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# Making extinction calculable

## Abstract

*Purpose*: This paper examines the role of the *IUCN Red List of Threatened Species* in achieving biodiversity conservation and preventing the extinction of species. The Red List is a calculative device that classifies species in terms of their exposure to risk of extinction.

*Design/methodology/approach*: The paper draws on theorising in the *social studies of finance* literature to analyse the Red List in terms of how it frames a space of calculability for species extinction. The analysis then traces the ways that this framing has overflowed, creating conditions for calculative innovations, such that assemblages of humans and calculative devices (i.e. *agencements*) are constructed with collective capabilities to act to conserve biodiversity and prevent species extinctions.

*Findings*: This paper has traced three ways that the Red List frame has overflowed, leading to calculative innovations and the construction of new *agencements*. The overflow of relations between the quality of "extinction risk", produced by the Red List, and other qualities, such as location, has created opportunities for conservationists to develop *agencements* capable of formulating conservation strategies. The overflow of relations between the identity of the "threatened species", produced by the Red List, and other features of evaluated species, has created opportunities for conservationists to develop *agencements* capable of impelling participation in conservation efforts. The overflow of ecological relations between species, discarded by the Red List's hierarchical metrology of extinction risk classifications, has created opportunities for conservationists to develop *agencements* capable of confronting society with the reality of an extinction crisis.

*Originality/value*: The paper contributes to the accounting for biodiversity literature by addressing its fundamental challenge: explaining how accounting can create conditions within society in which biodiversity conservation is made possible.

## 1. Introduction

99% of all species that have ever existed on Earth are now extinct (Barnosky et al., 2011). Extinction, when considered on a geological time-scale, over the 4.5 billion year history of life on this planet, is very common indeed. However, the fossil record indicates that rates of extinction have varied greatly over this time. Most notably, palaeontologists have identified five events in which Earth's biological diversity fell rapidly and suddenly by over 75%. These have been termed mass extinction events. Little is known for certain about what caused these events, but ideas include asteroid impacts and enormous volcanic eruptions. Biologists studying the present state of global biodiversity have established that the current extinction rate is considerably higher than the normal historic background rate (e.g. Ceballos et al., 2015). Such findings have led to speculation that humanity's overexploitation of the biosphere will be the cause of Earth's sixth mass extinction event (Kolbert, 2014).

The accounting for biodiversity literature seeks to respond to the problem of biodiversity loss by studying the ways that biodiversity can be brought into account in organisational decision-making (Jones and Solomon, 2013). Various mechanisms for accounting for biodiversity have been proposed in both academia and practice. These include models for stewardship accounting (Jones, 1996, 2003; Siddiqui, 2013), certifications (Cuckston, 2013; Elad, 2014), offsetting (Tregidga, 2013), corporate reporting (Atkins, Grabsch and Jones, 2014; Boiral, 2016; Rimmel and Jonall, 2013; van Liempd and Busch, 2013), and indicators (Thomson, 2014a).

A basic belief driving efforts to account for biodiversity is that accounting can act as what Miller and Power (2013, p. 558) call a 'productive force'. This means that accounting is understood, not merely as a practice of passively recording reality, but rather as a way to affect changes in human behaviour so as to reshape reality (Hines, 1988). Thus Jones (2014a) suggests that if accounting can make biodiversity visible to organisations, so that they (and their stakeholders) can see the effects of their actions on biodiversity, then this may impel those organisations to modify their destructive behaviour. That is, accounting for biodiversity might have a role to play in constructing a new reality in which biodiversity is conserved rather than destroyed.

However, the accounting for biodiversity literature has not, thus far, explained how visibility of biodiversity in organisational accounts will translate into any real material effects upon biodiversity loss. Indeed, Gray (2010) argues that organisations are so constrained by their financial imperatives that they simply do not have any choice but to operate in unsustainable (i.e. destructive) ways. Society may collectively recognise that biodiversity loss is undesirable, but that same society is organised in such a way that addressing the problem is practically impossible. Given this, simply making biodiversity visible in accounts is largely irrelevant as organisations are just incapable of acting any differently. The fundamental challenge for accounting for biodiversity, therefore, is to explain how accounting can create conditions within society in which it is made possible for people (and the organisations of which they are a part) to act to conserve biodiversity.

This paper takes up this fundamental challenge by drawing on theory from the *social studies of finance* literature concerning how agency – the capability for intentional action (MacKenzie, 2009b) – is achieved by assemblages of human actors and calculative devices through the construction of spaces of calculability (Muniesa, Millo and Callon, 2007). Thus, by understanding accounting as being embodied in calculative devices (Kornberger and Carter, 2010; Pollock and D'Adderio, 2012; Skaerbaek and Tryggestad, 2010), this paper seeks to study ways that accounting can provide human actors with the calculative equipment they need to construct spaces of calculability that make biodiversity conservation possible.

Whilst biodiversity loss is conceptualised in a variety of ways (see Jones, 2014b), in this paper it is held that the extinction of species is the greatest tragedy of biodiversity loss: whole forms of life – unique modes of existence – destroyed forever. The extinction of species is the ultimate expression of unsustainability (cf. Gray, 2010). If biodiversity loss is understood in these terms, then the challenge for accounting for biodiversity becomes: how is the prevention of species extinction made possible by calculative devices? In order to begin to answer this challenge, this paper will focus on one calculative device that pervades biodiversity conservation efforts.[1] This is the *International Union for the Conservation of Nature* (IUCN) *Red List of Threatened Species* (hereafter Red List). The Red List is a calculative device that classifies species in terms of their exposure to risk of extinction. The purpose of this paper is to examine the role of the Red List calculative device in achieving biodiversity conservation and preventing the extinction of species.

The remainder of this paper will be structured as follows: the next section will explain the concept of calculability and how this is achieved by assemblages of human actors and calculative devices; section 3 will briefly review the accounting for biodiversity literature so as to demonstrate the pervasiveness of the Red List device, and then analyse the calculation of extinction risk classifications performed by the Red List device; section 4 will discuss how the Red List device equips conservationists, such they are able to construct spaces of calculability and thus acquire agency to conserve biodiversity; section 5 will conclude the paper.

[1] The ways the Red List device pervades conservation efforts will be discussed in section 3 below.

## 2. Calculability and calculative devices

This paper seeks to examine the role of the Red List calculative device in achieving biodiversity conservation and preventing the extinction of species. A crucial insight, underpinning the study of accounting as a social practice (Hopwood and Miller, 1994), is that accounting does not merely passively record reality. Rather, by making some things visible and keeping others invisible, accounting actively constructs reality by affecting how people think and act (Hines, 1988). Accounting may therefore be understood as what Miller and Power (2013, p. 558) call a 'productive force', constructing spaces of calculability within which people come to think of their own ability to act – their own agency – in terms of the calculations that the space makes possible (Miller, 1992; Miller and O'Leary, 1987; Power, 2015). But how are such spaces of calculability constructed? How are calculations able to act upon people so as to make and shape their agency? These are central questions in the *social studies of finance* literature (MacKenzie, 2009b), which is an off-shoot of the *science and technology studies* literature (STS), and continues to have profound influence within the accounting literature (Justesen and Mouritsen, 2011; Vollmer, Mennicken and Preda, 2009; Vosselman, 2014).

The *social studies of finance* literature is underpinned by a commitment to materiality, in the sense that all relations between actors are understood to involve some form of concrete interaction (MacKenzie, 2009b). An actor's ability to calculate and to be able to act on such calculations – that is, an actor's agency – is understood to be determined by their access to, and embeddedness within, material assemblages of humans and calculative devices. Calculative devices are described by Muniesa et al. (2007, p. 2) as 'objects with agency'.

> [D]evices do things. They articulate actions; they act or they make others act' (p. 2).

