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What do we talk about when we talk about biodiversity conservation in the Anthropocene?

George Holmes

Abstract: Planetary changes associated with the Anthropocene challenge long-established ideas and approaches within biodiversity conservation, such as wilderness, wildness, native and exotic species, species and ecosystem diversity, and what counts as success in biodiversity conservation. This article reviews and analyses how the Anthropocene is being used within the literature on biodiversity conservation. It finds that the idea of a new epoch has been used to frame a broad range of new approaches and concepts to understanding and stemming the loss of biodiversity. These new ideas are diverse and sometimes contradictory, embracing a range of ethical values and positions. Yet the term Anthropocene is not widely used within the biodiversity conservation literature. Despite the cross-disciplinary nature of the Anthropocene, interdisciplinary research on these new concepts and approach is rare, and the insights of the humanities are almost entirely absent. Debates about conservation in the Anthropocene are a continuation of long running controversies within conservation, such as how it should relate to human development, and over the concept of wilderness. Overall, this review demonstrates that the literature on biodiversity conservation in the Anthropocene is not well established, is both diverse and new, whilst echoing longstanding debates in conservation, and it indicates what direction such literature might take in future

Keywords: anthropocene, assisted migration, biodiversity, biotic homogenization, conservation, development, novel ecosystems, rewilding

The notion of the Anthropocene has expanded rapidly in popularity in recent years, including in discussions of biodiversity conservation (see figure 1). The purpose of this article is to describe and analyse how scholars have talked about biodiversity conservation in the Anthropocene, with a particular focus on new concepts, arguments and strategies that have been explicitly linked to a response to the notion of the Anthropocene. As a concept, it allows us to think holistically across a range of biotic, abiotic and anthropogenic processes such as species loss, climate change, ocean acidification, disruption of biogeochemical cycles, and spread of exotic species, rather than treating these as separate issues. It has potential to link disciplines from across the humanities and the social and natural sciences. Most importantly, it challenges long-held concepts, ethical standpoints, policy positions and institutions within conservation, provoking examination about how decisions are made, by whom and on what basis. Recognising a human dominated epoch challenges both the goals and the tools of biodiversity conservation - Rudd's (2011) study found that conservation scientists strongly favoured re-evaluating the goals and standards of conservation success in an era of global climate change. This paper responds to this idea of new standards and goals by reviewing how biodiversity conservation has responded to the notion of the Anthropocene, as reflected in the scientific literature. This article begins by exploring different definitions of the Anthropocene, particularly how they interact with issues of biodiversity, before analysing how the term Anthropocene has been used within biodiversity conservation journals. It then examines the new concepts and strategies proposed for conservation from the issues raised by the Anthropocene.

This article does not claim to explore all possible discussions about biodiversity and the Anthropocene across the natural sciences, social science and humanities. This would be a huge task. Rather, its aim is to be more focused, tracing how the concept of the Anthropocene

51 has been used within biodiversity conservation journals, and in papers which explicitly
52 address both biodiversity and the Anthropocene in more general scientific journals, to inform
53 both knowledge of changing biodiversity and actions to conserve it. Analysing these papers
54 allows a focused analysis of a more coherent corpus of literature, rather than broader ideas of
55 the Anthropocene, although links are drawn to discussions in other disciplines. It also allows
56 an analysis of how the Anthropocene is used within the action-oriented discipline of
57 conservation biology, and therefore how it might be used as a basis for policy. Whilst there
58 are discussions of the Anthropocene and biodiversity conservation outside of academic
59 journals, such as in blogs, these are excluded to provide coherence to the literature, and
60 because analysing ideas which have passed the peer review shows not just what ideas have
61 been produced, but also which have begun to enter into the accepted canon of ideas, such as it
62 exists.
63
64
65 [figure 1 about here]

66 ***How is the Anthropocene defined and why does it matter?***
67
68 The term Anthropocene was popularised by a 2002 article by atmospheric chemist Paul
69 Crutzen:
70 "For the past three centuries, the effects of humans on the global environment have escalated.
71 Because of these anthropogenic emissions of carbon dioxide, global climate may depart
72 significantly from natural behaviour for many millennia to come. It seems appropriate to
73 assign the term 'Anthropocene' to the present, in many ways human-dominated, geological
74 epoch," (Crutzen 2002: 23)

Unlike previous notions of human-dominated epochs proposed in previous decades and centuries (e.g. Anthropozoic, Psychozoic, and Noösphere), the Anthropocene has gained scientific traction because we are now able to recognise the magnitude of the human impact on the environment, and there are serious discussions within stratigraphic commissions to recognise the Anthropocene as a distinct geological epoch (Zalasiewicz et al. 2010). Even if it has not yet been formally recognised within stratigraphy, it is increasingly being used within publications across the sciences, social sciences and humanities to denote an era in which human activities dominate global biotic and abiotic processes (Crist 2013), although as shown below, it is used variously to denote a proposed geological epoch, as a useful analytical device, and as shorthand for a human-dominated planet. Unless stated otherwise, this article discusses the Anthropocene as a catch-all term for an era in which human activities dominate many of Earth's key processes (biogeochemical cycles, evolutionary processes, etc), as this is the dominant definition implicit in the biodiversity literature. As this paper makes clear, the term Anthropocene is discussed much less frequently than the broader idea of a human-dominated planet.

Many definitions of the Anthropocene, such as Crutzen's, explicitly refer to climate change as the distinguishing feature of a human dominated epoch, perhaps because changing atmospheric chemistry is global whereas other processes such as biodiversity loss are locally variable. This is the case even within biodiversity-focused journals. Other criteria for distinguishing the Anthropocene include sediment loading of rivers, (e.g. Syvitski and Kettner 2011), species loss and spread of exotic fauna (e.g. Olden 2006) or combinations of these and other processes such as oceanic acidification and nitrogen runoff (e.g. Caro et al. 2012; Jacquet 2013). Whilst these definitions focus on the biophysical consequences of human activities, Ogden et al. (2013) focus on the human structures that have allowed these

impacts, recognising that other forms of human organisations have not had the same ecological impacts, inviting us to think carefully about who is the Anthro in Anthropocene (see also Jacquet 2013).

