Communicating with the Public about Emerald Ash Borer: Militaristic and Fatalistic Framings in the News Media

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Abstract: Invasive species can spread to new landscapes through various anthropogenic factors and negatively impact urban ecosystems, societies, and economies. Public awareness is considered central to mitigating the spread of invasive species. News media contributes to awareness although it is unclear what messages are being communicated. We incorporated Frame Theory to investigate newspapers' coverage of the emerald ash borer (EAB; *Agrilus planipennis Fairmaire* (Coleoptera: Buprestidae)), which has killed millions of ash trees in the continental United States. We conducted a content analysis of 924 news articles published between 2002 and 2017 to examine language framing (how a phenomenon like invasive species is constructed and communicated), information sources, management methods, recommended actions for the public and whether this communication changed overtime. Seventy-seven percent of articles used language evocative of distinctive risk framings, with the majority of these using negative attribute frames like invasion-militaristic and/or fatalistic language to describe EAB management. Few discussed positive impacts like galvanizing public support. Most articles used expert sources, primarily government agents. We recommend that public communications regarding invasive species be cautious about language evoking militarism and fatalism. Furthermore, invasive species communication requires a broader diversity and representation of voices because invasive species management requires community effort.

Keywords: content analysis; framing; Frame Theory; urban forests; militaristic metaphors; conservation communication; invasive species

1. Introduction

Non-native invasive species can negatively impact socio-ecological systems by exacerbating biodiversity loss, changing ecosystem function and causing socio-economic harm [1]. Challenges stemming from invasive species are predicted to increase via globalization, trade and climate change [2]. Reducing the distribution of invasive species requires significant involvement from the general public. The general public's perceptions about invasive species are complex and influenced by the psychoanalytic processes of the individuals involved, the invasive species itself, effects of the species, socio-cultural contexts, institutions, governance and policies [3]. An individual develops a perception of invasive species through knowledge systems including societal and public discourse like popular media [3].

Popular media plays an important role in shaping public perception, by increasing awareness of a topic and influencing opinions and perceived realties [4], particularly in relation to environmental risks like invasive species [5]. Very few studies have addressed media communication of invasive

species (see [6,7] for exceptions). In this paper, we present an investigation into media communication about an invasive insect, *Agrilus planipennis Fairmaire* (Coleoptera: Buprestidae; emerald ash borer; EAB), in the news media. We discuss language framings to better understand how a phenomenon like invasive species is constructed and communicated through news media, with particular emphasis on framings that may discourage public action and/or support of invasive species management. Sources of information in news articles, narratives about the impact of EAB, and management implications for environmental communication were also examined.

1.1. EAB in the United States

EAB is an invasive beetle that feeds primarily on ash (*Fraxinus* spp.) trees. It is the most expensive and ecologically disruptive invasive insect in the United States (U.S.) to date [2,8]. Native to Asia, EAB was first officially discovered in 2002 in Detroit, Michigan, arriving via shipping material [2]. Since EAB's introduction, the beetle has killed over 99% of ash trees in certain geographic areas of Michigan and Ohio [2] and caused the death of more than 10 million ash in the U.S. [9]. Additionally, due to canopy gap creation as ash trees defoliate, light-limited invasive plants have spread, disrupting understory composition [2]. Although EAB insects are naturally slow movers, their expansion is facilitated by anthropogenic factors, like moving infested firewood and nursery stock [10]. Public awareness and involvement are thus important to slowing the spread of the species.

In addition to ecological impacts, EAB also has serious socio-economic impacts. EAB has been very costly for urban municipalities because ash trees comprised a large proportion of urban tree canopy—over 20% in many U.S. cities [2]. EAB caused an average increase of $280.5 (± $79.9) million in annual municipal budgets [10]. Furthermore, the discounted cost of managing EAB could exceed $12.5 billion in 2020, including the cost of treatment, removal, and replacement of trees [9]. Additionally, EAB also has indirect impacts on human behavior and time use patterns like reduced recreational activities [11] and increased labor efforts associated with its management [12]. Overall, the large-scale death of ash trees and related cumulative effects of EAB quarantines have significant socio-economic effects [8].

To effectively manage EAB's economic and ecological impacts, it is pivotal to involve the general public because humans facilitate the beetles' spread by transporting firewood across geographic regions [13]. Additionally, private landowners manage a significant portion of the urban forest [14]. Thus, the impact of media representation on public perception can conceivably influence management decision by residents and, ultimately, characteristics of the urban forest. In a related example, a study of the media's representation of the hemlock woolly adelgid (*Adelges tsugae*) found that news articles often understate the complexities of management options and their associated risks, which could lead to ill-informed management decisions when consumers are not fully informed about the risks, uncertainties and even disagreements among scientific experts [6]. In addition, identifying and implementing acceptable EAB management in urban forests is complicated by the fact that decisions often involve aesthetics and an emphasis on risk reduction (e.g., preventing injuries and property damage), as well as economic analysis of management options [15].

We evaluated media coverage of EAB in the U.S. by conducting a content analysis of newspaper articles published between 2002 and 2017, representing the first 15 years from the initial official sighting of EAB. We addressed three key questions. First, what are the primary framings used to report news about EAB? Second, whose voices are represented in the reports about EAB? Third, what are some potential new communication approaches to effectively address EAB in the news media?