Assemblages of human actors and the devices that comprise their calculative equipment, with the capacity to calculate and to act collectively in ways that the assemblage's components alone could not, are referred to as *agencements*: a word that 'conveys the idea of a combination of heterogeneous elements … [that] are arrangements endowed with the capacity of acting in different ways depending on their configuration' (Callon, 2007, pp. 319-320). That is, agency is a collective achievement: in analysing an agent's capacities to calculate and to act, we must look to the networks of relations in which they are embedded, which equip them with capabilities to organise information about the world in ways that enable them to conceive their possible courses of action (Callon, 1998a). Thus the calculativeness of agents is not anything inherent in an individual, but rather is a result of their place within a socio-technical assemblage – an *agencement* – that, as an organised collective, is able to calculate. Miller and O'Leary (2007) suggest that this understanding of calculative agency, as emerging out of networked collectives of humans and devices, provides a way to conceptualise the role of accounting in creating possibilities for action. That is, accounting – embodied within various material devices – forms part of the equipment that delineates the calculative capabilities of *agencements*:

> Calculation and agency are two sides of the same coin. The agent-network is by construction calculative, but calculativeness could not exist without calculating tools, most notably the lowly and often disclaimed tools of accounting (Miller and O'Leary, 2007, p. 710)

The performance of a calculation, by any particular *agencement*, is described by Callon and Law (2005, p. 719) as a three-stage process:

> First, the relevant entities are sorted out, detached, and displayed within a single space. Note that the space may come in a wide variety of forms or shapes: a sheet of paper, a spreadsheet, a supermarket shelf, or a court of law – all of these and many more are possibilities. Second, those entities are manipulated and transformed. Relations are created between them, again in a range of forms and shapes: movements up and down lines; from one place to another; scrolling; pushing a trolley; summing up the evidence. And, third, a result is extracted. A new entity is produced. A ranking, a sum, a decision. A judgement. A calculation.

Callon and Law (2005) argue that this (re)definition dissolves the commonly made distinction between (quantitative) calculation and (qualitative) judgement: both are understood in the same terms, as the achievement of an outcome – a conclusion – from the manipulation of entities within a space. They suggest the term “qualculation”, first coined by Cochoy (2002), to highlight this blurring of the qualitative and quantitative in calculation. The important distinction is, therefore, not between spaces enabling calculation and spaces enabling judgement, but rather between spaces in which calculation/judgement (that is, qualculation) is possible, and spaces in which it is not. In this paper, the term calculation is used so as to be synonymous with this idea of qualculation, such that the term includes both quantitative and qualitative dimensions.

To help to conceptualise the idea of a space of calculability, Callon (1998b) invokes a metaphor, borrowed from Goffman (1974), of framing. Thus material arrangements of humans and devices can be understood to produce a boundary that separates a calculative process from the outside world. That is, an *agencement* may be understood as a mechanism for framing a space in which calculation can take place. Within this frame, the assumptions, norms, and conventions that regulate particular calculative actions are taken for granted. But these are rooted in the material devices (and human beings) that collectively constitute the frame. The construction of spaces of calculability takes work (Callon and Muniesa, 2005; Callon, 2016). That is, assemblages of human actors and calculative devices perpetually work to define those boundaries that frame the space, and that define those things that are brought inside the space (taken into account) and those things that remain outside it (not taken into account). In this way, *agencements* are, in a real, material sense, spaces of calculability: the configuration of arrangements of human actors and calculative devices that comprise an *agencement* define the nature of the space and thus the forms of calculations that are possible.

The work of framing spaces of calculability is never complete. Frames are never perfect. There will always be relations between entities inside the frame and others that remain outside it. These relations "overflow" the frame, such that the entities inside the frame are never wholly cut off from the world outside. That is, whilst the form of the calculations taking place within any particular frame might seem fixed and stable to those operating with this arrangement, all framing is necessarily fragile and transient, dependent upon continuing work to maintain the boundary between the space of calculability and the outside. Any particular framing – and thus any particular calculation – can always be challenged on the basis that there are material interactions that are not being brought into account. Such overflows offer opportunities for innovations whereby new configurations of humans and devices are assembled to construct new *agencements* and achieve new spaces of calculability (Revelino and Mouritsen, 2015). Any (re)framing will inevitably create the conditions for new overflows, resulting in a perpetual framing/overflowing dynamic in which innovations in configuration of *agencements* continually emerge to replace perceived failings in existing calculative arrangements (Callon, 2007).

This ever-present potential for the framing of spaces of calculability to yield new opportunities for reframing has inspired work in the accounting literature investigating how accounting creates the conditions for organisational innovation. Skaerbaek and Tryggestad (2010) analyse the role of calculative devices in the formulation and performance of corporate strategy. They find that calculative devices, such as net present value investment appraisals and responsibility-centres, rather than being constructed in response to strategic choices, are themselves integral to creating the conditions in which the framing of strategy is made possible. The availability of particular calculative devices constitutes what is deemed to be inside or outside the frame of strategic discretion and intervention. However, drawing this outside/inside boundary creates the conditions for overflows: defining some things as outside the strategic frame – as incalculable – invites efforts to acquire calculative equipment that will enable those things to be brought inside, and thus rendered calculable. In all, Skaerbaek and Tryggestad (2010, p. 122) argue that their analysis has led them to 'conceive of strategy as an emerging calculative collective and temporary achievement.'

Similarly, Kornberger and Carter (2010) investigate how calculative devices create the conditions for strategising by studying how city managers have responded to the production and circulation of various rankings of cities. They argue that the accounting calculations embodied in these ranking devices reduce the complex differences between cities to an unambiguous set of quantified qualities that invite direct comparison between cities. The accounting embodied within calculative devices thus 'delineates the playing field and defines the rules of the game' (p. 340): establishing the *a priori* conditions for competition between cities, and framing the possibilities for the formation of strategies by city managers. These findings echo those of Espeland and Sauder's (2007) sociological study of the ranking of law schools. Their analysis focussed on how commensuration – the 'transformation of qualities into quantities that share a metric' (p. 16) – affected the ways that managers of these schools were able to think about the choices for action available to them.

> Commensuration shapes what we pay attention to, which things are connected to other things, and how we express sameness and difference (p.16).

The effects of such ranking devices, that create hierarchical relations between entities through the quantification of qualities, may be understood in terms of how they constitute spaces of calculability in which new relations are formed that can have profound effects on actors' understandings of their own agency: on their possibilities for action (cf. Jeacle and Carter, 2011; Pollock and D'Adderio, 2012).

## *Achieving calculability*

In a seminal work in the *social studies of finance* literature, *The Laws of the Markets*, Callon (1998) distinguishes three problems facing efforts to construct frames around spaces of calculability. Callon's first problem concerns the identification of the material reality of the relations that are to be brought into account. For a relation to exist, there must be some tangible object travelling between agents, acting as the medium for their interaction. To render a relation calculable, this object must be identified. Callon's second problem concerns the identification of the agents whose relations between them are being brought into account. Identifying agents is intimately linked with identifying the material reality of the relation between them: agents may not be aware of how they are related to others before this. Callon's third problem concerns the establishment of a metrological framework for measuring the effects of those relations that are being brought into account. That is, some mechanism is required to quantify these effects, thus enabling direct comparison between them.

In *The Laws of the Markets*, Callon focussed on how interactions between market participants are made calculable. In particular, he sought to analyse how economic externalities can be brought into the frame of market calculations. Markets are thus characterised as perpetual efforts to create spaces of calculability, within which it is possible for agents to interact in ways that enable economic activity to take place. However, Callon's later work (especially Callon and Law, 2005; Callon and Caliskan, 2009) extends this concern with calculability to other arenas. This generalisation of the analysis of processes of framing spaces of calculability has led to greater emphasis being placed on how these processes of frame construction do not just reveal pre-existing agents and the relations between them. Rather, the process of framing actually creates agents with particular identities and with particular material relations between them that did not pre-exist the framing. This echoes the work in the accounting and sociology literatures (such as the works of Espeland and Sauder (2007), MacKenzie (2009b), Skaerbaek and Tryggestad (2010), and Kornberger and Carter (2010), discussed above), which emphasise the transformational effects of the achievement of calculability, whereby whole new ways of thinking and acting are made possible. Callon's (1998) three problems of achieving calculability must therefore be seen in this light: where Callon speaks of the work of identifying agents and their relations, and of measuring the effects of these relations, this may actually be work to create and define such agents and relations.

## *Framing environmental problems*

The accounting literature has investigated the role of carbon accounting in making possible efforts to address the environmental problem of global climate change. Such efforts, to render climate change calculable in ways that enable society to address it, have faced each of Callon's (1998b) three problems: global-scale assemblages of human actors and calculative devices have been constructed in ongoing efforts (i) to define emissions of greenhouse gases, (ii) to specify the agents responsible for emissions, and (iii) to construct a metrological framework to measure the effects of different activities upon climate change (Lohmann, 2009). These efforts have been characterised by Callon (2009) as *in vivo* experiments in the building of *agencements* that have the capability of rendering climate change calculable such that they can act to mitigate it.

> This is truly collective, distributed experimentation deployed in time and space, more or less chaotically or organized (p. 538).

