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Media myopia distorts public interest in US invasive plants

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Abstract Introduced invasive plants are a major environmental problem, but public interest in invasive plants is generally considered low compared to climate change and threatened flagship species, hindering support for effective management and policy. To understand what does drive public interest in invasive plants in the US, we investigated Google Trends search data from 2010 to 2020 for 209 introduced plant species found in the continental US. Using a phylogenetically-controlled structural equation model, we investigated three hypothesized drivers of interest: (1) plant abundance as quantified by national and state-level occurrence records in the Global Biodiversity Information Facility, (2) four key plant traits that might influence plant conspicuousness to the general public: ornamental use, human health risks, monoculture formation, and plants with positive economic value, and (3) media coverage, in particular the volume and sentiment of news articles over the same 10-year period. Public search interest was highest for the most abundant introduced species and those with human health risks, but significantly lower for ornamentals. News coverage was mostly negatively toned and disproportionately focused on a relatively small group of widespread invasive species, with significantly lower and more positively-worded coverage of ornamentals. Ultimately, we suggest that a narrow emphasis on a few highly covered 'notorious' invasive plant species, with lower and more positive coverage of ornamental introduced species, could send mixed messages and weaken public awareness of the threats of biological invasions. However, the generally strong linkages between public search interest and media coverage of invasive plants suggests ample opportunity to improve messaging and increase public awareness.

Keywords Invasive species · Culturomics · iEcology · Sentiment analysis · GBIF · Structural equation modeling

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Introduction

Strong public awareness of urgent environmental issues like biological conservation, pollution, and climate change has been linked to the development of new public policy (Miller et al. 2018), enhancing the need to understand what drives public awareness of environmental problems. Compared to climate change, public awareness of non-native or invasive species remains low (Courchamp et al. 2017; Jarić et al. 2020a), despite incurring nearly $27 billion in annual global costs (Diagne et al. 2021) and causing demonstrably negative impacts on native species (Gaertner et al. 2009), ecosystem function (Dukes and Mooney 2004), and even human health (Pejchar and Mooney 2009). Increased public awareness of invasive species can aid in early detection of invasions (Simberloff et al. 2013), strengthen public support for removal or mitigation efforts (Novoa et al. 2017; Cordeiro et al. 2020), and lead to more successful management outcomes (Jarić et al. 2020a). Thus, we need a stronger understanding of what drives public interest in invasive species.

Traditionally, public interest in environmental issues can be stoked using flagship threatened species (Verissimo et al. 2011), explaining the widespread popular appeal of charismatic megafauna like panda bears, whales, and tigers in conservation campaigns (Di Minin and Moilanen 2014). Although 'plant awareness' is generally lacking for many plant species (Wandersee and Schussler 1999; Parsley 2020; Stroud et al. 2022), certain plants indeed have 'charisma', i.e., a set of conspicuous traits that drive human interest. For example, invasive plants that form widespread and dense monocultures can be visually conspicuous (Lei and Bo 2004; Aguilera et al. 2010; Gurevitch et al. 2011), many invasive plants are still sold in the ornamental trade due to perceived attractiveness (Hulme et al. 2018), and some produce allergens (e.g., *Ambrosia artemisiifolia*), skin irritants (e.g., *Heracleum mantegazzianum*), or thorns, spines, and prickles that can harm humans and thus make them more memorable (Lazzaro et al. 2018). Conversely, some invasive plants are even known for their economic benefits, including kudzu (*Pueraria montana*, used as livestock feed, in fertilizer, and as erosion control), garlic mustard (*Alliaria petiolata*, purposefully introduced and still used for culinary purposes), and English ivy (*Hedera helix*, a commonly sold ornamental). Some of these charismatic plant traits are even linked to the likelihood of invasive species success (Gurevitch et al. 2011; van Kleunen et al. 2020), their portrayal in the media, and the research and policy attention given to these species (Jarić et al. 2020b), further suggesting that the identification of specific traits driving greater public interest could be used to tailor outreach campaigns for invasive plant awareness. Nevertheless, we still lack a comprehensive understanding of the extent to which plant 'charisma' is linked to public interest for most invasive plant species.

In addition to charismatic traits, the quantity and sentiment of news coverage is often a strong driver of environmental public awareness and opinion. In Japan, more frequent news reports on invasive plants and animals in local newspapers drives higher public interest (Fukano and Soga 2019), which can increase the likelihood that a species' introduction into a new area will be detected and subsequently removed (Simberloff et al. 2013). Moreover, one of the general rules in news coverage is that negative advertising works (i.e., 'if it bleeds, it leads') (Robertson et al. 2023), highlighting the importance of word choice and sentiment in science communication (Lennox et al. 2020). For example, sharks and other large predators are charismatic flagship species responsible for a variety of ecosystem stabilizing effects (Heithaus et al. 2008; Ripple et al. 2014), but their largely negative portrayal in the news impedes conservation efforts by producing fearful public perceptions (Muter et al. 2013; Bombieri et al. 2018). However, when media coverage of these species is more neutrally-toned, it can increase public support for shark conservation (O'Bryhim and Parsons 2015), Thus, both the volume and the sentiment of media coverage can influence public interest and inform environmental conservation campaigns, but the extent to which public interest for overlooked taxa like introduced plants can be stoked by the media is still largely unknown.

