



Applying machine learning to media analysis improves our understanding of forest conflicts

Isabella Hallberg-Sramek^{a,b,*}, Simon Lindgren^c, Jonatan Samuelsson^{d,e}, Camilla Sandström^f

^a Department of Forest Resource Management, Swedish University of Agricultural Sciences, Umeå 90183, Sweden

^b Forest and Nature Conservation Policy Group, Department of Environmental Sciences, Wageningen University, Wageningen 6700, The Netherlands

^c Department of Sociology, Umeå University, Umeå 90187, Sweden

^d Department of Historical, Philosophical and Religious studies, Umeå university, Umeå 90187, Sweden

^e Department of History of Science and Ideas, Uppsala University, Uppsala 75126, Sweden

^f Department of Political Science, Umeå University, Umeå 90187, Sweden

ARTICLE INFO

Keywords:

Forest policy
Agenda-setting power
Daily press
Topic modelling
BERTopic

ABSTRACT

Conflicts over the management and governance of forests seem to be increasing. Previous media studies in this area have largely focused on analysing the portrayal of specific conflicts. This study aims to review how a broad range of forest conflicts are portrayed in the Swedish media, analysing their temporal, spatial, and relational dimensions. We applied topic modelling, a machine learning approach, to analyse 53,600 articles published in the Swedish daily press between 2012 and 2022. We identified 916 topics, of which 94 were of interest for this study. Our results showed ten areas of forest conflicts: hunting and fishing (35 % of total coverage), energy (24 %), recreation and tourism (11 %), nature conservation (8 %), forest damages (6 %), international issues (5 %), forestry (5 %), reindeer husbandry (4 %), media and politics (2 %), and mining (1 %). The overall coverage of forest conflicts increased significantly over the study period, potentially reflecting an actual increase in forest conflicts. Some of the conflicts were continuously reported upon over time, while the coverage of others exhibited seasonal or event-related patterns. Four conflicts received most of their coverage in specific regions, while others were covered across the whole of Sweden. A relational analysis of the conflicts revealed three clusters of forest conflicts focused respectively on industrial, cultural, and conservation conflicts. Our results emphasise the value of using topic modelling to understand the overall patterns and trends of the media coverage of current land use conflicts, while also highlighting potential areas of emerging conflicts that may be of special interest for planners and policy-makers to monitor and manage.

1. Introduction

European forests, which cover 35 % of its land area (Korhonen and Ståhl, 2020), have traditionally been managed with a focus on providing wood, fuel, and local livelihoods (Radkau, 2008; Hölzl, 2010; Dargavel and Johann, 2013; Mårald et al., 2017). In recent decades, forests have also been expected to provide ecosystem services such as recreation, habitats for biodiversity, and climate change mitigation, making the management and governance of forests increasingly complex (Sandström et al., 2016; Beland Lindahl et al., 2017; Mårald et al., 2017; Elomina and Pülzl, 2021; Hallberg-Sramek et al., 2022; Winkel et al., 2022). The multiplicity of demands on forests generate difficult trade-offs, but neither EU nor Swedish policy offers guidance on how these potentially conflicting goals should be handled (Sandström et al.,

2016; Beland Lindahl et al., 2017; Aggestam and Pülzl, 2018; Elomina and Pülzl, 2021). Instead, such conflicts are left to be tackled on a case-by-case basis, and largely at local or regional levels, even when their implications cause ripples at a national or even international level. This situation is problematic, especially in Sweden where forest regulations are relatively weak (Appelstrand, 2012; Beland Lindahl et al., 2017; Lawrence et al., 2020; Sandström et al., 2020), public and private forest rights are strong (Sténs and Sandström, 2014; Nichiforel et al., 2018), a high proportion of forest land is privately owned (Pulla et al., 2013), and forests cover 69 % of the land (Korhonen and Ståhl, 2020). Based on an agonistic view on conflicts (Mouffe, 2013), we assume that conflict is a natural and inevitable part of human interactions and societal structures. We also assume that conflicts when approached and managed in a constructive manner, can lead to positive outcomes such

* Corresponding author at: Department of Forest Resource Management, Swedish University of Agricultural Sciences, Umeå 90183, Sweden.

E-mail address: isabella.hallberg.sramek@slu.se (I. Hallberg-Sramek).

as increased understanding, innovation, and social change.

Today, there is increasing competition between different types of media. The mass media have therefore become more focused on portraying issues that engage the public's interest than they were in earlier times of less media choice (Brants and van Praag, 2017). At the same time, the mass media also influences what issues the public consider important, by controlling which issues that get coverage, a phenomenon referred to as the agenda-setting power of media (McCombs and Shaw, 1972; Coleman et al., 2009; Crow and Lawlor, 2016; Djerf-Pierre and Shehata, 2017). As part of this agenda-setting role, the mass media control which actors and interests that are portrayed and reflected in the public debate, thereby not only acting as a space for communication of current issues, but also as an political actor that shapes the way in which these issues are framed (Park, 2013; Park and Kleinschmit, 2016; Hallberg-Sramek et al., 2020). This shapes what issues that are considered to be important to the public, while also influencing their understanding of these issues.

Temporal dynamics are important in the study of media, because issues covered by media compete for limited space at any given moment. Typically, media coverage of environmental issues, including forest issues, tends to decrease during periods of economic stagnation or crisis (Djerf-Pierre, 2013) and is amplified at others, for instance when the Kyoto Protocol was signed in 1997 (Kleinschmit and Sjöstedt, 2014) or when the vast wildfire in Västmanland occurred in 2014 (Öhman et al., 2016). Such events can serve to lower the threshold for related issues to receive attention, creating meta-cycles in media reporting (Djerf-Pierre, 2012).

Spatial and cultural proximity have proven to be important factors in how conflicts are covered in the media (Chang et al., 1987; Bendix and Liebler, 1999; Berglez and Lidskog, 2019). As forest conflicts typically arise over rights to land and resources, they are inherently both spatially and culturally bound. In Sweden, there are several layers of competing land use rights, including hunting and fishing rights, rights to public access (which includes recreation and foraging), indigenous Sami people's reindeer herding rights, mining rights, and forest ownership. Local and national conflicts often revolve around the relative strength and extent of these rights (Sténs and Sandström, 2013; Sandström et al., 2016; Brännström, 2017; Sténs and Mårald, 2020; Allard and Brännström, 2021; Jakobsson et al., 2021). Some land use rights, such as hunting, fishing and public access rights, are nationwide. Others are restricted to specific areas: for instance, Sami reindeer herding rights are limited to northern Sweden, and mining rights are limited to areas where the relevant mineral deposits are found. The structure of forest ownership also varies across the country: in southern Sweden the majority of forest land is owned by family forest owners, while in northern areas forest companies and the Swedish state control most forested land (Nilsson et al., 2019). This is important because forest owners' objectives in managing their forests vary according to their respective dependencies on forest resources for economic and other purposes. Different objectives may drive competing interests, and thus become the basis for conflicts.

At times, local conflicts have attracted national media coverage. Greenpeace demonstrations against harvesting in the mountainous forests of Njakafjäll and the old-growth forests of Arvliden in the late 1990's (Lisberg Jensen, 2002; Westling, 2012; Hallberg-Sramek et al., 2020), and local protests against a limestone quarry in Ojnare forest in 2005 (Örestig and Lindgren, 2017; Anshelm et al., 2018; Jönsson et al., 2021), soon escalated into national conflicts involving more interests. Some local conflicts are directly handled at the national level: for example, in 2009 the indigenous Girjas reindeer herding community sued the Swedish state to (re)claim their exclusive rights over fishing and small game hunting within their locality (Allard and Brännström, 2021). In both the Ojnare and Girjas cases, the conflicts continued for several years before finally being settled in court (Anshelm et al., 2018; Allard and Brännström, 2021), and they have now set precedents for subsequent cases. Thus, even such seemingly place-specific conflicts can

garner substantial interest and have a significant impact on the governance of forest rights and resources across the country.

While many forest conflicts share common traits, they generally remain poorly understood. Previous media analyses have provided important insights into specific forest conflicts, such as those relating to nature conservation (Bendix and Liebler, 1999; Sadath et al., 2013; Park and Kleinschmit, 2016; Riedl et al., 2018; Hallberg-Sramek et al., 2020; Jönsson et al., 2021), hunting (Niemiec et al., 2020; Zscheischler and Friedrich, 2022), mining (Örestig and Lindgren, 2017; Anshelm et al., 2018; Zachrisson and Beland Lindahl, 2019), forest property rights (Sténs and Sandström, 2013; Sténs and Mårald, 2020), wind power (Bjärstig et al., 2022), and bioenergy (Sjöstedt and Kleinschmit, 2016; Kangas et al., 2018). However, the relationships between different types of forest conflict have not been well-explored.

In this study, we aim to review the past ten years of forest conflicts, as covered by the Swedish media. We are particularly interested in their temporal, spatial and relational aspects. What are the main forest conflicts that the media has covered? Has this coverage changed over time and, if so, how? How have forest conflicts been covered in regional vs national media? How does the coverage of different conflicts relate them to each other? In addressing these questions, this paper contributes to the literature on forest conflicts, and how their portrayal in the media can best be understood.

This insight into media coverage of forest conflicts may enable policy makers and researchers to better understand how the public sees these issues. Assuming that the conflicts covered by the media accurately reflect actual land use conflicts, our results may also inform policy-makers and planners as to where conflicts require additional attention and potential interventions to manage the conflicts.

Furthermore, in modern, urbanised western contexts, individuals' relationships with forests are increasingly mediated through the mass media, and media attention to forest conflicts serves not only to reflect ongoing conflicts, but also structures our relationships with and perceptions of both forests and the social institutions governing and shaping them. Thus, mediatised conflict is "profoundly implicated in the conduct and contentions of contemporary societies" (Cottle, 2007, p.197). The media is "concerned with the production and distribution of knowledge in the widest sense of the word" (McQuail, 2010, p.82), and many forest conflicts hinge on contested knowledge claims and the social and moral values attached to those claims by different stakeholders. Our analysis can therefore also contribute to wider understanding of how shared forest knowledge is co-produced (Jasanoff, 2006) through the interactions between science, stakeholders, and the media.

