Experience Distributed in the Biodiversity Science-Base

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Abstract

Critics of biodiversity science and environmental governance point to exclusion and absence of diverse experience from science-based governance, sometimes effectively dividing domains of science and experience/values. This paper, following an alternate line of thought drawn from John Dewey's *Nature and Experience*, analyses a series of scientific publications on biodiversity from 1989-2020. It argues that experience abundantly populates the biodiversity science-base, although in highly distributed forms. Dewey's account suggests that knowledge of biodiversity derives from an unanalyzed continuum of experience. Reading the publications as traces of occurrences of encounters preceding, accompanying, and sometimes deriving from knowledge, the paper locates and characterises differentiated, sometimes impersonal gradients of experience, developing a figurative model of distributed biodiversity experience. It concludes that experiential diversity occurs widely in the science-base, but communication of and participation in this experience is frequently marginalised by the primacy of knowing.

Keywords. Biodiversity, experience, Dewey, knowledge, distribution

Introduction

"Listen to the voices of experience" advise the social scientist and museum curator authors of a 'Comment' in *Nature* (Turnhout et al., 2012: 454) responding to the 2012 initial meeting of IPBES, the Intergovernmental Platform for Biodiversity and Ecosystem Services IPBES (2019), in Panama. Turnhout and co-authors (2012) question the primacy of a 'science-based understanding' emphasising ecosystem services in the plans and actions of IPBES. They point to the limits of the scientific concept of biodiversity:

There is no single scientific definition of biodiversity, nor is there one that does justice to the many ways of living with and knowing nature that human cultures have developed. The IPBES has not taken adequate notice of this and is promoting a predominantly science-based understanding of biodiversity, with ecosystem services taking centre stage. (Turnhout et al., 2012: 455)

Much of the framing discussion and policy-making, they say, presumes the coherence, unity and consistency of biodiversity science. They highlight instead the need for connections between

"organized global knowledge and the many bio-diversity actors operating at multiple levels and scales" (Turnhout et al., 2012: 455). They call too for acknowledgment of "monetary, aesthetic and sacred values" in the meanings of biodiversity, and inclusion of actors such as farmers, fishers, businesses and indigenous people as "knowl-edge-holders" (Turnhout et al., 2012: 455).

The needs for inclusion, participation and voice are widely acknowledged in conservation biology and ecology. Calls for a greater role for social science, plural values and experiences date from the first major scientific conferences and publica-tions on biodiversity during the 1980s, and can be see in *urtexts* such as *Biodiversity* Wilson (1988). They continue through to the present (Miller, 2005; Castro and Mouro, 2016; Bonebrake et al., 2018; Stenseke and Larigauderie, 2018; Wyborn et al., 2020a). Repeatedly, however, attempts to engender everyday awareness of biodiversity (Prévot et al., 2018) or to increase public partici-pation in or enhance democratic deliberation concerning biodiversity founder. Almost a decade later after IPBES started, it seems as though these diverse voices and actors have not been centre-stage in biodiversity science, even if the problem of their bit-part roles has long been recognised. The Convention on Biological Diversity reports in 2020 that nearly all biodiversity targets relating to participation and knowledge partnerships (the 2010-2020 'Aichi Targets') have not been met (Greenfield, 2020; CBD Secretariat, 2020).

This paper starts from the proposition that biodiversity science already bears within it many forms of experience. Important components of biodiversity experience occur in science. If we could recognise those components, problems of inclusion, participation, and the permeability of scientific knowledge infrastructures to other knowledges might be re-framed. In order to test this proposition, I suspend the assumption that biodiversity is only about knowing, or knowledge in any narrow sense. I instead ask how scientists, situated and equipped, monitoring field plots, checking the fit of a species distribution model, conducting experiments in interspecies competi-tion or the dynamics of dispersion in a metacom-munity, experience biodiversity. A letter from ecologists to *Science* calling attention to the grief

of environmental scientists Gordon et al. (2019) hints at this possibility: knowledge is certainly a core component of biodiversity experience, but one that derives from embodied, affective, situated encounters between scientists, other people and other species. I suggest that the practices of ecologists, conservation biologists, taxonomists, and others is a distributed form of biodiversity experience, a distribution of experi-ences that invites restoration or re-introduction more generally.

Inhabiting the science-base

Seeking to bring wider experiences into knowl-edge of biodiversity or beginning to widen the concept of biodiversity itself (Wyborn et al., 2020b), I ask: what forms of experience occur in biodiversity science? The problem of tracking experiences of biodiversity resembles the chal-lenges faced by ecologists trying to measure bio-diversity. What to count (taxa, species, functions, genetic differences?), where and when to count them, on what scale to count them, and how to compare counts between different places: all of this makes assessment of biodiversity far from simple, especially when what is seen to be present is recorded much more than what is absent. Simi-larly, the occurrences of experience, their occur-rence in many interconnected situations, and even what counts as the occurrence of experience of biodiversity is bound to be unevenly dispersed and shaped by many different histories, processes and events. The concept of distributed experience endeavours to incorporate some of that plurality.

In this paper, the practical approach to the question of experience in the biodiversity sciences is artificial. I assembled and worked with around 134,000 publication records collected from the ISI Web of Science in response to the simple topic query 'biodiversity', delimited by the years 1989-2020.[1] I note that the resulting *biodiversity science-base* is not as extensive as 'genome' (500k Web of Science results) or 'cancer' (2.5M results), but this is an expansive literature, roughly as great as the high-profile area of computer science 'machine learning' (125k records). The records are limited, comprising titles, authors, abstracts, cited refer-ences, keywords and bibliographic fields. They

lack the density of documentation, practices and material culture of biodiversity science in its field, laboratory, analytical, knowledge infrastructure or policy/governance interfaces. I regard the publications records as analogous to observations of the presence of species in a field site. Although the observations are abundant, they give little clue to the assemblage of lives, histories, equipment, conferences, careers, institutions, funding measures, databases and research programmes of the scientists. Like any ecological assemblage, the biodiversity science-base encompasses niches, habitates and communities whose interactions and relations are not clear (Ovaskainen and Abrego, 2020: 5).

The Web of Science biodiversity dataset certainly presents, authoritatively perhaps, what Turnhout and co-authors (2012) point to as the 'science-based understanding.' But the movements of biodiversity experience through this collection of documents, documents dedicated to the communication of biodiversity knowledge, is not standardized or monolithic. The range of concerns in the science-base, its working methods, its connections to various geographies, policies, peoples and experiences are multiple and diffuse. Like scientific publication records more generally, the biodiversity science-base records the scale-shifting doings of the social (Latour et al., 2012). Traces of national and international governance, economies, cultures, media and many histories of colonisation, development and industry criss-cross it. Government policies, regulatory frameworks working at various levels of governance, conservation efforts and environmental management practices in sanctuaries, parks and other zones, popular culture and media attention such as wildlife or environmental documentaries, or everyday experiences as imaged on Instagram, in travel and tourism, or in any of the citizen science projects impinge upon it.

But there are people in the science-base pivotal to understanding of biodiversity experience in its inevitable mingling with the pressing realities of environmental management, global competition and the politics of climate change. The author list of almost 235,000 amounts to the population of a small city or the number of employees in a very large corporation. In various ways, this population

must have lived during 1990-2020 through many encounters with places, habits, biomes, landscapes and species.

