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# Medium-term evolution in French national newspaper coverage of the interrelations between biodiversity and agriculture

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**Abstract**

Agricultural landscapes are sites of difficult trade-offs between conservation and production objectives. The media play a part in shaping public opinion and policies and vice-versa. In line with the constructionist approach to public problems, we analyzed the role of media in the problem-framing of interrelations between biodiversity and agriculture. We investigated the medium-term evolution in French national newspaper coverage of these interrelations using a content and time analysis over a 19-year period (1999–2017). We applied a statistical method using IRaMuTeQ (interface of R) on seven daily newspapers (*Le Monde*, *Libération*, *La Croix*, *Les Échos*, *Le Figaro*, *L'Humanité*, and *La Tribune*; $N = 2{,}547$). Our results reveal the growing importance of agriculture in the public problem of biodiversity loss. The increase of agriculture/biodiversity coverage is driven by environmental issues and specific political events. However, the number of articles focused on biodiversity/agriculture dynamics remains low. Around 2007, the articles shifted from an international species-centered view to a national and local human-centered view. These evolutions in media-coverage create a space for ecologists, social scientists, and agronomists to combine their approaches and to develop and communicate on new actions in favor of biodiversity in agricultural landscapes.

**KEYWORDS**

agriculture, biodiversity, content analysis, human–wildlife interactions, media studies

## 1 | INTRODUCTION

In a context of increasing interactions between human activities and wildlife, agricultural landscapes have become the site of difficult trade-offs between biodiversity conservation and production objectives. Habitat loss primarily as a result of agricultural practices represents the main threat to the survival of many species. However, socio-economic, legal, and political factors all contribute to the dynamic changes in human–wildlife systems and agricultural changes in favor of biodiversity (Robertson & Schaik, 2001; Smith, Muir, Walpole, Balmford, & Leader-Williams, 2003).

Numerous studies and biodiversity research (Liu, Zhang, & Hong, 2011; Myers et al., 2000) including in the field of agriculture (Mattison & Norris, 2005) have

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explored biodiversity conservation and management. They reveal the extent to which knowledge on ecology and management of endangered species, habitats, and landscapes has evolved. They also present tangible evidence of the experience gained in managing projects in favor of biodiversity conservation. But biodiversity today, though originally regarded as a scientific problem, is now a public problem intricately bound up with our social and political world (Mauz & Granjou, 2010). From a constructionist approach, a problem is constituted not only on the basis of objective reality, but on processes of definition and negotiation between different stakeholders (Gusfield, 1981).

Numerous stakeholders are involved in the social construction of a public problem. More specifically, the agenda setting theory emphasizes the crucial role the media plays in influencing the importance accorded to different topics on the public agenda (McCombs & Shaw, 1972). Indeed, by focusing on certain aspects of an issue, the media contribute to the construction of a public problem and how important public opinion perceives the issue to be. In other words, promoting effective changes in land use and practices depends on communication practices and strategies (Ernoul & Wardell-Johnson, 2016; Hathaway et al., 2017). A better understanding of how the relation between biodiversity and agriculture is framed, is a critical issue for conservation scientists and agronomists if they are to promote effective actions in favor of biodiversity in agricultural landscapes. In this perspective this paper proposes a content analysis on how the printed media treats the interrelations between biodiversity and agriculture.

The interest in analyzing media coverage of environmental issues is booming. Climate change coverage in particular is greatly studied. Diachronic studies have shown an increase in media attention on climate change (while the coverage of biodiversity is not on the rise), tend to be related to specific events such as major discoveries, international conferences (Legagneux et al., 2018), or natural disasters (Miah, Kabir, Koike, & Akther, 2011). In addition, agriculture, unlike biodiversity, is cited as a major issue in newspaper articles on climate change (Miah et al., 2011), maybe because the concept of biodiversity loss is harder to comprehend, more diffuse and does not implicate major economic sectors (Zaccai & Adams, 2012). For some authors (Veríssimo, MacMillan, Smith, Crees, & Davies, 2014) linking biodiversity loss to climate change can be an opportunity to prevent biodiversity from becoming a declining priority. Our first hypothesis (H1) will therefore assume a constant media coverage of biodiversity and agriculture which is dependent on many factors such as other environmental issues, international conferences, or scientific discoveries. In newspapers, biodiversity and agriculture are also approached from the perspective of human–carnivore conflicts. For example, media coverage of bears or wolves shows conflict-oriented press articles (Chandelier, Steuckardt, Mathevet, Diwersy, & Gimenez, 2018; Kaczensky, Blazic, Grossow, & Strasse, 2001). However, conflict is not always at the heart of articles, even in an area such as pesticide use where the conflict of interests is patent. Newspapers can counterbalance pro-agricultural articles with those supporting environmentalism (Reisner, 2003). Consequently, we secondly hypothesize that (H2) the media coverage of agriculture and biodiversity is not only conflict-oriented and that it deals both with the positive and negative impacts of agriculture on biodiversity. Regarding the great variety of stakeholders involved in biodiversity conservation, government and environmental groups can be more often cited in the press than scholars (Jacobson, Langin, Carlton, & Kaid, 2011). However, as the concept of biodiversity is derived from science, we thirdly hypothesize (H3) that in addition to other stakeholders, scientists participate in the media framing of the agricultural dimension of the public problem of biodiversity conservation.

As biodiversity and agriculture have never to the best of our knowledge been analyzed to see how they co-occur in an analysis of media coverage, in this paper we investigate the nature of and medium-term evolution in the relations between agriculture and biodiversity in France from 1999 to 2017. First, in Section 2 we present the theory of the constructionist approach to a public problem and the quantitative content analysis that we applied on seven national newspapers. We then examine the results in terms of the topics, species, and stakeholders mentioned in the articles. Finally, in Section 4 we place a major emphasis on the time trends in media coverage and on the practical implications of our results for improving biodiversity conservation strategies.

