Policy analysis

A content analysis from 153 years of print and online media shows positive perceptions of the hellbender salamander follow the conservation biology

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A B S T R A C T

Print and online media may reflect changing perceptions about wildlife when viewed in a historical context, as conservation programs bring about increased awareness of declining species. With a proven history of public misunderstanding and persecution, we focused on a nongame and at-risk species, the hellbender salamander (*Cryptobranchus alleganiensis*). To determine whether public perceptions of hellbenders change according to societal interests over time and to test Shaw's conservation eras, we conducted a content analysis of 288 newspaper articles over the past 153 years of coverage through Conservation Eras, including: Exploitation (1850–1899), Protection (1900–1929), Game Management (1930–1965), Environmental Management (1966–1979), and Conservation Biology (1980–2016). In addition, we examined trends in more recent online media coverage. As measured by article frame (valence values), we detected an increase in positive perceptions about hellbenders in newspapers after 1980, which coincides with the Conservation Biology Era. Many articles published within the Exploitation Era included informative natural history while articles in the Conservation Biology Era included information about the species decline or efforts to conserve and restore populations. Article frames from the Conservation Biology Era were more positive than any other era ($X^2 = 111.79$, $p < 0.001$). Conservation efforts likely impacted online media coverage (via Google Trends), which increased following the federal listing of Ozark hellbenders and their successful captive rearing by the St. Louis Zoo in 2011. Because knowledge is generated and accessed more readily than ever, and we observed media is representative of societal changes, we anticipate a new era of conservation to follow the digital information age.

1. Introduction

It is of utmost importance that conservation efforts are supported by both the public and policymakers. A mismatch between governance and public opinion might occur because of flawed information or biases that are held by people or governmental decision-makers. Despite over a century of scientific support for species conservation, there are many misunderstood or even feared organisms that are overlooked by society at large and may receive less attention and potentially less support for conservation than charismatic megafauna. For centuries, society has shunned or even persecuted animals which provoke strong emotional feelings, like wolves (*Canis lupis*), alligators (*Alligator mississippiensis*), bats (Order *Chiroptera*), or snakes because of fear, hate, incorrect assumptions about perceived threats or risk of harm to themselves or their livelihoods (Fogelman, 1988; Prokop et al., 2009). Public perceptions of wildlife attitudes likely represent complex factors informed by stakeholder experience, occupation, level of education, location (rural versus urban), or social identity (Naughton-Treves et al., 2003; Roskaft et al., 2007; Kaltenborn et al., 2008). Moreover, scientists and conservation managers may not have utilized emerging forms of dissemination of information, as some of the myths and misconceptions of wildlife may be the result of inaccessible natural history knowledge, where only academic institutions hold primary literature, representing limited communication between scientists and stakeholders creating a knowledge gap and disconnect between researchers and the public (Gossa et al., 2015). Media often perpetuates commonly held beliefs and can reflect societal views on conservation issues (Gans, 2004; Muter et al., 2009). Consequently, fears may come from media stories that transcend generations through books, movies, television, and even printed news media (Kasperson and Kasperson, 1992; Altheide, 1997). The scientific community works to protect some of the most socially unaccepted organisms because research shows that they are more important to us alive and may provide ecological services. For example: as a predator, wolves positively support environments by controlling elk populations to minimize overgrazing (Ripple and Beschta, 2007); bats control insect pests and pollinate agricultural plants providing a large economic benefit to society (Jones et al., 2009); and alligators are ecosystem engineers that create small wetland depressions that support the survival of many species (Mazzotti et al., 2009). However, despite decades of scientific data, outreach, and education, many species continue to lack positive support for conservation from society at large.

Some shifts in support of species conservation might follow large social changes. However empirical data is lacking across historical time frames for many species to evaluate societal shifts in conservation while

providing a historical and ecological context for contemporary biological conservation (Rick and Lockwood, 2012). Shaw (1985) mapped out the United States history of societal changes regarding conservation, which he termed Conservation Eras (Shaw, 1985). These eras trace a history of Exploitation (1850–1899) and Protection (1900–1929) to Game and Environmental Management (1930–1979), and our current Conservation Biology era (1980–Present). Conservation eras outline how social changes respond to the use and misuse of natural resources, by showing investments in legislation that represent society priorities, like the Lacey (1900), Migratory Bird Treaty (1918), Tennessee Valley Authority (1933) Endangered Species (1966), Clean Air (1970), and many other United States Acts. Other Conservation Eras are marked by social movements, such as Earth Day (1972). Many of these acts were a direct response by society to the well-documented era of Exploitation where depletion of animals and resources resulted in public outrage and shifting societal views on wildlife conservation (Mahoney and Jackson, 2013). More recently, a debate is underway on how conservation biologists should embark on "new conservation" and elicit engagement and public support in the human-dominated landscape of the Anthropocene (Kareiva and Marvier, 2012; Holmes et al., 2017). The analysis of newspaper media and more recent social science research is a tool for both increasing the understanding of how information on imperiled species is conveyed and a method for guiding strategies which can support conservation efforts (Le Busque et al., 2019). It is vital for conservation efforts to assess public perceptions, as positive attitudes toward a species correlate with concern and support for the conservation of that species (Taylor and Signal, 2005; Wilson and Bruskotter, 2009; George et al., 2016). However, many questions remain to test if these conservation eras spanning long time spans truly reflect changing attitudes toward species of conservation concern or species involved in wildlife human conflicts. For example, do we see portrayal of species in media change, potentially becoming more favorable over time? How are non-charismatic species perceived in media? Do conservation efforts, many of which have increased over the last decade or more, translate to changes in attitudes conveyed toward conservation species? Do we need a new conservation era more reflective of ever expanding technology, social media, and almost instant access to information in the digital conservation age?