By way of example, MacKenzie (2009a) studies efforts to render commensurable the emissions of different greenhouse gases in terms of their impacts upon global warming, such that these impacts can all be expressed in the same currency (the equivalent of the emission of one tonne of carbon dioxide). He finds that, even though the formula for doing this draws upon contested data and relations between variables, the outcomes of the formula, written into a table of conversions, take on a facticity that is unquestioned by market participants. This calculative device, therefore, opens up the possibility for new actors to formulate strategies for participating in carbon markets. Mackenzie illustrates this with a case of a refrigerant chemical manufacturer that is able to earn large revenues from carbon trading by introducing a process in which one of its waste products (a very potent greenhouse gas) is incinerated rather than released into the atmosphere. MacKenzie (2009a, p. 441) suggests that the proliferation of (re)framings of human activities, so as to create new possibilities for addressing climate change, demonstrates that the characteristics of the capitalist market system 'can be changed by changing the calculative mechanisms that constitute it.'

Building on this insight, Cuckston (2013) analyses a tropical forest conservation project and shows how carbon accounting calculative devices (such as allometric equations for trees and shrubs, and decay functions for soils) were used to create new possibilities for acting to protect the forest and the wildlife within it. The communities that depend on the forest for their livelihoods were able to enter into new *agencements*, with the capability to render the forest calculable (in terms of carbon content) such that the forest could be brought into a new economic framing that was conducive to its conservation. However, Cuckston notes that this new way of framing the forest also creates the conditions for new overflows. For example, there are fears amongst some conservation groups that framing forests in terms of carbon could encourage the replacement of natural forests with less biologically diverse, but more carbon-dense, plantations. Further efforts to contain these overflows have spawned calculative devices, such as biodiversity certification standards for forest carbon credits.

In a more conventional organisational setting, Vesty, Telgenkamp and Roscoe (2015) study the way that the numbers generated by carbon accounting devices became integrated into the calculations (such as net present value) performed by the management accounting systems in a public utility company. That is, the measurements of the organisation's impacts on climate change were able to become part of the way that the organisation made decisions about capital investments. Vesty et al's analysis highlights how devices created for one purpose can become detached from those origins and reattached elsewhere, in ways that may not have been predictable in advance: the proliferation and evolution of calculative devices is a complex and chaotic process.

### *Framing species extinction*

The problem of biodiversity loss, and specifically of species extinction, is hugely complex: there are myriad interactions between humans and non-human species that can have destructive effects on biodiversity (Kolbert, 2014). This scale and complexity makes the problem a daunting challenge for society. It is not immediately clear that society has the capability to act to conserve biodiversity and to prevent species extinctions (Gray, 2010). Building such a capability will require the construction of *agencements*, such that framing new spaces of calculability creates new possibilities for conservation. In the next section, the Red List will be analysed as a calculative device that constitutes a beginning for the construction and proliferation of such *agencements*.

## 3. The Red List

*The International Union for the Conservation of Nature* (IUCN) was founded in 1948 as the world's first global environmental organisation. Its most high-profile contribution to conservation is its ongoing production of the *IUCN Red List of Threatened Species*. The Red List is described by the IUCN as being 'based on an objective system for assessing the risk of extinction of a species based on past, present, and projected threats' (IUCN, 2015c, p. 3). The stated goal of the Red List is to 'provide information and analyses on the status, trends and threats to species in order to inform and catalyse action for biodiversity conservation' (IUCN, 2015d).

The Red List classifies each assessed species into one of eight categories (see figure 1). Where there is insufficient data to support a classification, the species is placed in the *data deficient* category. The remaining categories form a hierarchical system of low to high extinction risk. The lowest classification is *least concern*, which includes species that are widespread and abundant. Moving upwards, the categories are *near threatened*, *vulnerable*, *endangered*, *critically endangered*[2], *extinct in the wild*[3], and *extinct*[4]. The vulnerable, endangered, and critically endangered categories are referred to collectively as the *threatened* categories. To qualify for a threatened category, species must meet specific quantified criteria. Species that do not meet the quantified criteria for threatened status, but are close to qualifying or are likely to qualify in the near future, are classified as near threatened.

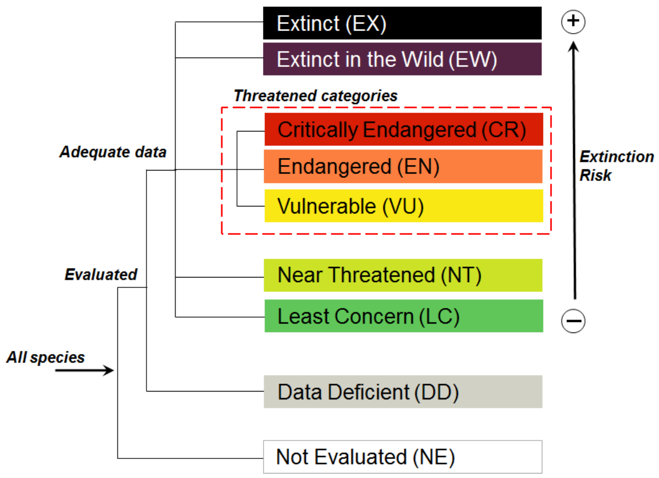


***Figure 1: IUCN Red List categories of extinction risk. Source: IUCN (2012)***

The Red List has so far (as per IUCN, 2015c) assessed and classified 73,686 species. This represents only 3.9% of described species. That is, 58% of vertebrates, 1.2% of invertebrates, 6.2% of plants, and 0.01% of fungi. Micro-organisms, such as bacteria, are not assessed. Estimates vary a great deal regarding the number of species on Earth that are yet to be described, ranging from 5 to 30 million species (Vie, Hilton-Taylor and Stuart, 2009). Assessed species on the Red List, therefore, represent a tiny proportion of total planetary biodiversity, and is highly biased towards certain groups of species.

[2] The critically endangered category includes a sub-category of "possibly extinct", which includes species 'that are, on the balance of evidence, likely to be extinct, but for which there is a small chance that they may be extant' (IUCN, 2014, p. 68).

[3] Species are extinct in the wild when they only survive in cultivation, in captivity, or as a naturalised population outside their historic range.

[4] Species are declared extinct when there is no reasonable doubt that the last individual has died.

*<u>The Red List and accounting for biodiversity</u>*

The classifications of species in terms of their extinction risk, performed by the Red List calculative device, have become fundamental to how researchers and practitioners understand the problem of biodiversity loss. The following brief review of the literature on accounting for biodiversity is intended to demonstrate the importance of the calculation of species' extinction risks to ongoing efforts to bring biodiversity into account in organisational decision-making.

The first seeds of the academic accounting for biodiversity literature were planted by Jones (1996, 2003), who devised a model for organisations to record, value and report on their 'natural inventory' (Jones, 1996, p. 285). The model was designed to make organisations aware of the habitats and species for which they have stewardship responsibilities. Jones is clear that in order to implement the model, organisations must draw upon numerous extant classification schemes in order to distinguish their various 'wildlife assets' (Jones, 1996, p. 283) and so build up a clear picture of their natural inventories. An important distinction, for example, is drawn between "critical" and "non-critical" species. Critical species are those 'rare and endangered species' (Jones, 1996, p. 290) requiring the greatest protection. Jones (2003) suggests that the Red List is used as a source of data on critical species. Taking up the Jones model, Siddiqui (2013) seeks to produce a natural inventory report for the Sundarbans mangrove forest in Bangladesh. Siddiqui's analysis relies upon data drawn from the Red List to identify and catalogue the critical species to be included in the inventory.

The accounting for biodiversity literature has also examined accounting practices in use in various regimes purporting to conserve biodiversity. Cuckston (2013), for example, as part of a study of a carbon accounting project designed to conserve the tropical forest of the Kasigau Corridor wildlife migratory corridor in Kenya, describes a certification scheme (the Climate, Community and Biodiversity Standard) which was meant to certify (among other things) that a project has generated 'net positive impacts on biodiversity' (CCBA, 2013, p. 42). One permitted way of demonstrating this (the way used by the Kasigau Corridor project) is to show that the site hosts 'globally threatened species (according to the IUCN Red List)' (p. 46). This can either be a single individual of a critically endangered or endangered species, or else at least 30 individuals or 10 pairs of a vulnerable species. Similarly, Elad (2014) studies the way that a forest product certification scheme (the Forest Stewardship Council) requires logging companies to compile and disclose biodiversity inventories, which are meant to be used in efforts to manage the forest sustainably. A central feature of these inventories is the identification and disclosure of threatened species within the forest so that plans can be drawn up to ensure their protection. Red List classifications of species' extinction risks, therefore, are seen to be deployed in the construction of certification standards designed to promote biodiversity conservation.