Here, we examine how US public interest in invasive plants is driven by plant abundance, conspicuous traits, and the quantity and sentiment of media coverage for 209 invasive plant species found in the continental United States. We used Google Trends search interest data from January 2010 to July 2020 to quantify public interest, obtained four key plant traits from online databases, and quantified both the number and the sentiment of media articles published on these

209 species over the same decadal timespan. We asked four primary questions: (1) Is public interest in these invasive plant species driven by their abundance? (2) Is public interest driven by plant traits? (3) Alternatively, is interest driven by the media, specifically the quantity and sentiment of news articles written on invasive plants? (4) How do these factors combine to drive interest in invasive plant species in the US?

Methods

Study species

To generate a list of the most common introduced plants in the US, and thus presumably the species most likely to be known by the general public, we first examined all 682 species listed as Invasive, Introduced, and Noxious plants in the US by the USDA (USDA, NRCS 2022). We refined the list to only those in the continental US and found in three or more states, resulting in a list of 144 introduced plant species. We supplemented this list with field observations of introduced plant occurrences from the National Ecological Observatory Network (NEON) vegetation sampling program. We utilized data from $N = 1059$ 400-m^2 annually sampled vegetation sampling plots at $N = 38$ NEON sites (NEON 2022), including only data from the most recent survey year for each plot. We retained the 100 most frequently recorded invasive plant species in the NEON dataset and combined them with the species from the USDA database, consolidating species using names from the USDA Complete PLANTS checklist (USDA, NRCS 2022). With 21 species overlapping between the two datasets, the combined list consisted of 223 species. *Phragmites australis* has both native and introduced populations in the US, but we kept this species in the dataset because the invasive genotype appears to much more conspicuous and common compared to the native genotypes in the US (Saltonstall 2002; Kettenring et al. 2012). We next removed seven agricultural species and seven species with ambiguous common names that would result in inaccurate Google Trends search interest results (see below), ultimately ending with a list of 209 introduced plant species in the continental US (Table S1).

Public search interest data

Recent research has increasingly used internet search interest data as a proxy for public interest in topics like North American bird species (Schuetz and Johnston 2019), Japanese invasive species (Fukano and Soga 2019), and numerous other environmental concerns (Ficetola 2013; Nghiem et al. 2016; Jun et al. 2018; Davies et al. 2018; Jarić et al. 2021). We used Google Trends search interest data to investigate public interest in our list of 209 introduced plant species in the continental US. Google search is the most widely used search engine worldwide, with a mean search share of 83.64% (range 78.55–88.65%) in the US from Jan 2010-July 2020 (https://gs.statcounter.com/search-engine-market-share/all/united-states-of-america/#monthly-201001-202007). For each species, we first searched for relevant common names in the USDA database, cross referencing candidate names against Google Trends 'related topics and queries' to find accurate common names that returned results relevant to each plant species of interest. Ultimately, we found 149 species with common names that returned relevant search interest on Google Trends, whereas a similar search using Latin binomials resulted in only 124 species, possibly reflecting the general public's relative inexperience and unfamiliarity with scientific names. Given that we were interested in the magnitude of general public search interest for invasive plants, we thus focus our analyses on search results using common names.

First, to determine the spatial extent of Google search interest in our species over the continental US, we retrieved "Interest by subregion" data, focusing on the continental US over a 10-year interval (January 2010 to July 2020). For each species, the regional search interest data returned a score for each state, ranging from 0 to 100, where states were scored relative to the state with the highest search volume (100) within each species. Second, to determine relative Google search interest across all 149 species over the 10 year time interval, we conducted pairwise comparisons where search interest for each species was compared to all remaining species for every day over the 10-year interval. The mean pairwise daily search interest was then averaged across all dates to give a relativized Google search interest score for each species compared to all remaining 148 species from January 2010 to July 2020 (Table S1).

Plant abundance data

To quantify each introduced plant species' abundance in the continental US, we obtained species occurrence records data from the Global Biodiversity Information Facility (GBIF) (GBIF 2022), which contains over 1.6 million species occurrence records. Using the "gbif" function of the "dismo" (v. 1.1–4) package in R (Hijmans et al. 2021), we used each species' scientific name to obtain total occurrence data recorded in the continental US (Table S1, 2023).

Plant trait data

We selected four plant traits that previous studies suggested would either contribute to invasiveness (Grotkopp and Rejmánek 2007; van Kleunen et al. 2010) or to charisma driving public interest (Behe et al. 1999; Kendal et al. 2012), including (1) economic value, in which invasive plants may be attractive for their positive economic uses (van Kleunen et al. 2020); (2) health risk, in which invasive plants may generate attention due to traits that can harm human health (Meyerson and Reaser 2002); (3) ornamental use, which indicates whether the plant is used for ornamental purposes; and (4) monoculture formation, which should be conspicuous to most non-expert observers.

