The Ecology of Invasions and the Invasions of Ecology: Reevaluating the Disciplinary Program of the Invasion Sciences

by

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Introduction

Since the early 1980s, invasion ecology\(^1\) has systematically transformed from one of the more obscure topics in ecological thought into an independent field that is now regarded as a robust, albeit ideologically embattled, natural science.\(^1\) The institutional expansion of the field culminated in the late 1990s, with the introduction of governmental agencies such as the United States Invasive Species Council and the Delivering Alien Invasive Species Inventories for Europe (DAISIE) Project in the European Union. These agencies were meant to establish management strategies that would help “prevent the introduction and spread of invasive species.”\(^\text{ii}\)\(^\text{iii}\) By recognizing that the “economic or environmental harm [and] harm to human health” caused by species invasions demanded their epistemic isolation from other ecological phenomena, the United States and European Union both supported the initiation of a scientific discipline that focused exclusively on invasions and their impacts.\(^\text{iv}\) A discrete community of experts focused on species invasions was granted complete control over a correspondent disciplinary program for the first time.\(^\text{v}\) As a result, invasion ecology has evolved from a disjointed body of theoretical discussions and applied sciences to a continuous federation of researchers, activists and academics, establishing itself as a true scientific discipline in the past 30 years. Its epistemic isolation, in fact, might even demand

\(^1\) For the purposes of this paper, the study of biological invasions will from hence on be addressed either as “the invasion sciences” or “invasion ecology” in order to draw greater attention to the discipline’s empirical work on ecological systems. Although drawing copiously from biology research—and necessarily rising out of its conclusions—invasion studies’ influence as a field of research has come most significantly in the form of its attempts to draw substantive conclusions on ecological systems and how the interactions between individual species constitute such systems. Invasion biology’s research of these interspecies interactions, however, is not to be dismissed as trivial, as it is the study delineating the individual strands that compose the larger webs captured by invasion ecology.
that it no longer be considered a *sub*-discipline of ecology, since its research citations are almost exclusively internal and interact very little with the larger body of ecological science.\textsuperscript{vi}

It is important to note, however, that the use of the word “invasion” in its singular form fails to represent the breadth of moral, ecological and philosophical considerations stemming from the research going on both within and around the field of invasion ecology. This eclectic body of academic research casts light on a serious epistemic issue that the field’s practitioners are only starting to publicly confront: despite its growth into a well-respected and heavily funded scientific vocation, the discipline has not managed to firmly establish itself as a unified, systematized discourse with any sort of predictive capacity or clear theoretical framework; neither a strict criteria for what constitutes a biological invasion nor a system for determining appropriate management systems has come into existence, for example.\textsuperscript{vii} More pressingly still, the field’s essential framework is still unsettled: some environmental philosophers argue that identifying “invasions” as a threat to vital ecological traits, and therefore to entire ecosystems themselves, mistakes arbitrary assignment of intrinsic value for forms of disinterested objectivity.\textsuperscript{viii} This paper is meant to synthesize and expand upon the ongoing philosophical dialogue on the values that underpin invasion ecology and to trace the evolution of these values from 1958, when *The Ecology of Invasions by Animals and Plants* was first published, until present day.

Before going any further, though, it would do some good to establish what scientific disciplines are and how they are formed. In the “Discipline of Nature and the Nature of Disciplines,” Timothy Lenoir characterizes scientific disciplines as “creatures of history reflecting human habits and preferences rather than a fixed order of nature.”\textsuperscript{ix} Indeed, the
grouping of certain phenomena into self-contained clusters of meaning depends on a commitment to already existing structures of knowledge and the underlying social motives from which those structures came. Species invasions, the founding notion behind invasion ecology, is a product of already existing bodies of knowledge—both the demarcation of different types of geographical space and different breeds of organisms, for instance, necessarily precede any theory of non-native species and species invasions. One of the essential conditions for a discipline’s emergence is the inability of incumbent scientific dialogues to account for a particular set of phenomena without having to create an entirely new set of theories that isolate the issue appropriately—Lenoir refers to this as the formation of “an institutional niche.” In an institutional niche, names may already exist for the individual set of phenomena concerned, but no scientific criteria that can fuse those semantically disparate concepts into one central concept is available: purple loosestrife (a species originally identified in Europe) was known to have “colonized” the Great Lakes region (a geographical place) long before any system was put in place that could categorically label purple loosestrife as an invasive species in the region.

Disciplines, though, do not just come out of a disinterested desire to account for linguistically indeterminate entities through a new vocabulary. Rather, by the time the discipline is conceived, the set of phenomena around which it is built will have already been recognized as a practical “problem” that current power regimes have a vested interest in solving. Lenoir uses organic chemistry and molecular biology as examples, claiming that

2 Lenoir spends a significant amount of his article discussing Foucauldian ideas of “power regimes.” Though these ideas will not be explored in this paper, it is important to keep in mind that Lenoir asserts that entrenched political institutions with very specific economic impetus and ample monetary resources are the main parties responsible for the vocational emergence of disciplines. This is very much in line with the narrative of invasion ecology’s inception, which will be traced in the coming pages.
both are normative fields of understanding conceived to meet “the needs of agriculture, industry, and medicine” rather than being politically impartial undertakings. Sociopolitical incentives call for the establishment of knowledge structures that are consistent with existing power regimes’ agendas. This, says Lenoir, is precisely how theoretical shortcomings come to be perceived by any community at all: as normative inadequacies that are preventing structures of power from suitably addressing and solving problems.

Perhaps what is most important about Lenoir’s argument is that a discipline reorients empirical research on a set of phenomena so as to treat it as a problem that must be solved instead of as a valueless entity, and then offers a set of practical applications that can be used toward solving it. The process of filling an institutional niche is therefore one of redescription, shaped by power regimes’ ongoing understanding of the phenomena as an obstacle to their own continuation. The resulting reorientation, both of empirical research and applied interaction with the “problem” phenomena, is reinforced financially and institutionally by the incumbent regimes of power, ensuring that the discipline continues to grow in the same problem-solving direction with which it started. Lenoir thus characterizes scientific disciplines as “discourses of power as well as instruments of knowledge production.”

Thomas Hughes’s description of interactions between technological and environmental systems in Networks of Power offers an excellent parallel to Lenoir’s theory of disciplines and problems. Hughes defines technological systems as man-made structures that are designed to predictably serve the political and economic interests of specific sociopolitical bodies. Ideally, these systems are closed, or entirely self-contained and insusceptible to all exterior influences: “the final state [of a closed system] can be predicted
from the initial condition and the internal dynamic.”

Open technological systems, on the other hand, are unable to account for external factors, and are therefore vulnerable to the influences of those “environmental systems” that cannot be adequately dealt with by any available technological capabilities. Hughes, like Lenoir, recognizes that these open systems become “problems of control” which necessitate some sort of institutional response.

According to Hughes, the openness of a system is almost singularly the result of a “reverse salient”—the failure of certain technological “sub-systems” (a generator in an electrical system, for example) to evolve at the same rate as other sub-systems, such that the former’s stagnation holds back the general system’s continued development. This reasoning leads Hughes to establish a point very much in line with the thinking of Lenoir—that inadequacies recognized in a technological-scientific discourse will often necessitate the introduction of a new, more self-contained system that can compensate for the inherent inadequacies of the incumbent system: “when a reverse salient cannot be corrected within the context of an existing system, the problem becomes a radical one, the solution of which may bring a new and competing system.”

Both Hughes and Lenoir assert that structures of discourse between research and technology—referred to as disciplines and technological systems, respectively—are not inherently intended to advance an accumulation of empirical knowledge, but are rather a response to the unexplained influence that certain environmental phenomena have on an established political order. The creation of scientific disciplines is therefore intended to reproduce, adapt and enforce already existing institutional configurations of knowledge so that the rules directing those configurations can be used to explain physical processes that were previously unaccounted for. Only when the phenomena are understood in the
overarching context of the dominant political institution can the power regime then exercise its own power over those phenomena, thus integrating them into a closed—or at least less open—technological system. In this vein, Lenoir believes that the discursive structure and vocabulary offered by a new discipline serves to “mediate...between [the existing] political economy and the production of knowledge [on a set of natural phenomena],” particularly in cases such as that described by Hughes, wherein a cultural or technological system’s point of vulnerability to environmental factors is identified and duly dealt with.

“Assembling, channeling and replicating the social and technical practices essential to the functioning of the political economy and the system of power relations that actualize [the discipline]” is thus the primary impetus driving the further pursuit of empirical research in a discipline and shaping its theoretical evolution. It is important to note, however, that Lenoir’s account does not espouse strictly anti-naturalist ideals: instead of claiming that empirical sciences fail to reflect real phenomena by constructing self-affirming vocabularies in their place, he stresses that disciplines’ situatedness within a specific social context makes it so that the set of real circumstances which they do reflect in their research is limited to understanding phenomena either as physical components of, or influences on, the incumbent political order.

In order to “meet the needs of society through the appropriate organization and coordination of scientific work,” then, each discipline separates itself into what Lenoir calls the “research program” and the “disciplinary program.” Disciplinary programs come directly out of the political concerns that power structures have in addressing a specific topic, and are meant to offer “a sufficiently broad theoretical vision, methods, and...an inventory of techniques and instruments” on which a field’s practical work is hinged. The research
program, on the other hand, is the process by which the theoretical framework is articulated in order to more clearly delineate and offer more effective methods for addressing the “problems” which necessitated the existence of the field in the first place. Upon initiation, the two programs enter a reciprocal relationship: while the research program provides a more thorough understanding of the topic and potential solutions to problems, the disciplinary program uses this information in order to practically apply the research program’s theories according to the needs of society.

It is not a difficult task to describe the emergence of invasion ecology using Lenoir’s vocabulary for the structure of disciplines: a very abridged history reveals the same confluence of political impetus, technological inadequacy and epistemological disjointedness that he believes precipitates any discipline formation. By the 1970s—long before invasion ecology was recognized as an independent discipline—several efforts to suppress species invasions had already been undertaken by government agencies around the world. Most initiatives, however, were regarded as unsuccessful, either because they failed to predict the environmental impacts of their own control efforts, resulting in adverse effects on landscapes such as chemical pollution, or because they simply failed to suppress invasions altogether.

The absence of any systematized framework that could account for ecosystems’ “vital characteristics on a multiplicity of spatial, temporal, and structural scales” and give ecosystem managers a theoretical vocabulary with which to communicate amongst themselves, led to the general disappointment of these programs.

Without a normative vocabulary to describe the causal structures of the problem, institutions concerned with the impacts of invasive species had little to no grounds on which they could justify extensive management efforts against invasions. Despite mounting
recognition that invasive species did threaten certain economic and ecological interests, then, the use of more expensive and effectual management techniques was difficult to defend politically. The substantial monetary losses that would inevitably come out of such efforts politically outweighed the obscure and unguaranteed benefits of successful species suppressions. To be sure, some past management operations had been successful, but the reasons for their effectiveness at the time were obscure at best. The futility of extensive invasion control attempts, such as those launched against Water Hyacinth in Zimbabwe and South Africa, had demonstrated that the use of some of the more expensive and seemingly suitable technologies could yield no results or even exacerbate invasions.\textsuperscript{xxxi}

Unequipped with a normative system that could politically legitimize management campaigns, most governments could do no better than resort to the less expensive, inferior management techniques when combatting invasions, if they decided to do anything at all: “evidently economics has limited their application.”\textsuperscript{xxxii} For concerned governments to start undertaking invasion management efforts on a broader scale, then, they required a set of standards to thoroughly evaluate the costs, likelihood of success and appropriateness of certain management techniques—in other words, a normative criteria that could justify management of non-native species. By the start of the 1980’s, invasion ecology was little more than a clear institutional impetus to moderate the non-native species causing economic or ecological damage, a mounting body of research that catalogued the issue and vague, relatively untested ideas of how to go about efficiently combating the threat of these invasive species.\textsuperscript{xxxiii}

Though a substantial amount of species invasions research had been ongoing since the start of the 20\textsuperscript{th} century, not much use could be made of that research as long as a
skeleton for an overarching, testable vocabulary on species invasions did not exist.xxxiv This lack of a theoretical paradigm, however, is most certainly the “institutional niche” that originally spawned the discipline of invasion ecology. To produce predictive and more effective management strategies, a more thorough, universal account of species invasions was needed—one that would “focus on species invasions as a global phenomenon rather than a local event” and also explicitly frame invasions as a “problem” whose damages could be categorically studied and quantified.xxxv Such a system would have to provide criteria which invasion managers and ecologists alike could use to achieve their respective aims and consolidate the two practices into one discipline. The distinction of non-native “invasive” species from native species and their ecosystems, a general blueprint for ecological and economic risk assessment, and measures for predicting invasions were just a few of the prerequisites for providing a universal vocabulary for the study of biological invasions.xxxvi

_Biological Invasions: A Global Perspective_, published in 1989 by the Scientific Committee on Problems of the Environment (SCOPE),³ was the first major piece of literature to explicitly synthesize empirical research on biological invasions with invasion management efforts around the world.xxxvi Though past books had attempted to unite invasion ecology under one overarching structure—most notably _The Genetics of Colonizing Species_, released in 1965—none had approached invasions in the same way that _Biological Invasions_ unequivocally had: as a globally continuous, man-made problem that required a systematic

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³ SCOPE is a subsidiary of The International Council of Scientific Unions (ICSU), a non-governmental scientific organization composed of 10 scientific committees that are meant to address multidisciplinary scientific issues. Founded in 1982, SCOPE was the foremost institution behind the drastic increase in empirical research on species invasions that occurred in the 1980’s. _Biological Invasions_ was the first synthesis of studies associated with SCOPE. Interestingly enough, the SCOPE acronym today stands for “Society for the Conservation and Protection of the Environment.”
Colonizing Species had framed management as peripheral to establishing a universal scientific vocabulary centered on the phenomena, devoting only one out of its 25 chapters to any mechanisms of control in an attempt to develop a more disinterested perspective on the matter. Biological Invasions, on the other hand, unambiguously treated management and empirical research as equally important components of its mission to learn how to cope with and combat the problem of invasive species around the world. This, of course, attests to invasion ecology’s emergence as a problem-oriented discipline that could not have been established without a body of vocational purposes and practical applications that garnered the support of incumbent power regimes. In line with Lenoir’s observations, the discipline of invasion ecology—not to be confused with the general study of invasions, which had been ongoing since the 19th century—was founded as a systemic response to a problem that could not be practically accounted for by contemporary systems of scientific and technological understanding. The ethical and epistemological implications of these developments, both theoretical and practical, will be explored later on in this paper.

Since the release of Biological Invasions, the body of empirical research in invasion ecology has given way to a highly prolific and discursive scientific discipline: over the past 20 years alone, the field has gone from producing about 100 published works per year to over 3,000. As the theoretical scope of the field has expanded with concepts such as “invasional meltdown,” coined to describe mutualistic relationships between different invasive species spreading through the same exotic landscape, empirical research in the field has brought similarly self-affirming results: one study, for instance, identified species invasions as “second only to habitat loss as a cause of [global species] endangerment.” Syntheses of ecological and economic research, meanwhile, have argued that invasions also
have severe economic impact on central hubs of trade and commerce—“the total annual cost of invasive alien species in Europe,” for instance, “are estimated at €12.5 billion.”

The heightened sense of urgency taken on in the literature of invasion ecology has had a mutually enforcing relationship with a growing body of invasion management campaigns. Concerted governments—most notably those of the United States, South Africa, and island nations such as Australia and New Zealand—have responded to species invasions over the past twenty years by supporting the development of chemical, biological and mechanical agendas for suppressions or eradications of invasive species characterized as economically or ecologically “destructive.” The concurrent theoretical expansions of other sub-disciplines of ecology have also buttressed the ongoing institutional growth of invasion ecology. Some of the fields, such as restoration ecology and conservation ecology, share almost identical agendas centered on conservationist ideals, while others, such as succession ecology, present useful theoretical and empirical research that is usually less explicitly driven by any sort of practical agenda.