Conversely, Tregidga (2013) develops a highly critical analysis of a biodiversity offsetting scheme, in which a mining company in New Zealand deployed a set of accounting practices that, whilst purporting to demonstrate no net loss of biodiversity, actually completely failed to take any account of three threatened species (as defined by the Red List) that were significantly affected by the company's operations (including a species of snail that was placed directly at risk of extinction from the company's mining site destroying its entire known habitat). Tregidga argues that, because of the exclusion of the extinction risks faced by these species from the accounting, the biodiversity offsetting regime could be seen to 'represent a mechanism through which particular species and habitat destruction can be justified, or at least hidden in its accounting' (p. 827).

In addition to market-based accounting practices, like certification and offsetting, the accounting for biodiversity literature has examined the emergence and development of corporate reporting on biodiversity. Rimmel and Jonall (2013) and van Liempd and Busch (2013) study biodiversity reporting by companies in Sweden and Denmark respectively. Similarly, Atkins et al. (2014) study biodiversity reporting by companies in the UK and Germany. Whilst corporate reporting on biodiversity is generally found to be of poor quality, each of these studies highlights how Red List classifications are used by companies to identify those species impacted by their operations, upon which they need to report. Atkins et al note that the Global Reporting Initiative (GRI) now recommend (in G4-EN14) that companies report 'the total number of IUCN Red List species and national conservation list species with habitats in areas affected by the operations of the organization, by level of extinction risk' (GRI, 2013b, p. 56). The relevance of this disclosure is explained by the GRI as follows:

> This indicator helps the organization to identify where its activities pose a threat to endangered plant and animal species. By identifying these threats, the organization can initiate appropriate steps to avoid harm and to prevent the extinction of species. (GRI, 2013a, p. 104).

As a final example of the way that the Red List has permeated the study and practice of accounting for biodiversity, Thomson (2014a) examines the reporting around the United Nations Convention on Biological Diversity (CBD), so as to understand the role of biodiversity indicators in international biodiversity governance. The CBD is an agreement between 196 national governments to act collectively to mitigate global biodiversity loss. The *CBD's Strategic Plan for Biodiversity 2011-2020* lists 20 targets (the *Aichi Targets*).

Strikingly, only one of these targets directly concerns species extinction. Target 12 states that:

> By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained (CBD, 2010a, p. 9).

The differentiation of species, in terms of their "conservation status" – the level of threat they face – is implicit in this target. The guidance for this target goes further and refers explicitly to the Red List, explaining that the target has two components:

> Preventing extinction – Preventing further extinction entails that those species which are currently threatened do not move into the extinct category. Of the more [than] 19,000 species known to be threatened globally, more than 3,900 are classified as critically endangered. Critically endangered species are considered to be facing an extremely high risk of extinction in the wild.
>
> Improving the conservation status of threatened species – an improvement in conservation status would entail a species increasing in population to a point where it moves into a lower threat status. Using the IUCN criteria a species would no longer be considered as threatened once it moved into the near threatened category (CBD, 2010b, p. 1).

The accounting for biodiversity literature is in an embryonic stage of development (Jones, 2014b). As such, the literature contains notable variety in terms of the different models being proposed and examined for bringing biodiversity into account. This brief review of the accounting for biodiversity literature illustrates the importance of Red List extinction risk classifications to ongoing efforts to bring biodiversity into account in organisational decision-making. Given this importance, it is pertinent to understand how these classifications are calculated, so as to inform an analysis of how the Red List device contributes to creating *agencements* that make extinction calculable in ways that open up possibilities for biodiversity conservation.

## *Calculating extinction risk*

Assessing a species requires an assessor to gather and synthesise all available data on a species' population size and trends, range, habitat availability, and threats (recent, current or projected). So assessing a species means compiling and analysing available data, not gathering new data through fieldwork. Assessments are carried out by IUCN teams, IUCN partner organisations, and by species experts external to the IUCN. In all cases, assessments are subjected to a 'rigorous process of scientific review' (IUCN, 2015a) from a designated Red List Authority[5], who will check that all required information is supplied in the correct format and that the Red List criteria have been 'applied appropriately and consistently' (IUCN, 2015b).

There are five Red List criteria, A-E, against which species must be assessed in order to be given an extinction risk classification. Each criterion sets out quantitative thresholds that species must meet in order to be assigned a threatened status (the vulnerable, endangered, or critically endangered categories). Each species must be assessed against each of the five criteria and is then assigned the highest threatened classification attained from any one criterion. The criteria are each based on 'biological indicators of populations that are threatened with extinction … [and] are designed to identify the symptoms of endangerment rather than the causes' (IUCN, 2015a).

Criterion A concerns the extinction risk indicated by a major decline in a species' population size, either in the recent past or likely in the near future. To qualify for a threatened status under this criterion, species must meet thresholds for actual and/or projected reduction in their populations over a period of either 10 years or 3 generations[6], whichever is longer. Different thresholds are used depending on whether the cause of decline is clearly understood and/or has now ceased and/or is reversible, and whether the reduction is in the recent past or has been projected into the near future (up to 100 years)[7]. Population reductions may be observed, estimated, inferred, or suspected. Calculations of population reductions may be based on direct observation (i.e. counting individuals), an appropriate index of abundance (for example, counting nesting females), a decline in measures of the species' spatial distribution[8] and/or habitat quality, actual or potential levels of exploitation, or

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[5] Red List Authorities (RLA) are networks, within the IUCN, of members with specialist expertise in particular groups of species.

[6] The generation length of a species is defined as the average age of the parents of the current cohort of newborn individuals.

[7] Where the causes of the population reduction are clearly reversible and understood and have ceased, then the thresholds are: ≥90% for critically endangered, ≥70% for endangered, ≥50% for vulnerable. Where the causes may not have ceased or may not be understood or may not be reversible, or where the population reduction is based (in whole or in part) on a projection into the future, then the thresholds are: ≥80% for critically endangered, ≥50% for endangered, ≥30% for vulnerable.

[8] The Red List uses two different measures of spatial distribution of a species: the extent of occurrence (EOO) and the area of occupancy (AOO). EOO is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred, or projected sites in which the species occurs. AOO is defined as the area within the EOO that is actually occupied by the species.

the effects of introduced species, hybridisation, pathogens, pollutants, competitors, or parasites.

Criterion B concerns the extinction risk indicated by a species having a restricted spatial distribution.  To qualify for a threatened status under this criterion, species must meet thresholds for one of two possible measures of spatial distribution[9], and meet two out of three additional conditions.  These conditions are (i) the species' population is severely fragmented[10] or exists in a small number of locations[11], (ii) there is an observed, estimated, inferred, or projected continuing decline[12] in spatial distribution, extent and/or quality of habitat, number of locations or subpopulations[13], or number of mature individuals, and (iii) there are extreme fluctuations[14] in spatial distribution, number of locations or subpopulations, or number of mature individuals.

Criterion C concerns the extinction risk indicated by a species having a small population that is declining or is expected to decline in the near future.  To qualify for a threatened status under this criterion, species must meet thresholds for the number of mature individuals[15] and must meet one of two conditions related to decline.  The first condition specifies quantitative thresholds for observed, estimated, or projected rates of continuing decline[16].  Alternatively, the second condition is that there must be an observed, estimated, projected, or inferred continuing decline (at any rate), plus one of three further conditions: (i) the population is

[9] These are EOO and AOO, see footnote 8 for explanation.  The thresholds for EOO are: <100km$^2$ for critically endangered, <5000km$^2$ for endangered, <20000km$^2$ for vulnerable.  The thresholds for AOO are: <10km$^2$ for critically endangered, <500km$^2$ for endangered, <2000km$^2$ for vulnerable.

[10] The term severely fragmented means that most of a species' individuals exist in small, isolated subpopulations.  Severe fragmentation of a species' population indicates a higher risk of extinction.

[11] Locations are distinct areas in which a single threatening event would affect all individuals of a species in that area.  The thresholds for number of locations are: 1 for critically endangered, ≤5 for endangered, ≤10 for vulnerable.

[12] A continuing decline may be recent, current, or projected, and is expected to continue unless remedial actions are taken.