Public support can be captured through media, such as newspapers. One methodology quantitative researchers use is content analysis, which can utilize descriptive statistics to assess public perceptions and opinions related to conservation issues or species of conservation concern (Jacobson et al., 2012). Content analysis can take many forms, either qualitative, descriptive of specific conceptual themes or quantitative, traditionally summarizing data extracted from printed media (Riffe et al., 1998; Krippendorff, 2004). Printed media is generated through reader interest, holding a record of citizen perspectives from in-person interviews, that are otherwise impossible to obtain from the past. Indeed, media newspapers often report on natural resource and wildlife issues of importance to the public and may be interpreted as a measure of public interest in either species of conservation concern or human wildlife conflict species (Killion et al., 2018). Most conservation related content analyses have focused on human-wildlife conflicts of either predatory or financially problematic species, such as bears (Siemer et al., 2007; Sakurai et al., 2013), cormorants (Muter et al., 2009), leopards (Bhatia et al., 2013), panthers (Jacobson et al., 2012) and sharks (Muter et al., 2013). While there is a growing body of scientific literature on species associated with human-wildlife conflict (Guerra, 2019), other species of conservation value have been ignored. Few content analyses have focused on non-charismatic and at-risk species such as amphibians, many of which are in decline (Stuart et al., 2004) even while still receiving some media coverage related to worldwide amphibian decline. Moreover, herpetofauna (amphibians and reptiles) are underrepresented in both popular printed and social media coverage as well as academic library holdings, when compared to charismatic megafauna such as mammals (Hecnar, 2009; Papworth

et al., 2015). Therefore, content analysis provides a tool to measure how public opinions and thus support for conservation change over time.

An ideal taxonomic group to assess how public perception follows conservation eras include amphibians and reptiles. Amphibians and reptiles are mostly harmless and ecologically important, yet despite this, they are often feared and persecuted (Ceriaco, 2012), with few studies investigating public perceptions of herpetofauna (Hartel et al., 2015) or how likely public attitudes toward amphibians shape support for conservation actions (Loyau and Schmeller, 2017). Of amphibians, the hellbender salamander (*Cryptobranchus alleganiensis*), is an ideal species to perform media content analysis given its large geographic range, recent declines (Wheeler et al., 2003; Burgmeier et al., 2011), and history of persecution (Nickerson and Briggler, 2007). Moreover, animals labeled ugly or slimy, like hellbenders, often provoke fear and negative appraisal by humans (Bennett-Levy and Marteau, 1984) and as less charismatic wildlife elicit repulsion by the public (Iosif et al., 2019). Hellbenders have an intriguing, often alarming, morphology when initially captured and examined by the public. Many people describe hellbenders as "troublesome", "poisonous" and that they "steal bait" (Nickerson and Mays, 1973). Perceptions of stakeholders toward hellbenders has shown positive attitudes prevail among riparian landowners or previous exposure and familiarity with the hellbender (Mullendore et al., 2014), however research is lacking framing the historical legacy of conservation in media coverage of the hellbender, an enigmatic animal. Understanding how wildlife-human dimension trends influence conservation management requires collection and analysis of human-nature interaction data from both a historical perspective and incorporation of more recent media communication (Miller, 2009; Toivonen et al., 2019). Therefore, we ask "whether public opinion follows policy changes?" and "do public attitudes, recorded from print media, toward a species follow legislative actions in the form of Shaw's Conservation Eras?" We chose an amphibian, the hellbender salamander (*Cryptobranchus alleganiensis*) because of a long history in print media for its public and scientific curiosity to address this question. Since hellbenders were not deemed declining until late in the conservation era, we hypothesize a spike in attitude change might follow if media drives public perception. Alternatively, if attitudes change with policy, then we might expect changes in attitude to occur slightly earlier.

To determine whether public attitudes toward a species would follow legislative actions, we examined 153 years of media coverage across the hellbender salamander's distribution in the United States. Specifically, this is a test of Shaw's conservation eras, whereby we can determine whether public sentiment aligns with large-scale policy changes. We characterize content of newspaper articles across several variables, including whether the articles were positive, negative, or neutral in nature (frame), story location, level of understanding (based on natural history reported), persecution of hellbenders (fishermen reports), coverage (thematic or episodic), and article topics. We also report on more recent trends in online media coverage of hellbender salamanders. Lastly, we relate these historical and present findings to future conservation efforts to better inform the public perception and management of hellbender salamanders and other species of conservation concern. Can we use content analysis along with Shaw's Conservation Eras to determine if we are progressively preserving a species?

2. Methods

2.1. Focal species

The hellbender salamander (*Cryptobranchus alleganiensis*) is a unique, widespread salamander which has often been vilified, misunderstood, and even intentionally killed and persecuted (Nickerson and Briggler, 2007; Reimer et al., 2014). Persecution continues to this day

based on anecdotal information across states from hellbender researchers and state agency personnel (pers. obs.). However, in 2011, the Ozark hellbender (*C. a. bishopi*), which is a subspecies found only in portions of Missouri and Arkansas, was listed as federally endangered, while the Eastern hellbender (*C. a. alleganiensis*) is a species of conservation concern in many states across its geographic range. The hellbender has received increasing media coverage characterized by a concomitant increase in conservation and research efforts within the past decade following the first confirmation of population declines (Wheeler et al., 2003). Following these conservation efforts, there has been an increase in social science research, using survey methods that focus on human attitudes toward hellbenders (Mullendore et al., 2014; Perry-Hill et al., 2014, and Reimer et al., 2014). Hellbenders are an ideal species for content analysis as they have a historically large geographic range, often found within tributaries of the eastern United States. These enigmatic, fully aquatic amphibians inhabit streams throughout the eastern and midwestern United States, including Alabama, Arkansas, Georgia, Indiana, Mississippi, Missouri, New York, North Carolina, Ohio, Pennsylvania, Virginia, and West Virginia (Petranka, 1998).

2.2. Data collection & content analysis

To ask whether the article frame (attitudes toward hellbenders) changed over different management eras, we followed the characterization of Shaw (1985), where the societal view of wildlife has changed over time. These five conservation time eras include Exploitation (1850–1899), Protection (1900–1929), Game Management (1930–1965), Environmental Management (1966–1979), and Conservation Biology (1980–2016).

