



# Distinguishing regeneration from degradation in coral ecosystems: the role of value

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## Abstract

In this paper I argue that the value attributed to coral reefs drives the characterisation of evidence for their regeneration or degradation. I observe that regeneration and degradation depend on an understanding of what an ecosystem looks like when undegraded (a baseline), and that many mutually exclusive baselines can be given for any single case. Consequently, facts about ecological processes are insufficient to usefully and non-arbitrarily characterise changes to ecosystems. By examining how baselines and the value of reefs interact in coral and algal reef examples, I argue that considering the value of an ecosystem is a necessity when describing processes like regeneration and degradation. This connects *value* as studied in socio-ecological and economic research with *values* as discussed in the philosophy of science literature. It also explains why such a broad range of processes may be considered regenerative, including those which introduce significant novelty, as well as pointing towards ways to mediate related debates, such as those surrounding novel and ‘pristine’ ecosystems.

**Keywords** Coral reef · Regeneration · Degradation · Value · Ecosystem · Baselines

## 1 Introduction

Coral reefs are increasingly threatened ecosystems. Both degradation and attempts at regeneration are pushing them into never-before-seen (novel) ecological configurations (Hughes et al. 2017; Graham et al. 2014). The status of such configurations may be unclear or disputed (e.g. Tye Pettay et al. 2015; Stat and Gates 2011). In

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theory, changes which restore aspects of the reef system, such as its functioning or structure, are regenerative (MacCord and Maienschein 2019). Conversely, changes which impede such aspects are considered degradation or damage<sup>1</sup> (Vásquez-Grandón et al. 2018). In practice, this distinction is not clear-cut, leading to debates over the status of ecosystems or the desirability of interventions to alter them (Hobbs, Higgs and Harris 2009; Graham et al. 2014; Filbee-Dexter and Smajdor 2019; Hoegh-Guldberg et al. 2008). Part of the problem is that descriptions must be relative to a baseline, i.e. a depiction of the undegraded state of the ecosystem in question. What a baseline contains has been left largely implicit (something I aim to remedy here), but is hugely consequential: using different baselines will produce different answers as to whether a change is regenerative, degradative, or neither (Soga and Gaston 2018; Ureta et al. 2020). As I show in what follows, these answers may differ drastically, producing mutually exclusive characterisations of the state of an ecosystem.

In this paper I address the problem of how regeneration is distinguished from degradation in practice, using the case of algal and coral reefs. I argue that there is nothing factual that prevents algal reefs being seen as non-degraded, or, conversely, coral-dominated reefs as degraded. To make the terms *regeneration* and *degradation* useful and non-arbitrary, they must be relative to aspects of reefs that are considered to be valuable. Whilst this invites charges of pernicious relativism, i.e. that all assessments of degradation and regeneration are therefore as good as each other, I argue that value actually prevents such an outcome. As such, value is a necessary part of these concepts. This shows an important and under-appreciated role for this sense of value in coral reef science and in philosophy of science/ecology generally (as well as a role for the social sciences in understanding and articulating such value attributions). It also helps address a problem faced by any general account of regeneration, namely by explaining what unifies the broad range of processes the label has been applied to, or else explaining why some of these cases are not really cases of regeneration. This is particularly challenging as some processes described as regenerative involve introduction of significant novelty, which seems at odds with the notion of regeneration as a recursive process. Another challenge is to account for the disagreements, seen throughout the history of regeneration studies, over what counts as a regenerative process.<sup>2</sup> The account I offer here can do this. It also pushes us to further recognise the necessity of taking a perspective in some areas of science, and suggests avenues for mediating disputes across some of these perspectives.

As regeneration is related both to health (i.e. how a system ought to behave or function) and to self-renewal (i.e. persistence and restoration) I build on accounts developed by philosophers in these areas. Philosophical analyses of cell self-renewal have suggested that it be distinguished from other processes by looking for

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<sup>1</sup> I use these terms synonymously throughout. I avoid the word degeneration, despite this offering a nice symmetry, because it is rarely used in ecology, conservation or coral reef science, as well as having unhelpful historical connotations (Lawrence 2010).

<sup>2</sup> For example in animals in the 20th C (Morgan 1901, pp. 19–25; Sunderland 2010) or in ecosystems today (Hobbs et al. 2009).

the persistence of some contextually defined set of characteristics across cell division (Fagan 2013, pp. 20–22). If these persist, and no significant deviations in cell characteristics are detected, the cell can be described as undergoing self-renewal. In attempts to define disease, accounts which treat it as statistical difference in characteristics across a class of organisms must limit which reference classes of organisms to include in the comparison. Comparing the pulse of a young organism to an old one may erroneously cast one of them as ill, for example. Reference classes will typically account for all sorts of variation in characteristics depending on the context (Kingma 2007, 2020). Both of these accounts stress that context, interests, and values shape the concepts we use. I build on this by developing an account which links pre-existent understandings of coral reef value to philosophical discussion about the role of values in science. Unlike the cases above, this account applies to reefs as ecosystems, rather than organisms or cells. That there are similarities across cellular biology, medical biology and ecology also suggests that the role for value outlined here may apply in cases of regeneration at different scales, thereby potentially forming part of an account of regeneration across living systems generally<sup>3</sup> (MacCord and Maienschein 2019).

I first look at the literature on values in science and the distinctive aspects of the coral case explored here. After this, I outline what an ecological baseline consists of, and use baselines to give definitions of regeneration and degradation. Different baselines will yield different descriptions of regeneration and degradation. Next, I examine the case of algal dominance, which is a textbook example of coral reef degradation. Even here, multiple distinct baselines can be employed, so algal takeovers labelled as degradation or regeneration. This threatens to make the application of the labels arbitrary, if only considering the facts of each case. It also crystalizes the problem: why are certain baselines employed in algal domination cases, leading to these cases being considered as degradation? To solve this, I look at what goes into the baselines employed in the algal domination case, and why. Value plays an important role here, driving the inclusion of some things (and some kinds of thing) and not others into baselines, with descriptions of degradation and regeneration thereby partly contingent upon the value attributed to reefs, i.e. not purely factual. This explains why algal domination is typically considered degradation, but also why there is disagreement over this. It also helps explain the prevalence of notions of purely factual baselines in coral science despite simultaneous recognition of the comparatively great value accorded to baseline states. Here, the value of certain coral reef assemblages serves as a justification for employing specific baselines, thereby ensuring regeneration and degradation are useful and non-arbitrary labels.

I then explore the merits and implications of this account, arguing it forces us to recognise the importance of perspective in this area of science, explains the

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<sup>3</sup> There are also important differences between regeneration as discussed here and illness/self-renewal of cells: ecosystems are more obviously shared and public systems, so have a larger set of stakeholders to consider; regeneration is not limited to function in the way talk about illness often is; the values involved here are of a different type to those typically discussed in other contexts (see next section); amongst other differences. For brevity's sake I do not further examine the differences and similarities here.

inclusion of a broad range of processes under the label *regeneration*, including those which introduce novelty, and also allows for the disagreement and shifts seen historically in which processes are considered regenerative. It further explains some of the virtues and vices of the ecosystem service and novel ecosystem approaches to ecology, as well as how future-oriented baselines are possible. Finally, I highlight some avenues for mediation between different perspectives on regeneration that this account suggests.

## 2 Values in coral science

That science is influenced by values is, by now, a well-trodden path, albeit more by philosophers than scientists. Science-value interactions come in many forms, starting with more seminal notions of underdetermination of theories by evidence (Quine 1951; Putnam 2002; Stanford 2017) and the role of epistemic values such as simplicity in theory choice (Kuhn 1977).<sup>4</sup> Since then, more cases of epistemic and non-epistemic values influencing both external and internal aspects of science have emerged, such as when evaluating the risks of accepting or rejecting hypotheses (Douglas 2016) or when making choices about the construction and application of concepts (Dupré 2007). Other developments include challenges to the epistemic/non-epistemic distinction (Rooney 1992), and accounts which show value influencing scientific practices as well as concepts (Lee and Helgesson 2020). More exotic ways of relating value to science have also been explored, such as treating the scientific laboratory as a site of production of various forms of value (Pinel 2020).