2. Methods and material

To capture the temporal, spatial, and relational dimensions of forest conflicts in the media, we have analysed news articles in the daily press using a machine learning technique called topic modelling. Topic model algorithms identify themes (or topics) in collections of texts (commonly referred to as documents) (Blei, 2012), and thereby allow for a clustering and relational analysis of large volumes of text-based information. This type of data-driven approach is able to analyse complex information, and we have used it to analyse: how the coverage of forest conflict topics has varied over time, how those conflicts have been covered by the media in different parts of the country and at different political levels (local/regional and national), and how the topics relate to each other. Topic modelling has previously been applied to review forest research and policy (Clare and Hickey, 2019; Nummelin et al., 2021; Firebanks-Quevedo et al., 2022), but this study is the first to apply it to media analysis in the context of forests.

2.1. Media selection and retrieval

This study focuses on how forest conflicts are portrayed in Swedish mass media during 2012–2022. While social media and other new media

platforms have emerged and expanded in recent decades, the daily press continues to wield significant agenda-setting power in Sweden (Djerf-Pierre and Shehata, 2017), where a majority of the population (68 % of people between 9 and 85 years of age) still rely on newspapers for their news (Ohlsson, 2021). The Swedish population also continues to have confidence in the information provided by newspapers, particularly local newspapers (48 % reporting fairly to very high confidence levels), while only 6–7 % claim to have the same confidence in information published on Twitter, Facebook and Flashback¹ (Ekengren Oscarsson and Sjören, 2022). For this reason, we have focused our investigation on local, regional, and national newspapers.

We used Mediearkivet Retriever (<https://app.retriever-info.com/>) to retrieve 53 575 articles from all local (n = 332), regional (n = 83), and national (n = 9) daily newspapers in Sweden, dated between January 2012 and May 2022. The search string included the words “forest”, “conflict” and similar words in Swedish (skog* AND (debatte* OR konflikt* OR kontrovers* OR bråk* OR oenig* OR strid* OR osämj* OR osams*)), and the articles retrieved included all editorial material in the newspapers, including news articles, reportage, and editorials. We also retrieved the following metadata for all articles: i. date of publication, ii. newspaper title, and iii. newspaper type (local, regional, national). Based on the metadata for newspaper title and newspaper type, we added metadata regarding the geographical region of all local and regional newspapers. All newspapers included in the study are listed in the [supplementary material](#), where we also have marked the ten most prominent sources in the material.

2.2. Topic modelling

A number of topic models have been developed, including Latent Dirichlet Allocation (LDA) (Blei et al., 2003), Correlated Topic Model (CTM) (Blei and Lafferty, 2007), Non-Negative Matrix Factorisation (NMF) (Févotte and Idier, 2011), and Structural Topic Models (STM) (Roberts et al., 2019). We used the recently released, state-of-the-art BERTopic, which uses a pre-trained language model (Grootendorst, 2022). We performed a set of preprocessing steps ahead of training the topic model. These included text lowercasing, tokenization (splitting the text into individual words), removal of special characters, numeric tokens, and punctuation. Furthermore we removed stopwords (words that are very common but of low significance), by applying the *stopwords-sv* dictionary provided by [Stopwords-ISO \(2022\)](#). To enable a variety of analyses, we trained the model using documents from different months and different geographical regions, so that each document was representative of a collection of articles. We applied BERTopic with the default hyperparameters (Grootendorst, 2022), while exchanging the default language models with the pretrained Swedish language model KB-SBERT (Rekathati, 2021). Instead of pre-defining the number of topics, as in LDA or STM (Blei et al., 2003; Blei, 2012; Roberts et al., 2019), BERTopic lets the model decide the number of topics. This resulted in 916 unique topics, a large proportion of which were judged to be irrelevant because the Swedish word for forest, “skog”, is widely used with other meanings in Swedish, including in names. We therefore filtered the topics manually by reviewing the top ten most frequent words for all topics (listed in the [Supplementary Material](#)), including only those topics that related to forests providing ecosystem services, forest stakeholders, forest management, and forest governance. Topics which consisted of book reviews, biographies, historical reports, and other non-relevant issues were excluded. This resulted in 10 % of the initial list of topics (94 of 916 topics) being included, which is comparable with a previous media analysis of place-based forest conflicts that analysed about 5 % of the total number of articles initially identified (Westling, 2012). As the scope of our study was broader than Westling

(2012), the higher proportion of topics included was judged to be appropriate.

2.3. Topic categorisation and analysis

All topics included were named according to the top ten most frequent words in that topic (Table 1). To analyse and visualise the topics, we applied a data-driven qualitative approach inspired by the inductive approach of grounded theory (Lindgren, 2014, 2020), iteratively clustering similar topics until they formed cohesive categories. For example, topics related to berry picking, bicycling, and mushroom picking formed one cluster, as they entail activities that take place in Swedish forests under the right to public access, while topics related to storms, wildfires, and herbivore browsing formed another cluster, as they all relate to forest disturbances. In cases where a topic related to several clusters, the topic was categorised based on the most prevalent words. This process of clustering and categorising resulted in ten categories being identified: i. energy, ii. forest damages, iii. forestry, iv. hunting and fishing, v. international issues, vi. media and politics, vii. mining, viii. nature conservation, ix. recreation and tourism, and x. reindeer husbandry (see descriptions in Table 1). Topics known to be related to climate change, such as biofuels, wetland restoration, and forest fires, generally lacked any explicit mention of climate change, and thus we did not create a specific category for climate change.

Finally, we analysed how the topics and topic categories were distributed temporally and spatially, and how they related to each other. For the temporal analysis the documents were divided by month and looked at topic probabilities: the trend for each topic category was then plotted and tested using linear regression analysis (see Fig. 1). Fig. 1 shows the absolute trends, but the total output of media articles from our selected sources declined by some 40 % during the time period² studied, meaning that the relative trend may be more positive than our results suggest. For the spatial analysis, we looked at topic probabilities for the documents divided by region. We used QGIS (<https://www.qgis.org>) to develop individual maps for each topic category, reflecting the proportional coverage of the topic categories in each region (Fig. 2). We used the proportional coverage rather than the absolute coverage because there were large differences in the total number of documents per region (Table 3), which is partly explained by some regions having more newspapers than others. For the relational analysis, we used BERTopic to create an “intertopic distance map” (Grootendorst, 2022). This map, shown in Fig. 3, displays the semantic distances between the conflicts in two dimensions (similar to a Principal Component Analysis), where the multidimensional model of topic categories has been reduced using Uniform Manifold Approximation and Projection for Dimension Reduction (UMAP) (McInnes et al., 2020). The size of each circle on the map reflects the relative prevalence of the corresponding topic category in the material (Sievert and Shirley, 2014).

3. Results

We identified ten areas of conflict that were portrayed in the Swedish media between 2012 and 2022. The most-reported conflicts were hunting and fishing (35 % of the coverage studied), energy (24 %), recreation and tourism (11 %), nature conservation (8 %) and forest damages (6 %), with the remaining topics receiving 5 % or less of the total coverage (Table 2). Several of the conflicts were covered continuously throughout the time period: these included energy, forestry, hunting and fishing, nature conservation, recreation, and tourism. Some conflicts were reported on in response to specific triggers such as forest damage, international events, and reindeer husbandry issues.

¹ Flashback is a Swedish online forum with over 1.5 million users (<https://www.flashback.org/>).

² As Mediearkivet Retriever does not allow for article searches using a blank search string, we used the very commonly used word “and” (“och” in Swedish) to get an estimation of trends in total media output.

Table 1
Topic categories and their descriptions.

Category	Description	Topics
Energy	Topics related to the production, transportation and consumption of forest-related energy and fuel, such as biobased fuels, wind power and power lines. It also includes the use of forests for carbon offsetting of travel emissions.	aviation fuels, aviation fuels ² , biofuels, biofuels Preem, biofuels Preem ² , car fuels ² , climate compensation, climate compensation ² , energy supply, power lines, wind power
Forest damages	Topics related to abiotic and biotic disturbances, e.g., storms, wildfires, herbivore browsing, pests and pathogens, causing forest damages and tree mortality.	browsing, crisis Gudrun, Dutch elm disease, firefighting, storms, wildfire Västmanland, wildfire Västmanland ²
Forestry	Topics related to forestry including forest ownership, forestry practices, managed forests, forest industries, and timber construction.	carbon dioxide, Christmas trees, diesel thefts (from forest machines), farm generational change, forest management plans, forest plantations, forestry, forestry ² , FSC forestry, gender equality, Norra Skog fusion, property rights, Swedish forestry model, wood construction
Hunting and fishing	Topics related to hunting and fishing, such as problems with carnivores (mainly Swedish grey wolfs <i>Canis lupus</i>), wild boars <i>Sus scrofa</i> , moose <i>Alces alces</i> , lead ammunition, game fishing, freshwater fish.	fishing, fishing ² , hunting, hunting fishing fair, lead ammunition, carnivores
International issues	Topics related forest issues in other countries and internationally, such as deforestation and conservation of tropical forests, environmental justice, international forest policies, poaching, and tiger conservation.	agroforestry, Amazon forests, Amazon forests fires, Amazon forests fires ² , biodiversity EU IPBES, Borneo rainforests, Borneo Sumatra rainforests, deforestation South Sudan, environmental justice, EU forest strategy, global biodiversity, indigenous people, palm oil, poaching, rainforest conservation, rainforest conservation ² , Stora Enso, tiger populations, tiger populations ²
Media and politics	Topics related to Swedish forest politics and policy, such as the January Agreement (between several political parties in the Swedish parliament), the Swedish Church Election (where members of the Church elects their political leaders), and Government declaration. It also includes topics related to Swedish public media and their role in portraying forest politics.	church election, forest programmes, government declaration, January agreement, January agreement ² , Swedish public media
Mining	Topics relating to mining: this exclusively comprises topics related to the Ojnare forests.	Ojnare forest, Ojnare forest ² , Ojnare forest ³
Nature conservation	Topics relating to nature, wetland, and beach conservation, including nature protection, woodland key habitats, forests in residential areas, and old-growth spruce forests.	beach protection, ecosystem conservation, forestry biodiversity, forestry woodland key habitats, nature protection, nature reserve, residential areas, residential areas ² , spruce forests, wetland restoration, wetland restoration ²
Recreation and tourism	Includes topics related to tourism and recreation,	animal transmitted diseases, animal transmitted diseases ² ,