Different start dates for the Anthropocene have been proposed, based on what human impacts are used to define it and to a lesser extent on how these might be identifiable in future geological strata. Steffen et al. (2007), who understand the Anthropocene largely in terms of climate change, date it to 1800 C.E., when atmospheric carbon concentrations exceeded the natural variation of the Holocene, with a second "Great Acceleration" starting in 1950 when human impacts, particularly carbon emissions, began to rapidly increase. This Great Acceleration would be relatively easily identified in future geological strata through the presence of radionuclides released from atomic weapons post-1945 (Zalasiewicz et al. 2010). Using sediment loading from rivers would place the start of the human impact earlier at 4000 B.C.E., accelerating since 1700 C.E. (Syvitski and Kettner 2011). Using human-induced extinctions of Pleistocene megafauna, and its ecological consequences, would date it to 50,000 B.C.E. (Corlett 2013).

Geologically, such debates over the Anthropocene's commencement are largely irrelevant. The ability of future geologists to distinguish Anthropocene strata is uncertain, and geological boundaries are often imprecise when measured at millennial timescales (Gibbard and Walker 2014; Zalasiewicz et al. 2008; Zalasiewicz et al. 2010) It is relevant for biodiversity conservation debates, as different start dates affect whether or not certain biodiversity distributions, processes and ecosystems are considered natural or appropriate, and therefore how conservationists should approach them. For example, dating the Anthropocene to Pleistocene megafauna extinctions challenges ideas about the naturalness of

125 many ecosystems and baselines for ecological restorations. Dating the Anthropocene to 1800
126 or 1950 C.E. might change how we view processes predating this, such as the Columbian
127 exchange or the creation of many ancient anthropogenic ecosystems. This date invites us to
128 distinguish between the ecological impacts of modern capitalist societies and other societies.
129 For example, Pellatt and Gedalof (2014) discuss the impact of Native Americans on
130 ecosystems over the last few millennia, and distinguish this from accelerated impacts from
131 European settlers during the Anthropocene, which they date to approximately 1750 C.E. Yet
132 with few exceptions (e.g. Rick et al. 2014), the ethical implications over how to date the shift
133 between acceptable and unacceptable human alteration of the environment are implicit rather
134 than explored explicitly.

135 ***How is the Anthropocene discussed in biodiversity conservation journals?***

136

137 To understand how ideas of the Anthropocene are being used within conservation, thirteen
138 leading biodiversity journals were analysed for how frequently the used the term
139 "Anthropocene" within the main text of articles published from 2004 to 2014. This is
140 summarised in figure 2. Additional searches were conducted within Scopus for journal
141 articles whose keywords, abstract or title included the words "conservation" and
142 "Anthropocene".

143

144 This literature reveals that the term 'Anthropocene" is not being widely used. Of 17,575
145 papers published in the selected journals from 2004-2014, only 59 used the term in the
146 abstract, title, keywords, or main body of the paper. High profile publications aiming to
147 predict the most important emerging issues in conservation (e.g. Sutherland et al. 2009;
148 Sutherland et al. 2010; Sutherland et al. 2011; Sutherland et al. 2012; Sutherland et al. 2013)
149 do not use the term. As figure 2 demonstrates, much of the usage that does occur within the

biodiversity conservation literature is casual and imprecise, used in passing to denote that the article in question is discussing human domination of ecosystems, without considering the validity of the term or the implications of using it, perhaps reflecting the term's utility for catching attention and as a shorthand for human impacts on the environment (Crist 2013; Zalasiewicz et al. 2010). Even articles which contain the Anthropocene within their titles often do not analyse the concept in depth (e.g. Paquet and Messier 2009).

[Figure 2 about here]

Papers citing the Anthropocene tend to be review rather than research articles. Of the 17,575 articles in the selected journals, 73.5% were classed by Scopus as research articles and 10.5% as review articles, with the remainder classed as notes, editorials, letters errata and other. Of the articles mentioning the Anthropocene, 62.6% were research articles and 23.2% were reviews. As figure 2 indicates, two journals (*Bioscience* and *Frontiers in Ecology and the Environment*) contain the largest number of articles when adjusted for total number of papers, albeit from a small sample. These both focus on review articles, with the latter aiming also to encourage engagement across different sub-disciplines within ecology and environmental research. This reflects the concept of the Anthropocene as an overarching framework for understanding environmental change, but as explored below, it may clash with dominant tendencies within biodiversity conservation research.

Whilst the term Anthropocene may not be being widely used, there is more evidence that related ideas are being discussed. For example, many of the new concepts and strategies proposed for conservation in the Anthropocene (see below), such as rewilding, assisted migration, and synthetic biology are each mentioned in the literature more frequently than the

175 notion of the Anthropocene (see figure 3), including in key overviews of issues in
176 conservation (e.g. Sutherland et al. 2009; Sutherland et al. 2010; Sutherland et al. 2011;
177 Sutherland et al. 2012; Sutherland et al. 2013).
178
179 [Figure 3 about here]
180
181 Importantly, there is little evidence to suggest that the broad concept of the Anthropocene, as
182 an epoch in which human activity dominates biogeochemical cycles and is manifest in
183 various symptoms such as climate change, species loss and ocean acidification, is being used
184 more frequently than the term itself. Papers citing the Anthropocene seem to discuss different
185 things to the broader literature on conservation. Analysis of the dominant keywords within
186 the overall literature, compared to the keywords in articles mentioning the Anthropocene,
187 shows that aside from issues of climate change, there is little overlap between the kinds of
188 topics mentioned in papers on the Anthropocene and the broader literature within
189 conservation (see figure 4). There is a reticence amongst scholars to link together phenomena
190 within biodiversity conservation. For example, whilst 2042 papers in the sample of
191 biodiversity conservation papers published between 2004 and 2014 use “climate change” as a
192 keyword, and 1948 use “endangered species”, only 128 use both. Thus not only is the term
193 Anthropocene rarely used, but it is unclear that the idea of the Anthropocene is being used
194 widely, and instead, particular issues in individual places are addressed in separate papers.
195
196 [Figure 4 about here]
197
198 There are various features of conservation biology which may have led it to relatively neglect
199 the notion of the Anthropocene. Firstly, within conservation biology scholars may be