There is an interesting change visible when shifting from values in science to science as producing forms of value: from *values* to *value* (or *forms of value*). Whilst this may be partly linguistic (these are of course related notions), much of the discussion of value in science has been about *values* as influencing the content and practices of science. Typically this involves ideals of sorts: simplicity, fruitfulness, accuracy, universality on one hand; personal, ethical and social values on the other (Douglas 2016; Rooney 1992; Elliott and McKaughan 2014). *Value*, in contrast, is more often attributed to entities or processes, and as such the immense cultural, economic and ecological value attributed to coral reefs.

The coral case nicely brings out a role for this sort of value in science. In coral science, the traditional philosophical path of value-ladenness is less well-trodden. For example, concepts such as the baseline state of a coral reef (explored in the next section) are often presented as simply given by nature. Disputes about baselines seem to revolve around factual questions, such as whether the correct timescale has been picked to represent a ‘pristine’ coral reef, i.e. whether the baselines employed have shifted from the true baseline (Jackson 2001; Bruno et al. 2014). Despite this, coral scientists frequently make appeals to the many and varied valuable facets of

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<sup>4</sup> Very roughly, epistemic values are those which promote the attainment of truth, such as accuracy, consistency, simplicity and fruitfulness (Douglas 2016). Non-epistemic values are any other form of value, typically values described as ethical, social, personal or religious.

coral reefs, for example comparing them in value to rainforests, stressing the many ways humans and other organisms depend on them, and describing the goal of coral reef management as sustaining coral reef contributions to human wellbeing (rather than simply returning reefs to their baseline states) (Knowlton 2001; NASEM 2019, p. 1; Bellwood et al. 2004).

On the one hand, then, coral reefs are bearers of immense value. On the other, what a reef ought to look like is treated as a factual matter. I intend to square these two with one another, offering an account of the role of *value* in influencing scientific concepts and practice. Here, the value attributed to aspects of the object of study itself (the coral reef) drives concept formation in coral science, shaping how evidence is characterised, and so how things are described and responded to (via baselines and the labels regeneration and degradation). This is because descriptions of changes to coral systems are underdetermined by the facts, so value must be employed to adjudicate between descriptions.<sup>5</sup> In this case, these forms of value are non-epistemic: ecological or economic, affective or aesthetic, for example. They are more often applied to particular entities, as in accounts of the laboratory as a site of value production (Pinel 2020). They aren't the typical kinds of non-epistemic value discussed in more traditional philosophy of science contexts, which are often instead spoken of in terms of social, political or personal values (Rooney 1992; Elliott and McKaughan 2014). Nor is value here influencing science purely through consideration of downstream risk (as in Douglas (2000)). There is, of course, likely overlap between *value* in the sense employed here, and *values* as regards discussion of non-epistemic values influencing science, for example in the role of aesthetic values guiding science and the aesthetic value of coral reefs.<sup>6</sup> Equally, this kind of role for non-epistemic values generally has been articulated before [e.g. in connection with the multiple goals of science (Elliott and McKaughan 2014)]. However, I hope here to draw more direct connections between these senses of value: value as studied in areas like ecology, economics, and anthropology, and as attributed to entities in the world; and values as influencing science.

There is also a large literature on value in ecology and conservation, including recognition of the essentially normative nature of conservation, such as its commitment to the value of biodiversity (Soulé 1985). Relatedly, there have been discussions about the role of concepts like biodiversity as meeting places for value and scientific judgment (Sarkar 2019). Values are also often noted as operating in areas such as health and wellbeing (Kingma 2007; Alexandrova 2018),<sup>7</sup> resulting in concepts and claims in these areas being considered 'thick' or 'mixed' (Putnam 2002; Alexandrova 2018). As such, it will not be surprising to philosophers versed in these areas that *regeneration* and *degradation* too are value-laden. What will hopefully be of interest here is an account of how they are value-laden, one which draws

<sup>5</sup> This is, in part, because the systems in question are environments for various agents, human and non-human, (some of) whose interests we have to consider.

<sup>6</sup> I do not explore this overlap any further here.

<sup>7</sup> Although even here a role for value is sometimes still denied, such as in purely naturalist accounts of disease (Powell and Scarffe 2019).

connections to the value of the object of study itself (coral reefs in coral science). It has previously been suggested that non-epistemic value should not directly influence the characterisation and interpretation of evidence (e.g. Douglas 2016); and that attributing value to the objects of study of ecology (such as specific organisms, species, functions or structures) can have a pernicious influence on ecological science, subtly skewing results and how they are presented (Vellend 2019). Whilst I do not deny this may sometimes be the case, I argue here that some value attributions are also necessary for concepts like regeneration and degradation to be useful and non-arbitrary. I also hope that the arguments here will help clarify debates around baseline choice in coral science, showing that aiming for pristine reefs is justifiable, but not on purely factual grounds.

### 3 Regeneration, degradation, and baselines

As we have seen already, distinguishing regeneration from degradation requires looking for restoration or impediment of some aspect of the system in question (MacCord and Maienschein 2019; Vásquez-Grandón et al. 2018). To determine if aspects of a system have been impeded or restored, a reference point is required. This point allows for comparison, by describing how the system in question ought to behave, that is, what characteristics it ought to have. Restoration or impediment is then judged relative to this reference point.

Such a reference point is sometimes called a baseline (Vásquez-Grandón et al. 2018; Campbell et al. 2009; Jackson 2001). They are based, at least in part, on the historical or present behaviour of either the specific system in question, or systems of that type (Vásquez-Grandón et al. 2018; Braverman 2020). Regeneration then becomes the movement of some system towards its baseline, i.e. movement towards how it ought to behave. This is *re*-generative, rather than simply generative, because the system is thought to either have actually exhibited those characteristics in the past, or to be the type of system which exhibits such characteristics. Degradation is the opposite: movement from a baseline, i.e. from how the system ought to behave (Hobbs 2016).

Baselines need to be indexed to a timescale, as time greatly alters the significance of events within ecosystems. What impedes aspects of a system on one timescale may restore aspects of it on another (and vice versa). A classic example is forest fire, which may kill many organisms on a short timescale, but be a vital part of regenerating habitats on a longer one (Johnstone et al. 2016). Not only this, but baselines must focus on a specific set of entities and characteristics, as ecosystems have many aspects to consider: compositions, functions, and structures among the most commonly mentioned (Hobbs et al. 2009; Vásquez-Grandón et al. 2018).<sup>8</sup> Not all of these will be included in regeneration or degradation claims, and indeed there may be some aspects of ecosystems which it is difficult to restore or prioritise

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<sup>8</sup> Baselines will also be indexed to a spatial scale, although I assume here that specifying entities and characteristics will do this sufficiently.

simultaneously, such as predator and prey populations, or populations of organisms occupying similar niches. That there are multiple non-linear paths to degradation and regeneration (and implicitly that there are multiple possible baselines) is sometimes recognised in the coral regeneration literature (Rinkevich 2005; Woodhead et al. 2019).

So, changes to a reef can be described in relation to the elements of the employed baseline. What exactly does a baseline consist of? This has often been left largely implicit. Using coral systems as an example, we can say that a baseline must consist of: (1) a desirable reef state (or dynamic set of states); (2) a set of measurable reef characteristics (or proxies for these) which are taken to correspond to that state; and (3) a spatiotemporal scale. Characteristics may include things like structure, function and composition. Regeneration is the movement of the characteristics of the system towards those depicted in the baseline state. As we see later, which sorts of characteristics are included will make a big difference to how changes are characterised. Note that baselines, in order to reflect ecosystems, may often need to be dynamic—i.e. depicting a range of some variables, or a cycle/pathway—rather than ‘states’ in a strict static sense (Vásquez-Grandón et al. 2018; Ureta et al. 2020).<sup>9</sup>

Several factors complicate this picture. How can we ensure we have a good baseline? More broadly, how can we decide how a living system, especially an ecosystem, ought to behave? One view is that baselines are given by nature: we must look for e.g. the objective proper functions of coral ecosystems, or how they behaved before significant human disturbances.<sup>10</sup> This provides the baseline (Campbell et al. 2009; Jackson 2001). Problems arise however, in that people often employ different baselines in the same cases, such as in the infamous ‘shifting baseline syndrome’. In this case, younger observers see ecosystems as less degraded than their older counterparts, having only experienced more heavily degraded ecosystems<sup>11</sup> (Braverman 2020; Pauly 1995). (Often, in the literature, the observers mentioned are scientists, although this applies to any kind of observer.<sup>12</sup>) This hints at a broader problem: what gets included in a specific baseline may vary, given the huge range of entities, characteristics and timescales available for the observer when describing the

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<sup>9</sup> This is to say that returning to a baseline may be a homeorhetic, rather than homeostatic, process (see Fabris 2018).

