UNDERSTANDING THE SOCIOECONOMICAL CONSTRUCTION OF NONNATIVE SPECIES

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ABSTRACT

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In this study, I seek to evaluate the relationship between the classification of a species as "invasive" and the rhetorical framework used by biologists/ecologists in their academic abstracts. The methods for this study include: a classification of language used in abstracts from the Web of Science database, a statistical analysis of the categories from the analysis, and a brief review of three case examples. "Invasive species" includes those organisms that have an impact on human health, the environment, or the economy (invasivespeciesinfo.gov, 2011). I posit that economic relationships will be the most commonly used discourse to frame nonnative species research, based on a social constructionist framework and grounded theory analysis of contemporary discourse. While a statistical analysis of the discourse used to describe invasive species in academic abstracts did not reveal any significant results, organisms classified as "invasive" have an association with an economic impact, indicated by the case examples.

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INTRODUCTION

Epistemological arguments regarding the social construction of nature draw attention to the influence of culture and politics in establishing scientific knowledge. Seemingly objective, scientifically founded assertions of truth, such as how biophysical science portrays the workings of the natural world are, to a certain extent, socially constructed interpretations; nature is "…not simply something out there that scientific knowledge more or less faithfully mirrors" (Proctor 1998, p. 353). Interrogating interpretations of nature, and more specifically, constructions of invasive species, requires a critical realist approach, recognizing not only, as relativists argue, that knowledge is socially constructed, but also accepting that there are natural laws independent of our social constructions (Proctor 1998, p. 362). Critical realism recognizes that perception is a key factor in how humans acquire knowledge and that subjective perceptions of our external world largely shape how we understand and interact with it. Thus, much of the knowledge we generally accept requires critical reflection on those assumptions we hold to be self-evident truths. Invasive species are an excellent example of a social construction, as they have significant and measurable impacts, yet our understanding and perceptions of them are largely shaped by social forces.

The term "invasive species" first began gaining popularity in the 1990s and has rapidly risen to the most frequently used term for nonnative plants, animals and microorganisms in the English corpus (Michel et al., 2010). The category of invasive species encompasses organisms ranging from the microscopic avian malaria to the water hyacinth – popular in garden ponds – to the domestic cat (Lowe, Browne, Boudjelas, and Poorter, 2000). The definition of invasive species is equally disparate, even in the discipline of ecology, with the actual meaning of the term still contested. For example, the United States Department of Agriculture (USDA) defines

an invasive species as: "1) non-native (or alien) to the ecosystem under consideration and 2) a species whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (invasivespeciesinfo.gov, 2011). This is an impact-centered definition. In contrast, Craig (2010) defines invasive species as representing those organisms "that have taken up residence outside of their normal geographic range, either through natural or anthropogenic mechanisms" (p. 2127), a significantly more location-specific definition. Colautti and MacIsaac (2004) take yet another approach, proposing a neutral terminology with a definitional framework developed from "current models that break the invasion process into a series of consecutive, obligatory stages" (p. 135), resulting in an "invasive" classification only used in the end-stages of environmental impact.

Prior to the 1990s, "exotic" and "introduced" were the most common terms used to describe foreign species. Regardless of biology, what changes for nonnative organisms when using these different terms is the conceptual framework. Robbins's (2004) review of the cultural development of invasives found that, "it is not species but sociobiological networks that are invasive" (p.140), which implies that the designation and descriptions of these organisms are not wholly ecological. Sagoff (2000) further supports the idea that invasives are socially constructed by drawing attention to the large numbers of nonnative U.S. agricultural plant species that are cultivated, genetically modified, and left to cross-fertilize with native and wild plants. These crops, along with their livestock counterparts, are rarely investigated for the cultural and ecological impact they have on the environment as nonnative species.

My study investigates the relationship between the classification of a species as "invasive" and the rhetorical framework utilized by biologists and ecologists in their academic abstracts. Using grounded theory to explore existing studies of invasives, I found the conflicting

definitional frameworks, combined with the relatively recent application of the term "invasive" in academic literature, indicate that further investigation is needed. I seek to examine the mechanisms contributing to such inconsistencies and also provide supporting evidence for the case of invasives as a social construction. While Subramiman (2001), Larson (2005), and Robbins (2004) clearly demonstrate the ways discourse is utilized to socially construct a false perception of invasive species, I seek to investigate the potential for underlying, economically-driven mechanisms to use invasives as scapegoats for other forms of environmental degradation.