Content analysis has been used extensively in the social and behavioral sciences and can consist of multiple methods, some of which are qualitative, inductive, while others are more quantitative and analytical (Neuendorf, 2016). More recently, quantitative content analysis has been applied to analyze the content and information conveyed in media and can be defined as the "systematic assignment of communication content to categories according to the rules, and the analysis of relationships involving those categories using statistical methods" (Riffe et al., 2019; Krippendorff, 2004). Moreover, this type of analysis can enable conservation biologist to better understand how species of conservation concern or conservation issues are portrayed in media over time (Wolch et al., 1997). We compiled articles for content analysis of United States newspaper coverage by using a combination of digital archives of printed newspaper media, published from the years 1863–2016. For newspaper articles, we used three search engines: 1) LexusNexis Academic (a database which searches recent newspaper and press releases), 2) Historical newspaper archives from Newspaper.com (http://www.newspapers.com) from the 1700's to 2000's and 3) Library of Congress Chronicling America (http://chroniclingamerica.loc.gov), which covers 1789–1924. Initial searches within databases included a variety of commonly utilized names for hellbender salamanders, for which we did not find any additional articles. Therefore, we screened documents using the following keywords: "hellbender(s)," "*Cryptobranchus*," "*Cryptobranchus alleganiensis*," "Eastern hellbender," "Ozark hellbender," "*Menopoma*," "*Necturus*," "mudpuppy(s)," and "waterdog". While other studies using data mining in conservation research suggest the Latin and vernacular names are highly correlated and can be used as an alternative for the other (Jaric et al., 2016), given our historical timeframe, we included a variety of search terms other than "hellbender". *Menopoma* refers to the former hellbender genus predating *Cryptobranchus* (Harlan, 1825). We included the key words "mudpuppy" and the genus "*Necturus*", as these two species have overlapping geographic ranges and are commonly confused. Moreover, the ability to distinguish between these two large stream salamanders has been identified as an important conservation priority for citizen science and reporting of species presence across the range. Authors reviewing

articles differentiated between mudpuppy-centric articles versus hellbender articles by carefully examining article content which included morphological descriptions (e.g., large gills) or were reports of salamanders outside of the historical range of the species. We excluded non-relevant articles which did not use the term "hellbender" as a biological species (e.g., articles referring to fishing lures, computer games, movies, etc.). We also excluded articles which were reprinted or were duplicates (exact same article, but reprinted in another newspaper or same article found in multiple databases). Articles were initially sorted by database, compiled, then randomly assigned to coders (authors) for screening content to minimize coder bias toward specific years or databases.

We developed a protocol for screening and coding articles following content analysis methodologies of Riffe et al. (1998) and Krippendorff (2004) and protocols examining wildlife-oriented media of Jacobson et al. (2012), Muter et al. (2013), and Burke et al. (2015). For a detailed description of content analysis variables and approach see Supplemental A1. In brief, authors coded all newspaper articles manually by using an iterative approach (Siemer et al., 2007; Dressel et al., 2012; Habib and Hinojosa, 2016). We classified articles as primary if the word "hellbender appeared in the title, headline, or in the first paragraph, and as secondary if the word "hellbender" was mentioned at least once, following other content analysis for wildlife (Krippendorff, 2004; Alexander and Quinn, 2012, and Jacobson et al., 2012). Each article was examined for 24 variables into five content categories: 1) general article information (e.g., publication name, date, state, word count), 2) article type (either feature reporting, news event, or editorial), 3) episodic (single event or observation of hellbender, etc.) or thematic coverage (long term trends or issues with hellbender decline or conservation), and 4) frame (valence value which reflects positive, neutral, or negative), 5) correct natural history (e.g., hellbender or mudpuppy correctly differentiated). List of articles used in content analysis available in Supplemental A2. Only authors were involved in full content analysis. To determine congruence for scoring and thus consistency of data scoring (intercoder reliability), a subset of articles ($n = 30$) were selected at random, divided and scored by both authors, which were in complete congruence for all areas except article topic and frame, which were both within 90% congruence (Fleiss' Kappa: both $P < 0.0001$, $Z = 7.91$, Kappa = 0.862; Fleiss et al., 2003) similar to Lombard et al. (2002), Siemer et al. (2007), VanDyke and Tedesco (2016), and Sutton et al. (2018). Using the phrases extracted from original articles, we determined the frequency of descriptive words used to describe hellbenders (Alexander and Quinn, 2012). We generated heat maps for newspaper locations using the open source heat map website (www.openheatmap.com).

To address our main hypothesis that perceptions about hellbenders will change according to conservation eras over time, we assigned articles a valence value for frame (positive, neutral, or negative) using several criteria (Houston et al., 2010; Rust, 2015). For example, articles were assigned a positive frame if they mentioned conservation efforts by federal or state entities, importance of hellbenders to the environment or ecosystem, legislation change or, protection status and providing ecosystem services. We assigned articles a neutral frame if they discussed multiple perceptions such that not just one dominated the article, for example, "hellbenders are ugly, but harmless." Finally, negative frames were assigned to articles referencing hellbenders as harmful in some way (e.g. consume fish), or with a negative description such as "lazy", "repulsive", "vile", or "hideous." Negative frames describe hellbenders undesirably (e.g. "beasts" or "ugly") but without a contrasting benefit to the ecosystem or uniqueness that describes them with an endearing quality. Moreover, we exhaustively documented the frequency of the most common words used to specifically describe hellbenders (e.g., odd, monster, strange, unique, cute, slimy, etc.) which would further inform perceptions and scoring. In summary, we scored the article frame as positive (1), negative (-1) or neutral (0), and then averaged scores from the articles for each year with the frame as the response variable and the historical era as the explanatory

Table 1
Content analysis covariate descriptions. For further detail, refer to Supplemental A1.