<sup>10</sup> The view of nature as undisturbed before the arrival of humans may often have deep theological roots (Robbins and Moore 2013) (with thanks to an anonymous reviewer for pointing this out). The idea of a singular pre-human-disturbance baseline, and that this is necessarily the most desirable or natural state for an ecosystem to exist in, is problematic, something I return to later. See Cronon (1996) for more on this.

<sup>11</sup> Note also that shifting baseline syndrome assumes such ecosystems really are more degraded, i.e. it takes some pre-existing baseline as given, with newer shifted baselines being incorrect (Pauly 1995). There is an interesting parallel here with the phenomenon of adaptive preference in economics, whereby people who live in seemingly objectively impoverished conditions give surprisingly positive evaluations of their quality of life (Nussbaum 2001, p. 135).

<sup>12</sup> I focus here on scientists, but I do not mean to suggest that they necessarily have any privilege or authority when it comes to valuing reefs. Many other stakeholders are also important to consider. The question of whose values matter when is a very important one, and one which I do not have the space to do justice to here.

system. As a result, it has been argued that baselines are contingent and constructed, so different observers in different contexts will not include the same things in their baselines (Ureta et al. 2020). From this a new problem emerges: if the distinction between degradation and regeneration is contingent upon the baseline, and if radically different baselines can be employed in a given case, the same process can be painted as regenerative, damaging or neither. As I show later, this is not simply ambiguity about the degree of degradation, because a focus on different timescales and characteristics can produce mutually exclusive descriptions. This makes the distinction between regeneration and degradation arbitrary when considering only the facts about a specific ecosystem. To avoid this there must be some reason to favour one baseline over another. I now turn to a textbook case of degradation, algal domination of reefs, and analyse how baselines are employed there.

#### 4 Algal domination and baselines

Reef systems need not be *coral* reef systems. At its broadest, a reef is an underwater ridge, and need contain no coral or living things at all, being purely geological. Often, however, a variety of organisms produce and sustain reefs, usually in concert with one another, including algae, sponges, corals and, in the case of regeneration strategies, humans (Sheppard et al. 2017). These organisms may be of vastly different types: whilst coral are Cnidarian animals which exist as polyps and colonies (and are cousins with jellyfish, hydra and anemones), algae are a disparate group of acellular, unicellular and multicellular organisms which lack true organs, generally use light energy to create food, and cause headaches for taxonomists (Sheppard et al. 2017; Vroom et al. 2006). When reefs are mentioned, it is typically in the context of coral reefs, i.e. reefs which corals play a significant role in building. Coral reefs are produced through collaboration between many organisms. Algae are one notable set of such organisms, playing important symbiotic roles which are essential for reef development, such as acting as a cement holding much of the rock together (Sheppard et al. 2017). A typical coral-dominated reef will contain much algae as well as coral. Coral-dominated reefs are the charismatic colourful tourist attractions that most people usually think of when reefs are mentioned. The algae is usually kept in check by the grazing of symbiotic reef organisms like herbivorous fish.<sup>13</sup> Whilst corals are themselves animals, coral reefs are ecosystems, and it is the ecosystem which I refer to throughout this paper.

Under some circumstances, the balance of coral and algae on the reef can be disrupted, shifting the configuration of the ecosystem. One possible set of outcomes is ecosystems dominated by algae. This process can also occur in either direction, with

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<sup>13</sup> It is worth noting that the term *coral-dominated* is not well defined, and subject to debate. Algae often play a larger role in coral reef building than is commonly realised, and the distinction between coral and algal reefs is not a neat one, with many mixed states existing. I return to these points later. I use the term coral-dominated here to refer to reefs in which coral play a larger role in reef-building than in algal reefs. Some authors have suggested referring to any coral reef as a *coralgal reef*, although this has (perhaps unsurprisingly) not caught on (Vroom 2011).

coral takeovers of algal-dominated reefs also possible, although less common (Graham et al. 2013). Algal-dominated reefs (algal reefs) are often a murky green, and support different combinations of organisms, having different ecosystem dynamics to coral-dominated ones (Vroom et al. 2006). It is worth noting here that the ecosystem dynamics of algal and coral reefs vary widely within these categories as well as between them (Fulton et al. 2019; Graham et al. 2014). The circumstances which cause algal takeovers of reefs vary. They can, for example, occur after coral bleaching, or after exposure to high levels of nutrients. Evidence suggests that in many places where anthropogenic stressors are higher, coral systems are more likely to become dominated by algae (Graham et al. 2013). Importantly however, algal reefs also occur independently of human influence, and represent one set of the many stable configurations reef systems can exist in (Vroom et al. 2006; Graham et al. 2013). This raises the question of why algal reefs are considered degraded.

#### 4.1 Algal reefs as degraded

*Algal domination* is often treated as synonymous with *degradation*. Given its association with human-driven stress, algal dominance of reefs is often used as a measure of how degraded a coral reef ecosystem is, particularly given the (often) striking visual differences which make it a convenient metric for assessing degradation (Vroom et al. 2006; Roth et al. 2018). Much research has been conducted into how to reverse or prevent shifts to algal-dominated states, as well as the kinds of things which trigger them (Graham et al. 2013; Rachmilovitz and Rinkevich 2017).

Shifts to algal domination are often associated with the death of many organisms and loss of species, including coral themselves and various fish, although the exact impacts vary depending on the situation (Fulton et al. 2019; Bellwood et al. 2004). Key ecosystem functions (such as inorganic carbon accumulation, and associated reef-building/habitat provision) will be impeded in the process, and the biodiversity of the reef system is likely to drop considerably (McClanahan 2002; Roth et al. 2018; Rachmilovitz and Rinkevich 2017). What was once a vibrant and diverse ecosystem may come to look murky, stagnant and lifeless (Bellwood et al. 2004). Furthermore ecosystem services, such as those supporting tourism, fish production or protection of coastlines against erosion, may be compromised (Woodhead et al. 2019).

The baselines being employed here are typically motivated towards reversing the impacts of anthropogenic disturbances (Rachmilovitz and Rinkevich 2017; Bellwood et al. 2004). This implies a timescale reaching back to before these disturbances, although there may still be considerable variation in how far back this should be. Descriptions of pre-human undegraded coral ecosystems typically stress a much higher abundance of large animals, both predators and herbivores, as well as higher coral cover of the reef, particularly by certain species of coral, such as long-lived coral which reproduce by mass spawning (Jackson 2001). Pre-human-disturbance timescales may vary from the past few decades (when the impacts of human disturbances became more obvious) to those much further back, for example before fishing and other activities reduced the prevalence of many marine organisms

associated with coral reefs (Campbell et al. 2009). Often more recent and acute disturbances are focused on, rather than more chronic long-term ones (Bellwood et al. 2004). It might still be argued however that the proper baseline, i.e. the one which reflects how coral ecosystems ought to behave, is whatever timescale excludes all human disturbance, i.e. represents a pristine reef system (Jackson 2001).

More important for our purposes are the entities and characteristics being focused on. Often, as is the case here, the baselines employed for characterising changes to reef systems are coral-dominated ones. They may also be focused on specific coral species (Graham et al. 2014; Bruno et al. 2014). Movement away from this (including sometimes changes in the type of coral) is degradation. Indeed, some authors actually define shifts to non-coral systems as degradation (Graham et al. 2014, p. 9). The characteristics highlighted often include attributes such as high coral cover of the reef, high biodiversity and high structural complexity (Graham et al. 2013). They also include a mixture of ecosystem functions serving humans (or ‘ecosystem services’) and serving other organisms. Common examples are habitat provision for a range of fish (Bellwood et al. 2004), accretion of carbon into reefs (McClanahan 2002), supporting flows of nutrients and energy (Moberg and Folke 1999) and supporting fishing and tourism (Graham et al. 2013). Whilst it is often recognised that pristine reefs—i.e. reefs as they appeared before human disturbance—are impossible to return to, these can still be employed as a baseline which can be moved towards (i.e. partial regeneration) (Graham et al. 2013).

