest development coming from them) may be higher with the implementation of non-treatment zones than with the compulsory set-aside areas.

Lastly, impacts may also be observed in land markets and in land use regulations. We might expect a decrease of land rent for agricultural plots located near sensitive areas and, on the contrary, an increase of value for developable plots located at the agricultural fringe. The question also arises as to who (developer or farmers?) will or should bear the adaptation cost associated with the non-treatment zone in case of new "sensitive areas" developing at this fringe.

4.2 Methodological discussion

Along with the current regulation, we considered 5m and 10m distances from to the outside limit of unbuilt amenity spaces surrounding buildings that can be considered as residential or hosting vulnerable people. It is a first attempt to assess the impact of this kind of policy with this degree of detail. In fact, previous works considered 10m and 150m distances from residential and undifferentiated (use unknown) buildings (Guilpart et al. 2022).

Data resolution can however involve some methodological issues. First, some current uses are not mapped if their area is below the minimum mapping unit of Ocs2d (MMU= 50m² for built areas, 300m² for other) or, for linear elements, if their width is below the minimum width (MMI=3m for roads; 3.5m for railways; 5m for grass strips and watercourses, and 10m for all other uses). This means that we can miss either isolated sensitive areas (i.e. exclusively surrounded by non-sensitive areas) smaller than 50m² or narrower than 10m, as well as isolated agricultural areas (i.e. exclusively surrounded by non-agricultural uses) smaller than 300m² or narrower than 10m. If a given agricultural use is adjacent to another given agricultural use, it will be merged to the latter if it is smaller than 300m² or narrower than 10m (5m for grass strips) (PPIGE, 2018). Other uses whose surface area or width is below their respective MMI or MMU can also be merged to (and so be considered as) sensitive or agricultural uses, even if they do not actually belong to these categories. Moreover, considering that the map resolution is at 1:2500 scale, an error of 4 to 6m is possible, and a 5m buffer consequently falls in this margin of error. However, this would imply an underestimation on our assessment only in the case of a 6m error in the location of the border between agricultural and sensitive areas encroaching on the agricultural area, and if the agricultural area (in general or in a specific agricultural use) is narrower than 11m (see Appendix 8). We therefore decided to consider 5m buffers rather than larger ones because they correspond to the requirement of the regulation with regard to low uses, i.e. over the great majority of agricultural uses in our area of study. We are however aware of the data accuracy limitations and the figures presented in results should be considered as orders of magnitude, not exact measures.

5. Conclusion

Based on the presented analysis, around 9% of the Nord-Pas-de Calais area can be considered as residential or hosting vulnerable people, that is, areas around which the use of agricultural pesticides has been forbidden since the end of 2019 unless specific conditions are met. Less than 1% of arable land (field crop, borders and strips, and horticulture) are impacted. This share is far lower than the percentages argued by the main farmers union. It may be partly explained because the agricultural area subject to a 10m buffer (permanent crops) accounts for less than 1% of the region's agricultural surface area. As expected, the share of agricultural land concerned by the regulation decreases along the urban to rural gradient.

Contrary to Ocs2d, the LPIS database allows us to assess the spatial impact of the regulation at farm level. Our results indicate that less than 1% of the regional agricultural area is impacted, and that 90% of farms have less than 2% of their total UAA concerned by the regulation, and less than 1% if we exclude areas with no or less dependence on pesticides. Farms are all the more likely to be impacted by the regulation when their plots are located in large urban areas, and to a lesser extent in small urban centers or in municipalities that are multi-polarized by median or small centers. This is also the case if they have a large share of land under permanent crops, horticulture, diverse uses, annual crops or fodder, and if they are specialized in market gardening or horticulture and fruit or other permanent crops. On the other hand, they are less likely to be strongly impacted by the regulation when the UAA is large (and when they have a large proportion of grasslands, as we did not consider them as pesticide intensive).

These results should be considered only as orders of magnitude, due to resolution limitations of the two databases, and with caution due to characteristics of the LPIS database. Whereas agricultural areas and the percentage of these areas that are buffered are rather similar for annual crops (i.e. the main region's agricultural uses) in Ocs2d and LPIS, these differences may be far from negligible for other uses (LPIS underestimates areas), depending on their location on the rural-urban gradient. Likewise, most of farms with the three most common specializations in the area (crops, dairy cattle polyculture and/or mixed farming) are fully taken into account. However, farms specialized in market gardening or horticulture, fruit or permanent crops are less well described, as are small organic farms but their practices would not be impacted by the regulation).

Special attention should thus be paid to the impact of this regulation on some farms such as small non-organic fruit/permanents crops or market gardening/horticulture specialized farms, especially when located in (large) urban areas. Those farms are indeed both the most impacted and the ones for which our results are the most likely to underestimate the share of utilized agricultural area actually concerned by the regulation.

Further analysis could also focus on evaluating the effective economic impacts of such a regulation, namely for some specific groups of farms, for instance, according to their specialization and location, or the characteristics of their plot organization. Related implications in terms on territorial or sectoral policies also represent an interesting research avenue.

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Acknowledgments:

This paper has been supported by the European Center for Humanities and Social Sciences (MESHS-Lille, France)

Thank you to Nicolas Rochard from the Agence Hauts-de-France 2020-2040 for his advice about the Ocs2d database, and the Regional Service for Statistical and Economic Information (SRISE) of Hauts-de-France's Regional Directorate of Food, Agriculture and Forestry (DRAAF Haut de France) for giving us access to the LPIS database at farm level.

Thank you to Kassoum Ayouba, Jean-Philippe Boussemart, Florence Jacquet and Aude Ridier, for their suggestions concerning the Discussion.

Appendices

Appendix 1: Preliminary analysis of the LPIS database

1) Groups of agricultural productions

To make analyses tractable, we allocate the 28 groups of agricultural productions described in the LPIS to 9 main types, as similar as possible to the uses described in the Ocs2d database. Those 9 types are:

- annual crops: mainly cereals, oleaginous and fodder crops, fibers, non-fodder legumes and also what is defined as "other industrial productions" in LPIS because in 99% of the areas in our study region, these other industrial productions are sugar beet;
- horticulture: vegetables, including non-tree fruit, and flowers;
- permanent crops: orchards and nuts production, and probably not in our region, vineyards and olive trees;
- grasslands: temporary or permanent meadows
- fodder: mainly grasses and annual crops used as fodder, so this category includes productions/uses that could potentially belong to the annual crops or grassland category of the Ocs2d;
- set-asides;
- rangelands: more or less wooded grazing areas;
- borders and strips: field or forest borders and some strips that can be eligible for CAP subsidies;
- diverse: everything else, mainly including agricultural areas temporarily not used (66%), wooded areas on former farmlands (17%), plant/tree nurseries (9%) and short rotation coppices (4%).