The analytical work on the records of titles, abstracts and citations base has several points of reference. A major influence comes from John Dewey's (1958) arguments in *Experience and Nature* for an empiricism that positions all experience in and of 'nature.' Much of Dewey's argument in this work and others such as *Reconstruction in Philosophy* (Dewey, 1957) centres on the "when and where of the act of selection" (Dewey, 1957: 30), an act that splits knowing off from unanalyzed facets of experience like a plank from a tree. There is much in Dewey's re-grounding of experience in nature that goes beyond social construction of knowledge claims or their re-grounding in the lifeworld experience.

In *Experience and Nature*, Dewey situates experience as an 'unanalyzed totality' of act and material, subject and object:

> "Experience" denotes the planted field, the sowed seeds, the reaped harvests, the changes of night and day, spring and autumn, wet and dry, heat and cold that are observed, feared, longed for; it also denotes the one who works and rejoices, hopes, fears, invokes plans, magic or chemistry to aid him, who is downcast or triumphant. It is "double-barrelled" in that it plants and reaps, recognizes in its primary integrity no division between act and material, subject and object, but contains them both in an unanalyzed totality (Dewey, 1958: 8).

Dewey's agroecological formulation lists fields and seasons before 'the one' who works or hopes. He resists the usual identification of experience with subjectivity or consciousness. Experience is a diverse, continuous hypervolume of affects, practices, expectations, things and thoughts, distributed across gradients of intensity. Much of *Experience and Nature* is directed against any splitting of experience into individual, personal or even human states of mind, and against any general ends or meaning. Although he retains the problematic term 'nature', he recasts it as the unanalyzed totality of experience. Dewey attaches experience to nature: "it is not experience which is experienced, but nature" (Dewey 1958: 4a]. 'Nature is experienced': the proposition

maintains a provocative ambiguity. Is Dewey saying that nature experiences too?[2]

What happens if we substitute the term 'biodiversity' for Dewey's 'nature'? With an eye on the acts, materials and unanalyzed totality of biodiversity, I navigated the science-base using analytical techniques such as keyword occurrence, citation analysis and topic models, many of which are now highly developed in digital STS and digital humanities. I heed Christopher Kelty and Hannah Landecker's call for "highly specific empirical work on the general" in contemporary scientific literatures (Kelty and Landecker, 2009: 177). Landecker and Kelty pose the problem of how to stage meaningful encounters with scientific literatures whose scale and distributed mode of existence eludes the grasp of reading focused on cases studies or individual works. They suggest that the material actions, problematisations and plots running through the science-base can only surface through methods that combine close reading with techniques for analysis of spread and circulation. Ecologically speaking, the problem of contemporary science-bases is their complicated community composition. In tracking experience across the science-base, I make use of tabulations, counts and plots of occurrences that would not be alien to ecological research but draw also on the methodological innovations developments in recent digital sociology and digital humanities (Marres, 2017; Jockers, 2013), and from cultural sociologies that argue for nuanced interpretative work through modelling large textual collections (Mohr and Bogdanov, 2013). I seek to perform a distant but depth reading (Moretti, 2013) of experience in the biodiversity science-base.

There is one final and overarching consideration in attending to the biodiversity science-base. The concepts and material actions associated with biodiversity sciences could and perhaps should more affect social science and humanities thinking. Ecological metaphors are common in social science and humanities research, but sometimes remain abstract. Recent scholarship works more closely with ecological thought. When Anna Tsing writes "I look for disturbance-based ecologies in which many species sometimes live together without either harmony or conquest" (Tsing, 2015: 5), she affirms an ecological concep-

tual cross-fertilisation resting on the resonant term 'disturbance.' Notions such as assemblage, niche-partitioning, distribution and metacommunity as well as disturbance, succession, colonisation, extinction or competition, may suggest ways of re-configuring understandings of experience. Working closely with the science-base can yield conceptual as well as empirical insights. Most immediately, for instance, it suggests ways of approaching the science-base ecologically. Jamie Lorimer's (2015) account of biodiversity also offers a lead here. He approaches biodiversity as a distributed accomplishment. He writes that biodiversity "came out of and is thoroughly dependent on the embodied, affective, and technological encounters between multiple species. (…) Biodiversity happens in an assemblage. It inherits and is haunted by particular knowledges, habits, instruments, territories, and practices" (Lorimer, 2015: 58). This suggests that experience of biodiversity, even in the biodiversity science-base, will be distributed not necessarily unified in a concept.

To summarise the approach: take a path that begins by observing explicit occurrences of experience in the biodiversity science-base, contrast those experiences with material actions projected on the basis of knowledge, maps secondary or derived paths running between occurrences of experience and projected actions, and then look for the latent mixing of experience that gives rise to the biodiversity assemblage. A series of plots and tables figure these different patches of experience not in the interests of statistical rigour but in view of empirically grounding a reading of the biodiversity science-base in view of its dispersal, connectivity and nestedness.

Occurrences of experience

Experience is not always named where it occurs. Dewey (1958) observes in *Experience and Nature* that "one would probably have to search long time through reports of special researches in order to find the word 'experience'" Dewey (1958: 2). The word 'experience' is actually quite common in the science-base, just as common in fact as the term 'global biodiversity', both occurring in 4.5 thousand documents in the collection. 'Central Mexico has experienced a decline its natural

Table 1. What experiences

pre	keyword	post
Climate and grassland ecosystems likely will	experience	the greatest proportional change in biodiversity
Northern temperate ecosystems are estimated to	experience	the least biodiversity change because major
Interacting species	experience	their surrounding landscape at different spatial
Most host-parasite systems are predicted to	experience	more frequent or severe disease impacts
whether populations have also	experienced	gene flow . These questions can
Pairing scheme and control sites that	experience	similar environmental conditions (16 %
In particular, food webs	experience	'rivet-like' thresholds past which
All other farms, however ,	experienced	greatly reduced diversity and abundance of
China , and Africa have	experienced	the highest rates of urban land
Places	experience	forest transitions when declines in forest
Sweden and Denmark now	experience	severe seasonal hypoxia , Synthesis of
Identifying regions projected to	experience	high magnitudes of
The Earth's terrestrial surface may respectively	experience	novel and disappearing climates by 2100
Increase the risk that species will	experience	the loss of extant climates or
some reefs have	experienced	relatively rapid recovery from severe bleaching
Based on that and on the	experience	of the projects reported in this
And those of native origin also	experienced	increased risk of local extinction after
For example , flatfishes have	experienced	little , if any , recovery
As well as the clades that	experience	them , our diversity tree provides
Butterflies	experienced	the greatest net losses , disappearing
However, in ponds that	experienced	drought , I found much higher
Biodiversity conservation and the extinction of	experience	. Biodiversity loss is a matter
Arrived at using theory and practical	experience	, include : the log series
Having	experienced	mass disease-induced mortality of the herbivorous
The new interactions and conditions	experienced	by the invader may influence both

vegetation.' 'Food webs experience "rivet-like" thresholds.' 'Some reefs have experienced relatively rapid recovery from severe bleaching.'