In this case then, at first sight, it seems there is an obvious baseline to compare changes in algal composition of reefs to: a coral-dominated, biodiverse, pre-human-disturbance baseline which provides a variety of ecosystem functions to nearby organisms, including humans. This might seem to suggest that in obvious cases such as algal domination, baselines need not be constructed, and are simply read off of nature. Even here however, a series of choices have been made which led to algal reefs being labelled degraded.

## 4.2 Alternative baselines

A variety of other timescales and sets of entities and characteristics could be employed here, producing different baselines. These different baselines will alter how algal reefs are judged: are they degraded, and if so, how badly?

With respect to timescales, longer ones may include reefs with compositions differing to those of modern reefs, even for those undisturbed by humans (Veron 2008, p. 72; Bruno et al. 2014). Shorter ones may allow for recent changes in characteristics such as species composition, as is the case with shifting baseline syndrome, or with the emergence of novel ecosystems.<sup>14</sup> They may also include human disturbances in the baseline (Jackson 2001; Hobbs et al. 2009). Further, the huge range of entities discernible, across both time and space, means that many different sets of entities could be focused on when constructing baselines. For example, algae or sea

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<sup>14</sup> Note that not all recent changes in composition will be clearly attributable to human disturbance, as with the case of Crown-of-Thorns starfish outbreaks (Sapp 1999).

urchins, which can prosper in different ecological configurations to coral, could have been prioritised (Bellwood et al. 2004).

Likewise, various sets of characteristics can be prioritised within baselines. Focusing on the composition, structure or function of an ecosystem will produce different baselines and so different characterisations of changes to ecosystems. Even within these sets of characteristics this is the case. One set of characteristics employed when characterising algal reefs is ecosystem functions. Algal reefs may be described as ecosystems with impeded functioning, and therefore as degraded (Done 1992). However, functions in ecosystems can be ascribed in a variety of ways and serve many possible purposes, goals, and actors.<sup>15</sup> Definitions of function in coral science may be as broad as ‘the movement or storage of energy or matter within ecosystems’ (Bellwood et al. 2019, p. 950). The various ways of ascribing function to parts of ecosystems will allow for the same changes to an ecosystem to be described in very different functional terms. Many of the functions in an ecosystem may also be incompatible. For example, some algal formations (‘fleshy macroalgae’) usually only appear when there are not many grazing herbivorous fish around. These formations, once developed, may make the area difficult to inhabit for such fish. As a result, habitat provision for these fish and algal formations may often be largely incompatible (Bellwood et al. 2004). In a broader sense, taking the coral ecosystem function definition from Bellwood et al. (2019), any movement of matter or energy in an ecosystem is going to preclude other such movements. Functions, structures and compositions may also be characterised with various degrees of abstraction. Functions may vary from providing habitats for a specific endemic reef fish to simply sustaining nearby human life. Composition may be detailed at a fine-grained scale, e.g. proportions of different coral species, or a coarser one, e.g. relative proportions of coral (regardless of species) to algae. Even a baseline focused on one kind of characteristic, such as ecosystem function or composition, will therefore involve many choices.

Constructing and employing different baselines will alter how systems such as algal reefs are characterised. Focusing on macroalgal formations, for example, will make algal reefs seem less (or not) degraded. Focusing on sea urchins may make algal reefs seem degraded in a different way. Focusing on some ecosystem functions, e.g. habitat provision for tropical fish, may make the reef seem more degraded than if other species, such as hardier invertebrates (which survive in coral and algal systems), are focused on. Likewise, focusing on groups of functionally equivalent

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<sup>15</sup> Without delving too heavily into the vast literature on function in philosophy, the function of something is, roughly, what it does, or what it’s for (Laubichler et al. 2015). To survey these briefly, functions can be: the impact elements of a system have had in such systems in the past (etiological accounts, e.g. Millikan 1989); the contribution they have to some higher-level capacity now (causal role functions e.g. Cummins 1975); what a thing regularly does (activity functions e.g. Love 2007). There are also debates about what types of functions can be assigned to parts of ecosystems (e.g. Lean 2020) which I ignore here, as they do not affect the arguments of this paper significantly. The key point is that a variety of functions can be ascribed in any one case, and these can be used to construct different baselines. Importantly, functions need not ground the normativity of baselines themselves, because the normativity is added by the process of including them in a baseline.

species (rather than individual species) will allow for different characterisations, as will different timescales.

So far, I have taken a textbook case of degradation, highlighted the specific baseline employed by this case, and argued that other baselines are conceivable, i.e. algal reefs are not necessarily degraded. By prioritising different entities, characteristics, or timescales, it is possible to produce contradictory and mutually exclusive descriptions of the same processes, meaning this is not simply a problem of vagueness, but one of underdetermination: the facts of a case simply are not enough to usefully characterise the phenomena. I now examine actual arguments made for the use of alternative baselines in assessing algal reefs. The ways these arguments are made will help reveal the specific role value plays in the production of non-arbitrary baselines.

### 4.3 The debate over algal reefs: degraded or different?

Some reef scientists have argued against the view that algal reefs should typically be seen as degraded (Bruno et al. 2014; Vroom 2011; Howe 1912). In doing so, they advocate for employing different baselines when assessing reefs and changes to them. I present three of these arguments here. In the next section I refer back to these to show how they invoke value and the consequences of this for the labels *regeneration* and *degradation*.

The first point often made by algae advocates (which I refer to as argument 1) is that coral and algal-dominated states represent diverse classes of ecosystem with varying levels of biodiversity and complexity (Fulton et al. 2019; Graham et al. 2014). It can sometimes be hard to distinguish between algal and coral dominance, given the imprecise nature of the notions, and within many reefs, including coral-dominated ones, the role of algae is underappreciated (Vroom 2011; Fulton et al. 2019; Howe 1912). Part of this may be due to coral species being more well-recognised and charismatic, with algae suffering from a ‘charisma gap’, i.e. having less charm or appeal than coral (Unsworth et al. 2019; Duarte et al. 2008). Here, focus on coral (as a more charismatic marine organism) can distract from other marine organisms such as algae.

The second argument (argument 2) in favour of different baselines is that algal reefs may support a variety of organisms, including carnivorous and herbivorous fish, invertebrates and macroalgae of varying complexity. They may also support ecosystem services, such as food or biofuel production. Algal and coral reefs may have some features in common, such as supporting some fish or invertebrates of the same type, providing habitats for some of the same organisms, and offering some of the same ecosystem services to humans, such as income provision or production of fish. Both sets of ecosystems form important parts of the wider marine seascape. They are both often important ecosystems in their own right, supporting a range of organisms and ecological functions (Fulton et al. 2019; Woodhead et al. 2019; Vroom 2011).

Finally (argument 3) it is also argued that not all algal reefs are produced by anthropogenic causes (Vroom 2011; Fulton et al. 2019). Appeals to pre-human

conditions as baselines may therefore not always be sufficient to justify considering algal reefs as degraded, especially as in many cases *algal-dominated* is assumed to be synonymous with *degraded* without regard to the actual origin of the system (Roth et al. 2018; Rachmilovitz and Rinkevich 2017; Vroom et al. 2006).<sup>16</sup> An interesting complicating factor here is that reefs which have more large predators (for example because fewer have been killed by fishing) may also have higher proportions of algae. This is because more large predators means fewer herbivorous fish, so less grazing, and more algae (Bruno et al. 2014). This suggests that some pre-human-disturbance reefs may have had higher proportions of algae present than some coral-dominated reefs today.<sup>17</sup>

Even in a textbook case of degradation, different baselines are sometimes employed. By focusing more on algae, or on other entities and characteristics associated with algal reefs, baselines are constructed which do not characterise many algal reefs as degraded, or else characterise them as less degraded. Indeed, given the right baseline, movement of a coral reef towards an algal state could be considered regenerative.