Some of the most well known studies of nonnative species describe the organism under investigation as influencing a new or pre-existing economic relationship (Garcia-Llorente et al., 2008). Invasives are presented in the literature as both a means of capital accumulation and an impediment to it, yet it is unclear how a nonnative's environmental impact affects its economic standing and the management strategies utilized to exert control over it. Drawing on a social constructionist framework and a grounded theory analysis of contemporary discourse, I posit that economic relationships will be the most commonly used discourse to frame nonnative species research.

Background

The rhetoric surrounding invasive species has been documented as constructing images of science-fiction aliens, militaristic enemies, and dangerous foreign nationals/immigrants (Larson, 2005; Subramaniam, 2001; Sagoff, 2000 and Paretti,1998). To illustrate, titles of academic articles from a search of "invasives" in the Web of Science database include: "As invasive species threat intensifies, U.S. steps up fight" (Simberloff and Schmitz, 1999); "Invasive Species: The Search for Solutions" (Dybas, 2004); "Friend or Foe? Invasive Species and Public Green Space in Toronto" (Foster and Sandberg, 2004); "Costs of Alien Invasive Species in

Sweden" (Gren, Isacs, and Carlsson, 2009); "American Perceptions of Immigrant and Invasive Species: Strangers on the Land" (Bruce, 2009). Newspaper articles take even greater liberties, frequently neglecting to indicate that the topic of the article is actually related to an ecological phenomenon:

> Alien Invasion: They're green, they're mean, and they may be taking over a park or preserve near you (Cheater 1992); Aliens Reeking Havoc; The Invasion of the Woodland Soil Snatchers (Stewart 2001); Native species invaded (ABC News 1998); It's a Cancer (Verrengia 1999a);10 Creepy strangler climbs Oregon's least-wanted list (Brinckman 2001); U.S. can't handle today's tide of immigrants (Yeh 1995); Alien Threat (Bright 1998); Biological Invaders Sweep In (Enserink 1999); Congress Threatens Wild Immigrants (Weiner 1996); Invasive Species: Pathogens of Globalization. (Bright 1999) (cited in Subramaniam, 2001, p.28).

The tone of the writing in such articles is frequently illustrative of xenophobic sentiments as, "Articles invariably end with a nostalgic lament to the destruction of native forests, and the loss of nature when it was pure, untainted, and untouched by the onslaught of foreign invasions" (Subramaniam, 2001, p.34). Subramaniam (2001) demonstrates how the "…xenophobic rhetoric that surrounds immigrants is extended to plants and animals" in the construction of invasives and attributes this "fear of the foreign" to increased globalization (p.29). The "fever pitch" of international trade, travel, and consumption, she argued, is resulting in a counter-movement, favoring the preservation of national cultures (Subramaniam, 2001, p.26). This counter-movement emerges in the biological literature through discussions of "ecological memory" and "ecological restoration," which utilize a preservationist discourse and values the environment as it was in its "original" state, original being defined as the time the dominant culture was formed

(Schaefer, 2009). While the rhetoric may differ, social scientists and ecologists concur in their understanding of invasives: "Invaders are increasingly evident around the world as the growing mobility of people and trade goods accelerates a longstanding process of contact and introduction" (Robbins, 2004, p.139).

Both Robbins and Subramaniam suggest that the construction of "dangerous alien invasive species" is, in part, a reflection of societal fears that (human) immigrants will "storm our borders" (Hartmann, 1998, p.114), reproducing exponentially and consuming local resources. These sentiments clearly overlap with those posited in population ecology: "Resource scarcities, often exacerbated by population growth, undermine the quality of life, confidence in government, and threaten to destabilize many parts of the globe" (as cited in Hartmann, 1998, p.114). Invasives are painted similarly to citizens of developing countries: hyper-fertile, adaptive, and responsible for the destruction of natural environments (Subramaniam, 2001). Both are simultaneously the recipients of xenophobic "pushback" and a result of widespread globalization. Both are also frequently represented as the cause of environmental degradation, while the actual causes of environmental degradation, such as the global capitalist market's drive to maintain profitability through expansion (Gould et al., 2004) are thus mostly ignored in mainstream literature. Larson (2005) suggests that addressing the underlying causes of invasion is avoided, as it would raise uncomfortable questions about our role as co-conspirators with invasives in our "urge to consume, to progress, to spread, and to travel" (p.499).

