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Anticipating Endangerment: The Biopolitics of Threatened Species Lists

Irus Braverman
University at Buffalo School of Law

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Abstract
The last two decades have witnessed an explosion of national and global lists of threatened and endangered species. This article draws on interviews with prominent list managers and observations of their assessments to explore the scientific practices of list-making in the context of species conservation. Delving into the complex calculations of risk and threat that take place in the process of ranking nonhuman species based on their probability of extinction, the article explores the threatened species list as a biopolitical technology of catastrophe governance. My focus on two prominent lists—the IUCN Red List of Threatened Species and NatureServe's assessment system—illuminates various characteristics of futuristic governance through the threatened species list, including its properties as a list-database hybrid and as a barometer of life. I also explore the biopolitical regime of ranking life and its focus on species, its governing of direct (human) threats and the nature-culture binary that this promotes, its status as scientific and apolitical and its aspiration for global reach, and the "species experts" versus "threat experts" divide that underpins its operations. The article concludes with a discussion on the effects of the lists' increasing automation and "algorithmization," as seen from the perspective of the lists' managers. The lists' "threat calculator" in particular quantifies and projects present and future threats to nonhuman species, using fuzzy numbers, ordinal scales, and open standards to anticipate and prevent the forth-coming Sixth Extinction.

Keywords: threatened species lists, biopolitics, algorithms, catastrophe governing, fuzzy numbers, threat calculator

The last two decades have witnessed an explosion of regional, national, and global lists of threatened and endangered species. By 2010, at least 109 countries had produced some form of a national list of threatened species (Miller, 2013, p. 198), and more than 25 listing systems of threatened species lists were used in North America alone (ibid., p. 192). This article will draw on my previous work on the biopolitical properties of threatened species lists and their economic regimes (Braverman, 2016; 2015a; 2015b; 2015c), as well as on a range of interviews with prominent list managers and observations of threat assessments, to explore species conservation's governing of present-future catastrophe through threat. I will focus on two prominent lists in particular: the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species (hereafter, the Red List), which is the first and most comprehensive attempt at a worldwide listing of threatened species by the oldest and largest global environmental organization, and NatureServe's imperiled status rankings, which are generated from this organization's massive database that documents the status of species and ecosystems in the United States and Canada. In 2000, NatureServe (then "the Association for Biodiversity Information") separated from The Nature Conservancy to become its own independent nonprofit.

The Red List and NatureServe have both had an incredible impact on environmental decision-makers around the world and in the North American region, respectively (Possingham *et al.*, 2002; Rodrigues *et al.*, 2006). Specifically, the Red List has inspired the development of numerous national and regional threatened species lists and functions as an important source for prioritizing protections under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)—a uniquely powerful international convention on trade (Miller, 2013). As for NatureServe, this organization actively collaborates with government agencies such as the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the U.S. Transportation Research Board, as well as with individual scientists, universities, and private organizations. NatureServe also feeds data into the Red List database, and the two organizations collaborate on ongoing assessments.

Nonetheless, scientists working on both lists insist that they are producing *scientific* threat rankings that do not carry direct regulatory power. The article will dwell on the myriad ways in which the scientific list is constructed, and on the enhanced political authority derived from its specific presentation as apolitical. I will also explore how threatened species lists are rendered actionable by government agencies such as British Columbia—with its Guidance for Threat Assessments and its adoption of the Threat Calculator—and by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)—the statutory body of scientific experts who assess and recommend how to rank Canada's imperiled species to the Canadian Government.

My article is situated at the nexus between a Foucaultian analytic of nonhuman biopolitics (Biermann and Mansfield, 2014; Lorimer, 2015; Rutherford and Rutherford, 2013; Shukin, 2009; Wolfe, 2015), related scholarship in geography and science and technology studies (STS) about the role of databases and models in governing nonhuman life (Bowker, 2000; Braverman, 2015c; Youatt, 2008), and the emerging literature on the present anticipation of futures (Adams and Grove, 2007; Anderson, 2010a; 2010b; Aradau and van Munster, 2011). The article will draw on these diverse scholarly accounts to explore the threatened species list as an exemplary biopolitical technology for catastrophe governance (Aradau and van Munster, 2011).

"List-keeping is at the heart of our body politic," argues Geoffrey Bowker in the conclusion to his seminal article on biodiversity databases, yet he does not develop this argument further (2000, p. 676). Drawing on Bowker's study of databases, I will continue where he left off by documenting the particular work of the endangered list in species conservation. I will ask: What does the technology of the threatened species *list* add to that of the threatened species *database*? While the database does not rank, the list does. The list's rankings, moreover, establish a system of prioritization that is future oriented. In other words, the threatened species list adds a futuristic element to the past- and present-focused database, not only assessing and ranking the endangerment level of species but also impelling action upon this ranking (albeit presenting itself, as mentioned already, as scientific and neutral and thus as not impelling any action).

In his work on anticipatory futures, Ben Anderson suggests that it is especially in response to three major threats to liberal-democratic life that anticipatory action has been formalized and legitimized: terrorism, trans-species epidemics, and climate change (2010b, p.

779). Despite the many differences between these three threats, he offers, they share several common characteristics: they are potentially catastrophic, namely each can irreversibly alter the conditions of life; the source of the disaster is somewhat vague; and the disaster is imminent, i.e. without some form of action "a threshold will be crossed and a disastrous future will come about" (ibid., p. 780). The problem that these three threats pose for efforts to protect certain forms of valued life, Anderson argues, is that they pertain to the future and are thus inherently uncertain.

This article proposes the existence of a fourth high profile threat to liberal-democratic life: extinction. Conservation discourses are increasingly proliferating that warn about our irreversible entry into the Anthropocene—the Age of Man—where massive, mainly human-caused eradications of nonhuman species threaten our existence on this earth, and the earth's existence altogether (Lorimer, 2015). Such events have famously been referred to as the Sixth Extinction. Elizabeth Kolbert, who coined this term, explains that, "If extinction is a morbid topic, mass extinction is, well, massively so" (2014, p. 3). Contra to Beck's thesis regarding the "incalculability" of certain modern risks, Anderson documents a range of practices that have been deployed to render the future present (2010, p. 783). The first practice he discusses, which is also the most relevant to species conservation, is calculation. It is in this context that Anderson emphasizes the importance of numbers, "which are then visualized in forms of 'mechanical objectivity' such as tables, charts, and graphs" (see also Porter, 1995). Still in the calculation context, Anderson highlights the extensive use of catastrophe modelling, for example the insurance industry's use of algorithmic models to predict and calculate loss by stochastic events (2010, p. 784).

And if massive species extinction is perceived as a future catastrophic event that looms over the existence of life as we know it, creating expansive databases, enumerating the relative viability and mortality rates of species, and calculating their risk and threat of extinction are at the core of the present scientific attempts to render this future actionable. By and large, conservation scientists have been performing and presenting such calculations and ranking in the form of a list: the threatened species list (for a discussion of the reasons for this, see Braverman, 2016; 2015b). Focusing on the threatened species list, this article will unravel the laborious calculations that go into ranking nonhuman species on a linear scale further from, or closer to, extinction. The *listing* of life is thus also a *making* of this life—it grants life. This interpretation infuses new meanings to the phrase "the liveliness of lists" (Leyshon and Thrift, 1999), which originally referred to the lists' ability to constantly proliferate and evolve. My article traces the liveliness of lists back to the flesh-and-blood scientists who create them and examines how they themselves conceive of their work.

The article will identify several elements of governing future catastrophe through biopolitical list-making, including the threatened species list's properties as a list-database hybrid and as a barometer of life, its regime of ranking life and its focus on species, its governing of direct (human) threats and the nature-culture binary that this promotes, its status as scientific and apolitical and its aspiration for global reach, and the "species experts" versus "threat experts" divide that underpins its operations. The article will also highlight the threatened species list's increasing automation and "algorithmization," as seen from the perspective of the list's scientists/managers, and the power of this heightened algorithmization to harness the unknown and translate it into authoritative rankings. Discussing the gradual shift of the list's calculations toward algorithms and automation, I explore the tensions that this process engenders between mystifying and demystifying the list's biopolitical operations. Specifically, whereas the threatened species list-database boasts of providing publicly accessible and transparent information, the production of this information becomes increasingly complicated as it is engulfed in a cloud of numbers, models, and algorithms. The list's "threat calculator" in particular quantifies, automates, and projects present and future threats to nonhuman species, using different technologies such as fuzzy numbers, ordinal scales, and open standards to account for uncertainty so as to better anticipate and prevent the forth-coming Sixth Extinction. Initially formulated in 1975 by Lotfi Zadeh as instances of fuzzy sets (Wang, 2014, p. 82), fuzzy numbers are generalizations of real numbers in that rather than referring to one single value, they refer to a connected set of possible values. Calculations with fuzzy numbers are part of an arithmetic theory that embraces uncertainty and renders it quantifiably, thereby establishing a fuzzy regime of governance.