Experience in the biodiversity science-base corpus occurs in some obvious and not-so-obvious ways. As the first table of experience below indicates, many usages of the term are impersonal: grasslands, temperate ecsytems, host-parasite systems, populations, food webs, places, clades and communities all undergo something. In all of these occurrences, experience principally concerns a change, or a transition, often a loss, reduction or risk. 'Experience' here is a synonym for 'undergoes' or 'suffers.' Experiences are oriented in time. Something has happened, is happening, or will happen, and the event is dramatic, great, drastic, severe, widespread or at a fast rate. Is there anything in the biodiver-

sity assemblage that does not experience in this sense? It is possible that biodiversity itself experiences something in this sense.

In the other occurrences, or around 25% of overall 'experience' in the science-base, experience concerns something learned or knowledge gained: 'arrived at using theory and practical experience', 'experiences of adaptive governance', 'own experiences of co-physiological indicators are presented', or 'past experiences play a crucial role' (see table below). For the most part, these experiences belong to human agents. Visitors, tourists, Belgians, citizens, residents, participants, or just people perceive, learn or have in interest. Scientists stand at some distance from this usage. In contrast to the impersonal experiences of the wetlands and rangelands witnessed by scientists, these experiences are marked by personal pronouns such as 'we' and possessive adjectives such as 'their.' The hallmark of attribution to human agents, or to recognisable forms of selfhood, is the plural noun 'experiences.' In this setting, experience often refers to the past. It can be 'life experience,' tradition, or the result of

Table 2. Who experiences

pre	keyword	post
The review concentrates on	experiences	of adaptive governance of social-ecological
On various knowledge systems and	experiences	for the development of a
And educated , their life	experiences	, and the options they
With a distinct dynamic and	experiences	alternative manifestations of environmental change
Here , own	experiences	on eco-physiological indicators are presented
Finally , past	experiences	play a crucial role in
The majority of conservation actions remain	experience-based	and rely heavily on traditional land
We found that many past	experiences	did not result in self-perpetuating
Applies knowledge gained from	experiences	in human and veterinary medicine
The design of powerful interpretive	experiences	. One of the aims
Memories of their wildlife tourism	experiences	and explores processes through which
Explores processes through which such	experiences	can lead to long-term changes
Strengthen these dimensions of memorable	experiences	in order to enhance visitor
Wildlife tourism ; Visitor	experiences	; Tourist behaviour ; Environmental
Developed through daily life	experiences	with the mutual relationship between
This article reviews these	experiences	, and their broader implications
Strategies build upon valuable local	experiences	and knowledge in traditional fanning
While also creating truly transformative	experiences	for tourists.
Human-modified landscapes . Southeast Asia	experiences	one of the highest rates
Common misconceptions through examining the	experiences	of two innovative approaches to
Based upon our	experiences	developing models for the state
Compare them with the field	experiences	of specialists for specific biomes
Article will discuss the Belgian	experiences	with MSP. It will
Based on our	experiences	, we recommend developing "
This paper we draw on	experiences	from this project to consider

organised activities such as experiments, projects undertaken, or policy or management practice: 'alterations of riparian', 'from this project', 'play a crucial role'. Experiences 'of/in/with nature' are common, followed by 'lessons/learning/drawing/gained from/perspectives on' something. Experience, when it is mentioned explicitly and associated with a human subject is either an encounter with action-oriented, knowledge-oriented situations such as parks, education, public engagements, ecotourism or collaborations, or a source of ideas, attitudes, perceptions, and views.

It is possible to see in the wordcloud (Figure 1.a) some of the ways in experience has been qualified when it is mentioned. 'Direct,' 'past', personal, practical and previous experience overshadow lived, less, negative, human, own and recent experience. Embodied, immersive, urban and formative experience fringe the cloud. The wordcloud derives from part-of-speech analysis of Web of Science records that mention experience. Where experience is used as a noun, I gathered all preceding adjectives, and tabulated these, including in the plot only those occurring three or more times. These qualifications of experience point to some focus of attention or awareness of biodiversity, possibly distinct from a vaguer and more extensive background field of meanings and immediate sensations or feelings. Many of these qualifiers concern a heightened focus – 'direct', 'practical', 'lived' or 'own'. It is not hard to see them also as somewhat individualizing. Terms such as 'personal,' 'first-hand', 'subjective', 'own' and 'individual' weight individuals as the locus of experience. But many of qualifiers of experience, such as 'operational', 'collective', 'empirical', 'positive' or 'aesthetic' are not specifically individual. They span times: 'past', 'prior', 'previous', 'first', 'long' and 'early' shade through 'recent' and 'ongoing' into 'new', 'present,' current, 'everyday' towards 'future'. They are somewhat dispersed in space: 'local', 'Australian' versus 'international', 'worldwide' or 'global.' Qualities of experience such as 'broad,' 'rich', 'sufficient', 'limited', 'good', 'considerable', 'vicarious', 'unique' or 'human' are similarly varied. These qualifying modes of experience – heightened awareness, identification with selfhood, connection with collective, movement along

Figure 1a. Qualifications of biodiversity experience

Figure 1b. Qualifications of biodiversity knowing

temporals gradient running from past accumulations to future reference, the spatial dispersion from bodily sensation to globe – are relatively diffuse, overlapping and indeterminate.

By comparison, the qualifications of 'knowledge' are less varied. The wordcloud Fig1.b shows the modifiers of knowledge in the biodiversity literature. The prominence of 'local', 'traditional', and 'indigenous' is obvious, shading off into 'native', 'social', 'European' or public. There are references to scientific knowledges in specific 'ecological', 'environmental' and 'biological' forms, but perhaps less than might be expected in a collection of documents whose primary purpose is to communicate and develop knowledge of biodiversity. It may be that knowing pervades the assemblage and only comes into discussion when there is some question about what kind of knowledges are relevant or important.

Modes of biodiversity action and their projection

Biodiversity is a concept intended order to draw attention to changes in the abundance of living things. It emerged in tandem with the institution

of conservation biology as an action-oriented scientific field (Sodhi and Ehrlich, 2010). Perhaps more explicitly than many any other scientific concepts, biodiversity envisages endpoints in action. The span and scope of these actions is broad, and they run through the biodiversity science-base, as noted above, from the outset. The 1991 *Convention on Biological Diversity* (CBD Secretariat, 2011) specifies many actions on the part of nation-states only a few years after initial scientific conferences coin the term 'biodiversity' (Wilson, 1988). Planned actions include protecting public and private areas such as sanctuaries and parks, regulating industries such as forestry, agriculture, aquaculture and fishing, and monitoring of local, national and international urban, marine and land habitats. These actions run across science, industry, markets, state and society. More recent international agreements such as the Aichi Targets (IPBES, 2019) expands the scope of anticipated actions.

The implicit and explicit anticipation of action in biodiversity has been the target of much criticism. Lorimer, for instance, understands 'biodiversity as biopolitics' (Lorimer, 2015: 75), with all the connotations of governmental modes

of power. Many critics point to the problems of economic understandings of biodiversity. Echoing McAfee (1999)'s earlier critique of 'selling nature', Turnhout et al. (2013) for instance suggest that an ecosystem service approach to biodiversity fragments 'social-natural relations' into calculable market transactions (Turnhout et al., 2013: 154) and forecloses more constructive or transformative engagements. Indigenous scholars point to the many difficulties in accommodating indigenous knowledges of biodiversity in ecological science (Langton, 2003) and conservation practice (Adams and Hutton, 2007). As Subramaniam (2014) points out, the defining interest of biodiversity in variations and differences has been coupled with elision and marginalisation of lived experiences of difference.

