Content analysis of newspaper coverage of wolf recolonization in France using structural topic modeling

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ABSTRACT

Populations of large carnivores are recovering in Europe and incur increasing conflict interactions with human activities. According to the agenda-setting theory, the media dissemination of information on these interactions is likely to contribute to shaping public perceptions of large carnivores. We conducted a content analysis of printed media coverage of wolf recovery in France over the period 1993–2014, ever since its natural return to southeast France. To do so, we used a recently developed statistical method – structural topic modeling – that allows to generate topics from large amount of texts and formulate new or assess existing hypotheses. This method formally includes covariates to explain variation in topic prevalence and content in a way that is similar to standard regression analyses. We contrasted content variation between articles in a regional (*Nice-Matin*; N = 742) and a national (*Le Monde*; N = 148) newspaper and analyzed time trends in topic prevalence. The most represented topics were mainly related to the management issues regarding wolf recovery. We found that *Le Monde* represented management issues in a generic manner associated with a perspective centred on carnivore species. In contrast, articles in *Nice-Matin* were about factual issues and associated with a human-centred viewpoint. This contrasted framing emphasizes the gap in representations of wolf management between citizens who directly interact with the wolf and favor detailed information content, centred on human views, and citizens who do not interact or only indirectly with the wolf who will focus on less detailed news, with a more ecological approach. We suggest that increased communication between local and national stakeholders and institutions could provide the context for a more balanced media content of interactions between carnivore species and human activities. This combination could attenuate the gap between regional and national representations.

1. Introduction

Interactions between humans and nature increasingly lead to human-wildlife conflicts (HWCs) (Redpath et al., 2013). With many stakeholders involved, HWCs occupy a substantial place in the establishment of environmental policy and are widely broadcasted to a large audience through mass media. In this context, the media coverage of environmental issues is being studied to better understand the social representations relayed by the media and their potential impacts on citizens (Gore and Knuth, 2009; Jacobson et al., 2012; Bhatia et al., 2013; Sakurai et al., 2013).

According to the agenda setting theory, the media is likely to have an impact on the representation of an issue, not necessarily by telling citizens *how* to think (opinions) but more likely by showing them *what*

to think, i.e. what should be the main themes about a specific question (McCombs and Shaw, 1972; McCombs, 2005). In this context, learning about the themes relayed in the media is a critical issue for conservation scientists who need to understand and feed social communication (Moscovici, 1977).

The interest of ecologists and conservation biologists for the study of the coverage of environmental issues is increasing. For example, the representation of climate change and global warming has been studied in a diachronic perspective through content analysis (Billett, 2010; Brossard et al., 2009), a method that seeks to extract information from texts using descriptive statistics (Krippendorff, 2004). Content analysis has also been used to study HWCs, most often involving animals that potentially may harm people (Jacobson et al., 2012; Bhatia et al., 2013; Sakurai et al., 2013). Usually, content analysis of an environmental

issue consists in the identification of the main themes (topics) and whether the coverage is positive or negative (valence) over a specific time period. By analyzing the topics, the valence of the articles (Jacobson et al., 2012; Bhatia et al., 2013) and the quoted sources (Brossard et al., 2009; Jacobson et al., 2012), content analyses allow a better understanding of how environmental issues are covered by media. With these methods, themes are defined by coders and are therefore dependent on their interpretations from the very beginning of the analysis.

In this study, our objective is to demonstrate that the framework of topic modeling (Blei, 2012), a statistical method to analyse topics and their content, enables to generate topics independently from the coders' intuition, and formulate new or assess existing hypotheses by formally investigate temporal trends and explain variation in content, in a way that is similar to standard regression analyses. Of particular interest, structural topic modeling (STM; Roberts et al., 2013) allows assessing the relationship between topic (content and proportion) and explanatory covariates such as author, date or episodic vs. thematic articles. By studying trends in topic proportions over time and explaining content variations with external factors, STM allows taking the context into account for a better understanding of the dynamic of social representations in a comparative and diachronic view. STM analyses have been developed and mostly used in political (Bauer et al., 2016; Grimmer and Stewart, 2013; Munksgaard and Demant, 2016) and education (Reich et al., 2015) sciences. It is only recently that the method has been applied in environmental sciences with a study showing how important topics can be extracted from thousands of scientific articles (Westgate et al., 2015) and to explore representations of climate change (Lynam, 2016).