The Biopolitics of Lists

I have argued elsewhere that threatened species lists are biopolitical technologies par excellence (Braverman, 2016; 2015a). The power of threatened species lists, I have contended, is founded upon their capacity to order life at the level of the biological *species*—what Foucault refers to as biopolitics, as distinct from (yet entangled and coproduced with) anatomopolitics (Foucault, 1990). Although Foucault limited his analysis to human populations, a significant body of work has recently emerged that expands it to nonhumans (e.g., Shukin, 2009; Rutherford and Rutherford, 2013; Wolfe, 2012), some of which focuses on conservation in particular (Biermann and Mansfield, 2014; Braverman, 2015c; Lorimer, 2015; Youatt, 2008). An interesting vantage may be gained from thinking about how the compilation of endangered species lists is a way of aggregating and calculating biodiversity at national, regional, and global scales, not unlike the ways that the "population" emerged out of the compilation of vital statistics and calculations of birth, morbidity, and mortality rates. But whereas in the case of human populations, the problem of morbid death has lately given away to that of morbid living: to a focus on "the quality of lived lives" and the "governmentalization of the living" (Wahlberg and Rose, 2015, p. 62), the discourse of species endangerment is still in the precursor stage, whereby the population-species serves as the central object of study, categorization, calculation, and ranking.

Of the various possible units of conservation, the project of thinking and governing through regimes that focus on *species* arguably lends itself most effectively to mainstream conservation's goal of preventing loss of biodiversity and extinction. Species are the core units by which biodiversity is measured and defined. The species unit enables both an abstraction—a grid over the Linnaean kingdoms (Foucault, 1970)—and an embodiment: a way of putting a singular and legible face on far less concrete conservation concepts such as ecosystems, habitats, and populations (Braverman, 2015a, p. 22). "The world of biodiversity data is radically singular," Bowker reflects (2000, p. 649). Furthermore, since humans understand themselves primarily as an exceptional species and therefore both relate to, and differentiate themselves from, other species, the project of classifying species has been central to the taxonomic ordering of the natural world (Braverman, 2016).

Indeed, for many conservation scientists the species is the foundational ontological unit through which (nonhuman) life can be calculated and known (Sandler, 2012). Compiling lists of threatened species enables the arrangement of species according to their viability and mortality rates, thereby rendering them comparable. Through their en-listing, down- and up-listing, multi-listing, and un-listing, nonhuman species can also be differentially governed, affirming and justifying which lives are more and most important to save (Braverman, 2016, p. 21). "It is important to identify those species that are endangered and those that are not," write conservation biologist Mark Burgman and his colleagues, "this being one of the parameters that determines the allocation of funds for protection of species." They explain that, "Lists are used to set priorities for conservation attention and funding, to elicit donations and votes in the political arena, and the number of endangered species is used as a benchmark in environmental reporting" (Burgman *et al.*, 2010, p. 102). Finally, the threatened species list also reifies the distinction between those who save (humans) and those who may be saved but who cannot save (nonhumans) (Braverman, 2016, p. 21).

At the same time, the potential death of so many species or other forms of life who are not rare, charismatic, or visible enough to warrant the threatened status designation—in Bowker's words, those "Things That Do Not Get Classified" (2000, p. 655)—falls outside the list altogether. As I have mentioned elsewhere, "[s]uch life forms are effectively 'list-less': incalculable, unmemorable, and thus killable" (Braverman, 2016, p. 23). But while much recent biopolitical work emphasizes thanatopolitics or necropolitics, this article adopts Foucault's affirmative stance on biopolitics, highlighting "the ways in which biopolitics can be more about life than death, about inclusion rather than exclusion" (Rutherford and Rutherford, 2013, p. 429). The fate of those listless species' lives who fall outside the realm of the threatened list does not configure into this account, which focuses instead on the viability and actionability of the listed.

Yet such a focus on the affirmative does not entail a disavowal of death. Quite the contrary, "to *make live* does not mean to avoid death altogether but to manage death at the level of the population. In a biopolitical regime, death is transformed into a rate of mortality, which is open to intervention and management. This transformation erases the fact that not all life is equally promoted" (Biermann and Mansfield, 2014, p. 259). Conservation management through species is especially potent because it corresponds more readily to the life-death binary than alternative conservation frameworks such as ecosystems. Ecologist Don Faber-Langendoen explains, accordingly, that "we think of extinction as a species term: there's a genetic pool that's gone when a species goes extinct" (interview). By contrast, ecosystems "don't really go away in the same way," he tells me. "Even if they fall apart, there are still pieces around." This is because "ecosystems are loosely organized entities, they're not highly organized like species, so there's always been a variety of approaches to classifying them" (ibid.). In light of their adaptability to biopolitical enframings such as mortality and extinction rates, and because they are both more visible and also lend themselves more readily to classificatory regimes and numeric calculations, species modalities have been the fundamental "elements of conservation" (Faber-Langendoen, interview), the central units for the scientific assessment of extinction risks. Accordingly, even when listers rank ecosystems (e.g., the IUCN Red List for Ecosystems and NatureServe's ecosystem assessments), their calculations are based on models that were initially developed for species (ibid.).

Governing Threat through Lists

The threatened species list's focus on species goes hand-in-hand with its modality of catastrophe governance, which seeks to identify and quantify present and future risks and threats to species with the goal of predicting and preventing their future extinctions. As the emerging security literature has shown, albeit mainly in the context of the terrorist attack, the definition and measurement of threat are central to the operation of anticipatory security regimes (Adams and Grove, 2007; Anderson, 2010a; 2010b; Aradau and van Munster, 2011).

How is threat defined and calculated in the context of species conservation regimes? British Columbia's Guidance for Threat Assessments presents a useful example. The Guidance relies heavily on both the Red List and NatureServe to define threats as "the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community or ecosystem) in the area of interest (globe, nation, or subnation)" (British Columbia Guidance, 2014, p. 1). The Guidance qualifies, however, that "for purposes of threat assessment, only present and future threats are considered" (ibid.). This disregard of the past makes sense, as conservation's listing project is "a performative process of rendering the future actionable" (Anderson, 2010a, p. 229).

In addition to the performative role highlighted by Anderson, however, my analysis emphasizes the list's biopolitical functions: it is through the list's detailed calculations of threat, and its production of hierarchical rankings of species lives based on this threat, that the project of making life is rendered actionable. To make it so, "expert knowledge needs to tackle its very limit: the unknown" (Aradau and van Munster, 2011, p. 6). As the security scholarship points out, risk (and threat) are different from uncertainty in the same way that "known unknowns" are different from "unknown unknowns." "'Unknown unknowns, 'expecting the unexpected,' 'imagining the unimaginable'—these all speak to the idea that while future catastrophic events need to be made actionable, they can't be planned for" (ibid., p. 107).

The Conservation Measures Partnership (CMP), a consortium of conservation organizations whose mission is to advance the practice of conservation by credibly assessing the effectiveness of conservation actions, focuses its assessments on "direct threats" (CMP, 2013, p. 12). Matt Muir of the CMP explains the practical advantages of this focus, and the relationship of threat to the unknown more generally:

> [L]ack of knowledge never killed an elephant. Lack of knowledge may be an important

> factor or driver of something else that causes elephants to die, but we really want to make sure that our applicants and grantees can articulate what that thing is that kills elephants. Maybe it's [that] they're using a certain pesticide on their crops that is incredibly toxic to elephants. . . . [W]hat we're trying to impact is the human behavior using that pesticide, [and not just general] ignorance and lack of knowledge (interview).