Table 1 (continued)

Category	Description	Topics
	including the right to public access, berry and mushroom picking, snowmobile driving, bicycling, tourism, and diseases that can be transmitted to humans from insects and animals (such as ticks, moose flies, voles, hares).	berry jam, berry pickers, berry pickers ² , bicycling, Bulgarian berry pickers, edible mushrooms, right to public access, snowmobile driving, Thai berry pickers, tourism, tourism eco parks
Reindeer husbandry	Topics related to reindeer husbandry and the indigenous Sami land use rights.	reindeer herding community, reindeer herding community ² , reindeer husbandry, Sami rights

Meanwhile the topics of media and politics and mining received little general coverage, although mining did constitute 28 % of the regional coverage in Gotland. The size and characteristics of each of the conflicts are presented in Table 2. In the following sections, we describe the temporal dimensions, regional distributions, and relationships between the different conflicts.

3.1. Temporal trends in media coverage of forests conflicts

Media reporting of forest conflicts in the Swedish media have significantly increased over the period from 2012 to 2022 (Fig. 1). Considering that the total number of media articles in the Swedish press decreased by some 40 % over the same time period, media coverage of forest conflicts has, in relative terms, increased even more than Fig. 1 shows. The conflicts that have received a significant increased coverage are energy, forestry, media and politics, nature conservation, and reindeer husbandry, while mining conflicts have received a significant decreased coverage (Fig. 1). Some conflicts, such as energy, forestry, and nature conservation, were covered continuously. Hunting and fishing, and recreation and tourism, were also covered continuously but with distinct seasonal peaks at relevant times (in the Autumn for hunting and fishing, and late Spring-early Autumn for recreation and tourism).

The main peaks in coverage of forest damages related to the vast wildfire in Västmanland in August 2014, multiple wildfires in July 2018, and the winter storm Alfrida in January 2019, when large areas of forests were damaged (Fig. 1). Peaks in coverage of international issues related to a global mission to stop poaching in Africa, led by the United Nations in February 2014, new reports on the status of Asian tiger populations in February 2019, and wildfires in Brazil in September 2019. The main peak in coverage of reindeer husbandry conflicts related to the government’s decision in March 2022, to allow Jokkmokk Iron Mines AB a processing concession in Kallak (Gällök in Sami) in Norrbotten, which is an area defined as being of national interest for both reindeer husbandry and mining.

3.2. Regional versus national coverage of forest conflicts

The regions with the highest media coverage of forest conflicts were Västra Götaland (14 % of all regional reporting), Gävleborg (9 %), Dalarna (8 %), Värmland (7 %) and Skåne (7 %), all of which are located in southern or central Sweden (Table 3). Most of these conflicts were reported on across the whole of Sweden, although the amount of coverage was higher in the relevant regions (see Fig. 2, Table 3). Other regional patterns also emerged: reindeer husbandry conflicts received proportionally more coverage in northern Sweden, particularly Norrbotten and Västerbotten; nature conservation received more coverage in southern Sweden and Stockholm; and forest damage received more coverage in southern and central Sweden. Mining conflicts were almost exclusively covered in Gotland. However, several of the conflicts that received nationwide coverage also received exceptionally high coverage in particular regional hotspots. Such hotspots included Västmanland

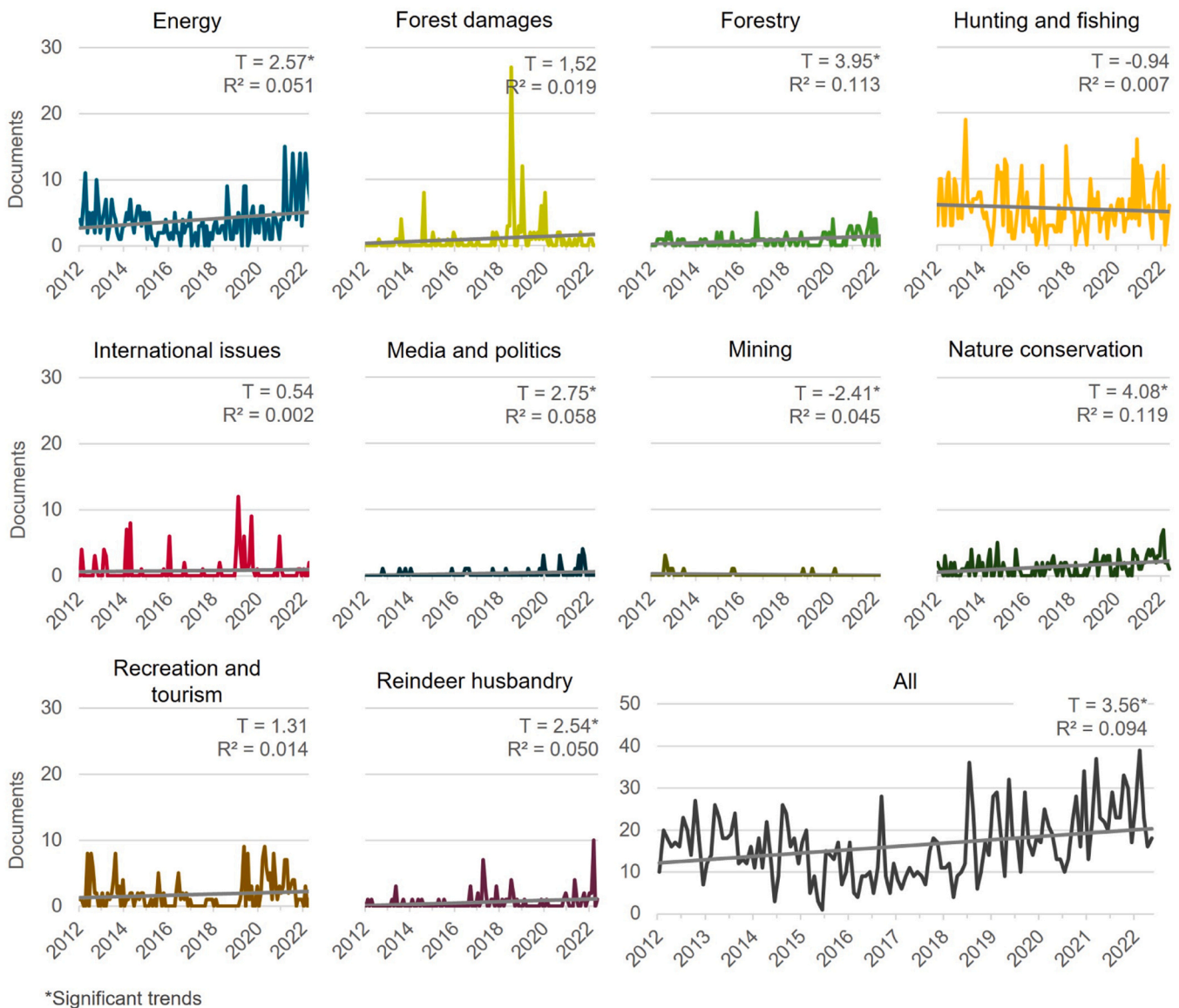


Fig. 1. Temporal distribution of forest conflicts portrayed in the Swedish media 2012–2022 (month by month). Each document represents a collection of articles, organised by month. The trends have been tested using linear regression. T-values above 2 reflect significant positive trends, t-values below -2 reflect significant negative trends, and t-values between -2 and 2 can be considered non-significant. Low R^2 -values reflect high variability of the monthly media coverage.

with regards to energy conflicts, Södermanland and Örebro for international issues, Stockholm and Kronoberg for forestry, and Uppsala with regards to recreation and tourism (Fig. 2, Table 2, Table 3).

Media coverage at the national level reflects the diversity of forest conflicts, with energy, hunting and fishing, and recreation and tourism being those received the most coverage, and media and politics and mining the least (Table 3). Comparing the national media coverage of forest conflicts with the regional average, the national media had a substantially greater focus on forest damages, forestry, and recreation and tourism, and gave less attention to hunting and fishing and nature conservation.

3.3. Relationships between forest conflicts

All conflicts, except forest damages, were closely or loosely related to another conflict. This is reflected in the intertopic distance map (Fig. 3) which illustrates the relationships between the conflict categories in terms of what words they include. Thus, the forest conflicts that are similarly framed in media are found close to each other (in Fig. 3) and

we have identified three clusters of conflicts that are similarly framed. The first cluster comprises industry-related conflicts, centring around forestry, which was closely related to mining and international issues, and more loosely related to energy. Opposite to this cluster, a second focused on conservation related conflicts, which included nature conservation and recreation and tourism, with a looser relationship to media and politics. The third cluster focused on cultural conflicts, and included hunting and fishing and reindeer husbandry.