200 focusing too much on individual species and places, and not enough on broader ecological
201 change and global trends (Rosenzweig 2001). Scholars may be focusing on individual sub-
202 disciplines such as invasive ecology, landscape ecology, without thinking about broader
203 cross-cutting themes (Olden 2006). This means that such an all-encompassing phenomenon
204 such as the Anthropocene becomes relatively neglected. Secondly, conservation biology has
205 been poorly integrated into the social sciences, particularly history, meaning it may have
206 missed on out on the insights these disciplines can bring to changing relations between
207 humans and the natural world (Agarwal and Ostrom 2006; Sörlin 2012). Related to this,
208 conservation biology has been slow to recognise the value of the long term view of ecological
209 change coming from paleoecology, humanity's role in these change and the insights this has
210 for recognising and valuing human modified landscapes (Willis and Birkes 2006). Instead, it
211 has had a rather short term view of the human influence, evaluating anthropogenic change on
212 a decadal or centennial scale, rather than the millennial view of paleoecology. For example,
213 there are different normative implications for conservation in Australia depending on whether
214 human impacts on the environment are assessed for recent centuries of European
215 colonisation, or the many millennia since aboriginal settlement (Hamilton and Penny 2014).
216 Thirdly, the notion of the Anthropocene may require taking a broad view of general trends in
217 conservation and biodiversity, to address simultaneously multiple challenges such as climate
218 change, exotic species and ocean acidification, and to fundamentally re-evaluate taken for
219 granted concepts and theories (see below) which may sit uneasily with a discipline which
220 focuses on individual empirical case studies. Finally, the concept of the Anthropocene
221 involves not just the challenging task of rethinking and redefining issues such as invasive
222 species, extinction and habitat, but also the ethical and normative underpinnings of these
223 concepts and of the conservation policies that have emerged around them, making the
224 Anthropocene a particularly challenging issue to address. For example, Robbins and Moore

225 (2013) explore how the vibrancy of debates that followed a proposal to rethink invasive
226 species reflected not just contention over the scientific underpinnings, but also over the
227 challenge to normative concepts which have underpinned much policy towards invasive
228 species (for other examples where seemingly technical and scientific issues in conservation
229 have ignited much controversy because of the implicit challenge to conservation norms and
230 ethics, see Cairns et al. 2014; Campbell, 2013). The tensions between new scientific concepts
231 and the implicit need for new ethics for conservation is a central theme to this essay –
232 Robbins and Moore (2013) argue that conservation in the Anthropocene is becoming
233 schizophrenic, caught between decrying the human influence on the environment, and
234 responding to the increasing visibility of the human values that underpin our knowledge and
235 approach to the environment.
236
237 The next three sections explore in more detail how the term and the idea of the Anthropocene
238 are being used. It firstly explores the debate around two recent essays on the subject of the
239 Anthropocene and conservation, before turning to new concepts and then new strategies for
240 conservation which have been explicitly linked to the term Anthropocene.
241

242 ***A new conservation for the Anthropocene?***

243

244 One area of discussion that merits relatively detailed examination is Kareiva et al's (2011)
245 piece "conservation in the Anthropocene". This is for several reasons. Whilst the original
246 essay was not published in a mainstream biology journal, responses to it have been (e.g. Doak
247 et al. 2014; Hunter et al. 2014; Kueffer and Kaiser-Bunbury 2013; Marris, 2014; Miller et al.
248 2014), including a follow-on essay (Kareiva and Marvier 2012). Such discussions correspond
249 to a large proportion of the citations of "Anthropocene" within the biodiversity conservation

literature. The essay both demonstrates the utility of the concept of the Anthropocene for conservation, by showing how changing ideas about biodiversity can be integrated into the goals, tools and norms of conservation, and also the casualness of its use, by using it as a general device to discuss new ideas in conservation more generally (such as the use of markets) rather than responding to the idea of changed global biogeochemical cycles which define the Anthropocene. As it attempts to define new norms and goals for conservation, it demonstrates both how new ideas are brought in when thinking about the Anthropocene, and how long running debates and issues about ethics, tools and concepts in conservation remain unchallenged and unaltered. Finally, the controversy it has generated demonstrates that discussions over how conservation should respond to the Anthropocene are not just about biology or conservation management, but about the ethics, norms and values of biodiversity conservation more broadly.

The key argument in this essay is that the concept of the Anthropocene implies that conservationists' focus on preserving pieces of wilderness on a planet where human activity dominates is "anachronistic and counterproductive", simultaneously futile, missing broader challenges of conserving nature in places heavily modified by humans, overly pessimistic of nature's resilience to anthropogenic pressures, and ignorant of the long term human influence on supposedly wild places. Elsewhere, in reply to Soule's (1985) highly influential postulates proposed at the emergence of conservation biology, Kareiva and Marvier (2012) propose new a new set of functional postulates for conservation in the Anthropocene, the first of which is a recognition that pristine nature separate from humans does not exist. This recognises human dominance of global biogeochemical processes, the hallmark of the Anthropocene, and uses it to propose a new direction, for example, a new conservation which focuses less on distant wildernesses and more on nature in human dominated areas such as cities and modern and

275 traditional agricultural systems (Kareiva et al. 2011; Kareiva and Marvier 2012). Elsewhere,
276 Kueffer and Kaiser-Bunbury (2013) argue that the existence of the Anthropocene requires a
277 move away from the idea that conservation is about saving nature from human influence (see
278 Palomo et al. (2014) for corresponding proposals for socio-ecological approaches to protected
279 areas in the Anthropocene).
280
281 Kareiva et al. (2011) follow this by arguing that a focus within Anthropocene-era
282 conservation on human-dominated areas necessitates integrating human development into
283 conservation, to broaden and strengthen support for conservation, and to make it more
284 effective. Part of this would be working closely with corporations. The second of Kareiva
285 and Marvier's (2012) functional postulates for Anthropocene conservation is that nature
286 should be protected because doing so benefits humans. These arguments should be seen as
287 part of long-running debates about the role of human development and corporations in
288 conservation (see Roe 2008).
289
290 There have been critical responses to Kareiva et al's (2011) argument within biodiversity
291 conservation journals. Several articles (e.g. Caro et al. 2011; Soule 2013) challenge the
292 ecological basis of this proposal, arguing that whilst the Anthropocene implies that all of
293 Earth's systems are modified by human action, there are extensive intact ecosystems where
294 human modifications are minimal, particularly in remote areas with low human population
295 density, and that these are worth conserving as wild places through traditional approaches
296 such as protected areas. They also argue that accepting the dominance of human modified
297 systems creates a moral hazard, as it may make it difficult to oppose further damaging
298 change, and may make controversial new conservation techniques (discussed below) seem
299 unproblematic (Caro et al. 2011). Jacquet (2013: 898) argues that the term Anthropocene may