1.2. Framing Theory and the News Media

Framing theory refers to "the process by which people develop a particular conceptualization of an issue or reorient their thinking about an issue" [16]. Specifically, communication and the media influence discourse around environmental issues (such as invasive species) through the ability to shape public perceptions and attitudes [5,17]. Most people receive scientific knowledge through mass media, rather than from academic publications or direct engagement with scientific studies [18,19].

Similarly, urban residents also receive information from local news sources [20]. However, there are very few assessments of the type of information residents receive about urban forests [20], and a lack of research into what content is communicated to the public in newspapers about invasive species (see [6,21] for an exception). Although newspaper readerships are generally decreasing, newspapers are still an important influencer of public opinion and decision making as they contribute to informal learning [22]. Media can emphasize or de-emphasize certain aspects of the coverage when communicating to their readership, thereby influencing what the public may prioritize [23–25].

By drawing attention to certain topics and highlighting specific components to the readers, the media contributes to issue framing [5,26,27]. Framing by the media is influential because it draws the public's attention to important issues, and it prioritizes components of the issues that are deemed most crucial. Negative stories about environmental issues, including those pertaining to risks and ecosystem disservices, can be misrepresented in the media when the relevant time frame and long-term ecological processes are not taken in consideration [28]. This misrepresentation may be problematic because the public may perceive environmental risks on a short time frame without also recognizing the long-term anthropogenic environmental implications [28].

The media also tends to present environmental issues as short-term and occurring suddenly, rather than presenting the long-term accumulation of complex anthropogenic factors [28]. Additionally, contemporary news media is primarily driven by events and thrives on "dramatic and often gloomy events" [17]. Emerald ash borer can be regarded as an example of a "dramatic and gloomy event," facilitating media narratives of dead trees and possible extinction of ash in affected areas. Thus, for effective natural resource management, it is very important to assess media representations [28]. Although the loss of urban trees to EAB is inherently negative, in terms of the aforementioned ecological and economic consequences, this gloomy representation may dissuade or overwhelm the public in their response if their management and prevention efforts are perceived to be futile. Therefore, more research is needed to better understand language framing and how this may impact the public's response to invasive species like EAB which spread quickly.

The media also plays a decisive role in whose voices are heard by the general public [29]. During media coverage of environmental risks, official statements by governments and other experts are usually the primary focus of coverage, while the general public's thoughts receive more passive coverage [30]. For example, a study of media coverage of the deaths of migrating ducks in Alberta, Canada primarily excluded the general public's perspective and focused primarily on government and expert opinions [24]. Although experts are usually trusted sources of information, it can also be argued that environmental issues like invasive species management requires public participation to prevent and control the spread of these species [5]. Therefore, invasive species management may present an opportunity to engage the public in this environmental discourse rather than the traditional linear model of knowledge sharing [5].

Although invasive species like EAB require substantial levels of action and preventive measures by the public [31], merely presenting people with information from experts does not change behavior [3,32,33]. Instead, the general public often interprets information based on the frames in which that information is embedded [32]. Framing refers to the presentation and highlighting of certain parts of a phenomenon to make them more memorable or prioritized [32,34]. Previous studies about how environmental issues are framed in the media include flooding [35,36], climate change [37,38] human–wildlife conflict [39], wolves [40,41], carbon storage [19], storm-related power outages [25], and wildlife-farming conflict [42].

Since invasive species management is a topic unfamiliar to large segments of the general public, it may create mistrust and tension between the experts and general public if they do not understand the reasons for certain management strategies, or if the public perceives that their opinions are not valued in the decision-making process [31]. In addition, it may be challenging for the public to conceptualize invasive species management if the framing of invasive species does not draw on familiar ideas [5]. Since framing by media can also influence people's decision making [23,25,35], it is pivotal to analyze

framing as it relates to public communication in order to better understand how messages are presented to the public [32]. The framing surrounding invasive alien species as the "enemy in war" is ubiquitous in many publications released by government and non-profit conservation organizations, and even academic outlets [43]. In a similar manner to how local people are the victims of destruction and exploitation in war, native flora and fauna are also seen as victims to these foreign invaders [21,44,45]. The militarism associated with invasive species control may be rationalized by the high socio-economic and environmental costs including the growing expenses associated with monitoring, managing and controlling these species. A large portion of threatened or endangered species are vulnerable to non-native invasive species, and in the U.S., $120 billion annually is spent on invasive species control [46].

Yet, there is increasing criticism about the militaristic language associated with invasion science [47–50]. Some scholars argue that conservationists should not judge a species by its origins but based on its ecological impacts and functions and suggest that invasive species discourses should use more pragmatic approaches that align with changing ecosystems [47]. Likewise, some scholars argue that invasion biology is culturally freighted and an "Edenic Science" aimed at restoring ecosystems to a mystical pre-Columbian period instead of accepting the flux or constant change in ecosystems [51]. This position is supported by recent arguments that highlight the ways "native" and "alien" are value-laden, social constructions that simplify realties [52,53], including that not all alien (i.e., non-native) species are invasive, and nor are all invasive species alien [1]. Some ecologists argue that native species can also exhibit invasive characteristics, resulting in socio-ecological damage [1], and disrupting framings that invasive species are akin to foreign invaders.