Covariate	Newspaper content analysis description
Article type	
News, event reporting	Standard news event reporting
Editorial	Article which denotes the editorial, largely opinion of a reader or author
Article frame	
Episodic	Case studies, or single observations of "hellbender" in streams, i.e. fisherman catches a hellbender on a line
Thematic	Connects trends and incorporates trends or larger themes in conservation
Article content	
Primary	Title or first paragraph "hellbender" is mentioned more than once in text; article focuses on a story covering "hellbenders"
Secondary	Title or first paragraph "hellbender" appears at least once; article content is mostly likely on amphibians in general and not on "hellbenders"
Article Topic	Using the title of the newspaper article, in addition to the first several paragraphs, determine the main topic of the newspaper article as it relates to "hellbender"
"Hellbender"	"Hellbender is main topic"
"Hellbender as attractions in zoos/aquariums"	"Hellbenders" are reported as attractions in zoos and aquariums.
"Hellbender as an example of an amphibian"	"Hellbenders" listed as one of many examples of amphibians
"Hellbender report of sighting"	"Hellbender" typically reported as caught or seen by fishermen
Hellbender conservation is main emphasis/ topic"	"Hellbender" is reported in the larger topic of conservation
Article frame	
Negative perception	Article discusses one or more negative effects or impacts of hellbenders; typically emphasis of reporting on "ugly", "monster" etc.
Neutral perception	Article is neither positive nor negative; discusses multiple perceptions such that not one clearly dominates, ie. "Hellbenders are ugly but important to the ecosystem"
Positive perception	Article discusses one or more positive description of hellbenders or impacts or importance to the environment or ecosystem services or examples of any state, federal, academic, or zoo efforts for conservation.

variable (Table 1). Examples for assigning article frame are included in Table 3. We calculated the mean difference in the perception between historical eras with a general linear model (GLM) followed by a Tukey HSD in the program R. A Tukey test was used as we compared eras that represent separate populations across different time periods, but are not considered continuous. GLM analysis method have been applied to newspaper media content analysis research questions (Chau et al., 2009; Habib and Hinojosa, 2016). This was also displayed using a simple linear regression to visualize how important the article frames were over time. We also analyzed data in the program R using pearsons Chi-squared test with simulated *p*-value (based on 2000 replicates) followed by a pairwise comparison from the chrisq.multicomp function of the package RVAideMemoire v 0.9-73.

2.3. Online media analysis

In addition to printed media, we used Google Trends to examine more recent online trends and word searches toward hellbender conservation since January 2004 (Google trend data available), similar to Nghiem et al. (2016), Soriano-Redondo et al. (2017) and Troumbis (2017). As many state management agencies, universities, and non-profit entities have adopted active outreach science programs focusing on the conservation of this unique species, we wanted to investigate more recent aspects of online media reporting. Briefly, to examine reporting trends we used the search volume with keyword "hellbender" which provides normalized trends ranging from 0 to 100 based on queries submitted to Google (Choi and Varian, 2012; Nghiem et al., 2016). We constrained the keyword search to "hellbender" as it is a standard common name and as an overall metric to increase the likelihood that Google searches were specific to "hellbenders" as other terms may have provided extraneous results. We also examined interest over time or Google searches for "hellbender" by region within the United States and report on these findings.

3. Results

3.1. General content analysis of newspapers

In total, we compiled 405 initial total articles and excluded 117 articles as duplicate or non-relevant. Therefore, from these three databases, we extracted 288 primary newspaper articles suitable for content analysis. Of the 288 newspaper articles, 267 (92.7%) were published in states within the current or former geographic range of the hellbender. The state with the most articles was New York, followed by Pennsylvania, Missouri, Ohio, and Indiana (Fig. 1). The eighteen states that represent the current or historical range of hellbenders, account for 90% of the news articles, where the other 10% came from states near the geographic range (Oklahoma and Kansas) and as far away as Oregon, having no hellbenders (Phillips and Humphries, 2005).

The mean and median number of words in articles was 317.6 and 251, respectively. The majority of articles used episodic coverage 207/288 (71.9%) over thematic coverage 81/288 (28.1%). Most articles 207/288 (71.9%) were categorized as primary articles for which the focus of the article was on hellbenders. The number of articles that correctly describe natural history or biology of the hellbender was 240/288 (83.3%), while the number of articles incorrectly describing natural history or biology was 36/288 (12.5%), with 12/288 (4.2%) not applicable with no natural history mentioned in article. The number of articles that mentioned conservation was 119/288 (41.3%), while the number of articles with no mention of conservation was 168/288 (58.3%), with 1/288 (0.4%) not applicable due to article type. The mudpuppy salamander was mentioned in 53/288 (18.4%) articles with only 10/288 (3.5%) of articles clearly misidentifying the mudpuppy and hellbender salamander either in text or in photo captions. However, the difference between a mudpuppy and hellbender was clearly described in only 34/288 (11.8%) of articles. Articles describing primarily hellbenders as an attraction or addition in aquariums was 44/288 (15.3%). Local observations by fisherman or hellbenders captured by local fisherman accounted for 65/288 (22.6%) newspaper articles while 26/288 (9%) mentioned palatability or consumption of hellbenders as a food source or fine cuisine.

The frequency of words most often used to describe hellbenders in 288 articles examined varied in content, with the most frequent occurrence including "ugly" (60/288) followed by "harmless" (33/288), and as a "lizard" (31/288). Additional words used in describing hellbenders include "slimy" (25/288), "monster" (14/288), "interesting" (13/288), "strange" (13/288), "odd" (11/288), "repulsive" (10/288), "hideous" (9/288), "curious" (9/288), "lazy" (8/288), "dirty" (8/288),
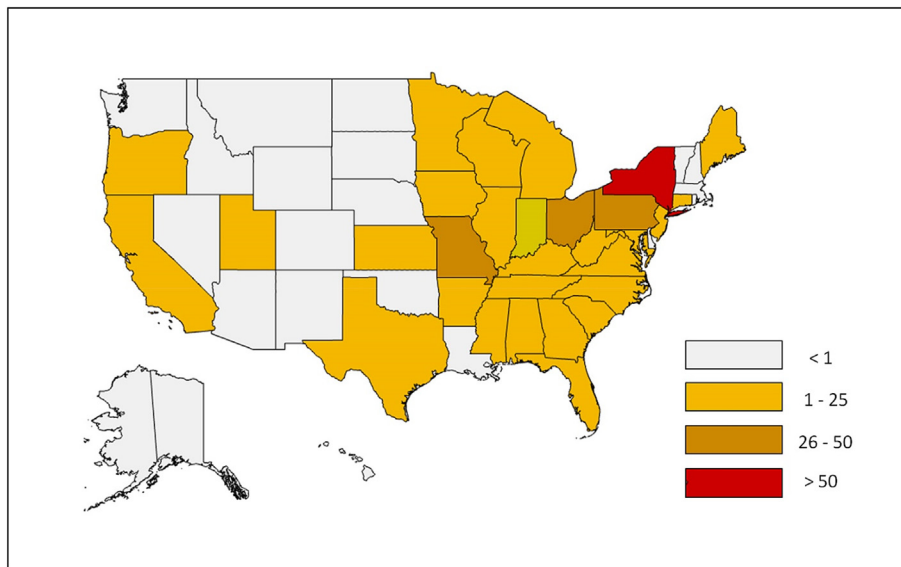
Fig. 1. Heat map of the density of articles published by location of newspaper. Note newspaper articles within states primarily distributed across the southeast and northeast United States, with > 50 articles including only New York, with Pennsylvania, Missouri, and Ohio with the 26–50 articles per state category.