#### 4.4 Anything goes?

So far then, looking at characterisations of algal reefs has seemed to suggest that facts alone can't tell us which baselines to employ, meaning that something more than the facts about changes to a reef is needed to usefully apply the labels degradation or regeneration. Even in seemingly obvious cases of degradation, multiple baselines are discernible, allowing for multiple characterisations, i.e. any case could be described as regenerative or degradative simply by employing a different baseline. Focusing on some entities and ignoring others can produce diametrically opposed characterisations of the same phenomena. And yet, some baselines are rightly considered more legitimate than others. Looking at how value is involved in baseline construction helps explain this.

### 5 Baselines and value

How can regeneration and degradation be distinguished if even in textbook cases of degradation, multiple distinct baselines can be employed? How can disagreement over what counts as degradation and regeneration be accounted for? Why are algal reefs typically, but not always, considered degraded? My solution to these questions

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<sup>16</sup> It is because of this that we cannot simply say that only algal reefs which were once coral reefs are degraded, as often algal reefs are labelled degraded without reference to their history (Vroom et al. 2006).

<sup>17</sup> This is an interesting case of shifting baselines, given that it has previously been suggested that newer shifted baselines make greater algal cover seem healthier than older baselines do (Braverman 2020). The example here suggests that whilst in the short term, coral scientists may have become more accepting of higher algal compositions, in the long term, they may have become less accepting of them. Shifting baselines may then operate in opposite directions at different temporal scales.

is linked to the value attributed to reef configurations. Much has been written about the influence of *values* on scientific concepts and practices (Kincaid et al. 2007; Lee and Helgesson 2020). As such, a role for value here might seem obvious to philosophers well-versed in these areas. There is an interesting tension in this example though. Coral science is filled with appeals to the many ways coral reefs may be valuable to different actors. But at the same time, baselines are often treated as given and value-free, for example: ‘The pristine or natural state of a population or community is called the baseline in conservation biology, and it serves as a guide for setting conservation and restoration targets’ (Bruno et al. 2014, p. 24). Even when baselines are the focus of discussion, the contingency of our view of nature recognised, and the value of a specific baseline is emphasised, debate focuses on simply pushing the timescale of the baseline back further to the true ‘pristine’ baseline (Jackson 2001). As such, there is often little explicit recognition of value-ladenness in the familiar sense. Squaring this tension not only helps in understanding what work the notions of regeneration, degradation and baselines are doing, but also points to an underappreciated role for value in science. The value highlighted in these cases is the considerable and varied *forms of value* attributed to coral reefs, including affective (Braverman 2018), economic (Costanza et al. 2014) and ecological (Knowlton 2001) forms, to name just a few. The connection between discussions of *values* in science and the *value* of coral reefs may not immediately seem obvious. I will show here that despite being attached to the entities being described, these forms of value operate like other notions of values in science, in this case shaping concept formation and characterisation of evidence.

Given the extensive philosophical writing on value, I have something like the definition employed by Leonelli (2016) in mind when I use the term here: value as the mode and intensity of attention and care paid by some actor towards something, along with the motivations underlying this (Leonelli 2016, p. 63). I focus largely on anthropocentric forms, albeit allowing for vicarious valuation, i.e. humans valuing something an organism depends upon because we value the organism itself.<sup>18</sup> By showing how value and baselines interact, as well as the implications of this, I hope to make sense of the algal case specifically and suggest some lessons for understanding regeneration generally.

## 5.1 Value drives baseline choice

To understand how reef value impacts baselines, and therefore judgements based on these, it is useful to look at the role played by value in arguments for using different baselines in the algal reef case. I focus here on arguments 1–3 outlined in Sect. 4.3. Importantly, I am not evaluating the merits of the arguments or values presented, but simply noting the relations between them. When observers describe regeneration or degradation, they focus on and include valued aspects of coral systems in their baselines. Other aspects are ignored. The kinds of characteristics included will also make

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<sup>18</sup> I do not get into debates over biocentric/anthropocentric accounts of value. Both fit with the arguments I present.

a big difference to what is permitted under the rubric of regeneration (I return to this in the next section).

Argument 1 had two key parts: that algal and coral systems are broad classes of systems which can be difficult to distinguish, and that algae play an under-appreciated role in many such systems. The claim is that algae should be given more precedence in baselines when assessing changes to reefs (Vroom 2011; Howe 1912). There is a claim about value underlying this: the low affective value of algae compared to coral has led to it being unduly ignored in baseline construction. This phenomenon, which has been termed the ‘charisma gap’, has been observed in other marine ecosystems too, whereby less charismatic ecosystems or organisms are afforded less resources for research and intervention, despite performing equally valuable ecological and economic roles (Unsworth et al. 2019; Duarte et al. 2008). This may be driven in part by the value attributions of the general population, in that popular sentiments may drive research funding and attention (Duarte et al. 2008). As such, argument 1 shows a role for affective value here in driving inclusion of specific entities and characteristics into baselines, with a focus on species composition.

Argument 2 stresses the vital roles played by both algal and coral reefs in ecological and economic systems. This argument amounts to the claim that algae have greater than recognised ecological and economic value. Attempts to shift the baselines used in assessing algal reefs have, in this case, been premised on claims that algae perform many important ecological and economic roles, such as providing habitats for sets of fish and invertebrates, supporting biodiversity and other ecosystems across the seascape, and providing opportunities for tourism and income provision<sup>19</sup> (Fulton et al. 2019). It is recognised that not all algal-dominated reefs will provide significant ecological and economic value, but still argued that many do, and so baselines should take more account of this. Here, appeals to value are once again being used to justify construction and deployment of different baselines, with a focus on the economic and ecological functions of the system.

A final appeal to value is visible in argument 3. Here, the claim is that not all algal reefs are anthropogenic, and that pre-human reefs may have had higher proportions of algae than is allowed for in baselines today. This is chiefly because humans have altered ecosystem dynamics through killing large predators, which has allowed herbivore numbers to increase, and therefore has reduced algal cover (Bruno et al. 2014; Vroom et al. 2006). The appeal here is to the value of algae as a part of a non-human-disturbed ecosystem. In this case then, the value being appealed to is related to naturalness, wilderness, or independence from human influence.<sup>20</sup> Again, these claims about the value of algal reefs are used to alter the legitimacy of including more algal elements in baselines, and thereby reappraise the status of reefs with more algae, reducing the extent to which they are seen as degraded (in some cases completely). This example again focuses on the species composition of the reef, i.e. the relative coral/algae proportions, rather than things like ecosystem services or

<sup>19</sup> Note that by invoking the wider seascape, the spatial scale of the baseline may have also been changed (again, because of the ecological value of reefs on this broader spatial scale).

<sup>20</sup> An explicit example of an appeal to this kind of value is given by Katz (2007).

functions. The truth or falsity of each of these claims about value is largely irrelevant for understanding regeneration and degradation here: what matters is that arguments for different baselines are accompanied by claims about the value of the things included in them.

As these arguments show, the perceived value of the aspects of the system drives their inclusion into or exclusion from the baseline. Whilst it has been recognised that value may drive preoccupation with different timescales (Campbell et al. 2009), there are further ways that baselines can vary, even those on the same timescale: they must also include a set of characteristics. This is visible in the algal domination example, where value attributions are linked to a focus on certain kinds of characteristic. The argument that affective value prevents proper consideration of algae focuses on inclusion of specific entities (coral and algae) into employed baselines, i.e. producing a baseline focused on species composition. The arguments about ecological and economic value are more about a set of reef system functions and services,<sup>21</sup> which reduces focus on specific entities such as species. I discuss some of the consequences of this in the final section. Finally, the appeal to the value of non-anthropogenic ecosystems, as in the claim that pre-human ecosystems would have had more algae than supposed, involves an appeal to species composition again: it focuses on the entities present and their historical relations to humans and the ecosystem.<sup>22</sup>

A range of other constraints will operate on the construction of baselines too, for example legal or epistemic ones (Hirsch 2020). Inclusion of something in a baseline, however, and employment of that baseline to judge changes to a system, is in part predicated on the value of some aspects of the system in question. This explains why some baselines are employed more frequently than others, and hence why algal domination is usually, but not always, seen as degradation. Broadly speaking, most observers see changes from coral to algal states as sacrificing more valuable aspects than are gained: i.e. the regenerative processes are trivial, and the degradative ones significant. The facts about some ecosystem then will not be enough to characterise it as degraded or regenerated, as some judgement of the value of the entities present in the system will be necessary to choose one perspective over another. Regeneration and degradation amount to movement of a system towards or away from some baseline, with the baseline focused on the valuable aspects of the system being observed. This makes any process regenerative (degradative) if it restores (impedes) some valued aspect of a system. Far from being an example of undue and pernicious direct influence of non-epistemic value on scientific concept formation, as warned against in e.g. Douglas (2016) and Vellend (2019), here value is required to make concepts useful, enhancing rather than undermining their use in scientific descriptions.