Muir therefore perceives threats as anchors that, through their materiality, can surpass the unknown. "They keep you sort of anchored to the ground as all these other currents swirl around you," he tells me. "Conditions are always changing on the ground," Muir continues. "There may be political changes, there may be funding fads." The focus on direct threats therefore "helps us understand what actually needs to happen, what *human activity* needs to change for the status of that conservation target to improve" (ibid.; emphasis added). Threat is what ties present to future through calculations that render the unknown known and actionable.

Tracing the ways in which threat is calculated also highlights how the nature-culture divide rears its multifarious head even in what seems like a technical and value-free enterprise (Braverman, 2016, pp. 28-32). For example, the threat assessment models studied for this project all emphasize direct threats by *human* activity; they do not include "biological features of the species or population such as inbreeding depression, small population size, and genetic isolation," which are instead considered "limiting factors." Defining the biological as a "factor" rather than as a "threat" resonates with traditional perceptions of agency as existing solely in the human realm, while biological attributes are deemed agentless. The British Columbia Guidance states along these lines:

> For the most part, threats are related to human activities, but they can be natural. The impact of human activity may be direct (e.g., destruction of habitat) or indirect (e.g.,

> invasive species introduction). Effects of natural phenomena (e.g., fire, hurricane, flooding) may be especially important when the species or ecosystem is concentrated in one location or has few occurrences, which may be a result of human activity. As such, natural phenomena are included in the definition of a threat, though [they] should be applied cautiously (ibid.; notes and citations eliminated).

As the Guidance clarifies, natural threats may be considered only if they are created or enhanced by human activity. Dave Fraser of British Columbia's Ministry of Environment explains that "natural threats are generally regarded as part of the milieu [that] the species evolved with. However, if the 'natural' threat is thought to be above background levels *or* a stochastic event can cause severe declines in the species, it would be ranked in the threats calculator" (Fraser, e-mail communication). Matt Muir of the CMP reflects: "To be honest, I don't think I've ever worked on a project that has used that wiggle room of focusing-in on natural phenomenon. There are enough problems to deal with in the world that are caused by human activities that we don't need to go into the natural phenomenon" (interview). Faber-Langendoen remarks similarly in this context: "In the current environment we are such a big threat that you may as well spend your time thinking about human threats" (interview).

Although no longer taken at face value by many conservationists (as evident by Fraser's use of scare quotes when referring to "natural" threats), the nature-culture binary, embodied here in the idea that one can make clear-cut distinctions between human-induced and "natural" threats, nonetheless performs a prominent role in the particular calculations of threat and risk performed through species conservation databases and models. In contrast with Bowker's statement that "it is within the database that the nature/society hybrid so well described by Latour and Haraway is born" (Bowker, 2000, p. 661; citations omitted), I would thus contend that within the threatened list database the nature-culture bifurcation not only gets reinstated but is simultaneously obscured behind the list's technical calculations. In what follows, I will trace the processes through which the list has come to be so highly calculated.

The List's Scientific Turn

For the last five decades, the IUCN Red List has provided "a map of how to do conservation" (Lamoreux, interview). During this time, the nature of list-making has also changed considerably. Don Faber-Langendoen is a senior ecologist at NatureServe and has been involved in the IUCN's listing of species and ecosystems going back to the beginning of these projects. He tells me that "the sense that governments should prevent extinction was not something that really hit the radar screen until the 1960s and 1970s," at which point "governments suddenly needed to figure out which species were most at risk" (Faber-Langendoen, interview). This occurred, in his view, mostly as a response to novel legislative changes introduced into the political sphere, such as the United States' Endangered Species Act of 1973. Faber-Langendoen recounts the need to quickly respond to these statutory challenges: "We started out as a 'BOGSAT': a Bunch Of Guys Sitting Around a Table. Then we moved into the stage of saying, 'Well, let's make the discussion more transparent. Let's write down and record the ways in which we consider these factors'" (interview). Accordingly, in 1994 the IUCN radically altered its formerly expert-based and discretionary ranking system into one that is rule-based and quantitative, and finalized these categories and criteria in 2001 (IUCN, 2001; see also Mace *et al.*, 2008).

Red List scientists Georgina Mace *et al.* describe the rationales behind this quantitative reform, and behind the scientification of the list more broadly. In order to provide a global index of biodiversity and identify those species most in need of conservation attention, they explain, "the classification system must be objective and transparent. It also needs to be applicable to a variety of species and habitats; standardized to yield consistent results independent of the assessor or the species being assessed; accessible to allow a variety of species experts to use it; scientifically defensible; and reasonably rigorous (i.e. it should be hard to classify species inappropriately)" (Mace *et al.*, 2008, p. 1427). Another Red List scientist writes that the list in its revised format is designed to provide "a standardized, consistent, and transparent method for assessing extinction risk, thereby increasing the objectivity and scientific credibility of the assessments" (Miller, 2013, p. 195).

The quantitative reform in threatened species governance has enabled a more global (geographically), universal (between species), and comparable (on both fronts) enterprise to emerge, at the same time making the list more globally actionable. These quantitative dimensions are also imbricated with other scientific characteristics of the list: objectivity, transparency, and repeatability. One scientist told me that this means that if another expert were to conduct the same assessment, she would reach the same result (Brooks, interview). The Guidelines for Appropriate Uses of IUCN Red List Data instruct accordingly: "The IUCN Red List is developed through contributions from a network of thousands of scientific experts around the world. . . . It uses a scientific process based upon objective criteria. Assessments are impartial, independent, and not politically driven. . . . The IUCN Red List is therefore a synthesis of the best available species knowledge from the top experts" (IUCN, 2011).

By emphasizing the strong correlation between scientific and global authority, the threatened species list transcends national politics, supporting a broad-scaled spatial and temporal mode of governance. Still, the mantra of the scientists involved in the listing project is that the list merely lists. The IUCN Guidelines emphasize, accordingly, that "the Red List should not be interpreted as a means of priority setting. . . . The category of threat simply provides an assessment of the extinction risk under current circumstances, whereas a system for assessing priorities for action will include numerous other factors concerning conservation action such as costs, logistics, chances of success, and other biological characteristics" (IUCN, 2014, p. 17). Similarly, NatureServe scientists reject the idea that its scientific listing is sufficient for assigning protections according to the U.S. Endangered Species Act. "They're not policy," Don Faber-Langendoen tells me about NatureServe rankings. "They're information that's publicly available, and Fish and Wildlife Service can use it to inform their actual policy decisions about what's endangered versus what's common, et cetera" (interview). Kieran Suckling of the Center for Biological Diversity explains this insistence on scientificity on the part of threatened species list managers: "the IUCN and NatureServe see themselves as being critical to creating and upholding the scientific consensus which, through its mere existence, places pressure on political interventions in regulatory decisions. So they [must] keep [themselves] out of the regulatory nexus as much as possible" (e-mail communication).

Although by its very nature, the threatened species list assigns value and priority to endangerment (for why else would endangerment be its sole measure?), it is precisely to maintain the scientific power of its judgment that the list's administrators insist that it is value-free. This insistence on the part of the conservationists that the Red List is never political but only scientific exposes the underlying ideal "that science describes nature (and nature alone) and that politics is about social power (and social power alone)" (Bowker and Star, 1999, p. 46).

The Public Database-List

To properly function as a biopolitical technology for future governance, the threatened species list must be founded upon, and must exist alongside, a meaningful database.

Accordingly, each of the Red List categories contains a list of species alongside details of their conservation assessment, all publicly accessible in the Red List's online database. Similarly, the NatureServe Explorer is a web-based database providing public access to information on more than 70,000 plants, animals, fungi, and ecosystems in the United States and Canada, offering in-depth coverage for rare and endangered species (NatureServe Explorer, n.d.). The NatureServe database includes conservation status assessments generated on state, national, and global levels based on information from dozens of state, federal, and institutional programs in Canada and the United States (NatureServe Strategic Plan, 2012-2016). As mentioned, NatureServe also feeds data into the Red List database, and the two organizations collaborate on ongoing assessments.

But the threatened species list is more than a database: in addition to its archival properties, the list ranks and hierarchizes, implying a set of priorities between species: the more threatened a species, the more valuable and grievable its members are. The Red List's category of Not Evaluated provides an interesting exception to its function as a list-database hybrid: although part of the list, this category includes no data (Brooks, interview). Mike Hoffmann is a senior scientific officer at the IUCN Species Survival Commission. He explains: "NE just indicates that no attempt to evaluate the status of the taxon has been made. In reality, any species not on the Red List (i.e., more than 90 percent of species) is NE" (e-mail communication).