Attempts to construct international or global monitoring systems have been problematised too. In his influential article "Biodiversity Datadiversity," Geoffrey Bowker argued that attempts to merge and unify ecological data in order to construct synoptic or panoptic measures of biodiversity are likely to founder on differences deriving from localities, practices and disciplinary histories (Bowker, 2000). Writing more than a decade later, Vincent Devictor and Bernadette Bensaude-Vincent maintain that efforts to unify datasets on biodiversity knowledge platforms blurs the scientific purpose of measuring biodiversity because data accumulation tends to become an end in itself (Devictor and Bensaude-Vincent, 2016: 9). Each of these assessments or evaluations of biodiversity pick up on projections of action mobilised by biodiversity.

It in no way detracts from these critical perspectives on the biopolitical, marketising, colonising or panoptic facets of biodiversity to suggest that there may be other modes of actions at work in the biodiversity science-base. For Dewey (1958), experience always implies actions, but modes of participation and acting vary widely, from habitual response under the pressure of circumstance to a dawning awareness that "changes everything" (Dewey, 1958: 316). Even "to get a new meaning *is* perforce to be in a new attitude" Dewey (1958: 316). All experience engages a situation, acts on it and is changed in so acting. The crucial question is

how. I note that Dewey's account is not species-specific, and perhaps not confined to the living:

> That an individual, possessed of some mode and degree be of organized unity, participates in the genesis of every experienced situation, whether it be an object or an activity, is evident. That the way in which it is engaged affects the quality of the situation experienced is evident. That the way in which it is engaged has consequences that modify not merely the environment but which react to modify the active agent; that every form of life in the higher organisms constantly conserves some consequences of its prior experiences, is also evident. (Dewey, 1958: 246)

Action always occurs in some organised or selected way – a niche, a habitat, a group, a community, a State, an organisation or institution, etc. Orientations to these situations vary. It may be proximity, inclusion, membership, belonging, identification, participation, contribution, watching, 'following', anticipation, etc. Action draws on practices, habits, techniques, materials and infrastructures to assemble people and things in a given situation. Who, how, when and where: these primary facets of biodiversity action are in some ways obvious, but also plural and highly distributed. Dewey (1958: 246) points to the latent but pervasive "operative presence of the self" in the acting, suggesting that all configurations of participatory experience imply an "intimate and omnipresent", but often unacknowledged agent.

Certain terms touching on the situation of actions frequently occur in parts of the biodiversity science-base. Actions can be grouped into general categories in view of how they affect situations. Starting from the 88 journals that have accumulated more than 250 publications during 1990-2020, I took a subset of around 55,000 titles and abstracts from the biodiversity science-base and coded them in two ways. I pattern-matched sets of words relating to broad actions grouped under twelve categories: care, conserve, intervene, fence, manage, market, monitor, prevent, protect, regulate, reduce, and restore. Some categories include a variety of related actions. For instance, the 'restore' category also includes regenerating, rehabilitating, reintroducing, reforesting, and rewilding actions. I also grouped the journals into

5 loose categories aligned with different situations: conservation, ecological science, general science, industry and society.

Both the action and situation groupings are problematic classifications. They do not exhaust biodiversity-related actions. An interested reading may miss action. The mention of an action – culling, restoring or weeding – certainly does not signify its occurrence, only that attention has been paid to it. The groupings collapse actions on different scales and modalities: constructing a fence is a much more specific action than managing an ecosystem or protecting a biome such as a reef or forest. Nor do our journal categories map more than roughly the differences between the situations mentioned above. I would expect *Conservation Biology* articles to have different concerns to *Zootaxa* or *Marine Policy*. Whether *Global Conservation and Ecology* falls in the conservation or the ecology category is harder to decide. Similarly, articles appear in high-profile general science journals such as *Nature* and *Science* for a range of reasons, sometimes associated with problems of global environmental governance, sometimes by virtue of catastrophic environmental change, and sometimes because it announces a technique or finding that lifts it above the specialised sub-fields of the biodiversity sciences.
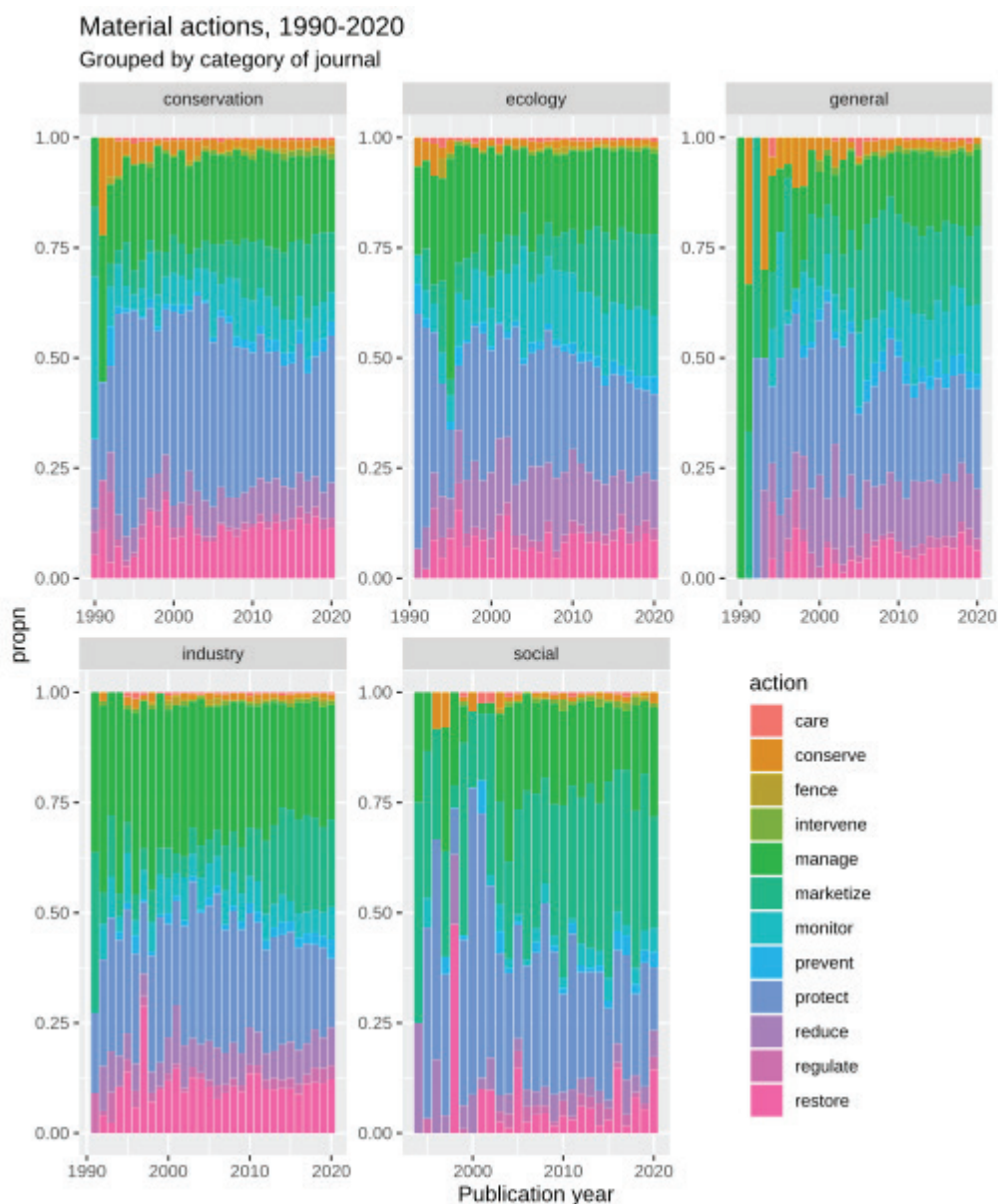