As the study of non-native species has expanded, however, the scientific and philosophical integrity of invasion ecology’s most foundational tenets has increasingly become the subject of severe academic skepticism: accusations of xenophobia; studies showing that invasive species are rarely responsible for native species endangerment; published pleas for less stigmatizing portrayals of invasive species; and characterizations of the discipline as “pseudoscience” have been among just a few of the criticisms offered of invasion ecology. The common thread among all of these accusations, in broadest strokes, is that anthropocentric interests are the sole influence on decisions relating to invasion
management and empirical research on the topic, and that any possibility of disinterested observation in the field is prevented by some intrinsic aspect of the field’s framework itself.

Some, such as Mark A. Davis, believe that this problem is a product of the terminology that has been uniformly endorsed by practitioners since Biological Invasions. This specific allegation is not geared toward the establishment of invasion ecology as a problem-oriented discipline, but rather what shape such a discipline took; the status of particular invasive species as “problem” is well-intended, according to Davis, and in many cases accurate, but the use of terms such as “invasion” and “indigenousness” prevents scientists, politicians and the general public from evaluating the impacts of non-native species outside of a framework which arbitrarily stigmatizes non-native species. The other indictment of invasion ecology, on the other hand, which comes primarily from environmental philosophers, asserts that conservationist ideals of “pristine ecosystems”—an ideal that invasive species are thought to impede—are themselves rooted in a value-laden aesthetics of ecology that has no rootedness other than our own historical preferences. “Aesthetic, religious, spiritual, historical [and] cultural” modes of judgment all collude to form the notion that native species have an inherent right to inhabit a particular place, and this notion has been confused for empirical fact.

This last claim, to be explored in greater depth in chapters three and four, would seem to bear some historical precedent: long before the field was anything more than a topic of hypothetical inquiry, intellectual ancestors of the field such as Robert Watson, a 19th century population ecologist, were researching the effects of species invasions with the explicit aim of anthropocentric interests in economically developed areas that relied on the interactions of certain native species. Referring to his theoretical work in population management, George
M. Thomson, another intellectual ancestor of invasion studies and author of *The Naturalization of Plants and Animals in New Zealand*, asserted that “the industry must have first consideration, and other [secondary] means found for protecting the wild things whose existence is threatened.”

None of this is to say, however, that all empirical research coming out of the field is rooted in purely aesthetic or culturally contingent viewpoints of the world. In fact, a large fraction, if not the vast majority, of criticisms lodged against invasion ecology have been offered by self-identified practitioners. Sometimes in the form of empirical research, and other times as theoretical inquiry, nearly all of the field’s self-critiques have, like Davis’s work, addressed the discipline’s perceived inadequacies by offering earnest proposals for theoretical solutions to the disciplinary structure. It is highly uncommon, however, for practicing invasion ecologists or biologists to raise questions that might epistemologically discredit the most prominent, intrinsic purposes of the field—namely, the protection and conservation of global biodiversity and species abundance.

Nevertheless, theoretical attacks launched against some of the main ideas behind the study of invasions have started to demand a reshaping of the field’s scientific framework. The primary subject of these attacks is the Diversity-Invasibility Hypothesis (DIH), which asserts that an ecosystem’s overall stability and productivity is intrinsically connected to the local abundance and variety of species. The causal connection of these two factors can be seen in works published as early as the 19th century, in books by Alphonse de Candolle and Joseph Hooker, and the theoretical thread has mostly persisted without many significant empirical challenges being launched against it. Now, the DIH—arguably the field’s most
fundamental theory—is being challenged by a growing community of well-respected practitioners who have provided empirical evidence that directly challenges its tenets.\textsuperscript{liv}

Invasion ecology is at a critical juncture in its development. While government and institutional support of the field continues to escalate, the abundant philosophical and empirical criticism being sprung onto the field—both from within its own ranks and outside of it—are demanding an adjustment of the linguistic and theoretical vocabulary used by the discipline to problematize invasive species, perhaps even so that species invasions are not even defined as problems at all. By looking at the historical arc of invasion ecology’s status as scientific discourse in Chapter One—from the periphery of theoretical ecology until 1958, to a slow 20 years of research accumulation and community formation, up until the rapid institutional growth that continues today—I will establish a firm sociopolitical basis on which to ground a comprehensive critique of the body of research that the field has amassed. The field’s foundation as a scientific discipline, I argue, has limited the metaphorical vocabulary of the field, and as a result has also limited the number of ways it can systematically respond to non-native species.

In Chapter Two, I offer a close reading of Charles Elton’s \textit{The Ecology of Invasions by Animals and Plants}, which continues to have a wide range of philosophical and practical influence on research done in the field.

In Chapter Three, I will outline contemporary philosophical and theoretical objections to the disciplinary program of the invasion sciences. The work of Brendan Larson, who points to the linguistic biases of the field, helps to articulate how invasion ecology’s current status as objective science restricts our understandings of and interactions with non-native species: the conflation of cultural values with objective fact, he claims, is preventing us from
attaining a more complete understanding of the phenomena at hand and, moreover, is helping to impose a social hierarchy. His proposed restructuring of the field’s linguistic vocabulary so as to make it more inclusive of marginalized framings of non-native species is synthesized with the work of Mark Davis, an active contributor to invasion ecology. Davis’s Dispersal-Invasibility Model, I suggest, offers a theoretical paradigm that could help to rectify the reification of entrenched cultural values and the theoretical shortcomings of the paradigm that dominates invasion ecology today. This does not mean, however, that the integration of his paradigm into the field’s framework will prevent or discourage management initiatives.

Finally, in Chapter Four, I offer an analysis of the ethics of species invasions in the broader context of ecology at large. The normative ethic of global biodiversity, I suggest, is brought directly into question by Davis’s new paradigm of species invasions, demanding a review of its role in the science of ecology at large. Drawing from the work of Mark Sagoff, who separates the ecological sciences into two disparate conceptions of nature—that of the economic utilitarian and that of the natural historian—I suggest that Davis’s new paradigm manages to merge some of the philosophical underpinnings of both. His Dispersal-Invasibility Model therefore offers a theoretical paradigm in which ecological and economic systems can interchangeably be framed as vital parts of one another, thus opening up ecology to entirely new forms of cultural discourse.
Chapter One
Reappropriation

The historical investigation begins by looking at *The Ecology of Invasions by Animals and Plants (EIAP)* by Charles S. Elton, a book almost universally regarded among invasion ecologists as the discipline’s singular foundational text.¹ Cited in academic texts at least 100 times per year since 1991, when the field was just beginning to get institutional recognition as a discipline, the book has come to be accepted as the first comprehensive synthesis of the ideas that had to be brought together for the study of non-native species to become an institutionally discrete, problem-oriented discipline.² In framing ecological invasions as a worldwide catastrophe of anthropogenic origin, Elton sought to use existing scientific literature to outline why and how invasive species presented a threat to human enterprises and ecological well-being, and what might be done to combat the problem: “it is not just nuclear bombs and wars that threaten us…there are other sorts of explosions, and this book is about ecological explosions.”³

Before gaining its canonical status in the early 1990’s, Elton’s book was not so widely cited among the invasion ecology community. The 1964 Biological Sciences Symposium held in Asilomar, for example, the first major multi-disciplinary meeting on global invasions that shortly after generated *The Genetics of Colonizing Species*, cited Elton’s work a mere three times.⁴⁵ This is not so surprising, since the contributors to *Colonizing Species* mostly avoided approaching the issue of non-native species as a problem or a threat to mankind; they were most concerned with isolating the underlying trends that made global species migrations a coherent set of phenomena without endorsing any sort of
practical approach to the issue. Toward this end, *Colonizing Species* almost never evokes images of catastrophe as Elton does in *EIAP*, depending instead on structures of knowledge like game theory and genetics to describe species invasions. The absence of an impetus to stop or suppress invasions in *Global Invasions* would understandably render a piece like *EIAP*, whose main accomplishment is the framing of species invasions as a problem in the context of ecological sciences, of little to use to the writers.

Research done under the supervision of SCOPE, on the other hand, including the work published in *Biological Invasions: A Global Perspective*, cited *Ecology of Invasions* at a prolific rate: almost 1 in every 3 publications published by SCOPE had some reference to the book. vi Used “always as a reference for the fact that invasions are important” and never to provide empirical evidence that helped support his theoretical work, Elton’s text was recognized in the 1980’s as the most authoritative demonstration of invasive species’ harmful impact, both on society and ecologies at large.vii Even when Elton is not referenced in research papers published in the discipline’s nascent years, it is hard to believe that the researchers were not at least indirectly influenced by his work, since so many of the terms and concepts that *EIAP* used to frame species invasions pervaded the discipline’s initial body of publications. The prevalence of Elton’s ideas in literature on invasions, as well as the direct correlation between the rising influence of his book and the institutional growth of invasion ecology, has brought Elton a sort of authoritative status as founder of invasion ecology, while *The Ecology of Invasions by Animals and Plants* has come to be thought of as the discipline’s “bible.”viii Today, the “Eltonian path of invasion biology” is believed to be the dominant school of thought in the field, making it the main subject of the theoretical and philosophical criticisms being launched against the study of invasions.ix
In “Charles Elton: Neither Founder Nor Siren, But Prophet,” Daniel Simberloff—regarded as the most steadfast advocate of the Eltonian path—argues that Elton’s role in the intellectual lineage of invasion ecology is greatly exaggerated in scholarly literature, and that Elton was not a founder but rather a prophet of the key concepts behind invasion ecology. He believes that other ecologists and biologists, specifically those working in the SCOPE program, recognized the problem presented by invasive species and went on to found the discipline of invasion ecology independently of Elton’s influence.\(^x\) The synthesis of problem-orientation and empirical research that came out of the SCOPE program in the 1980s—and not *Ecology of Invasions*—was therefore the first major force to recognize and fill the institutional niche that developed invasion ecology into a discipline. The prevalence of *Ecology of Invasions* in the literature of the field, he claims, is hardly more than coincidence, as the societal problems and the empirical research that compelled the discipline into existence endured regardless of Elton’s contributions. The only reason that Elton’s ideas have been so widely cited since the field was conceived, Simberloff contends, is that they are the most concise and clear expression of the theories that guide the research in the discipline.

Simberloff is right in many ways: Elton was by no means the first ecologist to identify the ecological and societal harms of invasive species, or even to use the term “invasions;” *EIAP* itself provides virtually no original empirical data to support its points; empirical research on non-native species up until the late 1980’s almost never referred to his works; and a long thirty years of research, theorizing and invasion management had to pass after the publication of *EIAP* until the genesis of a discipline could actually occur.\(^x\)^i These factors do well to suggest that “intellectual forces and/or societal issues made invasion biology an exciting, attractive research topic around the time of the SCOPE programme, not
a rediscovery of Elton’s classic.” But what implications, if any, does a reassessment of Elton’s role in the creation of the discipline actually have? Is his work not prevalent in the field regardless of whether or not he contributed to the discipline’s origination?

Ironically, Simberloff’s reassessment of Elton’s role in invasion ecology might make *The Ecology of Invasions* a more important landmark in the history of the discipline than the “founding father” narrative already makes it out to be. The reframing of Elton’s status—from the historical figure that almost singlehandedly conceived invasion ecology to an author whose theoretical ideas were retroactively selected to become the “foundational text”—reverses the narrative entirely; Elton’s text, as Simberloff says, was *not* the historically contingent foundation that it has been depicted as, but was rather chosen by the field as the consummate expression of its own theoretical framework.

By the 1980’s, sociopolitical interests had already made explicit demands of what a discipline studying species invasions would have to accomplish: the “destructive” invasions would need to be seamlessly incorporated into existing managerial systems and those not worth confronting needed to be identifiable. Before this could happen, however, researchers still needed a common theoretical framework for the problem—this would ensure that they oriented their work toward invasive species in the same way, setting the necessary foundations for a genuine disciplinary community with a normative vocabulary. It seems no coincidence, then, that the establishment of the discipline came during the same three-year period as the major spike in citations of *The Ecology of Invasions*. Once it was selected to be the authoritative text on why species invasions mattered—not, it should be noted, because it provided empirical research on individual species invasions—*EIAP*, over the course of three years, became the principal embodiment of the framework that invasion ecologists
could expound upon with their empirical research. Equipped with an adequate body of empirical research that defined what a species invasion was, the field needed an authoritative justification for why species invasions needed to be confronted by managerial systems—this is what Elton’s book was most focused on, explaining why it became such a cornerstone in the field.

By 1991, concepts originated in *The Ecology of Invasions* had already become the main linguistic and conceptual vehicles through which researchers could unite their works toward a specific goal, giving way to a tenable disciplinary program. This is precisely why the founder narrative is so pervasive—the ubiquitous use of Elton’s book served as a theoretical adhesive through which invasion scientists could exchange empirical research. Though it did not *originate* the ideas that founded the discipline, as Simberloff correctly claims, *EIAP* was recognized as those ideas’ most cogent exegesis. By conveying species invasions as drastic threats to economies and ecologies alike, the field gave itself the gravity it needed to procure support from larger institutional bodies. The analogy of *EIAP* as “the bible” of invasion ecology thus seems to resonate with near-definitive truth: though certainly written by Elton, the book’s composition by a historical figure is not nearly as important as the fact that invasion ecology drew it out of an otherwise obscure existence and into the center of the burgeoning field. The research community endowed *itself* with *Ecology of Invasions* by matching the ideas of the piece to the purposes of the discipline and then using Elton’s ideas to articulate in scientific terms the problem of invasive species. The founding father narrative has thus come about precisely because *EIAP* was recognized as the most complete articulation of the problems that invasion ecology sought to address—Elton is, indeed, a father, but only by virtue of reappropriation.
With these considerations in mind, a brief analysis of Elton’s text becomes essential to understanding the foundations of invasion ecology and its subsequent development. It is important to note which parts of Elton’s book have been emphasized, which ones have been ignored and which ones have been refuted by research in the field over the past twenty years. Because of *EIAP*’s popular status as foundational text, much of the criticism of the invasion sciences’ disciplinary program relies on a critique of *The Ecology of Invasions by Animals and Plants* itself. This is perhaps why Simberloff, as the foremost proponent of the Eltonian school,\(^4\) has tried to minimize the influence that Elton has had on the discipline. By demonstrating that the concepts of the book and those of the discipline are simply corresponding instead of coming from the same intellectual lineage, he is trying to extricate his peers in the field from any sense of beholdenness to Elton’s concepts: “…the explosion of research in invasion biology in the 1980s, and the directions research has taken since then, are not products of the monograph.”\(^{xiv}\)

But what reason would Simberloff have to distance the discipline from Elton? A review of Elton’s work in fact reveals some surprising disparities between his depiction of invasive species and the perception of indigenousness and invasiveness that is held today by most invasion ecologists. Matters on which Elton is entirely self-critical—including the conservation of “native systems” for purely economic interests, and not necessarily ecological ones; the long-term ecological impracticality of virtually all retroactive

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4 Simberloff is considered the most influential ecologist in the writing of US Executive Order 13112, which implemented the Invasive Species Council and laws pertaining to the management of invasive species in the United States. He has worked with SCOPE since the early 1980’s and also originated the idea of “invasive meltdown,” which many regard as the logical extension of Elton’s alarmist concept of “explosions.” He has also been the most publicly vocal critic of arguments that invasion ecology depends too much on ecological aesthetic or anthropocentric ideals. His work will be discussed in depth later on in this thesis.
management techniques; and the potential for a non-native species to actually support species richness in a particular area—all fall very much in line with some of the philosophical and theoretical criticisms being launched against the invasion sciences today. Whereas contemporary invasion ecologists rely on a fairly strict dichotomy between landscapes in their natural states and those which have been influenced by man, and the assumption that native systems have inherent ethical precedence over non-native systems, Elton is searching for “some wise principle of co-existence between man and nature, even if it has to be a modified kind of man and a modified kind of nature.”