At the same time, Hoffmann also clarifies that the Red List is not only about registering *threatened* species, but about registering *all* species. "You can't talk about the status of biodiversity globally unless you've assessed everything," he says. The Red List thus moves well beyond threatened species in its aspiration to map, measure, and assess *all* forms of life on earth. Simon Stuart, a key official in the Red List administration, articulates this aspiration when he and his colleagues describe two related initiatives: the Encyclopedia of Life and the Barometer of

Life. In their words:

> The Encyclopedia of Life (EOL) [is] a powerful initiative, . . . documenting every known species. Essential though the EOL is, it needs to be complemented by another project, the "Barometer of Life." This initiative would need to unite taxonomists, biogeographers, ecologists, conservationists, and amateur naturalists in a coordinated exploration of global biodiversity, with an emphasis on identifying which species are threatened. While the EOL will provide a Web page on every species, the barometer would compile conservation-related data on distributions, threats, and assessments of extinction risk on a subset of species broadly representative of biodiversity as a whole (Stuart *et al.*, 2010, p. 177).

The logical platform for this barometer, Stuart *et al.* argue, is the Red List. Introducing the barometer into the list, they continue, would also help fix its current bias toward higher vertebrates. In their words:

> The vast majority of species—including most plants, invertebrates, and lower vertebrates, and almost all fungi—are still grossly underrepresented. A more finely tuned barometer is within reach by expanding the taxonomic base of the Red List to make it much more representative of the diversity of life. We anticipate that a representative barometer will need to monitor the status of 160,000 species, roughly three times the almost 48,000 species currently on the Red List (ibid.).

One of the collaborators on this project is E.O. Wilson, who famously called scientists to "get on with the great Linnaean enterprise and finish mapping the biosphere" (quoted in Bowker, 2000, p. 645). In the context of the threatened species list, this imperial desire to know and govern the life of all species manifests in calculations of future extinction risks. Such calculations are performed by a veritable army of scientists who labor to assess each species' status.

Assessing the Data: Uniformity and Bias in Listing

The Red List's categories and criteria are meant to be "one size fits all"—they "apply to grasshoppers as well as blue whales," John Lamoreux of National Fish and Wildlife Foundation, also an active assessor in the IUCN Red List administration, tells me in an interview. Hoffmann tells me about the assessors that they vary greatly in both disciplinary orientations and geographic origin. "They might be field biologists, taxonomists, academics, government personnel, park managers, or any one of a number of people," says Hoffmann (interview). Nonetheless, he continues, they are trained to assess all species in a uniform manner. For example, the global assessment of mammals, which was completed in 2008, involved 1,700 experts. In the context of the IUCN, then, the process of "cooking" data has been carefully standardized and unified between the myriad "cuisines" to overcome its inherent "polyphony and polychrony" (INSERT SOURCE) enabling a globally-authoritative ranking system to emerge in the form of the Red List. The widely agreed-upon authority of the Red List thus invites a reexamination of Bowker's argument that "global panopticons are not the way to go in biodiversity data" (Bowker, 2000, p. 675).

To ensure the uniformity of the list's risk assessments, IUCN officials train assessors how to interpret the categories and criteria across varying taxa and geographies. According to Hoffmann, the biggest source of bias is when certain scientists want to list "their" species as threatened, "because they're worried that if it's not, they're not going to get money." The reverse also happens, with researchers who prefer a Least Concern listing, "so that they can collect their species, put it in a specimen jar, and do research on it." "Our job," Hoffmann tells me, "is to be the neutral, objective, adjudicators of that process" (interview). IUCN's Standards and Petitions

Subcommittee adjudicates disagreements over Red List designations. The adjudicators are "the experts in the criteria, and what they say . . . would essentially be considered gospel" (ibid.).

Another central challenge to the Red List's uniformity, according to Hoffmann, is of assessors being either too evidentiary or too precautionary:

> You either want perfect data, and therefore you are less likely to list something as threatened, so everything's going to go into Data Deficient, or you're very precautionary, you think everything's at risk, and so you throw it into a threatened category. Ideally, you want somewhere in the middle of those two things. . . . And so, to a large degree, we try to balance that by having experienced people on hand to guide the assessment process and by requiring some degree of training in the process (ibid.).

Since scientists tend to be very evidentiary by nature, Hoffmann continues, they often find it difficult to work with the Red List, especially in its growing tendency to use fuzzy numbers, i.e. ranges that depend on levels of uncertainty and confidence rather than hard numbers. To work around the difficulties, an administrative split between threat experts and species experts was recently introduced into the system (I will discuss this split, and the related use of fuzzy numbers, shortly).

Modes of Calculation

Calculation is at the heart of the threatened species list, establishing the connection between the biopolitical making and ranking of life and the future-oriented government of risk. As part of their scientific and quantitative turn, contemporary threatened species lists are founded upon a closed system of minutely defined categories and criteria, factors and ranks. Although both lists explored here, and endangered species lists in general, establish a biopolitical order of life that ranks species according to their projected risk of elimination, they nonetheless differ in their particular modes of calculation and thus arguably also in the values that determine their specific biopolitical rankings. This section will explore these discrepancies in the two lists' calculations of threat, contending that NatureServe's model presents a more futuristic and actionable approach in its fuzzier configurations, while pointing out that the Red List is gradually moving in the same direction.

The Red List classifies taxa into nine categories: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE) (IUCN, 2014). The three IUCN Red List threatened categories are: Critically Endangered, Endangered, and Vulnerable. The system consists of one set of criteria that are applicable to all species and that measure the symptoms of endangerment across the board. Five criteria, A through E, are used to classify a taxon within these categories. The criteria are: A) a reduction in population size; B) a small, reduced, fragmented, or fluctuating geographic range; C) a decline in size of an already small population; D) a very small or restricted population; and E) a quantitative analysis indicating the probability of extinction. To be listed as Critically Endangered, for example, a species must decline by 90 percent or more, cover less than $100km^2$, or consist of fewer than fifty mature individuals (IUCN, 2001). A species need only satisfy one criterion to be assigned to this category.

Unlike the Red List, NatureServe does not use the breakpoints in the ratings as thresholds; rather, these points are viewed as nodes along a continuum of risk that can be evaluated jointly with values from other factors. To determine a species' threat status or rank, NatureServe assessors calculate ten factors that impact the species' risk of extinction or extirpation. The ten status factors are grouped into three categories: rarity (six factors), threats (two factors), and trends (two factors). Each rank factor is given a point-score as well as a alphabetic rating (for range extent, for example, A to H quantifies the progressive range that a species covers, U represents Unknown, and Z represents Zero). For global element status, the final assigned conservation status rank uses the G1-G5 scale; an equivalent scale is assigned for national and subnational assessments. Finally, a GU status rank (G for Global, U for Unrankable) is assigned when there is not enough information to assess a species conservation status, or when the information for multiple factors is too imprecise (Faber-Langendoen *et al.*, 2012, p. 1-2).

Place Figure 1 here: *Ursus maritimus* (polar bear) is ranked G3 (Vulnerable) by NatureServe's status assessment.

Faber-Langendoen explains some of the differences in how NatureServe and the IUCN Red List calculate the particular ranking of a species' risk of extinction:

> IUCN uses the five major criteria and they make an assignment for each. Whichever one is most at risk determines the overall rating of the species. . . . Whereas in NatureServe we use what we call a "Weight of Evidence" approach, where we look at all the criteria that we have, and we actually have eight primary ones and two secondary ones, and we roll them together to look at the overall evidence, and that produces our assessment category (interview).

NatureServe's weighted system takes its ten factors, and enables the user to mathematically advantage those factors considered to have greater influence on a given category (threat, trend, or rarity) when determining the category's sub-score. This ultimately, of course, affects the overall ranking [REPHRASE]. For example, the category "rarity" weighs more than the category "threats" in a relationship of 70:30 (Faber-Langendoen *et al.*, 2012, p. 19). Hence, whereas the Red List uses categories and criteria as a hard interval ranking, NatureServe works with softer and fuzzier boundaries that arguably enable a more dynamic and flexible mode of biopolitical governance.