We summarized economic value for each species as a quantitative variable (1–5) extracted from CABI Invasive Species Compendium (ISC) database (CABI 2022) based on the World Economic Plants database, a global database of 16 categories of economic uses of plants (Wiersema and León 2016). The categories of positive economic uses include food, food additives, animal food, pollinator plants, invertebrate food, materials, fuels, nonvertebrate poisons, medicines, environmental uses, gene sources, and harmful organism hosts (van Kleunen et al. 2010), with the species having to satisfy at least one to receive a positive score. We categorized ornamental use, health risk, and monoculture formation as binary yes/no variables based on the CABI ISC database (CABI 2022).

News articles and sentiment data

To determine the quantity and sentiment of news articles describing each of these species, we compiled articles through a comprehensive search in LexisNexis Advance, a database containing news articles from over 60,000 news sources with an emphasis on newspapers (both online and print). We searched the common name for each species (as in Table S1), limiting the search to English articles published in the continental US within a 10-year interval (January 1, 2010 – July 1, 2020). To omit articles unrelated to invasive plants, we excluded articles that did not contain at least one of the following terms indicating a description of an invasive plant: plant(s), weed(s), tree(s), invasive, grass, leaf, leaves, and/or vine. We further excluded any potential scientific articles and journals in the LexisNexis results by removing results containing one or more of these phrases: "literature cited", "references cited", "methods and materials", "results" and "discussion", "table 1", and "fig. 1." This search resulted in 70,919 articles describing 175 species from our list (Table S1).

To quantify the sentiment of a subset of the media articles, we extracted the text from a maximum of 200 of the most relevant articles per species from the initial search. Article relevancy to our search criteria was ranked by Lexis Advance, with articles ranking higher based on the concentration, prominence, and exact phrasing of our search terms found in each article. This resulted in 16,391 articles describing 175 species. We noticed some duplicative articles across different news sources (e.g., due to multiple redistributions of the same article across different platforms). We removed these articles from the sentiment analysis by performing a text search using the "LNT_similarity" function from the "LexisNexisTools" (v. 0.3.5) package in R (Gruber 2021), removing articles that were 97% or more identical, leaving a total of 11,375 articles. We kept duplicated articles in the quantity of articles per species as we assumed that duplicative articles redistributed across different platforms would be indicative of high news interest in a particular species.

We further assessed articles for relevancy to the topic by manually reviewing subsets of these 11,375 articles. First, to parse out articles focusing on topics unrelated to invasive plants, we split articles into five topics through a Latent Dirichlet Allocation (LDA) topic model, using the "lda" function from the "topicmodels" (v. 0.2–11) package in R (Grün and Hornik 2011). LDA analyzes text documents and groups them into topics based on word frequency and relatedness. Two topics were deemed unrelated to

invasive plants, in which we identified and removed 33 unrelated articles. We then removed 12 additional articles mentioning species that had Google Trends topics and queries unrelated to invasive plants. We then manually examined articles for two species with outlier tones (see below), coltsfoot (*Tussilago farfara*) and water spinach (*Ipomoea aquatica*), removing 24 articles about cosmetic product ingredient lists and restaurant reviews. Finally, we manually reviewed the articles of a random subset of 14 species ($N = 1{,}175$ articles) and found 13 unrelated articles that we removed. In total, with 3 articles overlapping among groups, 79 unrelated articles were identified and removed, leaving 11,296 articles for analysis of sentiment. Ultimately, this process identified 79 out of 11,375 articles (0.6%) as unrelated to news articles about invasive plants, suggesting that 99.4% of the articles returned by our LexisNexis search were relevant to our search context and subsequent sentiment analysis.

We conducted a sentiment analysis on these 11,296 articles describing 175 species using the bing sentiment lexicon in the tidytext package (Queiroz et al. 2023). The bing lexicon assigns a binary classification of 'positive' or 'negative' to a dictionary of words (-1 for each negative word and + 1 for each positive word) (Hu and Liu 2004), from which we calculated a cumulative sentiment score for each species using all words in the subset of articles for each species (Table S1).

Statistical analysis

We ran all statistical analyses using R Statistical Software (v. 4.1.3) (R Core Team 2022). We first generated a phylogenetic tree for all species ($N = 209$) using the "ggtree" function in the ggtreeExtra (v. 1.6.0) package (Yu et al. 2017; Xu et al. 2021), based on the tree generated using the software Phylomatic by Phylocom (Webb et al. 2008) and the stored tree from Zanne et. Al. (2014) (Fig. S1). We then tested for phylogenetic relatedness among the continuous variables for all 209 species in the tree by calculating Blomberg et al.'s K (Blomberg et al. 2003) using the "phytools" (v. 1.0–1) package and the function "phylosig" in R (Revell 2012). We found phylogenetic signal for Google search interest ($K = 0.013$, $p = 0.040$), but not for national occurrences, total articles, or the sentiment of news articles (Table S2). We thus controlled for phylogenetic relatedness when possible by using phylogenetically-controlled general linear models using the "pgls" function in the "caper" (v. 1.0.1) package (Orme et al. 2018).