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<sup>21</sup> Although clearly individual entities can have economic and ecological value too, although these were not focused on in this example. Cases such as functions and services can be controversial because of the scope for novelty they can allow (explored in the next section).

<sup>22</sup> This may be an appeal to ecological or biological integrity, which is often appealed to in conservation (Callicott et al. 1999).

## 5.2 Arbitrariness and value

Recognising that many different, and some mutually exclusive, baselines may be employed in any case seems to threaten to make notions of regeneration and degradation arbitrary.<sup>23</sup> Suggesting that they are value-laden, and therefore not entirely empirical concepts, seems to further threaten this. Even in the relatively simple (compared to novel ecosystem cases) case of algal dominance, different value attributions lead to different characterisations of the same process.

However, by looking at the way alternative baselines are argued for, it becomes clearer that the value-laden aspects of the concepts save them from arbitrary application. To argue for the construction and employment of different baselines, advocates also argued for the value of these baselines. This was not a case of people simply asserting a value preference for a different baseline and ignoring the facts of the case. Instead, baselines act as an area of interesting overlap between value and fact, and between measurement and judgement. As with thick concepts (Putnam 2002) and mixed claims (Alexandrova 2018), regeneration and degradation claims involve a combination of value and fact, and not in a way that makes them simply undisputable assertions of personal preferences. Here then, the role for value is in gatekeeping what can be reasonably included in a baseline, simultaneously making the baseline relevant to those employing it. Baselines must be justified through arguments about the forms of value they recognise, be that related to affectivity, biodiversity, wilderness, ecosystem functions or economics. Both the facts about an ecological process (how do characteristics change) and an understanding of what is valuable about the ecosystem in question (which of these characteristics matter) are required in order describe something as regeneration or degradation. The concepts are thereby only arbitrary if value is excluded from the scientific process.

The disagreement over the extent to which algal domination is an indicator of degradation comes down, in part, to how people value aspects of living systems. This does not mean that such disagreements are therefore intractable. The philosophy of medicine is instructive here: accounts of disease which highlight a role for value are sometimes charged with pernicious relativism about what counts as a disease, i.e. they make the concept of disease arbitrary, or make all applications of it equally legitimate, there being no way to dispute them. Such accounts are only perniciously relativist if a very specific metaphysical position is taken on value: that value judgements cannot be reasonably debated (Glackin 2019). In most contexts, such a position on value is not usually taken, so in the same way as we can confidently say slavery is wrong (which plainly involves both value judgements and

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<sup>23</sup> Note that the problem here is not so much that baselines are constructed, given that construction (or social construction) does not necessarily threaten the existential status of something, or prevent it from having significant impact on other aspects of the world (see, for example, Hacking 2003). The problem here is that many very different baselines can be constructed for a single case. Without recourse to value, there will be no way to adjudicate between them, rendering the descriptions built on top of them (regeneration, degradation) entirely contingent upon arbitrarily employed baselines.

facts), we can say that anthropogenic murky green reefs with little complexity or diversity are degraded.<sup>24</sup>

It is because of value judgements that, generally speaking, algal domination is seen as degradation. In many cases, what people value will line up, and so cases will be described similarly (Hobbs 2016).<sup>25</sup> This is obvious if we push the case of algal domination even further: in cases of clearly anthropogenic and very low complexity algal reefs, which usually have very low biodiversity too, even advocates of more algae-sympathetic baselines will employ the language of degradation (Fulton et al. 2019; Vroom et al. 2006). The value of the entities being described ensures the labels regeneration and degradation are useful and non-arbitrary, rather than undermining them.<sup>26</sup> Where there are disagreements over which types of value are legitimate bases for constructing baselines, debate will be more intractable. Understanding the relations between baselines, value and regeneration can help with such disagreements. I address this now, in the final section, along with some of the other implications of this view.

## 6 Implications

People value reefs, and that value plays a role in characterising changes to reefs as regenerative or degradative. Here I explore the implications of this view, for understanding conservation and regeneration generally, novel ecosystems specifically, and for mediating disputes.

### 6.1 Pristinity, value and the social sciences

The arguments here are that baselines (often tacitly) encode the value judgements underlying descriptions of changes to ecosystems [for a similar approach to biodiversity as encoding values, see Sarkar (2019)]. Value drives inclusion of different timescales, entities and characteristics into baselines. A result of this is that even those baselines which favour a pre-human ‘natural’ or ‘pristine’ ecosystem state are

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<sup>24</sup> Whilst regeneration and degradation claims are relative to value, there are still absolutist and relativist positions on value which could be taken here, both of which will allow for value-laden, non-arbitrary and useful notions of regeneration and degradation. Versions of both may allow for some descriptions to be much more reasonable or legitimate than others. Defenders of relativism would argue that a relativist account only implies there is no neutral perspective from which different baselines can be absolutely ranked (e.g. Kusch 2020; Veigl 2020). This still allows for baselines to be more legitimate than one another, to be reasonably debated, and for cases to yield widespread agreement. The key difference is whether statements about degradation/regeneration are true objectively (absolutism) or intersubjectively (relativism).

<sup>25</sup> Note that even if value judgements do line up, factual disagreements may still operate. There are also other influences on baselines, as is explored in Ureta, Lekan and von Hardenberg (2020). Recognising the role for value in baselines can help facilitate discussion (explored in Sect. 6).

<sup>26</sup> By useful here I do not necessarily mean usefulness for intervening in the world. Often the labels degradation/regeneration are used without any plan to intervene. They may simply be useful for understanding the nature of the changes to a system.

still choosing timescales, entities and characteristics, driven by value considerations. This makes sense of the tension visible in the coral science literature between looking for correct baselines, and between recognising that different configurations of coral systems have benefits and costs for different organisms. Often, pristine baselines are presented as not only the correct baseline, but also hugely valuable states. See, for example, Jackson (2001), who talks about how much richer a truly pristine reef would seem to us today (p. 5416). On my account, it is because of the value of such ecosystemic arrangements that we often consider them the correct baseline to aim for, rather than these baselines being the correct ones and therefore valuable, or it simply being a coincidence that baselines depict valuable states of affairs.

That value underlies these descriptions (and any attendant interventions) makes it more important that social scientists engage with attempts at regeneration in systems with multiple stakeholders, as with coral ecosystems. The forms of value attributed to reefs are regularly examined in economic, ecological and social sciences, or combinations thereof [see, for example, Moberg and Folke (1999) or Braverman (2018)].<sup>27</sup> By shaping baselines and scientific concept formation, these forms of value become interesting in a new sense for those engaged in describing/inducing changes to ecosystems (coral scientists, ecologists, conservationists) and those interested in understanding these practices (philosophers and social scientists of science). In order to understand coral regeneration, we need to understand the value attributions different groups bring to the table when evaluating changes to coral reefs. This is in line with attempts to produce combined socio-ecological models of coral ecosystems (Aswani et al. 2015; Hughes et al. 2017). In the context of coral science, the implication is that understanding the value judgements of coral scientists themselves (as well as other stakeholders) is important, given that they have influence over descriptions of and responses to changes to reefs.<sup>28</sup>

## 6.2 Perspective and life-worlds

The need for value in describing the sorts of changes discussed here is in part due to the multiple sets of interests (human and otherwise) involved in systems like coral reefs. To describe changes relevantly and usefully we must weigh in on the side of some sets of interests and not others. Describing or inducing regeneration and degradation is always done from a perspective, and the same cases may look very different from other perspectives (Hobbs 2016). Just as the baselines used to evaluate a forest will be constructed differently for a lumberjack, bird enthusiast, naturalist, or berry forager, so they will also be constructed differently when they are considered with different humans or other organisms in mind. Organisms have different life-worlds, and the same setting will be significant for them in different ways (Uexkull

<sup>27</sup> Note that this is only one of many possible roles for value: I have only covered the value of the entities being described, rather than more traditional notions of epistemic/non-epistemic value (discussed in Sect. 2, and not the focus of this paper).