4. Discussion

In this study, we applied state-of-the-art topic modelling to review how forest conflicts were covered in the Swedish daily media between 2012 and 2022. Our study reveals ten forest conflicts that received significant coverage in this period. The diverse conflicts reflect the multiple, often conflicting, expectations that are placed on forests, to provide benefits to society (Sandström et al., 2016; Beland Lindahl et al., 2017; Aggestam and Pülzl, 2018; Elomina and Pülzl, 2021; Hallberg-Sramek et al., 2022; Winkel et al., 2022). Our results suggest

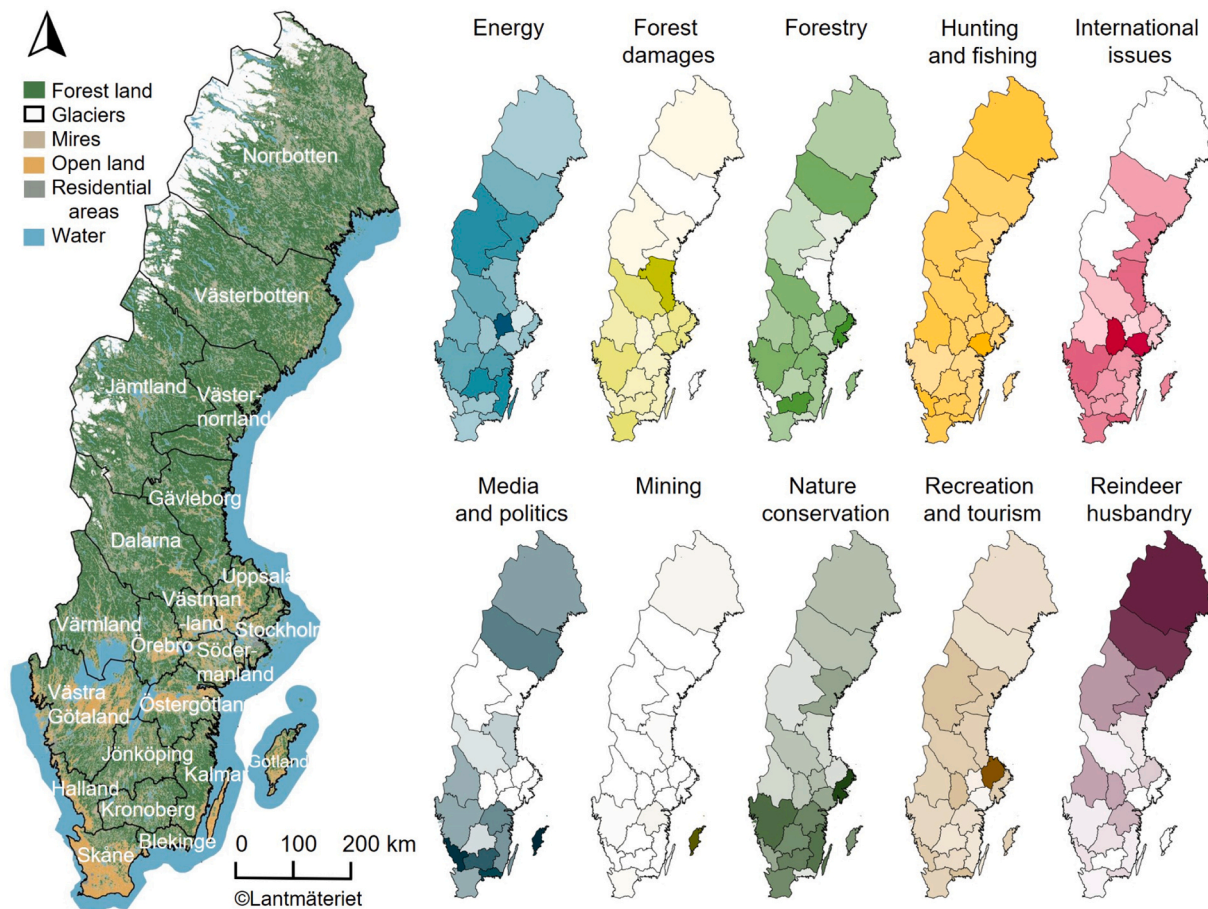


Fig. 2. Regional distribution of forest conflicts portrayed in Swedish media. The darker the color, the higher the proportional media coverage was of that conflict in that area. The left map was produced with data from Lantmäteriet (the Swedish Land Survey).

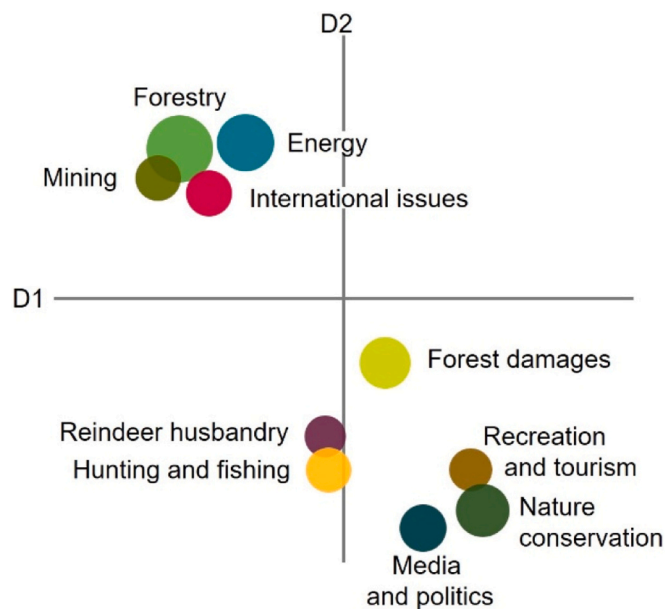


Fig. 3. Intertopic distance map displaying the semantic relationships between forest conflicts portrayed in the media.

that coverage of most of these conflicts has increased over the period, possibly reflecting an increase in forest-based land use conflicts, or at least an increase in the media's and the public's interest in them. Media

reporting of some conflicts was primarily regional or had regional tendencies, and there were differences between these issues and those which were covered at a national level, reflecting the spatial dimensions of land use conflicts. Finally, we identified three main clusters of conflicts: industrial, conservation, and cultural conflicts. In the following section, we discuss our findings in light of previous relevant studies.

The overall coverage of forest conflicts had increased significantly over the time period. The increased coverage was mainly focused on conflicts related to energy, forestry, media and politics, nature conservation, and reindeer husbandry. This could reflect an increase in actual land use conflicts, as a result of increasing demands being placed on forests to provide various benefits to society, as emphasised by previous studies (Sandström et al., 2016; Beland Lindahl et al., 2017; Mårald et al., 2017; Elomina and Pütz, 2021; Hallberg-Sramek et al., 2022; Winkel et al., 2022). However, it could also reflect an increased interest for conflicts in society, as the transition to a highly competitive media landscape have resulted in media being more inclined to report on issues of interest to the public, rather on issues the media think the public should be interested in (Brants and van Praag, 2017). Regardless of the reason for increased coverage, it could be of interest to policy makers and planners to monitor and manage these emerging areas of conflicts.

While some of the expectations on forests that are reflected in the material reviewed here have been central to forest management since its beginnings, they are now being discussed in new contexts. For example, forests have historically played an important role in local energy supply, primarily as firewood (Radkau, 2008; Hölzl, 2010; Dargavel and Johann, 2013; Mårald et al., 2017). However, during the fossil energy transition, the use of forests for energy in Europe decreased until the oil crisis of the 1970's, at which point demand started to rise again (FAO,

Table 2
An overview of the forest conflicts portrayed in Swedish media 2012–2022.

Forest conflict	Documents	Document proportion	Main topics	Temporal characteristics	Regional tendency	Greatest coverage	Closely related to
Energy	494	24,1 %	Bioenergy and wind power	Continuous	None	Västmanland	None
Forest damages	121	5,9 %	Storms, wildfires and herbivore browsing	Event-related	Southern and central Sweden	Gävleborg	None
Forestry	101	4,9 %	Swedish Forestry Model, gender equality, and climate change mitigation	Continuous	None	Stockholm, Kronoberg	Mining, International issues
Hunting and fishing	710	34,6 %	Hunting of wolves, wild boar, moose, and problems related to carnivore predation	Continuous, Seasonal	None	Södermanland	Reindeer husbandry
International issues	102	5,0 %	Deforestation and biodiversity conservation	Event-related	None	Södermanland, Örebro	Forestry
Media and politics	41	2,0 %	Church election and government declaration	NA	None	Gotland and Halland	None
Mining	14	0,7 %	Limestone quarry in Ojnare forest	NA	Gotland	Gotland	Forestry
Nature conservation	172	8,4 %	Biodiversity conservation in woodland key habitats, nature reserves, residential areas	Continuous	Southern Sweden	Stockholm	Recreation, tourism
Recreation and tourism	221	10,8 %	Berry and mushroom picking, bicycling, and the right to public access	Continuous, Seasonal	None	Uppsala	Nature conservation
Reindeer husbandry	75	3,7 %	Reindeer husbandry and Sami rights	Event-related	Northern Sweden	Norrbottnen, Västerbotten	Hunting and fishing

2023). Today, we see that forest-based energy is largely debated in the context of climate change, the focus being on biofuels and wind power (see also Söderberg and Eckerberg, 2013; Sjöstedt and Kleinschmit, 2016; Bjärstig et al., 2022). Something similar has occurred with hunting conflicts, where the recent (re)-introduction of Swedish grey wolves and wild boars (Massei et al., 2015; Peterson et al., 2019; von Essen and Allen, 2020; Markov et al., 2022) has created new specific sources of conflict within a longstanding pattern of conflicts around hunting. Thus, although some of the conflicts are far from new, they are now being discussed in new contexts.