We first analyzed whether species' occurrences predicted search interest at the state level using a linear model with species as a fixed effect using the "lm" function in R ($N = 444{,}579$ occurrences at the state level). We log-transformed (+ 1) species state-level occurrences to improve heteroscedasticity. At the national level, we ran a phylogenetically controlled general linear model ($N = 209$), log (+ 1) transforming national GBIF occurrences to improve heteroscedasticity, testing whether national occurrences predicted search interest. While both state- and national-level models contained many zeroes, qualitative results between models with and without zero values did not change. We also used a phylogenetically controlled general linear model to examine whether national occurrences, number of news articles, and article sentiment (the variables most strongly correlated with search interest; Fig. S2), explained Google search interest per species. We log-transformed (+ 1) number of news articles and national GBIF occurrences to improve heteroscedasticity.

Finally, to tease apart the direct and indirect relationships between individual variables, we constructed a phylogenetically-controlled structural equation model (SEM) showing the direct and indirect predictors of Google search interest. Paths were defined based on our hypotheses and past examples (Fukano and Soga 2019) and lead to a "saturated" model in which all potential paths were included. We omitted a directed path between number of articles and article sentiment because it was not clear the direction of causality and leaving this path within the basis set led to poor fit, since the two variables were highly correlated. Instead, we specified the bidirectional correlated error ($r = -0.71$), indicating the potential for an unmeasured external driver of the measured correlation. As a result, we could not derive a goodness-of-fit index, such as a χ^2 statistic. Instead, we relied on R^2 values reported by the "pgls" function as indicators of model confidence, assuming high explanatory power across all variables implied adequate fit across the entirety of the structural equation model. We ran a piecewise SEM manually in R using three phylogenetically controlled general linear models ($N = 175$ plant species with complete data for

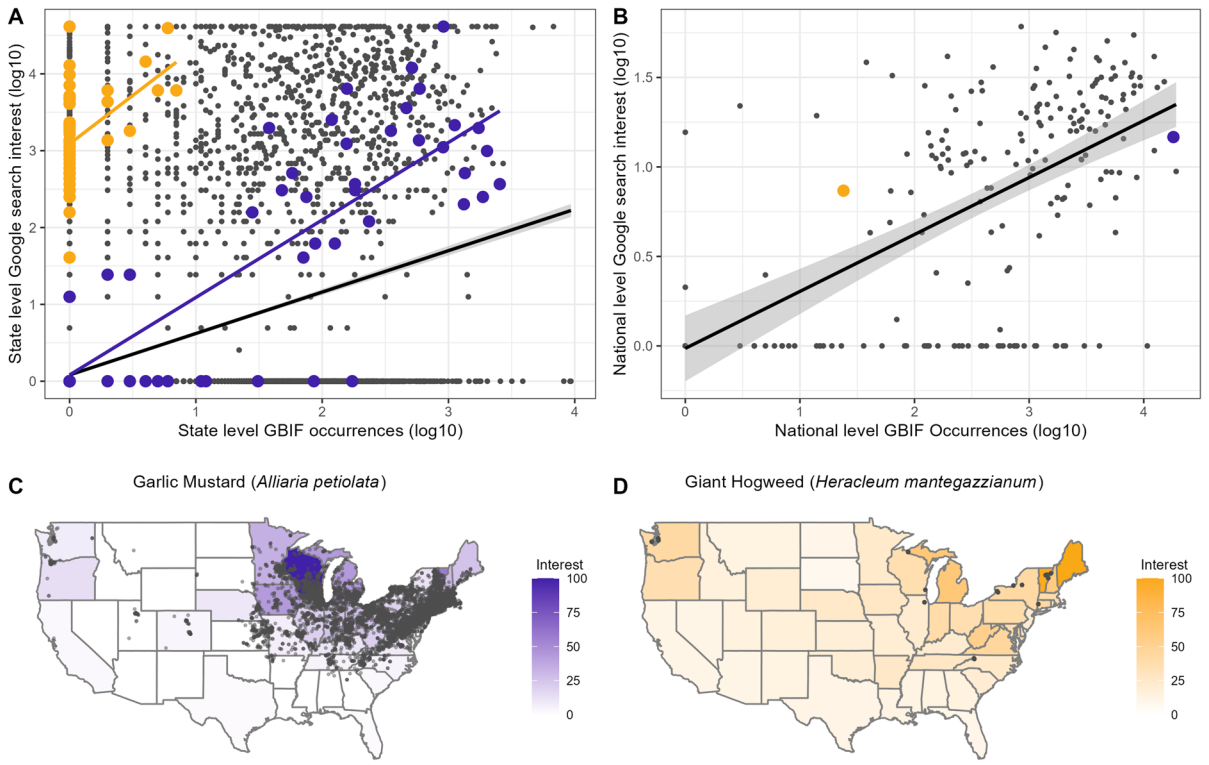

Fig. 1 Relationship between species occurrence records and Google search interest. **A** A linear regression with species as a fixed effect describing the relationship between state-level species occurrences and Google search interest ($N = 446{,}823$ occurrences across 48 states for 209 species). The regression and values for garlic mustard (*Alliaria petiolata*) and giant hogweed (*Heracleum mantegazzianum*) are highlighted in purple and orange respectively. **B** A phylogenetically controlled linear regression ± 95% confidence intervals denoting the relationship between national-level species occurrences and Google search interest (N = 209 species, with garlic mustard and giant hogweed symbols denoted by color). Maps of species occurrences in the continental US and normalized state-level interest for **C** garlic mustard and **D** giant hogweed