<sup>28</sup> Insights from areas such as behavioural economics may be useful here, as is noted by Vellend (2019) in relation to ecology generally.

2010).<sup>29</sup> Corals, for example, are both organisms themselves and habitats for many other organisms (Rinkevich 2005). Baselines may include aspects relevant for some habitats and not others and impact different habitats and organisms in opposing ways. Regeneration favouring the algae found in low-complexity reefs is likely to be degradation for most other organisms. The same system can be regenerated in multiple senses, so systems can't be simply regenerated without taking a perspective on them: aspects of them must be picked and prioritised. Whilst it has been suggested that attributing value to the objects of study in ecology can have undue and negative influence on the scientific process (Vellend 2019) (something I do not deny here), I have argued that such value must also necessarily play a role for concepts like regeneration and degradation to be useful and non-arbitrary. Baselines, then, operate as claims about the value of certain perspectives. Being explicit about what baselines contain can help clarify whether observers are operating from the same perspective and prioritising the same things.

### 6.3 Regeneration and novelty

That regeneration is perspectival helps with the problem mentioned at the start: a general account of regeneration must explain why a huge range of cases have been described as regenerative, or else why some of them are not genuine instances of regeneration. This is made trickier by the emergence of novelty in some cases. Examples of processes labelled regenerative include: homeostasis, organism development, reproduction, growth of extra heads, replacement of organism parts with different ones, wound repair, forest regrowth after fire, reshaping of landscapes after introduction of wolves, and replacement of limbs with prosthetics (Morgan 1901; Johnstone et al. 2016; Monbiot 2013; Stark 2018). The processes in this list introduce novelty to varying degrees.

On the account I have presented here, all of these processes may be considered regenerative. To be regenerative, a process must simply restore some valued aspect of the system in question, given that this aspect is included in a baseline. Different baselines may take different timescales and characteristics or entities as their focus, and so allow for very different processes to amount to regeneration. Depending on what is included in the baseline this may allow for a lot of novelty to be introduced. In the case of a damaged embryo developing into a healthy organism (Morgan 1901), the organism as a temporally extended entity is being focused on, and it is this which is restored. In the case of organisms growing extra heads (Lenhoff and Lenhoff 1991), the heads themselves are focused on, and it is functioning heads (rather than the pre-disturbance state of the whole organism) which are restored. Focusing on heads and their functioning, rather than the whole organism, may be driven by the scientific value attributed to such processes, as it was in some of the earliest animal regeneration experiments (Lenhoff and Lenhoff 1991). There is a connection with accounts of self-renewal in cells here. Only a certain set of

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<sup>29</sup> With thanks to Sophie Gerber for suggesting the connection with Uexkull and life-worlds.

characteristics will be measured in experimental setups observing cell self-renewal. As long as those characteristics being focused on are restored, changes in other characteristics, or the appearance of new characteristics, will not prevent a case being considered self-renewal (Fagan 2013, p. 22). However, if other characteristics are focused on, a case of self-renewal may be reappraised. Cases of regeneration and degradation may similarly be reappraised depending on which characteristics the observer pays attention to and cares about (i.e. which characteristics they value). Strictly speaking, systems are always different once regenerated, and although the degree of difference can vary greatly, their valued characteristics are the same (unless partially regenerated, in which case they are at least closer to how they were before requiring regeneration<sup>30</sup>).

That different contexts will enable many different processes to be described as regeneration is a positive feature of this account. By including different timescales, entities or characteristics in a baseline, for example because of the scientific value of doing so, parallels between processes commonly considered regenerative and other process, such as those considered damaging, may be exposed and explored. Cancer, for example, is noted to have similarities with other regenerative processes (Schäfer and Werner 2008). Being able to view such phenomena in a different light may help expose fruitful differences and similarities between them and more intuitive cases of regeneration.<sup>31</sup>

#### 6.4 Novel ecosystems, ecosystem services and future-oriented baselines

This understanding of baselines, value and regeneration helps explain the controversy surrounding novel ecosystems and ecosystem services. Debate surrounds the status of novel ecosystems, which differ significantly from past ecosystems yet are not necessarily degraded (Hobbs et al. 2009). I have argued that changes can introduce any amount of novelty and still reasonably be considered regenerative as long as they restore some valued characteristics. Debate over novel ecosystems may be caused by two issues then: first, that within a single baseline, some characteristics are restored and others impeded.<sup>32</sup> Second, that there are multiple reasonable

<sup>30</sup> Regeneration may be partial in two senses: 1. It may not move all the way towards the chosen baseline; 2. Movement towards a baseline will mean movement away from other baselines (i.e. not everything is restored). I have argued here that all regeneration is partial in this second sense.

<sup>31</sup> With thanks to Lucie Laplane for pointing this out. For a different, coral-specific, example, bleaching can be recharacterized as a regenerative process in the right context and with the right baseline. Investigations into bleaching have sometimes treated it as an adaptive phenomenon which may help the coral readjust its resident microbes to better suit changing environmental conditions (Obura 2009). As such, bleached states may be included in the dynamic baseline aimed at for regeneration, if a degree of occasional bleaching is thought to be normal or healthy for coral. Treating it as such may help in understanding and preventing excessive bleaching, or else harnessing it to regenerate coral (something which is being trialled (Buerger et al. 2020)).

<sup>32</sup> Introduction of new valuable characteristics, without impeding or restoring others, may also complicate this. In the language of medicine, this would be an enhancement rather than a treatment, with the difference between these coming down to how the baseline state is conceived (i.e. whether the improvement is a movement towards the baseline or not). The distinction between these can therefore be contentious (Juengst and Moseley 2019).

evaluative standpoints available to construct baselines from, and so several legitimate baselines.

The problem of multiple reasonable evaluative standpoints being available is crystallised in controversy over ecosystem services. Often, the ecosystem service framework is charged with instrumentalising living things, treating nature as primarily valuable for its roles in serving human wellbeing (Schröter et al. 2014). A feature of baselines I have presented here is at the root of this: even on the same timescale, they may focus on different kinds of characteristic. Ecosystem services, along with the functional approach to ecology often associated with novel ecosystems (e.g. Bellwood et al. 2004; Hobbs et al. 2009), allow for a focus on the activities of an ecosystem rather than a concern for specific entities or species compositions. Such activities may, if desired, be characterised in very abstract ways, such as simply supporting a wide range of living things, or specifically supporting human wellbeing. By focusing on such characteristics, radical changes in other variables such as species composition can be described as regenerative. Organisms fulfilling similar roles from an anthropocentric instrumental perspective may be able to replace one another without this being evaluated negatively. Even in less anthropocentric guises, organisms may be grouped by their ecological functions and treated as fungible if they perform the same ones (Bellwood et al. 2004). For those with other perspectives on the value of the living system in question, such as those who consider a species intrinsically valuable, sacrificing some species and allowing them to be replaced by others in the name of regeneration will seem absurd. Intrinsically valuing a species may result in its inclusion in a baseline, meaning it is not fungible at all, and cannot be lost without moving away from the baseline (Maguire and Justus 2008). Likewise, for those that value specific historical configurations (sometimes termed ecological or biological integrity (Callicott et al. 1999)), baselines which allow for that to be compromised in the service of other valued aspects, such as ecosystem functioning or biodiversity, will seem unacceptable.