Larson (2005) examined the militaristic discourse framing invasives as the "enemy" and found that the metaphors used to describe invasives "harbor inaccuracies," which contribute not only to the public's misunderstanding of nonnative species, but also to misperceptions by conservationists themselves. This discursive framework also invokes "militaristic ways of

thinking that are inconsistent with a sustainable relation between humans and the natural world" (Larson, 2005, p.496). Similar to the rhetoric depicting nonnative species as immigrants, the militaristic discourse creates a polarized "us vs. them" relationship. Placing responsibility on the variously defined, yet consistently foreign, "other" does not rectify native species extinction or the degradation of habitats; it only continues to perpetuate a culture of environmental scapegoating (Bobertz, 1995).

These fears and anxieties projected onto invasives, like those associated with global population and migration, often include false assumptions. Many ecologists have demonstrated that both the introduction and the spread of invasives are solely the result of human interference in previously undisturbed ecosystems (Larson, 2005; Foster and Sandberg, 2004). Ballast water carried in international ocean liners (Dybas, 2004), packing crates used in freight shipments (Simberloff and Schmitz, 1999), the process of urbanization (Schaefer, 2009) and a myriad of other trade, tourist, and recreational activities have been linked to cases of species invasion (Perrings et al., 2005; Meyerson and Money, 2007). Thus it is not necessarily the species, but the human impact that frequently leads to an ecosystem's vulnerability to invasion. Human interference provides the launching point from which several non-native species have subsequently entered and devastated communities and ecosystems.

Focusing on invasives as the enemy masks the fact that our fears of deteriorating ecosystems and disappearing species are largely due to contemporary methods of production in industries around the world. These "treadmill of production" practices favor economic efficiency "as an unquestioned social good, although many of its externalities are treated piecemeal by various social agencies" (Schnaiberg, 1980, p. 215). Thus it can be inferred that the economic methods and practices mentioned previously take precedence over any risk of biodiversity loss

through introduction of non-native biota; capitalism prevails. The rhetorical analyses of the discourse surrounding invasives by Subrahmiam, Larson, and Robbins further point to the use of nonnative species as scapegoats for larger social problems; a misconstrual of seemingly objective biological facts through discourse (mis)use transforms invasives into scapegoats.

Similar to the biblical scapegoat who, through ritual, receives the sins of the Children of Israel and bears them away into the desert wilderness leaving the people cleansed of sin, the invasive scapegoat, through ritual, scientific investigation, absorbs the worries and uncertainty[1] of the global community and bears them away through its own dissolution. Eradication of non-natives is achieved via costly environmental management programs, yet permits communities to continue believing, whether consciously or unconsciously, that their own environmentally-detrimental practices can continue unchanged: "business as usual." Both the biblical and invasive scapegoats are the result of an active social construction, with unwanted thoughts and feelings projected on to the nonhuman entity.

The scapegoating of invasives provides an opportunity for corporate and political powerholders to direct attention away from real and urgent environmental problems. This scapegoating is often subtle and is accepted without question by many societies as it falls within the dominant human exemptionalist archetype: we rational (and often wealthy and often white) humans know what is best –and worst- for the global environment (Curry 2011; Dunlap and Catton, 1994). Even if societies were made aware of the intentional scapegoating of invasives it would "… not necessarily result in a more informed, participatory, and critically aware

[1] Worries and uncertainty related to issues such as the effects of climate change, loss of biodiversity, increasing deforestation, etc. are more deeply linked to concerns for how the planet can possibly continue to sustain current rates of growth and consumption (Curry, 2011).

citizenry" as the global powerholders "deploy science and the 'symbols of science' in ways that constrain public debate and critical, balanced understanding of the strengths and limitations of scientific knowledge" (Lahsen, 2005, p. 139).