2) Overlaps

Preliminary analyses of the LPIS database revealed that there are some overlaps between areas drawn by farmers (called "polygons" in the following) (as also observed by Guilpart et al., 2022). Those overlaps are possibly due the declarative character and the scale of the map on which farmers had to draw their plots. More precisely, we obtain a difference of 0.24 km² between the area obtained by summing the area of each polygon (8088.61km²) and the total area covered by those polygons without overlap (8088.36 km² i.e. 65% of our 12,482.35 km² study area).

When we merge all the polygons belonging to the same type together (so that we have no overlap of polygons of the same type), only 0.11 km² of overlap remains. When we merge all the polygons belonging to the same holding (so that we have no overlap of polygons belonging to the same holding), overlapping is about 0.22 km².

Appendix 2: Representativeness of LPIS in terms of agricultural uses (comparison of areas with Ocs2d)

The first step to check if LPIS can reasonably be used to analyze the impact of no-pesticides zones is to compare total and buffered agricultural areas in LPIS to those in Ocs2d according to agricultural use and the rural-urban gradient.

If we compare total agricultural areas given by the two databases (0A), we see that there is 5.83% of difference. Low uses represent 8051.81 km² (i.e. 99.55% of the agricultural area) in LPIS vs. 8583.22 km² (i.e. 99.93% of the agricultural area) in Ocs2d. Permanent crops represent 4.77 km² (i.e. 0.06%) in LPIS vs. 5.79 km² (0.07%) in Ocs2d. Focusing on the two most common uses, arable land and grassland, we observe that arable land accounts for 6392.96 km² (i.e. 79.04% of the agricultural area) in LPIS versus 6628.23 km² (i.e. 77.1% of the agricultural area) in Ocs2d. Grassland accounts for 1607.76 km² (i.e. 19.88% of the agricultural area) in LPIS[4] versus 1955 km² (i.e. 22.7% of the agricultural area) in Ocs2d. The ratio in the last column of 0 suggests that the agricultural area is overall well covered (R=0.94), especially arable land[5] (R=0.96). However, even the distribution of uses within this category differ significantly between the two databases, namely with larger areas in horticulture according to LPIS (those areas are classified in "annual crops" in Ocs2d, see Table B). The ratio for grasslands and permanent crops is a bit lower but still high (R=0.82).

[4] 1658.85 km², i.e. 20.51% if we add set-aside. Set-aside is rather counted in "Grasslands" as over the 51.09 km² declared as setaside in LPIS (see 0), 32.42 km² are located on grasslands according to Ocs2D, while 9.22km² are located in annual crops (and the remaining in other uses according to the Ocs2d).

[5] Even if the distribution of uses within this category differs, with, e.g., larger areas under horticulture, according to the LPIS.

		LPIS		Ocs2d		R=Ratio area LPIS/area Ocs2D
Total		**8088.49**	**100.00%**	**8589.01**	**100.00%**	**0.941725531**
Low uses		**8051.81**	**99.55%**	**8583.22**	**99.93%**	**0.938087338**
Arable land		**6392.96**	**79.04%**	**6628.23**	**77.17%**	**0.964504853**
Including	Annual crops	5430.49	67.14%	6566.37	76.45%	0.827015535
	borders and strips	22.26	0.28%	41.3	0.48%	0.538983051
	Horticulture	859.2	10.62%	20.56	0.24%	41.78988327
Grasslands		**1607.76**	**19.88%**	**1955**	**22.76%**	**0.822383632**
Set-aside		51.09	0.63%	--	--	--
Permanent crops		**4.77**	**0.06%**	**5.79**	**0.07%**	**0.823834197**
"Classic uses" (everything except "diverse" and "rangeland")		**8056.58**	**99.60%**	**8589.02**	**100.00%**	
Diverse		29.15	0.36%			--
Rangelands		2.76	0.03%			--

Table A: Areas per type of use according to LPIS and Ocs2d (in km² and in percentage of the total agricultural area according to each database within the boundaries of the NPdC region).

If we spatially intersect the two databases (Table B), we observe that within the 8088 km² that LPIS covers, 7959 km² correspond to areas presented as agricultural by Ocs2d (and almost 21 km² correspond to agricultural infrastructures in Ocs2d), meaning that 92.67% of the agricultural areas according to Osc2d is present in LPIS. 37 km² of LPIS areas correspond to areas in forestry according to Ocs2d and the remaining 72 km² of LPIS areas correspond to diverse others uses (not agriculture or forestry) according to Ocs2d. If by "covered by LPIS" we mean that those areas are present in the LPIS, irrespective of the category of use the farmer declares for them, then annual crops are those that are covered most comprehensively (96.76%) by the LPIS (81.72% declared as annual crops, 12.90% declared as horticulture, and the remaining 2.14 % declared under other types). They are followed by grasslands (80.07%, with 74.93% declared as such, the remaining 5.14 % being declared under other types). About other uses, 65.51% of grass strips are covered by LPIS (31.30% declared as such and 15,94% declared as annual crops, the remaining 18.27 % declared under other types, mainly set-aside and grasslands) and 59.45% of permanent crops are covered by LPIS (with 53.25% declared a such). Lastly, 46.42% of horticultural areas are covered by LPIS (29.47 declared as such and the remaining 16.95% declared under other types, mainly "diverse" and "annual crops").

As mentioned by Cantelaube and Carles (2014), the most likely reason for such differences is that those productions/uses are less eligible for CAP aid.