## 2 | METHODS

### 2.1 | Theoretical background

According to the constructionist approach to public problems, mainly developed since the 1970s, a problem is not only based on an objective reality, but also on processes of definition, construction, and negotiation between different stakeholders (Gusfield, 1981) which influence the imagined, proposed and finally retained solutions. To be public, a problem must mobilize an audience, enter the public space, be addressed by public authorities or be on the political agenda (Dewey, 1927). Biodiversity loss, which emerged in the 1980s in the academic field, was

included on the political agenda and addressed by public authorities in the early 1990s. Inspiring public policies and stimulating the interest of the general public, biodiversity loss has become a public problem (Mauz & Granjou, 2010). Biodiversity loss in agricultural landscapes, with an apparent conflict between different and legitimate values and social representations (Brennan, 2004), and its inscription on the policy agenda could also be examined as a public problem or at least as one part of the public problem of biodiversity.

The main contribution of the constructionist approach is to take into account the role played by social actors and the interactions between them in defining problems. For a problem to be construed as public, there needs to be an intellectual and social construction, an attribution of responsibility and inclusion on the public agenda (Felstiner, Abel, & Sarat, 1980) to which both whistleblowers and media contribute. By selecting certain aspects of an issue, the media influence the distribution of power (Entman, 2007) and the importance public opinion attributes to an issue. According to the agenda setting theory, a theory deployed in the study of mass-communication, the media have an impact on both the public's representations of an issue and on agenda-setting (McCombs & Shaw, 1972). Referring to the constructionist approach to a public problem and to the agenda setting theory, this paper aims to complete qualitative studies on the public problem of biodiversity loss (Mauz & Granjou, 2010) with the addition of a quantitative analysis of the interactions between agriculture and biodiversity in French mass media.

## 2.2 | Data collection

The units selected for content analysis were articles published in national French daily newspapers from 1999 and 2017. We selected seven leading newspapers: *Le Monde* (approximate paid circulation between 2013 and 2017: 274,128), *Libération* (85,879), *La Croix* (92,225), *Les Échos* (126,263), *Le Figaro* (311,295), *L'Humanité* (37,080), and *La Tribune* (approximate paid circulation between 2001 and 2005: 82,337). In the "Europresse" database we searched for articles containing the words "biodiversité" (biodiversity) and "agriculture," or "biodiversité" (biodiversity) and "agriculteur" (farmer), excluding proper nouns. These generic keywords were chosen to capture the diversity of the interactions between biodiversity and agriculture. The word "agriculteur" and "agriculture" were both selected because in French these words are often used interchangeably. We retained the headline and the body of the articles, and we deleted endnotes, photographs and their description. We obtained 2,547 articles in total, from *Le Monde* (732 articles), *Libération* (387), *La Croix* (336), *Les Échos* (340), *Le Figaro* (313), *L'Humanité* (254), and *La Tribune* (185). For each article, we assigned as covariate the year of publication (from 1999 to 2017).

## 2.3 | Statistical analyses

Content analysis makes replicable and valid inferences through the extraction of information on data derived from text (Krippendorff, 2004), and allows the analysis of media messages (Riffe, Lacy, & Fico, 1998). Content analysis method is based on a coding protocol to identify the characteristics of texts and analyze them using descriptive statistics (Krippendorff, 2004). Usually, a content analysis of environmental issues in the press identifies the main topics, the valence (positive or negative) of the coverage and the framing of press articles (Bhatia, Athreya, Grenyer, & Macdonald, 2013; Siemer, Decker, & Shanahan, 2007). Iyengar (1991) developed a two-part classification scheme dividing episodic (event driven) and thematic (issue oriented) articles, that for some issues, induce attributions of individual or societal responsibility respectively. In these standard content analysis procedures, coders define the topics, the valence, and the framing.

Therefore, even if training and double blind procedures are performed on content analysis, the identification of article characteristics is dependent on the choices of the coders. A statistical method to analyze content can partly help to overcome subjective bias and to develop a more critical look at the material (Chaves, Dos Santos, Dos Santosa, & Larocca, 2017). In this study, we use the software IRaMuTeQ based on R software and *python* language, to extract information from texts using descriptive statistics. This approach improves the robustness of results and reduces the impact of analyst biases (Sbalchiero & Tuzzi, 2015). However, the results must be used with caution and their interpretation requires vigilance and verification of the primary text, which the software permits. The advantage of such a systematic investigation is in the processing of a huge amount of data both in terms of the number and length of texts. However, the formatting of the raw data is still a time-consuming process. Similarly, correcting spelling mistakes (words not recognized by the software) can take time (Arnoult, 2015), but this problem is marginal in press articles unlike interviews.

The content analysis procedure presented in this paper consists of three steps (Figure 1). In step 1, we followed a content analysis division classifying the press articles as either primary agriculture and/or biodiversity

| Step | Analyse | Data | | Result |
|---|---|---|---|---|
| 1 | Main topic classification | All articles *n = 2547* | | Article : S A B A/B |
| | | All articles *n = 2547* | A/B articles *n = 65* | |
| 2 | Correspondence factor analysis (CFA) | X | X | Media coverage drivers |
| | Divisive hierarchical clustering (DHC) | X | | Topics on dendrogram<br>$X^2$ score between year and topic |
| 3 | Species record | X | | Number of mentions in all articles<br>$X^2$ score between species and topic |
| | | X | X | Number of articles (*all, A, B and A/B*) mentioning the species |
| | Stakeholders record | X | | Number of mentions in all articles<br>$X^2$ score between stakeholders and topic |

**FIGURE 1** Workflow diagram of the media analysis

article or secondary article (Jacobson et al., 2011). In step 2, we studied the main topics discussed around biodiversity and agriculture from a diachronic perspective. During step 3, we focused on species and stakeholders. Then, deploying a comparative approach, we analyzed the correlations with the topics previously identified. We preprocessed articles to keep only the root of words by lemmatization and also compound words using a dictionary of French expressions.