The militarization of invasive species (or the use of alternative framings) can arguably produce varying influences on public perception of these species and appropriate management actions. Yet, to the best of our knowledge, few studies assessed the coverage of invasive insects in the media. Therefore, we analyzed the media representation of an emerging invasive species, EAB, in newspaper reports, to examine media framing, representation and overall communication to the general public.

2. Materials and Methods

2.1. Media Sample Selection

We identified news articles and news briefs using NexisUni, a platform which provides full access to newspaper articles, although the available articles only represent major news databases. We analyzed media reports (news articles and briefs) from national and local newspapers. We limited our media analysis to news reports between 1 July 2002 and 31 December 2017. The start date reflects the first official discovery of EAB as an invasive species in Michigan, USA [2].

An initial search used the search phrase "emerald ash borer" and restricted the search geographically to the U.S., which identified 1483 relevant news items. Although LexisUni can identify duplicates, we also manually checked for duplicate articles. We then removed articles that were irrelevant to our study, primarily because they only mentioned EAB in one sentence or less. For example, an article that only mentioned EAB in the following capacity was removed: "Experts say the leaf drop isn't a sign of any disease problems, such as emerald ash borer". Other articles that were deemed inappropriate for our analysis included articles mentioning that EAB would be discussed in council meetings, as part of budget plans, tax plans, recap/reviews of general events, future or past workshop topics, recaps of town hall meetings, or articles with only one sentence confirming EAB discovery in a given locale. After removing duplicate and irrelevant articles, we had 924 news items for final analysis.

2.2. Content Analysis and Coding Protocol

We evaluated the media coverage of EAB by conducting a content analysis—a method used to assign meaning about a discourse [16,25]. To code the articles, we used a combined deductive and inductive coding approach [35,54]. Through this approach, we used key words that were included in previous studies [44,45] along with observations that were taken from articles themselves to

create meaning [35,54]. Specifically, we used deductive coding to produce the following preliminary codes, before we started analyzing the articles: language used (invasion-militaristic, optimistic); the ecological, social and economic impacts of EAB; information sources consulted; treatment options; and management options.

After identification of this initial set of codes, we expanded the codebook using inductive reasoning (Table 1). The inductive approach includes reading the articles and adding new codes that capture relevant content but were not included in the initial set. As a result, we added the following codes: framing (anthropomorphism, fatalism), EAB discovery (experts, general public), call to action for the general public (private landowners and/or recreationists). We also coded for publication year and state of the article. The articles were analyzed using NVivo 12 Pro (QSR International, Doncaster, VIC, Australia), a qualitative software program.

Table 1. Primary coding frames for quantitative content analysis of newspaper articles addressing EAB. * Indicates codes added using inductive reasoning.

Category	Coding Options	Number of Articles
Framing language used	Invasion-militaristic	422
	Fatalistic *	386
	Anthropomorphic *	144
	Optimistic	79
Impacts of EAB	Negative impacts	848
	Death of ash trees, or other tree species	796
	Economic costs	393
	Ecosystem services loss	163
	Other	143
	Danger to people, property or hazardous *	130
	Loss of biodiversity or other ecological impacts	91
	Positive impacts	259
	Galvanize public support *	130
	Wildlife benefits like habitat, food *	108
	Increased business (i.e., arborists, private foresters) *	29
	Other (furniture, memorabilia, woody biomass) *	19
Information sources consulted *	Experts	882
	Government agents (including extension agents)	748 (96)
	Other	202
	Academics/scholars	127
	General public	98
	Business owners/associates	40
	Private arborists/foresters	39
	Nursery owners *	11
Call to action for the public *	Private landowners	453
	Adhere to firewood regulations (not move firewood, etc.)	182
	Be aware/educate themselves *	152
	Contact professionals *	127
	Inspect their trees *	120
	Apply chemical treatment	119
	Recreationists, other *	117
	Adhere to firewood regulations *	114
	Decide what to do *	114
	Other (i.e., donate money, adopt a tree, etc.) *	101
	Volunteer data collection	75
	Remove ash trees *	69
	Workshops *	66
	Replant trees *	52
	Tree specialist's selection *	40
	Do not disturb EAB traps *	6
Discuss management and treatment methods	Silviculture	478
	• Cutting or removal of tree species	384
	• Diversify tree species *	211
	• Pre-emptive removal of ash trees *	78
	• Disposal	117
	Containment and eradication (quarantine)	332
	Chemical treatment	295
	Traps	129
	Biological control	63
	Do nothing	26
	Other (including use of sniffing dogs, etc.)	17

To ensure scientific rigor in our coding methods [55], all three researchers met throughout the analysis to discuss assigned codes, their identifications and justifications in the text. Although all coding was done by the first author, all three coauthors created the codes by reading a subsample of articles in the beginning of the coding process and independently coded them, then discussed any discrepancies including coding disagreements, missing but relevant codes and other important categories. The first author then coded all articles. Afterwards, the two coauthors independently coded a random sample of 20 articles. The three coders had 100% agreement as to the presence of a framing in each subsampled article, and there was 83% agreement between at least two of the coders based on the specific coding framing—invasion-militaristic, fatalistic, optimistic and anthropomorphic.