	Columns: agricultural uses according to LPIS										
Lines: agricultural uses according to Ocs2d	*Annual Crops*	*Borders and strips*	*Fodder*	*Grasslands*	*Horti-culture*	*Perm. crops*	*Diverse*	*Range-lands*	*Set-aside*	*Area covered by the LPIS database (in km²) and % of Ocs2D area corresponding to the line*	*Area according Ocs2d (in km² and in % of the Ocs2d total agricultural area)*
Grassland (km² and % of the total grassland area according to Oscd2D)	*32.64* *1.67%*	*1.37* *0.07%*	*25.90* *1.32%*	*1464.87* *74.93%*	*1.68* *0.09%*	*0.80* *0.04%*	*4.99* *0.26%*	*0.59* *0.03%*	*32.42* *1.66%*	***1565.27*** ***80.07%***	***1955.00*** *22.76%*
Grass-strips (km² and % of the total grass-strips area according to Oscd2D)	*6.58* *15.94%*	*12.93* *31.30%*	*0.37* *0.89%*	*2.49* *6.04%*	*1.11* *2.68%*	*0.02* *0.05%*	*0.35* *0.84%*	*0.00* *0.00%*	*3.21* *7.77%*	***27.06*** ***65.51%***	***41.30*** *0.48%*
Annual crops(km² and % of the total annual crops area according to Oscd2D)	*5366.32* *81.72%*	*6.35* *0.10%*	*52.90* *0.81%*	*63.91* *0.97%*	*846.79* *12.90%*	*0.23* *0.00%*	*8.05* *0.12%*	*0.01* *0.00%*	*9.22* *0.14%*	***6353.79*** ***96.76%***	***6566.37*** *76.45%*
Horticulture (km² and % of the total horticulture area according to Oscd2D)	*1.00* *4.87%*	*0.05* *0.24%*	*0.09* *0.43%*	*0.21* *1.00%*	*6.06* *29.47%*	*0.24* *1.17%*	*1.87* *9.09%*	*0.00* *0.00%*	*0.03* *0.15%*	***9.54*** ***46.42%***	***20.56*** *0.24%*
Permanent crops (km² and % of the total Permanent crops e area according to Oscd2D)	*0.04* *0.67%*	*0.01* *0.11%*	*0.00* *0.00%*	*0.05* *0.88%*	*0.13* *2.22%*	*3.08* *53.25%*	*0.11* *1.91%*	*0.00* *0.01%*	*0.02* *0.39%*	***3.44*** ***59.45%***	***5.79*** *0.07%*
SUM of Ocs2D agricultural uses covered by LPIS (km² and % of the agricultural area according to Oscd2D)	***5406.58*** *62.95%*	***20.70*** *0.24%*	***79.26*** *0.92%*	***1531.54*** *17.83%*	***855.77*** *9.96%*	***4.37*** *0.05%*	***15.37*** *0.18%*	***0.61*** *0.01%*	***44.91*** *0.52%*	***7959.10*** *92.67%*	***8589.01*** *100.00%*
Area in LPIS per category (and % of the total LPIS area = 8088,48)	5430.49 (67.14%)	22.26 (0.28%)	81.01 (1.00%)	1607.76 (19.88%)	859.20 (10.62%)	4.77 (0.06%)	29.15 (0.36%)	2.76 (0.03%)	51.09 0.63%)		

Table B: Intersection of LPIS areas and Ocs2d

If we study the difference in agricultural areas according to the urban-rural gradient, the largest differences are observed in the urban centers of large Urban Areas (9.1%) and the smallest in close suburbs of middle-size UA (5.5%) (Table C)

	Agricultural area according to Ocs2d	Agricultural area (except rangeland and diverse) according to LPIS km²)	Relative difference between "classic uses" according to Ocs2D and classical uses according to LPIS
Large centers	***1655.67***	***1505.69***	***-9.1%***
Close periphery of large centers	2879.83	2721.03	-5.5%
Areas multi-polarized by large UAs	1965.30	1858.57	-5.4%
Peri-urban areas of large UAs (close periphery + multi-polarized)	***4845.13***	***4579.60***	***-5.5%***
Large UAs (center + peri-urban)	**6500.80**	**6085.30**	**-6.4%**
Medium-sized centers	78.84	72.39	-8.2%
Close periphery of medium-sized centers	35.17	34.06	-3.2%
Small center UA	120.82	114.08	-5.6%
Close periphery of small centers	5.59	5.27	-5.7%
Area multpolarized by medium-sized or small UA	1295.89	1223.68	-5.6%
Medium-sized and small centers	***199.66***	***186.47***	***-6.6%***
Peri-urban of medium-sized and small areas (close periphery and multi-polarized)	***1336.65***	***1263.01***	***-5.5%***
Medium-sized and small UAs (center and peri-urban)	**1536.30**	**1449.48**	**-5.7%**
Areas out of urban influence	**551.91**	**521.79**	**-5.5%**
Total (UA and out of influence)	**8589.01**	**8056.57**	**-6.2%**
All centers	**1855.33**	**1692.16**	**-8.8%**
All peri-urban areas	**6181.78**	**5842.61**	**-5.5%**
All urban areas	**8037.10**	**7534.77**	**-6.3%**

Table C: Agricultural areas according to database and urban-rural gradient

Last, the "Agence Bio" counted 7666 ha of area certified as organic in 2015 (Agreste Haut-de-France 2016), while according to LPIS, the areas under organic farming amounted to 7258 ha (i.e. 94.7% of the area indicated by Agence Bio).

If we focus on buffered areas, they concern 43.03 km² out of 8056.57 km² (i.e. 0.53%) of classic agricultural uses according to LPIS, versus 73.81 km² out of 8589.01km² (i.e. 0,86%) of agricultural uses according to Ocs2d. There is thus a 41.7% difference between the two databases. This means that a large part of the Ocs2d data that are not covered by LPIS should be located near sensitive areas and that we have therefore underestimated the impact of the buffers by using the LPIS database to asses them. However, if we consider arable land, we obtained an area and a percentage impacted (20.97 km² out of 6392.95 km² i.e. 0.33% of arable land in LPIS) that are closer to those obtained with Ocs2d (29.47 km² out of 6628.23 km² i.e. 0.4% of arable land in Osc2d) than for other uses (a 28.8% difference between the two databases). For grasslands (+set aside[6]), the area impacted is 21.96 km² (out of 1658.85 km² i.e. 1.32%) in LPIS versus 44.27 km² (out of 1955.00 km² i.e. 2.3%) in Ocs2d, which is far less satisfactory (50.4% of (28.8% of difference). Despite limitations, using LPIS data to analyze the impact of 5m buffer is then more convenient to study impacts on arable land than on grasslands, mainly because most of those arable lands are annual crops in the region, and because annual crops are all taken into account in the LPIS database. The impact on grasslands is underestimated, probably because grasslands are not so well covered by LPIS and because the parts that are not covered should be located near sensitive areas. Lastly, 0.09 km² (out of 4.77 i.e. 1.89%) of permanents crops are impacted by 10m buffers, while calculations with Oscd2 give 0.07 km² (out of 5.79 i.e. 1.25%), which is in the same order of magnitude (0).