We use STM in a case study of HWC. To this aim, the extensive cover by national and local press of the return of wolves to France since 1992 has been particularly interesting in terms of the wide range of stakeholders strong positions that have been revealed, even though some are not even directly involved in the conflict. Once considered as one of the most widespread species in the northern hemisphere, the wolf was extirpated from a large part of its habitats by humans during the last few centuries (Mech and Boitani, 2003). In North America and Europe its contemporary recovery is due to multiple factors including a radical change of the predator's perception (Chapron et al., 2014). From being hunted for reward because of its destructive impact on human activities, especially livestock breeding, the wolf has now become a strictly protected species under the international law, and is considered as a keystone species embodying the symbol of wilderness (Caro, 2010). In this context, the interaction of wolves with agricultural activities in a landscape traditionally devoted to sheep grazing has led to strong conflicts between stakeholders arguing for wolf protection and those demanding the downgrade of its legal status, if not the complete removal of the species. In France, the wolf has spontaneously recolonized from Italy, first in southeastern Alps (Mercantour national park), before colonizing a large part of the French mountain areas (Louvrier et al., 2017). Since 2004, wolf management has been based on a derogation to the Habitat's Directive that allows for a wolf removal quota and the establishment of regulation policy (Duchamp et al., 2017). This strategy has placed the French government in an equivocal situation whereby the strictly protected type of management is associated with an increasing wolf removal. Although this dual management was first elaborated to mitigate the conflict, farmers are still impacted by predation and pursue their claims to downgrade the wolf protection status, whereas ecologists remain opposed to the current regulation policy (Lalo and Degeorges, 2017). The confrontation of those claims is frequently associated with an argumentation either based on an ethic centred on the inclusion of animals, plants and land to the community of life (Leopold, 1949) or on a worldview where humans are the primary holders of moral standing (Lombardi, 1983). It often leads to the exclusion of either the wolf or the breeder, feeding the roughness of the conflict instead of its mitigation (Chandelier et al., 2016).

The media began covering this HWC soon after the first wolves were detected in the south-east of the Maritime Alps in 1992. Newspapers in particular built a specific representation of the debates and the events related to wolf presence, and thus took a position regarding the nature- or the human-centred main approaches. In this paper, our aim is to identify whether national and regional newspapers are closer to a nature-centred or human-centred worldview. We collected a corpus of French printed press articles covering the period from 1993 to 2014. We analyzed variations between the framing of a HWC statewide and in the area where the wolf has recolonised (the Alps), to better apprehend social representations of the conflicts in the media at different geographic scales. We analyzed temporal trends in the topics highly represented in the corpus and explained vocabulary variation for each topic with type of newspaper (regional vs. national) as a covariate. We hypothesized that the geographical diffusion and the target audience of the media would impact topic prevalence. Specifically, because the regional newspaper *Nice-Matin* is published and disseminated in the Alpes-Maritimes – the area where the species is most present and livestock farmers most impacted – it is more likely to emphasize human aspects of the wolf presence. On the contrary, the state-wide diffusion of *Le Monde* may induce a more general perspective of the issue, based on large carnivore protection, and thus be closer to a holistic and nature-centred approach.

2. Methods

2.1. Data collection and pre-processing

The data collected for content analysis are printed press articles published in local and national French daily newspapers over the period 1993–2014. We considered a local press group *Nice-Matin* and a leading national newspaper *Le Monde*. The press group *Nice-Matin* covers the south eastern area of France, and in particular the Alps where the wolf was first re-observed in 1992 and has been present since then. We collected articles following the relevance sampling search process (Krippendorff, 2004). We selected documents containing the word 'loup' ('wolf') from the 'Europresse' database (http://www.europresse.com/default.aspx) for *Le Monde*, and from local archive center for *Nice-Matin*. We then removed articles in which the word 'wolf' did not refer to the animal.

In another step, we selected documents that were exclusively dedicated to the wolf, hereafter *primary* articles. In order to identify such articles, we considered a representative sample by selecting documents with the word 'loup' ('wolf') in the title. Based on this sample, we calculated the ratio of the number of occurrences of the word 'loup' ('wolf') over the total number of words in each document for *Nice-Matin* and *Le Monde* separately, then for each newspaper we identified the boundaries of the interval that contained 95% of the sample distribution of ratios. A threshold was defined as the lower boundary of this interval; above that threshold, an article was qualified as primary.

The articles were then preprocessed by word stemming to keep only the root of a word and the removal of punctuation and stop words that contributed little to topic determination. These operations were conducted with the tm package (Feinerer et al., 2008) in R (R Core Development Team, 2015). Hereafter, we used "word" to refer to truncated words that result from the word stemming.

2.2. Statistical analyses

We used topic modeling to interpret patterns in our corpus through a small number of thematic elements – the topics – that were statistically defined using sets of words that co-occurred with unusual frequency (Blei et al., 2003). We used STM that has recently been developed to specifically incorporate covariates measured at the level of the document, here the newspaper articles (Roberts et al., 2016). These covariates can be incorporated to explain variation in *prevalence*, i.e. how much of an article is

Table 1
Description and 20 highest-weighted words (keywords) for each of the 15 topics considered in the analysis of *Le Monde* and *Nice-Matin* corpus. Topics are ranked by decreasing prevalence in the corpus.