Forest conflicts have overall received increased media interest and coverage during the study period, both in relative and absolute terms, however, in the middle of the period examined when there was a clear decline (Fig. 1). The low point is associated with the “European refugee crisis”, which began in 2015 as a consequence of the Syrian civil war, and received much attention in both the Swedish and international media (Holmes and Castañeda, 2016; Yantseva, 2020). This finding corroborates previous research which has shown that in times of crisis there is less media coverage of environmental issues (Djerf-Pierre, 2013). With regards to the specific forest conflicts identified here, some of them were reported on continuously while others showed a more event-related or seasonal pattern (Table 2). This shows that, for several of the conflicts, it is hard to compete with other issues in the media, except during particular events or when they are “in season”. Conflicts around recreation and tourism received significantly greater coverage during the Covid-19 pandemic, mirroring the widespread increase in outdoor recreation and tourism that was observed across Europe (Derks et al., 2020; Fredman and Margaryan, 2021; Hansen et al., 2022; Hedenborg et al., 2022). However, given the vastly increasing proportion of people enjoying recreation in the forest during the pandemic, we would have expected an even bigger increase in media coverage of related conflicts. Perhaps this reflects the way in which the crisis of the pandemic itself dominated media coverage, suppressing reporting of other issues.

Comparing media coverage in different parts of the country, several of the forest conflicts we identified, such as reindeer husbandry and mining, were clearly regional. Reindeer husbandry was largely reported on in northern Sweden, which was expected given that Sami reindeer herding rights are limited to the northern part of the country, and spatial and cultural proximity are important factors in media reporting (Chang et al., 1987; Bendix and Liebler, 1999; Berglez and Lidskog, 2019). Mining conflicts were primarily reported in Gotland, focusing on the

Ojnare conflict (see also Anshelm et al., 2018; Jönsson et al., 2021), although there were other mining conflicts ongoing in Sweden during the period studied (Zachrisson and Beland Lindahl, 2019; Fjellborg et al., 2022). One mining conflict identified in this study was framed in the media in such a way that it was categorised as a reindeer husbandry conflict. In contrast, the Ojnare conflict was broadly framed as a mining conflict, even though it is also a nature conservation conflict (see Anshelm et al., 2018; Jönsson et al., 2021). This reflects the framing power of media, which has the power to highlight certain aspects of an issue while assigning less attention to other aspects (Entman, 1993; Crow and Lawlor, 2016). It also reflects a limitation to this type of binary topic modelling, where each document is only classified according to one topic, rather than several. Thus, we believe that future applications of topic modelling, specifically BERTopic, on conflicting issues could be benefitted by calculating probabilities of multiple topics in a document, and thus improve our understanding of the interactions between different areas of conflicts.

Some of the conflicts that received coverage across the whole of Sweden also had regional tendencies or hotspots. One of these was forest damages, which was reported on more frequently in southern and central Sweden, with a particular regional hotspot in Gävleborg. This is because the major events reported on, wildfires and storms, occurred in southern and central Sweden, and Gävleborg was impacted by both during the period studied. At the same time, conflicts relating to forest damages do also occur in northern Sweden, for instance the multi-damaged forests of Norrbotten and Västerbotten (Normark, 2019). However, they did not get the same media coverage as the storms and wildfires which dominated the forest damages category. Nature conservation conflicts were proportionally covered more in southern Sweden, with a hotspot in Stockholm. This reflects the pattern of forest ownership in southern Sweden, where there is a higher proportion of family forest owners who have smaller properties, more limited resources, and stronger personal relationships to their forest holdings than other types of forest owner (Nilsson et al., 2019; Swedish Forest Agency, 2023). Family forest owners often consider formal forest protection to constitute a threat to their property rights and forest-based income (Götmark, 2009; Widman, 2016; Hallberg-Sramek et al., 2020; Sténs and Mårald, 2020; Jakobsson et al., 2021). The particular hotspot in Stockholm could possibly be explained by the city having the highest proportion of protected forests (in nature reserves and national parks) and woodland key habitats in the country (Wester, 2016; Statistics Sweden, 2021). However, to fully grasp the underlying reasons for these patterns,

Table 3
Number and proportion (in parentheses) of documents per topic category and region. Each document represents a collection of articles organised by region.

Region	Energy	Forest damages	Forestry	Hunting and fishing	Inter-national issues	Media and politics	Mining	Nature conservation	Recreation and tourism	Reindeer husbandry	Sum
Blekinge	8	(20)	1	(3)	1	(3)	0	(0)	1	(3)	40
Dalarna	37	(26)	11	(8)	4	(3)	0	(0)	17	(12)	141
Godland	1	(6)	0	(0)	1	(6)	5	(28)	2	(11)	18
Gävleborg	34	(21)	24	(15)	11	(7)	1	(1)	18	(11)	163
Halland	9	(16)	2	(4)	3	(5)	0	(0)	7	(13)	56
Jämtland	24	(32)	1	(1)	0	(0)	0	(0)	11	(15)	74
Jönköping	37	(33)	4	(4)	5	(5)	0	(0)	7	(6)	111
Kalmar	35	(33)	4	(5)	3	(3)	0	(0)	6	(6)	105
Kronoberg	4	(17)	1	(4)	1	(4)	0	(0)	2	(9)	23
Norrbotten	11	(14)	1	(1)	0	(0)	1	(1)	6	(8)	77
Skåne	21	(16)	11	(8)	8	(6)	1	(1)	14	(10)	135
Stockholm	8	(19)	3	(7)	1	(2)	0	(0)	5	(12)	43
Södermanland	8	(14)	4	(7)	6	(11)	0	(0)	1	(2)	57
Uppsala	2	(6)	2	(6)	1	(3)	0	(0)	12	(39)	31
Värmland	32	(23)	6	(4)	3	(2)	0	(0)	15	(11)	137
Västerbotten	26	(23)	0	(0)	5	(4)	0	(0)	8	(7)	115
Västernorrland	28	(32)	1	(1)	5	(6)	0	(0)	11	(13)	88
Västmanland	27	(47)	2	(3)	1	(2)	0	(0)	2	(3)	58
Västra Götaland	65	(26)	19	(7)	18	(7)	1	(0)	23	(9)	254
Örebro	9	(17)	1	(2)	6	(11)	0	(0)	8	(15)	53
Östergötland	18	(28)	2	(3)	3	(5)	1	(2)	5	(8)	64
Regional media	444	(24)	100	(5)	88	(5)	10	(1)	186	(10)	1843
National media	50	(24)	21	(10)	14	(7)	4	(2)	35	(17)	208

this type of machine learning approach would need to be complemented with in-depth analysis in specific regions and on specific topics, for example through qualitative content analysis or by interviewing experts and stakeholders, to understand both the natural conditions and cultural contexts that are shaping the media coverage of these conflicts.

Comparing the coverage of forest conflicts by the national and regional media, we observed that the national media tend to focus more on issues relating to the broader public, such as storms and wildfires (forest damages) and recreation and tourism, and give less attention to issues that concern specific stakeholder groups such as hunters and fishers (hunting and fishing) or family forest owners (nature conservation).

In our relational analysis, which shows which conflicts were similarly framed, we identified three main clusters of conflicts: industrial conflicts, conservation conflicts, and cultural conflicts. An unexpected finding within these results was that international conflicts, which included topics related to deforestation and biodiversity conservation, formed part of the industrial cluster, while national nature conservation conflicts, including topics related to biodiversity conservation in woodland key habitats, nature reserves, and residential areas, was part of the conservation cluster. Although both of these conflicts seem to be centred around biodiversity, it may be that their framing had different focuses. The framing of international conflicts tended to focus more on the cause of the problem, i.e., industrial interests, while the framing of the national nature conservation conflicts tended to focus more on the solution of the problem, i.e., conservation, thereby placing them in different clusters. This finding could suggest that there is a need to provide more background information when reporting on foreign issues than on national issues, because they are both culturally and spatially distant (Chang et al., 1987; Berglez and Lidskog, 2019).

This study emphasises the value of machine learning and topic modelling to review large volumes of material generated by the media. Topic modelling allowed us to review the broad range of forest conflicts covered in the Swedish daily press, going beyond previous media analyses that have studied particular forest conflicts (Bendix and Liebler, 1999; Sadath et al., 2013; Sténs and Sandström, 2013; Park and Kleinschmit, 2016; Sjöstedt and Kleinschmit, 2016; Kangas et al., 2018; Riedl et al., 2018; Hallberg-Sramek et al., 2020; Niemiec et al., 2020; Sténs and Mårald, 2020; Bjärstig et al., 2022; Zscheischler and Friedrich, 2022). While the approach did include manual selection and categorisation of topics, it was substantially less time-consuming than a purely qualitative media analysis. It also allowed us to do data-driven quantitative descriptive analysis (see also Lindgren, 2020; Nummelin et al., 2021) of the forest conflicts portrayed in the media, which highlighted the temporal, spatial, and relational characteristics of the conflicts, while also allowing new conflicts to be discovered. At the same time, topic modelling should not be used in replacement of other types of in-depth analysis, such as qualitative content analysis. It should rather be seen as a complement, that can highlight general patterns, while other types of analysis are better at explaining the nature or underlying causes of different conflicts.

Furthermore, our results suggest the need for a discussion about the role of the media in the creation of socially held ideas and understandings of forests in Sweden. Given the prevalence and recent increase in media coverage of forest conflicts, evident from our data, the argument could be made that forests are increasingly conceived of as sites of social contention and conflict. In other words, our results suggest that forests in Sweden today are understood as less of a stable, knowable, and governable natural entity, and more of an artefact emerging from the interplay of social institutions, imaginations, and interests. Over recent decades, multiple areas of knowledge have been reimagined to accommodate a broader range of perspectives, values, and forms of expertise (Collins and Evans, 2002; Nieto-Galan, 2016). This includes areas such as nuclear energy (Anshelm, 2000; Anshelm and Galis, 2011), medicine (Epstein, 1996; McCormick et al., 2003; Landzelius, 2006; Samuelsson, 2022), and the environment (Jamison, 2001; Walker and

Walsh, 2011; Egan, 2017), as well as science in general (Funtowicz and Ravetz, 1993; Nowotny et al., 2001, 2003; Agar, 2008; Heymann, 2017). Similarly, Mårald and Westholm's (2016) analysis of Swedish forest policy documents reveals a recent shift from the idea of the forest as a stable and predictable object to an understanding where "[u]ncertainty, choices, and conflicting interests formed the basis of [a] new approach to what we may be able to know" (p. 15). Our results indicate that such an understanding is increasingly being co-produced by the interactions of the news media, science, stakeholders, and policymakers. However, the regional differences and the relational clustering of conflicts also suggest that imagining forests in all their social and cultural embeddedness is a complex and regionally varied phenomenon that requires further research and analysis. Finally, the ways in which portrayals of forest conflicts relate to one another in our data, can help situate them as part of wider cultural imaginaries. As such, they both tie into and shape our ideas about nature, society, economy and industry, how social identities are formed and related to one another, and how they are perceived as influencing issues of conservation, preservation, and resource management.