		Ocs2d		LPIS		Ratio	
		Area buffered in km² and in % of the total area in each use		Area buffered in km² and in % of the total area in each use		Area buffered LPIS / area buffered Ocs2d	% buffered LPIS / % buffered Ocs2d
Arable land		***29.47***	***0.4%***	***20.97***	***0.33%***	***0.712***	***0.738***
Including	Annual crops	28.15	0.3%	17.02	0.31%	0.605	0,949
	Horticulture	0.7	1.7%	3.04	0.35%	4.345	0,209
	Borders and strips	0.62	3.0%	0.31	1.39%	0.500	0,462
	Fodder	--	--	0.60	0.74%	--	--
Grasslands		***44.27***	***2.3%***	***21.96***	***1.32%***	***0.496***	***0.585***
Including (for LPIS)	Grasslands	44.27	2.3%	20.66	1.29%	0.467	0,568
	Set-aside	--	--	1.30	2.54%	--	--
Low uses		**73.74**	**0.9%**	**42.94**	**0.53%**	**0.582**	**0.621**
Permanent crops		**0.07**	**1.25%**	**0.09**	**1.89%**	**1.249**	**1.515**
Classic uses		**73.81**	**0.86%**	**43.03**	**0.53%**	**0.583**	**0.622**
Others (if 5m buffered)		0.58	9.53%	31.91	0.45	1.42%	0.781
Including	Diverse	--	--	0.44	1.50%	--	--
	Rangelands	--	--	0.02	0.58%	--	--
Others (if 10m buffered)		0.70	11.48%	0.94	2.96%	1.352	0.258
Including	Diverse	--	--	0.91	3.12%	--	--
	Rangelands	--	--	0.04	1.32%	--	--
Total if other uses are 5m buffered		74.39	0.87%	8088.48	43.48	0.54%	0.585
Total if other uses are 10m buffered		74.51	0.87%	8088.48	43.97	0.54%	0.590

Table D: Characteristics of buffered areas according to LPIS and Ocs2d

If we take the urban-rural gradient into account (Table E), we observe the largest difference in suburbs of small UA (54.7%) and the lowest in suburbs of middle-sized UA (36.5%)

	Agricultural area in buffers according to Ocs2d ("classical uses", in km² and in % of total classical uses area according to Ocs2d)		Agricultural area in buffers according LPIS ("classical uses", in km² and in % of total classical uses area according to LPIS)		Relative difference in buffered areas according to Ocsd2D and LPIS (LPIS-Ocsd2)/Scs2d
Large poles	***23.77***	***1.44%***	***13.64***	***0.91%***	***-42.6%***
Close periphery of large centers	22.45	0.78%	13.36	0.49%	-40.5%
Areas multi-polarized by large UAs	15.17	0.77%	8.99	0.48%	-40.7%
Peri-urban of large UAs (close periphery + multi-polarized)	***37.61***	***0.78%***	***22.35***	***0.49%***	***-40.6%***
Large UAs (pole + peri-urban)	**61.39**	**0.94%**	**36.00**	**0.59%**	**-41.4%**
Medium-sized centers	0.65	0.83%	0.31	0.43%	-52.3%
Close periphery of medium-sized centers	0.18	0.51%	0.11	0.34%	-36.5%
Small center UA	0.76	0.63%	0.42	0.37%	-43.7%
Close periphery of small centers	0.04	0.67%	0.02	0.32%	-54.7%
Area multi-polarized by medium-sized or small UA	8.04	0.62%	4.57	0.37%	-43.1%
Medium-sized and small centers	***1.41***	***0.71%***	***0.74***	***0.40%***	***-47.7%***
Peri-urban of medium-sized and small areas (close periphery and multi-polarized)	***8.26***	***0.62%***	***4.71***	***0.37%***	***-43.0%***
Medium-sized and small UAs (center and peri-urban)	**9.67**	**0.63%**	**5.44**	**0.38%**	**-43.7%**
Areas beyond urban sphere	**2.76**	**0.50%**	**1.59**	**0.30%**	**-42.3%**
Total (UA and beyond urban sphere)	**73.81**	**0.86%**	**43.03**	**0.53%**	**-41.7%**
All urban centers	**25.18**	**1.36%**	**14.38**	**0.85%**	**-42.9%**
All peri-urban areas	**45.87**	**0.74%**	**27.06**	**0.46%**	**-41.0%**
All urban areas	**71.05**	**0.88%**	**41.44**	**0.55%**	**-41.7%**

Table E. Characteristics of buffered areas according to LPIS and Ocs2d

Appendix 3. Representativeness of LPIS in terms of holdings

Within the boundary of our study area, 12,087 farms claimed areas (i.e. drew them in the register) in the 2015 LPIS database. For 11,293 of them, we know both that the head of the farm is located in NPdC, and what their total UAA is. Of those, 13 have drawn a surface area that is null / 11,280 have drawn an area in LPIS. If we focus on the differences between the total area declared in LPIS (i.e. drawn by farmers) by each farmer and the total UAA of the farm (given by the Regional Directorate for Food, Agriculture and Forestry), we observe that, as expected, the area declared per holding is on average lower that the total UAA (Table F0). More precisely, 1.85% of the 11,280 farms have less than 75% of their UAA covered and 37.66% have between 75% and 100% of their UAA declared in LPIS. What we did not expect was to have areas declared that were larger than the UAA. Yet, 58.19% of holdings declared an area that accounts for more than 100% but less than 105% of the UAA – which can be considered as a margin of error when declaring areas in LPIS – and 1.29% of them declared an area at least 5% larger than their UAA, which can hardly be considered as such (Table G). The DRAAF was unable to give us an answer regarding those “oversized” declarations and we did not observe any striking particularities of the farms concerned (in terms on size, type of uses, types of production, etc.).

	mean	sd	IQR	Min	1st quart.	Median	3rd quart.	Max	# obs.
UAA	71.65	59.13	70.48	0.14	28.79	58.94	99.27	752.67	11280
Area in LPIS	70.48	57.63	69.70	0.11	28.38	58.24	98.08	752.68	11280

Table F: Descriptive statistics of UAA and area in LPIS for farms that have their head of holding in NPdC, and for which UAA is known

% of UAA drawn in LPIS	]0-25]	]25-50]	]50-75]	]75-100]	]100-105]	>105	all farms
Number of farms:	15	50	144	4248	6677	146	11280
in % of 11280 farms:	0.13	0.44	1.28	37.66	59.19	1.29	100

Table G: % of UAA drawn in LPIS for farms that have their head of holding in NPdC, and for which UAA is known

A high percentage of difference between the UAA and the LPIS area can relates to a small area when the UAA is small. On the contrary, 1 ha of difference is a very small share of the UAA for large farms. Therefore, we decided to consider as “over-declaring” any farm for which:

- the difference “area in LPIS minusUAA” is larger than 1 ha,for farms that have a UAA lower that 100 ha;

- or for which the area in LPIS in % of the UAA was larger than 101%,for farms with a UAA larger than 100 ha.

According to these rules, we have identified that 10,345 farms are "well described", i.e. more than 95% of their UAA is declared and they have not "over-declared". They account for 91.71% of the 11,280 farms, 91.61% of the 11,293 NPdC farms for which we know the UAA and 82.89% of the 2010-2020 average number of farms in NPdC according to agricultural censuses. According to average and median values, the "well described farms" farms have a lower UAA than other holdings described in LPIS (the holdings that are not well-covered or over declaring one's for which we know the total UAA). However, the "well described farms" are similar, in terms of areas, to those described in the 2020 Census (0).