[13] Subpopulations are distinct groups within the population, with little demographic or genetic exchange between them.

[14] Extreme fluctuations means that population size or distribution area varies frequently by at least one order of magnitude (i.e. a factor of 10).

[15] The thresholds for number of individuals are: <250 for critically endangered, <2500 for endangered, <10,000 for vulnerable.

[16] The thresholds for rates of continuing declines are: 25% in 3 years or 1 generation (whichever is longer) for critically endangered, 20% in 5 years or 2 generations (whichever is longer) for endangered, 10% in 10 years or 3 generations (whichever is longer) for vulnerable.

made up of small subpopulations[17], (ii) the vast majority of the population are in one subpopulation[18], or (iii) there are extreme fluctuations in the number of mature individuals.

Criterion D concerns the extinction risk indicated by a species having a very small population. To qualify for a threatened status under this criterion, species must meet thresholds for the number of mature individuals[19]. Alternatively, for a vulnerable classification (i.e. not for endangered or critically endangered), species may meet a threshold for either spatial distribution or for number of locations[20] as long as there is a plausible threat to the species that could drive it towards critically endangered or extinct in a very short time.

Finally, criterion E requires the use of a quantitative analysis[21] to calculate the probability of a species' extinction in the future. To qualify for a threatened status under this criterion, the quantitative analysis must show a probability greater than specified thresholds within specified time periods[22].

With each species assessment, a species account is created on the IUCN's central online database called the *Species Information Service* (SIS). When an assessor conducts an assessment, they are prompted by the SIS software to enter each of the variables in each of the criteria into the correct boxes on the computer screen. The SIS software then automatically calculates the appropriate classification of extinction risk for the assessed species. In addition to the species' extinction risk classification, the SIS account of an evaluated species contains taxonomic information, a justification for the classification (i.e. a description of the qualifying criteria that led to the classification), and all supporting data used to determine this classification, as well as narrative information concerning geographic range, population, habitat and ecology, known threats, conservation measures, and known

[17] The thresholds for number of mature individuals in each subpopulation are: ≤50 for critically endangered, ≤250 for endangered, ≤1000 for vulnerable.

[18] The thresholds of % of mature individuals in one subpopulation are: 90-100% for critically endangered, 95-100% for endangered, 100% for vulnerable.

[19] The thresholds for number of individuals are: <50 for critically endangered, <250 for endangered, <1000 for vulnerable.

[20] The spatial distribution threshold is AOO being <20km$^2$. The number of locations threshold is ≤5.

[21] The most common type of quantitative analysis used is a Population Viability Analysis (see Gerber and Gonzalez-Suarez, 2010)

[22] The thresholds for probability of extinction in the wild are: ≥50% in 10 years or 3 generations (whichever is longer, up to 100 years maximum) for critically endangered, ≥20% in 20 years or 5 generations (whichever is longer, up to 100 years maximum) for endangered, ≥10% in 100 years for vulnerable.

forms of human use and trade of the species. Each account also contains geographic information system (GIS) data, which can be downloaded and/or visually represented on a map to show the estimated spatial distribution of the species. Periodically (approximately bi-annually), all species accounts are extracted from the SIS and used to produce the published Red List.

### *Making extinction calculable*

The above description shows how the Red List calculative device produces a definitive, unambiguous output – one of eight possible extinction risk classifications for each evaluated species – which is extracted from a complicated process of identification and manipulation of variables within a single space. Each of the five criteria acts to quantify particular qualities of the evaluated species, such that each species is rendered commensurable in five different ways. Thus each evaluated species obtains measurements of its extinction risk status with respect to rate of decline in its population (criterion A), its geographic range (criterion B), its population size and decline (criterion C), its population size (criterion D), and its probability of going extinct in the near future (criterion E). In each of these criteria, qualities are detached from a range of available data, transported to a single space – the SIS computer programme – and subjected to various manipulations such that a result – a risk classification – is extracted. A final calculation then extracts the highest classification from these five results. This extinction risk classification outcome is thus a huge simplification of a mass of entangled information.

The process of arriving at species extinction classifications fits Espeland and Sauder's (2007, p. 17) characterisation of commensuration as 'a means for organizing, integrating, and eliminating information.' The vast majority of what is known about species – their ecological contexts and ethological characteristics – is discarded in favour of a few choice variables deemed to represent dimensions of their exposure to the risk of extinction. Also in keeping with Espeland and Sauder's observations, the commensuration of species in this way 'simultaneously unifies and distinguishes the objects that it encompasses or evaluates' (p. 19). Species are united by a common metric: they share the newly created quality of extinction risk. Species are also distinguished from each other, in terms of the hierarchical relationship between different extinction risk categories. Thus any evaluated species can be meaningfully compared with any other to differentiate whether it is more, less or equally threatened with extinction. As a calculative device, then, the Red List has a potentially transformative effect on the way that humans comprehend non-human species, both individually and collectively: it imposes a form of identity upon species, not as peculiar organisms embodying unique forms of life, but rather as examples of threatened biodiversity.

The Red List device, as part of an assemblage of assessors, computer hardware and software, and an array of research databases, achieves a form of calculability for species extinction, whereby relations between humans and non-human species are framed so as to address, in specific ways, each of Callon's (1998b) three problems of achieving calculability. (1) The material reality of relations between humans and non-human species are identified in terms of human actions inflicting extinction risk upon non-human species. (2) The related agents are identified in terms of species: that is, the collective human species is responsible for inflicting extinction risk upon each evaluated non-human species. (3) The metrological framework comprises a hierarchical structure whereby evaluated species are differentiated and compared in terms of being exposed to greater, lesser, or equal levels of extinction risk. However, as with all efforts to frame spaces of calculability, the calculability achieved by the Red List device is neither perfect nor complete: each aspect of the framing creates the conditions for overflows. Each of the ways that Callon's (1998b) problems of achieving calculability have been addressed in the construction of the Red List device are open to challenge on this basis. These potential overflows offer opportunities for calculative innovations: for the assembly of new configurations of humans and devices so as to construct *agencements* that render species extinction calculable in ways that create new possibilities for conservation. The next section will discuss some of the ways that conservationists have constructed such *agencements*: assembling the calculative equipment they need to make biodiversity conservation possible.

## 4. Making species conservation possible

The Red List device frames species extinction so as to achieve a calculability that is (inevitably and necessarily) incomplete and imperfect in numerous ways. The various aspects of this calculability (defined by the ways Callon's (1998b) three problems have been addressed) have been achieved by choosing to isolate and quantify certain qualities, and by discarding others. Thus there exist further relations that overflow this framing. The existence of such overflows creates opportunities for conservationists to innovate by assembling new *agencements* that can identify and capture these overflowing relations in ways that construct new calculabilities for species extinction and enable possibilities for conservation. Using Callon's (1998b) three problems as a guiding framework, this section will discuss how overflows in different aspects of the Red List's calculability have created opportunities for conservationists to construct new *agencements*. Thus this section will explain how, by becoming part of the calculative equipment of conservationists, the Red List device has been able to 'catalyse action for biodiversity conservation' (IUCN, 2015d).

## *The quality of "extinction risk"*

The Red List's way of addressing Callon's (1998b) first problem of achieving calculability, concerning the identification of the material reality of the relations being brought into account, is to identify – or, rather, to invent – the quality of "extinction risk". That is, humans inflict extinction risk upon non-human species. However, this way of framing the relations between humans and non-human species is the outcome of a dramatic simplification of the entangled web of interactions that exist in the world between humans and non-human species that result in this infliction of extinction risk. All of this contextual information, which explains the causes of extinction risk in specific situations, is discarded in the calculation of extinction risk performed by the Red List device. These causal relations overflow the frame constructed by the Red List.

The identification/invention of the "extinction risk" quality, detached from the (overflowing) context in which extinction risk is produced for any particular species, creates the conditions for conservationists to (re)combine this quality with certain contextual qualities in ways that may enable conservationists to act to reduce extinction risks, and thus conserve species. That is, conservationists are able to frame spaces in which extinction risk is combined with other objects, abstracted from the available information about species, so as to calculate and extract outcomes that aid conservation.

One influential effort to achieve a calculability that enables conservation is the work of the Alliance for Zero Extinction (AZE), which is described as:

> … a joint initiative of biodiversity conservation organizations from around the world, [which] aims to prevent extinctions by identifying key sites, each one of which is the last remaining refuge of one or more Endangered or Critically Endangered species (AZE, 2016b).