Place Figure 2 here: A comparison between NatureServe and the Red List. Source: Master et al.. 2012: 54. Footnote 1 referenced in the table explains that, "Species ranked GXC and GHC are presumed or possibly extinct in the wild across their entire native range, but are extant in cultivation, in captivity, as naturalized population (or populations) outside its historical native range, or as a reintroduced population not yet established. The C modifier is only used with status ranks at a global level, and not at national or subnational levels. Similarly, IUCN's EW status is only used at a global level." Source: Master et al.. 2012, p. 54.

NatureServe's use of ordinal scales is another aspect of its inclination toward fuzzy governance. The ordinal system means that although an A rating represents a greater risk of extinction or extirpation than a B rating, the magnitude of the difference is not specified. Although ordinal scales provide less resolution and make it more difficult to combine factor ratings, they are useful in particular settings because they do not require knowledge of the precise numeric distance from one category to the next, or to the endpoint, as conservation scientists typically do not know exactly how far apart the attributes are from each other. In other words, the ranks do not provide the precise quantity of "peril" between the categories of "imperiled" and "critically imperiled"; instead, one only needs to rank species as more or less imperiled than others, thereby ranking the categories on a linear scale according to their relative risk of extinction (Faber-Langendoen *et al.*, 2012, p. 1-2). The use of ordinal scales thus enables a differentiation of extinction risks along shifting lines that are meaningful to conservation practitioners (Sutula *et al.*, 2006, p. 168-9). The risk of extinction becomes an "ordinal variable," namely a variable that is both exclusive and intrinsic (Bernard, 2004, p. 47).

Place Figure 3 here: Value ranges for NatureServe's conservation status ranks (Faber-Langendoen *et al.*, 2012, p. 21).

Despite the differences between the two listing systems and the underlying normative preferences embedded in such differences, "we have worked hard to agree on the information that we're going to gather so that at least if we do a NatureServe assessment we can then use that same information to then feed it into the IUCN approach" (Faber-Langendoen, interview). Furthermore, since NatureServe functions as IUCN's de facto "red lister" in North America, "we end up producing ratings that are both NatureServe ratings and IUCN ratings," Faber-Langendoen tells me. Although he wishes that there was a "single data entry" approach, he notes that "currently we gather the information and we actually have to enter it into our approach and then enter it again with other information for the IUCN approach." "It's a little painful," he admits. So while each list has maintained its own complex administrative culture, list makers also strive to streamline and universalize their processes so that they can more easily create a network of interconnected lists that feed into each other (Braverman, 2016, p. 33).

Governing Uncertainty through Fuzzy Numbers

The move toward fuzzy numbers arguably constitutes the second, more recent, turn in threatened species lists' mode of governance. This move incorporates an earlier shift in mathematics toward a framework of "fuzzy mathematics" (Wang, 2014, p. 82). Put simply, instead of hard and fixed numbers, fuzzy numbers theory enables the use of estimates and probabilities as indications of uncertainty type and of confidence levels (Akçakaya *et al.*, 2000, p. 1004). A regime of fuzzy governance thus emerges the result of the need to better harness the unknown, a central component of futuristic governance. Fuzzy number models and their resulting information can be represented as triangular, trapezoidal, or rectangular fuzzy graphs, depending on the level and type of uncertainty in each case (ibid.). Such models are applied to varying degrees by the listing scientists. While NatureServe is already moving toward fuzzier governance, as described above, an article from 2010 calls upon Red List administrators to similarly apply "fuzzy sets" to deal with some of the problems that arise from uncertainty.

Scientists have identified two types of uncertainty in the listing process: epistemic uncertainty—i.e. the uncertainty arising from incomplete data, limitations of measurement accuracy et cetera—and vagueness, which they define as the existence of borderline cases arising from language (Regan *et al.*, 2000, p. 101). They explain about the latter type of uncertainty:

> Consider the vague concept "endangered." To most people, and most biologists, it means to be in danger of extinction, to be vulnerable to loss. One way of creating a tractable definition of a vague concept such as "endangered" is to simply draw a line. So that a species is deemed endangered if it has less than n members, then removing one member will turn a non-endangered species into an endangered species […]. The term "endangered" is now a technical term defined to mean "less than n members," quite a different meaning to that found in a dictionary or understood by most people (ibid., p. 102).

The problem with the Red List, according to these scientists, "is that there really ought not to be sharp boundaries between the various IUCN categories" (ibid., p. 103). "In practice," they write,

> uncertainty close to the boundaries of these classifications is resolved by applying the precautionary principle, under which the person classifying a species will err on the "safe" side and classify the species as critically endangered unless reasonably sure it is not. But such decisions are not always transparent, they are subject to individual interpretations of reasonable safety, and they raise the spectre of the manager being unable to distinguish between species that are "definitely" endangered and those that are only "perhaps" endangered. Fuzzy boundaries, however, are more forgiving with imprecise data. … [They] allow the separation of threatened and non-threatened species without providing sharp cut-off points (ibid., pp. 102, 103).

While it asks Red Listers to acknowledge the prominent place of uncertainty in their calculations, this scientific account nonetheless defines unknowability only in terms of uncertainty, thereby neglecting other unknowns that are inherent to governing future catastrophe. Indeed, catastrophe "speaks to the limit of knowledge and radical unknowability. It allows us to consider how knowledge and its limits . . . intervene in practices of governing and subjectification" (Aradau and van Munster, 2011, pp. 5-6). The expansion of fuzzy governance by Red List scientists could become a model for thinking about how to incorporate the unknown risks inherent to governing future catastrophe into the listing system.

"Species Experts" versus "Threat Experts"

Largely, the move into the domain of the fuzzy is performed by scientists who are trained as generic experts in the listing process (herein, the "threat experts"). Although they are typically species experts in their own right, these generic experts do not participate in the listing process for their expertise on the assessed species (other species experts serve this purpose), but rather for their knowledge of how to make lists. Indeed, the growing complexity of listing processes and their enhanced algorithmization (as discussed below) necessitate increasingly prominent roles for threat experts in their production.

Both the use of fuzzy numbers and the division between species experts and threat experts were evident in the threat assessment of the mountain holly fern (*Polystichum scopulinum*) by the Government of British Columbia, which I observed in December 2014. During this assessment, educated guesses, ranges, and estimates were brought forth by the threat experts to manage uncertain knowledge. Hence, for example, instead of marking the fern's generation time as "Unknown," the threat experts suggested that the species experts identify a "good possibility" that they live between 10 and 20 years, thereby documenting the three generation time frame as 45 (triple the average between 10 and 20). More generally, the threat experts guided the fern experts to adopt statements such as "there's a good possibility," "it's a hard thing to judge, but my personal opinion is […]," and "it may be hypothetical, but I'd like to offer that […]." These statements exemplify the shift from hard numbers to the realm of fuzzy ranges and probabilities, especially when hard numbers are difficult to obtain. "The important thing," explains Muir of the CMP, "is to try not to be paralyzed by that lack of data but put your best estimate forward." To achieve this, the threat experts "push our comfort limits as scientists to make claims that, in our academic world, when we write a paper, we would be very hard-pressed to say without giving a lot more evidence or a lot more sources of information" (Muir, interview). The concept coined by the CMP to reflect the necessary balance between strict adherence to scientific rules and procedures, on the one hand, and flexible and adaptive assessments, on the other, is "open standards." "We have developed these Open Standards so that they can be applied at any geographic, temporal, or programmatic scale," the CMP states (2013, p. 1).

The growing reliance on fuzzy numbers and open standards in the lists' administration has dictated a parallel increase in their reliance on algorithms. This algorithmization is evident, for example, in the adoption of the "threat calculator" by different threatened species list administrations.

The Threat Calculator

In March 2014, I attended the list assessment meeting of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Since 1977, COSEWIC's 150 or so scientific experts convene twice a year to assess Canada's imperiled species. In 2003, the Canadian Species at Risk Act (SARA) mandated the government of Canada to consider COSEWIC's designations when listing wildlife species at risk. According to Dave Fraser, a government official of British Columbia and chair of COSEWIC's Criteria Working Group, the Canadian government endorses between 50 and 75 percent of COSEWIC's assessments and assigns legal protections for those formally listed species (interview).