each variable). We log-transformed (+1) number of news articles, search interest, and GBIF occurrences to meet the assumptions of homoscedasticity of variance. We standardized coefficients by multiplying the model-estimated coefficients by the ratio of the standard deviations of each predictor over the response, to be able to draw comparisons across variables measured in different units.

Results

Across 209 introduced plant species in the continental US, we found weak phylogenetic signal for Google search interest ($K = 0.013$, $p = 0.040$). The relatively low values for K for these and the remaining continuous traits tested (Table S2) indicate less phylogenetic signal than expected, with high search interest occurring more frequently across the phylogenetic spectrum than expected, but no other significant phylogenetic patterns (Fig. S1).

We found a positive relationship between Google search interest and occurrence of invasive species, both at the national level ($R^2 = 0.66$, $F_{1,207} = 397.8$, $p < 0.001$) and at the finer-grain state level ($R^2 = 0.31$, $F_{209,10449} = 23.7$, $p < 0.001$) (Fig. 1A, B). Notably, some species had high spatial congruence of search interest and occurrences, including garlic mustard (Fig. 1C). In contrast, some species like giant hogweed had high search interest across the US but only localized occurrences (Fig. 1D). Similarly variable spatial congruence between search interest and abundance were also observed for other species (Fig. S3). Alligatorweed (*Alternanthera philoxeroides*), garlic mustard, white clover (*Trifolium repens*), ground ivy (*Glechoma hederacea*), and common dandelion