3. Results

Of the 924 coded news items published between 2002 and 2017, 35 states were represented (Figure 1) based on the search results obtained in NexisUni. Most articles about EAB came from Minnesota, Wisconsin, Iowa, Indiana, Ohio, Illinois, Pennsylvania, Colorado and New York. Throughout our results, whenever a percent of articles is mentioned, this reflects the proportion of all articles (924).
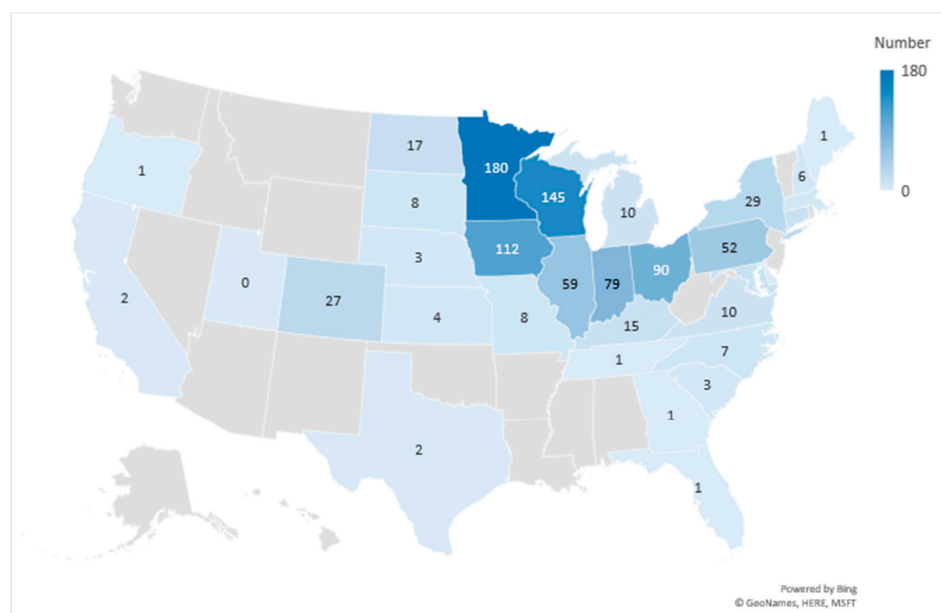

Figure 1. Map of the continental U.S. showing states where articles were sourced. Map was created using Microsoft Excel Map Charts.

3.1. Framing of Articles

Of the 924 articles deemed relevant to our study, 718 (78%) explicitly used a framing lens, while the others presented information without using a lens we coded for. Specifically, 46% (of the 924 total) were invasion-militaristic, 42% fatalistic, 15% used some form of anthropomorphism and 9% expressed optimism. Some common expressions indicative of the invasion-militaristic frame included defending the front lines, combating the invasive species, and lost battles (Table 2). Fatalism was the second most commonly expressed framing of EAB. The fatalistic framing includes statements in news articles like "with the demise of ash trees inevitable," "it [EAB] pretty much goes from tree to tree unstoppable" and "it's a matter of if, not when" (Table 2).

Anthropomorphic statements include "a methodical killer—of ash trees" and "the trees could very soon fall victim to the emerald ash borer". The optimistic framing includes narratives that highlight how EAB provides an opportunity to teach people about the benefits of diversifying the urban forest (i.e., the silver lining) or increased hope in the use of science and genetic engineering to find a solution. Overall, there was an increase in the number of articles published over time. Communication about

EAB varied in the fifteen years between 2002 and 2017 (Figure 2). There was an increase in 2008 which started declining in 2014. The frames used in each article, specifically invasion-militaristic and fatalistic frames followed a similar pattern of rapid increase followed by a decline starting in 2014.

Table 2. Most common framings expressed in the news articles.