"unique" (7/288), "beast" (6/288), and "cute" (5/288).

3.2. Considering conservation eras

Across 153 years of newspapers since 1863, the view about hellbenders (article frame) were mostly neutral (49.7%) and positive (34.0%) with only 47 (16.3%) representing negative perceptions about hellbenders. This is consistent with a recent human dimension survey that found overall attitudes toward hellbender salamanders were neutral (Reimer et al., 2014). Articles with neutral frame were distributed throughout time while articles with negative frame were more prevalent in earlier conservation eras and present until the 1980's. Episodic coverage occurred throughout conservation eras, while thematic coverage increased over time with 90.1% of thematic coverage occurring during the Conservation Biology Era. Perceptions were clearly different over time with an upward trend of article frame where articles described hellbenders more positively over the last 40 years ($R^2 = 0.45$, $P < 0.0001$, Fig. 2), which coincides with the Conservation Biology Era (1980–2016). The number of articles included in our analysis across conservation eras are as follows: Exploitation (36), Protection (47), Game Management (50), Environmental Management (15) and Conservation Biology (140; Table 2). Articles within the Conservation Biology Era were more positive regarding the view of hellbenders, and

Fig. 2. A simple linear regression analysis of articles we scored as negative (−1), neutral (0), and positive (+1) perceptions about hellbenders over time.

Table 2
Time analysis of Five eras of wildlife management. Here we categorized articles based on their article frame (valence) for being negative, neutral, or positive about hellbenders, and plotted them according to the history of conservation, categorized as era's (Shaw, 1985). Note, our data starts at 1863, not 1850 for the Exploitation Era.

Perceptions of hellbenders 1863–2016					
Dates	Era	Negative	Neutral	Positive	Grand total
1863–1899	Exploitation	14	22		36
1900–1929	Protection	14	31	1	46
1930–1965	Game management	11	34	5	50
1966–1979	Environmental management	5	10		15
1980–2016	Conservation biology	3	45	92	140

many reporting on species conservation efforts and how the species might be important to people. Positive perceptions were greater in the Conservation Biology Era than any other ($X^2 = 111.79$, df = NA (simulated), $p < 0.001$, Fig. 3). All other eras ranged between neutral to negative in their perception about hellbenders and were statistically different than the Conservation Biology Era (all $P < 0.0001$, Fig. 4). The largest difference was between the Conservation Biology and Exploitation Eras ($P < 0.0001$; +0.110 SE; $t = −6.968$, Fig. 4). The articles which incorrectly described natural history decreased over time (18: 1863–1899, 13: 1900–1929, 4: 1930–1965, 1: 1966–1979, 0: 1980–2016) indicating natural history errors describing species biology or taxonomy were greater in older articles.

3.3. Online media analysis

The analysis of Google Trends, reflected by overall web search queries, indicated a peak of online interest (with 100 searches) for "hellbenders" during December of 2011 (Fig. 5). Overall, how often the term "hellbender" was searched relative to the total number of searches on Google showed a great deal of fluctuations by month with no clear trend for increased overall coverage from 2004 to 2016, with exception to a peak in December of 2011. The highest rankings by geographic region for google Trends for searches for "hellbender" were within the geographic range of the species and included states in order of highest ranking: West Virginia, the District of Columbia, Missouri, Georgia,
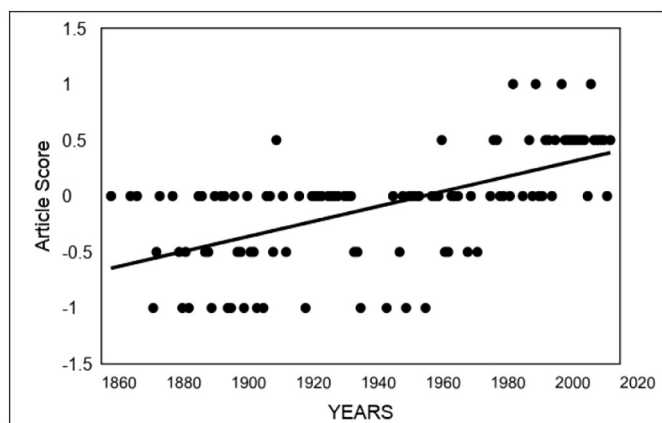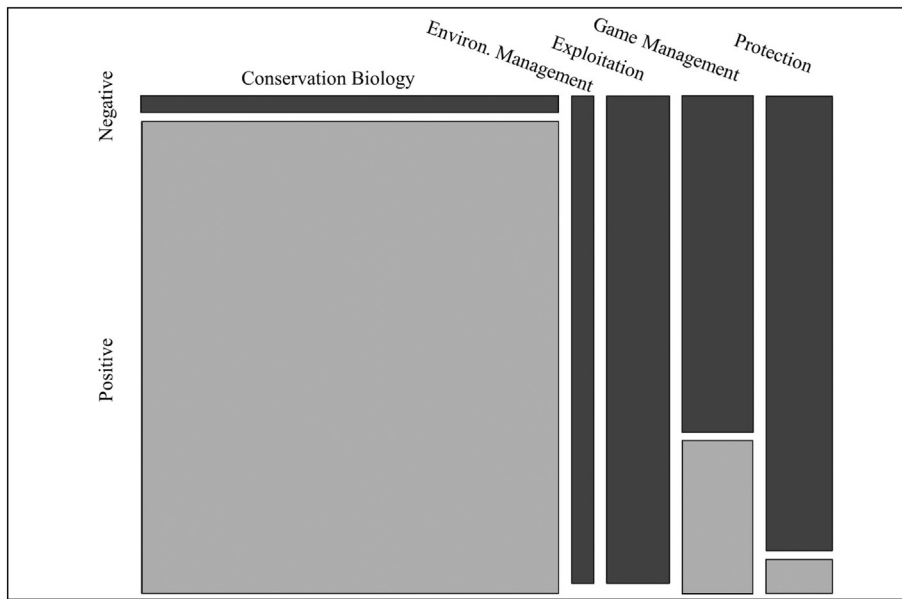
Fig. 3. Mosaic plot showing results from chi-squared contingency table analysis for positive (green) and negative (red) article frame values across Conservation Eras. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Tennessee, Arkansas, Kentucky, Pennsylvania, North Carolina and Ohio.