300 have environmentally damaging consequences, referring to the "Anthropocebo effect… a
301 psychological condition that exacerbates human-induced damage—a certain pessimism about
302 humanity that leads us to accept humans as a geologic force and destruction as inevitable",
303 reducing motivation to fight back against human activities. As with previous arguments in
304 favour of incorporating human development goals into conservation, the argument was
305 critiqued as a grave distraction from the principle goals of conservation (Soule 2013).
306
307 Kareiva et al's (2011) argument is partly new. It is the first high-profile attempt to use the
308 concept of the Anthropocene to ask questions about what is conservation is, what it should
309 be, and how it should work on a human-dominated planet. One of the three authors was the
310 chief scientist at The Nature Conservancy, the world's biggest conservation NGO, and
311 another its director of science communication, indicating that the essay's ideas may influence
312 conservation strategy and practice, rather than being solely a conceptual argument. Yet much
313 of the argument is not new. The critique of the relative place of wilderness and human-altered
314 systems in conservation, and of integrating humans, human development and markets into
315 conservation are not new, and have both been discussed in conservation journals and formed
316 the basis of major policy interventions (Adams et al. 2004; Brockington and Igoe 2006; Roe
317 2008). The debates prompted by the article mirror wider debates over these long standing
318 issues, being ill-tempered with authors criticising not just the perceived efficacy of
319 opponents' proposals for conservation but also their ethical underpinnings (Hunter et al.
320 2014; Marris 2014; Marvier, 2014). Authors tend to portray opponents' positions as
321 exaggerated caricature, whereas the positions are closer than the language used would
322 suggest (Hunter et al. 2014 - see also Rudd, 2011; Sandbrook et al. 2011), and despite the
323 long history of pluralistic values, priorities and approaches in conservation, where
324 conservation organisations have simultaneously enacted projects to preserve wildernesses and

to conserve urban nature, and strategies which have a strong focus on human development with those that have none. Hunter et al. (2014) position proponents and opponents of new conservation as somewhat anthropocentric and biocentric respectively, and argue that they are complimentary positions, each appropriate to their own niche. Characterising the positions in this way illuminates the divergent ideas about what is to be conserved in the Anthropocene. Anthropocentrists (e.g. Kareiva et al. 2011) focus on the conservation of ecosystem services and functions where nature brings benefits to humanity, whereas biocentrists (e.g. Caro et al. 2012, Miller et al. 2014) focus on individual species, unique ecological assemblages and processes such as evolution, reflecting nature's intrinsic value (see below). Additionally, some arguments made by Kareiva et al. such as integrating corporations and human development goals into conservation, are not immediately relevant to the idea of a planet whose biogeochemical cycles have been altered by humans. In the case Kareiva et al's essay, the concept of the Anthropocene does not offer much that is new. Instead, it is used in an attempt to reframe long running debates within in conservation, even where the links to the Anthropocene are tenuous, involving not just the science of conservation but also its moral dimensions, as well as broader discussions of what it is that conservation should be saving. The next section is an exhaustive exploration of instances where the idea of the Anthropocene has been linked within biodiversity conservation journals to new concepts and tools for conservation. These implicitly and explicitly question the moral underpinnings of conservation and challenge its basic concepts, goals and broader purpose.

New concepts for biodiversity conservation in the Anthropocene

Before discussing new concepts, it is worth discussing various papers within biodiversity conservation journals using the term Anthropocene which propose that certain concepts

should be rejected or given much less prominence as an explicit reaction to the Anthropocene and accompanying changes (global climate change, spread and establishment of exotic species, etc). These are in addition to concepts of wilderness and the idea that conservation is about saving nature from human influence, as discussed above. Whilst varied, these are united by a view that certain theories and approaches are no longer apply to the new conditions of the Anthropocene, particularly ideas of particular bits of nature belonging in particular places. For example, climate change challenges ideas that any species has an easily defined habitat, within which it can be defined as native and outside of which it can be described exotic. As Robbins and Moore (2013) show, such calls are controversial, not least because they combine calls to rethink the science of biodiversity conservation with calls to rethink its ethics and normative outlook. Rethinking this also requires reforming related structures and policies, such as legal frameworks for invasive species management which have particular definitions for native and exotic species, historic species range and other concepts. One fundamental goal of such frameworks, that of growing populations of endangered species until they can prosper without human intervention, may need to be reconsidered as rapid and large scale climate and habitat change may mean some species will be forever reliant on intensive human management for their survival (Braverman 2012; Carroll et al. 2014). Ideas such as stable ecosystems, or equilibrium biogeographies, have been identified as irrelevant or outdated for the Anthropocene, as current and projected environmental changes are of a greater magnitude, rapidity and uncertainty than those addressed by these concepts (Kueffe, 2013; Young 2014). As an alternative, Willis and Burkes (2006) propose that records of rapid environmental change from paleoecology can provide insights for conservation in the Anthropocene, as well as specific strategies for Anthropocene conservation such as rewilding (see below), although conservation biology has historically drawn few insights from paleoecology. Janzen (2009) argues that traditional

375 approaches to studying ecological change, particularly test plots, are inappropriate for the
376 Anthropocene as they assume that ecological processes must be studied in isolation from
377 human activity, and instead argues that humans should be considered not as an external
378 pressure but as a component of ecological processes. Together, these present substantial
379 challenges to long-held ideas and principles in conservation biology, and the magnitude and
380 moral dimensions of this challenge may explain the reticence of conservation biologists to
381 use the term and concept of the Anthropocene.
382
383 In place of these outdated ideas, a number of new concepts for conservation in the
384 Anthropocene have been proposed within the biodiversity conservation literature. Whilst the
385 term Anthropocene has been used to frame them as new ways of thinking about biodiversity
386 in the Anthropocene, they also have a life of their own, circulating outside of the literature on
387 the Anthropocene. As shown in figure 3, these tend to be cited more frequently within
388 leading biodiversity conservation journals than the Anthropocene. These new concepts share
389 two key ideas: that human activity should not be viewed as an external force disturbing the
390 patterns and processes of species distribution and ecological change, but as a fundamental
391 driving force alongside the biotic and abiotic factors traditionally considered by biologists
392 and ecologists, and that within this, a rethinking and scaling up of ideas about how we
393 evaluate what species belong in which places. Whilst there is some alignment within these
394 new ideas, they are also heterogeneous and sometimes contradictory.
395
396 Firstly, Ellis and Ramankutty (2008) argue that longstanding ideas about biomes, based on
397 combined abiotic and biotic factors, are out of date as they do not recognised that humans are
398 also a crucial factor in shaping patterns of biodiversity. Instead, they propose that
399 Anthropocene-era conservation should recognise anthromes, or anthropogenic biomes, co-