Figure 2a. Modes of biodiversity action in high-volume journals

Intervention Dictionary Keys for Web-of-Science "biodiversity" publications, 1995-2020
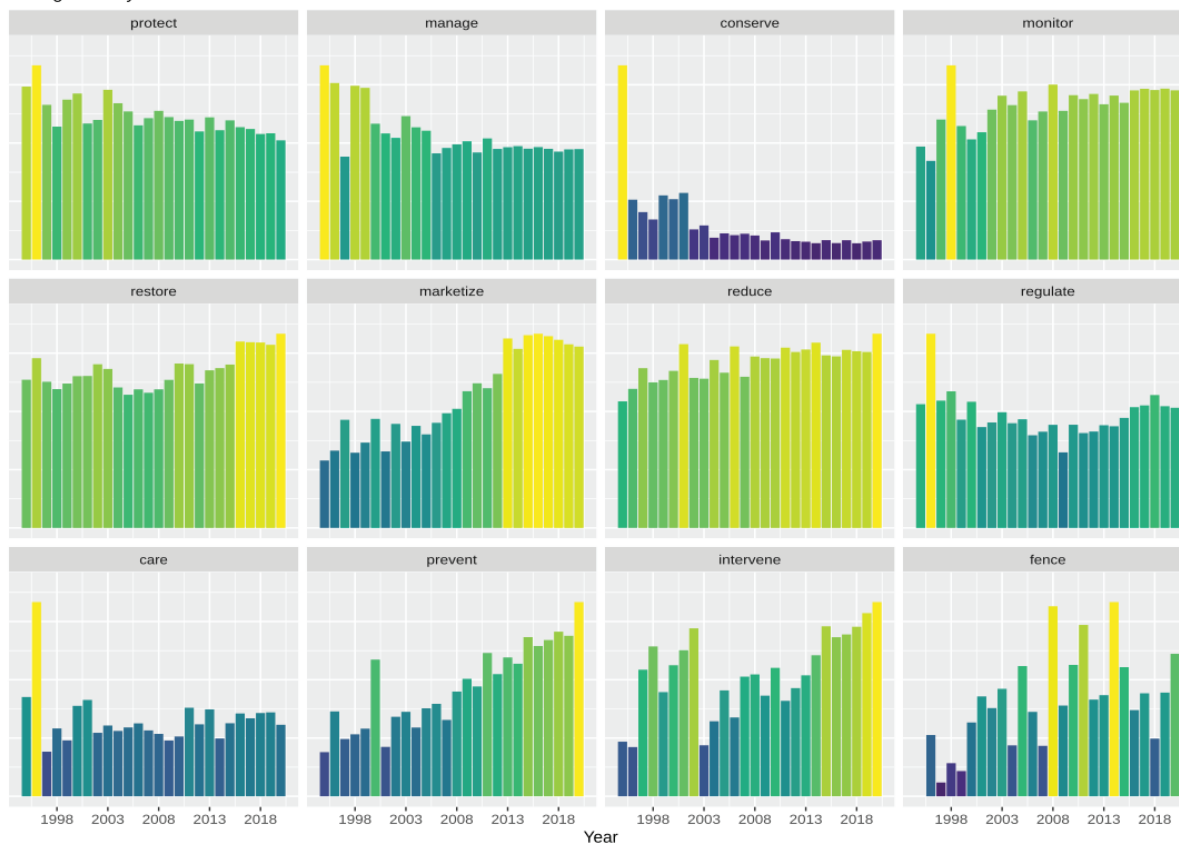Changes in key occurrence over time

Figure 2b. Key modes of action over time

Despite these limitations, the aim in this part of the analysis is to track how actions are generally distributed across the biodiversity science-base. Figure 2a points to the varying proportions of action in the differently situated facets of the biodiversity science-base. The distribution of these modes of action, actions that we might regard as anticipated endpoints of experience, varies over time and situation in biodiversity science. As the plot of their occurrence over time in Figure 2b suggests, specific actions concerning the marketised value of biodiversity such as offsetting grow markedly as do technical actions concerning reduction. Conversely, the relative lack of variation between quite different settings of ecology, general science, industry, conservation and society suggest something about implicit projections of action in biodiversity as a conceptual apparatus.

Paths back to things

Knowledge of biodiversity lies between the two endpoints of something/someone and the action-situations I have been discussing. On the one hand, occurrences of experience in the biodiversity science-base relate to something suffered or undergone, affecting persons or places. On the other hand, biodiversity actions play out as movements in the most plural sense of that term, modifying situations as well as the active agents. Many paths run between the unanalyzed totalities of being-affected and sites of action. Some, but only some, run through the biodiversity science-base.

In Dewey's account of experience, invented concepts such as 'biodiversity' are 'refined, secondary objects', derived from systematic experimentation, testing and modelling. They work by creating new loops or circular paths in experience:

they define or lay out a path by which return to experienced things is of such a sort that the meaning, the significant content, of what is experienced gains an enriched and expanded force because of the path or method by which it was reached (Dewey, 1958: 5)

The derived or refined object acts as a track, an "advantageous shortcut" in William James' (1976: 65) terms back to an experience, an experience now qualified in some way by connections, relation or even continuity with other experiences that were previously distinct. These paths 'enrich' or 'expand' experience in terms of its meaning or 'significant content.' The enriching or expanding done by a concept is closely connected to the path and to movement along that path. What movements, what paths does biodiversity lay open?

The time-varying proportions of around 16,000 author-supplied unique keywords in the biodiversity science-base show something of the neighbourhoods of biodiversity knowing (Figure 3a).[3] In the plot, the standing concern with diversity, species richness (the number of different species in a given location) and taxonomy come as no surprise. Conservation is an anchoring constant.

The growing concern with climate change, ecosystem services and sustainability have global resonance, and are affiliated with practices of management, monitoring, planning, agriculture and forestry. A series of topics concerned with change - disturbance, deforestation, restoration, extinction, fragmentation, and urbanization – are less prominent, but spread over time. Another set of keywords concerned with ecological theories and measures of diversity – beta diversity, functional traits, endemism, community structure, phylogenetic diversity, dispersal and succession – pervade the literature as the working concepts and theories of biodiversity. The keywords span scientific fields (ecology, taxonomy), abstractions (biogeography, beta diversity), processes (succession, disturbance, ecosystem function, competition, urbanization), places (forest, urban, landscape, protected areas, Australia), actions (restoration, conservation, management, monitoring), species (ants, birds, coleoptera) and institutions (IUCN). The 'refined, secondary object' called biodiversity coordinates the connection and intersection between many paths. It is thick concept, diversely realized, just like the situations it seeks to describe.