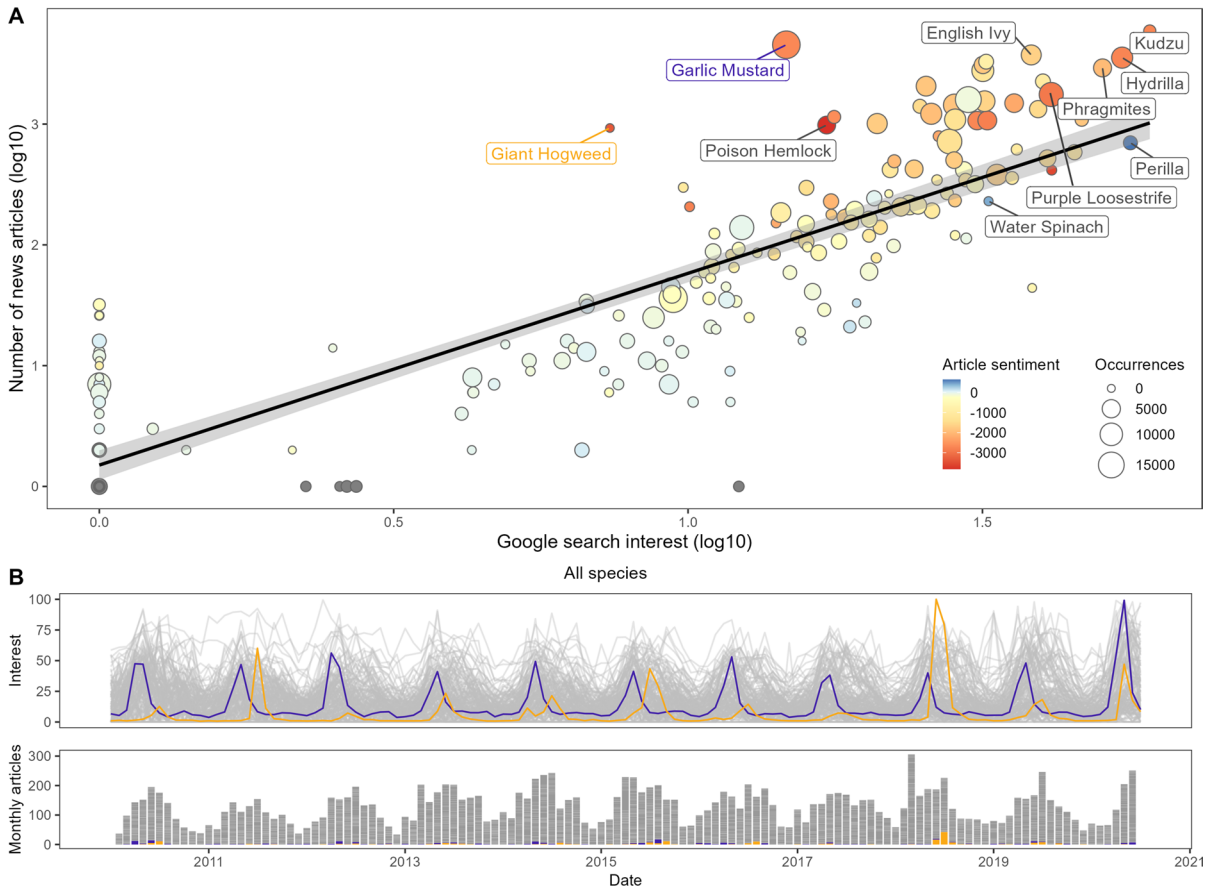

Fig. 2 Relationship between quantity and sentiment of media articles, Google search interest, and national occurrences. **A** Phylogenetically controlled multiple linear regression describing the relationship between Google search interest, number of news articles, article tone, and national occurrences ($N = 175$ species). Species with highly positive or negatively toned media articles are labeled. **B** Time-series of Google search interest and number of news articles published per month, from January 2010 to July 2020 for all species. Google search interest and monthly articles for garlic mustard (*Alliaria petiolata*) and giant hogweed (*Heracleum mantegazzianum*) are highlighted in purple and in orange, respectively

(*Taraxacum officinale*) had the highest number of occurrences (Table S1). Kudzu, perilla (*Perilla frutescens*), hydrilla (*Hydrilla verticillata*), phragmites, and Russian olive (*Elaeagnus angustifolia*) had the highest relative search interests (Table S1).

In a linear model comparing only the most highly correlated variables (Fig. S2), Google search interest was highest for species that had numerous mostly negative news articles mentioning them (Fig. 2, number of news articles: $F_{3,171} = 98.3$, $p < 0.001$; article sentiment: $F_{3,171} = 57.0$, $p < 0.001$), which was driven primarily by species with high numbers of occurrences in the US (occurrences: $F_{3,171} = 7.1$, $p = 0.008$; overall model: $R^2 = 0.48$, $F_{3,171} = 54.17$, $p < 0.001$, Table S3). Further, both search interest and the number of articles over time followed a seasonal pattern, peaking in summers and decreasing in winters (Fig. 2B).

The structural equation model revealed some surprising direct and indirect drivers of search interest (Fig. 3). For example, based on comparison of standardized effect sizes, the greater the number of articles on a species, the more frequently it appeared in Google searches ($\beta = 0.50$, $p < 0.001$), suggesting that more attention by the media translates to more public interest (Figs. 2, 3). The second strongest predictor of Google search interest was plant abundance: the most widespread and abundant invasive plants were searched more frequently ($\beta = 0.32$, $p < 0.001$). Risk to human health was also positively related to search

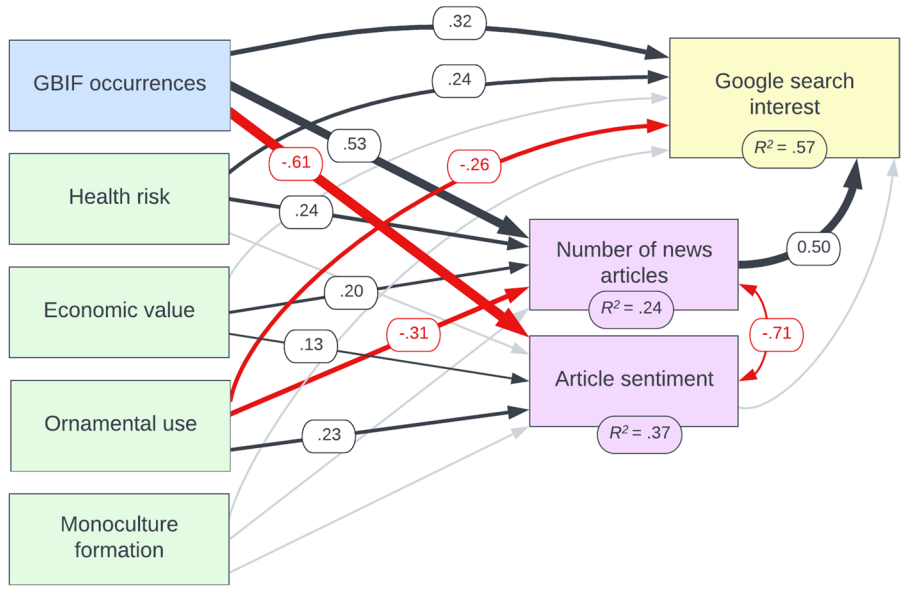

Fig. 3 Path diagram depicting the direct and indirect drivers of search interest in 175 invasive plant species in the continental US. Red arrows indicate a negative relationship and black arrows indicate a positive relationship. The double-headed arrow signifies the (residual) correlation between the responses. The width of each arrow indicates the relative strength of the relationship – i.e., the standardized coefficient (β), which is also numerically depicted on each arrow. Semi-transparent arrows indicate non-significant relationships ($p > 0.05$)

interest: the more harmful to humans the invasive species, the more Google users incorporated them into their queries ($\beta = 0.24$, $p < 0.001$). Perhaps surprisingly, ornamental invasive plants were searched less frequently than non-ornamentals ($\beta = -0.26$, $p < 0.001$).