400 productions of abiotic, biotic and human forces. The concept has been applied within
401 conservation research (Martin et al. 2014). One challenge for understanding anthromes and
402 related ideas is that doing so requires combining knowledge and approaches spanning the
403 social and natural sciences, and incorporating feedback between social and environmental
404 processes when predicting future changes. At present such socio-ecological systems have
405 been predominantly studied within the social, rather than natural, sciences (Hicks et al. 2010;
406 Kueffer 2013). Anthromes can contribute to conservation, as even highly human-dominated
407 systems such as intense agriculture can act as refuges for endangered species, although so far
408 conservation efforts have focused on less densely populated anthromes (Martin et al. 2014;
409 Thomas 2013).
410
411 An important feature of the Anthropocene is the spread of species into new places through
412 human activities including agriculture, infrastructure development, accidents, pets and
413 horticulture. Whilst at a global level the number of species are decreasing, the number of
414 species present within most ecosystems has increased over recent decades and centuries, as
415 numbers of newly arrived exotic species outnumber local extinctions, and this trend is
416 forecasted to continue (Ellis et al. 2012; Olden 2006; Thomas 2013). As discussed above,
417 existing concepts of invasive, exotic and native species have been critiqued as outdated for
418 the Anthropocene, and new ways of looking at these have been proposed. The first is that
419 exotic species, at a local level, may be considered benign or even beneficial. Whilst only 10%
420 of introduced species become established, only 10% of these become an invasive problem,
421 leaving 99% of new arrivals as unproblematic (Williamson and Fitter 1996). Ecosystems with
422 very large amounts of exotic species, such as urban gardens, can support stable levels of
423 native species (Ellis et al. 2012). Exotic species can provide vital ecosystem services and
424 support endangered species (Davis et al. 2011). Secondly, there are calls to move beyond

425 dichotomies between native and non-native species. This partly inspired by paleoecological
426 evidence which indicates that many species considered native have been deliberately or
427 accidentally introduced by humans in previous centuries or millennia, and that some species
428 may have been historically present in an area, only to become locally extinct, and then
429 classified as exotic when they return (Willis and Birks 2006). The implications of these two
430 points for policy is that legislation on exotic species may need to redefine basic concepts, and
431 that environmental managers may need to reconsider whether eradication of non-native
432 species in an ecosystem is desirable (Davis et al. 2011).
433
434 A third way of rethinking native and exotic species which has been explicitly linked to the
435 Anthropocene is through global biotic homogenisation. Whilst the previous two new concepts
436 on exotic species focused on potentially benign or beneficial trends occurring at local scales,
437 this highlights negative trends at a global scale. Biotic homogenisation considers how the
438 spread of exotic species has led to an increase similarity between different ecosystems, as
439 similar ecological communities are being created around the world - distinct local ecologies
440 are being replaced by homogenous cosmopolitan ecologies (McKinney 2005;Olden, 2006;
441 Sax and Gaines 2011) As a variant on the concept of the Anthropocene, some authors have
442 proposed the notion that we are living in the Homogecene/Homogocene, (Olden et al. 2004;
443 Rosenzweig 2001), an epoch defined by widespread biotic homogenisation, taking place in a
444 place called the New Pangaea (McKinney 2005), a reference to the super-continent which
445 existed between 300-175 million years ago, in which all the planet's major land areas were
446 connected, allowing species to spread across them and create similar communities
447 worldwide. Olden (2006: 2028) refers to the "global anthropogenic blender", mixing species
448 through introductions, although biotic homogenisation can also occur through extinctions,
449 particularly given that certain genii are under greater threat than others, and because human

activities are tending to produce the same kinds of habitats worldwide (e.g. cities) with the same kinds of niches, which favour certain species (McKinney 2005; Olden 2006). Within biotic homogenisation, there can be increased taxonomic, genetic or functional similarity between different places, with causal links between these (Olden 2006). Understanding novel ecosystems challenges traditional approaches within conservation biology; it requires isolated sub-disciplines (invasive ecology, extinction biology, community ecology, landscape ecology) to work together (Olden 2006), to focus on global trends in invasions rather than longstanding tendencies to focus on individual invasive species (Rosenzweig 2001), and to challenge longstanding ideas on what defines a biological community and how they change over space and time (Olden, 2006).

Whilst species introductions are creating a tendency for places to become more biologically similar, in some locations they are creating new ecological communities in the form of novel ecosystems. These are defined as ecosystems which contain new combinations of species which lead to new ecosystem functions, and which have been created by human action, but do not depend on ongoing human intervention to be maintained (Hobbs et al. 2006). This latter point is important in distinguishing novel ecosystems from other phenomena which is dependent on human actions, such as anthromes and socioecological systems. The deep and self-sustaining nature of this transformation may make novel ecosystems particularly apt for the Anthropocene, as they show a permanent rather than transient and temporary human influence, conditional on its continuation. Novel ecosystems involve not just changes in species, but also the interactions of this with abiotic factors such as soil hydrology and composition (Hobbs et al. 2006). They can be can be created either as exotic species are introduced into existing systems, or as human dominated systems such as agricultural areas are abandoned and go feral (Hobbs et al. 2006). One well-known novel ecosystem is Green

475 Mountain on Ascension Island in the mid-Atlantic, where scientific and geoengineering
476 experiments led by Victorian botanist Joseph Hooker to introduce a mixture of plants from
477 across the world's tropical regions to a relatively barren island has creating a thriving
478 ecosystem composed of species that would not otherwise be found together (Wilkinson,
479 2004). On a smaller scale, Collier (2013) proposes that dry stone walls are examples of novel
480 ecosystems. Such novel ecosystems are expected to increase in number and extent in the
481 Anthropocene, although there is some geographic unevenness in their emergence (Hobbs et
482 al. 2006), and they are predicted to be less extensive than altered systems which can be
483 restored (Murcia et al. 2014). Novel ecosystems might provide vital ecosystems services –
484 the creation of which formed part of the rationale behind their creation on Ascension – or
485 provide habitat for conserving endangered species (Lindenmayer et al. 2008; Wilkinson
486 2004), although their inherent value their aesthetic, moral, historic or scientific value, has not
487 featured prominently in the literature. In contrast, echoing Jacquet's (2013) notion of the
488 Anthropocebo effect, and indicating the normative as well as scientific questions posed,
489 Murcia et al (2014) warn that the concept of novel ecosystems is potentially political
490 dangerous as it could be used to justify environmental damage. Doubts remain over our
491 ability to identify and define novel ecosystems, particularly the threshold dividing them from
492 normal ecosystems undergoing normal processes of change (Murcia et al. 2014). Although
493 conservation biology has drawn few insights from paleoecology, evidence of past instances
494 of unique movements of species adapting to new conditions, such as interglacial periods, may
495 provide insights into novel ecosystems and their evolution and potential management
496 (Lindenmayer et al. 2008; Young 2014). They also challenge longstanding notions of what
497 constitutes a species' habitat and what defines an ecosystem (Lindenmayer et al. 2008).
498