Figure 3a. Keywords in biodiversity science 1990-2019

Perhaps more significantly than their time-varying proportion, the network of associations between concepts in Figure 3.b, a network that omits for the sake of legibility almost 98% of the keywords present in the biodiversity science-base, begins to suggest just how many paths or itineraries might return to experienced things.[4]

Each of the keywords shown above is a waypoint on such a path, and their appearance in the map of keywords marks a commonly taken path. Even commonly travelled paths running through conservation, ecosystem services, climate change traverse many different intermediate steps (for instance, in the many thousands of keywords not

Keyword graph for top 340 author-supplied keywords
Showing only the main connected component

Figure 3b. Keywords networked in biodiversity science 1990-2019

plotted), as well as a manifold of experience that has not been keyworded by authors.

The plurality of differences and dimensions folded into the keywords – between living and non-living, horizons receding from particular locations such as the Cerrado or Madagascar to Earth, the references to variety and variation, the practices of measuring and observing, the biological levels running from genes to species and ecosystem, the many practices and actions – suggest that encounters with biodiversity are highly path-dependent. Major junctions such as conservation, climate change and ecosystem services in network of paths can be avoided by following paths going through taxonomy, abundance, species richness or fragmentation. This forest of connections point to the many configurations that might be experienced as 'biodiversity.'

The figure of a latent distribution

Imagine the full network of biodiversity knowing, a network in which every connection and variation in knowledge of biodiversity has been labelled and plotted in its associations. Would the vast network capture biodiversity experience? Identifying experience with what is known, or reading the biodiversity science-base in terms of scientific knowledge alone, radically curtails the run of experience. As Dewey puts it:

> What is really "in" experience extends much further than that which at any time is *known*. From the standpoint of knowledge, objects must be distinct; their traits must be explicit; the vague and unrevealed is a limitation. Hence whenever the habit of identifying reality with the object of knowledge as such prevails, the obscure and vague are explained away (Dewey, 1958: 20).

The keyword paths mark traits that can be made explicit – fragmentation, biomass, dispersal, connectivity, alpha diversity, beta diversity and so forth – amidst the plural abundance of encounters with plants, insects, mammals, birds, reptiles, fungi and fish in forests, reefs, neotropics and farms subject to fire, ecotourism, land-use change, disturbance, habitat loss, grazing, restoration, deforestation, drought and urbanization. Dewey

says experience includes much that is "uncertain, unpredictable, uncontrollable, and hazardous" (Dewey, 1958: 42) mixed with "sufficiencies, tight completeness, order, recurrence" (Dewey, 1958: 47). "Refined method and products" (Dewey, 1958: 36) of knowing, such as concepts, models, measurements, techniques of observing or recording, select for regularities or stabilities in experience.

The selection of points of ordering or recurrence does not exhaust or eliminate the affects, enjoyments, hazards, precarities or intricacies of concrete experience. Actually, the ongoing refining of derived objects highlights the overflows of concrete experience. Departing from experience, they sometimes open a path back to experience with fresh eyes or a "cultivated naivete" (Dewey, 1958: 37). It is not as if uncertainty or unpredictability derives from the less real contingencies of events, and stability and predictability from underlying or inherent order. Uncertainty animates experience. Organised and habituated in predictable outcomes *and* brimming with surprise and novelty, experience mixes stability and precarity.

Are there any indicators in the science-base of this indeterminacy, beyond the negative image seen in the refined, secondary objects that run shortcut paths through experience, abbreviating or compressing variations?

At this point, I start to run up against the limits of the tools of quantitative text analysis. Statistical models of large document collections offer a slender lead. Although sometimes treated as an automated text summarization technique (Blei and Lafferty, 2007), I re-purpose topic models to assist in figuring, not modelling, the connective tissue of experience in the biodiversity science-base. In normal practice, given a number of topics, topic models seek to identify a corresponding number of sets of terms that best capture words likely to occur together in a document. Documents in the collection, from the perspective of the topic model, can be modelled as generated by topics variously mixing. The statistical intuition of the model is that a document collection, here the biodiversity science-base, is generated by probabilistic distribution of words called 'topics' mixing together as documents. Some documents will contain high proportions of prevalent topics

and others may be heterogeneous mixture of relatively rare topics (Mohr et al., 2015).

This model of the generation of documents is highly artificial. It itself, viewed from the perspective of experience, is a secondary object, refined and derived from regularities and recurrences observed in the accumulation of words in a document collection. I therefore use it carefully, and perhaps against the grain.

If traces of unanalyzed totality of experience can be found in the more abstract reaches of the science-base, then it should be more easily seen elsewhere. Data gathered in field sites or laboratories often ends up in models. I sampled from the biodiversity science-base dataset all records mentioning 'model' or 'predict' in their title or abstract.[5] 33,000 publications or around 30% of the biodiversity science-base refer to models or

predictions. This subset presents a significant test case for the concept of distributed experience in several respects. Modelling and predicting relies heavily on derived or secondary objects such as probability distributions, ecological theory and extensive datasets derived from sensors and databases. Researchers communicate models using a mixture of numbers (counts, probabilities), figures such as diagrams, maps and charts. Models point to results derived from calculation more than observation or narrative.

A topic model for 50 topics (k=50) roughly corresponds to the number of sub-headings on the Wikipedia 'biodiversity' entry Wikipedia (2020) as it stands in 2020, but the topic distribution across the documents in the Web of Science dataset presents a rather different set of processes. In the plot of topics (Figure 4a), the length of the
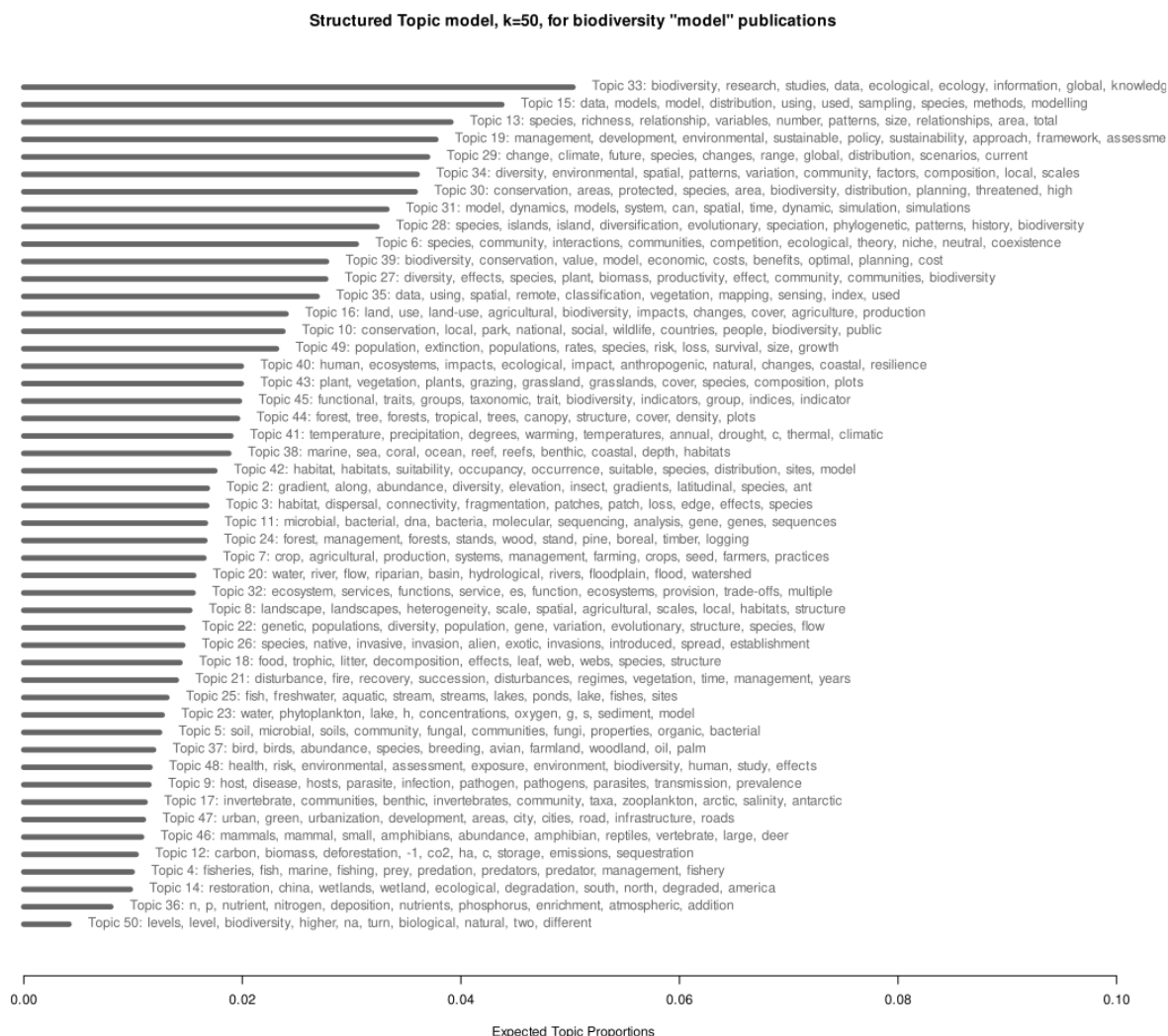