The "threat calculator" in particular exemplifies how technologies of calculation established in the context of the "apolitical" list converge into political systems of ranking. In 2009, NatureServe developed the threat calculator to automate the process of assigning conservation status ranks. Of the three ranking categories (rarity, threat, trends), NatureServe's threat calculator measures only the second category, namely the level of threat. The threat calculator has already been adopted by several national listing systems and is currently adjusted to automate certain parts of the Red List ranking system as well. Recently, COSEWIC adopted NatureServe's threat calculator and has been applying it across the board to assess the threat category of all candidate species. According to Dave Fraser, who has pushed for the threat calculator's application in Canada: "It became really clear that we needed a more transparent and consistent way of classifying future threats, [which was] very difficult to do when everybody was using a different set of words" (interview).

In place of a "different set of words," the threat calculator is an Excel spreadsheet with a dropdown menu onto which assessors inscribe the relevant figures according to three threat categories: scope, severity, and timing. Based on this data, a computer program then calculates the Overall Threat Impact, which is expressed through a four-point score: Very High (red), High (orange), Medium (yellow), or Low (green) (Master *et al.*, 2012, p. 27; see Figure 4). "Because it's a prediction into the future," Fraser tells me, "you have no way of measuring its accuracy." Nonetheless, he explains, "if you've got High or Very High scores you're looking at species that are automatically going to be strong candidates for having met the decline criteria that would lead to a listing" (Fraser, interview). This way, what matters most is not future consequences that may or may not occur, but "the capacity to act in the face of uncertainty, to render data *actionable*" (Amoore, 2011, p. 29). Indeed, the beauty of the futuristic vision is precisely that it does not have to be true. "In fact, expectations are often particularly fruitful when they fail to materialize" (McGoey, 2012, p. 8). In the words of Brian Massumi: "Threat is the future cause of a change in the present" (2005, p. 35).

Place Figure 4 here: Screen shot from NatureServe's Overall Threat Impact table, used with permission.

Fraser describes the benefits of the automated threat calculation process: "It's the same reason that you have checklists to operate an aircraft. Here's a step-by-step process and here is how you check every instrument and everything down the line before you take off. So this does the same thing: it makes you go through all the threats and make sure that you've understood and actually accounted for every potential threat to this species and assessed whether it's a big deal or not" (interview). And although a moss is not comparable to a whale from a biological point of view, Fraser explains, "the *future* for this moss is looking Low, Medium, or High—and from our point of view, that's all we need to know." This depiction calls to mind Amoore's "data derivatives," which she defines as visualized risk flags or scores "drawn from an amalgam of disaggregated fragments of data, inferred from across the gaps between data and projected onto an array of uncertain futures" (Amoore, 2011, p. 24).

Uncertainty plays an important role in the threat assessment. Fraser highlights that while "the threats calculator [gives] us a way of confirming what we were seeing," this is not always the case. Sometimes, he continues "there are declines and the threat calculator did not predict them and cannot explain why." Fraser continues:

[When] there's nothing in the threats calculator that clearly explains why something is

> happening, then the other alternative is there's something going on that we don't understand. . . . [In these cases,] there is the ability to either put in "Unknown" when you have a threat that you just don't understand how big it is or what the scope of it is, or you can use range ranks which says, "Okay, it's somewhere between 'small' and 'large' but I don't know where it is in there." . . . But what this does, at least as far as we are concerned, it tells you when you've got a lot of uncertainty (interview).

Uncertainty (in terms of "known unknowns" at least) is therefore not excluded from the calculus; rather, it is identified as such and thereby governed differently in that it is harnessed toward governing the known. The unknown thus provides "a different kind of abstraction that is based precisely on an absence, on what is not known, on the very basis of uncertainty" (Amoore, 2011, p. 27).

Just how powerful the threat calculator is exemplified by its default automatic operation: if a species is assessed through the calculator as having Very High or High impact levels, it automatically qualifies for listing regardless of any other factors. "This is a lot of power," Fraser acknowledges. Precisely because of this immense power, and despite his leadership role as Mr. Threats Calculator, Fraser cautions against relying too heavily on the calculator. "The caution is, of course, [that] it's relatively easy to score too alarmistly," he tells me, adding, "you have to be careful you don't give it too much weight because it is based on future predictions and that's always a bit dicey." "Scientists hate predicting the future," he further explains, "because it's very hard to quantify. So we take these Very Highs and Highs *cautiously*, because one of the problems with this system is that many experts tend to be quite alarmist and they're not experts on the threats calculator, they're experts on the species" (interview).

Fraser's words of caution call attention to the ways in which computerized algorithms are slowly replacing the experience and professionalism of the species experts. Substituting precision for validity, the threat calculator replaces ethical conflicts over the content of the entries with seemingly technical data calculations (Bowker and Star, 1999, p. 24). Fraser provides an example of how this displacement unfolds in practice:

> A little while ago I ran through an assessment with a species of bird that nests in old growth trees. The biggest threat to that species, according to the experts, is logging. But when we actually assessed the amount of logging that's going to happen in the next decade against the range of that species, it only came out as a medium threat, and that amazed them. They thought, 'well, if this is only a medium threat, what does a high threat look like?' And I gave them some examples of some species that have high threats. And it put the whole thing into some perspective. The biggest threat you're dealing with may not be such a big deal when you look at the fate that other species have in assessment. So it's a very good way of evening the playing field between species, and that's really important when you deal with the assessment of everything, from mosses to whales (interview).

As a generic and global conservation value, threat works to "even the playing field" between widely disparate species and their experts.

But the displacement of man by machine, and that of local and species experts by global and generic assessment processes, is never absolute nor complete. The assessment process includes formal points of entry that enable, invite even, the infusion of "subjective," expert-based knowledge. One such point occurs when the calculator generates a final threat rank ("calculated rank"), but the database includes an option for the assessor to insert a different rank ("assigned rank"), providing she inserts an oral explanation ("assigned rank reason") (Figure 5). Margaret

Ormes of NatureServe explains: "There are times when . . . you as a scientist may not agree with what the calculator is returning. So if people decide to stick with their assigned rank, if they decide that their assigned rank is correct and the calculated [one] is wrong, they [can] document why they are keeping it. . . . We wanted to allow for the fact that scientists may decide that the calculated rank is just simply incorrect" (Ormes, interview). When the assigned and calculated ranks differ from each other, the first assumption, however, is that the assessors "miscoded a field in some way" (ibid.).

Place Figure 5 here: NatureServe's Excel spreadsheet with figures from an old assessment. Courtesy of Margaret Ormes, NatureServe.

Algorithms and (De)mystification

The threat calculator is one of a growing number of tools and techniques that automate the threatened species lists' assessment process. Increasingly, NatureServe uses such algorithm-based tools, encoded into rules, to translate disparate data on species or ecosystems into rankings. Although they are seemingly technical, close attention to the algorithmic rules of operation can help unveil the assumptions and values imbedded in the list's assessments and ranking. For example, when the typical point-based ranking system is irrelevant or impossible, algorithmic rules kick in that define a "state of exception" to the point- and weight-based rules, identifying instances in which the rules do not apply. In such instances—which are numerous—the status is assigned automatically, overriding the discretion of scientists. For example, an automatic status of Unrankable ("U") is assigned without any further calculations in those cases for which the minimum factor combination requirements have not been satisfied. In practice, the automatic rules that preclude detailed calculations look like this:

> *Rule: Automatic X [i.e., Extinct] Status Assignment Based on Extreme Rarity IF* at least one of the *rarity* status factors Range Extent, Area of Occupancy, Population Size, or

> Number of Occurrences has an assigned status rating of Z [i.e., zero] *AND* the assigned status ratings for the remaining *rarity* status factors are Z AND/OR range ratings that include Z, *THEN* an X = Extinct/ Eliminated or Extirpated (GX, NX, SX) conservation status is automatically assigned for the element (Faber-Langendoen *et al.*, 2012, p. 15; highlights in original).

The technical aspects of this rule demarcate both the span and the limit of scientific knowledge.

More broadly, the threat assessments' growing reliance on algorithms goes hand-in-hand with the emergence of modelling as the current trend in scientific method, which in turn is intimately related to the assessors' increased use of fuzzy numbers. Indeed, algorithms replace scientists' discretion and old-fashioned hard numbers with rule-engendered, automated calculations. The gradual algorithmization of the threatened listing process thus emerges not only as a way of managing a growing mass of information, but also as a way of filling in the gaps and holes in the known and replacing them with calculated predictions of the unknown. Consequently, algorithms are indispensible for assessing future threats, the bread-and-butter of the list's biopolitical project. The prevalence of algorithms in list production has had profound effects on the transparency and the public availability of these lists. To understand why, one needs to consider how algorithms work and how they affect the data they work upon.