AZE, equipped with the Red List and with various databases of information on species, have framed a space in which extinction risk is combined with qualities concerning the locations inhabited by these species, in a way that identifies what the AZE (2016a) call 'epicenters of imminent extinction'. Proposed sites are assessed against three criteria: (i) endangerment, meaning the site contains at least one species whose Red List extinction risk classification is either endangered or critically endangered; (ii) irreplaceability, meaning that the site contains the overwhelming majority (>95%) of the known population of the species for at least one part of its lifecycle (e.g. wintering or breeding); and (iii) discreteness, meaning the area has a definable boundary with a distinct ecological character. The AZE has therefore utilised the output of the Red List device as an input for its own calculative device. Thus the extinction risk quality, produced by the Red List device, has been brought into a new calculation, so as to determine the locations of those places on Earth where the highest levels of extinction risk are concentrated. This outcome makes extinction calculable in a way that enables conservationists to formulate strategies to prevent extinctions, by working to protect these AZE sites.

Just as with any framing, the calculability achieved by AZE is neither perfect nor complete. Conservation strategies formulated on the basis of the AZE calculations will, for example, fail to conserve species that are facing imminent extinction but whose populations are distributed across two or more sites. Similarly, such conservation strategies will fail to conserve species that may be facing imminent extinction but have not been evaluated by the Red List (as mentioned previously, only a very small proportion of described species have been evaluated), or have been evaluated but placed in the “data deficient” category. There are thus relations between species and places that overflow the AZE frame. These overflows do not render the AZE calculation incorrect. Rather, the AZE simply becomes part of the calculative equipment of conservationists, alongside other calculative devices. For example, a similar kind of calculative device, but with more inclusive criteria, is the *Important Bird and Biodiversity Areas* initiative run by Birdlife International. This, too, connects Red List extinction risk classifications of species to the locations they inhabit, so as to identify sites of conservation significance. However, the criteria include thresholds for vulnerable, near threatened, and data deficient species (in addition to endangered and critically endangered) and so captures a broader set of species. Also, the thresholds concerning the concentration of species in specific locations are lower than for AZE. So whilst the AZE device calculates the sites of ‘the most imminent species extinctions’ (AZE, 2016b), the *Important Bird and Biodiversity Areas* device calculates the sites ‘of international significance for conservation of birds and other biodiversity’ (Birdlife International, 2016).[23] So different configurations of the space of calculability, produce outcomes that equip conservationists in different ways.

Just as Kornberger and Carter (2010) described the city ranking device in their study as creating the *a priori* conditions for city strategising, and Skaerbaek and Tryggestad (2010)

[23] At the time of writing there are 588 AZE sites and 13,092 Important Bird and Biodiversity Areas.

describe strategy as an emergent calculative collective achievement, so the above examples illustrate how the production of the "extinction risk" quality, by the Red List device, creates the conditions in which strategising for conservation is made possible. Relations between this newly produced quality of "extinction risk" and other qualities of species (such as the geographical locations in which their populations exist), which were discarded in the Red List calculations of extinction risk, overflow the frame that bounds the Red List's space of calculability. It is this overflowing that opens up opportunities for calculative innovation, whereby further calculative devices (like AZE) can be constructed. Species extinction becomes reframed as a problem that can be addressed through specific targeted actions (like protecting habitat in particular locations). Consequently, acting as a constituent part of assemblages of human actors and calculative devices, the calculability achieved by the Red List contributes to the production of *agencements* with collective capabilities to formulate strategies for conservation, and thus to prevent species extinctions.

### *The "threatened species"*

The Red List's way of addressing Callon's (1998b) second problem of achieving calculability, concerning the identification of the agents whose relations are being brought into account, is to identify agents in terms of species. Humanity is reduced to a single (destructive) collective force. Non-human species are reduced to specimens of "threatened" (or not threatened) biodiversity: the Red List constructs an identity for evaluated species that is based, not on the features and peculiarities of their form of life (the biological and behavioural relations that define their ecological and ethological existence), but rather on their status in terms of the calculated threat to their continued survival. That is, the whole collective of the human species is understood to be acting upon (inflicting extinction risk upon) whole collectives of each evaluated non-human species. This way of framing the complex interactions between humans and non-humans is the outcome of a great simplification: individual humans, and groups of humans, will have considerably varying impacts upon individuals, and groups, of non-human species. These vastly complicated networks of relations between human and non-human agents are discarded in the process of evaluating the extinction risk of a species. These relations thus overflow the frame constructed by the Red List.

The identification of evaluated species in terms of being "threatened", and the various gradations of "critically endangered", "endangered" and "vulnerable", detached from the (overflowing) tangled web of life in which these species are situated, creates the conditions for conservationists to seek to construct new relations between individual humans (and groups of humans) and these threatened species: relations that are conducive to conservation. That is, conservationists can enrol the "threatened species" into *agencements* capable of defining and defending the interests of these species in their own continued survival.

Whilst it might sound strange to speak of non-human species becoming part of *agencements*, Callon's (1986) famous paper, concerning the scallops of St. Brieuc Bay, has demonstrated the analytical power of treating human and non-human actors symmetrically: of 'the abandonment of all *a priori* distinctions between the natural and the social' (p. 196). In the scallops case, Callon describes how scientific researchers came to be able to speak for, and represent the interests of, the scallops. The scallops in the bay were in severe decline due mostly to overfishing by local fishermen. The researchers set out to develop a conservation strategy for the scallops. The plan was to offer the scallop larvae a shelter above the sea floor, protected from predators and from the local fishermen, so they could mature undisturbed and thus restock the bay. But little was known about the lifecycle of this particular species of scallop, so the researchers' plan was predicated on a hypothesis that, during the larval stage of their lifecycle, this species anchored itself to the sea floor. The researchers thus proposed a particular identity for the scallops (as creatures whose larvae anchor themselves to the sea floor) and then set about enrolling the scallops into this identity.

> The question which is asked by the three researchers supposes that they [the scallops] can anchor themselves and will 'accept' a shelter that will enable them to proliferate and survive (Callon, 1986, p. 202).

What follows is a series of efforts to 'impose and stabilize' (p. 203) this identity by using various material devices to encourage the scallops to submit to this identity (by anchoring themselves to the shelters), such that researchers and scallops can 'construct a system of alliances' (p. 204) which serves the interests of both parties. The alliance formed is one in which those scallops that do anchor themselves to the shelters become understood as representatives of the species: demonstrating their compliance with the identity defined for them by the researchers. In turn, the researchers, by counting the anchored scallops and turning these numbers into graphs as part of scientific reports, are able to represent the scallops of St Brieuc Bay. The researchers have mobilised the scallops such that the researchers are able to speak for the scallops. They have simplified the complex behaviours of the scallops at different parts of its lifecycle to an unambiguous truth: this species anchors itself, and this is the key to their continued survival in the bay. Callon (1986) does not use the word, but the scallops, researchers, and numerous material devices that connect them together, form an *agencement*, with powers to act collectively. By ‘acting as a single unit of force’ (p. 208), the researchers and the scallops attain an agency to argue in favour of the scallops’ (now clearly defined and established) interests.[24]

Just as scallops and researchers were able to act collectively, so the “threatened species” identity, constructed by the Red List, creates the conditions for conservationists to be able to speak for these species in ways that are conducive to their conservation. The challenge for conservationists is to mobilise the “threatened species” identity so as to enrol humans (and human organisations) into new *agencements* that are able to act to prevent these species’ extinction. One strategy for achieving this is exemplified by the conservation charity, WWF. When a person visits their website homepage, for example, they are immediately invited to ‘adopt a snow leopard’ (WWF, 2016a). In exchange for donating £3 a month, the visitor will receive a cuddly snow leopard toy, and a magazine three times a year called *My Snow Leopards* updating them on the progress of snow leopard conservation. The blurb encouraging the visitor to subscribe reads:

> Powerful, captivating and incredibly vulnerable to threats like poaching, loss of prey and conflict with people. Help us protect this endangered big cat (WWF, 2016a).