Structured Topic model, k=50, for biodiversity "model" publications

Topic 33: biodiversity, research, studies, data, ecological, ecology, information, global, knowledg
Topic 15: data, models, model, distribution, using, used, sampling, species, methods, modelling
Topic 13: species, richness, relationship, variables, number, patterns, size, relationships, area, total
Topic 19: management, development, environmental, sustainable, policy, sustainability, approach, framework, assessme
Topic 29: change, climate, future, species, changes, range, global, distribution, scenarios, current
Topic 34: diversity, environmental, spatial, patterns, variation, community, factors, composition, local, scales
Topic 30: conservation, areas, protected, species, area, biodiversity, distribution, planning, threatened, high
Topic 31: model, dynamics, models, system, can, spatial, time, dynamic, simulation, simulations
Topic 28: species, islands, island, diversification, evolutionary, speciation, phylogenetic, patterns, history, biodiversity
Topic 6: species, community, interactions, communities, competition, ecological, theory, niche, neutral, coexistence
Topic 39: biodiversity, conservation, value, model, economic, costs, benefits, optimal, planning, cost
Topic 27: diversity, effects, species, plant, biomass, productivity, effect, community, communities, biodiversity
Topic 35: data, using, spatial, remote, classification, vegetation, mapping, sensing, index, used
Topic 16: land, use, land-use, agricultural, biodiversity, impacts, changes, cover, agriculture, production
Topic 10: conservation, local, park, national, social, wildlife, countries, people, biodiversity, public
Topic 49: population, extinction, populations, rates, species, risk, loss, survival, size, growth
Topic 40: human, ecosystems, impacts, ecological, impact, anthropogenic, natural, changes, coastal, resilience
Topic 43: plant, vegetation, plants, grazing, grassland, grasslands, cover, species, composition, plots
Topic 45: functional, traits, groups, taxonomic, trait, biodiversity, indicators, group, indices, indicator
Topic 44: forest, tree, forests, tropical, trees, canopy, structure, cover, density, plots
Topic 41: temperature, precipitation, degrees, warming, temperatures, annual, drought, c, thermal, climatic
Topic 38: marine, sea, coral, ocean, reef, reefs, benthic, coastal, depth, habitats
Topic 42: habitat, habitats, suitability, occupancy, occurrence, suitable, species, distribution, sites, model
Topic 2: gradient, along, abundance, diversity, elevation, insect, gradients, latitudinal, species, ant
Topic 3: habitat, dispersal, connectivity, fragmentation, patches, patch, loss, edge, effects, species
Topic 11: microbial, bacterial, dna, bacteria, molecular, sequencing, analysis, gene, genes, sequences
Topic 24: forest, management, forests, stands, wood, stand, pine, boreal, timber, logging
Topic 7: crop, agricultural, production, systems, management, farming, crops, seed, farmers, practices
Topic 20: water, river, flow, riparian, basin, hydrological, rivers, floodplain, flood, watershed
Topic 32: ecosystem, services, functions, service, es, function, ecosystems, provision, trade-offs, multiple
Topic 8: landscape, landscapes, heterogeneity, scale, spatial, agricultural, scales, local, habitats, structure
Topic 22: genetic, populations, diversity, population, gene, variation, evolutionary, structure, species, flow
Topic 26: species, native, invasive, invasion, alien, exotic, invasions, introduced, spread, establishment
Topic 18: food, trophic, litter, decomposition, effects, leaf, web, webs, species, structure
Topic 21: disturbance, fire, recovery, succession, disturbances, regimes, vegetation, time, management, years
Topic 25: fish, freshwater, aquatic, stream, streams, lakes, ponds, lake, fishes, sites
Topic 23: water, phytoplankton, lake, h, concentrations, oxygen, g, s, sediment, model
Topic 5: soil, microbial, soils, community, fungal, communities, fungi, properties, organic, bacterial
Topic 37: bird, birds, abundance, species, breeding, avian, farmland, woodland, oil, palm
Topic 48: health, risk, environmental, assessment, exposure, environment, biodiversity, human, study, effects
Topic 9: host, disease, hosts, parasite, infection, pathogen, pathogens, parasites, transmission, prevalence
Topic 17: invertebrate, communities, benthic, invertebrates, community, taxa, zooplankton, arctic, salinity, antarctic
Topic 47: urban, green, urbanization, development, areas, city, cities, road, infrastructure, roads
Topic 46: mammals, mammal, small, amphibians, abundance, amphibian, reptiles, vertebrate, large, deer
Topic 12: carbon, biomass, deforestation, -1, co2, ha, c, storage, emissions, sequestration
Topic 4: fisheries, fish, marine, fishing, prey, predation, predators, predator, management, fishery
Topic 14: restoration, china, wetlands, wetland, ecological, degradation, south, north, degraded, america
Topic 36: n, p, nutrient, nitrogen, deposition, nutrients, phosphorus, enrichment, atmospheric, addition
Topic 50: levels, level, biodiversity, higher, na, turn, biological, natural, two, different

0.00   0.02   0.04   0.06   0.08   0.10

Expected Topic Proportions

Figure 4a. 50 topics in biodiversity science modelling subset

Figure 4b. Association between topics

horizontal lines indicates the proportion of the overall document topics covered by that topic. In fact, the most prevalent topic in the biodiversity science-base is precisely 'biodiversity knowledge' or ecological approaches to biodiversity, and the second covers use of models to predict species distribution. The first dozen topics all remain quite general or overarching, ranging across questions of climate change, conservation, protected area management and trophic interaction. Actions such as planning, protection, monitoring, preserving, or restoring meet ecosystem services, landscape management, invasions, and, the overarching climate-change/mass extinction topics. These high profile topics, typical of the biopolitical, marketising and panoptic facets of biodiversity science, are fringed by many specific places and concerns. Large parts of the fringes are taxonspecific: trees, microbes, beetles, bacteria, birds, fish, fungi. Some are habitats: coasts, islands, reefs, fields, forests, rivers, soils and streams. There are many habitat, niche and biome-related processes including fragmentation, disturbance, invasion, burning, wind, floods, infection and precipitation.