This, then, draws attention to the ways in which invasion ecologists have reappropriated many of Elton’s claims into a less self-aware theoretical framework. Today, the same political incentives for maintaining native ecosystems that Elton embraces have been replaced by reified notions that native species are idealized embodiments of their natural habitats, and that nativeness is therefore in and of itself adequate justification for management campaigns, an agenda disparaged by certain environmental philosophers as “ecological aesthetics.”

Elton’s own career in invasion suppressions is largely indicative of the same anthropocentricity that he acknowledges throughout the book: he worked for the British government during World War II to suppress or eradicate the spread of various rodents that were threatening the national food supply during World War II. This was a cause he gave himself to with utmost passion, as evidenced by his correspondence with Aldo Leopold during the 1940’s, and that he never pretended to be for some purpose greater than the British war effort. The following review of *The Ecology of Invasions*, then, is meant to show that Elton, unlike many invasion ecologists today, was in fact entirely cognizant of the political
incentives for conservation, and that he publicly embraced his own prioritization of mankind’s survival over purely environmental entities:

“People do have to grow things in order to live and make a living, they need land, and good crops. It is no use pretending that conservation for pleasure or instruction, or the assigning of superior rights to animals will ever take precedence over human survival. Nor should it.”
In its opening pages, Charles Elton introduces *The Ecology of Invasions* as a synthesis of faunal history, ecology and conservation, “three different streams of thought with which I have been closely concerned during the last thirty years or so,” to be used together as epistemological vehicles for the examination of invasive and non-native species on a global scale.¹ Such an approach was innovative, perhaps even unheralded, because invasive species had been addressed until that point by people participating in each of those individual discourses, but never all three at once—both Joseph Hooker and Alfred de Candolle, for instance, had limited their otherwise far-reaching analysis of non-native species to aneikotaxonomy, “the classification of man-accompanying plants,” while James Ritchie focused on the effects of invasive species in a small geographic region in *The Influence of Man on Animal Life in Scotland*.² iii

Though recognized as a threat to certain human interests and confronted via biological control methods as early as the 19th century, invasive species—endowed by 1958 with an excess of alternative names, including “noxious,” “naturalized” and “denizen”—were nothing more than a topic of inquiry for ecologists, botanists and biologists alike that fed into broader modes of discourse, including the influence of man on pristine landscapes and patterns of evolution. Elton’s book was among the first to approach non-native species as a mode of discourse in and of itself, as an issue that suggested an independent set of rules that did not necessarily adhere to any existing theoretical frameworks.⁴ Such an undertaking
required Elton to look at as many instances of species invasions as possible in order to ensure that his treatise was sufficiently supported by the existing body of analysis on the subject.

What made Elton’s book so noteworthy, then, was not its fusion of separate, albeit deeply overlapping, scientific dialogues in order to consider the issue on its own terms, but rather the geological and chronological breadth of the examples that he used to make global generalizations about species invasions. Unlike his peers, Elton offered an analysis of species invasions that was not limited to one region, time period or trophic level—animals, plants and pathogens from many different places and periods are all given ample attention in *EIAP.* Elton separates types of species invasions by establishing distinct categories of geographical space in which invasions can occur: major continents, remote islands and bodies of water. According to Elton, these types of regions can be distinguished both by the structures of the interactions between organisms going on within them, and the relationships, or lack thereof, that those regions have with other areas of the world.

Elton claims that ecological communities such as tropical rainforests, which maintain more far-reaching and intricate webs of relations between a higher number of species, are analogous to more “organized human communities.” A more varied ecological system, in which each species has a firmly established ecological role, is far less likely to have “a vacant niche” that an exotic species can fill and exploit in order to integrate itself, just as a human immigrant might find it more difficult to prosper in a country that has already established a self-sustaining web of relations, duties and traditions amongst its citizens. Greater complexity of societal or ecological networks signifies lower vulnerability to perforations by foreign forms, and even when such perforations do occur, it is doubtful that the empty niches are significant enough for the non-native to propagate and out-compete its
peers so dramatically that it significantly alters the basic locus of the system. In fact, Elton claims that the introduction of non-native species in particular circumstances often helps to increase the general productivity of undisturbed, already diverse landscapes, by extending the web of native species relations, adding a new form of productivity and therefore buttressing the landscape so that it is less vulnerable to noxious invasions. Foreign species that acclimate to an undisturbed landscape as a result of their ability to fulfill essential ecological roles more efficiently than native species appear to raise no major moral objections in Elton’s book. Introductions like this, he points out several times, have been going on since long before humans inhabited the earth, and to object to such changes would seem arbitrary, and in many cases even counter-intuitive if our ultimate end is to achieve a healthy, stable ecology that can sustain modern institutions. Non-anthropogenic species migrations and displacements, Elton acknowledges, were indeed significant catalysts of the global evolutionary trends that formed the landscapes upon which we still depend today, and to malign the presence of any non-native species solely on the basis of its exoticism would be a blatant disavowal of a perfectly sound ecological process.

What, then, constitutes a species invasion for Elton and why does he consider them such a pressing issue that so urgently demands our attention? What criteria are there to distinguish a species invasion from a well-established non-native species that does not harm a system, and on what philosophical grounds should we be made to care about such occurrences? When is a species considered native and when is it non-native? For this, Elton turns to Alfred Wallace, who delineated six regions of the world that have been “isolated for such long periods that they have kept or evolved many special groups of animals.” Ever since the splitting of Pangaea, geological barriers such as mountain ranges and oceans have
effectively kept these regions of the world apart, rendering instances of species migration from one to another exceedingly rare, though certainly not impossible.\textsuperscript{xii} Over the course of millions of years, these isolated realms eventually gave way to the “separate nature reserves of Tertiary times,” constituted by systems of species interactions that were specially adapted to the geographical and ecological conditions from which they originated—Elton says that each of Wallace’s Realms spent millions of years “emerging like a photograph in a slow developer” until humans could bear witness to their existence.\textsuperscript{xii} Though the emergence of these realms was interrupted a few times by geological phenomena such as the land bridge over the Bering Strait or the migration of extremely adaptable species like the barn owl, each of which gave way to a marginal number of “dislocations as catastrophic as the entry of the sea lamprey into the inner Great Lakes or the spread of Asiatic chestnut fungus in America,” such incidents were the exceptions to otherwise robust separations, allowing each region to realize its own distinctive ecological identity.\textsuperscript{xiii}

Elton and Wallace assert that the realms emerged from teleological paths of evolution, giving way over millions of years to increasingly cohesive, well-adapted and productive networks of species, and finally culminating in the contemporary ecological epoch. For Elton, the relationships between species that had arisen by this time in each one of Wallace’s Realms were the key ecological characteristics that enabled the realization of modern civilization, and which we continue to depend upon for sustenance. But certain practices are causing the realms to lose their distinctiveness, resulting in a global homogenization of the world’s biota, and threatening to undo the integrity of the systems on which we have depended for so long:
“If we look far enough ahead, the eventual state of the biological world will become not more complex but simpler—and poorer. Instead of six continental realms of life, with all their minor components of mountain tops, islands and fresh waters, separated by barriers to dispersal, there will be only one world, with the remaining wild species dispersed up to the limits set by their genetic characteristics, not to the narrower limits set by mechanical barriers as well. If we were to build six great tanks, fill them with water and connect them all to each other by narrow tubing blocked by taps; then fill these tanks with different mixtures of a hundred thousand different chemical substances in solution; then turn on each tap for a minute each day; the substances would slowly diffuse from one tank to another…It might take quite a long time before the whole system came into final equilibrium, and when this had happened a great many of the substances would have recombined and, as specific compounds, disappeared from the mixture, with new ones or substitutes from other tanks taking their places. The tanks are the continents, the tubes represent human transport along the lines of commerce; but it has not proved possible to turn off the taps completely, even though we might often wish to do so. And although there is a Law of the Conservation of Matter, there is no Law of the Conservation of Species.”

Elton points out that airplanes, freshwater canals and ballast water tanks on ships, by fulfilling their purpose of connecting different markets around the world are simultaneously connecting the formerly isolated ecological systems to which each of those markets is bound. By offering shelter for crossing over otherwise intraversable geological barriers between realms, modes of global transportation are fueling an unprecedented mass migration of non-native species from region to region. And as our own avenues for intercontinental transportation expand, so do those that non-native species can use to transcend their own natural limitations—the process of global species homogenization, Elton believes, appears to be gaining more momentum everyday. It would seem, though, that this metaphor fails to address one of the most crucial characteristics of Wallace’s Realms—that every indigenous species, having undergone adaptation to the place in which it has been isolated for thousands of years, has an inherent competitive advantage against any non-native species that attempts to establish itself in a foreign biota. How could it be possible for a non-native species, adapted to an entirely separate set of geological and ecological circumstances, to outcompete
indigenous species in their own native biota? The tank-tube metaphor hardly alludes to the possibility that the tanks in and of themselves have inherent identities, and are therefore more conducive to the inhabitation of indigenous species over others. Elton does not once mention in this analogy conditions that distinguish regions of the world from one another, such as the aridity and climate of each continent. Instead, the composition of the tanks depends exclusively on how unguarded the tubes through which exchange occurs are, and not on any sort of innate characteristics that the tanks might possess.

This omission is by no means a mistake: Elton warns that the ecological idiosyncrasies that originally differentiated the continents from one another, much like the geographical barriers that have physically separated them for millions of years, are quickly dissipating. While transportation has facilitated the movement of species from realm to realm, agricultural and industrial development in economic hubs has altered the basic equilibrium of the continents, opening up ecological niches and bringing the basic ecological make-up of each region closer to one another. The intricate webs of species interactions that came out of evolutionary development are continuously being modified in order to suit the basic needs of man, and more often than not, those alterations entail an extensive simplification of the native ecology:

“\[The earnest desire of man has been to shorten food-chains, reduce their number and substitute new ones for old. We want plants without other herbivorous animals than ourselves eating them…Keep down or kill or drive away all competitors. Shorten the food-chain and harvest more energy.\]”

Once they are transported from their own native habitat to a new biota, then, foreign invaders, once unable to penetrate the robust web made up by native species interactions, are newly capable of exploiting ecological niches that have been opened to make room for
purposes of human sustenance and development. In Britain, for instance, burgeoning populations of non-native weed species appear predicated on the continued spread of “cornfields and road-side waste” through the landscape—the elimination of natural competitors in these agriculturally developed areas and their geographical continuity through Britain provide a thread of available host sites through which weeds can quickly propagate, unfettered by native fauna and other influences that would have impeded their proliferation.\textsuperscript{xvi} Elton therefore sees it as no surprise that so many non-native weeds and birds first appear in major cities or on roadsides before they spread on a broader scale into less developed areas. Since they are doubly loci of transportation and places where “ecological resistance” has already been reduced in order to facilitate agricultural or industrial growth, cities and roads are extremely conducive to the spread of species that are well-adapted to anthropogenic changes in landscapes.\textsuperscript{xvii} The sudden removal or stifling of \textit{any} part of that fragile dynamic, especially in an economic hub—where non-native species are arriving at the most frequent rates via intercontinental transportation—very well may, and usually will, lead to the successful integration of a non-native species.

Once non-native species establish themselves in an area disturbed by human practices, they are often able to expand their domain of influence beyond the most manipulated parts of a landscape and into the landscape features which remain from the original systems. When the basic ecological equilibrium has been shifted by human practices, it is likely that many native species surviving in the area no longer have one, or even several, of the mechanisms that formerly stabilized their population: trees in Germany and England suffering from presumably anthropogenic “disbalance with the climate or soil,” Elton explains, were more vulnerable to consumption by the longicorn beetle, which is not known
to harm the same species of trees in its native habitats. The disturbance caused by agricultural and industrial development in the regions and the accidental introduction of a species that was not considered harmful in its native habitat coalesced to ultimately pose a significant threat to the populations of multiple native species. This is the trend to which Elton hopes to alert his reader, and which he believes is an affront to both the health of ecologies around the world and the maintenance of modern civilization.

Empty niches will arise wherever a landscape has been simplified or a food chain shortened by man, offering non-native species a chance to integrate themselves into the new dynamic and outcompete or overwhelm native species that have already been compromised by anthropogenic development in some way. A species invasion can be discerned from a harmless introduction when the spread of a non-native is so severe and its competitive advantage against native species so significant that its presence is thought to cause the endangerment or extinction of a particular indigenous species, and to play an active role in the simplification of that landscape. The task we are faced with, then, is “to manage, control, and where necessary alter the patterns of food-chain in the world, without upsetting the balance of their populations” so that the landscapes we use are no longer so vulnerable to species invasions. This provides context for the larger crisis to which EIAP was meant to alert the general public: human modes of transportation and the development of landscapes are allowing a limited number of species that are particularly well-adapted to human practices, most frequently in the form of weeds or pests, to spread into places that have been severely altered by humans. As a consequence, several species endemic to small geographical regions around the world are in danger, first by virtue of the modifications we have made to their native ecologies and our own methods for shortening food chains, but also
as a consequence of the species from different regions of the world that are able to thrive in these altered systems. Meanwhile, the species that thrive in systems marked by anthropogenic development, such as the cottony cushion scale insect, which has spread from Australia to such disparate ecologies as Japan, Egypt, Europe and South America, are exceeding their original geographical limitations and propagating throughout the world, stifling the biotic diversity that Wallace’s Realms gave way to. Though it is unclear in Elton’s book what exactly the specific criteria for an invasion is, particularly concerning native species that spread in a comparably noxious way to non-native invaders, the crux of the problem that is global species invasions could not be any more explicit—this is a phenomenon caused by human practices, and it is presenting an immediate threat to the sustaining of global species and biotic diversity.

It would not be at all far from the truth to say that, with the exception of the attributed connection between biological diversity and vulnerability to introduction of foreign species, each of the major points of *Elton* is accepted on a virtually universal scale in the invasion science community. Invasion ecologists still rely on many ideas articulated by Elton, including the causal connection between species invasions and economic development and the notion that global species diversity is diminishing as a result of this relationship. *Elton* is still widely believed to be an essential source of primary reading for students who want to introduce themselves to the fundamental mechanistic processes behind species invasions and the theoretical structure on which the discipline is founded. Though certain ideas proposed in the book are under intense empirical scrutiny from practitioners in the field, the causal structures and trends ascribed to global species invasions put forth in *Elton* are still largely consistent with the growing body of empirical evidence offered by the invasion sciences.
The Ecology of Invasions by Animals and Plants, however, was not only intended to provide a disinterested overview on global species invasions. Indeed, the original notion of a species “invasion” implies a clear ethical position on the matter, one that Elton was not in the least bit reluctant to broadcast publicly. Released in 1958, the book came at a time when Leopoldian concepts such as land ethic and conservationism were exiting their nascent stages and starting to gain legitimate public attention among both natural scientists and policy makers. Elton himself was in frequent communication with Leopold, as the two found that their philosophical and political views were very much in line with one another’s, and that those ideals imbued the scientific work of each with a deeper political purpose. Their findings in different continents gave them more varied geographical samples that they could use to deepen their respective inquiries into a variety of topics, of which species invasions and the anthropogenic homogenization of biota, unsurprisingly, were two of the more frequently discussed. In their letters to one another, both Elton and Leopold emphasized the importance of sitting in solitude to consider the ethical ramifications of anthropogenic changes to biota around the world and what they could and should do to ensure that their moral principles were reflected in their scientific work and advocacy.