Often referred to as the father of algorithm analysis, computer scientist and mathematician Donald Knuth defines algorithms as a "set of rules or directions for getting a specific output from a specific input." "The distinguishing feature of an algorithm," he explains, "is that all vagueness must be eliminated; the rules must describe operations that are so simple and so well defined that they can be executed by a machine" (Knuth, 1996, p. 59). Communications scholar Tarleton Gillespie would disagree with Knuth on the transparent nature of algorithms. He argues that algorithms operate upon data by "selecting" the most relevant data. "Algorithms are inert, meaningless machines until paired with databases upon which to function," Gillespie writes (2014, p. 169). The data is prepared for the algorithm, he argues, "cleaned up" so that the algorithms could then act upon it, seemingly automatically. The *ostensibly* automatic work of the algorithm is both an intentional and a crucial part of its function, he explains, as "algorithms are also stabilizers of trust, practical and symbolic assurances that their evaluations are fair and accurate, free from subjectivity, error, or attempted influence" (ibid.). Unlike Knuth, Gillespie argues that the criteria and code of algorithms are generally obscured and their procedures hidden. There is something "impenetrable about algorithms," he says. "They are deliberately obfuscated, and they work with information on a scale that is hard to comprehend" (ibid.). For Gillespie, the algorithm is more in line with what Bruno Latour refers to as a "blackboxing technology," a form of scientific knowledge whose "work is made invisible by its own success," becoming obscure through its own complexity (Latour, 1999, p. 304).

My interviewees for this project have, for the most part, voiced Knuth's and rejected Gillespie's approach, offering that at least in the context of endangered lists, algorithmization is generally a transparent and demystifying process. Margaret Ormes explains along these lines: "A lot of people felt that the NatureServe ranking process was too much of a blackbox. . . . There was a lot of subjectivity. So the goal was to create something that was not a blackbox, something that was transparent and repeatable" (interview). She clarifies: "[W]e really wanted a methodology that would be repeatable, so that if two people used the same data that they would come up with the same rank. So that's what the calculator helps address, that repeatability factor. And it also makes our ranks more transparent. So if I send the rank calculator to someone they can see exactly how that rank was arrived at, and they can disagree with the data, if they have more information; it can take the mystery out of how the ranks are assigned" (ibid.). Faber-Langendoen of NatureServe explains, similarly, that:

> Those species folk, they may not know what the algorithm is doing, because they are not the ones who are assigned to do the ranking. They are there giving evidence, if you will. But if something seems really wrong to them, then the assessor should have the ability to explain exactly how this works. So although this is an algorithm, we don't want to hide away how it works because this would defeat the purpose of the entire process. There are models that are real blackboxes. I've used models where I don't know what's going on, and I don't like it, because I can't actually really see what it's doing. So there are these kinds of problems with ecological models. In the case of the IUCN and NatureServe, [however,] we tried to make sure this doesn't happen (interview).

Population biologist Bob Lacy uses more complicated algorithmic models to assess the viability of populations as part of a Population Viability Analysis (PVA) (for example, under the Red List's Criterion E). His position on the effects of algorithms is that:

> [A]lgorithms make explicit how we think the processes work, rather than leaving the judgments to be based on undocumented conceptual frameworks and arguments by biologists to just "trust me, I am the expert." Yet I can also see that for many others who don't know what those computer programs are doing, the sense of trust versus demystification goes the other way: they might be willing (or maybe not) to trust that we know what we are doing with the calculations and simulations, but for them the analyses are not at all transparent (Lacy, e-mail communication; see also Braverman, 2015c).

Finally, from Matt Muir's perspective: "As long as people understand that the algorithm is based on these criteria and these sorts of value judgments, then they shouldn't be mystical, right? They shouldn't be magical. But I think there's a risk that, for some people, algorithms replace critical thinking" (interview).

While the assessment performed in the context of the threatened species list is undoubtedly becoming more and more mechanized and algorithmic, scholars and scientists alike debate about whether these processes are mystifying or demystifying, obfuscating or revealing. Communications scholar Ted Striphas (2015) identifies the historic basis of this tension in the semantics of the term "algorithm," which encompasses both "algorism" (associated with zero, empty, cypher) and "algorithm" (i.e., deciphering). In effect, "on the one hand, we have *algorithms*—a set of mathematical procedures whose purpose is to expose some truth or tendency about the world. On the other hand, we have *algorisms*—coding systems that might reveal, but that are equally if not more likely to conceal. The one boasts of providing access to the real; the other, like an understudy, holds its place" (Striphas, 2015, pp. 404-5). Striphas emphasizes that what is at stake in algorithmic culture is the privatization of process (ibid., p. 407). Similar debates have also unfolded in the STS scholarship on medicine, where scholars argue that mathematization has by no way done away with the qualitative assessments and subjective interpretations of statistical significance (Armstrong, 2007). In the context of the threatened species list, too, the algorithmization process encompasses the tensions between public and transparent processes and expert or private decision-making.

Conclusion

Threatened species lists place a grid over the animal and plant kingdoms, furnishing particular forms of nonhuman life with both a dataset and a threat rank that together establish their singularity and elevate them from other, unevaluated and unranked, forms of life. Life, represented here in species units, must be assessed and ranked if it is to be protected and saved from the catastrophe of mass extinction. But whereas the process of list-making in conservation is about affirmatively saving species-conceived life, it also sorts out and regulates to the domains of non-protection such forms of life who are not valued and privileged. The life that is worth conserving obtains meaning through an expansive calculus that deals with the future's unknowability through ostensibly technical solutions, such as fuzzy numbers, open standards, and ordinal scales.

Focusing on two prominent data-listing-ranking systems for threatened species—the IUCN Red List of Threatened Species and NatureServe—my article has illuminated the extensive behind-the-scenes labor that goes into the process of calculating the imperilment level of a species. This labor designs databases that increasingly encompass not only threatened species but all species; the data is then fed into ranking systems that elaborately calculate the species' risk of extinction. I have dwelled in some detail on the differences and similarities between the two lists' ranking systems, demonstrating the minute dilemmas experienced by their administrators and the transformation of their procedures toward an increase in quantification, automation, and algorithmization alongside their move toward fuzzier forms of governance. Such reflections illuminate that not only lists but listers, too, are lively players in this process. My article has given some of these listers—a range of scientists with myriad voices—a long-neglected presence in the process, rendering their labor and motivations visible. The "threat calculator" in particular both reveals and embodies the underlying tensions between known and unknown, hard and fuzzy numbers, automation and discretion, species experts and threat experts, and, finally, the mystifying and demystifying aspects of algorithmization.

At the end of the day, the Red List and NatureServe risk rankings—though ostensibly scientific and apolitical—serve as the authoritative basis for establishing priorities for the conservation of actual species by a large number of governmental and nongovernmental agencies. I have documented in particular how this scientific ordering is translated into action in the context of Canada's list of endangered species. Considered together, threatened species lists enable the emergence of expansive biopolitical projects of making and anticipating the future of species life.

Interviews and Observations

Brooks, T. Head, Science and Knowledge Unit, IUCN. Telephone, January 25, 2014.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Participatory observation. Halifax, Canada, April 27 - May 2, 2014.

Faber-Langendoen, D. Senior Research Ecologist. NatureServe. Telephone, February 3, 2015; August 6, 2015.

Fraser, D. Unit Head, Species Conservation Science. Ministry of Environment, Province of British Columbia; Member, COSEWIC; Chair, Criteria Working Group. In-person, April 29, 2014; Telephone, June 18, 2014; e-mail communication, December 9, 2014.

Hoffmann, M. Senior Scientific Officer. Species Survival Commission, IUCN. Telephone, January 9, 2014; e-mail communications, March 27, 2014; June 26, 2015.

Lacy, R. Population biologist, Former chairperson, CBSG. E-mail communication, June 24, 2014.

Lamoreux, J. Biodiversity Analyst, National Fish and Wildlife Foundation. Telephone, January 7, 2014.

Muir, M. Member, Conservation Measures Partnership. Telephone, December 16, 2014.

Ormes, M. Director, Science Information Resources, NatureServe, University of Massachusetts

Boston. Telephone, November 1, 2014.

Suckling, K. Executive Director, Center for Biological Diversity. E-mail communication, August 3, 2015.