4. Discussion and implications

Based on our newspaper content analysis, there was a strong positive change in media portrayal for both article coverage (increasing thematic) and article frame about hellbenders following the Conservation Biology Era (1980). Prior to 1980, we found that newspapers primarily described hellbender appearance (i.e. ugly, nasty looking), but followed by more negatively charged comments about being poisonous, or harmful to fish harvest (as an "enemy of fishermen"). Older articles did not mention a positive role but primarily focused on the fear or disgust of hellbenders. In several articles, hellbenders were consumed, represented from titles, like "Hellbenders eaten in the cause of Science" (SA2 Article #163, 1906). While several articles before 1980 mention hellbender physical appearance as "ugly", these descriptions are also noted in more recent articles but balanced with positive descriptions of their importance to people and concerns for the hellbender plight. In many instances, these physical descriptions were used more to grab the reader's attention followed with an

overwhelmingly positive account. One of the more common observations we noted after 1980 was a more balanced description about hellbenders, like a concomitant description as "ugly but harmless." After the Conservation Biology Era started, threats to hellbender survival were described more often, and many newspapers regarded the animals as harmless and indicators of good water quality. Even more recently published articles mention a disparagingly physical description of hellbenders in the title (Supplemental A3). An example of this includes an article titled "Nasty looking critter holds vital clues to our environment" (SA3 Article #235, 2012). We observed several examples of newspaper articles which mentioned both physical appearance while also describing some conservation value of the hellbender, including "…it may be slimy and ugly, but this creature is part of our river as such it deserves to survive" (SA3 Article #266, 2002). The positive frame of several recent articles included mention of conservation management programs and descriptions of hellbenders as "rare" or a "unique species in decline." These articles were especially present during the early 2000's when several zoos, state agencies and universities established both captive rearing, and research.

We successfully applied Shaw's conservation era template to hellbenders, as there was a negative attitude toward them, even when
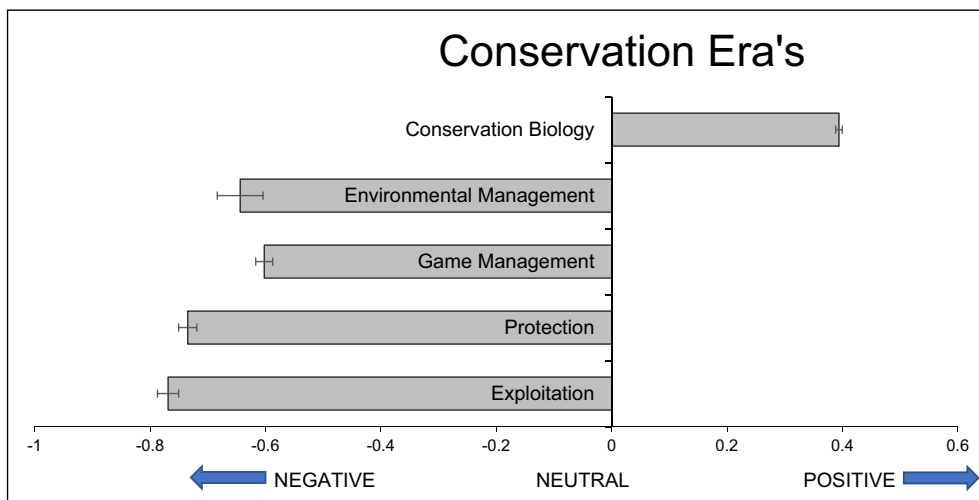

Fig. 4. Mean valence values (± SE) for article frame during Conservation Eras (Exploitation, Protection, Game Management, Environmental Management, and Conservation Biology). Closer to zero shows a more neutral condition while positive and negative are closer to 1 and −1, respectively. Means based on maximum likelihood modeling procedures may not always create a whole number.

Table 3

Content analysis representative text and frame examples. Specific article information found in Supplemental A2.

Article information	Article title	Representative text	Article frame
(SA2:21); The Sun, 09/23/1893, New York City, New York	"A Plaque of Hellbenders, that is what Susquehanna River fishermen say has come upon them"	"fishermen are not only disgusted, but alarmed....ugly enough in its appearance to deserve the name...it will steal ducks and chickens....part lizard part fish...taking their bait...he had 165 big alligators (hellbender) on the line...so many thus are thrown on the shore"	1: Negative
(SA2:176); The News Journal, 07/21/1964, Mansfield, Ohio	"Salamander caught near Mt. Vernon"	"...nearly two feet long...amphibian was recently caught...looks like a weird prehistoric monster...lives in large unpolluted streams and rivers..."	2: Neutral
(SA2:271); The Springfield News, 02/02/2006, Springfield, Missouri	"Trouble for Hellbender could be Trouble for us"	"They may be large, ugly and slimy, but hellbenders are an important Ozarks resident...dwindling population could point to trouble for humans...something in the water that is harming them, could also be affecting us..."	3: Positive

natural resources were only preserved for economic benefits. But when we as a society started broadly valuing ecosystems, hellbenders were more valued. However not even the ESA helped change attitudes toward hellbenders as the species was not listed. This study helps us understand how the Conservation Biology Era might have helped improve attitudes toward all species, even those deemed unimportant or of little economic value to society. Despite the over-all negative frame from older articles (pre-1980), the natural history science reported was often extensive. In fact, we noted that many older articles often included more detail about hellbender biology and ecology than several more recent media descriptions. Alternatively, as we also noted most articles incorrectly describing natural history to be pre-1980s, this may be reflective of natural history science in general lacking for Amphibia altogether (e.g., hellbenders described as lizards or reptiles). Altogether many of the older natural history information included in media across conservation eras allowed for the public to become more informed about hellbender biology, including overall size of this unusually large salamander, the fact that it is fully aquatic, coloration, as well as even occasional mention of diet. If science information is not greater than the past, then why did public perceptions about hellbenders change in the Conservation Biology Era?