The Ecology of Invasions by Animals and Plants, like much of Leopold’s work, is just as much an explanation of causal structures in ecology as it is an ethical treatise on why action must be taken to ensure that the most essential incarnations of those structures stay intact. Elton spends the last half of the book reasoning why species diversity and the distinguishing characteristics of biota should be thought to possess intrinsic value, infusing a clear sense of moral consequence into the global anthropogenic spread of non-native species. Today, however, the segments of the book in which Elton offers the ethical grounds for why
invasive species be viewed as a global threat are widely considered amongst invasion ecologists to be nothing more than “profound for the time,” hardly meaningful additions to any contemporary scientific discourse.\textsuperscript{xxvi} Ironically, it is the universal acceptance of his moral convictions as quasi-empirical fact that has rendered this part of Elton’s book into a cultural anachronism. The discipline of invasion ecology is innately grounded in the same philosophical conclusions that Elton carefully justifies in over 20 pages of prose, namely, that biotic diversity is desirable, that species invasions, as direct menaces to that diversity, are undesirable, and that managerial action therefore should be taken in order to suppress species invasions.

As a result, Elton’s explication of these priorities has been reduced to nothing more than a theoretical groundwork from which the invasion sciences have already departed and evolved, rather than a text with which the field can continue to engage in a meaningful dialogue. A reawakening of the moral inquisition into why combatting species invasions ought to occur and what form such action ought to take, as Elton does in \textit{EIAP}, would require invasion ecologists to undertake a philosophical reevaluation of their own vocation. Indeed, such an inquisition is ongoing within the fringes of the field, and is raising significant philosophical questions about the political and scientific integrity of the invasion sciences as they stand today. The same questions provided in Elton’s book—about the value of biodiversity and the generalized impacts of invasive species, for instance—are being met with a new set of answers by a small community of invasion ecologists and philosophers, and these answers are dictating a general restructuring of institutional approaches to species invasions. Even in these conversations, however, Elton’s ethical and theoretical framework
for species invasions still serves as the basic template of concepts and causal relationships from which those challenging the conventions of the field depart.

Having delineated what constitutes a species invasion in the first seven chapters of *EIAP*, Elton uses the eighth and ninth chapters, “The Reasons for Conservation” and “The Conservation of Variety,” to articulate his own ethical ecological principles and then deduce what an applied response to a species invasions would have to accomplish to ensure that those principles are upheld. Elton explains that he understands the concept of conservation to be “the keeping or putting in the landscape of the greatest possible ecological variety—in the world, in every continent or island, and so far as practicable in every district.” xxvii A concerned interest in maintaining ecological diversity, he says, consolidates three otherwise divergent ecological attitudes that are each held to be true by different factions of people: first, the belief that all living beings on this planet have an inherent right to live in their native lands and to continue thriving in their native communities without human interference; second, that the variety of species and ecological systems provides mankind with a diversity of sensations which amuses and inspires us everyday, and that to diminish this variety would also limit the range of experiences that we are capable of having; and third, that the exponential growth in human population and expanding material standards are simplifying ecological systems, threatening both biotic diversity and the capacity of the earth to sustain any civilization at all. xxviii It is therefore of utmost importance—largely for our own self-interested purposes, Elton is unashamed to admit—that we seek to preserve the biological diversity in the world.

The ultimate objective of Elton’s book is to establish a framework for empirical understanding that can be used to pursue a viable equilibrium between the simplifying but
efficient practices of civilized man—including agriculture, urban development and industrialism—and the less predictable but more robust structures of native landscapes upon which those practices depend. Because robust endemic communities are necessary to protect ecological systems from invasions, the species diversity of an area should be regarded as essential to the systems of agricultural and industrial production that invasions threaten to restrain. Only the intricately woven webs of species-rich landscapes can foster uninterrupted biotic diversity, and so our practices of unsuppressed “simplification for efficiency” must be curtailed, or at least carefully scrutinized, so that they can work in greater harmony with endemic ecological communities and not open new niches that invaders can exploit. xxix It is in the best interest of both the human and non-human inhabitants of the Earth that our institutions begin drawing from “the practices upon which nature actually works, not on which an engineer or chemist works,” so that Wallace’s Realms can retain at least some traces of their individuality and vigor as we continue to live within them. xxx The stability of native biotic populations, and therefore the continuation of civilization as we know it, is hinged on our own ability to recognize the importance of biological diversity, and our willingness to make it into an institutional priority.

Managerial solutions such as “quarantine and the massive campaigns of eradication,” Elton says, are in fact necessary, but only insofar as they are “ways of buying time” while we figure out how to more graciously integrate ourselves into ecological systems. xxxi Temporary solutions such as DDT and herbicides might be necessary to ensure that already successful species invasions go no further in threatening the practices on which we depend, but they must not be confused for permanent solutions to the homogenization of the Earth’s biota. Such a conflation, Elton claims, would feed into the perpetual deferral of systemic change,
and in some cases might even actively contribute to the problem—the application of DDT, for instance, often exacerbates biological invasions by eliminating native species.\textsuperscript{xxxii}

Instead of indefinitely depending on institutional stopgaps, Elton asserts, human society must formulate a more holistic set of practices that offers “a connective tissue binding together the separate organs of the landscape,” so that our institutions and the native ecologies on which those institutions depend can foster a reciprocal, mutually sustaining relationship.\textsuperscript{xxxiii} Species diversity is the simplest, most straightforward barometer that we can use to determine the influence our practices have on native ecosystems and whether our aims to conserve ecological systems are succeeding.

More than 50 years after the publication of Elton’s book, both local and global biodiversity are still topics of prolific discussion amongst invasion ecologists and biologists, and are still pervasively used as empirical measures for determining the impact that invasive species have both on particular ecosystems and the world. The contemporary role of biodiversity as a criterion for ethical and empirical judgment in the ecological sciences, furthermore, has been a prominent topic of inquiry amongst ecologists and environmental philosophers alike. Later on, I will explore how investigations of biodiversity’s normative influence have manifested themselves within the invasion sciences, and how the invasion sciences, in turn, have lent themselves to these investigations.
Chapter Three
Reification

In “Science, Discourse, and Literature,” James Bono constructs a framework for understanding the relationship between the language a scientist uses to refer to observable phenomena, and the evolution of the theories that depend on language to convey empirical observations. Indeed, Bono argues that science relies on metaphor to be able to study phenomena at all, asserting that “metaphors provide…linguistic tools for obtaining a purchase upon the empirical world.” The metaphorical framework used to articulate a research project for the first time, however, inevitably restricts theoretical evolution to a limited number of possibilities—namely, only those that comply with the presupposed metaphorical framework and its underlying cultural assumptions. The value of empirical observation and theoretical evolution is therefore derived exclusively from science’s capacity to graft concrete and emplaced cultural beliefs onto observed phenomena so that we are better able to incorporate those phenomena into our belief systems. The study of medicine, for instance, is at once making real strides in empirically understanding the human body, but only in the service of advancing our cultural desire to find means for eradicating disease.

The evolution of theories is framed by scientific realists as the asymptotical approach toward a more literal, less metaphorical understanding of an empirical world which can only be fully understood with truly objective terms, which falls outside the epistemological realm of culture. But Bono contends that the scientific realist conception of theory-constitutive metaphors fails both to recognize the cultural
situatedness of science as a social institution and to account for the power of language to shape and mold our understanding of the world. Theory articulation is in fact achieved when the scientific community—dependent on culturally contingent, metaphorical understandings of the world—are able to gain greater practical control over the phenomena which they seek to observe through better understanding of underlying causal structures. But the theory-constitutive metaphors do not become more literal as the theories that employ them gain empirical and objective reproducibility; rather, the world becomes more responsive to the same metaphors that scientists originally chose to define it. Notions of scientific objectivity, Bono asserts, make us believe that this heightened ability to impose our metaphorical framework onto the empirical world is in fact a move away from metaphor, and toward literalness. But the prescriptive power of metaphor is not lost as the descriptive capacity of empirical evaluation increases—both are equally fundamental components of the scientific project, and neither would be successful without the other.

The emergence of new scientific discourses, then, are direct reflections of cultural or social change, of a society’s espousal of certain ideals and the metaphorical vocabulary necessary to express them. Those ideals will persist within the science as long as the original paradigm for understanding the set of phenomena is still in place. The cultural associations of theory-constitutive metaphor “may be submerged, or even deliberately veiled by rhetorical ploys aimed at enforcing the objectivity and authority of a given scientific discourse, but nevertheless they reveal, under scrutiny, the values-implications embedded in a particular discourse.”

Claims
to objectivity, then, often become impositions of social hierarchies, at the apex of which scientists and their associates are able to impose their own metaphorical understanding of the world as objective fact, rather than as a limited, embodied understanding of the world. Though such claims might not always be problematic, there are particular instances in which the invocation of objectivity in place of admission to a cultural or metaphorical understanding can restrict people from engaging with phenomena in a more holistic and thoughtful manner.

In his recent history of the invasion sciences, Mark A. Davis identifies “two roads, one less traveled than the other,” whose different approaches to the same set of phenomena are marked by fundamentally disparate theoretical and linguistic paradigms.iii The more traveled path is the same that I have already identified as the recognized discipline of invasion ecology at large. Born out of The Ecology of Invasions, and later Biological Invasions: A Global Perspective, this path explicitly associates itself with a particular set of conservation aims, using Elton’s original linguistic framework to demarcate specific species introductions as ecological problems. The criteria for determining what is and is not a problem that advocates of this path employ are ostensibly very much in line with the same criteria originally conveyed by Elton in EIAP: a species, either native or non-native, whose spread through a landscape directly endangers the continuation of native ecological processes or native species that are an integral part of that system’s protective ecological web is considered invasive, and therefore problematic in some respect.

These criteria, and the framing of an invasion as a problem, consistently rely on the following underlying assumptions: that the biodiversity of a native ecosystem
is the product of a natural process by which a community of species evolved in a symbiotic fashion, each establishing its own characteristic niche in the process; that higher biodiversity signifies the greater specialization and more efficient use of resources by each native species; that higher biodiversity therefore directly determines how vulnerable a landscape is to a foreign species’ successful integration into the ecological system; and that the established presence of a non-native species is always either a signal or a source of disruption to a native landscape’s self-sustaining ecological diversity. Davis notes that those scientists and environmental managers who still hold these ideas to be true make up the most publicly visible, politically viable contingent of the field. Their work has been the theoretical source of most, if not all, managerial efforts to have come out of invasion ecology—such action, it would seem, is inseparable from normative framings of species invasion as a problem that exists within the world.

Daniel Simberloff has perhaps been the most prominent leader of this faction since the 1980’s, having expanded some of Elton’s ideas on species invasions into newer, more alarmist concepts that demand the attention of the general public. His theory of “invasional meltdown,” for instance, along with other studies on the homogenizing impacts of invasive species, has been used as evidence to advocate for such severe strategies as a “guilty until proven innocent” approach to all non-native species. Though Simberloff has admitted that the impacts of many, if not most, non-native species are not necessarily ecologically harmful, he contends that those which do pose a threat to systems of native species interactions are dangerous enough to demand constant vigilance from institutions and invasion scientists alike. Without an
undying commitment to the protection of native species from potential invasions, Simberloff argues, invasion scientists will lack the impetus necessary to solve the problem of species invasions. The formulation of a universally applicable theory to predict and prevent future invasions and to effectively subdue those that have already occurred is therefore the disciplinary program that Simberloff endorses. Species invasions, according to this belief, are direct threats both to human interests and the same intrinsically valuable, native ecological characteristics values by Elton. Mark Davis refers to this more popularized framing of species invasions and its concomitant research community as the “Eltonian path” of invasion ecology.

The other path, which Davis explicitly sympathizes with in his paper—he might in fact be considered its most influential advocate today—was originated by the 1964 Asilomar Conference, which was intended to foster discussion on “the kinds of evolutionary change which take place when organisms are introduced into new territories.” As the mission statement suggests, almost all participants in the conference made a conscious effort at not committing to or implicitly associating their research with any managerial system of response to foreign species, striving instead to study the phenomena of non-native species on exclusively empirical, disinterested grounds. Whereas the Eltonian path has always had a clear practical motive for its research on invasive species, the expectation that any specific type of interaction with non-native species would come out of their research was non-existent among participants in the Asilomar Conference. As a result, the theories that emerged from this body of research assumed what Davis calls a more “value-neutral” identity. In this vein, advocates of the Asilomar path generally avoided using terms such as
“invasion,” “alien” and “indigenous,” which had explicit cultural connotations. Instead, they resorted to using words such as “colonizer” and “introduction” to describe the phenomena at hand, sometimes even avoiding distinguishing species on the basis of their geographical origin altogether. This linguistic framework was not only indicative of already existing philosophical differences between the Eltonian and Asilomar paths, but also a dynamic element of their ongoing separation: the respective metaphorical structures of the two paths acted simultaneously as manifestations of separate belief systems, and as normative frameworks that dictated the outlook that future contributors would assume when studying non-native species.

Today, a contingent of invasion scientists and associated philosophers still espouses the views and vocabularies of the Asilomar path, but they do not have the same type of institutional support as those working to advance the Eltonian path—federal governments leading the study of non-native species, such as that of South Africa and the United States, have made it clear that species invasions are thought to be tangible and significant threats to their environmental and economic priorities, and they have not failed to act accordingly. United States Executive Order 13112, ratified in 1999 by President Clinton, marked the culmination of the Eltonian path’s institutional ascendancy by declaring a “War on Invasive Species” and establishing an Invasive Species Council responsible for “preventing spread of invasive species from areas where they are present, and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.” Like other nations before it, the United States had founded an institutional body that was tasked simultaneously with advancing the empirical study
of non-native species as an ecological phenomenon, and with acting to ensure that the impact of harmful species on pristine, native landscapes was minimized. It goes without saying that the juncture at which practical action and knowledge formation converged in this institution was encapsulated by one ubiquitous word: “invasion.”

As a result of the overwhelming institutional support for systems of knowledge that construct the problem of “invasive species,” the writings of those who openly sympathize with the aspirations of the Asilomar Conference tend to be oriented in direct opposition to the metaphorical systems originated in *ELAP* and which are still endorsed by governmental institutions around the world. The condemnation and dismantling of the current paradigm on which the discipline relies has thus become a more salient concern than the pursuit of an alternative system for understanding interactions between species of different geographical origins, and perhaps with good reason. Before any alternative normative framing of species origin and migration can gain real institutional recognition, it will be necessary to methodically expose the limitations of the incumbent paradigm. To this end, critics of the Eltonian path have launched a two-pronged offensive against the discipline as it stands today: first, against the metaphors that guide ongoing research in the field; and second, against the theoretical structure of the discipline that has materialized alongside those metaphors.

Brendan Larson, a philosopher and evolutionary ecologist, has offered an extensive set of rebuttals to the systems of language used to study invasive species. He firmly endorses Bono’s belief that the role of language in science is a fundamental stimulus for the direction our empirical research takes, as it binds us to an esoteric,
incomplete framing of the phenomena at hand. In the case of invasion ecology, the institutions supporting the use of a “militaristic system of metaphors” to frame invasive species have failed to acknowledge the limitedness of their metaphors by invoking claims of absolute objectivity in reference to those metaphorical frameworks. vii As a result, a research community that consistently conflates its own cultural and political interests with objective fact has restricted scientific understanding of non-native species to nothing further than varying degrees of antagonism, preventing the realization of a substantive theoretical program that has a firm empirical basis. The role of the field’s most constitutive term, “invader,” lends itself to Larson’s point: originally meant to describe foreign species that were deemed harmful, but purportedly not prohibited from being used for insidious native species as well, the word has come to encapsulate the entire scientific field, while no word for describing phenomena such as innocuous non-native species or harmful native species has received a comparable degree of attention.