The literature on biodiversity conservation and the Anthropocene has also considered issues of how new species might emerge in the future through synthetic biology and new forms of hybridisation. These place humans as a key influence in speciation and evolution, a deeper, more permanent and more fundamental form of human altered nature. Unlike anthromes, biotic homogenisation and novel ecosystems, which reflect historic and ongoing processes, these issues are only just emerging. As Redford et al. (2013) demonstrate, the creation of new species or an increased genetic diversity within a species through synthetic biology has great potential to alter the ethics and practices of conservation, yet it has been almost entirely neglected. This lacuna is partly because even multidisciplinary conservation has not yet engaged with molecular biology, and there are great differences in approach, practices, culture and motivations between conservation and molecular biologists. Synthetic biology offers a complex mix of threat and opportunity for conservation biology, from the broader social and environmental implications of genetically modified agriculture to the potential use of synthetic biology to create targeted interventions to save species and ecosystems, and how these should be understood and regulated has yet to be determined (Redford et al. 2013). The Anthropocene has also created new species without such technology, as introduced species hybridise with natives of the same genus. Thomas (2013) argues that such hybridisation, where formerly separate species of the same family are brought together through human action to create new accidental hybrids, is a characteristic of the Anthropocene, and such hybridisation may equal the pace of extinction. Yet such new hybrids may not be valued in the same way as pre-existing species – Thomas (2013: 7) points to the lack of concern at the extinction of a newly created hybrid compared with concern with extinction over species which emerged prior to the Anthropocene, and argues that "deliberate persecution of the new — just because it is new — is no longer sustainable in a world of rapid global change".

524 ***New strategies for biodiversity conservation in the Anthropocene***

525

526 [Figure 5 about here]

527

528 As well as new concepts, there are also proposals for new strategies for conserving
529 biodiversity in the Anthropocene. These are heterogeneous and sometimes contradictory, but
530 there are four key features. Firstly, like new concepts discussed above, they have been
531 explicitly linked to the term Anthropocene, but they also have a larger life outside of papers
532 using the phrase and idea of the Anthropocene. Secondly, they can be divided along a
533 spectrum from those which celebrate human-managed nature, managing environments for
534 maximum human and non-human benefit, to those which celebrate self-willed nature, which
535 seek to allow nature to take its own course (see figure 5). They roughly conform to Hunter et
536 al's (2014) characterisation of anthropocentric and biocentric attitudes towards nature in the
537 Anthropocene respectively. The former are more positive about the Anthropocene, valuing at
538 least some of the changes related to it, and the latter strongly decrying it. They are not
539 necessarily contradictory, as each may be more applicable in different places and for different
540 issues. Thirdly, there is a key theme, partly building on the new concepts discussed above, of
541 tackling issues of species belonging in particular spaces. Finally, there is an emphasis on
542 restoring ecosystem processes which have been lost in the Anthropocene, part of a broader
543 move in conservation away from preserving individual species to preserving ecological
544 processes such as particular ecosystem functions or long term evolutionary processes.

545

546 There are calls for research and action to concentrate on the species, biomes and geographical
547 areas predicted to undergo the greatest and most rapid change as the Anthropocene
548 progresses (Ellis et al. 2012). Whilst some species, evolved to specialist niches, may not be

549 able to rapidly adapt to the new conditions of the Anthropocene, others have flexibility and
550 other characteristics that allow them to dominate in the aftermath of rapid environmental
551 change – what Correa and Baker (2011) label disaster taxa. Others, such as Kareiva et al.
552 (2011) argue that conservationists should respond to the Anthropocene by focusing less on
553 unmodified wild areas and more on modified systems such as urban and agricultural areas.
554 Contrasting this, there are also calls to retain historic approaches to conservation as the
555 Anthropocene develops, such as conserving wild areas, and creating protected areas (Doak et
556 al. 2014).
557
558
559 Following on from rethinking exotic species and their correct places are revised approaches
560 to managing them, with related proposed changes in legislation and regulatory tools on exotic
561 species. Instead of eradicating exotic species, particularly where doing so is difficult,
562 expensive or undesirable, it is proposed that management efforts should focus on maximising
563 desirable outcomes, such as their role in supporting endangered species or providing valuable
564 ecosystem services (Habel et al. 2013; Kueffer and Kaiser-Bunbury, 2013; Seastedt, 2008).
565 Others have proposed that conservation should respond to the Anthropocene by deliberately
566 spreading species beyond current ranges through assisted migration. Species which in future
567 find the their current ranges inhabitable due to climate change, and which are unable to
568 migrate to new habitable areas, may require direct human intervention to move them and
569 allow them to flourish in new places (Carroll et al. 2014). The idea has flourished in recent
570 years (Figure 3). Although current ecological knowledge, particularly invasive ecology, and
571 models of future climate change can help predict the success of these moves, there is
572 uncertainty over what species might require translocation, how this might work, and risks
573 over the impact of translocated species on native biodiversity (Mueller and Hellman 2008;

574 Schimel et al. 2013). Some have called for controlled experiments (McLachlan et al. 2007;
575 Schimel et al. 2013). Whilst assisted migration is largely discussed as a future conservation
576 approach, it is already being applied to some species, notably the Florida torreya (*Torreya*
577 *taxifolia*) (McLachlan et al. 2007).
578
579 As well as moving species in response to climate change, there are proposals to move species
580 in order to recreate recently lost ecosystem functions, replacing an extinct species that had a
581 key ecosystem function with an extant and exotic surrogate species (sometimes referred to as
582 analogue species or taxon substitutes). For example, native trees on the island of Mauritius
583 suffer from the extinction of native fauna which acted as seed dispersers, and a controlled
584 introduction of Aldabra giant tortoises showed that they could replicate this role (Griffith et
585 al. 2011). As with other proposed deliberate species migrations, there is uncertainty over the
586 efficacy of this, whether surrogates can accurately recreate the role of extinct species,
587 particularly as the ecological baselines may have changed since extinction, and concerns
588 remain over long term risks such as their deleterious impact on native species, and there are
589 calls for controlled experiments (Corlett 2013 – Kueffer and Kaiser-Bunbury 2013 argue that
590 islands are ideal for this). The introduction of surrogate species can be thought of as the
591 deliberate creation of novel ecosystems, in that humans are bringing together configurations
592 of species that would otherwise not be found together, which alter ecosystem functions (albeit
593 to a previous state), which can persist without ongoing human interventions, and which can
594 aid the conservation of endangered species.
595
596 Scaling up from surrogate species, there are proposals to respond to the Anthropocene by
597 recreating past ecosystems at a landscape scale through rewilding. Rewilding is the
598 reinstitution of ecological processes which have been lost through human actions, notably