UAA (ha)	Mean	SD	IQR	Min.	1st quart.	Median	3rd quart.	Max	Number of obs.
No area in LPIS	51.92	78.12	53.55	0.74	3.44	8.87	56.99	271.62	13
<95% of UAA in LPIS	99.65	79.15	98.69	1.03	41.15	84.41	139.83	520.32	582
Well described in LPIS	**69.75**	**57.39**	**69.55**	**0.14**	**27.82**	**57.37**	**97.37**	**752.67**	**10345**
"Over-declaring"	81.00	58.30	58.51	0.66	44.28	73.41	102.79	405.26	353
NPdC farms with UAA known	***71.62***	***59.15***	***70.51***	***0.14***	***28.76***	***58.88***	***99.27***	***752.67***	***11293***
2010 Census	62.28	57.82	70.35	1.00	17.95	49.83	88.30	1000.00	13133
2020 Census	70.40	63.28	79.12	0.00	21.54	56.94	100.65	726.31	11499

Table H: Number and UAA of farms according to the way they are represented in LPIS

The farms with the three most common specializations in the area (crops, dairy cattle polyculture and/or mixed farming) are quite well covered (Table I.). Most of farms specialized in other kinds of livestock breeding are also rather well represented. Farms specialized in market gardening or horticulture, fruit or permanent crops, and farms that are not classified (according to LPIS/DRAAF data) are the least well covered. We note that many of the farm with those specializations according to censuses are considered as "unclassified" in the LPIS/DRAAF database. Lastly, 192 of these 10,345 farms declared areas in organic farming (with organic areas accounting for more than 75% of the area declared for 120 of them). "Agence Bio" figures from 2015 show that there were 340 farms doing organic farming (with their head of holding in the region, Agreste 2016)[7]. While the area under organic farming seems

[7] According to 2010 Census, there were 217 farms in NPdC practicing organic farming. This number had risen to 599 in the 2020 census, including 418 entirely organic.

to be rather well taken into account in LPIS, there is a huge difference in the number of organic farms provided by the two sources of information. A possible explanation is that those farms not present in LPIS would be small farms, not CAP subsidised for their organic production. More details about the "well-covered" farms are given in Tables J and K.

Specialization	No area in LPIS	<95% of UAA in LPIS	**Well described in LPIS**	"Over-declaring"	NPdC farms with UAA known	**Well described /NPdC farms with UAA known**	2010 census	2020 census	**well-covered in % of 2010-2020 average number of farms**	NPDC farms with UAA known in % of the of 2010-2020 average number of farms per specialization	2010-2020 average number of farms in % of the 2010-2020 average total number of farms
field crops	8	274	**5279**	221	5782	**91.30%**	5900	5932	**89.23%**	97.73%	47.40%
market gardening or horticulture	0	5	**129**	12	146	**88.36%**	504	513	**25.37%**	28.71%	4.07%
wine growing	0	0	**0**	0	0	**--**	3	4	**0.00%**	0.00%	0.03%
fruits or other perm. crops	0	1	**12**	1	14	**85.71%**	36	52	**27.27%**	31.82%	0.35%
cattle - milk production	0	96	**1439**	27	1562	**92.13%**	2039	1458	**82.30%**	89.33%	14.01%
cattle - livestock and meat	0	22	**327**	5	354	**92.37%**	536	466	**65.27%**	70.66%	4.01%
cattle - milk, livestock and meat combined	0	11	**277**	12	300	**92.33%**	348	330	**81.71%**	88.50%	2.72%
sheep and/or goats, and/or other herbivores	1	4	**160**	3	168	**95.24%**	706	335	**30.74%**	32.28%	4.17%
pigs and/or poultry	0	21	**340**	8	369	**92.14%**	689	461	**59.13%**	64.17%	4.61%
mixed farming and/or mixed livestock	2	106	**2221**	63	2392	**92.85%**	2663	1938	**96.54%**	103.98%	18.43%
not classified	2	42	**161**	1	206	**78.16%**	37	10	**685.11%**	876.60%	0.19%
Total	13	582	**10,345**	353	11293	**91.61%**	13461	11499	**82.89**	90.498	100.00%

Table I: Number of farms according to specialization and way they are represented in LPIS.

Specialization	mean	sd	IQR	Min	1srt quart.	Median	3rd quart.	Max	Number of observations
field crops	68.51	59.90	72.71	0.17	23.80	54.12	96.51	752.67	5279
market gardening or horticulture	48.47	61.74	54.98	0.14	10.14	22.26	65.12	360.66	129
fruits or other perm. crops	21.02	13.45	17.32	4.60	11.98	17.04	29.30	51.59	12
cattle - milk production	74.87	46.83	54.86	0.32	43.28	64.94	98.13	324.78	1439
cattle - livestock and meat	26.06	29.49	32.41	0.31	5.57	15.71	37.98	265.86	327
cattle - milk, livestock and meat combined	80.88	49.22	63.19	0.33	47.00	72.76	110.19	293.69	277
sheep and/or goats, and/or other herbivores	18.90	25.29	16.99	0.23	3.90	9.35	20.89	119.73	160
pigs and/or poultry	55.75	43.96	47.22	0.20	27.21	44.79	74.43	341.72	340

mixed farming and/or mixed livestock	83.75	58.70	70.02	0.23	42.85	72.09	112.87	564.89	2221
not classified	42.07	43.41	51.94	0.71	8.54	33.10	60.48	231.39	161

Table J: Descriptive statistics of farm UAA per specialization among well-described farm subset

	mean	sd	IQR	Min	1srt quart.	Median	3rd quart.	Max	Number of observations
No organic area	69.92523	57.44634	69.630	0.14	27.9400	57.540	97.5700	752.67	10153
More than 75% organic	43.44225	32.88774	52.245	1.25	12.1700	39.690	64.4150	158.71	120
Less than 75% organic	89.05278	68.05718	80.730	1.47	37.4675	78.935	118.1975	288.37	72

Table K: Descriptive statistics of farm UAA among well-described farm by level of involvement in organic farming

Appendix 4: Sensitive and agricultural areas according to Ocs2d database

Total area studied (NPdC + near border area): 13,735.53 km²	Ocsd2
Sensitive areas : total (in km² and in % of the total area studied)	1179.92 8.60%
Sensitive areas: housing – continuous urban in km² and in % of sensitive areas)	244.31 20.70%
Sensitive areas: housing – discontinous urban fabric in km² and in % of sensitive areas)	780.45 66.10%
Sensitive areas: multifamily housing estate (in km² and in % of sensitive areas)	32.38 2.70%
Sensitive areas: isolated housing – in km² and in % of sensitive areas)	73.4 6.20%
Sensitive areas: schools and universities (in km² and in % of sensitive areas)	36.47 3.10%
Sensitive areas: hospital (in km² and in % of sensitive areas)	12.92 1.10%