In step 1, we recorded the articles according to their main topic (Jacobson et al., 2011):

- Primary biodiversity articles (*B articles*) have biodiversity as their main subject with the word "biodiversity" in the headline or first paragraph and again in the remaining text.
- Primary agriculture articles (*A articles*) have agriculture as their main subject with the words "agriculture" or "farmer" in the headline or first paragraph and again in the remaining text.
- Primary agriculture and biodiversity articles (*A/B articles*) specifically address the relationship between biodiversity and agriculture with the words "biodiversity" and "agriculture" or "farmer" in the headline or first paragraph and again in the remaining text. With respect to our method, these articles are also included respectively in *A* and *B articles*.
- Secondary articles are articles where "biodiversity," "agriculture," and "farmer" do not appear in the headline or the first paragraph but appear in the remaining text.

Second, in step 2, we performed two temporal content analyses, firstly on *all articles* and then on the *A/B articles* using a correspondence factor analysis between words and years. This analysis brought out the most representative words and sentence segments for each year. Reading them, we were able to identify the drivers behind the media coverage.

Then, to identify the article topics precisely, we classified articles using divisive hierarchical clustering (DHC) adapted to text data named the ALCESTE procedure (Reinert, 1983, 1990). This method divides the corpus according to lexical heterogeneity and classifies the press articles. Unlike a classification based on agglomeration, such as ascending hierarchical classification, the DHC focuses on the lexical differences between the press articles. Low occurrence words are not retained in the DHC, so this method highlights recurrence (word frequencies, co-occurrences, specificities) (Arnoult, 2015). We chose this method because of its relevance for the analysis of a large corpus (Ratinaud & Marchand, 2012). This topic selection is entirely reproducible and we obtained a dendrogram of statistically independent topics, complete with their most representative words. Of the 2,547 articles, 2,390 were classified (93.84%). As the interpretation of words depends on sentence contexts, we isolated sentence segments around these representative words; and as the interpretation of words and sentences are context-sensitive, we completed the classification by personally reading the five most representative articles of each topic. We then named the topic accordingly. This interpretation of topics is analyst-dependent and more subjective.

We performed a $\chi^2$ measurement between the topics and the covariate year to analyze the effect of time on topics. If the correlation of the covariate year was negative, the $\chi^2$ score was written negatively. We selected only positive $\chi^2$ scores to examine the evolution of each topic's coverage in the media and we recorded the topic with the highest $\chi^2$ score for each year.

Third, in step 3, we recorded the species mentioned in the articles and the number of mentions for each. We isolated the most recurrent species and we tested the correlation between the name of the species and the topics by a $\chi^2$ score to analyze the context in which species were mentioned. We did the same with the stakeholders.

To further analyze the relation between the species and the media coverage, we counted the number of articles mentioning the species. We repeated the count for each category of article we had defined (*A*, *B*, and *A*/*B articles*).

We preprocessed and analyzed data using an R (R Core Team, 2018) interface: IRaMuTeQ (Ratinaud & Déjean, 2009). More information on the use of IRaMuTeQ is available on Supporting information.

## 3 | RESULTS

### 3.1 | Number of articles and primary articles

Of the 2,547 articles:

- 504 are primary agriculture articles—19.8% (*A articles*);
- 342 are primary biodiversity articles—13.4% (*B articles*);
- 65 are primary biodiversity and agriculture articles—2.6% (*A/B articles*);
- 1,766 are secondary articles—69.3% (*S articles*).

We observed a growing media coverage of agriculture and biodiversity from 1999 (60 articles) to 2017 (196) with a peak in 2007 (241) (Figure 2). 2007 was the year the Grenelle Environment Forum was held. The first rise in media coverage linking agriculture and biodiversity corresponded to the Johannesburg Summit in 2002. Biodiversity and agriculture media coverage is not constant and is mainly driven by specific political events. More recently, the debate on the prohibition of neonicotinoids, a class of insecticides considered toxic particularly for pollinators, has revived the media coverage. This debate is also a strong factor behind the media coverage of the *A*/*B articles* that is, articles whose main subject is the interrelation between agriculture and biodiversity. Indeed, *A*/*B articles* increased between 2004 (two articles) and 2017 (five articles) and had a media coverage peak of eight articles in 2005, 2011, and 2016. The media coverage of agriculture/biodiversity interrelations remains low, is driven by specific events, interest ebbs and flows, and there are very few articles overall.

### 3.2 | Topical content

The divisive hierarchical clustering revealed eight topical classes of articles (Figure 3 and Table S1). Three topics were related to policies and comprise 38.7% of articles: international policies, national policies, and the Grenelle