Though advocates of the Eltonian path claim that the definition of “invasion” does not categorically exclude native species, it seems reasonable to claim that native species’ status as a part of the same ecological systems which stand to be threatened by species invasions makes it epistemologically impossible to classify a native as “invasive,” even when it might be demonstrated as ecologically harmful in some respect. The use of the descriptor “native” to refer to a species implies that that species is already in its proper place, that its presence is the result of the same teleological, ecological process described by Elton as the geological separation and evolutionary development of Wallace’s Realms. The recognition of a native species
as “invasive,” then, would require exhaustive epistemological substantiation that its
current ecological character somehow transgresses or exceeds the limitations of the
“native” or “natural” identity that it once possessed. Empirically exhibiting these
traits seems to be an impossible task, though advocates of the Eltonian path argue
otherwise. In practice, “native” and “invasive” are antithetical terms: no species has
to date been classified as both “native” and “invasive” to the same landscape. viii

On the other hand, the separateness of foreign species from native landscapes
makes it so that any impact they may have on native systems can be construed as a
legitimate “invasion.” A species’ transgression of delineated geographical boundaries
between continents, ecosystems or nations is easily identified in empirical terms as an
unprecedented change in natural systems, satisfying the first norm necessary to
classify a species as “invasive.” The second norm, which we might simply refer to as
“threat to the native landscape” can take a broad number of forms, and often does not
require an explanation beyond the successful establishment of the non-native species.

As a result of these linguistic inadequacies, Larson claims, invasion ecologists
and stakeholders are too often predisposed to “conflating spread with impact,”
explicitly implicating almost all non-natives as harmful, or even malicious, while
privileging native species without any empirical basis for this distinction. ix This has
precipitated a number of gratuitous campaigns against non-native species that are
easily classified “invasive,” but are of little or no ecological significance. Instead,
political motives concealed within invasion ecology’s metaphorical framework are
dictating what appears to be the classificatory scheme. In Great Britain, for instance,
support for eradicating the non-native American grey squirrel on the grounds that it is
replacing the native red squirrel—a political campaign that has received support from concerned ecologists since the early 20\textsuperscript{th} century—is no longer framed as a merely aesthetic or patriotic value, but also as an empirical, objectively determined scientific truth. Since the late 1970’s, this issue has gone from having explicitly nationalist and aesthetic origins, to also being rooted in an objective ecology that relies on a hierarchy prioritizing nativeness, not ecological function, as its main criterion: “the popular case against the grey squirrel is so entrenched that it is largely impervious to research findings suggesting that its initial spread was not responsible for the red’s decline.”\textsuperscript{x}

Though the two species of squirrel are essentially identical in terms of their ecological function, the American grey squirrel can now be demonized “objectively” on the basis that it is rapidly replacing the nationally iconic red squirrel. Nativeness, in other words, has become an empirical measurement that signifies intrinsic ecological value, whereas foreignness—particularly if it is replacing something that is native—is objectively harmful to the ecology. Rigorous research to prove that natives are more biologically productive or conducive to the health of an ecosystem becomes unnecessary, as native species are imbued with an inherent right to that place. Non-native species, meanwhile, can only be defended if they are exhaustively shown to offer an empirical ecological value that outweighs the inherent detriment of their invasiveness. Objective support for the eradication of the American grey squirrel has therefore needed to point no further than the species’ foreignness, and the fact that it is taking the place of the native red squirrel, regardless of how vital the red squirrel actually is to the functioning of the entire ecosystem.\textsuperscript{x} The use of language in
invasion ecology, then, and the failure of its most prominent advocates to publicly recognize the cultural situatedness of the field’s normative framework “may actually undermine [the same] conservation objectives” that invasion ecology was originally intended to support by directing our attention to issues that are not rooted in genuine ecological concerns.\textsuperscript{xii}

Throughout his works, Larson openly acknowledges that particular non-native species unequivocally have a detrimental impact on the landscapes they inhabit, so much so that they “might someday undermine the ecological services and functions on which human survival depends.”\textsuperscript{xiii} Furthermore, he recognizes that aesthetic judgments on ecology, such as the valuation of certain species over others, have an indisputable place in human culture. The intention of his writing, then, is not to challenge the legitimacy of any particular contingent’s cultural motives or even to assert his own ethical priorities on the field of invasion ecology. In fact, he aligns himself with many of the political ideals which he thinks invasion ecology originally came out of—the intrinsic value of nature, for instance, is an ethical priority he claims to share with the founding virtues of the field.\textsuperscript{xiv} Instead, Larson is drawing our attention to the field’s failure to uphold the same principles that it was originally conceived to support, and which he too believes are worthwhile aims, namely, global biodiversity and the robustness of ecosystems.

His critique is thus restricted to the incumbent metaphorical and theoretical systems employed by invasion ecologists, and is not intended to discredit the notion that particular invasive species demand immediate and unyielding managerial attention.\textsuperscript{xv} As a “crisis discipline,” invasion ecology is inseparable from the very real
impacts that non-native species do have on landscapes that are ascribed intrinsic value—this, Larson makes clear, is not his issue of concern. What troubles him is the way in which the cultural values that the discipline’s existence depends on, and the militaristic metaphors which are used to articulate and perpetuate those values, have been obfuscated by the same breed of self-affirming scientific realism that Bono is denouncing in his paper. This, he says, has diverted the discipline away from its original intentions by allowing invasion ecologists to work for nothing more than the continuation of the discipline, so that invasion ecology’s “underlying values [rely on] an extensive metaphoric web, rather than scientific evidence, to justify its use.”

It is the vocational nature of scientific discipline which is most responsible for the field’s diversion from its pioneering values. Invasion ecologists, Larson notes, have depended “on diverse stakeholders for their support of eradication and/or restoration projects” since the inception of the field in the 1980’s. This group of stakeholders ranges from the chemical companies whose herbicides and insecticides are used to eradicate invasive species to any institution or individual with a motive—political, practical, aesthetic, economic or otherwise—for eliminating or managing those species. Militaristic metaphors, he claims, were meant to directly appeal to the already existing concerns of those stakeholders whose support could help to establish an institutional discipline centered around the issue of species invasions. Though the desire to establish this discipline, Larson acknowledges, very well could have come from a genuine sense of ethical concern among the ecologists who coined and advocated the usage of militaristic metaphors, the coupling of these metaphorical systems with invocations of “objectivity” also made it so that the value-ladenness of
these fears was no longer explicit to the public. Experts on species invasions had inextricably tied a particular theoretical and metaphorical paradigm to notions of objective fact, rendering the acknowledgment of the cultural and epistemological limitations of their studies, and the inclusion of alternative ideas about invasive species, impossible.

_The Ecology of Invasions_ is considered by many, including Larson himself, to have originated the conflation of objective fact with an overly stigmatized notion of non-native species. But Elton’s book in fact exemplifies the type of ethical self-awareness that Larson claims invasion ecology has been devoid of since its inception. _EIAP_ is abundant with Elton’s acknowledgement of his own theoretical ideas’ limitations and the distinctly human ethics from which they arise. The health of ecology, he makes clear, ought to be advocated both as an end in and of itself and as a resource necessary to sustain contemporary human practices. In fact, he openly acknowledges that “the reconstitution of communities to make them rich and interesting and stable [could] include a careful selection of exotic forms, especially as many of these are in any case going to arrive in due course and occupy some niche.” Such sentiments, it seems, are a far cry from the self-affirming denunciation of non-native species that Larson is criticizing. Elton’s admission that his ideas about invasive species were “only part of the story” created a scenario in which Davis’s two paths—the Eltonian and the Asilomar—could indeed exist alongside one another and engage in a thoughtful, mutually respectful discourse.

At some point in the 1980’s, however, as the ideas on biodiversity and nativeness from _EIAP_ were being reappropriated by a new generation of ecologists to
shape invasion ecology’s disciplinary program, Elton’s explicit acknowledgment of his own views’ value-ladenness and theoretical immaturity was gradually replaced with widespread invocations of objectivity. General trends casually observed by Elton, such as the correlation between the degree to which native species still thrived in a system and that system’s biological diversity, were elevated to a new theoretical status that assumed these were not only trends, but general systems of causality.

The integration of Elton’s hypotheses on species diversity, migration and productivity into one general theory, designated the Diversity-Invasibility Hypothesis, made it so that the most important criteria for judging ecological health—namely, biodiversity and biological productivity—could now be empirically encapsulated by a singular overarching criterion: a landscape’s nativeness, or, more specifically, its “biological integrity.” The inaccuracy of this attribution, it is worth noting, has been demonstrated consistently in empirical studies over the course of the past 20 years, but the Diversity-Invasibility Hypothesis has largely retained its façade of epistemological authority among invasion scientists. Though both Mark Davis and Larson attribute these deceptive claims of objectivity to The Ecology of Invasions by Animals and Plants, it seems much more appropriate to consider the 1983 initiation of the SCOPE program, which gave Elton’s ideas an entirely new cultural context and epistemological authority, as the historical point at which the field started to assume the posture of empirical valuation that it still has today.

The creation of the discipline in the 1980’s and the reappropriation of Elton’s hypotheses into a generalized theoretical framework thus opened the problematization of invasive species into two separate discursive realms: as a threat to the already self-
evident economic and aesthetic motives that came along with the preservation of
certain native species, and as a threat to the empirical ecological health or biological
integrity that was now categorically tied to the preservation of all native species and
nativeness in general. As a result, the small contingent of ecologists who claimed to
possess an empirical understanding of non-native species as a threat to the well-being
of ecologies had positioned themselves to become the centralized, authoritative
research community upon which institutions with convergent values could rely for
political legitimacy. As in the case of the American grey squirrel’s propagation
throughout Great Britain, those who wanted to eliminate non-native species for
aesthetic, economic or political purposes—the British government and a large
demographic of the British population—now had the power to simultaneously raise
issues of literal, empirical ecological impact that non-native species were committing
by infiltrating the landscape and reducing its biological integrity. It is Larson’s belief
that this has hardly changed since the inception of the discipline and that “a guise of
objectivity is [still] being used to buttress advocacy…blurring the boundary between
persuasion and the findings of scientific research.”

It is not too difficult, Larson contends, to decipher exactly what ethical
priorities are being advocated for in the use and dissemination of militaristic
metaphors to study invasive species. Embedded within these metaphors, in fact, are
the same modern conceptions of nature that often stand in direct opposition to more
holistic conservationist ideals. Larson is talking most prominently about the modern
duality between nature and culture, which he believes reveals itself in the
dichotomous portrayals of the native landscape and the non-native species that
contaminate it. The invasive species is framed as a sign of human contamination, of artifice that does not belong among the species that make up the virgin, idealized landscape. This dichotomy, he says, neglects the reality of a hybrid world, of a world in which our culture is implicated as a part of nature: “we are embedded within invasive species, from their causation to their formulation as a problem.”

Rather than understanding the ecological world as a dynamic entity that is engaged in a reciprocal, synergistic relationship with our own practices, it becomes something more mechanistic, which has a state that is inherently, empirically ideal and another that is not. When a pristine landscape is contaminated by a foreign species, it is framed as the result of cultural or “anthropogenic” processes, rather than the regular oscillations of a fluctuating natural world that is intertwined with cultural practices, a world of which we should consider ourselves a vital part. We are framed as its stewards, keepers and arbiters, while our situatedness as its inhabitants and its creatures is rendered peripheral, if not invisible—anthropogenic impacts do not fall under the epistemological realm of the natural, rendering species invasions inherently “unnatural” and therefore undesirable.

By making the natural world into a phenomenon that science can empirically idealize, militaristic metaphors, and the claims to objectivity that go along with them, are placing the natural world under the ontological purview of modern culture. What seems like the stigmatization of those modern practices that cause the majority of anthropogenic species introductions—globalization, agriculture and urbanization being the most obvious three—is actually “a denial of what is, a fear of change and a methodology of hierarchical control” that effectively shifts our attention away from
those cultural practices which cause ecological damage and onto a phenomenon that is only tangentially related. xxv An anthropomorphized set of species has drawn our attention away from our own practices, and we are made to believe that their presence is in some way damaging ecologies, when in fact it is our own practices that are most at fault. What Larson identifies as an implicit dichotomy between nature and culture is therefore more accurately characterized as a socially constructed hierarchy in which nature is subsumed by culture, reduced to a mechanistic entity whose idealized form can be reached through the articulation of scientific theory and the advancement of our capacity to manipulate its structures.

The shroud of objectivity, then, is being used to impose a very particular set of aesthetic, practical and moral considerations onto the ways we relate with the ecological world, and to deny the implicatedness of our practices within it. In support of this, Larson points out that the same institutions responsible for the migration of foreign species are often the same ones that are so vehemently opposed to their presence: the American grey squirrel, brought over the Atlantic Ocean as a result of globalized trade, is being eradicated on the grounds that it conflicts with what is objectively “native,” or on a more fundamental level, what is “natural.” These criteria, ironically, are dictated by the same society that heralded in the grey squirrel’s original introduction through its participation in trans-oceanic trade. The invocation of this intrinsic characteristic, furthermore, is epistemologically sufficient to overshadow the mounting array of empirical data that indicates that the American grey squirrel is not altering native systems in any significant or detrimental manner other than its replacement of the nationally revered red squirrel, an impact which
itself has been questioned within the discipline.\textsuperscript{xxvi} The privileged epistemological legitimacy of objective science is being used to suit a small set of aesthetic and ethical interests, preventing the societies that defer to the authority of invasion ecology from dynamically engaging with a wider range of ethical considerations. The hierarchy by which scientists can enforce “objectivity” to enforce particular political interests on the general public, Larson points out, is exemplified in invasion ecology.

Other invasive species, such as the purple loosestrife, have been similarly demonstrated through empirical research to have little to no impact on the stability or diversity of native systems, bringing up legitimate questions about wholesale initiatives launched against their existence in countries like the United States.\textsuperscript{xxvii} But like the American grey squirrel, their presence as non-native in a foreign landscape is framed by invasion ecologists as intrinsically unnatural and therefore objectively un-ecological. Even worse, extensions of the militaristic metaphors are growing increasingly performative, going so far as to call upon fearful images of natural disasters as possibilities if non-native species are not to be handled appropriately. The notion of “invasional meltdown,” for example, coined by Daniel Simberloff in 1999, describes a hypothetical process by which “non-indigenous species…facilitate each other’s establishment and/or continued existence… [becoming] biological allies that together constitute a synergistic juggernaut crushing native peoples and their ecosystems.”\textsuperscript{xxviii}

Such hypotheses lend a more profound sense of gravitas to the intrinsic, objective undesirability of non-native species, and a greater sense of urgency to the consequent eradication and suppression campaigns. Though the purple loosestrife has
been empirically exhibited to have near-identical ecological impacts as native species of affected wetlands in Ontario, for example, the hypothetical possibility that the species could assist and exacerbate the introduction of other, more harmful non-native species in something resembling an invasional meltdown has been used as empirical justification for its eradication. \textsuperscript{xxix} Though Simberloff admitted six years after he coined the phrase that an invasional meltdown had “yet to be conclusively demonstrated,” his hypothesis had already been cited hundreds of times in the invasion science community as objective support for management campaigns against invasive species around the world. \textsuperscript{xxx} The Eltonian path, it seems, has successfully fostered a system whereby cultural paranoia is preventing the general public from paying adequate attention to the entire body of available empirical research, or even the contradictions of the dominant metaphorical systems. The fear of the contaminating influence of man and the fall of a virgin nature might be emotionally overpowering our capacity for holistic evaluation of species migrations.