Appendix 5: Impact of buffers in % of the total UAA: complement

Classic use only ?	mean	sd	IQR	Min	Med	3rd quartile	Last decile	Max	n
field crops	**0.82**	**1.32**	**0.77**	**0.00**	**0.46**	**0.96**	**1.75**	21.55	5279
market gardening or horticulture	**0.97**	1.46	1.02	0.00	**0.47**	1.16	2.30	8.38	129

fruits or other perm. crops	**1.47**	1.69	2.45	0.00	**0.95**	2.46	3.25	5.29	12
cattle - milk production	**0.71**	**0.74**	**0.57**	**0.00**	**0.54**	**0.88**	**1.38**	10.11	1439
cattle - livestock and meat	**1.63**	2.10	1.46	0.00	**1.01**	1.92	4.00	18.35	327
cattle - milk, livestock and meat combined	**0.98**	**2.14**	**0.64**	**0.00**	**0.56**	**0.99**	**1.57**	31.10	277
sheep and/or goats, and/or other herbivores	**1.90**	2.10	1.95	0.00	**1.16**	2.40	5.00	11.25	160
pigs and/or poultry	**0.91**	**1.64**	**0.78**	**0.00**	**0.62**	**1.06**	**1.67**	22.81	340
mixed farming and/or mixed livestock	**0.78**	**1.00**	**0.64**	**0.00**	**0.52**	**0.92**	**1.57**	14.73	2221
not classified	**0.92**	**1.53**	**0.84**	**0.00**	**0.50**	**0.99**	**1.83**	13.35	161

Impact of buffers in % of the total UAA of “well described” farms according to their specialization, if only classic uses are buffered.

buftot_other10_pctsau	mean	sd	IQR	Min	Med	3rd quartile	Last decile	Max	n
field crops	0.89	1.87	0.81	0.00	0.49	1.01	1.85	91.02	5279
market gardening or horticulture	1.21	1.93	1.06	0.00	0.60	1.25	3.10	14.88	129
fruits or other perm. crops	2.43	4.62	2.50	0.00	0.95	2.50	3.27	16.60	12
cattle - milk production	0.74	0.78	0.59	0.00	0.56	0.91	1.44	10.11	1439
cattle - livestock and meat	1.67	2.11	1.50	0.00	1.06	1.96	4.06	18.35	327
cattle - milk, livestock and meat combined	1.01	2.23	0.63	0.00	0.57	1.00	1.58	31.10	277
sheep and/or goats, and/or other herbivores	2.00	2.17	2.32	0.00	1.18	2.79	5.33	11.25	160
pigs and/or poultry	0.95	1.66	0.80	0.00	0.64	1.09	1.84	22.81	340
Mixed farming and/or mixed livestock	0.82	1.06	0.69	0.00	0.54	0.98	1.66	14.73	2221
not classified	1.04	2.23	0.83	0.00	0.50	0.99	1.83	21.50	161

Impact of buffers in % of the total UAA of “well described” farms according to their specialization, if “other uses” are 10m buffered.

	mean	sd	IQR	Min	Med	3rd quartile	Last decile	Max	n
No organic area in LPIS	0.85	1.30	0.74	0.00	0.51	0.98	1.74	31.10	10153
More than 75% of farms in LPIS area are organic	0.93	1.38	0.87	0.00	0.47	1.02	2.31	8.38	120
Organic area in LPIS but fewer than 75% of the farms in LPIS area	1.01	1.50	0.75	0.00	0.47	1.00	2.62	7.94	72

Impact of buffers in % of the total UAA of “well described” farms according to their type of production (organic or not) if only classic uses are buffered.

	mean	sd	IQR	Min	Med	3rd quartile	Last decile	Max	n
No organic area in LPIS	0.90	1.65	0.79	0.00	0.54	1.04	1.84	91.02	10153
More than 75% of farms in LPIS area are organic	1.05	1.80	0.91	0.00	0.52	1.09	2.46	14.88	120
Organic area in LPIS but fewer than 75% of the farms in LPIS area	1.22	2.32	0.83	0.00	0.49	1.10	2.63	16.60	72

Impact of buffers in % of the total UAA of “well described” farms according to their type of production (organic or not) if “other uses” are 10m buffered.

Appendix 6: Correlations between % of farms' UAA buffered and farms characteristics

« Classic uses » impacted by buffers in % of total UAA	% of UAA impacted if other uses are subject to a 5m buffer	% of UAA impacted if others uses are subject to a 10 m buffer	% of UAA in large poles.	% of UAA in close *periphery of large poles*	% of UAA in *Municipalities mutipolarized by large urban areas*	% of UAA located in *medium poles*	% of UAA in close *periphery of medium poles*	% of UAA in *small poles*	% of UAA in close *periphery of small poles*	% of UAA in *Municipalities mutipolarized by medium or small urban areas*
0.60	0.60	0.53	**0.27**	-0.01	-0.07	-0.03	-0.03	-0.04	-0,01	**-0,15**
% of UAA located out of urban influence	% of UAA in poles	% of UAA located in close peripheries of poles	% of UAA located in *mutipolarized municipalities*	% of UAA located in peripheries	% of UAA located in a large UA (pole. perih. multipol)	% of UAA located in a medium or small UA (pole. perih. multipol	UAA	Annual crop area	Annual crop area in % of UAA	Horticulture area
-0.10	**0.26**	-0.02	**-0.17**	**-0.19**	**0.19**	**-0.16**	**-0.17**	**-0.14**	**0,12**	0,02
Horticulture area in % of UAA	Fodder area	Fodder area in % of UAA	Permanent crop area	Permanent crop area in % of UAA	Grassland area	Grassland area in % of UAA	Rangeland area	Rangeland area in % of UAA	Set aside area	Set aside area in % of UAA
0.16	-0.05	0.00	0.07	0.05	**-0.19**	**-0.21**	-0.01	-0.01	0,00	0,03
Organic area	Organic area in % of UAA	Diverse area	Diverse area in % of UAA	Borders and strip area	Borders and strip in % of UAA					
-0.03	-0.02	-0,02	0,02	0,06	0,13					

Table 1 Pearson correlation with the % of UAA that is both buffered and non-organic areas of annual crops, permanents crops, horticulture and fodder