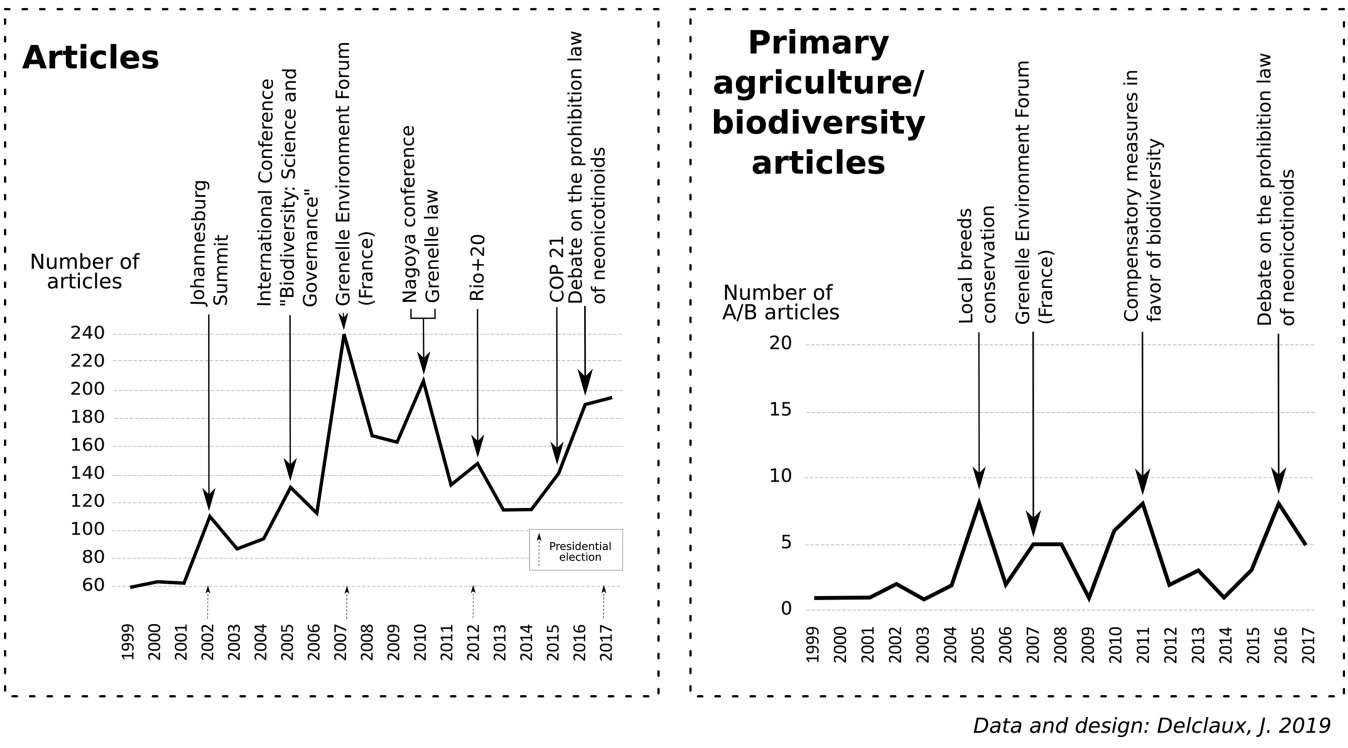


**FIGURE 2** Number of articles and primary agriculture/biodiversity articles from 1999 to 2017

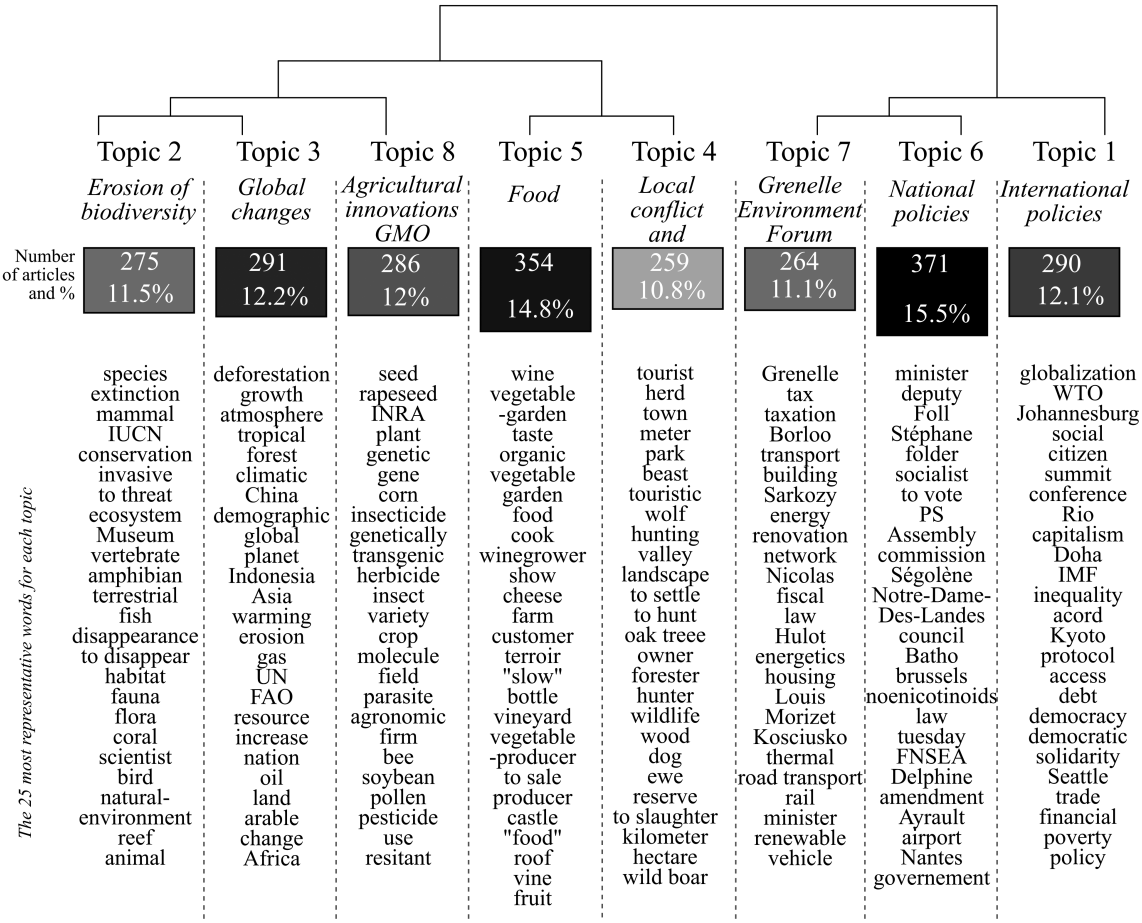


**FIGURE 3** Number of articles and most representative words in the eight topics of articles containing "biodiversity" and "agriculture" (or "farmer") in national French press from 1999 through 2017 (Dendrogram from the divisive hierarchical clustering)

Environment Forum. Three topics concerned biodiversity loss (35.7% of articles): in general terms, related to global changes, and genetically modified organisms (GMOs): although the latter topic is an agricultural innovation, GMOs appeared closer to articles on biodiversity loss than to others in the clustering. 14.8% of articles linked biodiversity and agriculture to food issues. The negative impact of biodiversity on agriculture also appeared (10.8% of articles) within topics related to local conflicts in touristic areas.