5. Conclusions

In conclusion, our topic modelling approach has shone a light on media coverage of various forest conflicts in Sweden. Our results revealed that media coverage of forest conflicts has increased over the studied period, possibly reflecting an actual increase in such conflicts, or at least an increasing interest in these types of conflicts. This contributes to an understanding of forests as conflict-laden, which in turn may fuel forest conflicts and increase polarisation among different interests. Hence, it should be of special interest to policy-makers and planners to monitor and manage these potentially emerging and/or escalating conflicts.

Interestingly, the analysis also highlighted the regional and relational characteristics of these forest conflicts, emphasising their complexity, while also stressing the need to understand the specific regional contexts that shapes land use conflicts. To better understand the underlying nature and causes of the specific conflicts reviewed, these conflicts need also to be studied and addressed in their specific contexts. However, by applying this review of a broad range of forest conflicts, we can improve our understanding of the general patterns of these conflicts, and thereby offer insights which may inform policy-makers and planners about those conflicts that may require further attention.

Funding

Isabella Hallberg-Sramek was funded by "Bring down the sky to the earth: how to use forests to open up for constructive climate change pathways in local contexts" financed by Formas – a Swedish Research Council for Sustainable Development, grant number 2017–01956. Isabella Hallberg-Sramek and Jonatan Samuelsson were funded by Future Forests, the platform for interdisciplinary forest research and research communication at SLU (Swedish University of Agricultural Sciences), Umeå University and Skogforsk.

CRedit authorship contribution statement

Simon Lindgren: Writing – review & editing, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation. **Isabella Hallberg-Sramek:** Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Camilla Sandström:** Writing – review & editing, Supervision, Funding acquisition. **Jonatan Samuelsson:** Writing – review & editing, Resources, Methodology, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

The media sources and data are provided in the supplementary material.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.landusepol.2024.107254](https://doi.org/10.1016/j.landusepol.2024.107254).

References

- Agar, J., 2008. What happened in the sixties? Br. J. Hist. Sci. 41, 567–600. <https://doi.org/10.1017/S0007087408001179>.
- Aggestam, F., Püzl, H., 2018. Coordinating the uncoordinated: the EU forest strategy. Forests 9, 125. <https://doi.org/10.3390/f9030125>.
- Allard, C., Brännström, M., 2021. Girjas Reindeer herding community v. Sweden: analysing the merits of the Girjas case. Arct. Rev. 12, 56–79. <https://doi.org/10.23865/arctic.v12.2678>.
- Anshelm, J., 2000. Between salvation and doomsday: about the political idea history of nuclear power in Sweden 1945-1999 [Mellan frälsning och domedag: om kärnkraftens politiska idéhistoria i Sverige 1945-1999]. Symposium. 91-7139-474-5.
- Anshelm, J., Galis, V., 2011. (Re-)constructing Nuclear Waste Management in Sweden: The Involvement of Concerned Groups, 1970–2010. In: Kumar, S. (Ed.), *Integrated waste management*. IntechOpen, 978-953-307-447-4.
- Anshelm, J., Haikola, S., Wallsten, B., 2018. Politicizing environmental governance—a case study of heterogeneous alliances and juridical struggles around the Ojnare Forest, Sweden. Geoforum 91, 206–215. <https://doi.org/10.1016/j.geoforum.2018.03.003>.
- Appelstrand, M., 2012. Developments in Swedish forest policy and administration—from a "policy of restriction" toward a "policy of cooperation. Scand. J. For. Res. 27, 186–199. <https://doi.org/10.1080/02827581.2011.635069>.
- Beland Lindahl, K., Sténs, A., Sandström, C., Johansson, J., Lidskog, R., Ranius, T., Roberge, J.-M., 2017. The Swedish forestry model: More of everything? For. Policy Econ. 77, 44–55. <https://doi.org/10.1016/j.forpol.2015.10.012>.
- Bendix, J., Liebler, C.M., 1999. Place, distance, and environmental news: geographic variation in newspaper coverage of the spotted owl conflict. Ann. Assoc. Am. Geogr. 89, 658–676. <https://doi.org/10.1111/0004-5608.00166>.
- Berglez, P., Lidskog, R., 2019. Foreign, domestic, and cultural factors in climate change reporting: Swedish media's coverage of wildfires in three continents. Environ. Commun. 13, 381–394. <https://doi.org/10.1080/17524032.2017.1397040>.
- Bjärstig, T., Mancheva, I., Zachrisson, A., Neumann, W., Svensson, J., 2022. Is large-scale wind power a problem, solution, or victim? A frame analysis of the debate in Swedish media. Energy Res. Soc. Sci. 83, 102337 <https://doi.org/10.1016/j.erss.2021.102337>.
- Blei, D.M., 2012. Probabilistic topic models. Commun. ACM 55, 77–84. <https://doi.org/10.1145/2133806.2133826>.
- Blei, D.M., Lafferty, J.D., 2007. A correlated topic model of Science. Ann. Appl. Stat. 1, 17–35. <https://doi.org/10.1214/07-AOAS114>.
- Blei, D.M., Ng, A.Y., Jordan, M.I., 2003. Latent dirichlet allocation. J. Mach. Learn. Res. 3, 993–1022 <https://dl.acm.org/doi/10.5555/944919.944937>.
- Brännström, M., 2017. Forestry and reindeer husbandry on the same land: a legal study of land ownership and Sami reindeer herding rights (doctoral thesis). Umeå University, Department of Law, Umeå. 978-991-7601-687-9. (<http://urn.kb.se/resolve?urn=urn%3Anbn%3Ase%3Aumu%3Adiva-133884>).
- Brants, K., van Praag, P., 2017. Beyond media logic. J. Stud. 18, 395–408. <https://doi.org/10.1080/1461670X.2015.1065200>.
- Chang, T.-K., Shoemaker, P.J., Brendlinger, N., 1987. Determinants of international news coverage in the US media. Commun. Res. 14, 396–414. <https://doi.org/10.1177/009365087014004002>.
- Clare, S.M., Hickey, G.M., 2019. Modelling research topic trends in community forestry. Small-Scale For. 18, 149–163. <https://doi.org/10.1007/s11842-018-9411-8>.
- Coleman, R., McCombs, M., Shaw, D., Weaver, D., 2009. Agenda setting. The Handbook of Journalism Studies. Routledge, pp. 167–180, 0203877683.
- Collins, H.M., Evans, R., 2002. The third wave of science studies: studies of expertise and experience. Soc. Stud. Sci. 32, 235–296. <https://doi.org/10.1177/0306312702032002003>.
- Cottle, S., 2007. *Mediatized Conflict*. McGraw-Hill Education, Maidenhead, 9780335214525.
- Crow, D.A., Lawlor, A., 2016. Media in the policy process: using framing and narratives to understand policy influences. Rev. Policy Res. 33, 472–491. <https://doi.org/10.1111/ropr.12187>.
- Dargavel, J., Johann, E., 2013. *Science and Hope: A Forest History*. White Horse Press, Cambridge. ISBN 978-1-874267-73-7.