National occurrences were the strongest predictors of both article quantity and sentiment: the more widespread the invader, the more articles ($\beta = 0.53$, $p < 0.001$) and the more negative the sentiment ($\beta = -0.61$, $p < 0.001$) (Fig. 3). The remaining significant predictors of article sentiment were ornamental use and economic value. Introduced plants in the ornamental trade were written about more positively than non-ornamentals ($\beta = 0.23$, $p < 0.001$), and the less valuable the invader, the more negative the sentiment ($\beta = 0.13$, $p = 0.006$). Similarly, invaders that posed a more significant risk to human health had more articles written about them ($\beta = 0.24$, $p = 0.002$), as did species with economic value ($\beta = 0.20$, $p < 0.001$). Perhaps surprisingly, ornamental invasive plants were covered less frequently by the news ($\beta = -0.31$, $p < 0.001$). Finally, in contrast to our expectations, monoculture formation had no significant influence on search interest or the quantity and sentiment of news coverage (Table S4, Fig. 3).

While we were unable to obtain a global goodness-of-fit test for our SEM, the predictors explained a high proportion of variance in each of the responses: from $R^2 = 0.24$ for number of news articles, $R^2 = 0.37$ for article sentiment, and $R^2 = 0.57$ for Google search interest. With over half the variance explained, we are reasonably assured that we are not omitting key explanatory variables and are reasonably confident in the inferences drawn above.

On average, most news articles mentioning our study species were negatively toned (*Mean* = -10.4, *standard error* = 0.30). The average cumulative sentiment across all species (analyzing all words in all articles for each species) was also negative (Table S1, *Mean* = −669.1, *standard error* = 67.6). Poison hemlock (*Conium maculatum*), Russian thistle (*Salsola collina*), giant hogweed (*H. mantegazzianum*), purple loosestrife (*Lythrum salicaria*), and Canada thistle (*Cirsium arvense*) had the most negative cumulative sentiments (Table S1). The most common negative words in all articles were "weed" and "invasive," whereas the most common positive words were "free," "effective," and "top" (Table S5).

Discussion

Our results highlight some common drivers of both Google search interest and news coverage for 209 invasive plant species in the continental US over a 10-year period. The most widespread and abundant species, for example, were covered more frequently in the news, written about in mostly negative tones, and

searched for more frequently. Species with human health risks also generated more searches and more news articles. Taken together, these results suggest that public interest in invasive species in motivated primarily by the likelihood of encountering these species in nature and their direct consequences for health and well-being, with further amplification via exposure in the public media. Thus, increasing the media coverage of invasive plant species, and particularly articles that detail their negative impacts, could generate increased public awareness and ultimately be used to influence invasive plant policy.

Surprisingly, however, ornamental introduced plant species generated less public search interest, fewer news articles, and were written about less negatively than other species. Economically-valuable introduced plants were also written about more and with less negative coverage. We speculate that this coverage results in mixed messages; widespread and harmful introduced species generate intense negative media coverage, but this message may be tempered by more positive coverage of other species. This mixed messaging may hamper efforts to remove introduced plants from the ornamental trade as well as the broader effort to increase public awareness of invasive species. Nevertheless, the consistently strong linkages between public search interest and news coverage of invasive plants in the US suggests ample opportunity to better tailor media outreach, tone, and public education in the future.

Media coverage is a demonstrably strong driver of public interest for multiple environmental issues, and when used effectively, can help change behaviors. For example, heavy media coverage of droughts in San Francisco, California from 2005 to 2015 were linked to a subsequent decrease in urban water consumption (Quesnel and Ajami 2017). In Japan, a dramatic increase in media coverage of global warming led to increases in public concern over anthropogenic warming (Sampei and Aoyagi-Usui 2009). In the US, invasive wild pigs are an increasing problem, and the amount of congressional activity on policy to control them is directly linked to increased negative media coverage (Miller et al. 2018). However, in our study, 60 of 209 (29%) of some of the most common invasive plant species in the US generated no Google search interest over a 10-year period. This same group had only 191 articles written about them over the same time-period (out of 70,919 articles, or only 0.27% of total news articles on these species). In contrast, over 50% of news articles were written about only 10 species, and 80% of news articles covered just the top 25 species (Table S1). We suggest that the media's disproportionate focus on relatively few 'notorious' invasive plant species, while generally ignoring the vast majority of invasive plants, could be indicative of a substantial communications shortcoming in addressing the invasive plant problem in the US. This myopic view also undercuts the potential threat posed by incipient invaders: most invaders take many decades for their populations to grow to a size to generate problems for human well-being (Crooks 2005), implying that any of these less well-known species could become the next 'notorious' plant at any point in the future.