Outspoken advocates of the Eltonian path have largely feigned unawareness of the capacity that their metaphors have for taking hold over public perceptions and dictating the direction of scientific judgment. Instead, they espouse a scientific realist philosophy that theory-constitutive metaphors are nothing more than linguistic tools for referring to phenomena and empirically reflecting underlying trends in the world. As tools for research and communication among scientists, theory-constitutive metaphors are necessary for the pursuit of a more approximately true theoretical program, and though they may have cultural origins, they are stripped of their literariness as the theories they compose become more universally applicable to the
phenomena. Such a belief, however, implicitly signifies a denial that there are many
different, equally valid ways of looking at the world, asserting instead that there is
only one, objective ethical framework that will lead us to empirical knowledge. In
some disciplines, acceptance and implementation of a specific set of ethical priorities
as objective fact can guide us to substantive theoretical knowledge—in the case of
medicine, for instance, the stigmatization of disease has trained our attention onto its
mechanisms, and we have in turn acquired greater control over them. In other
scientific disciplines, however, unequivocal acceptance of cultural metaphors and
their underlying virtues can limit theoretical programs to a more esoteric set of ethics,
serving a very limited range of human desires and transforming the science into
something that hardly amounts to more than superstition. It seems fair to say that
the use of militaristic metaphors among invasion ecologists, and the implicit
acceptance that “native” species are inherently natural and therefore axiomatically
valuable, has been the ethical framework upon which the Eltonian path depends.

In “Confronting Introduced Species: A Form of Xenophobia?” Simberloff
acknowledges the fact that metaphors such as “invasiveness” carry a certain cultural
connotation, and that they might have even originated from certain nationalistic
interests in the 19th century, but he maintains that notions of invasiveness do not
currently embody “aesthetic judgments or appeals to questionable concepts of
naturalness, [but rather] constitute a cogent, ethical basis for management of
introduced species.” Invasion ecologists, he argues, have for many years
acknowledged the ecological benefits that non-native species can have, and no
metaphorical system has made such evaluations more or less likely. Simberloff takes
on the position of a scientific realist, contending that metaphors of invasiveness are simply devices for getting to deeper empirical truths about the world. His paper, however, plays perfectly into the self-perpetuating cycle of performative “objectivity” that Larson and Bono are both drawing our attention to, as it relies on the notion that nativeness is an intrinsically valuable ecological trait which demands our unequivocal support. These ecological concerns, he posits, require no explanation, as they are axiomatic truths which stand distinctly apart from more utilitarian, anthropocentric reasons for combatting invasive species:

“I believe the strongest ethical bases, and possibly the only ethical bases, for concern about introduced species are that they can threaten the existence of native species and communities, and that they can cause staggering damage, reflected in economic terms, to human endeavors.” xxxiii

Though Larson has obvious objections to its current scientific paradigm, he is a firm believer that a disciplinary study of species invasions can in fact play a vital role in engaging on a deeper level with issues that are of actual ethical importance, including the preservation of global biodiversity. What he is objecting to is the way in which “a particular frame of thought, one that has begun to seem self-evident and inexorable because it has been repeated so often,” has taken hold over our relationship with this set of phenomena, precluding us from engaging with it in any way other than those which we already know.xxxiv Two different hierarchies—the epistemological one that puts value claims on “native” and “non-native,” and the institutional one that allows the people making those claims to retain social authority through invocations of scientific objectivity—have colluded to render a complete discourse on the matter almost impossible, privileging a very limited ethical
framework that appeals to a specific set of human interests. The interests of invasion ecology have strayed from their founding ethical commitment of fighting for biodiversity by equating indigenousness with ecological health, thus replacing it with a very particular breed of “biophilia.”

As it stands today, invasion ecologists’ normative prioritization of native species over foreign ones restricts them to a singular practical commitment—the reduction of the impacts that species deemed invasive have on their native counterparts. Though advocates of the Eltonian path implicitly assume otherwise, this ethical cause is not tantamount to other ecological commitments, such as the preservation of biodiversity, the maximization of biological productivity, or even the defense of native species. In fact, mounting empirical evidence suggests that species invasions often have positive connections with some of these ethical considerations. This is perhaps what is most problematic about the current paradigm: the assertion that Elton’s ecological ideas are objective fact has equated “nativeness” with general ecological health, enforcing the implementation of a theoretical paradigm that is not based in empirical fact. The inadequacy of this paradigm, Larson contends, is even evident in the metaphorical systems we use to capture invasive and native species: “paradoxically, while it is often argued that native communities are more ‘stable’ than those that have been invaded, they are also described as ‘defenseless,’ ‘delicate,’ ‘fragile,’ ‘susceptible,’ ‘vulnerable,’ and ‘weaker’ than invaders.”

In this vein, Larson’s argument is not calling for a disinterested system of understanding that strives for absolute objectivity, as “such detachment embodies an
ideal of science that does not apply very well to invasion biology. Indeed, science can only be considered a worthwhile undertaking because it serves certain cultural values, and not merely because it gives us a deeper understanding of the world’s underlying trends. Those advocating the study of invasive species from an entirely disinterested, unmotivated standpoint are implicitly espousing a “postmodern denial of any ultimate value system, a view that could serve to undermine contemporary conservation efforts,” rendering them just as guilty of diverting our attention from ecological issues that really matter.

What Larson is suggesting, then, is an open acknowledgment of the cultural values that undergird our current study of non-native species, so that other frames of knowing might be able to introduce themselves into the conversation, allowing us to more clearly identify those species which are actually imperiling valuable ecological services, regardless of their geographical origins. The new paradigm, Larson contends, would encourage us to seek “long-term coexistence with new species rather than an unrealistic return to a former state without them.”

The implementation of a new metaphorical and theoretical paradigm in the invasion sciences, one which more directly and explicitly aligns itself with real conservationist values and does not assume that nativeness has intrinsic ecological value, would need to publicly acknowledge its own ethical framework so as not to exclude other cultural priorities from discussions about species. This way, even though aesthetic preference for native species such as the red squirrel would no longer fall under the realm of the objective ecological sciences, it would still be possible for interested parties to defend native species on the grounds of cultural or
personal preference. These arguments, however, would reclaim their value-ladenness, while entering into a reciprocal dialogue with a scientific discipline that is more objectively drawing attention to the ecological role that each species has in a hybrid ecosystem, and redirecting “our focus from the problem out there to the much more challenging one discussed here, that of the relation between different people holding differing views of nature.”xlii Such a paradigm, Larson contends, would give ecologists the proper means to replace the implicit endorsement of the nature/culture duality with a more overt value system that allows them “to simultaneously embody their biodiversity values and to be objective.”xlii

To understand the insufficiencies of invasion ecology’s current metaphorical and theoretical paradigms, we might turn to Lawrence Slobodkin’s definition of “reification,” an event which he argues is especially pervasive in the ecological sciences, particularly in invasion ecology:

“To reify consists of assigning to a word, quantity or image an illegitimate ontological status. Reifications must fit comfortably into language, although they need have no empirical meaning. Both reification and hypothesis formation, at their simplest, consist of attributing reality beyond the borders of empirical experience, or even with no empirical experience whatsoever.

Reification involves premature acceptance of the validity of a hypothesis. Ideally, hypotheses assign a temporary or contingent reality, which is then tested empirically so that the hypothesis can be discarded if necessary. It can be argued that all theoretical advance is made by tentatively assigning reality beyond the data and then testing the result. Under the best of circumstances, a hypothesis has a short life span. It is either discarded as false or nonsensical or becomes established as a scientific fact.

Hypotheses, if they are neither tested nor discarded for other reasons, become reifications. They become problematic if they are in principal untestable, or if they remain untested but are still invoked in empirical settings. The distinction between a hypothesis and a reification is that the hypothesis is tested and replaced, while a reification becomes an untestable foundation stone. When a research area loses its dynamism, its hypotheses become reifications.”xliii
It would seem as if invasion ecology’s reappropriation of Elton’s ideas into the Diversity-Invasibility Hypothesis, along with the acceptance of biological integrity as an empirical barometer for other measures of ecological health, constitutes what might be considered a discipline-wide reification—the hypothesis has been misinterpreted as axiomatic truth, rendering it unaccountable to evidence which contradicts or challenges its arrangement. Indeed, empirical evidence has been mounting over the past twenty years that Elton’s hypothesis is not an accurate reflection of causal relationships between the ecological phenomena being considered. Large-scale studies reveal little correlation between the diversity of an ecosystem and its invasibility; non-native and native species have been exhibited as “functionally indistinguishable;” invasive species have been shown to be “passengers” rather than “drivers” of change to native ecosystems; and, most importantly, though global biodiversity has been on the decline, local biodiversity is generally increasing, particularly in areas of the world in which non-native species have established themselves. But as long as Elton’s theoretical notions and the associated metaphorical systems continue to be reified by the invasion ecology community, these studies cannot be incorporated into the field’s general paradigm. The denial of the cultural situatedness of the discipline is dependent upon a dismissal of the theoretical inadequacies that go along with the underlying presumptions of the Diversity-Invasibility Hypothesis. For a new metaphorical system and self-awareness in the discipline to be implemented as Larson hopes, a new theoretical paradigm also needs to come into place.
Over the course of the past fifteen years, Mark Davis has worked to develop an alternative theoretical framework for understanding the invasibility of landscapes and the impacts that non-native species can have on native ecosystems. This paradigm, condensed into two hypotheses—the Fluctuating Resource Availability Theory and the Dispersal-Invasibility Model—largely satisfies Larson’s and Slobodkin’s call for a more value-neutral system of understanding foreign species that does not necessarily preclude concerned parties from taking political action to serve vital or arbitrary human interests. Davis, like Larson, acknowledges that “some species introduced by humans have driven extinctions and undermined important ecological services” and therefore do legitimately demand attention from institutions capable of combatting or compensating for their impacts. But he also holds that the current system of metaphorical and theoretical understanding, intrinsically constitutive of the Eltonian path of invasion ecology, gratuitously stigmatizes the global interchange of species when, in fact, species migrations frequently play a crucial role in stabilizing the influences of human impacts on native ecological processes. His Dispersal-Invasibility Model is therefore intended to establish a framework for understanding species migrations that does not depend on our own aesthetic intuitions of “native” and “foreign” but instead presents ecologies as fluctuating causal structures in which our own culture is implicated.

Since the establishment of the discipline and the integration of the Diversity-Invasibility Hypothesis, invasibility (how vulnerable an ecological community is to the successful establishment of a foreign species) has been framed as a direct function of an area’s biological diversity. This is the primary assumption of causality on which
the DIH is dependent. The theory has hardly strayed from Elton’s original articulation at all, outlined earlier in the first chapter: a landscape which has a higher variety of individual species will also have a lower number of ecological niches that require filling, making that landscape less vulnerable to the successful introduction and propagation of species which have been introduced from a foreign landscape.<xix> Anthropogenic homogenization of landscapes through agriculture, industry and urbanization, according to the DIH, can open up expansive niches that give species more well-adapted to human practices a competitive advantage, while presenting significant challenges to native species, whose populations were established and dependent on the natural, non-human systems that preceded modern civilization. Though it is not an intrinsic part of Elton’s theory, contemporary advocates of the DIH have come to assume that native species are of greater ecological value because they were a part of the natural systems which anthropogenic practices have contaminated.

Such an understanding of species invasions would seem to play very nicely into the nature/culture dichotomy that Larson is critiquing in the field’s metaphorical framework: invasive species are a reflection of homogenous, globalized human influence, while native species are thought to be a fundamental part of the complex, idiosyncratic harmonies responsible for nurturing our society into existence. Anthropogenic influences on biological communities are not thought to be ecological processes in and of themselves, but rather contaminants whose influence ought to be eradicated or subdued to ensure the survival of nature. Biological integrity—both on the local and global scales—is thus commonly framed as a reliably normative
measure of human impact on an ecosystem, and concurrently how “healthy” that native landscape is thought to be. The rapid decrease in global biodiversity has been said to be a reflection of the loss in biological integrity and, furthermore, as grounds for declaring the modern age its own epoch in geological time, interchangeably referred to as the “Anthropocene” or the “Homogocene,” named respectively for the influence that human civilization has had on the Earth and for the biologically homogenizing impacts of that influence.¹ The use of these terms tends to carry a morose tone, apocalyptic in its diagnosis: biodiversity is mother nature’s only means of defense against human impact, and we are methodically, perpetually suppressing it for our own purposes. But these designations fail to acknowledge a key global trend in ecological systems: the rise in local biodiversity throughout the world, particularly in areas that also have high rates of species colonizations. This fact has made it extremely clear that Elton’s theories do not accurately reflect the actual causal structure of ecologies.

The Dispersal-Invasibility Model is a significant milestone because it does not frame biological integrity or biological diversity as the primary criteria for diagnosing a landscape’s health, but rather as ecological characteristics that are just as epistemologically significant as any other. In his theory, Davis reverses the relationship that biological diversity and invasibility are conventionally thought to have in determining the ecological makeup of a particular landscape, providing a mechanistic account for why communities with high rates of invasion also tend to have high species diversity. Higher biological diversity, he theorizes, can in fact be
framed as the product of an ecosystem’s increased vulnerability to introduction by foreign species:

“Although we have participated in the diversity-invasibility debate, we now believe that the debate has been misdirected since Elton first proposed the diversity-invasibility hypothesis. The original, and hitherto uncontested, assumption of the diversity-invasibility hypothesis is that diversity (D) is the independent variable and invasibility (I) is the dependent variable. Thus, for more than forty years, ecologists have been debating the equation I=f(D). However, perhaps all along we should have been debating D=f(I). We believe that invasibility, not diversity, is the more fundamental essence of a community, and that diversity does not give rise to invasibility, but rather emerges from it. In other words, we believe that invasibility, a condition that represents the integration of many local processes, is one of the two major drivers of diversity at the local level, the other being regional processes involving dispersal from the regional species pool.”

According to the Fluctuating Resource Availability Theory, a community’s susceptibility to the colonization and establishment of non-native species, or its invasibility, is dependent on two factors. First, the rate at which species from other ecological systems are entering or attempting to enter is a critical determinant in whether or not non-native species will be successfully introduced. This variable, known as propagule pressure, is also an essential part of the Diversity-Invasibility Hypothesis. The second factor in determining a landscape’s invasibility—the most distinguishing characteristic of Davis’s paradigm—is the availability of certain limiting ecological resources. The availability of resources, Davis contends, is a constantly fluctuating variable that can come out of anthropogenic and natural cycles alike. Defined as “the difference between gross resource supply and resource uptake,” resource availability can undergo significant oscillations over the course of years or even less, depending on a plurality of factors. More important is that resource availability, unlike biological diversity, does not have to apply to an entire
community, but rather can be identified in very particular pockets of that community. This allows for greater specificity in the empirical evaluation of a community: temporally, spatially and otherwise. No longer do ecologists simply have to evaluate a community’s invasibility based on such generalist properties such as diversity or homogeneity when, in fact, that community is composed of a vast multiplicity of inter-species relationships.!