	« Classic uses » impacted by buffers in % of total UAA	% of UAA impacted if other uses are subject to a 5m buffer	% of UAA impacted if others uses are subject to a 10 m buffer	% of UAA in large poles.	% of UAA in close *periphery of large poles*	% of UAA in *Municipalities mutipolarized by large urban areas*	% of UAA located in *medium poles*	% of UAA in close *periphery of medium poles*
« Classic uses » impacted by buffers in % of total UAA	1.00	0.99	0.85	**0.17**	-0.04	-0.04	-0.01	-0.02
% of UAA impacted if other uses are subject to a 5m buffer	0.99	1.00	0.90	**0.17**	-0.03	-0.04	-0.01	-0.02
% of UAA impacted if others uses are subject to a 10 m buffer	0.85	0.90	1.00	**0.14**	-0.02	-0.04	-0.01	-0.01
	% of UAA in *small poles*	% of UAA in close *periphery of small poles*	% of UAA in *Municipalities mutipolarized by medium or small urban areas*	% of UAA located out of urban influence	% of UAA located in a large UA (pole. perih. multipol)	% of UAA located in a medium or small UA (pole. perih. multipol	% of UAA in poles	% of UAA located in close peripheries of poles
"Classic uses" impacted by buffers in % of total UAA	-0.03	0.03	-0.06	-0.07	0.09	-0.06	**0.16**	-0.04
% of UAA impacted if other uses are subject to a 5m buffer	-0.03	0.03	-0.06	-0.07	0.09	-0.06	**0.16**	-0.03
% of UAA impacted if others uses are subject to a 10 m buffer	-0.02	0.02	-0.05	-0.06	0.08	-0.06	**0.13**	-0.02
	% of UAA located in *mutipolarized municipalities*	% of UAA located in peripheries	UAA	Rangeland area	Rangeland area in % of UAA	Fodder area	Fodder area in % of UAA	Set-aside area
"Classic uses" impacted by buffers in % of total UAA	-0.08	**-0.12**	**-0.27**	-0.01	-0.01	-0.06	-0.01	-0.06
% of UAA impacted if other uses are subject to a 5m buffer	-0.08	**-0.12**	**-0.27**	0.00	0.01	-0.06	-0.01	-0.06
% of UAA impacted if others uses are subject to a 10 m buffer	-0.07	-0.09	**-0.24**	0.02	0.03	-0.05	-0.01	-0.05
	Set aside area in % of UAA	Horticulture area	Horticulture area in % of UAA	Grassland area	Grassland area in % of UAA	Organic area	Organic area in % of UAA	Annual crop area
"Classic uses" impacted by buffers in % of total UAA	0.05	**-0.12**	-0.03	-0.10	**0.25**	0.09	0.09	***-0.27***

% of UAA impacted if other uses are subject to a 5m buffer	0.05	**-0.12**	-0.02	-0.10	**0.24**	-0.01	0.01	***-0.27***
% of UAA impacted if other uses are subject to a 10m buffer	0.04	**-0.10**	0.01	-0.10	**0.19**	-0.01	0.02	***-0.23***
	Annual crop area in % of UAA	Permanent crop area	Permanent crop area in % of UAA	Diverse area	Diverse area in % of UAA	Borders and strip area	Borders and strips in % of UAA	
"Classic uses" impacted by buffers in % of total UAA	**-0.26**	0.04	0.02	-0.04	-0.03	0.04	0.01	
% of UAA impacted if other uses are subject to a 5m buffer	**-0.26**	0.04	0.03	-0.03	-0.04	0.04	0.05	
% of UAA impacted if other uses are subject to a 10 m buffer	**-0.22**	0.04	0.04	0.00	-0.03	0.06	0.16	

Pearson correlations between the percentage of UAA impacted and characteristics of farms in the area

Appendix 7: details of linear statistical regressions

Regression 1					
Residuals					
Min	1Q	Median	3Q	Max	
-1.8391	-0.3077	-0.1159	0.1194	22.2352	
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-0.1207880	0.0422293	-2.860	0.004241	**
% of UAA in a large UA	0.0027669	0.0003841	7.203	6.30e-13	***
% of UAA in medium-sized center	0.0007520	0.0011679	0.644	0.519652	
% of UAA in periphery of a medium-sized	-0.0006524	0.0015047	-0.434	0.664592	
% of UAA in small center	0.0015830	0.0009567	1.655	0.098050	.
% of UAA in periphery of a small center	0.0010092	0.0043332	0.233	0.815848	
% of UAA in *municipalities muti-polarized by medium-sized or small center*	0.0008553	0.0004558	1.876	0.060633	.
UAA (ha)	-0.0026479	0.0001328	-19.946	< 2e-16	***
% of UAA organic	-0.0003645	0.0007247	-0.503	0.615039	
% of UAA in annual crops	0.0052537	0.0003141	16.726	< 2e-16	***
% of UAA in borders and strips	0.0796323	0.0093747	8.494	< 2e-16	***
% of UAA "diverse"	0.0045376	0.0034280	1.324	0.185637	
% of UAA in rangeland	-0.0013677	0.0051743	-0.264	0.791529	
% of UAA in set-aside	0.0039947	0.0024892	1.605	0.108560	
% of UAA in fodder	0.0060604	0.0016221	3.736	0.000188	***
% of UAA in horticulture	0.0079476	0.0004964	16.012	< 2e-16	***
% of UAA in permanent crops	0.0157520	0.0027677	5.691	1.29e-08	***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 0.7468 on 10328 degrees of freedom					
Multiple R-squared: 0.1117, Adjusted R-squared: 0.1103					
F-statistic: 81.14 on 16 and 10328 DF, p-value: < 2.2e-16					
Variance inflation factors					
% of UAA in a large UA	3.971438	% of UAA in annual crops			1.221319
% of UAA in medium-sized center	1.141668	% of UAA in borders and strips			1.045099
% of UAA in periphery of a medium-sized center	1.094034	% of UAA "diverse"			1.007933
% of UAA in small center	1.165831	% of UAA in rangeland			1.003124
% of UAA in periphery of a small center	1.008610	% of UAA in set-aside			1.006730
% of UAA in *municipalities muti-polarized by medium-sized or small center*	3.416922	% of UAA in fodder			1.073061
UAA (ha)	1.076554	% of UAA in horticulture			1.139721
% of UAA organic	1.133109	% of UAA in permanent crops			1.053287