The average number of articles per topic was 298.8. The most prevalent topic was related to national policies (371 articles) and discussed debates around bills both on biodiversity conservation and land-use planning. The least prevalent topic concerned human–wildlife conflicts (259 articles) and presented the negative impact of wolves on sheep farming and wild boars on crops.

The actors and institutions mentioned were related to (a) policy: names of the French president, minister of Ecology, minister of Agriculture and citizens; (b) sciences: the Natural History Museum in Paris and the French National Institute for Agricultural Research; (c) international institutions: the World Conservation Union (IUCN), the United Nations, the Food and Agriculture Organization of the United Nations, the World Trade Organization, and the International Monetary Fund; (d) occupation: producers, winegrowers, vegetable producers, and hunters; and (e) unions: National Federation of Agricultural Holders' Unions (FNSEA).

## 3.3 | Main species and topics

We recorded 29 species mentioned more than 15 times. Of the total 2,517 mentions, 67.5% referred to 3 species: the bee *Apis mellifera* (913 mentions), the wolf *Canis lupus* (603), and the bear *Ursus arctos* (183). Other species were: tuna (69), elephant (63), bumblebee (62), wild boar (56), deer (47), frog (45), bustard (42), whale (38), hamster (33), mosquito (33), partridge (31), ladybug (29), dragonfly (27), shark (27), lynx (23), lark (22), hornet (21), tit (19), hedgehog (18), crayfish (18), eagle (17), dolphin (17), marmot (16), toad (15), seal (15), and vole (15).

The three dominant species were positively correlated with one or two topics (Figure 4 and Table S2). The word

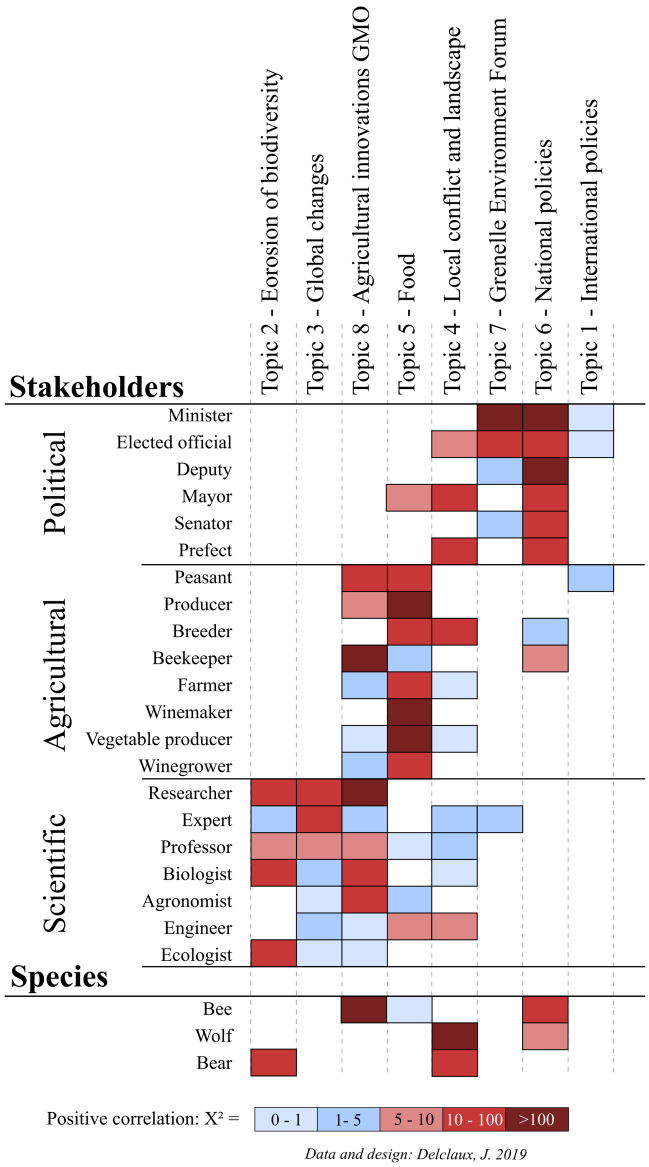


**FIGURE 4** Relationships (with a positive $\chi^2$ score) between stakeholders, species and topics

"bee" correlated with the topics GMOs and national policies. Similarly, the word "wolf" had a positive correlation with national policies, but more strongly with the topic of local conflict. The same could be observed for word "bear," but "bear" also correlated with the topic of biodiversity erosion.

Bee (*A. mellifera*) was the dominant species in the newspaper coverage of the interrelations between agriculture and biodiversity. "Bee" appeared in 218 articles and in 9 *A/B articles* (Table 1) and was found both in articles focusing on biodiversity and those focusing on agriculture. Although "wolf" (*C. lupus*) appeared in 70 articles, it only came up two times in *A/B articles*. "Bear" (*U. arctos*) was mentioned in 28 articles, but never in *A/B articles*.

**TABLE 1** Distribution of species by article type

| Number of ... mentioning the word | "Bee" | "Wolf" | "Bear" |
|---|---|---|---|
| *All articles* | 218 | 70 | 28 |
| *A articles* | 46 | 6 | 6 |
| *B articles* | 51 | 18 | 7 |
| *A/B articles* | 9 | 2 | 0 |

## 3.4 | Stakeholders and topics

We recorded 21 stakeholders mentioned more than 53 times. Three stakeholders were dominant: minister (1,467 mentions), peasant (1146), and researcher (959). Other stakeholders were: producer (660), expert (623), breeder (438), elected official (382), deputy (376), mayor (313), beekeeper (253), professor (212), biologist (179), agronomist (162), engineer (158), senator (146), prefect (92), winemaker (77), vegetable producer (72), winegrower (53), and ecologist (53).