Topic	Keywords	Representative text of the topic	Description
6	Wolf, shot, attack, farmer, authoriz, more/less, livestock, harvest, protect, driven hunt, prefect, animal, hunting, associ, national, last, be, alpes-maritim, arrest, franc	In accordance with the 'wolf national plan', 24 wolves can be killed each year. Within the last 12 months, only 8 wolves have been shot following legal procedure – adding to 4 wolves killed by poaching. 'We reinforce in an unprecedented manner the legislative arsenal which is about to allow a much better protection for livestock breeders', indicated the minister of agriculture Stéphane Le Foll. Ségolène Royal [minister of ecology] is on the same line.	Lethal methods of wolf regulation
8	Wolf, attack, more/less, livestock, breeder, beast, ewe, dog, sheph, animal, two, shepherd, all, park, day, sheep, since, be, compens, comm	It has been 30 years that the man is working as a shepherd, but lately he has started to get discouraged. 'My grandfather and my father were farmers. When I started I was 14, I had one sheep. I doubt my children will take over the profession. Before the wolf, it was like a vacation here!'. His first attack was in 1997, five years after the return of the wolf to the Mercantour mountain.	Consequences of wolf presence (farmers' experience centred)
10	Wolf, franc, commiss, more/less, agricultur, national, minister, president, deput, presenc, breeder, all, predator, estros, park, area, elected officials, measur, protect, associ	In the departments affected by the wolf presence, members of parliament have also claimed the instauration of an economic treatment better adapted to the crisis situation the farmers are suffering from. M. Hervé Gaymard announced that meetings with agricultural syndicates and representatives of departments concerned by the wolf will be organized soon. He recalled his visceral attachment to the farmers' defense in mountain areas facing this large predator.	Debates involving stakeholders and institutions
12	Wolf, park, alpha, center, more/less, saint-martin-vésub, boreon, two, all, animal, three, visitor, first, pack, comm, franco, fact/done, other, day, project	One by one, they [cages] were opened, letting wolves go outside on their own will. Born captive and hosted in Prague and Pilsen zoos until then, they seemed immediately at ease. They surely were a bit numbed and sensitive to the slightest noise, sometimes baring their fangs to their congeners. Very used to human interaction though, they got close to many photographs and cameramen who were there for the event. They almost posed few centimetres from their lenses.	Representation of wolves and human public interactions
1	Wolf, child, more/less, all, fairy tale, animal, hour, story, human, big, book, good, other, film, spectacl, small, fact/done, franc, current, discover.	On the wolf's track in December. The ATOU association [...] organizes a one month event. The aim is to celebrate with full honours the return of the wolf in the area. From Saturday, 2nd of December, to Thursday, 2nd of January, visitors will walk along the tracks of Barnabé, the grey wolf of Tourettes. A full-scale staging of its travels, a decorated medieval village, wolves alive, exhibitions, fairy tales, Christmas party and entertainments... The month is going to be as fun as friendly.	Historical and pedagogical dimensions of wolf presence
4	Wolf, ewe, beast, sheep, livestock, more/less, since, attack, two, dog, other, animal, sheph, all, slaughter, breeder, park, mercantour, last, shepherd.	Michel Gougeon, the shepherd who watches over its one thousand ewe flock was suspecting something for a while: a wolf ruled in the area. The properties of the attacks – "only during night, without letting any injured animals and without touching the viscera", he said – were typical of the large predator and not of stray dogs.	Consequences of wolf presence (wolf-centred)
9	Wolf, park, mercantour, two, animal, more/less, can, lupus, national, other, last, according to, predator, administ, since, all, approximatively, first, valley, species.	In the National Parks rangers often count animals, directing their telescope on specific lands. What a surprise they had when they saw in their telescope two wolves, on the 5th of November 1992, in the National Mercantour Park (Alpes-Maritimes), from which they could observe during half an hour their flexible and prudent walk.	Wolf recovery and human interactions France/Italie
13	Wolf, shepherd, breeder, more/less, livestock, attack, two, all, patou, predator, comm, pastoral, park, sheep, dog, mayor, sheph, other, do, mercantour	Several thousands of people came, in the context of the wolf controversy, to support the pastoral economy at the Saint-Roch event. Demonstrations have hardly gathered so many people in Tende streets! Yesterday, several thousands of people came all day long in order to pay tribute to the shepherd of Haute-Roya, during the traditional celebration of Sain-Roch.	Demonstrations and claims in reaction to wolf presence
11	Wolf, hunter, more, hunt, animal, species, mercantour, mouflon, chamois, bernard, popul, comm, all, last, park, baudin, wild boar, faun, wild, high	The wolf slows but does not reverse – as hunters said – the growth curve of chamois in the Mercantour mountain area. However, where he is well implanted, he notably contributes to the decrease of mouflon population.	Interactions between wolves and fauna
7	Wolf, agricultural, more/less, president, breeder, farmer, agriculture, chamber, all, also, young, mountain, do, other, comm, good, still, fact/done, achievement	In the Belledone mountain, a wolf is lurking. Not happy enough to kill, he hanged it. Not satisfied to hang the wolf to trees, he hanged it by the back legs. Not yet stuffed of his odious wolf hanged by the back legs lynched for the example, he wrote a sign: "fed up with wolf". Odious crime.	Reactions to wolf presence
2	Wolf, breeder, two, manifest, hautes-alp, more, animal, between, franc, sheep, plac, after, against, all, gap, have, hour, beast, other, ewe	Behind the banners "save the wolf" or "wolf killed: French state is a poacher", the demonstrators gathered Place Masséna, as well as others at the same time in Paris, after the shooting of two wolves in Drôme and Isère, and a female bear in the Pyrenees.	Demonstrations of militant groups
14	Park, wolf, mercantour, more/less, two, common, all, council, chart, national, mayor, fact/done, vall, comm, last, do, other, be, big, first	Fifty kilometres from Nice as the crow flies, an alpine sanctuary, wild and protected. The wolf got it right and settled there. On this Friday in June in the Mercantour mountain area, the wolf was not there. Neither the sheep, for which the transhumance has not begun yet. Yesterday, they would have been impatient but now, they don't feel like that anymore.	Wolf presence in the Mercantour national park
5	Wolf, more/less, animal, franc, associ, human/man, mercantour, park, give, all, give back/make, shepherd, since, comm, fact/done, good, organis, protect, wild, burl	For millennia, the wolf is the symbol of evil. Fenris contests the power of Odin in the Scandinavian beliefs and the hard look of Ysengrin that is haunting the German mythology. In terms of image, as we would say nowadays, the catholic religion and its sanctification of the lamb, symbol of purity and innocence, was not about to get anything better for the wolf case.	Wolf representations
3	Wolf, captur, mercantour, park, more/less, animal, two, predator, hunt, scientif, three, equipment, other, collar, all, be, species, wolf, lupus, since	This is the first time in France, a female wolf has been captured, measured, equipped with a transmitter and then released. An event that was awaited and prepared for two years. Two park rangers (Gérard Millischer and Gérard Caratti) were affected to the daily task. They set the collar on the wolf, during the night of 12 to 13 of July.	Scientific monitoring of the wolf
15	Breeder, wolf, livestock, shepherd, sheph, help, dog, protect, franc, pastoral, more/less, associ, ovine, year, var-., volunteer, animal, park ranger, all, mountain pasture	During three weeks they help the farmer or the shepherd in watching livestock in order to avoid canid attacks (either dogs or wolves). This is their core mission, but they still contribute to the everyday life of the farmer or the shepherd. Since 1999, 33 volunteers have given their time and their passion for this program.	Alternative solutions to livestock protection