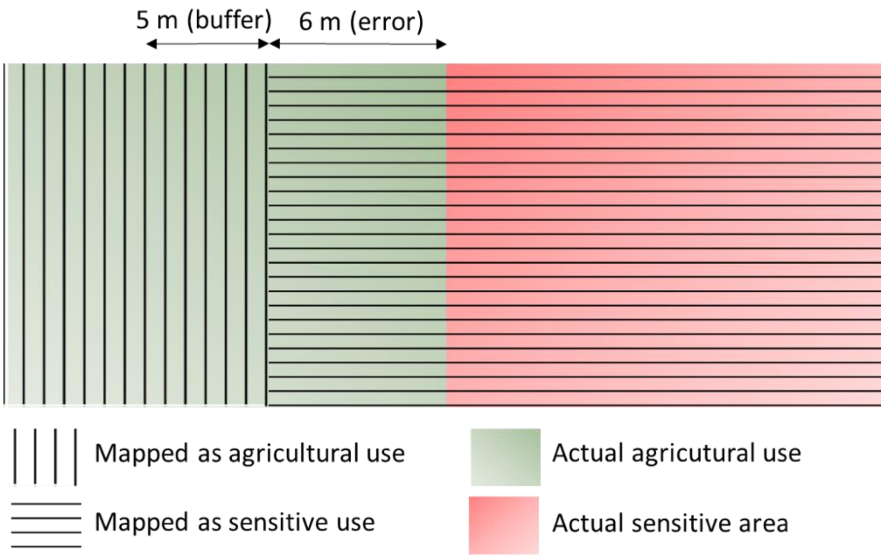
Regression 2					
Residuals					
Min	1Q	Median	3Q	Max	
-1.8419	-0.3076	-0.1167	0.1195	22.2569	
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.4017961	0.0409121	9.821	< 2e-16	***
% of UAA in a large UA	0.0027899	0.0003841	7.263	4.05e-13	***
% of UAA in medium-sized center	0.0007711	0.0011681	0.660	0.509216	
% of UAA in periphery of a medium-sized center	-0.0006114	0.0015049	-0.406	0.684560	
% of UAA in small center	0.0016016	0.0009569	1.674	0.094232	.
% of UAA in periphery of a small center	0.0009660	0.0043339	0.223	0.823626	
% of UAA in *municipalities muti-polarized by medium-sized or small center*	0.0008681	0.0004560	1.904	0.056973	.
UAA (ha)	-0.0026509	0.0001329	-19.952	< 2e-16	***
% of UAA organic	-0.0003732	0.0007249	-0.515	0.606624	
% of UAA in grasslands	-0.0052251	0.0003145	-16.615	< 2e-16	***
% of UAA in borders and strips	0.0745823	0.0094075	7.928	2.46e-15	***
% of UAA "diverse"	0.0006355	0.0034275	0.185	0.852903	
% of UAA in rangeland	-0.0064680	0.0051697	-1.251	0.210908	
% of UAA in set-aside	-0.0012016	0.0025149	-0.478	0.632794	
% of UAA in fodder	0.0008232	0.0016133	0.510	0.609859	
% of UAA in horticulture	0.0027159	0.0005223	5.200	2.03e-07	***
% of UAA in permanent crops	0.0105897	0.0027725	3.820	0.000134	***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 0.7469 on 10328 degrees of freedom					
Multiple R-squared: 0.1114, Adjusted R-squared: 0.11					
F-statistic: 80.89 on 16 and 10328 DF, p-value: < 2.2e-16					

Variance inflation factors			
% of UAA in a large UA	3.969911	% of UAA in grasslands	1.420510
% of UAA in medium-sized center	1.141648	% of UAA in borders and strips	1.052050
% of UAA in periphery of a medium-sized center	1.093947	% of UAA "diverse"	1.007277
% of UAA in small center	1.165911	% of UAA in rangeland	1.000977
% of UAA in periphery of a small center	1.008610	% of UAA in set-aside	1.027257
% of UAA in *municipalities muti-polarized by medium-sized or small pole*	3.417937	% of UAA in fodder	1.061003
UAA (ha)	1.078005	% of UAA in horticulture	1.261490
% of UAA organic	1.133172	% of UAA in permanent crops	1.056529

Regression 3					
Residuals					
Min	1Q	Median	3Q	Max	
-1.4157	-0.3270	-0.1171	0.1267	22.4547	
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.32311373	0.04024171	8.029	1.09e-15	***
% of UAA in a large UA	0.00350339	0.00038755	9.040	< 2e-16	***
% of UAA in medium-sized center	0.00094045	0.00118633	0.793	0.427951	
% of UAA in periphery of a medium-sized center	-0.00005519	0.00152890	-0.036	0.971203	
% of UAA in small center	0.00137228	0.00097212	1.412	0.158087	
% of UAA in periphery of a small center	0.00035507	0.00440404	0.081	0.935743	
% of UAA in *municipalities muti-polarized by medium-sized or small center*	0.00059231	0.00046173	1.283	0.199596	
UAA (ha)	-0.00222134	0.00013441	-16.527	< 2e-16	***
% of UAA organic	-0.00100436	0.00070570	-1.423	0.154703	
Specialization = Market gardening or horticulture	0.20135352	0.06795392	2.963	0.003053	**
Specialization = Fruit or other perm. crops	0.83906963	0.22098560	3.797	0.000147	***
Specialization = Cattle - milk production	-0.22562089	0.02321997	-9.717	< 2e-16	***
Specialization = Cattle - livestock and meat	-0.42969487	0.04400689	-9.764	< 2e-16	***
Specialization = Cattle - milk, livestock and meat combined	-0.25657396	0.04709267	-5.448	5.20e-08	***
Specialization = Sheep and/or goats, and/or other herbivores	-0.39761533	0.06135235	-6.481	9.54e-11	***
Specialization = Pigs and/or poultry	-0.03026729	0.04250695	-0.712	0.476447	
Specialization = Mixed farming and/or mixed livestock	-0.10612765	0.01935039	-5.485	4.24e-08	***
Specialization = Not classified	-0.14528517	0.06082851	-2.388	0.016938	*
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 0.7589 on 10327 degrees of freedom					
Multiple R-squared: 0.08272, Adjusted R-squared: 0.08121					
F-statistic: 54.78 on 17 and 10327 DF, p-value: < 2.2e-16					

Variance inflation factors			
	GVIF	Df	GVIF ^(1/(2*Df))
% of UAA in a large UA	3.914715	1	1.978564
% of UAA in medium-sized center	1.140640	1	1.068007
% of UAA in periphery of a medium-sized center	1.093756	1	1.045828
% of UAA in small center	1.165527	1	1.079596
% of UAA in periphery of a small center	1.008886	1	1.004433
% of UAA in *municipalities muti-polarized by medium-sized or small center*	3.394971	1	1.842545
UAA (ha)	1.068661	1	1.033761
% of UAA organic	1.040428	1	1.020014
Specialization	1.169255	9	1.008725

Appendix 8



5 m (buffer)
6 m (error)
Mapped as agricultural use
Mapped as sensitive use
Actual agricutural use
Actual sensitive area