Although the Conservation Biology Era was not unique in science discovery and reporting about hellbenders and other species, we believe there must be fundamental differences that distinguishes it from other eras that explain why perceptions about such an enigmatic animal would change. The Conservation Biology Era was marked by the Forsythe-Chafee Act in 1980, which laid the groundwork for later comprehensive wildlife management plans and funding for states not

tied to game animals. Unlike the early eras of over-exploitation, game and environmental management, the conservation era was not solely tied to organisms, like game animals, that provided a direct resource benefit to people. The idea for wildlife action plans was to keep common species common, where each state received federal funds to develop an action plan to identify and manage for protection and recovery of imperiled species in the state. Indeed, we have witnessed a reversal of management agencies paying bounties for "pest species", which can be traced in England as far back as the 13th Century (Harting, 1994) or in Finland where over twenty pest species had bounties in 1741 (Pohja-Mykra et al., 2005), to these same entities developing conservation plans and promoting research and outreach. Action plans were appealing because they could potentially help remove species from federal protection, such as the Endangered Species Act of 1973. These modern action plans included dramatic increases to research and outreach budgets, which exposed the public to active conservation efforts for enigmatic and previously persecuted species like hellbenders. This renewed emphasis on funding research and interest in species management may have resulted in further production of research products and outreach materials and increased awareness in online or newspaper media.

Many research products were generated for non-game organisms in the conservation era, where by the early 2000's, the peer reviewed studies on hellbenders increased dramatically as hellbenders were recognized as declining (Wheeler et al., 2003). On October 5, 2011, the Ozark hellbender salamander was listed as an endangered under the Endangered Species Act (USFWS, 2011a). In addition, the Saint Louis Zoo and Missouri Department of Conservation successfully bred the first
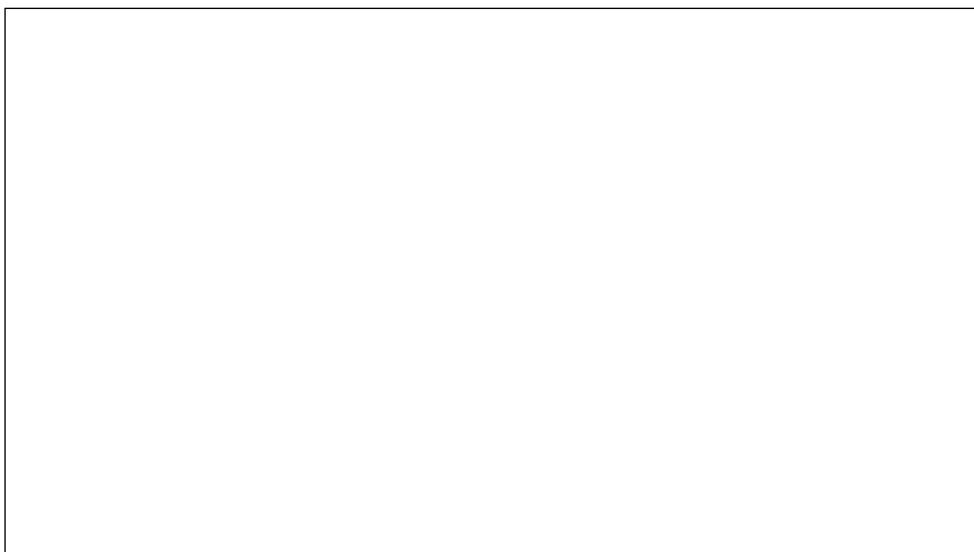

Fig. 5. Google Trend for the term "hellbender" within the United States for 2004 to 2016. Data retrieved 3/26/2018. Google Trends scaled on range of 0 to 100 (y-axis) denoting search phrase adjusted or proportional interest and date with year and month shown (x-axis). Note peak observed during December of 2011.

ever Ozark hellbenders in captivity on November 30, 2011 (Gallagher et al., 2011). Both of these events likely contributed to the peak representing high levels of online interest or Google searches for "hellbender" we observed in Google trends (Fig. 4). State conservation outreach efforts, via pamphlets and other media, that encourage fishermen to "cut the line" in Missouri, Indiana, and North Carolina, might have helped to dispell myths about hellbenders being poisonous and reducing fish stocks (Burgmeier et al., 2010; USFWS, 2011b). This observation is in stark contrast to historical efforts meant to purposefully vilify the hellbender as a "destroyer of fish" or efforts in West Virginia sportsmen's groups to eradicate these salamanders as enemies of fish and game" (Nickerson and Mays, 1973), which was likely widespread among managers and the public alike. Even recent misconceptions abound with reports alleging game wardens have placed a "bounty" on hellbenders or (Baker, 2017) or reports from the public deliberately harming or killing hellbenders when found in North Carolina (Williams et al., 2019). Researchers should utilize multiple formats of communication outside of academic venues (e.g., radio, TV, documentaries, blog posts, art, or engaging public presentations) as these methods of integrating human dimensions may improve conservation policy, practice, and outcomes as part of conservation social science (Bennett et al., 2017). Currently, the amount or research and funding needed to appropriately conserve species has been outpaced by the number of at-risk species identified (Wilson et al., 2016), potentially obfuscating conservation in practice and conservation in the future.