| Framing	Representative Quotes
Invasion-militaristic 1. Representing EAB as the enemy and using combat language like "front lines", "weapons", "war against the enemy" [45] 2. Representation of native species as "victims" or needing protection. Representation of EAB as "the villain" [45,56]	"Unveiled its a new weapon in the fight against the invasive emerald ash borer" "You have to get on the problem before battle lines are fully drawn" "… Emerald ash borer's march across Michigan to the front lines of a losing battle"
Fatalistic 1. Hopelessness about how to manage the species 2. Lack of preparation to address the issue	"It pretty much goes from tree to tree unstoppable." "There's nothing we can do to eliminate it" "It's only a matter of time … The chances are very high for us to lose all our ash trees. A complete wipeout"
Anthropomorphistic 1. Applying human attributes to EAB, usually as a villain or antagonist 2. Applying human attributes to ash trees, usually as a victim or species that need protecting	"Many trees recently have been falling victim to the emerald ash borer" "A tiny, shiny green insect that's invaded the United States from Asia has become more than just an increased nuisance. It's become a methodical killer—of ash trees" "Southeastern North Carolina will likely be spared the wrath of the emerald ash borer"
Optimistic 1. This represents some positive benefits of EAB or 2. Some hope that is attributed to EAB 3. Some benefits of EAB include their role as 'teachers' [45]	"After the devastation [caused by EAB] comes regrowth … This is a moment for us to pause in our planning for the future while we remember and honor those [loss of ash trees] who came before us and brought us to this place" "Finally, there's a glimmer of good news in Minnesota's battle to save its ash trees. Tiny wasps released in 2011 to fight the destructive emerald ash borer have successfully reproduced, spread geographically and are attacking the pest" "Since 2008, about 800 trees have been planted at the fairgrounds, an effort that only became more important after the discovery in Boulder County of the beetle called the emerald ash borer"
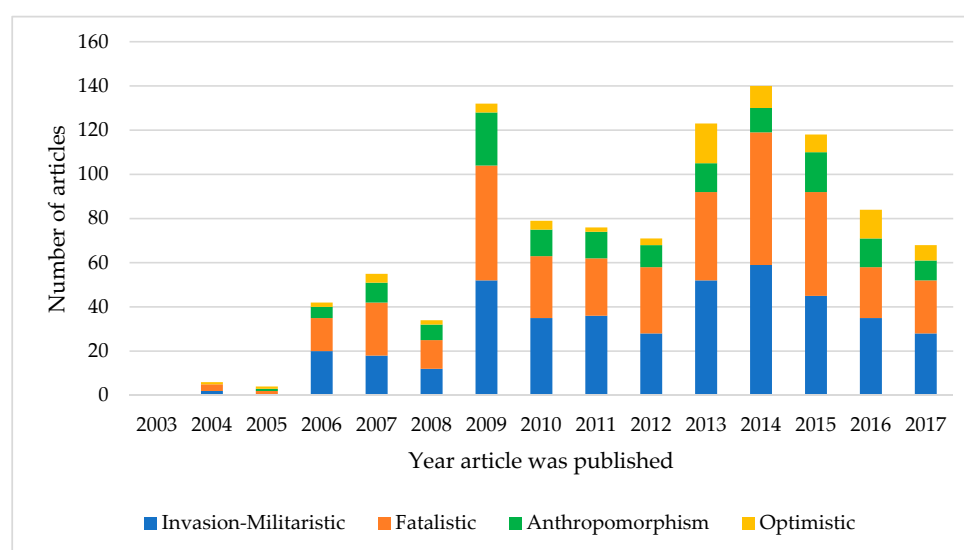
Figure 2. Framing trends overtime based on year articles were published.

3.2. Information Sources Consulted

Most news items used expert voices. More specifically, 890 articles (96%) explicitly mentioned their information sources. All 890 articles used expert voices, while 98 articles included the general public along with expert representation (Figure 2). None of the articles exclusively featured the non-expert general public as an information source. Of the articles that included only expert representation, 81% featured government officials including state and federal agents, city foresters, parks and recreation officials, extension agents, mayors and other government agents (Figure 3).
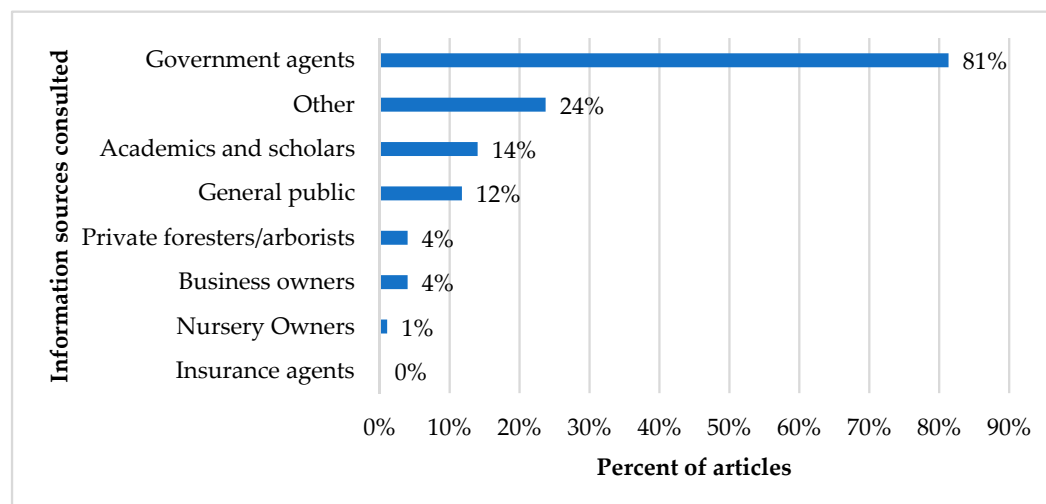
Figure 3. Information sources consulted.

3.3. Impacts of EAB Highlighted in Articles

Most articles highlighted the ecological, social, and/or economic impacts of EAB (93%). Articles usually mentioned the negative impacts of EAB and to a lesser extent some positive impacts. The negative impacts include death of ash trees (86%) and other ecological impacts or biodiversity loss (10%). The articles also highlighted EAB's impacts related to tree hazards like the danger of dead or dying trees to people, property or other hazardous impacts (14%). Forty-three percent of articles included economic costs related to control, prevention, chemical treatment, hiring contractors, removal and disposal. Of the economic costs highlighted, 61 articles (7%) emphasized the economic costs associated with ash wood products loss like baseball bats, loss of employment wages and impacts on the wood products and manufacturing industries. In terms of ecosystem service loss, 163 articles (18%) highlighted that EAB also results in a reduction in benefits such as shade, aesthetics, cooling effects and loss of property value.