associated with a topic, or variation in *content*, expressed by the words used within a topic. We built a model in which we considered i) an interaction between the two covariates year of publication (from 1993 to 2014) and newspaper (*Nice Matin* vs. *Le Monde*) on prevalence and ii) the effect of the covariate newspaper on content. To select the number of topics, we fitted models with 5, 10, 15, 20, 25, 30, 50 and 100 topics. Based on Roberts et al. (2014) recommendations, we were led to consider 15 topics to capture topic diversity without impeding topic interpretability. The description of the selected topics was based on the inspection of the 20 top words and the reading of the 5 newspaper articles that were most representative of each topic. While the first step of topic selection is based on a statistical algorithm hence entirely reproducible, the second step of interpretation is more subjective and clearly relies on the analyst's expertise and his/her knowledge of the issue at hand. These analyses were conducted with the stm package (Roberts et al., 2015) in R (R Core Development Team, 2015).

3. Results

In total, we collected 339 articles for *Le Monde* and 868 for *Nice-Matin*. They were qualified as primary when the ratio of the number of occurrences of the word 'loup' ('wolf') over the total number of words was above the threshold of 1.93 for *Le Monde* and 0.98 for *Nice-Matin*. Following filtering, the primary corpus contained 148 articles from *Le Monde* and 742 from *Nice-Matin*.

The inspection of the 15 topics (Table 1, see Table S1 in suppl.

materials for original french content) we identified through the STM approach illustrates that while the most prevalent topic is related to lethal methods of wolf regulation, the least prevalent is dedicated to the alternative solutions for livestock protection, showing a focus on more direct management of the wolf. The second and sixth most prevalent topics refer to the consequences of the wolf recovery but remain distinct by their focus on the farmer and on the wolf, respectively.

For clarity, we now focus on the four most prevalent topics in the following detailed analysis, each representing at least a 10% proportion of the total prevalence, and 46% when cumulated.

While the three most prevalent topics (lethal regulation, farmers' field experience of the wolf, debates involving stakeholders and institutions) are related to the conflicting issue of wolf presence in France, the fourth is associated with the public representation of wolf and human interactions (Table 1).