Baskin (2002) asserts that, "in general, for every case of invasion some sector of society makes a profit" (cited in Garcia-Llorente et al., 2008, p. 2970). This statement may seem unlikely, as it is frequently the rhetoric of "costs" that accompany descriptions of nonnative species. For example, Simpson (2004) states:

> The total annual cost of invasive species to human societies worldwide can therefore be estimated to be in the hundreds of billions of dollars, including the costs of control, detrimental effects on human health, and losses in agricultural production and ecosystem services. This enormous sum far exceeds the combined annual cost of all natural disasters (Munich Re Group 2004) (p. 613).

This rhetoric of "costs" also resonates with Gren, Isacs, and Carlsson (2009) as they argue that the negative impacts of some invasive species, "…such as production losses resulting from alien pests in agriculture or degradation of power plants and water treatment plants caused by zebra mussels in the Great Lakes, have been documented in a number of studies since the 1960s" (p.135). However, what becomes noticeably absent from both examples is a complementary focus on the "profits" generated by and from nonnative species. The three case examples following the statistical Results section presented later in this paper exemplify the complicated relationship between profits, costs, and nonnative species and support Baskin's claim that nonnative species influence *some* sector of the economy, regardless of the valence of their impact.

METHODS

Dataset

The data source for this study is the Web of Science database, an online, searchable archive of scholarly publications. Web of Science is a unique research platform that indexes over 100 years of both cited and citing works, enabling users to search across time, disciplines, and journals of publication. It is recognized in the academic community as one of the top tools for research and teaching. The benefits of using Web of Science include access to an "Analyze Tool" that gives the user the ability to group search results and analyze and identify research trends across sets of publications (wokinfo.com, 2011). Table 1 provides a summary of the publication trends for the terms I used in this study.

Table 1. Web of Science Search Results showing the top five groups for each analysis category.

Search Term	**Funding Source**	**Publication Years**	**Subject Areas**	**Country of Publication**
Invasive species	NSF ⇒ ~3.5%	Most papers published from	Env Sci Ecology ⇒50.7%	US ⇒ 46.5%
	Australian Research Council ⇒ 1.6%	2000 onwards. Highest number of papers published	BD Conservation ⇒ 17%	Australia ⇒ 9.8%
	NSERC of Canada ⇒ 0.7%	in 2010 (17.5%).	Plant Science ⇒12.8%	Canada ⇒ 7.7%
	CNPQ ⇒ 0.6%		Marine Freshwater Bio ⇒ 10.5%	France ⇒ 7.2%
	USDA ⇒ 0.6%		Entomology ⇒ 5.9%	England ⇒ 5.6%
Exotic species	NSF ⇒ 2.5%	Most papers published from	Env Sci Ecology ⇒ 46.1%	US ⇒ 43.4%
	CNPQ ⇒ 0.7%	1997 onwards. Highest number of	Plant Science ⇒ 11.1%	Australia ⇒ 10.9%

Table 1 (cont'd)

	Dept. of Energy ⇒ 0.5% EU ⇒ 0.5% FEDEMIG ⇒ 0.5%	pubs in 2006 (9.7%).	BD Conservation ⇒ 10.9% Marine Freshwater Bio ⇒ 10.3% Forestry ⇒ 9.7%	Canada ⇒ 6.1% England ⇒ 4.2 Franc ⇒ 3.8%
Introduced species	Australian Research Council ⇒ 1.5% NSF ⇒ 1.3% DST ⇒ 0.6% Czech Republic ⇒ 0.4% NSF of China ⇒ 0.4%	Most papers published from 1986 onwards. Highest number of pubs in 2002 (8.8%).	Env Sci Ecology ⇒ 32.6% Marine Freshwater Bio ⇒ 16.7% Entomology ⇒ 16.3% Plant Science ⇒ 11.9% BD Conservation ⇒ 10.5%	US ⇒ 37% Australia ⇒ 11.1% Canada ⇒ 7.1% England ⇒ 6.7% France ⇒ 5%

The following terms were searched in the title and abstract of the publication: "invasive species," "exotic species," and "introduced species." "Exotic" and "introduced" serve as comparisons for the term of interest: "invasive." The results returned by each search of the database were recorded and included: article title, author(s), year of publication, journal of publication, and search term. All searches were run within a 48-hour period in November 2011. Abstracts included in the search results were reviewed and independently coded to create three additional categorical variables: Globalization Discourse, Species Classification, and Impact Attribution of nonnative species (see Table 2).