Although most articles focused on the negative impacts of EAB, 259 articles (28%) also mentioned some positive effects of EAB. Fourteen percent of all articles talked about the benefits of EAB in terms of galvanizing public support. This public support included community volunteer groups to replant trees, donations to support treatment and reforestation efforts, school and community groups and overall public engagement in conservation. Other positive benefits include increased business for arborists, private foresters and businesses (3%) and increased wildlife habitats, like dead trees serving as habitat for other species in forest ecosystems, and food sources for species such as the pileated woodpecker and bats (12%). In contrast to the death of ash trees causing eventual loss of ash wood products, a small fraction of the articles highlighted the benefit of an increase in ash wood supply, due to tree removal, used to make furniture, memorabilia, art and even research into using dead ash as input for woody biomass energy (2%). We also found that 25% of the articles compared EAB with other types of invasive species, primarily the negative impacts of the Dutch elm disease (caused by the *Ceratocystis ulmi* fungus) and Asian long-horned beetle (*Anoplophora glabripennis*).

3.4. Management Strategies

Overall, our results demonstrate the change in treatment of EAB overtime along with the possible latent effects of EAB discovery and evolution in management strategies and treatment options (Figure 4). These management strategies included quarantine, survey traps, best practices for disposal of EAB-infected wood products, diversifying tree species and doing nothing. The most common management strategies explicitly highlighted in the articles were: (1) quarantine (36%), (2) diversify tree species (23%), (3) survey traps for monitoring (14%), (4) disposal techniques (8%), (5) do nothing (3%) and (6) other—including the use of trained dogs (2%). The most common treatment methods identified were (1) cutting or removal of trees (42%), including 13% of articles discussing pre-emptive removal of trees; (2) chemical treatment (32%); and biological control (7%).
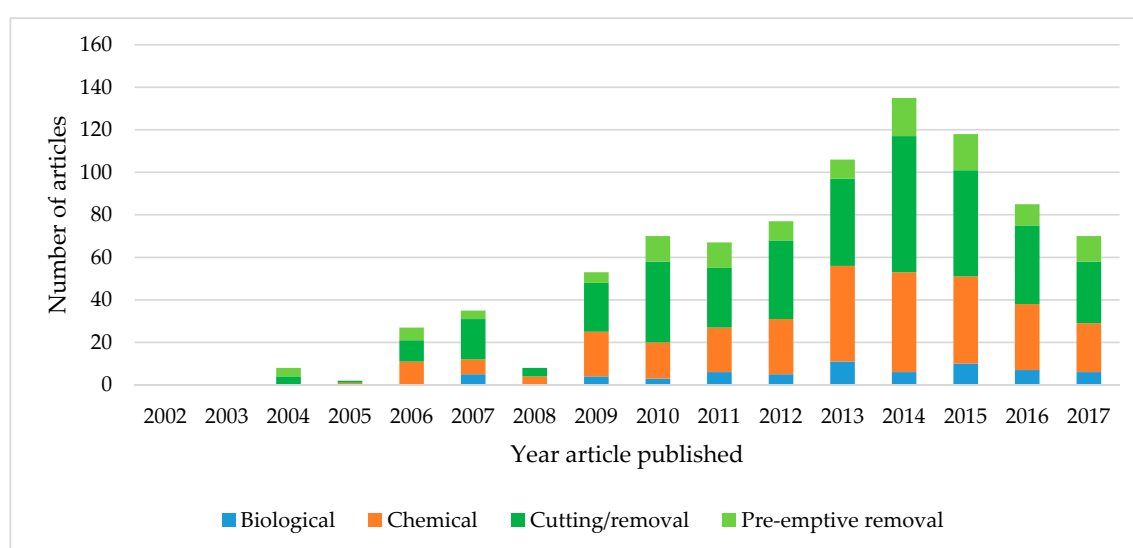

Figure 4. Treatment options for EAB discussed overtime in news articles between 2002 and 2017 in the U.S.

In the U.S., EAB was discovered in Detroit, Michigan, in 2002, gradually spreading to neighboring states (Table 3). The lag effect between discovery, distribution and visual impacts overtime may be representative of the increased number of articles published between 2009 and 2014.

Table 3. Year EAB was officially discovered in each state (Source: USDA—Animal and Plant Health Inspection Service).