An accompanying video shows a snow leopard walking in harsh frozen terrain, before cutting to an image of a hanging snow leopard fur, presumably a consequence of poaching. The voiceover pleads: ‘with your support, we can help them survive’ (WWF, 2016a). If the website visitor is not impressed by snow leopards, there are a range of other wild animals they could adopt instead: a Bengal tiger (endangered), Asian elephant (endangered), giant panda (endangered), polar bear (vulnerable), black rhino (critically endangered), or mountain gorilla (critically endangered). These are all examples of iconic species: the poster-children of conservation (Castree, 2014). WWF itself describes them as ‘animals that provide a focus for raising awareness and stimulating action and funding for broader conservation efforts’ (WWF, 2016b). By constructing a frame in which threatened species are represented by an iconic wild animal, WWF, and other conservation groups with similar fund-raising strategies, create a space in which an individual person feels they are capable of acting effectively. Species extinction can feel like an insurmountable problem that is beyond the capabilities of any single person to address. However, the plight of a snow leopard, as it struggles to survive in a harsh environment, surrounded by specific tangible threats, is perhaps more

[24] As it turns out, this particular alliance is eventually betrayed and, for a variety of reasons, the conservation strategy at St Brieuc ultimately fails. This betrayal serves to highlight how all alliances – all *agencements* – are tentative, temporary achievements.

tractable. Even though the website visitor may never see an individual of this species in the wild, this framing invites them to form a personal connection with the species, and (hopefully) to provide funds that will help to ensure its continued survival. Equipped with the Red List, the WWF has made species extinction calculable for individuals in a way that constructs new relations between these individuals and particular threatened species: relations that enable the conservation of these species and the prevention of their extinction.

A similar process of *agencement*-building has been documented by Atkins, Barone, Maroun and Atkins (2015b) in a study of disclosures in South African listed companies concerning conservation of rhinoceros. They find that South African companies are using their corporate reporting to present themselves as being involved, mostly through the provision of funds, in efforts to save the rhino from extinction. Atkins et al highlight the activities of a conservation group called the Rhino Action Group Effort (RAGE) in raising the public profile of rhino poaching. The Rhino's iconic status as one of Africa's Big 5 (alongside the lion, elephant, buffalo and leopard), and its identity as a *critically endangered species*[25], have created conditions in which corporations are impelled to ally themselves with conservation efforts.

The above examples thus illustrate how the Red List's production of the identity for species as "threatened" (or as "critically endangered", "endangered" or "vulnerable") creates the conditions in which conservationists are able to construct new kinds of *agencements* – new sets of relations between humans and non-human species – with collective capabilities to conserve species and prevent their extinction. Relations between this newly produced "threatened" identity and other ecological and ethological features of species (such as the kind of terrain they occupy and the specific threats they face), which were discarded in the Red List calculations of extinction risk, overflow the frame that bounds the Red List's space of calculability. It is this overflowing that opens up opportunities for making the extinction of a particular species calculable in ways that evoke an emotional response. That is, species extinction becomes reframed so that, rather than being an abstract set of risk classifications, it becomes something concrete and something judged to be unacceptable. Consequently, acting as a constituent part of assemblages of human actors – and, indeed, non-human species – and calculative devices, the calculability achieved by the Red List contributes to the production of *agencements* with collective capabilities to impel people (and, indeed, corporations) to want to play a part in making conservation happen.

[25] Sub-Saharan Africa has two species of rhinoceros. The white rhinoceros is classified as near threatened. The black rhinoceros is classified as critically endangered.

*An extinction hierarchy*

The Red List's way of addressing Callon's (1998b) third problem of achieving calculability, concerning establishing a metrological framework to measure the effects of those relations that are being brought into account, is to establish a set of hierarchical relations between species that differentiate them on the basis of their levels of exposure to extinction risk. In this sense, extinction risk is a quantified quality, whereby species can be directly compared in terms of being more, less, or equally exposed to extinction risk. This commensuration of species, so as to evaluate them using a common metric, requires that species are detached and isolated from their relations within the ecological networks they inhabit. That is, the calculation performed by the Red List device treats each species as a separate, independent entity, and calculates its extinction risk on the basis of variables concerning only that species (population size and decline, geographic range, and such like). Thus the framing of the Red List device discards all the interconnections of different species that make up the web of life that is the global biosphere. These interrelations overflow the frame constructed by the Red List.

The metrological framework produced by the Red List device, which replaces the vastly complex interconnected relations between species with a straightforward set of hierarchical relations between species, creates the conditions for conservationists to frame spaces of calculability that make visible and comprehensible the ongoing impact of human society upon global biodiversity. One such framing has been developed by the IUCN. It has produced a calculation that detaches classifications of extinction risk for species from the Red List, manipulates and combines them in a way that enables the extraction of an outcome representing what the IUCN calls a *Red List Index*:

> Put simply, the number of species in each Red List Category is multiplied by the Category weight (which ranges from 0 for Least Concern, 1 for Near Threatened, 2 for Vulnerable, 3 for Endangered, 4 for Critically Endangered and 5 for Extinct in the Wild and Extinct). These products are summed, divided by the maximum possible product (the number of species multiplied by the maximum weight), and then subtracted from one (IUCN, 2009, p. 7).

The result is a number between 0 and 1, where 0 indicates that all species included in an index have become extinct (or extinct in the wild), and 1 indicates that all species included in the index are categorised as least concern. Indices are calculated for different groups of species, such as birds, mammals, amphibians, and corals, to provide an aggregated measure of their collective exposure to extinction risk. Indices are recalculated periodically so that trends in aggregated extinction risk can be tracked over time. Red List indices present a clear picture of worsening extinction risk (see figure 2).

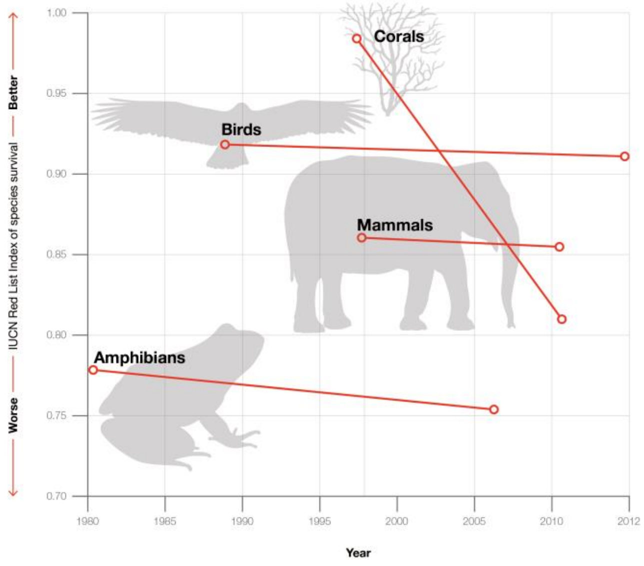


***Figure 2: Changes in IUCN Red List indices for different species groups. Source: IUCN (2015c)***

The IUCN promotes the Red List Index as a kind of 'barometer of life' (IUCN, 2015c, p. 10). It has been adopted by the *United Nations Convention on Biological Diversity* (CBD) as an indicator for Target 12 of its strategic plan (discussed in section 3 above), which aims to prevent species extinction and improve the conservation status of threatened species. The latest *United Nations' Biodiversity Outlook Report*, which reviews the progress of the CBD's strategic plan, concluded with respect to target 12 that:

> … based on our current trajectory, this target would not be met by 2020, as the trend towards greater extinction risk for several taxonomic groups has not decelerated since 2010. Despite individual success stories, the average risk of extinction for birds, mammals, amphibians and corals shows no sign of decreasing (CBD, 2014, p. 87).

Framed in this way, the challenge of biodiversity loss becomes evident and stark. The Red List metrological framework has enabled the construction of a space in which extinction has been made calculable as a crisis facing humanity and the planet we inhabit.