599 species extinctions, although Jorgenson (2015) notes the varied and imprecise usage of the
600 term has allowed it to catch the public imagination. The spatial and temporal scales of
601 rewilding projects vary from small-scale controlled introductions of a single species which
602 recently became locally extinct (Sandom et al. 2012), through attempts to recreate past
603 landscape ecologies by introducing numerous surrogates for megafauna which went extinct in
604 recent centuries (Lorimer and Driessen 2013) through to proposals for continental scale
605 ecological change using surrogates for extinct pleistocene megafauna (Donlan et al. 2006,
606 Tanentzap et al. 2013). The geographical variance in ideas about the nature and scale of
607 rewilding in North America, Europe and elsewhere is partly due to environmental differences
608 (human densities, species and habitat loss) but also cultural differences, such as ideologies of
609 wildness (Jorgenson 2015). Large scale rewilding has an emphasis not just on reinstating lost
610 ecological functions, but also ecological dynamism (e.g. nutrient cycling, non-equilibrium
611 vegetation changes) and evolutionary processes, so rather than creating facsimiles of past
612 environments it aims to allow change to occur without human intervention beyond the tacit
613 role of humans in starting the rewilding process (Lorimer and Driessen 2013; Donlan et al.
614 2006). It focuses on lost megafauna, ostensibly because megafauna act as keystone species
615 and because they are disproportionately likely to suffer from human-induced extinction
616 (Donlan et al. 2006) although it also reflect the tendency within conservation whereby large
617 charismatic animals attract disproportionate amounts of research, financing and attention.
618 There are also proposals to combine rewilding with synthetic biology through de-extinction,
619 the restoration of extinct species through genetic technology, rather than purely using extant
620 species as surrogates for extinct species (Donlan 2014, Seddon et al. 2014). One partial move
621 towards this is back-breeding and de-domestication, in which domesticated fauna (horses,
622 cows) are selectively bred to recreate their now extinct wild ancestors, which are left to roam
623 (relatively) wild (Lorimer and Driessen 2013). Rewilding is more ambitious than ecological

624 restoration in its spatial and temporal scale, its focus on megafauna, and its emphasis on a
625 dynamic, self-willed nature rather than more domesticated, controlled, human-led change. As
626 such, it faces particular policy and political challenges through its incompatibility with
627 existing conservation strategies and legislation, particularly regarding invasive species and
628 socio-natural landscapes, and the tendency of many conservation policies (e.g. EU Natura
629 2000 scheme) to promote low-level human intervention over absence of direct management,
630 although many current rewilding projects require a level of human intervention, which causes
631 philosophical contradictions (Lorimer and Driessen 2013). Seddon et al. (2014) argue that the
632 broad rewilding movement is shifting from recreating wilderness to something which
633 integrates humans alongside restored ecological processes. Limited rewilding projects in
634 England have been critiqued as an attack on local culture, particularly the role of traditional
635 farming in creating a socio-natural landscape (Convery and Dutson 2008). As with surrogate
636 species and assisted migration, there is a lack of knowledge creating uncertainty over the
637 risks and opportunities of reintroducing species for rewilding, but with additional issues.
638 Firstly, paleoecological knowledge over how past ecosystems functioned is uncertain and
639 contested (Corlett 2013; Lorimer and Driessen 2013). Secondly, there are few practical
640 opportunities for controlled experiments of landscape scale rewilding, unlike assisted
641 migration or surrogate species. Yet given that rewilding is about self-willed nature changing
642 and evolving without human influence, an element of uncertainty over how rewilded
643 landscapes will change is a perhaps a desirable outcome.
644
645
646 ***Discussion: what should we talk about when we talk about biodiversity conservation in the***
647 ***Anthropocene?***
648

In summary, a broad range of new concepts and new approaches have been proposed for dealing with the challenges of the Anthropocene. Some concepts (e.g. biotic homogenisation and beneficial exotic species) appear to contradict one another, and the diverse range of approaches reflect a broad range of ethical premises about how humanity and nature should interact, and mirror longstanding divisions within biodiversity conservation. Yet the term "Anthropocene" is not being widely used within biodiversity conservation journals, and is predominantly used as shorthand for an era of large scale anthropogenic change rather a fuller exploration of its consequences.

Fragmentation or pluralism

There are several important additional points to make about this literature. Firstly, despite the heated discussions between opposing viewpoints, and way in which proposed new approaches for conservation in the Anthropocene seem to pull in opposite directions (e.g. rethinking urban nature versus landscape scale rewilding) there is some compatibility within this. Different concepts and strategies are each appropriate to different circumstances – traditional wilderness-focused protected areas or large scale rewilding might be the most appropriate for the wild places identified by Caro et al. (2014), whereas irreversibly modified systems might be best managed by considering novel ecosystems and valuing exotic species. Kueffer and Kaiser-Bunbury (2013) argue against the fragmentation of conservation in response to the multiple challenges of the Anthropocene, yet conservation has always been pluralistic (Rudd 2011; Sandbrook et al. 2011), and such pluralism is perhaps the best way to react to the new concepts and approaches developing in response to the Anthropocene (Marvier 2014).

Interdisciplinarity

674 Secondly, there are calls for increased interdisciplinarity for biodiversity conservation in the
675 Anthropocene. This is not just between subdisciplines (e.g. paleaoecologists and invasive
676 ecologists working together to understand novel ecosystems), but also between natural
677 scientists, social scientists and humanities scholars in the Anthropocene, ecosystems are no
678 longer driven purely by natural factors but by these in combination with social and economic
679 factors, and approaches to understanding them needs to reflect this (Hicks 2010; Ogden et al.
680 2013). Yet despite this, only a few articles (e.g. Rick et al. 2014) take this seriously, perhaps
681 reflecting broader failures within conservation to generate widespread interdisciplinary work
682 despite multiple calls to do so (e.g. Agrawal and Ostrom 2006). One particular failing is that
683 whilst the contribution of the social sciences is recognised within biodiversity journals, albeit
684 to a limited extent, the humanities are not. Sörlin (2012) argues that early conservation
685 efforts, which were based on natural sciences, and more recent efforts, which also included
686 social sciences, have both failed, and an approach which also integrates the humanities may
687 be more successful. One consequences of not taking the humanities seriously might be the
688 relatively narrow ways in which nature is valued in the Anthropocene (see below).
689
690 *Rethinking success, and rethinking what we are conserving*
691 Thirdly, given that old ideas and approaches are being rejected and new ones introduced,
692 there is a need to rethink what counts as success in conservation – a normative re-evaluation.
693 This is implicit rather than explicit in many discussions. One example of a new evaluation of
694 successful conservation in the Anthropocene is the recognition that some species will always
695 be dependent on intense human management for their survival, challenging current
696 approaches to endangered species management which aim to be a temporary measure to
697 restore species numbers to a sustainable level (Braverman 2014). Merely having a species
698 surviving is a different form of success to having a species thrive without human