Table 2. Descriptive statistics of select variables used in logistic regression.

Economic Impact	Present			Not Present	N
	14 (17.3%)			67 (82.7%)	81
Species Classification	Invasive	Exotic	Introduced	Multiple	
	18 (22.2%)	12 (14.8%)	9 (11.1%)	42 (51.8%)	81
Globalization Discourse	Present			Not Present	
	13 (16%)			68 (84%)	81

As Google Ngrams identified the rise of the term "invasive species" from 1990 onwards, only those studies published between 1990 and 2011 were included in the dataset.

This is exploratory research, thus the minimum number of data points required for each search term when running a logistic regression were included in the data set (Peduzzi, Concato, Kemper, Holford, and Feinstein, 1996); the first 30 results returned by Web of Science, as sorted by number of citations, were retained. This method was utilized to ensure that the studies with the highest potential impact were included in the analysis.

Measures

The dependent variable is "Impact Attribution" and was constructed by reviewing each abstract and determining how the author(s) framed nonnative species: as having an impact on human health, the environment, and/or economic associations. For example, if an author cited that several million dollars had been spent on eradicating a nonnative species, that abstract was classified as "economic." If an author discussed the declining health outcomes of a human community after the introduction of an invasive, this was classified as "health." (Note: only impacts to human health were classified as "health"; impacts to non-human health were

classified as “environmental”). I used critical discourse analysis to analyze the underlying assumptions present in the language of the publication. Abstracts including more than one type of classification were coded appropriately and also included in this analysis, as well as those abstracts that did not attribute an impact. However, a “strength of classification” measure was not developed. In order to use this variable as the dependent variable for a logistic regression, “Impact Attribution” was recoded into “Economic Impact” with “1” indicating the presence of an economic relationship in the abstract and “0” indicating no economic reference.

Independent variables utilized in this analysis include: Species Classification (invasive, exotic, introduced, or multiple), search term (invasive, exotic, or introduced), year of publication, journal of publication, and Globalization Discourse, a variable representing whether an abstract included a reference to a global impact. As suggested earlier, the expectation was that classification of a nonnative species as “invasive” was most likely to be tied to an economic Impact Attribution. Thus, “exotic” and “introduced” served as comparative search terms. Species Classification and Globalization Discourse were both developed through codification of the abstracts. Species Classification is a categorical variable, developed due to apparent inconsistencies between the search term and the discourse utilized by the authors in the written abstract. Frequently, authors used multiple nonnative species terms in their abstract, which varied from either the term used in the title of the publication or the search term. The Species Classification variable captures inconsistencies between the search term and the term(s) prescribed to nonnative species in the abstract. Globalization Discourse is a categorical variable used to capture the global component of invasive species; if the abstract attributed the species under investigation to multiple continents or used terms, such as “global,” “worldwide,” “international,” etc. the abstract was coded as utilizing “Globalization Discourse.”

Statistical Analysis

All statistical analyses were run using IBM SPSS Statistics 19. Logistic regression was used to assess how well the set of categorical predictor variables (search term, year of publication, journal of publication, Species Classification and Globalization Discourse) explained the categorical dependent variable, Economic Impact. Multicollinearity of independent variables was assessed using Pallant's (2010) suggestion of running a multiple linear regression and reviewing the collinearity statistics in the coefficients table. As all variables had tolerance values greater than 0.1, the variables had low correlation within the model. Variables were not highly correlated. The percent of missing data from this dataset was 10% (n=9), leaving a total of 81 abstracts for analysis. Outliers were assessed by comparing predictor variable means to the 5% Trimmed Mean, calculated in the descriptive table.

RESULTS

Descriptive statistics are provided in Table 2. There were relatively few nonnative species described as impacting human health, with only three abstracts referencing a measured negative effect on the physical condition of individuals. Of the sample, 46.7% of authors used multiple terms related to nonnative species in their abstract. A total of 15.6% of the abstracts selected referenced an economic relationship, the same percentage that utilized globalization discourse (there was no significant overlap between groups).