With growing conservation issues in a more connected world, we now ask how the next conservation era will be defined within the information age. Online media provides an advantage where people have more information available to them than ever to learn about issues concerning species and may provide conservation agencies improved ways to directly reach the public. However, to grab the reader's attention, many online media sources, including social media, may hold more embellished descriptions than traditional print media (Muralidharan et al., 2011). Our results would suggest that the real changes will come when conservation funding leads to conservation action. Many researchers and even private non-governmental agencies are exploring the potential of online crowdfunding campaigns to support conservation projects (Dahlhausen et al., 2016). Perhaps these funding sources will lead to more conservation efforts that reach beyond the traditional federal status process that works to protect species after they are deemed to be at risk. Changes in perception in conservation biology may include a substantial change or shift in how society views natural resources, from a resource that is meant to be exploited for the benefit of humans, to a resource that we must preserve or use sustainably (Sodhi and Ehrlich, 2010). For example, recent interest has been generated for having hellbenders nominated as university mascot (Editorial, 2013) and designated as a state amphibian in Pennsylvania (Bond, 2019). Moreover, studies published online incorporate more pictures, increase followers and conservation projects which utilize social media could increase conservation management goals (Wu et al., 2018).

We did find a positive test of Shaw's Conservation Eras using content analysis. Content analysis has documented that attitudes toward at risk and historically stigmatized species have the potential to change over time and become positive as media frames reflect an increasing awareness of conservation needs of a species (Ernoul and Wardell-Johnson, 2016; George et al., 2016). To our knowledge, few studies have used content analysis to address conservation questions across time frames longer than several decades (Habib and Hinojosa, 2016; VanDyke and Tedesco, 2016) or across conservation eras. This is striking given that incorporating the human dimensions of wildlife management (e.g., societal values, knowledge, and behaviors) may directly translate to achieving management goals (Miller, 2009). Moreover, media coverage of wildlife may have a considerable bias toward larger species or terrestrial mammals (Lyngdoh et al., 2017). However, one caveat of content analysis application to conservation includes

limiting subjectivity and bias in human coders as they score article frames (positive versus negative), which includes a human scoring element and requires far more time than standard word counts as articles may contain both negative, neutral, and positive descriptors. However, this can be overcome when developing specific protocols that align with content analysis research questions and hypotheses. Future content analysis on conservation issues could incorporate threats facing specific species. Our study found that both policy and public support seem to align.

In cases where policy and public support do not align, further work should be done to change perception of species, either by policy or to influence public perception using contemporary methods. To better inform contemporary conservation policy it is vital to assess both public support for conservation and how social media can generate greater support for conservation of species across regions. Wildlife managers must take into consideration the historical legacy of both negative and positive perceptions to fame efforts to promote stakeholder support and knowledge. Indeed, managers need to account for lack of collaborative communication with stakeholders, of which many may provide managers with information on either current distributions or historical anecdotes of species in decline where previous knowledge is lacking (Williams et al., 2019). Content analysis may provide a valuable tool for other species of conservation concern, particularly as media and technological advances help people obtain more information from online sources to accomplish this goal (Athreya et al., 2015). Conservation managers should consider targeting these online media outlets for species conservation programs to potentially increase support for species conservation. Therefore, we recommend wildlife managers, state agencies, and conservation programs incorporate content analysis to further understand public perceptions of several at risks species and improve communication methods with public stakeholders using both online and printed media. In doing so, scientists can ameliorate some conflicts and challenges using adaptive management and value of information into the conservation decision making process (Bolum et al., 2019). Because the majority of newspaper articles covering hellbenders were episodic in nature (i.e., typically a single capture of an individual hellbender by a fisherman), we suggest that conservation managers and stakeholders continue to develop media coverage with thematic over episodic themes. For example, online and print media coverage could focus on thematic themes which include broader content, such as the importance of hellbenders in the ecosystem or to water quality and conservation and restoration efforts. This may increase the communication of conservation priorities conveyed to the public in both local and national media.

We hope for a strong era of conservation to enter a new paradigm in the information age, where we no longer wait for a species to be in decline, taking a more proactive rather than reactive way of conserving species. Moreover, as species deemed either more "charismatic" or "anthropomorphic" may elicit increased financial support by the public over species endangered status (Colleony et al., 2017), media coverage of conservation efforts in both traditional, online, and social formats should altogether engage, inform, and provide a mechanism for feedback, promoting improved conversations between managers, conservation biologist, and stakeholders or the public at large. The next era of future conservation may determine the ultimate fate of not only hellbenders, but of other freshwater and terrestrial flora and fauna, many of which are characterized by high extinction rates with the potential for large loss of biodiversity (Ricciardi and Rasmussen, 1999; Jonson et al., 2017). As we embark further into the 21st Century, with human consumption and global ecological change and potential for increasing extinctions and decline of biodiversity, referred to as the Anthropocene era (Crutzen, 2002), wildlife conservation agencies and policies must adapt to ecological and society conditions with new tools, collaborations, and dissemination of information (Decker et al., 2016; Redmore et al., 2017). Consequently, this "digital conservation" should embody increased communication for nature conservation and ensuing

conservation policy with the conservation community incorporating new innovative conservation solutions (Arts et al., 2015; Berger-Tal and Lahoz-Monfort, 2018). Indeed, conservation education programs which incorporate perceived risk and attitudes toward wildlife can impact stakeholder perceptions (Skupien et al., 2016). The future may be characterized by a society moving further away from exploitation and subjugation of natural resources to a more equilibrium perspective, not unlike that from first nations of America (Clarkson et al., 1992), where people are part of the system, and thus hold a larger stake in conservation. As Beston (1928) stated regarding animals and conservation issues: "through the glass of knowledge, we see a feather magnified and the whole image distorted," conservation biology may need a new era whereby we can impact positive change while preserving biodiversity, incorporating both historical and future perceptions of wildlife into active conservation management involving stakeholders, managers, and education programs which promote public support of conservation issues. More studies can apply content analysis to Shaw's Conservation Eras to determine where to apply strategies to gain public or policy support for conservation.

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CRediT authorship contribution statement

Shem D. Unger: Conceptualization, Data curation, Formal analysis, Methodology, Investigation, Resources, Visualization, Writing - original draft, Writing - review & editing.**Caleb R. Hickman:** Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing - review & editing.

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.

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