State	Year of Discovery
Michigan	2002
Ohio, Maryland; Virginia	2003
Indiana	2004
Illinois	2006
Pennsylvania; West Virginia	2007
Missouri; Wisconsin	2008
New York; Kentucky; Minnesota	2009
Iowa; Tennessee	2010
Massachusetts; Connecticut; Kansas	2012
New Hampshire; Colorado; Georgia; North Carolina	2013
New Jersey; Arkansas; District of Columbia	2014
Louisiana	2015
Oklahoma; Texas; Nebraska; Alabama; Delaware	2016
South Carolina	2017

Although chemical control was mentioned in several articles in 2007, it re-emerged in 2009 and slowly increased, with highest years in 2013 and 2015. Silvicultural options included physical cutting or removal of ash tree species, pre-emptive removal of ash trees and diversifying tree species (Figure 4; Table 1). The articles which mentioned diversifying tree species emphasized planting other tree species like oaks (*Quercus* spp.), maples (*Acer* spp.), poplars (*Populus* spp.), sweet gum (*Liquidambar styraciflua*), Kentucky coffee (*Gymnocladus dioicus*) and birch (*Betula* spp.) trees. In addition, diversifying the urban canopy with more than one tree species also indicates an effort to learn a lesson from overreliance on ash in urban landscapes. For example, one city forester in North Dakota mentioned that "he's trying to avoid planting just one variety [of trees so] the chance of any disease or pest destroying all the trees on the boulevard is almost non-existent". A similar explanation was expressed by an urban forester in Ohio as "to avoid another infestation or disease again decimating a large portion of the city's trees . . . [the city] is replanting a diverse group of species to replace the ash".

In addition to general management strategies, 54% of all articles also had an explicit call to action for the general public. The majority of these articles (49%) were directed at private landowners and instructed them to: (1) adhere to firewood regulations (20%), educate themselves about EAB (16%), contact professionals (14%), apply chemical treatment to ash trees (13%), inspect their trees (13%), remove ash trees (7%) and decide what to do to manage EAB on their properties (12%). In addition to asking for landowner's involvement in EAB management, 13% also had a call to action for recreationists, primarily instructing them to adhere to firewood regulations including the burning, transporting and distribution of ash wood products. An additional 8% also had a general call for the public to assist in volunteer data collection (i.e., citizen science) about EAB.

4. Discussion

Although there are criticisms about the militaristic language used to communicate invasive species [47,49,50], this language framing clearly dominated news coverage of EAB. There was a general increase in the number of articles using language frames like invasion-militaristic, anthropomorphism and fatalism over time. However, the number of articles published about EAB started decreasing in 2014, which also parallels a reduced use of evocative language framings. This decrease in the number of articles may also imply reduced publicity overall, as EAB was no longer a novel news story. On the one hand, this may indicate an increased awareness among journalists and the public (and thus less demand for EAB coverage), but it could also allude to decreased interest over time, as EAB topics were no longer as sensational.

Even though some experts have recognized the pitfalls of using militaristic language [57], this framing may be pervasive because it is self-evident and grabs people's attention [58]. However, militaristic framing reinforces inaccuracies [45] and contributes to loss of scientific credibility by promoting xenophobia and social misunderstandings [44]. Scholars argue that using terms like "alien", particularly when "alien" species are negatively framed as invaders, discourages interest in urban forestry, most notably among immigrant populations [59]. This is concerning, as management of EAB is dependent on public action and support.

Furthermore, studies also show that using an invasion-militaristic framing towards conservation can be counterproductive and ineffective [44], even isolating some audiences [5]. For example, the portrayal of the invasive Asian carp (*Cyprinus carpio*) as an outsider and imminent threat may inadvertently prioritize the management of these species and take attention away from other invasive species that are more harmful, and even further anti-immigrant discourses [60]. A study of bait vendors in Wisconsin found that opinion leaders among the group felt more self-confidence, or higher self-efficacy, when they consumed media that focused on actionable items, but they also had lower self-confidence, or lower self-efficacy, when they consumed media that sensationalized aquatic invasive species [7]. Therefore, we suggest that the current communication of invasive species using militaristic framings may have the unintended effect of reducing actionable responses.

Although the invasion-militaristic framing used to communicate about invasive species has been well studied, the fatalistic framing is less explored in the literature, yet was very common in our study. Fatalistic framing suggests that the spread of EAB, and subsequent loss of ash, is inevitable regardless of management and treatment actions. We offer three possible explanations for the prevalence of this fatalist perspective in the news media. First, experts and the general public feel a sense of powerlessness towards managing EAB. Second, the suggested management methods are not perceived as effective. Third, the legacy effect of invasive pests and diseases (like Dutch elm disease, caused by a strain of *Ceratocystis ulmi* fungus, chestnut blight, caused by *Cryphonectria parasitica*, and Asian long-horned beetle, *Anoplophora glabripennis*), which have collectively killed millions of trees in the past [2,8], may have overwhelmed management responses from both experts and the general public. This fatalistic framing is comparable to fatalism expressed in health issues [61] or climate change [62,63], which can lead to inaction, conflicting with efforts to meaningfully address the issue.

Although fatalism and militaristic frames were prominent, it is also noteworthy that anthropomorphism was also present. Although there are limited studies about anthropomorphism and invasive species communication, anthropomorphism is widely used to illustrate various relationships between humans and non-humans, including plants and animals [64]. While anthropomorphism may help people provide meaning and make sense of interactions with the non-human species, the pervasive use of anthropomorphism can also be a double-edged sword, as this approach only favors species that are charismatic, consequently disregarding non-charismatic species [65]. Invasive species like EAB are represented with human-like menacing features (e.g., using strategic intelligence to kill ash trees, having emotions like wrath and anger) while the declining ash trees are featured as hopeless victims to the EAB villain. More research is needed to better understand how the public is interpreting, understanding and responding to these different media portrayals and narratives of non-native invasive species and native species, and their socio-ecological impacts. Because invasive species management requires public participation, there is a research need to understand the message frames that may or may not motivate people to participate.