Threat Assessment. Mountain holly fern (*Polystichum scopulinum*), the Government of British Columbia. Conference call observation, December 9, 2014.

References

Adam, B. and Groves, C. (2007) *Future Matters: Action, Knowledge, Ethics.* The Netherlands: Koninkijke, Brills.

Akçakaya, H. R. *et al.* (2000) Making Consistent IUCN Classifications under Uncertainty. *Conservation Biology* 14(4): 1001–1013.

Amoore, L. (2011) Data Derivatives: On the Emergence of a Security Risk Calculus of Our Times. *Theory, Culture and Society* 28(6): 24-43.

Anderson, B. (2010a) Security and the Future: Anticipating the Event of Terror. *Geoforum* 41: 227-235.

Anderson, B. (2010b) Preemption, Precaution, Preparedness: Anticipatory Action and Future Geographies. *Progress in Human Geography* 34(6): 777-798.

Aradau, C. and van Munster, R. (2011) *The Politics of Catastrophe*. London: Routledge.

Armstrong, D. (2007) Professionalism, Indeterminacy, and the EBM Project. *BioSocieties* 2: 73-84.

Bernard, H. R. (2004) *Research Methods in Anthropology: Qualitative and Quantitative Approaches*, 4th ed. Lanham: AltaMira Press.

Biermann, C. and Mansfield B. (2014) Biodiversity, Purity, and Death: Conservation Biology as Biopolitics. *Environment and Planning D: Society and Space* 32: 257-273.

Bowker, G.C. (2000) Biodiversity Datadiversity, *Social Studies of Science* 30(5): 643-683.

Bowker, G.C. and Star, S.L. (1999) *Sorting Things Out: Classification and Its Consequences*. Cambridge, MIT Press.

Braverman, I. (2015a) En-Listing Life: Red is the Color of Threatened Species Lists. In: R. Collard and K. Gillespie (eds.) *Critical Animal Geographies.* London: Routledge/Earthscan, pp. 184-202.

Braverman, I. (2015b) Is the Puerto Rican Parrot Worth Saving? The Biopolitics of Endangerment and Grievability. In: K. Gillespie and Lopez P. (eds.) *Economies of Death.* London: Routledge/Earthscan, pp. 73-94.

Braverman, I. (2015c) *Wild Life: The Institution of Nature.* Stanford: Stanford University Press.

Braverman, I. (2016). The Regulatory Life of Threatened Species Lists. In: I. Braverman (ed.) *Lively Legalities: Animals, Biopolitics, Law.* London: Routledge, pp.19-36.

British Columbia Guide to Recovery Planning for Species and Ecosystems Appendix 5: Guidance for Threat Assessments. April 2014, Version 1.2.

Conservation Measures Partnership (CMP). Open Standards for the Practice of Conservation. April 2013, Version 3.0.

Faber-Langendoen, D., *et al*. (2012) *NatureServe Conservation Status Assessments: Methodology for Assigning Ranks*. Arlington, VA: NatureServe.

Foucault, M. (1970) *The Order of Things: An Archeology of the Human Sciences.* New York: Vintage Books.

Foucault, M. (1990) *The History of Sexuality: An Introduction, Volume 1.* New York: Vintage Books.

Gillespie, T. (2014) The Relevance of Algorithms. In: T. Gillespie, P.J. Boczkowski, and K.A. Foot (eds.) *Media Technologies: Essays on Communication, Materiality and Society*.

Cambridge: MIT Press, pp. 167-194.

International Union for Conservation of Nature (IUCN) (2014) *Guidelines for Using the IUCN Red List Categories and Criteria Version 11* [online]. Available at: http://jr.iucnredlist.org/documents/RedListGuidelines.pdf.

International Union for Conservation of Nature (IUCN) (2011) *Guidelines for Appropriate Uses of IUCN Red List Data, Version 2* [online] Available at: http://www.iucnredlist.org/documents/RL_Guidelines_Data_Use.pdf.

International Union for Conservation of Nature (IUCN) (2001) *IUCN Red List Categories and Criteria Version 3.1* [online] Available at: http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria.

Knuth, D.E. (1996) Algorithms. In: Knuth, D. E. (ed.) *Selected Papers on Computer Science.* Cambridge, UK: Cambridge University Press, pp. 59-86.

Kolbert, E. (2014) *The Sixth Extinction: An Unnatural History.* New York: Henry Holt and Company.

Latour, B. (1999) *Pandora's Hope: Essays on the Reality of Science Studies.* Cambridge: Harvard University Press.

Leyshon, A. and Thrift, N. (1999) 'Lists Come Alive': Electronic Systems of Knowledge and the Rise of Credit Scoring in Retail Banking. *Economy and Society* 28(3): 434-466.

Lorimer, J. (2015) *Wildlife in the Anthropocene: Conservation After Nature.* Minneapolis: University of Minnesota Press.

Mace, G.M., *et al.* (2008) Quantification of Extinction Risk: IUCN's System for Classifying Threatened Species. *Conservation Biology* 22(6): 1424–1442.

Massumi, B. (2005) Fear (the spectrum said). *Positions* 13(1): 31-48.

Master, L., *et al.* (2012) *NatureServe Conservation Status Assessments: Factors for Assessing Extinction Risk.* Arlington, VA: NatureServe.

McGoey, L. (2012) Strategic Unknowns: Towards a Sociology of Ignorance. *Economy and Society* 41(1): 1-16.

Miller, R.M. (2013) Threatened Species: Classification Systems and Their Applications. In: S.A. Levin (ed.) *Encyclopedia of Biodiversity* 2nd edition, vol. 7. Waltham, MA: Academic Press, pp. 191-211.

NatureServe Explorer (n.d.) [online] Available at: http://explorer.natureserve.org/

NatureServe, NatureServe Strategic Plan 2012-2016 [online] Available at: http://www.natureserve.org/sites/default/files/publications/files/natureserve-strategicplan-final.pdf

Pimm, S.L., *et al.* (2014) The Biodiversity of Species and Their Rates of Extinction, Distribution, and Protection. *Science* 344(6187): 987-998.

Porter, T.M. (1995) *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life.* Princeton: Princeton University Press.

Possingham, H.P. *et al.* (2002) Limits to the Use of Threatened Species Lists. *Trends in Ecology & Evolution* 17(11): 503–507.

Regan, H.M., Colyvan, M, and Burgman, M.A. (2000) A Proposal for Fuzzy International Union for the Conservation of Nature (IUCN) Categories and Criteria. *Biological Conservation* 92: 101-108.

Rodrigues, A.S.L. *et al.* (2006) The Value of the IUCN Red List for Conservation. *Trends in Ecology and Evolution* 21(2): 71–76.

Rutherford, S. and Rutherford, P. (2013) Geography and Biopolitics. *Geography Compass* 7(6): 423-434.

Sandler, R.L. (2012) *The Ethics of Species: An Introduction.* Cambridge: Cambridge University Press.

Shukin, N. (2009) *Animal Capital: Rendering Life in Biopolitical Times.* Minneapolis: University of Minnesota Press.

Staeheli, U. (2012) Listing the Global: Dis/Connectivity Beyond Representation? *Distinktion: Scandinavian Journal of Social Theory* 13(3): 233-246.

Striphas, T. (2015) Algorithmic Culture. *European Journal of Cultural Studies* 18(4-5): 395-412.

Stuart, S. *et al.* (2010) The Barometer of Life. *Science* 328: 177.

Sutula, M.A. *et al.* (2006) A Practical Guide for the Development of a Wetland Assessment Method: The California Experience. *Journal of the American Water Resources Association* 42(1): 157-175.

Wahlberg, A. and Rose, N. (2015) The Governmentalization of Living: Calculating Global Health. *Economy and Society* 44(1): 60-91.

Wang Y. (2014) "On a Theory of Fuzzy Numbers and Fuzzy Arithmetic." In: *Advances in Applied and Pure Mathematics. Proceedings of the 2nd International Conference on Mathematical, Computational and Statistical Sciences (MCSS '14)*, pp. 82-90.

Wolfe, C. (2012) *Before the Law: Humans and Other Animals in a Biopolitical Frame.* Chicago: University of Chicago Press.

Youatt, R. (2008) Counting Species: Biopower and the Global Biodiversity Census. *Environmental Values* 17: 393-417.