Direct logistic regression was performed to assess the impact of economic rhetoric on the classification of a nonindigenous species. The model contained four independent, or predictor, variables: Species Classification (invasive, exotic, introduced, or multiple), search term (invasive, exotic, or introduced), year of publication, and Globalization Discourse. A logistic regression of the sample with Economic Impact as the dependent variable contained non-significant results for the Omnibus tests of model coefficients (greater than .05); the Hosmer and Lemeshow results, however, were significant (greater than .05, at 0.858). These results indicate mixed support for the model. The model was not statistically significant x^2 (7, N = 81) = 2.21, p > .001, indicating that the model was unable to distinguish between abstracts utilizing an economic discourse and those which did not. The Cox and Snell R Square (0.027) and Nagelkerke R Square (.045), indicated that between 2.7% and 4.5% of the variability was explained by this set of variables. All four of the independent variables were non-significant, with year of publication the only variable having a positive B value, indicating that a later year of publication increases the probability of economic impact rhetoric (with an odds ratio of .69).

CASE EXAMPLES

The following three case examples provide insights into how perceptions of invasives are developed, have broad applications and potentially shift over time. These species were chosen based on the rich data available, as well as widespread public awareness of their various effects.

Nile Perch

The introduction of Nile perch in eastern central Africa in the 1950s is well known for its destructive impact on the ecology of Lake Victoria, the world's second largest body of fresh water and source of the Nile River. The lake's lengthy perimeter spans the countries of Uganda, Tanzania, and Kenya. Nile perch has contributed to the extinction of over 200 endemic marine species through heavy predation. Indirectly, their presence has led to increased deforestation and soil erosion, as well as a significant increase in the growth of nonnative algae and water hyacinth (Lowe et al., 2000). These indirect impacts are due to the extra wood required by locals to dry the oily skin of Nile perch and the subsequent increase in aquatic nutrient levels from run-off. Despite its significant environmental effects, the Nile perch is best known for its economic impact. Originally introduced by white land-owners to counteract the severe drop in indigenous fish species (such as tilapia), commercial exploitation of the Nile perch has usurped control of the fishing industry from local small-town fishing communities, driving many traditional fish traders into extreme poverty. The Nile perch market created new employment opportunities such as low-wage processing and factory positions and resulted in perch fillets becoming Tanzania's top export to Europe (Sauper, 2004).

Nutria

The nutria, also known as the water rat or coypu, is a large, semi-aquatic rodent native to South America. This species was introduced to the US in the 1930s as part of the growing international fur market. Nutria are frequently mistaken for beavers and therein lies their attraction: fashion trends of the time favored long-haired, wild-fur garments and the coypu had several qualities (coat, size, birth rate, etc.) that made them favorable for farming (nutria.com, 2007). Demand for nutria fur kept prices high through the 1950s and led to their "controlled" introduction in Europe and Asia. However, as fashion trends shifted to favoring leather and the international fur market began to shrink in the 1980s, nutria "escaped" from abandoned farms and spread throughout US coastal wetlands, destroying marshes by exceeding the local carrying capacity. As the market price of pelts decreased, hunters and trappers began to lose interest, shifting their focus toward more valuable raccoon and coyote pelts. In 2002 the Louisiana Department of Wildlife and Fisheries developed a control strategy for this mammal, now viewed as a pest, via a new incentive payment program for trappers (nutria.com, 2007).

Zebra Mussels

Originally native to eastern Europe, the zebra mussel has a long history of ocean-jumping; making its debut "invasion" in Great Britain in 1824, the zebra mussel then spread to the Netherlands (1827), Czech Republic (1893), Sweden (1920), Italy (1973), and across the Atlantic ocean to the Great Lakes in the USA (1988), with its most recently reported introduction in California (2008) (Hoddle, 2011). These invertebrates, which typically grow to the size of a fingernail, are greatly feared for their potentially devastating economic impacts. Zebra mussels are known to clog pipes, screens, and other water intake structures, increasing maintenance costs for major corporate industries, such as water treatment and power plants. The organisms can also

adversely affect recreational and tourist industries as zebra mussels frequently accumulate on marine surfaces (docks, boat hulls, buoys, anchors, and beaches). The intense fear of zebra mussels is evidenced by the costly advertisement campaign launched to limit their spread and encourage recreational boaters to take precautions, such as hosing boats and emptying live wells before moving between waterways. Like many other invasive species, the global spread of zebra mussels have been linked to international trade, more specifically, the transfer of mussels through ballast water discharged from thousands of transoceanic ships (Costello, Drake, and Lodge, 2007). The damage to local ecologies, evidenced by the decline in native mussels through attachment and competition for food, is greatly overshadowed by the damage to economies (i.e., the estimated $500 million spent annually to manage mussels). Focusing on the environmental impacts of zebra mussels could also potentially draw attention to the *positive* ecological benefits of zebra mussels, such as enhanced filtration rates and "improved water clarity, and reduc[tion in] the eutrophication of polluted lakes" (Hoddle, 2011).