Invasive species are predicted to increase, and will require more financial resources and increased management as the issue escalates. For example, diversifying the urban forest includes a common management strategy to have no more than ten percent of a single tree species within the urban tree canopy [64]. Therefore, the fatalism communicated in articles may represent this increased pressure on managers to address the uncertainties of invasive species and the sheer amount of effort their management represents. These factors may foster a sense of powerlessness in response to invasive species management, thereby creating the opposite desired effect of proactive management. Furthermore, the win/lose scenarios emphasized with such defeatist language can also be counterproductive [5] as it may discourage engagement not only to manage EAB, but also to other emergent environmental issues. For example, the belief that climate change is unstoppable can hinder behavioral and policy change to address it [63].

Most articles portrayed only expert representation and voices. This may be the predominant representation because experts are recognized as the leading source of information and scientific knowledge. However, this mode of communicating science can be problematic because it reinforces the science versus society, experts vs. public divide. Invasive species like EAB impact people's daily lives in a variety of ways including their livelihoods, emotions, connection to nature, recreation opportunities, and property values. Therefore, relying only on "expert" voices misses the opportunity to democratically engage with the community [31,45]. The traditional top–down model of passing expert knowledge to the general public may promote credibility but can also dissuade public engagement by not supporting a process of co-creating viable strategies to address emerging invasive species [66,67].

Our findings echo other research that the public is usually absent or poorly represented in media coverage of environmental issues while expert perspectives—especially from the government, industry leaders, environmental non-governmental organizations and scientists—are the most highly represented because of their access to media outlets [24,29]. Although expert advice is generally

regarded as credible, invasive species management can have divergent perspectives, even among experts [68,69].

Like Leppanen et al.'s (2019) analysis of the media coverage of the hemlock woolly adelgid [6], our study also found divergent perspectives among experts communicate in articles—for example, some experts advocated for the chemical treatment of ash trees, while others advocate for preemptive tree removals. Experts may disagree about the impacts of invasive species, strategies to manage them and the overall effectiveness of control efforts [68,69]. These divergent perspectives can provide various options for private landowners, but it may also be a source of confusion and uncertainty for what landowners should do to minimize their risk. Therefore, some scholars argue that experts should be more transparent with stakeholders and the public about the uncertainties of invasion science [6,47,69] while providing consistent and understandable arguments to reduce the disconnect between science and society [70].

Although most articles featured expert voices, it is interesting to note that more than half of the articles in our study included a call to action for the general public including landowners and recreationists. This finding is interesting because most articles only featured expert voices while simultaneously asking for an involved general public in the management of EAB. This presents a complex challenge because studies show that the general public have direct impacts on the effectiveness of management programs. On the other hand, the public's perceptions of whether to manage a species depends on their perceptions of costs and success of management efforts [71]. Overall, the use of expert voices and presentation of articles using militaristic and fatalistic language may be having a counterproductive impact on the general public, whose experiences, and perceptions about EAB management should be prioritized and included. The situation represents a missed opportunity to deliberately and democratically involve the public who have significant power in the distribution of invasive species across the landscape [72].

5. Conclusions

Our study examined how information about a mobile invasive species is communicated in news media. Overall, we found that invasion-militaristic framing is prevalent in many articles, even though it is often critiqued in the scientific literature. While fatalistic framings were also common, there has been very little discussion in the literature about this frame related to invasive species communication. Invasion-militaristic and fatalistic framings can eventually lead to people becoming insensitive to environmental stressors when they are predominantly framed as "urgent", "defending enemy lines" or "we are fighting a losing battle". Furthermore, the representation of trees' demise, combined with a call to action for the general public, may be ineffective because on the one hand, it is reported that trees will die regardless, but in the same articles, there are calls for people to protect their trees and not spread the insects. As invasive species are a growing environmental issue, it becomes even more important to consider effective strategies that can promote positive engagement. For example, studies about climate change communication show that using imagery and icons that are directly connected to personal emotions and everyday living is a better engagement strategy than using feared-based methods [73] and using frames highlighting gains is more effective than using frames highlighting loss [74].

Our study raises the question of how to effectively communicate invasive species issues to the non-expert general public. Future studies can provide deeper understanding of this communication challenge by (1) investigating the preferences of conservationists in terms of invasive species message framing, (2) investigating the strategies and adaptation mechanisms used by forestry professionals to communicate about invasive threats, and which communication strategies are most effective in altering public behavior and engaging the general public to manage EAB and other invasive insects, and (3) examining how invasive species communication has changed throughout time, particularly the potential to build on communal memories of past invasion events. Designing effective communication strategies and identifying desired messages are particularly important when there are multiple

treatment and management options available, and when invasive species control may have only limited effectiveness without substantial public buy-in.

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