3.1. Influence of covariates on topical content

There was a marked difference in the way the wolf was designated in each newspaper (Fig. 1). Apart from the topic dedicated to wolf lethal regulation (topic 6), the word 'loup' ('wolf') was more associated with *Nice-Matin* for the three other most prevalent topics. In the national newspaper, the wolf was designated by more generic words such as 'animal', 'prédateur' ('predator'), or 'espèce' ('species'). The topic dedicated to wolf lethal regulation (topic 6) showed content variations between newspapers in treatment of wolves and livestock, and that of
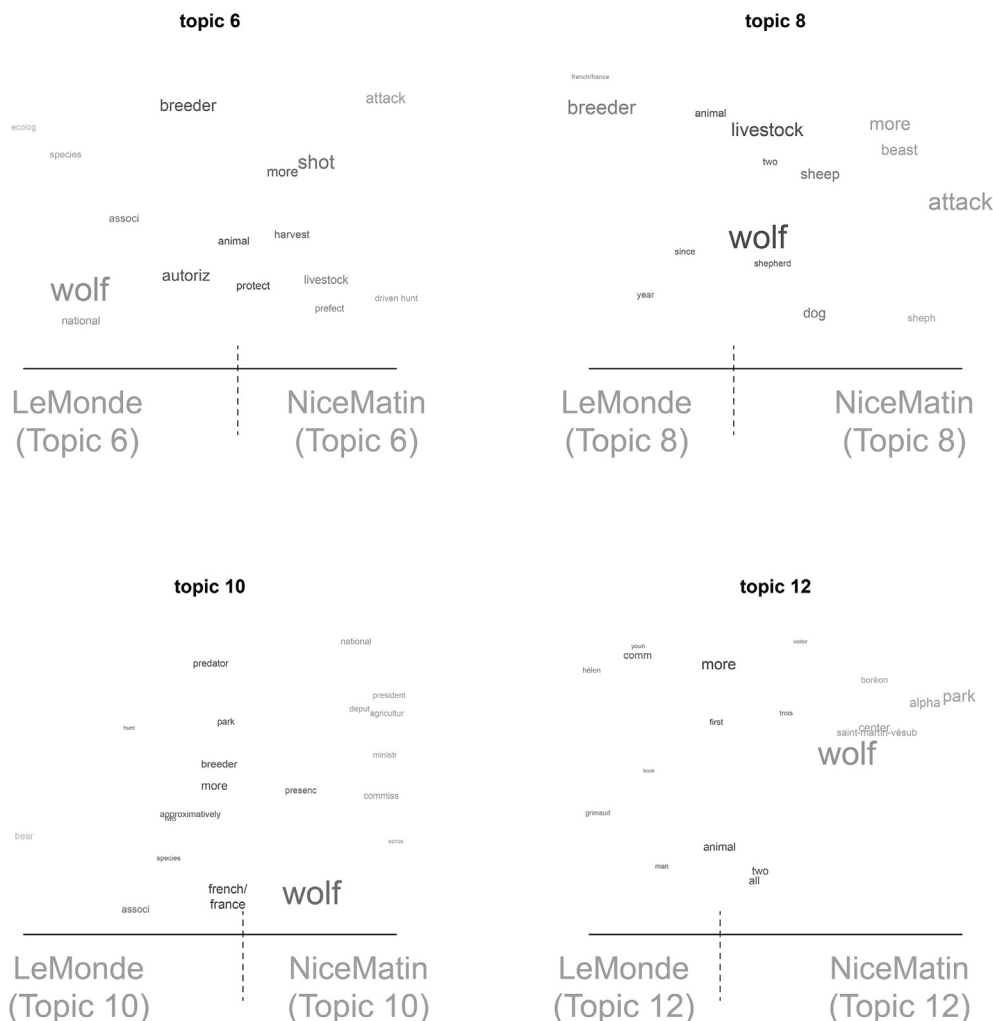

Fig. 1. For each topic (6, 8, 10, 12), a representation of words that are more associated with *Le Monde* or *Nice-Matin*. The weight of a word is proportional to its size. Words in the middle are more common in both newspapers while words on the edges are more heavily associated with the corresponding newspaper (See Fig. S1 in suppl. materials for original french words).

stakeholders and regulation harvesting. *Le Monde* focused on the wolf, with the mention of words more related to an ecological view ('espèc'/'specie'; 'écolog'/'ecolog'). *Nice-Matin* concentrated on the livestock impacted by the wolf ('troupeau'/'livestock', 'attaqu'/'attack'). Stakeholders mentioned in *Le Monde* belonged more to civil society ('assoc', 'eleveur'/'livestock breeder') while *Nice-Matin* focused on a specific administrative stakeholder with the word 'préfet' ('prefect'). Lethal regulations were addressed through concrete actions in *Nice-Matin* ('tir'/'shot', 'prélev'/'harvest', 'battu'/'driven hunt'). In *Le Monde*, the word 'autoris' ('authoriz') referred to the legal implementation of wolf's lethal regulation.

In the topic related to the field experience of the farmers (topic 8), *Le Monde*'s most represented word was 'éleveur' ('breeder'), while *Nice-Matin*'s top words referred to the predator-prey interaction of wolf and livestock ('breb/'sheep', 'bêt'/'beast', 'chien'/'dog'), with an emphasis on the attacks ('attaqu'/'attack'). The words 'troupeau' ('livestock') and 'loup' ('wolf') also referred to predator and prey, but were more commonly represented in both newspapers. The reference to the farmer is made with the stem words 'berger' and 'berg' ('shepherd'/'sheph'). As the following extract shows, *Nice-Matin* depicts the predator-prey interaction attack through the shepherd's prism:

> Ever since, at the Cavetiere's farm, a cow and a horse are missing. Jonathan is very worried, just like his mother. "By foot, by horse and by car, we have organized several rounds with friends and neighbours. We went up to Saint-Barnabé and Coursegoules. We also asked the hunters and the hikers but it remains impossible to find those animals. The wolf must have made them run". But where? And then? What have they become?
>
> *Nice-Matin*, 2010-11-24

The topic dedicated to debates toward the wolf's presence (topic 10) was characterized by a higher association of the word 'loup' ('wolf') with *Nice-Matin*, as well as a higher representation of institutional stakeholders ('député'/'deputy'; 'ministr'; 'president'), showing that the wolf debate is directly linked to the institutional area. In contrast, *Le Monde*'s topic focused not only on the wolf but also on carnivore species as the use of words such as 'our' ('bear'), 'espèc' ('species') and 'prédateur' ('predator') illustrates. The following representative extract shows that the mention of large carnivore is associated with conflicts induced by several species:

> The protection of large predators in France is questioned. After voting the Bonrepaux amendment, ordering the capture of bears implanted in the Pyrénées, the passions have risen up. Wolves in the Alps might be the next target.
>
> *Le Monde*, 2000-04-04

Considering the topic related to the public representations of wolf and human interactions, *Nice-Matin* emphasizes the wolf and zoological parks where wolves are hosted in the Alps ('Boréon', 'parc', 'alpha', 'Saint-martin-vésub'), whereas *Le Monde* mainly focuses on a public figure, a famous classical pianist (Hélène Grimmaud), who studies wolf behaviour and has a passion for them. The representative articles from *Le Monde* emphasize the interactions between artists and wolves, as illustrated in the following extracts:

> The pianist arrived half an hour late, tiny but strong. […] "We are right in the middle of a wolf vaccination and the day was restless. We had to isolate those animals. They know what is going to happen and they hate this day.
>
> *Le Monde,* 2003-10-30

> On screen, this best-seller [autobiography] tells the story of a young jewish girl during the occupation […] In 1941, she desperately decides to join her deported parents in Ukraine, […] Only with a compass, the little girl survived thanks to the wolf protection that she experienced in a German forest.
>
> *Le Monde*, 2008-02-28

3.2. The effect of time and newspaper on topic prevalence

Le Monde's topics are all slightly increasing, though the confidence interval remains too large to draw any conclusions. Three of the four most prevalent themes increased in *Nice-Matin*. The topic dedicated to debates involving wolves, stakeholders and institutions (topic 10) has however decreased with a steep slope (Fig. 2).

4. Discussion

We conducted a STM analysis of a 21-year corpus on media coverage of grey wolf recovery in France. Our objective was to identify whether *Le Monde* and *Nice-Matin* differed their reference to the wolf conflict by either focusing on human or carnivore species' aspects and in terms of their use of the most prevalent topics.

4.1. Main findings

Our STM analyses showed that the most represented topics were related to management aspects (wolf regulation – specifically lethal methods and debates) and to the impact of the species on farmers' activities. This result is consistent with a longitudinal study of the wolf controversy in North American newspapers (Houston et al., 2008). In France and North America, wolves are mainly apprehended through their conflicting impacts on human activities and through aspects of lethal regulation, which is likely to underline negative aspects of the wolf recovery. However, in France we found that the representation of wolves and human public interactions was the fourth most represented topic suggesting that the species is also apprehended through less conflicting dimensions.

Only one out of the four most represented topics steeply decreased in prevalence in the regional press over the period. All other topics increased for both newspapers. This illustrates an important decline of the representation of debates involving wolves, stakeholders and institutions in *Nice-Matin*, which may be related to the progressive decrease in dialogue toward alternative management options after two decades of incentive policies that have been led without a proper scientific knowledge of their direct efficiency (Eklund et al., 2017). Focusing on content variations between *Nice-Matin* and *Le Monde*, we showed that topics dedicated to lethal methods of regulations and debates (topic 6 and 10) were more related to the large carnivore issue in *Le Monde*, and to human stakeholders and concrete actions in *Nice-Matin*. However, the topic dedicated to the impact of the wolf focused on farmers in the national newspaper. The regional media referred more to wolf and livestock interaction. Likewise, *Le Monde* focused more on human individuals for the topic related to the public representation of wolf and human interactions, whereas *Nice-Matin* had a higher representation of the wolf, anchored in specific places such as zoological parks.