Case Example Summary

All three examples highlight the role of economics, and more specifically the role of humans in their drive to expand the global capitalist market, prior to the introduction of a nonnative species and subsequent ecological devastation. As discussed earlier, this emerges in the rhetoric of both "costs" and "profits." These case examples provide evidence of a relationship between the classification of a species as "invasive" and the rhetorical framework used by biologists and ecologists in their studies, yet the significance and strength of these relationships requires further investigation. A larger sample size of abstracts and case examples may provide further insight.

SIGNIFICANCE

While Robbins, Larson, and Subramaniam have excelled in investigating the rhetoric and "naturecultures" surrounding invasive species and their embeddedness in cultural frameworks (Haraway, 1991), they approached the subject from a broad-based philosophical perspective, reviewing those articles that contributed to their arguments non-empirically. Similar to other classical and contemporary sociological theorists, they developed rich arguments that incorporated the scholarship with which they were most familiar, but a quantitative review of the literature had yet to be reported. For example, it is unclear exactly how many publications and journals influenced these scholars in the construction of their arguments. Furthermore, there are theoretical divides in the ecological and biological sciences and it may be unfair to lump such a diverse body of researchers into the single category of "conservationists." However, Robbins, Larson, and Subraminiam have laid the groundwork for this and future systematic investigations of the various discourses used to frame invasive species.

DISCUSSION

Although my analysis of the discourse used to describe invasive species in academic abstracts was not statistically significant, there remains a strong likelihood that organisms classified as "invasive" in a capitalist, Western-dominated world have an affiliation with an economic impact. This is evident from the case examples described. However, interrogating the discourse in abstracts may not reveal underlying, systemic relationships. For example, Scarce (1999) documents that funding plays a major role in the politics of biological and ecological research, as only those proposals consistent with the goals and mission of the funding agency receive financial support. His argument is consistent with foundational Weberian views of bureaucracy because institutions frequently operate to further economic and political goals. It is also possible that funds may only be allocated to the study of specific species. While I did not systematically evaluate the species of focus in each study, it was clear that certain organisms were of more interest than others. For example, in this dataset four articles (5%) focused specifically on zebra mussels and two articles (~2%) examined invasive grass species in Hawaii.

Scarce's (1999) article, "Who or What is in Control Here? Understanding the Social Context of Salmon Biology," is relevant as it illustrates how salmon are probably one of the most studied fish in the world due to their economic value and yet remain poorly understood biologically because of sociopolitical forces. In the case of salmon, both "external, macrolevel social forces such as political and economic entities" and "microlevel social factors… including interagency politics and the elites that supervise funding decisions" (Scarce, 1999, p.772) control salmon biology and, more specifically, the distribution of research funds. It is also feasible that nonnative species fall victim to the same social forces, resulting in funding allocations to species of interest to the global market. An analysis of funding trends may better uncover the

mechanism(s) by which a nonnative species becomes "invasive," using a Weberian understanding of bureaucratic organizations and their limits as a guide.

Scarce (1999) supports the argument that federal agencies are more likely to fund research on a species or environmental problem that is of specific interest to the bureaucratic institution. He states: "funding is an expression of social control, especially the power of the agencies that identify areas worthy of research support and that distribute research dollars" (p. 768). This makes it more probable that biologists and ecologists will frame their research proposals around short-term solutions for nonnative organisms with invasive tendencies that impact economic relationships (i.e., recreational, agricultural, trade) due to salience to the funding agency. This leaves research into long-term environmental management solutions, which Scarce (1999) articulates as "basic research," well under-funded (p.772).[2] Scarce candidly states, "whether they are employed by governments, by corporations, or as consultants, biologists' work is made possible by political momentum or, perhaps, by political expediency, not by some mythical 'scientific imperative'" (p.772). Other scholars provide support for this statement, arguing for the reversal of centralized control over the production of knowledge (see for example Lahsen, 2005; Beck, Silvio, Funtowicz and Ravetz, 1992).