These stakeholders can be classified into three categories: political, agricultural, and scientific stakeholders. Stakeholders from associations or NGOs are not shown, not because they are not present in the press articles, but because of the methodology deployed. First, associative positions are common nouns with different meanings that the software cannot distinguish. For example, the "head of mission" position, a common title in associations, is processed as two different words: "mission" and "head." Consequently, the tracking of these types of positions is impossible. Second, stakeholders from association movements are numerous and often designated by their proper names or their respective media personalities. Likewise, we cannot distinguish the context in which these personalities are mentioned. Despite this, some NGO names emerged in the clustering (Figure 3): IUCN (158 mentions) or FNSEA (192 mentions), but others do not appear as easily.

We observed a significant division of stakeholder categories according to the topic (Figure 4 and Table S3). Political stakeholders were positively correlated with policy topics: Grenelle Environment Forum and national policies with national actors and local conflicts between biodiversity and agriculture with local political actors. Agricultural stakeholders were positively correlated with food and innovation topics. Scientific stakeholders were positively correlated with the topics of biodiversity erosion and global changes.

## 3.5 | Effect of time on topics

We observed an effect of the covariate year on the topical content of the articles (Figure 5 and Table S4). Between

2001 and 2006, three topics were dominant: the erosion of biodiversity was positively correlated with 2001 ($\chi^2 = 7.324$), international policies with year 2002 ($\chi^2 = 125.743$), and global changes with 2006 ($\chi^2 = 14.309$).

The GMOs topic was positively correlated with year 2003 ($\chi^2 = 9.077$) and 2008 ($\chi^2 = 6.226$), while the Grenelle Environment Forum correlated with 2007 ($\chi^2 = 172.009$), 2010 ($\chi^2 = 14.579$), and 2012 ($\chi^2 = 9.256$). The topic of local conflict and landscape was positively correlated with 1999 ($\chi^2 = 6.981$) but also with 2010 ($\chi^2 = 5.190$).

After 2013, two topics were dominant: food in 2015 ($\chi^2 = 18.353$) and 2017 ($\chi^2 = 5.999$) and national policies in 2012 ($\chi^2 = 9.013$), 2013 ($\chi^2 = 14.532$), 2016 ($\chi^2 = 30.586$), and 2017 ($\chi^2 = 9.972$).

## 4 | DISCUSSION

### 4.1 | Rise in media coverage and political events as drivers

In view of the results, we have rejected parts of the first hypothesis (H1). Biodiversity and agriculture media coverage is not constant and we observed a significant overall rise as well as peaks related to specific political events (Figure 2). Indeed, the increasing number of articles, multiplied by a factor of three between 1999 and 2017, can be explained by three main reasons. First, biodiversity, a neologism coined during a scientific conference in 1986 (Wilson, 1988), brings together three levels of natural systems: genes, species and ecosystems. Thus, biodiversity allows connections to be established between many disciplines such as ecology, biodiversity conservation and environmental management. The number of scientific papers on this concept has exploded since the 1990s (Liu et al., 2011). Thus, in the 1990s, under the impetus of scientific research, biodiversity loss became a public problem (Mauz & Granjou, 2010). Our results show that scientists were mainly involved in topics on biodiversity loss, topics that were themselves more discussed in the years before 2007. Between 1999 and 2007, scientists, especially biologists, agronomists and ecologists, often acted like whistleblowers, highlighting the harmful effects of agriculture on biodiversity in the media.

Second, agriculture has repeatedly been identified as one of the largest contributors to biodiversity loss (Maxwell, Fuller, Brooks, & Watson, 2016). Agricultural landscapes cover over 45.2% (29 billion ha) of France's surface area in 2017 (AGRESTE, 2018) and play a substantial part in biodiversity loss through the high degree of mechanical interventions, uses of pesticides and chemical fertilizers (McLaughlin & Mineau, 1995) and landscape simplification with the disappearance of semi-natural elements such as hedges (Landis, 2017). In national newspapers, 35.7% of articles focused on the downsides of biodiversity/agriculture interactions. Articles on GMOs, dealt, but not exclusively, with these downsides on the basis that "biodiversity does not like GMOs" (*La Croix*, 2005) and was "contaminated," "altered," or "reduced" as a result. In addition, the media talk about the impact of agriculture on various species and environments, alongside discussions on deforestation, population growth and climate change. These kinds of articles describe and link diverse global problems, and thus explain the mention of iconic species far removed from agricultural landscapes such as elephants, whales, tuna or dolphins. The agricultural dimension of the biodiversity loss problem is linked to environmental issues in the press, in which agriculture features as one of many threats: "Climate or biodiversity, you should not choose! Restoring nature can improve ecosystems resilience to climate change. [...] However, many of these natural habitats have been severely degraded by urbanization, intensive agriculture, pollution and many other causes" (*Libération*, 2015).