Surprisingly, although negativity is widely used to generate readership and 'sticky' messages in a variety of news media (Robertson et al. 2023), the broadly negative sentiments in our investigated news articles did not translate into more Google search interest in the SEM when accounting for other covariates, like abundance and health risk (Fig. 3). However, negative article sentiments were significantly correlated with search interest in both the correlation matrix and in the limited linear model testing the strongest interactors (Fig. 2, Fig. S2). Thus, we found at least partial evidence that negative media coverage of invasive plants in the US leads to greater interest. Poison hemlock, phragmites, purple loosestrife, garlic mustard, and kudzu were some of the most negatively described species, with words like "aggressive," "difficult," and "dense" being among the most frequently used negative words, suggesting that 'a loss of control' is one potentially sticky message about invasive plants.

Moreover, species with human health risks generated intense negative news coverage that coincided with strong search interest, confirming the newsroom adage that 'if it bleeds it leads.' For example, search interest in giant hogweed was relatively high and occurred largely throughout the US despite its relatively limited distribution (Figs. 1D, 2A). Giant hogweed produces a photoactive sap that can burn human skin when exposed to sunlight (Chan et al. 2011), resulting in widespread media coverage after a particularly notable incident widely covered by the news media in July 2018 (Fig. 2B). Indeed, "poisonous," "toxic," "burns," and "dangerous" were among

the ten most frequently used words in the sentiment analysis on articles mentioning giant hogweed. A few grass species with high search interest in our study, like timothy grass (*Phleum pratense*) and bermudagrass (*Cynodon dactylon*), pose a health risk through their production of allergens (Fuchs et al. 1997; Liao et al. 2020). Similarly, common ragweed (*A. artemisiifolia)*, a noxious invader in Europe, also produces allergens that have been linked as an important factor causing hay fever in North America, where it is native (Bassett and Crompton 1975; Smith et al. 2013). Another common invader with high search interest was multiflora rose (*Rosa multiflora*), a species that by harboring infected ticks (*Ixodes* spp.), can amplify opportunities for transmission of Lyme disease pathogens (Adalsteinsson et al. 2018). Cheatgrass (*Bromus tectorum*), another invader with high search interest, increases the risk of wildfires in the western US (Bradley et al. 2018), posing a health risk to local residents (Black et al. 2017). Recent research suggests that articles detailing the higher health risks of invasive plants can motivate individual landowners to better manage invasive plants on their properties (Clarke et al. 2021), suggesting increasing public support for invasive species management can be traced to increasing knowledge of these negative human health risks (Novoa et al. 2017).

We initially hypothesized that plants' ability to form monocultures would make them more noticeable to the public, but our results show that monoculture-forming invasive plants were not searched for more. However, this lack of search interest may stem from a relative lack of news articles on these species (Fig. 3), again highlighting a missed opportunity for education and outreach. For example, despite being a problematic and prolific invader of eastern forest understories (Sedio et al. 2020), Japanese stiltgrass (*Microstegium vimineum*) had relatively low search interest and few articles written about it (Table S1). Nevertheless, there were exceptions, as both the common reed *Phragmites* and the notorious invader kudzu ('the vine that ate the South'), both monoculture-forming species, were some of the most commonly-covered and most searched for species (Fig. 2A). Search interest and news coverage also displayed clear seasonal fluctuations (Fig. 3B), peaking in the summer when plants are productive and therefore most noticeable, suggesting that local conspicuousness is likely a key driver of search and media interest through time.

Importantly, analyses such as ours cannot reveal the potential for bi-directional or feedbacks within the proposed causal network. Thus, although public search interest is highest for invasive plant species written about more in the media, suggesting that media coverage drives search interest, it is also possible that increasing search interest simultaneously drives science writers to write more articles on species already garnering interest in a feedback loop. Other studies that analyzed search interest in and media coverage of invasive species also concluded that the relationship could be circular (Fukano and Soga 2019). Conversely, it is also possible that search and media interest are unrelated to each other but driven by the same external factors. For example, both search interest and news article frequency followed a strong seasonal pattern (Fig. 2B), suggesting that search and media interest could be peaking independently when plants are most visible to both journalists and the general public. Ultimately, because both Google search interest and the number of news articles were driven by most of the same factors already included in our model, especially plant abundance and health risk (Fig. 3), it is quite possible that journalists and the general public are interested in the same aspects of invasive plants.

Conclusions

While the scientific community is largely aware of and interested in the ecological consequences of invasive plants, the general public, barring a few 'notorious' species, is not (Courchamp et al. 2017). Our findings highlight the quantity and sentiment of media coverage as potentially key to filling this gap between the scientific community and the public. Collaboration among invasion biologists, journalists, and practitioners is essential to developing effective media campaigns and efforts to raise awareness. The expansive research on public communication of issues like climate change and endangered species has informed and altered how the scientific community has communicated with the public about those issues (Lennox et al. 2020). Similar research for invasive species, however, is lacking in comparison. Ultimately, we found strong linkages between public interest and media coverage, especially for widespread invasive plant species that pose human health risks. However,

news coverage focused disproportionately on relatively few invasive plant species. We speculate that this myopic coverage, coupled with less negative sentiments describing invasive ornamental plants, weakens public awareness of the threats of biological invasions. Fortunately, the overall strong congruence between public search interest and media coverage suggests that tighter integration between scientists and science communicators could increase public awareness of invasive plants in the future.

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Declarations

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