- Derks, J., Giessen, L., Winkel, G., 2020. COVID-19-induced visitor boom reveals the importance of forests as critical infrastructure. *For. Policy Econ.* 118, 102253 <https://doi.org/10.1016/j.forpol.2020.102253>.
- Djerf-Pierre, M., 2012. When attention drives attention: Issue dynamics in environmental news reporting over five decades. *Eur. J. Commun.* 27, 291–304. <https://doi.org/10.1177/0267323112450820>.
- Djerf-Pierre, M., 2013. Green metacycles of attention: Reassessing the attention cycles of environmental news reporting 1961–2010. *Public Underst. Sci.* 22, 495–512. <https://doi.org/10.1177/0963662511246819>.
- Djerf-Pierre, M., Shehata, A., 2017. Still an agenda setter: traditional news media and public opinion during the transition from low to high choice media environments. *J. Commun.* 67, 733–757. <https://doi.org/10.1111/jcom.12327>.
- Egan, M., 2017. Survival science: crisis disciplines and the shock of the environment in the 1970s. *Centaurus* 59, 26–39. <https://doi.org/10.1111/1600-0498.12149>.
- Ekegren Oscarsson, H., Sjöström, T., 2022. Företroendebarmetern 2022. *Medieakademien*, Online. <https://medieakademien.se/fortroendebarmetern/>.
- Elomina, J., Pöhl, H., 2021. How are forests framed? An analysis of EU forest policy. *For. Policy Econ.* 127, 102448 <https://doi.org/10.1016/j.forpol.2021.102448>.
- Entman, R.M., 1993. Framing: towards clarification of fractured paradigm. *J. Commun.* <https://doi.org/10.1111/j.1460-2466.1993.tb01304.x>.
- Epstein, S., 1996. *Impure Science: AIDS, Activism, and the Politics of Knowledge*. Univ of California Press, Berkeley, p. 0520921259.
- FAO, 2023. FAOSTAT: Forestry Production and Trade. <https://www.fao.org/faostat/en/#data/FO>.
- Févotte, C., Idier, J., 2011. Algorithms for nonnegative matrix factorization with the β -divergence. *Neural Comput.* 23, 2421–2456. <https://doi.org/10.48550/arXiv.1010.1763>.
- Firebanks-Quevedo, D., Planas, J., Buckingham, K., Taylor, C., Silva, D., Naydenova, G., Zamora-Cristales, R., 2022. Using machine learning to identify incentives in forestry policy: towards a new paradigm in policy analysis. *For. Policy Econ.* 134 <https://doi.org/10.1016/j.forpol.2021.102624>.
- Fjellborg, D., Beland Lindahl, K., Zachrisson, A., 2022. What to do when the mining company comes to town? Mapping actions of anti-extraction movements in Sweden, 2009–2019. *Resour. Policy* 75, 102514. <https://doi.org/10.1016/j.resourpol.2021.102514>.
- Fredman, P., Margaryan, L., 2021. 20 years of Nordic nature-based tourism research: a review and future research agenda. *Scand. J. Hosp. Tour.* 21, 14–25. <https://doi.org/10.1080/15022250.2020.1823247>.
- Funtowicz, S.O., Ravetz, J.R., 1993. Science for the post-normal age. *Futures* 25, 739–755. [https://doi.org/10.1016/0016-3287\(93\)90022-L](https://doi.org/10.1016/0016-3287(93)90022-L).
- Götmark, F., 2009. Conflicts in conservation: Woodland key habitats, authorities and private forest owners in Sweden. *Scand. J. For. Res.* 24, 504–514. <https://doi.org/10.1080/02827580903363545>.
- Grootendorst, M., 2022. BERTopic: Neural topic modeling with a class-based TF-IDF procedure. *arXiv (preprint arXiv:2203.05794)*. <https://doi.org/10.48550/arXiv.2203.05794>.
- Hallberg-Sramek, I., Björsting, T., Nordin, A., 2020. Framing woodland key habitats in the Swedish media—how has the framing changed over time? *Scand. J. For. Res.* 35, 198–209. <https://doi.org/10.1080/02827581.2020.1761444>.
- Hallberg-Sramek, I., Reimerson, E., Priebe, J., Nordström, E.-M., Mårald, E., Sandström, C., Nordin, A., 2022. Bringing “climate-smart forestry” down to the local level—identifying barriers, pathways and indicators for its implementation in practice. *Forests* 13, 98. <https://doi.org/10.3390/f13010098>.
- Hansen, A.S., Beery, T., Fredman, P., Wolf-Watz, D., 2022. Outdoor recreation in Sweden during and after the Covid-19 pandemic—management and policy implications. *J. Environ. Plan. Manag.* 1–22. <https://doi.org/10.1080/09640568.2022.2029736>.
- Hedenborg, S., Fredman, P., Hansen, A.S., Wolf-Watz, D., 2022. Outdoorification of sports and recreation: a leisure transformation under the COVID-19 pandemic in Sweden. *Ann. Leis. Res.* 19 (1) <https://doi.org/10.1080/11745398.2022.2101497>.
- Heymann, M., 2017. 1970s: Turn of an era in the history of science? *Centaurus* 59, 1–9. <https://doi.org/10.1111/1600-0498.12146>.
- Holmes, S.M., Castañeda, H., 2016. Representing the “European refugee crisis” in Germany and beyond: deservingness and difference, life and death. *Am. Ethnol.* 43, 12–24. <https://doi.org/10.1111/amet.12259>.
- Hözl, R., 2010. Historicizing sustainability: German scientific forestry in the eighteenth and nineteenth centuries. *Sci. Cult.* 19, 431–460. <https://doi.org/10.1080/09505431.2010.519866>.
- Jakobsson, R., Olofsson, E., Ambrose-Oji, B., 2021. Stakeholder perceptions, management and impacts of forestry conflicts in southern Sweden. *Scand. J. For. Res.* 36, 68–82. <https://doi.org/10.1080/02827581.2020.1854341>.
- Jamison, A., 2001. *The Making of Green Knowledge: Environmental Politics and Cultural Transformation*. Cambridge University Press, Cambridge, 9780521792523.
- Jasanoff, S., 2006. *States of Knowledge: The Co-Production of Science and the Social Order*, 1st ed. Routledge, Abingdon. 9780415403290.
- Jönsson, J., Mårald, E., Lundmark, T., 2021. The shifting society syndrome: Values, baselines, and Swedish forest conservation in the 1930s and 2010s. *Conserv. Sci. Pract.* 3, e506 <https://doi.org/10.1111/csp2.506>.
- Kangas, H.-L., Lyytimäki, J., Saarela, S.-R., Primmer, E., 2018. Burning roots: stakeholder arguments and media representations on the sustainability of tree stump extraction in Finland. *Biomass Bioenergy* 118, 65–73. <https://doi.org/10.1016/j.biombioe.2018.08.006>.
- Kleinschmit, D., Sjöstedt, V., 2014. Between science and politics: Swedish newspaper reporting on forests in a changing climate. *Environ. Sci. Policy* 35, 117–127. <https://doi.org/10.1016/j.envsci.2013.02.011>.
- Korhonen, K., Ståhl, G., 2020. Criterion 1: Maintenance and Appropriate Enhancement of Forest Resources and their Contribution to Global Carbon Cycles. In *FOREST EUROPE, 2020: State of Europe’s Forests 2020*. Ministerial Conference on the Protection of Forests in Europe - FOREST EUROPE, Liaison Unit Bratislava. <https://foresteurope.org/state-of-europes-forests/>.
- Landzellius, K., 2006. Introduction: patient organization movements and new metamorphoses in patienthood. *Soc. Sci. Med.* 62, 529–537. <https://doi.org/10.1016/j.socscimed.2005.06.023>.
- Lawrence, A., Deuffic, P., Hujala, T., Nichiforel, L., Feliciano, D., Jodlowski, K., Lind, T., Marchal, D., Talkkari, A., Teder, M., 2020. Extension, advice and knowledge systems for private forestry: understanding diversity and change across Europe. *Land Use Policy* 94, 104522. <https://doi.org/10.1016/j.landusepol.2020.104522>.
- Lindgren, S., 2014. Qualitative analysis, Coding, Thematization [Kvalitativ analys, Kodning, Tematisering] In: (C)Hjerm, M., Lindgren, S., Nilsson, M. (Eds.) (C), Introduction to social science analysis [Introduktion till samhällsvetenskaplig analys]. Gleerups utbildning AB, Malmö, Sweden. 978-91-40-68612-1.
- Lindgren, S., 2020. Data theory: Interpretive sociology and computational methods *Polity Press*. 978-1-5095-3928-4.
- Lisberg Jensen, E., 2002. As one shouts in the forest: Modernity, power and diversity in the struggle for Njakafjäll and in the Swedish forestry debate 1970–2000 [Som man ropar i skogen: Modernitet, makt och mångfald i kampen om Njakafjäll och i den svenska skogsbruksdebatten 1970–2000] (doctoral thesis). Lund Studies in Human Ecology 3, Lund University, Lund, Sweden. 91-628-5100-4.
- Mårald, E., Westholm, E., 2016. Changing approaches to the future in Swedish forestry, 1850–2010. *Nat. Cult.* 11, 1–21. <https://doi.org/10.3167/nc.2016.110101>.
- Mårald, E., Sandström, C., Nordin, A., 2017. *Forest Governance and Management Across Time: Developing A New Forest Social Contract*. Routledge, 9781138904309.
- Markov, N., Economov, A., Hjeljord, O., Rolandsen, C.M., Bergqvist, G., Danilov, P., Dolin, V., Kambalin, V., Kondratov, A., Krasnoschapka, N., 2022. The wild boar Sus scrofa in northern Eurasia: a review of range expansion history, current distribution, factors affecting the northern distributional limit, and management strategies. *Mammal. Rev.* 52, 519–537. <https://doi.org/10.1111/man.12301>.
- Massei, G., Kindberg, J., Licoppe, A., Gacic, D., Šprem, N., Kamler, J., Baubet, E., Hohmann, U., Monaco, A., Ozoliņš, J., 2015. Wild boar populations up, numbers of hunters down? A review of trends and implications for Europe. *Pest Manag. Sci.* 71, 492–500. <https://doi.org/10.1002/ps.3965>.
- McCombs, M.E., Shaw, D.L., 1972. The agenda-setting function of mass media. *Public Opin. Q.* 36, 176–187. (<https://www.jstor.org/stable/2747787>).
- McCormick, S., Brown, P., Zavestoski, S., 2003. The personal is scientific, the scientific is political: the public paradigm of the environmental breast cancer movement. *Sociol. Forum* 18, 545–576. <https://doi.org/10.1023/B:SOFO.0000003003.00251.2f>.
- McInnes, L., Healy, J., Melville, J., 2020. UMAP: Uniform Manifold Approximation and Projection for Dimension Reduction. *ArXiv (arXiv:1802.03426v3)*. <https://doi.org/10.48550/arXiv.1802.03426>.
- McQuail, D., 2010. *McQuail’s Mass Communication Theory*. Sage, London, 9781473902510.
- Mouffe, C., 2013. *Agonistics: Thinking the World Politically*. Verso Books, 1781681147.
- Nichiforel, L., Keary, K., Deuffic, P., Weiss, G., Thorsen, B.J., Winkel, G., Avidbegović, M., Dobsinská, Z., Feliciano, D., Gatto, P., 2018. How private are Europe’s private forests? A comparative property rights analysis. *Land Use Policy* 76, 535–552. <https://doi.org/10.1016/j.landusepol.2018.02.034>.
- Niemiec, R., Berl, R.E., Gonzalez, M., Teel, T., Camara, C., Collins, M., Salerno, J., Crooks, K., Schultz, C., Breck, S., 2020. Public perspectives and media reporting of wolf reintroduction in Colorado. *PeerJ* 8, e9074. <https://doi.org/10.7717/peerj.9074>.
- Nieto-Galan, A., 2016. *Science in the Public Sphere: A History of Lay Knowledge and Expertise*. Routledge, 1315640740.
- Nilsson, P., Roberge, C., Fridman, J., Wulff, S., 2019. *Forest statistics 2019*. Department of Forest Resource Management, Swedish University of Agricultural Sciences, Umeå. https://www.slu.se/globalassets/ew/org/centrb/rt/dokument/skogsdata/skogsdata_2019_webb.pdf.
- Normark, E., 2019. Multi-damaged young forest in Västerbotten and Norrbotten counties - Possible measures to mitigate the problems [Multiskadad ungskog i Västerbottens- och Norrbottens län - Möjliga åtgärder för att mildra problemen]. Swedish Forest Agency. <https://www.skogsstyrelsen.se/globalassets/om-oss/rapporter/rapporter-20222021202020192018/rapport-2019-10-multiskadad-ungskog-i-vaesterbottens-och-norrbottens-lan.pdf>.
- Nowotny, H., Scott, P., Gibbons, M., 2001. Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty. *SciELO Argentina*, 0745626076.
- Nowotny, H., Scott, P., Gibbons, M., 2003. ‘Mode 2’ revisited: the new production of knowledge. *Minerva* 41, 179–194. (<http://www.jstor.org/stable/41821245>).
- Nummelin, T., Hänninen, R., Kniivilä, M., 2021. Exploring forest sector research subjects and trends from 2000 to 2019 using topic modeling. *Curr. For. Rep.* 1–15. <https://doi.org/10.1007/s40725-021-00152-9>.
- Ohlsson, J., 2021. *Mediebarometern 2021*. Nordicom, Göteborgs universitet, Göteborg. 978-91-88855-62-6. <https://doi.org/10.48335/9789188855626>.
- Öhman, S., Giritli Nygren, K., Olofsson, A., 2016. The (un) intended consequences of crisis communication in news media: a critical analysis. *Crit. Discourse Stud.* 13, 515–530. <https://doi.org/10.1080/17405904.2016.1174138>.
- Örestig, J., Lindgren, S., 2017. Local moral economies: the space, place, and locality of social media mobilisation. *Globalizations* 14, 884–895. <https://doi.org/10.1080/14747731.2017.1286175>.
- Park, M.S., 2013. The dual role of the media in environmental communication as a public sphere and as political actors. *For. Sci. Technol.* 9, 33–38. <https://doi.org/10.1080/21580103.2012.759162>.
- Park, M.S., Kleinschmit, D., 2016. Framing forest conservation in the global media: an interest-based approach. *For. Policy Econ.* 68, 7–15. <https://doi.org/10.1016/j.forpol.2016.03.010>.