4.2. Generic vs. specific representation of the conflict

In each of the most prevalent topics, *Nice-Matin* appeared to be more anchored in the specific conflict caused by the wolf return in France, whereas *Le Monde*'s most represented words were linked to a generic view of the issue, either centred on legislative processes (topic 6) or large carnivore issues (topic 10). In the topic dedicated to the representation of wolves and human public interactions, *Le Monde* representative extracts showed a focus on the artistic dimension and on the wolf in general, instead of representing the specific interactions with the wolf population that came back to France from the Italian Alps. *Nice-Matin*'s topic was strongly anchored in specific places with the mention of zoological parks hosting wolves in the area. The geographical closeness between the regional newspaper and the specific places mentioned can explain the higher representation of such places in *Nice-Matin*. However, in *Le Monde*, the association of the topic with
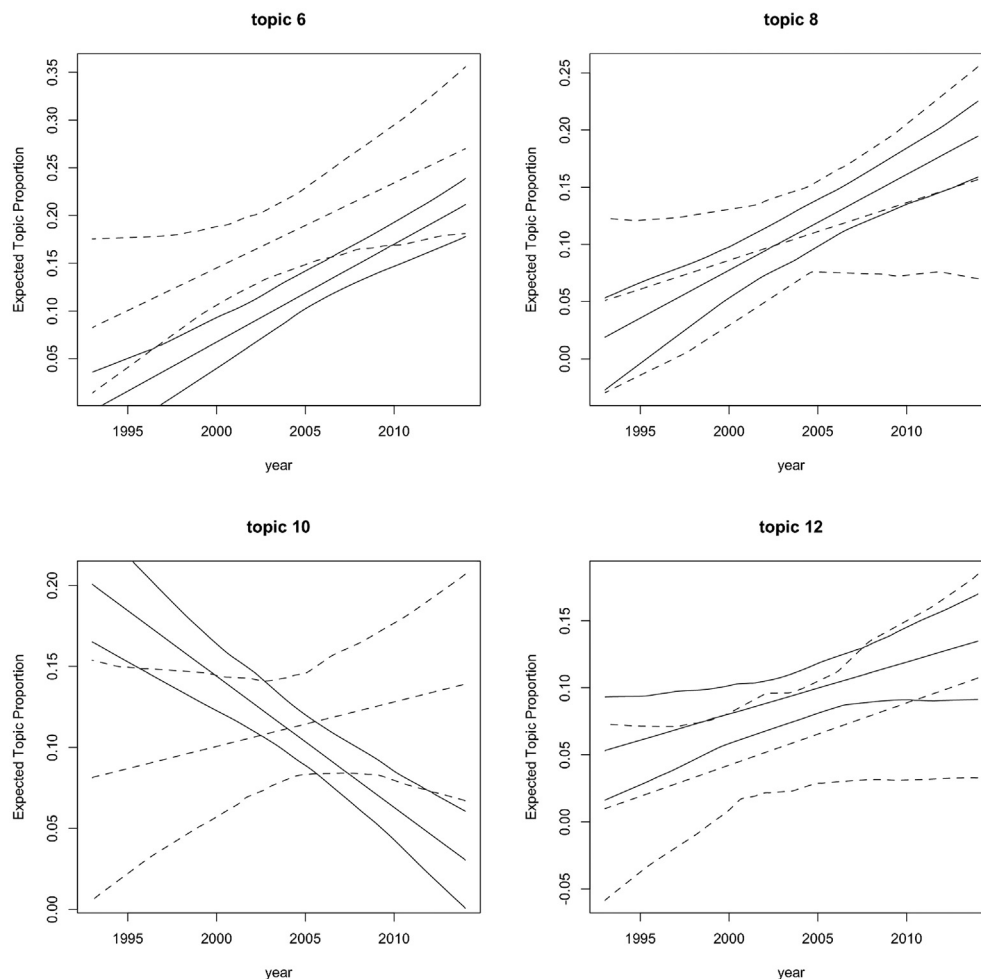
Fig. 2. The interactive effect of time and newspapers (*Le Monde* and *Nice-Matin*) on topic prevalence with confidence intervals. In solid line: *Nice-Matin*, in dotted line: *Le Monde*. There were no constraints on the response variable (topic proportion), hence the possibility to get negative values.

art and humans showed that the potential positive aspects of the wolf were not directly related to the current social-ecological implications of its presence. Thus, the attractiveness of the species and its potential added value for local development was mostly emphasized in *Nice-Matin*, and was much less mentioned in *Le Monde*.

4.3. Position of newspapers toward nature- or human-centred world-views

In *Le Monde* and *Nice-Matin*, respectively generic and specific representations of the topics were associated with contrasted prevalence of words referring to stakeholders and species for topic 6 and 10. In the regional newspaper, topics directly related to the management issue of the species were strongly anchored in human aspects of its presence. Embedded in institutional and administrative dimension, wolf management has a more concrete representation and is strongly related to humans directly involved in its control in *Nice-Matin*. *Le Monde*, however, referred to the issue in a more generic manner, focusing on wolf, members of civil society (topic 6) and large carnivores (topic 10).

Apart from the fact that the wider context covered in *Le Monde* can be related to its national distribution, which is remote from the specific area impacted by carnivores (Gore and Knuth, 2009; Jacobson et al., 2012), the use of generic terms is also likely to achieve a mitigation of the conflict by reporting the attention on a wider issue and avoid the emotional aspects that might be associated with the word 'loup' ('wolf'). Although anchoring the controversy into a larger context by using wolf's hypernyms can be an efficient mean toward conflict attenuation, it is also likely to miss the specificities of wolf presence in France.