699 intervention, in its own habitat as part of ecosystem dynamics and evolutionary processes.
700 This links to a fourth area of discussion, which is how responses to the Anthropocene reflect
701 changes in what is being conserved. Again, this is often implicit rather than explicit, and
702 perhaps reflects longstanding and often deliberate ambiguities within conservation about
703 what is meant by biodiversity (Takacs 1996). For example, Kareiva et al. (2011) argue that
704 the global alteration of biogeochemical cycles and evolutionary processes by human action
705 means that conservation should move away from its focus on conserving wilderness as
706 people-free nature, and instead, imply that conservation should primarily value and conserve
707 nature as it benefits humans, as ecosystem services (see Hunter et al. 2014). In crude terms,
708 assisted migration principally aims to conserve individual species, rewilding aims to conserve
709 ecosystem service, ecosystem dynamics and evolutionary processes, whilst surrogate species
710 aims to conserve individual species and ecosystem dynamics. Overall, there is a move away
711 from conserving wildernesses hermetically sealed from human influence and to a lesser
712 extent, individual species. Instead, there is more focus on ecosystem dynamics, very long
713 term processes such as evolution, and ecosystem services. What is missing from this is
714 valuing processes and landscapes for their intrinsic cultural or historical value precisely
715 because they are created by humans. For example, Ascension Island's novel ecosystem can
716 be valued for the insights it provides into ecosystem change, co-evolution, ecosystem services
717 and geoengineering, but also as a historical and cultural artefact of Victorian science,
718 exploration and imperialism, just like Joseph Hooker's notebooks and collections. Instead,
719 the human influence that leads to the emergence of novel hybrids (see Thomas 2013) means
720 that these new forms of life are valued less than their progenitor species. There is an
721 expanding literature in the humanities on more-than-human nature, and our ethics towards
722 breeds, species and landscapes which are products of human and non-human actions, and on
723 how they should be valued (see Lorimer's 2012 review of the relevance of this to the

724 Anthropocene). This has yet to be recognised within the biodiversity conservation literature.
725 Rudd's (2011) survey of conservation scientists found that, relative to other conservation
726 goals, preserving the spiritual and cultural value of nature is a very low priority. During the
727 Anthropocene, new species combinations, new ecosystem dynamics, and possibly (with
728 synthetic biology) new species may emerge, yet it is unclear from the literature how this
729 should be valued by conservationists.
730
731 *Human organisation for successful conservation in the Anthropocene*
732 Fifthly, the question of broader human values and forms of social organisation are often not
733 explicitly addressed. As Ogden et al. (2013) argue, the Anthropocene can be seen as a
734 product of a particular form of economic, social and political system. Some articles within
735 biodiversity journals do link their arguments to broader economic and social questions (e.g.
736 Miller et al. 2014) but there is a limited response in biodiversity conservation journals to
737 Adams' (2013) call for a broader discussion within conservation about what kind of society
738 and economy is necessary if we are to successfully conserve biodiversity in the
739 Anthropocene. This is perhaps because such discussions do not fit easily within the aims and
740 scope of many biodiversity journals or the grant-making criteria of research funding bodies,
741 or a failure to integrate the social sciences and the humanities, and their insights into such
742 issues (e.g Castree et al. 2014; Lorimer 2012). Rethinking the ethics of relationships between
743 humans and nature has been a key theme in social science and humanities literature on the
744 Anthropocene (Castree 2014; Lorimer 2012) It is here that the value to biodiversity
745 conservation of the concept of the Anthropocene, and the insights of the social science and
746 humanities, become apparent. Moving away from treating individual issues such as one
747 invasive species in one place, and the effects of climate change in another, and thinking in
748 terms of an overarching framework that links together many biogeochemical processes as

749 well as forms of human organisation, provokes important questions about the moral
750 underpinnings, ethics and norms of biodiversity conservation – what it is, what it aims to do,
751 and how it can and should accomplish this. It may prompt the formulation of a set of
752 postulates that can account for this new reality and its messiness. Rudd's (2011) study
753 indicates that this may earn acceptance.
754
755 *Adopting the Anthropocene*
756 Finally, many issues and approaches have been raised within conservation as a response to
757 the Anthropocene, yet the term is relatively rare in the biodiversity conservation literature.
758 The new concepts and ideas discussed above which have been explicitly linked to the term
759 Anthropocene have a bigger circulation outside of the literature on the Anthropocene, and
760 few articles are linking diverse issues together into a coherent response to the Anthropocene.
761 There are several possible explanations for this. The Anthropocene is a relatively recent
762 concept, albeit one with deeper roots, and its importance and implications for biodiversity
763 conservation are yet to be fully developed (Zalasiewicz et al. 2010). The concept of the
764 Anthropocene implies thinking across various forms of global environmental chance (climate
765 change, biodiversity loss, the spread of invasive species) but these appear to be treated
766 individually rather than collectively. The moral and normative challenges it poses might be
767 unwieldy and difficult to address. The uptake of the Anthropocene, a concept which demands
768 interdisciplinarity, is perhaps constrained as part of the broader disconnect in conservation
769 biology between calls for interdisciplinary research and articles and research which take such
770 an approach. Conservation scholars could be more interested in focusing on individual
771 problems and issues without looking to link to the work of others – invasive ecologists and
772 rewilding ecologists may be too focused on their own areas of research to link with one
773 another. Even if there was an interest in disciplines and sub-disciplines and advocates of

774 different approaches working together, the responses to the Anthropocene are perhaps too
775 fragmented and at times contradictory for a united and coherent response to the
776 Anthropocene to emerge in the literature. Indeed, as discussed above, a united approach may
777 not be desirable. It is also possible that the term Anthropocene is too vague, with too many
778 interpretations, to be of much use in understanding and responding to changes in biodiversity.
779 Yet given the trajectory of use of the term and the proposals to rethink concepts and
780 approaches in biodiversity conservation as a direct response to a human-dominated planet,
781 conservation biologist may not be able to neglect it for much longer.
782
783

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