Third, the political dimension of biodiversity/agriculture interactions was very present, featuring in 38.7% of articles, because biodiversity has gone from being a

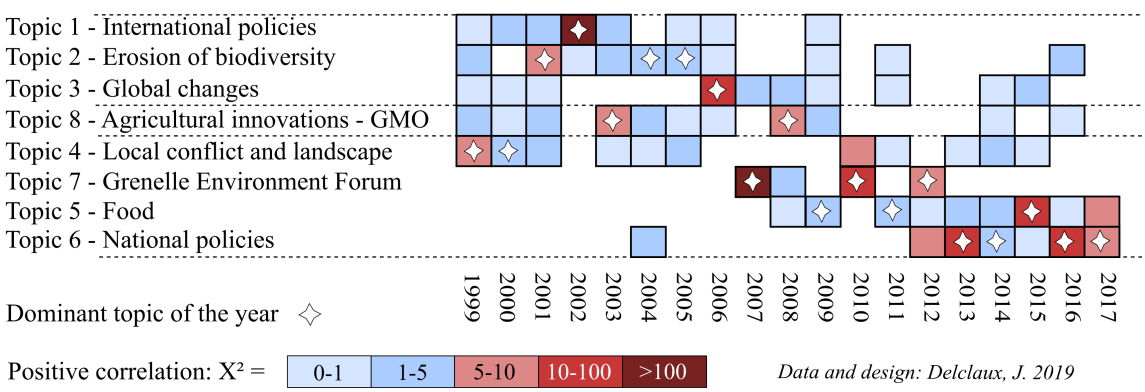


**FIGURE 5** Effect (with a $\chi^2$ score) of the covariate year on topic

purely scientific concept to becoming a political slogan (Väliverronen, 1998). The factors driving media coverage are linked to international or national political events or years of presidential elections. In 2002, the Summit of Johannesburg triggered the first peak in media coverage. The summit discussed the effects of intensive agriculture on soil degradation and water pollution. In 2007, the Grenelle Environment Forum (French debate on environmental issues that resulted in the passing of two laws in 2009 and 2010) was the most important contributing factor to media coverage both for all articles and *A/B articles*. This event was mediatized as the catalyst for transforming biodiversity loss into a major public problem in environmental issues: "biodiversity moved from obscurity to being among the first political environmental concerns" (*La Tribune*, 2009).

Our results show that the agricultural dimension is not absent from the framing of biodiversity loss as a public problem. Contrary to what we hypothesized (H1), the media coverage of biodiversity and agriculture increased between 1999 and 2017, and even if the concept of biodiversity loss is more diffuse (Zaccai & Adams, 2012), the media coverage was driven by specific events which are not natural disasters or episodes of ecological crisis but mainly political events. In printed media, biodiversity loss is not presented as an isolated problem, but belongs to different environmental issues where the impacts of agriculture are highlighted.

## 4.2 | Time trend: from international nature-centered articles to national and local human-centered articles

The time trend analysis revealed an evolution in article topics. Articles focusing on the negative impact of agriculture on biodiversity loss were more present in the early 2000s. The topic of local conflicts, recurrent over the time period studied, did not focus on the negative role of agriculture on biodiversity. This topic was limited to two large carnivores: the wolf (*C. lupus*) and the bear (*U. arctos*). While the bear (*U. arctos* and *U. maritimus*) correlated to biodiversity erosion and seemed to enjoy a positive image as an example of threatened biodiversity, the wolf (*C. lupus*) correlated to the topic of national policies and was addressed from the political perspective of its regulation with the deployment of a national action plan. Even if we selected articles on biodiversity and not on a particular species, human–wildlife conflicts attract a lot of media attention and they concerned 10.8% of articles on agriculture and biodiversity. In these articles, agriculture was not perceived as a threat but was itself threatened by species that are harmful to both agricultural activity and landscape: "If livestock farming disappears, it is the end of the village, the end of life in these small valleys. Only the second homes will remain. Because of the wolf, many breeders have already abandoned their pastures. Grass and brush have grown back. The forest will continue to grow, and the habitat will close in" (*Libération*, 2014).

Since 2007, the food topic has become more prevalent. In some of these articles, agricultural intensification was presented as the solution for feeding a growing global population that is expected to reach 9 billion people over the next few decades. To meet the need for 70–100% more food by 2050 (Godfray et al., 2010), these articles advocated increasing irrigated areas to improve yields, and claimed that "agricultural production [had] to be multiplied by 1.85" (*Le Figaro*, 2011). But alternative ways were also discussed: "Can organic farming feed the planet?" (*L'Humanité*, 2016) was a recurring question. As in other foreign newspapers (Cahill, Morley, & Powell, 2010), organic agriculture was mediatized in a positive light: "Organic agriculture therefore has, compared to conventional agriculture, a very positive impact on all the components of the environment: water quality, soil fertility and preservation of other aspects (biodiversity, natural resources)." (*Les Echos*, 2002). Thus, the printed media also highlight the positive role of agriculture to the public problem of biodiversity loss through innovative agricultural practices such as organic agriculture or agroecology.

Two other topics were more widespread in the 2010s: the Grenelle Environment Forum and national policies both provide evidence of modifications to the way biodiversity and agriculture have been considered. Indeed, between 1999 and 2007, biodiversity loss was most frequently addressed at an international and global scale within topics on international policies, global changes or erosion of biodiversity. Since 2007, the national and local levels have become predominant. This change of scale was accompanied by a change of viewpoint. Before 2007, the most frequent articles developed a nature-centered view featuring the use of words such as "species," "bird," natural "habitats," "ecosystems," or "forest." With the emergence of the local scale, the articles became more human-centered deploying words relating to humans, individuals and political actors. Part of the second hypothesis is therefore rejected (H2), because national press articles are not only nature-centered but have also developed a human-centered viewpoint since 2007.

This changeover from 2007 both in scale and viewpoint marks a transformation of the framing of biodiversity as a public problem. The erosion of biodiversity is no longer just presented as a distant problem affecting Africa's or Asia's iconic animals or biodiversity hotspots

(Brooks et al., 2002; Myers et al., 2000) but also as a threat to common species (Gaston & Fuller, 2008). The press reports an increased concern about biodiversity loss and agriculture not only in a political context but also in social contexts, challenging us in our daily lives and territories, for example in the choices we make in our food consumption.