It is not too unreasonable to think of Davis’s conception of resource availability as a more mechanistic explanation of the same phenomenon that Elton characterized as empty ecological niches: “no significant amount of space or other limiting resource goes unused for long.” Indeed, the Fluctuating Resource Availability Theory adequately accounts for the facilitative influence that human projects can often have for species invasions, one of Elton’s main concerns when writing EIAP. According to Davis’s theory, certain anthropogenic disturbances can act like any other ecological disturbance, such as natural disasters or spread of disease, by lessening the number of individuals that are consuming a particular resource in a community, by increasing the number of available resources in that community, or by doing both at once. Davis uses grazing, pest outbreaks and widespread disease among vegetation as examples of natural events that stimulate resource availability—it should be considered no coincidence that Elton uses the same examples to illustrate open niches in The Ecology of Invasions. In the context of the Fluctuating Resource Availability Theory, each of these incidents reduce the area’s “light, water and nutrient uptake” by eliminating the vegetation of a particular area, thus making the conditions conducive to the colonization of a non-native
species. Conversely, increases in resource supply are made possible by other natural incidents: high rainfall increases the available water supply; eutrophication increases the available nutrient supply; and the removal of a tree canopy increases the amount of available sunlight.\textsuperscript{lv} Monocrop farming, one of the primary examples used by Elton in \textit{EIAP}, also lends itself very well to the Fluctuating Resource Availability Hypothesis: wide swathes of land are devoted to cultivating one type of plant, increasing the number of available resources for herbivores, while a certain number of chemicals are applied to the landscape to eliminate the species that might consume that crop, reducing resource uptake. While Elton defines this as the shortening of the food chain and the opening up of an empty ecological niche that could be filled by an invader, Davis simply refers to it as resource availability. In this case, both point to the same phenomenon: “the reason that [anthropogenic] disturbances often facilitate invasions may be due to an increase in resource availability caused by a reduction in resource uptake…or by a pulse of new resources.”\textsuperscript{lvii}

It is important to note that, unlike the Diversity-Invasibility Hypothesis, the Dispersal-Invasibility Model does not frame anthropogenic disturbance as directly oppositional to any “native” or “natural” processes, but rather as an ecological event that occurs within the ontological sphere of a biological community. Indeed, the Dispersal-Invasibility Model’s framing of human activity as a process that falls within the realm of ecology allows for concerned scientists to understand ecological systems as the type of hybrid, fluctuating system that Larson is arguing for. A species’ colonization of a community is no longer mistakenly framed as a sign of that system’s decrease in diversity and a human-caused descent from a more idealized
ecological status. In the context of the DIM, there is no intrinsic value judgment as to whether “native” or “non-native” is natural or not. Rather, it a colonization is simply a sign that resources are available for some reason or another—anthropogenic or otherwise—and that there is sufficient propagule pressure for a foreign species to be introduced. Furthermore, the fact that Davis attributes a community’s species richness and diversity specifically to the colonization of non-native species renders species invasions an even more morally ambiguous issue: “although it is true that the breakdown of the world’s dispersal barriers will result in a homogenization of Earth’s biota, homogenization is not synonymous with low diversity. In the future, different regions of the world will be more similar than they are now. They will also be more diverse.” lvii

As a complement to this more mechanistic framework for understanding species colonizations, Davis proposes “substituting a more familiar term for ‘invasibility,’ perhaps ‘environmental suitability’ or ‘hospitableness of the environment.’” lviii This suggests that Davis’s theoretical paradigm is intended to complement a shift in linguistic framework that allows for more holistic discourse on species migrations. However, Davis, also strongly endorses the idea that certain species invasions do merit swift and thorough attention so that we might be able to curtail their ecological impact. This endorsement, though, never appeals to notions of an objectively ideal ecology—rather, Davis acknowledges that all of these priorities come directly out of our cultural situatedness and practical needs. lix The Dispersal-Invasibility Model is simply meant to act as a more value-neutral guide when deciding which invasive species actually present a threat to our activities, and
predicting when there is a significant pocket of resource availability that might be conducive to the introduction or propagation of a species that could threaten our own interests—even, Davis admits, when those interests amount to nothing more than the aesthetics of nativeness.\textsuperscript{lx} Davis emphasizes, however, that the predominant framing of invasive species as one of the greatest threats to native species’ survival is greatly exaggerated by the current invasion ecology community, perhaps entirely unjustified.\textsuperscript{lxii} Along with his historical analysis of how the field in its current form came into fruition, the Dispersal-Invasibility Model is his contribution to “the essential task of transforming the study of invasions from a diffuse anecdotal subject to a predictive science.”\textsuperscript{lxii}

This task, it seems, is very much underway, at least in the margins of the field. Though advocates of the Eltonian path still have support from various governmental institutions and stand by the general theory and metaphors associated with the Diversity-Invasibility Hypothesis, the number of invasion ecologists encouraging mechanistic models similar to the Dispersal-Invasibility Model and concurrent metaphorical framing of the issue is gradually rising, and the mechanistic understanding of Diversity as a function of Invasibility continues to undergo further empirical specification. Each of these models necessarily align themselves with Larson’s proposed undertaking of assuming a more value-neutral metaphorical framework for the field in order to encourage a more inclusive discourse on the topic of non-native species. As per Bono’s analysis of the field, a metaphorical reorientation, undergirded by a different set of cultural values, is shifting the field to a new understanding of the observed phenomena. But to consider it a revolution of
metaphor might be something of an overstatement: “Once metaphors are dislodged and discarded, replaced by others, metaphoric exchange can assume the mantle of ‘revolution.’ But though their effects may appear like that of a sudden shift of gestalt, such metaphoric ‘revolutions’ are grounded in interpretation, not, I would argue, in an unmediated perceptual drift.”

Indeed, the Dispersal-Invasibility Model and its associated metaphorical paradigm have largely come out of an ongoing negotiation with many of the underlying ethical assumptions of the Diversity-Invasibility Hypothesis, and not only its theoretical inadequacies. The epistemological tools for delineating individual communities and quantifying such ecological characteristics as biodiversity, biological productivity, and ecosystem services, for instance, have been necessary for providing the empirical evidence that supports Davis’s refutation of the incumbent paradigm. The acknowledgment of invasion ecology’s inadequacies, though perhaps unflattering to its current practitioners, has provided the theoretical and metaphorical foundation for the newly emergent paradigm, and as the new paradigm continues to undergo further specification, there is no doubt that it will retain many of the observational tools and ethical assumptions bestowed upon it by its predecessor.
Chapter Four
Reevaluation

Though Larson and Davis limit their investigation of a particular political or ethical agenda to the context of invasion ecology, it seems clear that the same tenets implicitly endorsed among invasion ecologists are not isolated to this one discipline. In fact, the invasion sciences are part of a larger movement in ecology which has emphasized the importance of native ecosystems, biodiversity and biological productivity as concomitant ends toward which the ecological sciences should direct their observational and practical powers. A number of distinct yet interdependent ecological disciplines, with a similar set of theoretical principles as invasion ecology, have emerged: conservation ecology, restoration ecology, and community ecology are each grounded in the same notion of an objectively ideal ecology which anthropogenic influence threatens to destroy, and which particular conscious actions, grounded in empirical observation and managerial response, can help to protect and cultivate. The ongoing theoretical doubt being cast on the Diversity-Invasibility Hypothesis, then, represents a growing faction of ecologists and philosophers who oppose the conceptualization of nativeness as an empirical barometer for an ecological system’s general health and the intrinsic value of a species. As Larson and Davis both note, the unquestioned use of militaristic metaphors and the Diversity-Invasibility Hypothesis has made it so that holistic discourse on the matters of species invasions and conservation cannot go on within concerned research communities, since a particular approach to non-native species—the adversarial, militaristic
approach—proactively limits the body of observational evidence that the field can use for theory articulation and ongoing discussion.

But figures such as Larson and Davis, who oppose the current paradigms held by these disciplines, do not necessarily object to the conservationist aims which these paradigms are ostensibly meant to serve. As noted in the previous chapter, both writers hold biodiversity to be an aim worth pursuing both on anthropocentric and legitimately ecological grounds. Its status as one of the most significant measurements for determining the health of ecologies is undisputed by both writers. Their objection to *The Ecology of Invasions by Animals and Plants*, then, rests not in Elton’s prioritization of maximal biodiversity as the ultimate end toward which ecologists should direct their efforts, but rather in a response to the faulty causal structures that the Eltonian path uses to describe the dynamic systems of ecologies. The reappropriation of Elton’s hypotheses into the DIH has brought about “the failure of ecologists to reject wrong ideas and faulty interpretations” as to how to effectively work toward the preservation of biodiversity, and has made it so that the ongoing problem of mass species extinction remains largely unaddressed by the same scientists that intend to address it.

Davis’s proposed structural changes to invasion ecology are thus meant to recalibrate the field so that it can more closely align its theoretical program with its founding ethical underpinnings—by no means are those underpinnings ever brought into question. Indeed, he still believes that the study of non-native species should continue to rely on the same criteria for ecological evaluation—with the obvious exceptions of ecological integrity and nativeness—and strive for the traditional
conservationist aim of maximum biodiversity. Causal misattributions such as the linear association between nativeness and biodiversity, however, which have kept their place in the theoretical paradigm of invasion ecology must be removed from the science in order to more thoroughly understand the phenomena at hand. Much of the empirical evaluation that is emerging from research in the discipline which could be used toward conservationist efforts, he claims, is being undervalued and underutilized merely by virtue of the fact that it contradicts the mistaken causal connection of biodiversity and nativeness. A shift in our causal framing of the issue is thus necessary to effectively pursue the ethics that ecology is legitimately intended to realize, rather than preoccupying our efforts with other, merely aesthetic interests which are at best tangentially related to real ecological concerns.

Both Davis and Larson subscribe to the belief that biodiversity ranks among one of those legitimate concerns, implicit in their consistent recognition that extinctions are intrinsically bad. Neither, however, goes so far as to explain why they hold this to be inherently true—the assumption is left untouched by both, despite the fact that their works are deeply tied up in the issue. Perhaps they do not feel a need to explain the importance of biodiversity because its significance has been articulated and explained many times before by ecologists and environmental philosophers, exemplified by Elton’s work in *ELAP* and the notion that Elton’s analysis, if published today, would seem so self-explanatory as to be anachronistic. Perhaps they assume that ecologists already acknowledge that biodiversity is an inherently human interest, thus preventing it from being mistaken as objectively “good” in the same way that many have errantly come to think of nativeness as categorically indicative of other
ecological properties. Because its status as an ethical end is already explicit, they might claim, ecologists do not confuse biodiversity with an *a priori* indication of other measures of ecological health, and are by default constantly engaged with the ethical implications of their research and practical action.

On the other hand, however, the unquestioned prioritization of biodiversity that both Davis’s and Larson’s works implicitly endorse could constitute a reification just as faulty as the connection between nativeness and biodiversity which they so adamantly oppose. Is it possible that Davis and Larson have their own ideals about what ecological health is, ideals that are not necessarily biodiversity in and of itself, and that their implicit acceptance of biodiversity as a legitimate aim for conservation might not fall exactly in line with those personal beliefs? Is it therefore possible that their adoption of biodiversity as an adequate representation of their ecological ideals constitutes a reification much like that going on between nativeness and biodiversity, wherein one property is mistakenly thought to be causally indicative of the other? Yes, it certainly is. But as long as neither writer questions the prioritization of biodiversity in the ecological sciences, or states explicitly why he believes biodiversity ought to be the primary objective for all conservation efforts, as Elton does in *EIAP*, we are left to assume that both Larson and Davis simply hold biodiversity to be an axiomatic aim for all conservation, just like most of ecology at large has done for decades. As an ethical belief, the prioritization of biodiversity cannot be argued against on any empirical grounds—it is not falsifiable in the same way that the Diversity-Invasibility Hypothesis’s implicit connection between diversity and invasibility could be disproven by empirical observation. This
imperviousness to empirical objection, however, does not prevent us from analyzing the broader ethical framework in which the prioritization of biodiversity in ecology is established. In fact, its obscurity as one of the foundational principles of the ecological sciences only makes such a task more critical for understanding the ethical underpinnings of invasion ecology.

Davis’s failure to engage directly with the normative underpinnings behind the ecological sciences would not be such a problem if his own work did not draw direct attention to those same ethical quandaries. But by redefining the causal structures that bring about biodiversity, his Dispersal-Invasibility Model is making the status of biodiversity as a singular criterion for ecological evaluation far murkier than it was before, albeit more firmly founded in empirical observation. His evidence that local ecosystems are increasing in biodiversity while mass extinction continues on a global scale not only challenges conceptions of causality posited in the Diversity-Invasibility Hypothesis, as I explored in Chapter Two, but also newly separates biodiversity into two distinct realms: the local and the global. Split into two separate properties that are today inversely correlated, biodiversity’s status as criterion for ethical judgment is brought directly into question.

In “The four questions: What does the introduction of exotic species do to diversity?” Michael Rosenzweig says that the inverse trajectories of local and global biodiversity is symptomatic of the ongoing ecological formation of a “New Pangaea.” Characterized by the merging of all formerly isolated provinces through processes of species introduction that are operating “so rapidly that we blur or even obliterate all provincial differences,” this New Pangaea seems very similar to Elton’s breakdown
of Wallace’s Realms. But Rosenzweig’s conception of the role that species migrations actively play in this homogenization is notably different from that which has been espoused by the Eltonian path of invasion ecology: “the breakdown of isolation between separate biogeographical provinces does not, in itself and by itself, pose a permanent threat to global species diversity.” Rather, Rosenzweig suggests, global biodiversity is being severely threatened exclusively by habitat loss and destruction.

As our understanding of the causal mechanisms behind species invasions grows more complex, so too does the ethical dilemma surrounding species invasions: are we to eliminate a non-native species on the grounds that it is out-competing an isolated population of some endemic species and therefore reducing global biodiversity, or are we to allow that non-native species to propagate because its presence increases local diversity? And how are we to act in the most prevalent form of species introductions, wherein there is no explicit causal connection between the spread of a non-native population and the decline of a native one? Are we then to simply believe that the increase in local biodiversity caused by a species introduction makes it so that the non-native species is seen as an intrinsically valuable addition to the system?

The differentiation between local and global biodiversity as oppositional traits leaves ecologists with an ethical quandary as to what shape future conservation efforts ought to take in order to support an ecological ethic. The same ideals of biological diversity which have been so essential to the normative framework of ecology and environmental activism seem difficult to maintain now that biodiversity
has been split into two separate realms. Though Davis does not address it, the Dispersal-Invasibility Model’s successful description of formerly undefined ecological mechanisms necessitates a broad reevaluation not only of the theories conceived to pursue an underlying ethics, but also of the ethics themselves. Is there an objective or non-question-begging definition of biodiversity that can still be used to dictate an ethic of ecology? viii

An understanding of the philosophical framework from which the prioritization of biodiversity originates appears necessary to understand the ethical implications that the integration of the DIM into invasion ecology would have for our interactions with and modes of understanding nature. What type of relationship between nature and man has the philosophical framework of ecology as a social movement historically promoted, and is such an ethical framework commensurable with a new paradigm that does not set any clear precedent between the global and the local, such as the Dispersal-Invasibility Model? Is it possible that the Dispersal-Invasibility Model’s reframing of the causal mechanisms behind species introductions also demands that ecologists who support biodiversity as an axiomatic end undertake a restructuring of their own ethical attitudes?

In “Biodiversity and the Culture of Ecology,” Mark Sagoff describes two frameworks of ecological thought that correspond well with Davis’s description of the Eltonian and Asilomar paths of invasion ecology. These two frameworks, he claims, are rooted in deeper philosophical or religious conceptions of nature that represent fundamentally different systems for situating ourselves in relation to the rest of the world. According to Sagoff, the two paradigms both prioritize global
biodiversity, but their convergence at this ideal does little to suggest their otherwise entirely divergent ethical attitudes. The most predominant path of ecology, he claims, is predicated on notions of the Great Chain of Being, which implies a teleological progression of nature toward greater efficiency and ecological perfection, much like that embedded in the Diversity-Invasibility Hypothesis. Coming originally out of theological tenets, this framework of nature supports the idea that “the diversity of living things results not from mere contingency or chaos but serves larger purposes, instantiates universal principles and ideas, or expresses an intelligible order or a meaningful plan.” 