Furthermore, the Red List's metrological framework has enabled biologists to construct another highly provocative framing of global biodiversity loss: the threat of a modern-day, human-induced, mass extinction event (Barnosky et al., 2011; Ceballos et al., 2015). The basis of this framing is a manipulation of Red List classifications so as to calculate and extract a contemporary rate of species extinctions, measured in terms of extinctions per million species-years, E/MSY. That is, the number of species which go extinct each year for every million species existing on the planet. Various calculations of modern extinction rates have been performed on the Red List extinction risk classifications, focussing on different taxonomic groups, using different time periods, and making different assumptions about the likelihood of the recovery of species in different Red List categories (Barnosky et al., 2011). For example, Ceballos et al. (2015) uses only data for vertebrate species, because these are the most complete data in terms of the percentage of described species that have been evaluated. They perform two calculations: (i) a *highly conservative* estimate using only vertebrate species classified as extinct, and (ii) a *conservative* estimate using only vertebrate species classified as extinct, extinct in the wild, and critically endangered (possibly extinct)[26]. The number of vertebrate species in these categories (representing the number of vertebrate species extinctions since 1900) is compared to the total number of evaluated vertebrate species to extract a modern extinction rate for vertebrate species. This is compared to a conservative estimate of historic background extinction rate for vertebrates of 2 E/MSY, calculated from analyses of fossil records. They find that, over the past century, the extinction rate for vertebrates has, under highly conservative assumptions, been 22 times the historic background rate and, under conservative assumptions, been 53 times the normal background rate. They conclude from this:

> Our analysis shows that current extinction rates vastly exceed natural average background rates, even when (i) the background rate is considered to be double previous estimates and when (ii) data on modern vertebrate extinctions are treated in the most conservative plausible way. We emphasize that our calculations very likely underestimate the severity of the extinction crisis because our aim was to place a realistic "lower bound" on humanity's impact on biodiversity. Therefore, although biologists cannot say precisely how many species there are, or exactly how many have gone extinct in any time interval, we can confidently conclude that modern extinction rates are exceptionally high, that they are increasing, and that they suggest a mass extinction under way—the sixth of its kind in Earth's 4.5 billion years of history (Ceballos et al., 2015, p. 3).

The above examples thus illustrate how the Red List's metrological framework, which differentiates species in terms of their level of exposure to extinction risk, creates the conditions for conservationists to construct further spaces of calculability that render society's impact on global biodiversity visible and comprehensible in provocative ways. Relations between species, which define how species collectively comprise complex ecosystems and Earth's biosphere, and which were discarded in the Red List calculations of extinction risk, overflow the frame that bounds the Red List's space of calculability. It is this overflowing that opens up opportunities for calculative innovations, whereby further

[26] As mentioned in section 3, critically endangered (possibly extinct) is a sub-category of the critically endangered category, whereby the species is believed likely to be extinct, but there is a chance that it is not.

calculative devices (like the Red List Index or various measures of an extinction rate) can be constructed. Species extinction becomes reframed so that, rather than being a compilation of individual species facing their own existential threats, it becomes a perceptible planetary crisis: a global ecological disaster. Making extinction calculable in this way may, if it can become embedded in the public consciousness, provoke societal reflection, debate, and demands for change in how we interact with non-human species (cf. Atkins, Atkins, Thomson and Maroun, 2015a; Thomson, 2014b, 2015). Consequently, acting as a constituent part of assemblages of human actors and calculative devices, the calculability achieved by the Red List contributes to the production of *agencements* with collective capabilities to confront society with a measure of what is happening to the biosphere. The question remains, however, how (if at all) such calculability of species extinction can elicit further calculative innovations so as to equip society to make conservation possible.

## 5. Conclusion

This paper began by reflecting on Gray's (2010) concern that our capitalist society is organised in such a way that profit-seeking organisations are fundamentally unable to act as responsible stewards of the natural environment. The relentless pursuit of financial performance means that such organisations simply aren't capable of acting to conserve biodiversity. Given this, what is the point of accounting for biodiversity? If it is simply about making corporate impacts upon biodiversity visible (cf. Jones, 2014a) then it is unlikely to achieve much. Even if profit-seeking organisations can see the damage they are causing to the biosphere, they will still be driven by their financial imperatives and thus powerless to do much to change it.

This paper seeks to respond to this pessimism about whether accounting for biodiversity can be what Miller and Power (2013) call a productive force by focusing on how accounting might contribute towards creating conditions in society in which biodiversity conservation does become possible. In order to do so, this paper has drawn on theorising from the social studies of finance, which conceptualises the capacity to act in terms of being a collective achievement of assemblages of humans and calculative devices – that is, *agencements* – that are able to frame a space of calculability (Callon, 1998b, 2016).

This form of enquiry has been pursued in the extant accounting literature by researchers studying the role of accounting, embodied in calculative devices, in addressing the problem of climate change (Cuckston, 2013; MacKenzie, 2009a; Vesty et al., 2015). Such work has revealed some of the ways that climate change impacts have been rendered calculable so as to create possibilities for mitigation, such as carbon trading. Callon (2009) suggests that this perspective creates an understanding of carbon accounting as being part of global collective experiments in the construction of *agencements*. This paper has adopted this perspective for the study of accounting for biodiversity. That is, efforts to render species extinction calculable may be seen to be experiments in the construction of *agencements* that are capable of conserving biodiversity and of preventing species extinctions.

This paper has analysed the role of a particular calculative device – the Red List – in framing species extinction in ways that create conditions conducive to conservation. The Red List's calculations of extinction risk classifications were found to produce a calculability in which humanity is seen to inflict varying levels of extinction risk upon evaluated species. That is, within the space of calculability created by the Red List, evaluated species are rendered commensurable, such that they share a common metric and can be meaningfully compared in terms of being more, less, or equally threatened with extinction (cf. Espeland and Sauder, 2007). However, the power of the Red List comes from the ways that this space of calculability is able to overflow. Entities within the Red List's frame interact with entities outside the frame, and it is this overflowing that creates conditions for calculative innovations. Such innovations frame species extinction in different ways, so as to create new calculabilities for extinction and new possibilities for action to conserve species.

This paper has traced three ways that the Red List's frame has overflowed, leading to calculative innovations and the construction of new *agencements*. The overflow of relations between the quality of "extinction risk", produced by the Red List, and other qualities, such as location, has created opportunities for conservationists to develop *agencements* capable of formulating conservation strategies. The overflow of relations between the identity of the "threatened species", produced by the Red List, and other features of evaluated species, has created opportunities for conservationists to develop *agencements* capable of impelling participation in conservation efforts. The overflow of ecological relations between species, discarded by the Red List's hierarchical metrology of extinction risk classifications, has created opportunities for conservationists to develop *agencements* capable of confronting society with the reality of an extinction crisis.

The extant literature has largely conceptualised the role of accounting for biodiversity in terms of being a way to hold corporations accountable for their impacts upon biodiversity (Boiral, 2016; Jones, 2014a). This understanding has led some researchers to assert that an effective accounting for biodiversity needs to represent biodiversity in economic terms because this is the only language that corporations and policy-makers ultimately understand (Jones, 2014c; Khan, 2014; van Liempd and Busch, 2013).

> In the sense of accounting as a calculative technology, biodiversity can only be "accounted for" if species can be "valued" in financial terms (Jones and Solomon, 2013, p. 678).

An economic framing may well have a role to play in encouraging policy-makers to see and comprehend their own self-interests in biodiversity (cf. TEEB, 2010). Yet such a framing is unlikely to be sufficient, by itself, to create conditions in society where it becomes possible to prevent ongoing species extinctions. Such a framing, in which biodiversity is made calculable in terms only of its usefulness to human society, will remain blind to the uniqueness of individual species and the tragedy of their extinction (Hines, 1991; Lehman, 1996; Maunders and Burritt, 1991). But the analysis in this paper has revealed a role for accounting for biodiversity that goes beyond (largely futile) efforts to encourage corporations to behave like environmental stewards. That is, accounting for biodiversity may instead be conceptualised as a tool for conservationists, equipping them to be able to do the work of preventing species extinctions. To create conditions in society in which conservation becomes possible, the focus cannot be solely on corporations, which are driven by financial imperatives (Gray, 2010), but rather on people and organisations who seek to serve the interests of those non-human species comprising Earth's biosphere.

In a paper setting out a utopian vision of a sustainable world, Atkins et al. (2015a, p. 666) call for 'normative "explorations" of alternate mechanisms of accountability … where imagination and creativity are unrestricted by pre-existing conceptions of the role of accounting'. The above analysis offers a way forwards for answering this call. Researchers seeking to contribute to the development of an accounting for biodiversity that is a productive force that contributes to preventing species extinctions, may find it fruitful to structure their imaginings using Callon's (1998b, 2016) notion of *agencements*. That is, researchers might ask how particular forms of accounting, embodied within calculative devices, become part of assemblages of humans and devices that have collective capabilities. Crucially, researchers might also ask how the spaces of calculability, which enable such capabilities, might overflow, creating the conditions for further calculative innovations. Future research could continue to examine the productive force of the Red List by studying (or imagining) further ways that its framing of species extinction can overflow so as to lead to new framings and new capabilities. Other calculative devices may also provide good starting points for such research. The challenge posed by this paper, to researchers, is to explain how accounting for biodiversity can equip our society to act to conserve species and thus to prevent humanity from becoming the cause of Earth's sixth mass extinction event.

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