## 4.3 | Agriculture and biodiversity: how to improve the media coverage?

More than 69% of articles were secondary articles, that is, articles that have little to do with the interrelations between biodiversity and agriculture. The number of articles focused on agriculture (19.8%) was greater than those focused on biodiversity (13.4%), though selection criteria including "agriculture" and "farmer" as keywords could have influenced this result. Over the 19-year period, only 2.6% of articles discussed the relationship between agriculture and biodiversity as their main subject. As *all articles*, the peaks in media coverage of *A/B articles* appeared in relation to specific political events, namely the Grenelle Environment Forum and the debate on whether or not to prohibit neonicotinoids. Even if the number of *all articles* continues to increase, improving media coverage of environmental issues can be an opportunity to better address the agricultural dimension of the public problem of biodiversity loss.

Of these 65 *A/B articles*, 13.84% mentioned the bee (*A. mellifera*). Here too, the bee was the queen of mass media (Smith & Saunders, 2016) but this coverage can mask the role of other pollinators (Klein, Steffan-Dewenter, & Tscharntke, 2003; Smith & Saunders, 2016). The bee owes its success to its symbolic and educational role in explaining the concept of ecosystem services through its role as pollinator. Thus, using a flagship species as a vehicle for scientific concepts and awareness appears as a way of increasing the media coverage of the interrelations between biodiversity and agriculture. Although media coverage alone does not protect against extinction (Courchamp et al., 2018), other pollinators and more broadly common species such as hedgehog, frog or tit, could move higher up in the general public's concern if they were more often represented in newspapers. This failing can also reflect a lack of current knowledge on other types of biodiversity, and more generally on the complex interrelations between agriculture and biodiversity.

The analysis of the links between stakeholders and topics reveals a segmented distribution. Political stakeholders are correlated with political topics but not with articles raising the alarm on biodiversity loss and global changes. Political stakeholders are involved in the press with the agenda-setting of the public problem of biodiversity loss. The topic of human–wildlife conflicts, while seemingly giving priority to political stakeholders, is actually the only one to involve stakeholders from all three categories, namely political, agricultural and scientific. The topic of agricultural innovations involves only two of these categories: agricultural and scientific stakeholders. In the media coverage of biodiversity and agriculture, biologists and ecologists are presented as whistleblowers as to the dangers weighing upon biodiversity, including intensive agriculture. These results reflect a disposition among articles to mention only one category of stakeholder. In our opinion, to improve society's understanding of the complexity of the problem it is necessary to compare the points of view and representations of all stakeholders. As Le Roux et al. (2008) we wish to stress the interest in engaging a dialogue in the press across scientific disciplines, from ecology to agronomy, including human and social sciences which are seldomly mentioned on this subject in the media. We are not referring to a scientific dialogue as much as to a broader societal dialogue based on concrete situations and worded in a widely known vocabulary. Such improved forms of communication could play an important role in modifying cultural and symbolic meanings and values associated with biodiversity and agriculture, with the broader objective of ultimately increasing the implementation of biodiversity conservation practices in farming.

## 4.4 | Assets and limitations

Content analysis is often conducted over a limited period and on articles from a small number of newspapers. Using divisive hierarchical clustering is a way of identifying topics from the data rather than hand-coding the articles via an unsupervised classification method. It increases the possibility of handling a large corpus of texts and allows for the analysis of a long period from many newspapers (Ratinaud & Marchand, 2012). Including the publication-year covariate allows us to explain variations in topical content. The correspondence analysis highlights the major factors driving media coverage, but their interpretations are dependent on the analyst's knowledge of the issue.

Determining the authorship and affiliation of both the articles themselves and the quotations that may feature in them, is essential in identifying the positions and the role of all stakeholders connected to the issue. Due to the high number of texts analyzed, the method cannot take this information into account and needs to be improved. For the same reason, the method does not allow an identification of the valence (positive or negative) of the claims made by the stakeholders. To complete

this work a content analysis within each identified topic could quantify the valence of articles and provide the specific point of view of each stakeholder on each topic. In addition, IRaMuTeQ, an interface of R, constitutes a black box in which we can only act on a few parameters and we cannot modify the scripts. It is therefore necessary in order to deepen these analyses to develop this kind of method directly under R.

The scientific outputs of our work show the value of media studies as a way of understanding the agricultural dimension of the public problem of biodiversity loss. Our results confirm the growing importance of agriculture in this public problem. Our first hypothesis (H1) has been partially rejected because the media coverage is not constant and has increased by a factor of three since 1999 under the impetus of various factors. However, the growing number of newspaper articles inspired by breakthroughs in scientific knowledge and political events reveals how biodiversity is becoming step by step an agenda-setting problem.

As regards our second and third hypotheses (H2, H3), theses have to be refined with changes over time and topics. This is related to a changeover beginning in 2007 of scale and viewpoint in the articles: the media coverage goes from international nature-centered articles to national and local human-centered articles. Furthermore, we confirm the mention of both positive and negative impacts of agriculture on biodiversity. On hypothesis 3 (H3), that assumed the mention of various categories of stakeholders, namely political, scientific, environmental and agricultural, we observed that their respective presence is topic related: that is, scientists as whistleblowers are more frequently mentioned in articles focused on the impact of agriculture on biodiversity loss.

The number of articles discussing the relationship between biodiversity and agriculture as the main subject remains low and represents only 2.6% of articles. To increase this number and to improve the general public's concern and knowledge about the complexity of the interrelations between agriculture and biodiversity, four ways seem possible: to draw on positive and illustrative flagship species (not only the most remarkable); to communicate more on interdisciplinary scientific concepts and concrete results; to take advantage of the mounting interest in environmental issues in media to insert information on the agriculture and biodiversity topic; and finally to share the points of view of different stakeholders be they from the world of science or on-the-field actors all within the same press article.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHOR CONTRIBUTIONS

J.D. conceived and designed the study, collected and analyzed the data. J.D. and P.F. wrote the manuscript and contributed to subsequent revisions of the article until finalization.

## ETHICS STATEMENT

This work required no special permits outside of basic ethical guidelines for the production of science.

## DATA AVAILABILITY STATEMENT

This paper was based on press articles archived in the Europresse database [Europresse.com], available by subscription.

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