In the context of theology, such a view implied that nature is intricately interconnected and interdependent, an unknowable order that is dictated by God’s will. Human beings, in turn, were obliged to protect every single part of that order, no matter how immediately obvious each part’s contributions to our own purposes may be.

Over the course of the 20th century, however, these religious ideals were “demystified” so that they could be reappropriated into modern ecological theories. The superorganism theory, which claimed that ecological systems are ordered and develop similarly to the individual organisms of which they are composed, was the first articulation of this ideal. Like organs in an animal, every part of the ecological superorganism was assumed critical to its survival, and the loss of one species could therefore endanger the well-being or stability of the entire system. Over the course of a few decades, this paradigm eventually gave way to the theory of ecosystems, which similarly delineated different spatial areas into their own self-contained, intradependent ontological entities, but allowed ecologists to also account for species
populations on their own terms. These two paradigms are similar insofar as they both espouse an ideal of ecological systems being led “in law-like ways through orderly successive changes to species composition to achieve a state of mature homeostasis in which the stability and diversity of the system are the greatest it can achieve under the given conditions.” The scientific articulation of these metaphorical ideals helped to mark a new era in environmental advocacy: endangered species could be supported on the empirical grounds that extinction could contribute to the downfall of an entire intradependent system, and scientific support also came from ecology to argue against a number of agricultural and industrial developments that were thought to be interrupting the linear evolution of pristine landscapes.

As Larson notes, however, such theories were dependent on an implicit ontological distinction between the conscious homo sapien and the rest of the natural world, a commitment that no other empirical science had made before. Though this isolation of the natural world from the cultural seems to be founded on deeply arbitrary grounds, it in fact constituted an attempt by ecologists to articulate a social utility toward which their empirical findings could be applied, and which could therefore harvest social and institutional legitimacy for their profession. Indeed, the theoretical framework for identifying native ecosystems, and studying idealized structures was tantamount to incorporating them into larger societal engines which sought to “manage the earth for improved efficiency.” These aims were manifested, Sagoff claims, in the burgeoning fields of environmental engineering and biotechnology. The theoretical criteria for ecological value, as a result, became increasingly entwined with underlying orientations toward nature as utilitarian
resource, while the ecological sciences continued to provide theoretical grounds for the subordination of nature to cultural or economic pursuits.

The fact that so many agricultural staples are disregarded in the invasion sciences, when they in fact could effortlessly be considered just as non-native to pristine systems as any invasive species, is a direct testament to the underlying engineering objectives of the Eltonian path and modern ecology at large. The social utility of crops, marked by their ontological separation from the ecological world, inculcates them from criticism in the context of the ecological sciences. Indeed, the role they play in the same institutional mechanisms of which native systems are also considered a critical part, and our relatively comprehensive understanding of their mechanistic structures in an isolated scientific context, renders them unproblematic: they are already a part of the broader “technological system.” The openness of the system—in other words, its vulnerability to environmental forces—becomes the main concern for a discipline with explicitly utilitarian aims. The natural phenomena whose causal structures we do not yet have the capacity to empirically understand and manipulate (e.g. invasive species), that reveal the vulnerability of our technological systems to the natural world, become the subject of our ecological concern.

Because agriculture and pristine systems are similarly considered fundamental components of modern economic systems, anything that threatens to disrupt our management of either one—and it is worth noting that invasive species in fact threaten both—inherently becomes a problem. A system of environmental engineering which is predisposed to increasing its systems of mechanistic control, rather than drawing them back, limits the possible set of responses to non-native
species: agricultural weeds are addressed with the application of herbicides rather than adopting more holistic forms of permaculture; filter feeders that can spread through bodies of water due to high levels of pollutants hardly provoke any discussion of water pollution, but rather of how to control, subdue or eradicate the non-native species. It is no coincidence that non-native species are anthropomorphized through linguistic systems hinged on “invasion,” dislocating most sense of agency that could be attributed to the cultural practices responsible for an invasion and onto the species itself. The framing of a non-native species as “enemy” to an ecological system, then, is in fact rooted in the inadequacies of our own modes of mechanistic understanding. The zebra mussel, perhaps the most prominent archetype of invasive species at large, was addressed accordingly in 1990:

“As you know, the Great Lakes community is under siege. Our enemy is smaller than the tip of my little finger. Its only artillery is its bivalve shell and uncanny ability to attach itself to almost any surface. Its offensive character is its tremendous reproductive rate. Whole communities are affected by this menace.”

Like many other ecological disciplines, then, the Eltonian path seeks to gain control over the phenomena which surpass our mechanistic understandings of the natural world so that we might be able to integrate those phenomena into the realm of cultural enterprise. Sagoff asserts that this type of ecology, grounded in utilitarian conceptions of nature, “warns us against the extinction of species,” and therefore values global biodiversity exclusively “on prudential grounds—for example, because one never knows when one might have a use for some chemical compound they might contain” or, as in the case of invasion ecology, because the replacement of a native species with a non-native one is thought to pose a threat to the fragile
organization of a native ecosystem. This path, then, ultimately does not strive for the conservation of nature or biodiversity as ends in and of themselves, but rather as contributions to the advancement of modern institutions’ capacity to mechanistically understand and control the natural world. This vision can only be realized by maximizing the epistemological scope of our objective understanding, and it seems as though the preservation of all species so that we might be able to objectively classify them is a critical component of this undertaking.

Even Daniel Simberloff, writing in 1980—before the SCOPE program launched him into international prominence on the issue of species invasions—acknowledged the economic appeal of the ecosystem paradigm, a theory upon which his own claims about species invasions are still entirely dependent today:

“One suggestion for the apparent paradigmatic status of the ecosystem concept in the face of conflicting data is that it provides support for the notion of self-regulatory powers inherent in unfettered capitalism. For if a community of organisms, naturally selected each to maximize the representation of its own genes, can be shown to be analogous to a single organism whose parts all work to a common purpose, so ought a competitive capitalism to produce a unified whole which benefits all. This is an old notion; Adam Smith’s metaphor was that of a hidden hand converting the profit-maximizing activities of individuals into the good of the whole. That this should be true for ecological systems is questionable on both evolutionary grounds and the grounds of observed ecology irregularity…Even were it true for ecology, I suspect that it is not the primary attraction of the ecosystem paradigm; but one ought always to recognize the strength with which a basic philosophy, even an economic one, structures our perception of apparently unrelated phenomena. Perhaps the most convincing argument that the main attraction of holism is not as a subtle justification of capitalism is that it has adherents with long-standing, impeccable Marxist credentials.”

As Simberloff suggests, the ecosystem paradigm’s wide-ranging allure is not rooted directly in its ideological parallelisms to capitalist economic theory. However,
this does not mean that the recognition of the theory by circles of disparate economic
philosophies was not grounded in political or cultural influences. Indeed, the
ecosystem paradigm’s framing of an objectively ideal natural state plays directly into
a very specific ideology, one that frames the natural world as a resource which is
subordinate to the pursuit of ultimate social ends, and which can appeal equally to
capitalist and Marxist thinkers. Indeed, Simberloff’s characterization of an ecological
system as “a single organism whose parts all work to a common purpose” seems to
more closely resemble a Marxist system than it does a capitalist one. The ecosystem
paradigm, then, garners support from advocates of these disparate economic
frameworks not because it is grounded specifically in either one, but rather because
its metaphorical system for framing those phenomena endorses a utilitarian
orientation toward nature which those economic ideologies both espouse, though
toward different ends. In both instances, the instrumentalist framing of nature allows
Marxists or capitalists to project the metaphorical framework of their economic
system onto empirical modes of ecological understanding, allowing for the
ontological integration of natural systems into the predominant economic agenda. As
a result, the economic agenda is itself elevated to the ontological status of the
“natural,” of which all phenomena are a fragment. By setting up a universal
vocabulary that can be applied at once to the economic and ecological worlds, the
ecosystem paradigm allows Marxists and capitalists to more easily talk about
ecological systems in the context of economic interests.

Supporters of the Eltonian path and their advocacy for global biodiversity still
rely plainly on the privileging of economic objectives over ecological ethics. Cost-
benefit analyses which quantify the influences of invasive species in terms of monetized properties such as “ecological resources,” “ecosystem services,” “ecological integrity” and “biological productivity” are proposed by Simberloff et. al. as the most promising method for impartially determining the type of systematic response, or lack thereof, which a species invasion merits. But the range of proposals the community can offer is skewed by the ideological underpinnings inherent to its status as scientific discipline. Practical recommendations, devised to maximize social utility for the institutions that problematize species invasions, necessarily depend on the implicit distinction of nature from culture, a claim that is patently false and fails to take into account the active role we play in the ecological world. It therefore makes ample sense that invasion ecology has failed to establish itself as a predictive science, since it feeds directly into a system of control that ontologically excludes itself from ecological systems that it is in fact deeply implicated in. The theoretical inadequacies of the Diversity-Invasibility Hypothesis, indeed, come out of its inability to recognize that diminishing levels of nativeness and increasing colonization rates are not causally connected, but rather are both results of the confounding ecological variable that is human development of landscapes.

The alternative culture that Sagoff points to in “Culture of Ecology” relies on different philosophical conceptions of nature, and consequently presents species diversity as an axiomatic ethic rather than a utilitarian one. By focusing on recording localized experiences of natural phenomena, this culture of ecology—exemplified by traditions in natural history—seeks not to offer mechanistic, law-like systems of causality that depend on broad generalizations, but rather contends that “rich
descriptions” of the relations between individual organisms and their habitats should be the primary concern for the study of the natural world. Notions of an ideal ecological state and a general linearity in ecological systems is thus cast aside in favor of a conception of nature as constantly fluctuating and stochastic, perhaps ideal at all states, as something which we cannot define through universal causal structures because we are ourselves a vital part of its fluctuations. According to natural historians, the only possible way to attain a remotely substantive understanding of nature is not by means of empirical theories, but rather through a growing body of anecdotal description and a continuing sense of curiosity: “appreciation then comes down to the intense and patient observation of details, not speculation about overarching harmonies.”

Though such a system of understanding does not necessarily contribute to any practical causes—manipulating nature more efficiently or even species preservation, for example—it does encourage a more personalized, emotional connection with the various forms of nature in a way that notions of scientific disinterestedness fail to do. The preservation of biodiversity and native species thus become ethical priorities, but only on the explicit grounds that they are meaningful to us, not part of some objective ideal: “Insofar as a sense of place is important to human beings—insofar as it is important to people themselves to be native to a place—then it is crucial to maintain an affiliation with its native and indigenous species.” Such a localized affiliation, Sagoff contends, firmly situates the individual within the natural world, and offers a fundamental purpose for opposition to the cultural and ecological homogenization being wrought by modern forces of globalization. Unlike those who support the
Diversity-Invasibility Hypothesis and its metaphorical frameworks, natural historians’ advocacy for global biodiversity is explicitly rooted in a strong, personalized affinity for local ecologies.

Though Davis positions his model of species migrations within the context of traditional paradigms of ecology, the Dispersal-Invasibility Model does not fall gracefully in line with either the utilitarian or the natural historian conception. Instead, it appears to fuse some of the normative assumptions from both into a new theoretical paradigm, making it appear at first like a series of internal contradictions. Though the model is meant to offer ways for understanding ecological phenomena such as species migrations and inter-community species exchange as mechanisms, it does so by placing cultural forces within the realm of those causal structures. Economic practices causing variation in ecological fluctuations are thus no longer excluded from scientific critique as they are in invasion ecology today, and yet the same empirical criteria (ecological stability, biodiversity, biological productivity, etc.) that feed directly into more utilitarian framings of nature are still available for systemic evaluation. Moreover, the general causal structures that the DIM offers can only be observed in the form of contingent, localized phenomena, manifested in an unlimited range of scopes and contexts and impossible to predict on the basis of one all-inclusive, generalist property. A personalized historical understanding of the individual phenomena at hand—in other words, an understanding of the local natural history that includes all of its features, “natural” and “unnatural” alike—is rendered necessary for any empirical attributions of law-like organization to arise.
Perhaps this is exactly what Davis is referring to when he says that the participants in the 1964 Asilomar Conference assumed a more “value-neutral” approach to species invasions and when he advocates for a linguistic and theoretical shift toward more “objective” scientific framings of non-native species. Indeed, his Dispersal-Invasibility Model does allow institutions to evaluate nature for economic or aesthetic ends, but it does not contain an implicitly axiomatic ideal. By placing culture and nature within the same nonhierarchical ontological realm, the DIM at once provides a more complete framework for making the invasion sciences into a predictive, empirical discipline, while also ensuring that stakeholders in the issue of species invasions are held publicly accountable for their own subjective interests. Non-native species, shed of their personified identity and no longer assumed independent agents of ecological change, are newly framed as reflections of a constantly fluctuating ecological world. Though this applicability to a more general set of causal structures can be used toward utilitarian ends insofar as it further enables the description of natural systems as machine, it also offers an opportunity for us to empirically reflect on the impacts that our cultural practices have on those mechanized systems, and how the those systems, in turn, shapes those cultural practices.

According to Davis, nonhierarchical paradigms such as the Dispersal-Invasibility Model stand in direct contradiction to the philosophical ideals espoused by Charles Elton. Indeed, it is easy to claim that Elton is responsible for originating the Eltonian path of invasion ecology, and even easier to suggest that the Eltonian path in its current form is a precise articulation of his philosophical outlook.
But the popularized status of Elton as the “founder” of invasion ecology draws attention away from the field’s inherent position as a scientific discipline.

This paper has focused on the ways in which this cultural condition has imparted invasion ecology with an intrinsic purpose, wherein it is tasked with the advancing of a generalized mechanistic characterization of nature that can feed directly into instrumentalist relationships with natural systems. Since invasive species are classified on the basis that they represent shortcomings in those mechanistic understandings, invasion ecology since its inception in the 1980’s has been restricted to varying degrees of antagonistic attitudes toward the phenomena it studies.

The development—or, rather, the stagnation—of the invasion sciences’ disciplinary program, then, seems to be an exemplary demonstration of the ways in which metaphorical systems for understanding the natural world can take hold over our practices, and how claims of objectivity can be used to reinforce those systems and their concordant ethical aims. Despite a mounting body of theoretical and ethical objections coming from within and outside of the field, invasion ecology has yet to undergo a paradigm shift from the empirically archaic modes of valuation that depend on an arbitrary ontological separation of nature and culture. Criteria such as “nativeness” and “ecological integrity”—the origins of which can be traced to as early as the initiation of the SCOPE program in the 1980’s—are still supported by advocates of the Eltonian path today, signifying the failure of its supporters to improve upon those criteria with a theoretical paradigm that carries any sort of predictive capacity.
As the Dispersal-Invasibility Model continues to undergo further theoretical articulation in the form of empirical research, advocates of the Eltonian path are in the midst of a critical historical juncture. The cultural limitations intrinsic to the Diversity-Invasibility Hypothesis are being exposed in the form of theoretical inadequacies, most salient in the growing body of evidence showing that non-native species do not actively contribute to changes to native systems, but rather are “passengers” of more overarching forms of ecological change. The Eltonian path’s intrinsic identity as a traditionally managerial science, however, prevents it from accounting for the implicatedness of culture within ecological systems unless it is to categorically reject its most foundational assumption of an idealized nature, worth pursuing perpetually so that a broader technocratic mechanism can retain maximal utility out of natural systems. A reevaluation of those principles and an attempt to keep them in tact is very much underway, but it seems safe to assume that invasion ecology is due for a major paradigm shift imminently, or, even more drastically, a collapse of its identity as distinct scientific field altogether.
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