Interestingly, *Le Monde* emphasized specifically human stakeholders whereas *Nice-Matin* adopted an approach more centred on animal species (wolf, livestock) for topics related to the impact of the predator on the ground and to the representation of its public interactions with humans.

By focusing more on the farmers in presentation of the topic dedicated to the impact of the wolf on livestock, *Le Monde* puts emphasis on human suffering and psychological effects of the wolf presence, and thus induces the empathy of the audience for the most involved stakeholder of the conflict. In *Nice-Matin*, the topic is associated with the representation of predator prey interaction that induces an important focus on domestic animal loss and injuries, and thus also emphasizes empathy of the audience for the breeder who has lost part or all of its livestock. The regional newspaper thus remains centred on the impact of the wolf on human stakeholders. By underlining either ecological or human aspects of wolf predation, *Nice-Matin* and *Le Monde* tend to focus on the same specific stakeholder (the breeder). In addition, *Nice-Matin* underlined more the traditional aspects of the profession with the use of the word 'berger' ('shepherd').

In *Le Monde,* the topic dedicated to the representation of wolves and human public interactions is not directly related to the wolf issue, and the positive representation of the species is limited to the human area of art. In *Nice-Matin*, the topic is both anchored in space (zoological parks) and highly related to the wolf, showing that the focus on the species is associated with its presence in areas designed by humans. The much reduced presence of human stakeholders associated with a higher representation of the word 'loup' ('wolf') contrasts with the topics related

to wolf management. The focus on the wolf is enabled here by the captive nature of the species. Both in *Le Monde* and *Nice-Matin*, the potential radiance of the wolf is narrowed to an area designed by humans, either conceptually (the art for *Le Monde*) or spatially (zoological parks for *Nice-Matin*).

4.4. Potential consequences of either generic and nature-centred or specific and human-centred combination in newspapers for topics related to management issues

The generic representation of the management topics in *Le Monde* is associated with an approach related on more global and ecological aspects. In contrast, the specific approach of *Nice-Matin* is embedded in human management of the wolf. Combining generic or specific information with more nature-centred or human-centred world-view is likely to have an impact on the public perception of the conflict depending on the newspaper. The audience directly involved with the wolf will rather look for more detailed information, and then will have access to a more human oriented approach with *Nice-Matin*, whereas a reader with indirect interactions with the predator will be attracted to a less detailed description of the conflict, which is more focused on a broader ecological dimension. This focus is likely to reinforce the opposition between rural and urban representations of the conflicts, and emphasize gaps in the national and regional management of the wolf.

Although the nature of the impact of media on citizens' perception still remains difficult to state, mass media studies often give access to strong social representations, especially for HWCs, as most people are more likely to learn about species such as large carnivores through mass media than through direct interactions with them (Jacobson et al., 2012; Bhatia et al., 2013). The media tend thus to be part of the construction of public opinion on a HWC such as the wolf issue.

4.5. Assets and limitation of STM

Many studies on HWC media coverage have been conducted on limited periods (no more than 10 years), using mainly descriptive statistical methods. STM is a consistent tool for agenda setting theory, as it provides a statistical framework to identify the topics that define an issue in a corpus, hence adding a powerful tool to the social scientist's toolbox (Grimmer and Stewart, 2013). STM is an unsupervised method in the sense that the topics are inferred from the data rather than assumed prior to analysis, which is different from supervised methods where the topics are defined by hand-coding a corpus of documents. Besides, an advantage of the STM approach is its ability to handle large corpus of texts that would be otherwise difficult, if not impossible, to manage with more traditional techniques based on human coding. A recent comparison showed that the identification of topics with STM provided similar results to human coding (Roberts et al., 2014).

In this respect, STM could be a useful tool in a preliminary stage to rapidly explore large sets of documents to identify pertinent existing or new hypotheses that that can be tested with more qualitative approaches on media corpus (valence, discourse analysis), or semi-directive interviews. These interviews, possibly made of open-ended survey responses, can be fruitfully analyzed with STM (Roberts et al., 2014), therefore establishing a virtuous circle between qualitative and quantitative methods (Drury et al., 2011; Rust et al., 2017). Finally, STM allows scientists to perform regression-type analyses by including covariates (metadata) to explain variation in prevalence and content. Despite these advantages, STM has a number of limitations. Besides the complexity of the method and the difficulty in planning survey experiments (Roberts et al., 2014), the method does not allow a direct quantification of valence that is of interest when studying HWC press coverage (e.g. Jacobson et al., 2012). In our case study, the valence associated with either the wolf or the farmer could be tested in further analyses.

In conclusion, our work highlights the value of using structural topic

modeling to address media coverage of a HWC. The increase of interactions and exchanges between national and regional scales could allow a more diversified media coverage of the wolf issue. Combining detailed information and both nature and human-centred content could help fill in the gaps between local and national representations of the human/wolf conflict. As HWCs are increasingly covered by the media worldwide, being able to identify trends in the main topics assigned to an issue will contribute to a better understanding of the social representations that underlie environmental issues and may be useful to shape new representations and improve conservation actions, dialogue processes, public perception of HWCs and communication strategies for state services and/or conservation NGOs.

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