If the lack of objectivity in funding decisions is so well-documented, why do these processes continue to survive? Weber asserts that the institution of bureaucracy rests upon "expert training of individuals, a functional specialization of work, and an attitude set for

[2]Scarce (1999) distinguishes between two main types of research: basic and applied. He defines basic as engaging more practicality and establishing a thought-provoking mode of research (p. 770).

habitual and virtuoso-like mastery of single yet methodically integrated functions" (Gerth and Mills, 1946, p. 229). He also emphasizes that bureaucratic power, or more specifically legal-rational power, is attained through shared recognition of authority by the public. Therefore, having once invested bureaucratic funding agencies with authority it becomes incredibly difficult to interrogate the basis of that power. This is especially true of groups such as the National Science Foundation, which is expected to reflect the goals and cultural values of the American society for whom it was founded.

It is also probable that federal and corporate institutions are unprepared to deal with the implications of long-term research into nonnative species, which will likely further unearth human industrial, cultural and economic practices that decimate the environment around the world. As global climate change continues unmitigated, species and ecosystems will shift even more drastically. Research along these lines would "directly confront the complexity of how we are changing the planet" and likely require corporate giants to alter their methods of production (Larson, 2005, p. 499). Directing attention to the roots causes of "invasion" would potentially require a shift of expenses and responsibility to corporate and industrial entities as well.

Another method of interrogation that has potential to reveal a significant relationship between invasives and economics is an analysis of the species under investigation in each of the publications. Out of the hundreds of species categorized as invasive, which are dominating the literature? Only 3.3% of the 81 abstracts reviewed for this study focused on a microscopic species, aspergillosis, and it is clear that this focus is due to the presence of the species in respiratory sites of AIDS victims. Certainly, funding between nonnative plants and animals is not divided equally as not all animals are rated as detrimental as some plants and vice versa, but where do the trends emerge? In returning to the case examples, we see that some of the best-

known and most researched species, Nile perch, nutria, and zebra mussels, are those that have significant economic ties to market powerholders, global impacts, and whose effects on humans perpetuate interest in the species.

Geographic relationships are also worthy of note as the Globalization Discourse variable reveals that 16% (n=13) of the abstracts reviewed incorporated either rhetoric describing the global distribution of nonnatives or the effect of nonnatives in at least two continents. This indicates that invasives are frequently viewed as a problem of the global environment and broad ecological systems. This is not surprising as, mentioned earlier, the global spread of trade and travel is linked to increased cases of invasion.

It may be tempting to explore whether those species categorized as "invasive" are largely native to "peripheral" countries, spreading out to dominate those ecosystems in "core" nations, as suggested by Subramaniam's discussion of xenophobic language. Wallerstein argues that peripheral countries play a qualitatively different (i.e., less central role) in the Political Economy of the World-System (PEWS) (Roberts and Grimes, 2002); how might that role translate to contributing to the spread of invasives? These questions may appear to be worthy of further exploration as several of the top funders supporting research on invasive, exotic, and introduced species are based in "core" nations (see Table 1). However, many of the core nations have contributed to the spread of nonnatives in other core nations, such as through the introduction of North American largemouth bass to Europe for recreational fishing and the introduction of Australian eucalyptus to the California area for agricultural and medicinal purposes (Garcia-Llorente et al., 2008). In addition, islands often take the spotlight in ecological research as they frequently provide controlled settings in which to study the effects of a non-indigenous species, regardless of their designation as core, peripheral or semi-peripheral nations.

In summary, the rapid spread of nonnative species is a real and significant environmental issue, yet the extent of the capitalist economic system's influence on the management of invasives remains unclear. My study has revealed the variation in language used to describe invasives, but further research is necessary to unearth the subtle (and not-so-subtle) ties between capitalism, globalization, bureaucracy and species introduction. In addition, ecologists and conservation biologists should be encouraged to consider the sociological construction of their species of interest when engaging in research projects; understanding the social context of a species is key for understanding its biology.

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