- Peterson, M.N., von Essen, E., Hansen, H.P., Peterson, T.R., 2019. Shoot shovel and sanction yourself: self-policing as a response to wolf poaching among Swedish hunters. *Ambio* 48, 230–239. <https://doi.org/10.1007/s13280-018-1072-5>.
- Pulla, P., Schuck, A., Verkerk, P.J., Lasserre, B., Marchetti, M., Green, T., 2013. Mapping the distribution of forest ownership in Europe. European Forest Institute, Joensuu. (<https://efi.int/publications-bank/mapping-distribution-forest-ownership-europe>).
- Radkau, J., 2008. *Nature and Power: A Global History of the Environment*. Cambridge University Press, 978-0-521-61673-7.
- Rekathati, F., 2021. The KBLab Blog: Introducing a Swedish Sentence Transformer (accessed 2023-01-05). <https://kb-labb.github.io/posts/2021-08-23-a-swedish-sentence-transformer/>.
- Riedl, M., Hrib, M., Jarský, V., Jarkovská, M., 2018. Media analysis in a case study of Sumava National Park: a permanent dispute among interest groups. *For. Policy Econ.* 89, 71–79. <https://doi.org/10.1016/j.forpol.2016.07.009>.
- Roberts, M.E., Stewart, B.M., Tingley, D., 2019. Stm: an R package for structural topic models. *J. Stat. Softw.* 91, 1–40. <https://doi.org/10.18637/jss.v091.i02>.
- Sadath, N., Kleinschmit, D., Giessen, L., 2013. Framing the tiger — a biodiversity concern in national and international media reporting. *For. Policy Econ.* 36, 37–41. <https://doi.org/10.1016/j.forpol.2013.03.001>.
- Samuelsson, J., 2022. Knowledge, Controversy, and Quicksilver. Debating Mercury Poisoning from Dental Amalgam in Sweden in the Late 20th Century [Kunskap, kontrovers och kvicksilver. Debatten om amalgamförgiftning i det sena 1900-talet Sverige] (Doctoral thesis). Umeå University, Umeå. 978-91-7855-723-3. <http://urn.kb.se/resolve?urn=urn%3Anbn%3Ase%3Aumu%3Adiva-192200>.
- Sandström, C., Carlsson-Kanyama, A., Lindahl, K.B., Sonnek, K.M., Mossing, A., Nordin, A., Nordström, E.-M., Rätty, R., 2016. Understanding consistencies and gaps between desired forest futures: an analysis of visions from stakeholder groups in Sweden. *Ambio* 45, 100–108. <https://doi.org/10.1007/s13280-015-0746-5>.
- Sandström, C., Carlsson-Kanyama, A., Rätty, R., Sonnek, K.M., Nordström, E.-M., Mossing, A., Nordin, A., 2020. Policy goals and instruments for achieving a desirable future forest: experiences from backcasting with stakeholders in Sweden. *For. Policy Econ.* 111, 102051 <https://doi.org/10.1016/j.forpol.2019.102051>.
- Sievert, C., Shirley, K., 2014. LDavis: a method for visualizing and interpreting topics. In: *Proceedings of the Workshop on Interactive Language Learning, Visualization, and Interfaces*. Association for Computational Linguistics, Baltimore, Maryland, USA, pp. 63–70.
- Sjöstedt, V., Kleinschmit, D., 2016. Frames in environmental policy integration: are Swedish sectors on track? *Environ. Plan. C: Gov. Policy* 34, 515–528. <https://doi.org/10.1177/0263774X15602895>.
- Söderberg, C., Eckerberg, K., 2013. Rising policy conflicts in Europe over bioenergy and forestry. *For. Policy Econ.* 33, 112–119. <https://doi.org/10.1016/j.forpol.2012.09.015>.
- Statistics Sweden, 2021. Formally protected forest land, voluntary set-asides, consideration patches and unproductive forest land. Year 2018 - 2021. Statistics Sweden. <http://www.statistikdatabasen.scb.se/sq/118317>.
- Sténs, A., Mårald, E., 2020. Forest property rights under attack”: actors, networks and claims about forest ownership in the Swedish press 2014–2017. *For. Policy Econ.* 111, 102038 <https://doi.org/10.1016/j.forpol.2019.102038>.
- Sténs, A., Sandström, C., 2013. Divergent interests and ideas around property rights: the case of berry harvesting in Sweden. *For. Policy Econ.* 33, 56–62. <https://doi.org/10.1016/j.forpol.2012.05.004>.
- Sténs, A., Sandström, C., 2014. Allemansrätten in Sweden: a resistant custom. *Landscapes* 15, 106–118. <https://doi.org/10.1179/1466203514Z.00000000029>.
- Stopwords-ISO, 2022. stopwords-sv. GitHub repository. <https://github.com/stopwords-iso/stopwords-sv>.
- Swedish Forest Agency, 2023. The Statistical Database. Swedish Forest Agency. <https://pxweb.skogsstyrelsen.se/pxweb/en/Skogsstyrelsens%20statistikdatabas/?rxid=03eb67a3-87d7-486d-acce-92fc8082735d>.
- von Essen, E., Allen, M., 2020. Not the Wolf Itself: Distinguishing hunters’ criticisms of wolves from procedures for making wolf management decisions. *Ethics Policy Environ.* 23, 97–113. <https://doi.org/10.1080/21550085.2020.1746009>.
- Walker, K., Walsh, L., 2011. No one yet knows what the ultimate consequences may be”: how rachel carson transformed scientific uncertainty into a site for public participation in silent spring. *J. Bus. Tech. Commun.* 26, 3–34. <https://doi.org/10.1177/1050651911421122>.
- Wester, J., 2016. Current status of woodland key habitats [Nulägesbeskrivning om nyckelbiotoper]. Swedish Forest Agency, Jönköping.
- Westling, U., 2012. Space for conflict: forest conflicts in the Swedish press 1990–2011 [Utrymme för konflikt: skogliga konflikter i svensk press 1990–2011]. Umeå University. <http://urn.kb.se/resolve?urn=urn%3Anbn%3Ase%3Aumu%3Adiva-56577>.
- Widman, U., 2016. Protecting forests through partnerships (doctoral thesis). Statsvetenskapliga institutionens skriftserie 2016:3, Department of Political Science, Umeå University, Umeå, Sweden. 978-91-7601-578-0. <http://urn.kb.se/resolve?urn=urn%3Anbn%3Ase%3Aumu%3Adiva-127072>.
- Winkel, G., Lovrić, M., Muys, B., Katila, P., Lundhede, T., Pecurul, M., Pettenella, D., Pipart, N., Plieninger, T., Prokofieva, I., 2022. Governing Europe’s forests for multiple ecosystem services: Opportunities, challenges, and policy options. *For. Policy Econ.* 145, 102849 <https://doi.org/10.1016/j.forpol.2022.102849>.
- Yantseva, V., 2020. Migration discourse in Sweden: Frames and sentiments in mainstream and social media. *Social Media + Society* 6, 2056305120981059. <https://doi.org/10.1177/2056305120981059>.
- Zachrisson, A., Beland Lindahl, K., 2019. Political opportunity and mobilization: the evolution of a Swedish mining-sceptical movement. *Resour. Policy* 64, 101477. <https://doi.org/10.1016/j.resourpol.2019.101477>.
- Zscheischler, J., Friedrich, J., 2022. The wolf (Canis lupus) as a symbol of an urban–rural divide? Results from a media discourse analysis on the human–wolf conflict in Germany. *Environ. Manag.* 70, 1051–1065. <https://doi.org/10.1007/s00267-022-01719-3>.