This also helps make sense of the notion of forward-looking baselines, suggested as a solution to our inability to return to pristine states (Braverman 2020). How can we regenerate an ecosystem back to something it never was? By relaxing a focus on historical species and their compositions, baselines can nevertheless include some element of the past (e.g. ecosystem functioning) but also represent radical change from it. Even future-oriented baselines, then, involve return to a historical state, just in a more abstract way. For many people, in cases where a return to a specific composition is not possible, such forward-looking baselines may seem a feasible or desirable way that regeneration can still be carried out. Conversely, a more concrete focus on historical species composition may explicitly deny a place for humans, and prevent any environment with humans in it from being considered regenerated. Debates over such cases will come down to how observers value human-influenced nature, and in part whether human activity is seen as disturbing that value or compatible with it<sup>33</sup> (Callicott et al. 1999). Depending on how nature is valued then, and

<sup>33</sup> This, may, in part, have theological roots (Robbins and Moore 2013). These views are reflected in different ecological practices, such as treating humans as disturbing conditions (i.e. excluding them from baselines, or not building them into models) or treating them as normal parts of the ecosystem (Inkpen 2017).

which kinds of characteristic are included in baselines, it is possible to allow for regeneration to take place even when species or structures irreversibly disappear, or where the end-state includes heavy human influence.<sup>34</sup>

## 6.5 What counts as regeneration? Shifts, disagreements and mediation

On this account, what counts as regeneration will come down to which timescales, entities and characteristics are valued and prioritised, something which cannot be decided simply by observing the regenerating system. Whilst some people may consider coral to algal shifts as degradation, others may disagree. Similarly, shifts between dominance of different types and arrangements of coral species, or algal species (i.e. shifts within rather than between coral or algal reefs), may also be seen as degradative or regenerative. Decisions must be made about which sacrifices are acceptable and which characteristics are to be attended to and cared about. These are decisions about what to value, and how to rank various forms of value, and people may disagree or change their minds over these decisions.

Shifts in the way aspects of living systems are attended to and cared about will produce shifts in what is described as regeneration or degradation. As shown earlier, some reef scientists have argued that the value of reefs dominated by algae is underappreciated (Vroom 2011; Fulton et al. 2019; Howe 1912). Algal reefs, supporters claim, have important ecosystemic functions for a variety of organisms, including humans (Vroom 2011; Fulton et al. 2019; Howe 1912). A consequence of this underappreciation is that the vulnerability of certain types of algal reef, particularly those which are complex and support greater biodiversity, is also underappreciated (Fulton et al. 2019; Vroom 2011). For example, some species of algae, including those essential for much coral-reef building, have skeletons more susceptible to damage from ocean acidification than coral skeletons (Vroom 2011). Similarly, more complex algal reefs may be pushed by disturbances into less complex and less diverse states (Fulton et al. 2019). Recognising these threats may drive shifts in targets for regeneration. In the future, complex and diverse algal reefs may become less prevalent, and regeneration of degraded algal reefs (or other forms of reef) back into their former non-degraded algal states may be necessary. This is simply an indication that when the value attributed to an ecosystem state shifts—e.g. because it becomes less prevalent, or its features better appreciated—it can become a target for regeneration attempts.

Where there is contention over the description of changes to an ecosystem, recognising baselines as value-driven can help. Baselines represent an arena where

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<sup>34</sup> Note that in the extreme, this account of baselines could accommodate a fully artificial reef, designed and manufactured for e.g. economic benefit and populated with charismatic reef species. Baselines could be constructed for this with purely anthropocentric and economic motives, and so the reef could be legitimately described as regenerating with only these considerations in mind. The point of this example is that baselines need not only be applied to non-manmade systems, and may be useful in more artificial cases (e.g. urban ecology). With thanks to an anonymous reviewer for suggesting this example.

scientific measurement and value judgements interact<sup>35</sup> producing *mixed* descriptions (Alexandrova 2018). Making the value aspects of regeneration and degradation claims explicit is both important and difficult. It is important because debates over degradation and regeneration may not be resolvable in arguments which only consider facts. Not only this, but when left unexamined, value-judgements represent a potential source of systematic bias.<sup>36</sup> It is difficult because many different forms and sources of value may operate simultaneously, influencing choices during baseline construction in subtle and complex ways.

By making the timescale, entities and characteristics of the baseline employed in a given description explicit, justifications for including these in the baseline will also typically be made explicit too. Just as with the algal case, elements of baselines will often come packaged with reasons why we should care about them, i.e. the value judgements supporting them. By doing so, disputes may be mediated more effectively, and the source of disagreement located clearly. In the algal reef case, for example, a lack of clarity about baselines hides several different disagreements. Some arguments are about the potential economic value algal reefs could provide for local populations, such as through providing a farm for biofuels. By making clear that the baseline in evaluating reefs is in this case about functions which perform economic roles, it becomes clearer that for some people, this debate is resolved by answering a purely factual question: can this algal reef support local incomes to the same degree as a coral one? However, for others who prioritise different forms of value, such as the intrinsic ecological value of coral reefs, this debate will be harder to resolve.

Other arguments in the algal case focus on wilderness value of undisturbed reefs. Again, in this case, by making baselines explicit, it is more obvious that some disagreements may be factual, and hence resolvable by simply asking: how much algae was there on some reef at some specific place and time? For those focused on other forms of value, the answer to this question may be less relevant, and so the debate more intractable. By not making baselines explicit, several debates are had at once (e.g. about both the economic and historic status of reefs) and across value contexts, making what is actually at stake unclear. Advocates of both algae-sympathetic and other baselines may be in agreement about the economic, ecological and historical value of some states, but as long as baselines remain unclear, and which forms of value are being appealed to left only implicit, these agreements will remain hidden. Making the baselines explicit, and so teasing out the values underlying them, allows for opportunities for reconciliation to be spotted. Once the epistemological, ontological and value commitments of different stakeholders are made clearer, partial overlaps can be looked for, and even in places where there are no overlaps, different ontologies and value schemes can be combined in ways that produce fruitful

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<sup>35</sup> This is akin to accounts of biodiversity as a meeting place for scientific measurement and value judgements (Sarkar 2019).

<sup>36</sup> As in cases such as implicit judgements about the value of non-native species skewing the results of ecological studies in under-appreciated ways (Vellend 2019). I have argued here that in a sense bias is necessary, but this does not mean it should go unexamined.

outcomes for a range of stakeholders (Ludwig and El-Hani 2020). Such mediation is particularly important given the increasing calls for active methods to save coral reefs, which feature more direct interventions in coral biology and ecology, and so are likely to introduce more novelty (Anthony et al. 2017).

## 7 Conclusion

I set out here to distinguish regeneration from degradation in the context of constructed baselines, and to explain how the value of the systems being baselined influences the construction of these concepts. First, I suggested that baselines consist of an undegraded ecosystem state, a set of characteristics and entities representative of this state, and a spatiotemporal scale. Regeneration and degradation are movements towards or away from the baseline, which depicts how the system ought to behave. I then showed that even in textbook cases of degradation, such as algal dominance of coral reefs, many baselines are available, some of which are very different. By looking at how advocates of different baselines presented their arguments, I argued we can see a role for the value of aspects of the system being described, in driving which entities/characteristics and timescales are included, and in making some baselines more reasonable or legitimate. This explains why algal domination of coral reefs is typically, but not always, seen as degradation: because in many contexts, the elements lost are cared about more than those restored or maintained. In other value contexts however, this need not necessarily be the case. Rather than simply negatively skewing research, the value of the ecosystem in question is a necessary part of baselining and describing changes to it. More broadly, this shows that the value of objects of scientific study may influence their own characterisation within science, in addition to values (as in social or personal ideals) performing this role. The account of regeneration I have presented explains why very diverse processes, including those that introduce significant novelty, have all been described as regenerative: because they employ different baselines, but all involve restoration of some valued characteristics relative to these. Value commitments are encoded in baselines, driving disagreements over the status of some processes, but making baselines an opportune tool for exposing such value commitments, thereby clarifying disputes. Value-laden baselines are fruitfully perspectival, allowing us to understand regeneration and degradation in the context of what matters about the system in question, rather than in a vacuum.

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## Compliance with ethical standards

**Conflict of interest** Not applicable.

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