This profusion of processes, scales, places and problems is not exhaustive, and it could be perhaps aggregated or disaggregated into greater and smaller units in the social spaces and times of scientific research. In contrast to the topics of the Wikipedia article or a typical textbook in ecology or conservation biology such as (Mittelbach, 2012), this distribution of places, processes and problems also presents many occurrence of experience. Topics 10, 29, 41, and 47, for instance, do not show the term 'experience(s)' in the plot, but contain it deeper in the set of words composing that topic.

The network Figure 4b, like the keyword networks, shows associations between topics. (Topic proportions appear in size of node labels, and co-occurrence of topics in thickness of edges.) The mixing between topics varies in density. Some highly prevalent topics are not highly connected. The 'climate change' topic can be found in many publications, but does not mix with many other facets of biodiversity. It is as if climate change is a salient concern but not deeply integrated into knowledges of biodiversity. Taxon or habitat specific topics often lie around the edges. 'Insects and spiders', 'bacteria,' 'fire disturbance' or 'freshwater fish' connect directly to central topics such as 'species richness' or 'phylogenetic diversification'. More centrally, topics such as 'landscape,' 'biomass,' 'community dynamics,' 'species models' or 'ecosystem managing' have a much richer connectivity to both the edges of the network and to other central nodes of the network.

If the association of topics forms an assemblage, then the relation between the topics, their co-occurrences, perhaps gives us some sense of how experiences are connected, of how regularities and recurrences move along constantly evolving corridors between encounters with living things, places, histories and futures. Almost by definition, any single document appears in a topic model as a contingent mixture of topics. The topic models and network plots of topic correlation map research experiences of biodiversity.

The situation presented in the topic models, with its generative mixtures of places, lifeforms, observations, actions, institutions and apparatuses, figures something more general, the unanalyzed totality of experience in the biodiversity science-base. It suggests that biodiversity experience might be understood as a set of latent processes, varying in number, giving rise to occurrences gathered in various combinations as observations, documents, records and publications. The actual combinations derive from the distributions, but the elements of a topic mix regularities, signpost patches of dispersed variations and record specific encounters with an unanalyzable totality. This approach to biodiversity, to its conceptual connectivity as well as its fragmented measures and values, tracks gradients of different intensity running through a hypervolume of places, histories, apparatuses, institutions, concepts and actions.

Does the relational weave of topics, along with the places, species, problems and processes referred to there, help us understand something of the processes of identification or engagement entailed in experience? The gradients of regionality, intervention, distribution or change woven through biodiversity research are themselves components of biodiversity experience. They crisscross lifeworld and societal systems of production, governance and regulation. The occurrences of research experience traced in the science-base are highly mixed, and this helps us see biodiversity science as both subject and object, matter and idea.

Conclusion

Biodiversity science begins with some experience of things – a specimen in a museum drawer, a stand of trees, a pond, a reef, a tank of phytoplankton or a city park. On many occasions it aims to wend its way back to things: a restored woodland, a newly named species, a protected area, a re-introduced population, removal of weeds or feral predators, a series of patches connected by corridors in a landscape, or perhaps in human digestive tract or a cheese rind.

It is rare to find any direct consideration of what it would mean to experience biodiversity rather than nature, wilderness or 'the environment.' Despite the frequent news of threats to and loss of biodiversity, despite the accumulation of biodiversity knowledges and biodiversity media, ranging from documentary to online image media, experiences of biodiversity remains somewhat amorphous and elusive.

How is it possible to attend to the 'voices of experience' in biodiversity science? Scientists themselves constitute nodal points in the distributed networks of biodiversity experience. Like farmers, tourists, residents, landowners or citizens, their 'mode and degree of organized unity' not only, as Dewey points out, affects the environment, but acts on themselves. The presence, largely latent, of experience in the science-base is not primarily observed as knowledge, or knowledge claims. Knowledge, according to Dewey, can be understood as a network of paths that select and connect recurrent or regular features in experience in order to project plans, strategies, interventions, initiatives, policies, priorities and programs of action. But this selection, as well as the predictions and actions it mobilises, derives from and is secondary to a more primary flow of experience, the latent fluxes of felt, intimately coordinated yet often vague or obscure qualities, the empirically ephemeral occurrences, replete with diverse but intensely immediate dependencies.

For whom would recognition of distributed biodiversity experience matter? Biodiversity is an unusual construction, difficult to concretise yet intricately woven into governance, knowledges and indeed economies (Dempsey, 2016). Unlike some scientific constructs, it lends itself to felt

immediacies, situations and processes of change. Less prominently than the figures of Gaia (Lenton and Latour, 2018), planet (Chakrabarty, 2019), or Anthropocene Earth System (Steffen et al., 2011), the mixture of places, methods, practices of observation, measurement and intervention in the biodiversity science-base point to a complex patchwork of experience. Like Gaia, planet or Earth, biodiversity assembles lands, cities, water, soil, air, people, States, markets, and life-forms scaling across places and times.

Biodiversity, however, presents no single point of attachment. Gradients of biodiversity experience have a wider distribution than what is typically associated with people, with their views, attitudes, or considerable knowledges. Biodiversity overflows species and their distributions. Stakeholders, participants, citizens, indigenous, aboriginal and tribal peoples and traditions are often explicitly mentioned, but the unanalyzed experiential totality in the biodiversity science-base also includes what is reported to have undergone, suffered, tolerated, or enjoyed something. This is suggested by the figurative modelling of latent distribution of topics and their associations in the biodiversity science-base.

For anyone affected by it, the biodiversity science-base is an assemblage whose composition records many knowledges, actions, forms of awareness, and engagements, biodiversity might be understood as the conceptant (Mackenzie, 2019) that gives it consistency. Awareness, affects, attachments and beliefs or convictions animate the science-base. Although biodiversity science endemically occasions experience, such occurrences are typically unacknowledged ('we give so little heed to it'). Scientists and others encounter urban landscapes, land-use changes, protected areas, policy-making processes, public engagement, leaf litter in an old-growth forest, 'invasive weeds', ornithological records, maize fields, coral reefs, parks, LandSat imagery or iNaturalist observations, but along paths that follow regularities and recurrences amenable to sensing, observation, selection and collection.

I am calling for, and have sought to enact, an identification with the distributed nature of biodiversity in the science-base. "Only by identification with remaking the objects that now obtain", writes Dewey, "are we saved from complacent objectivism" (Dewey, 1958: 246). The work of understanding how distributed experiences occur in the science-base aims to reconstruct or remake biodiversity as an assemblage, preserving knowledges and their ongoing derivation, but also pointing to different potentialities in it.

Should biodiversity science be reconstructed in the light of distributed experience? In their recent call for collaborative biodiversity knowledge, Timothy Lenton and Bruno Latour (2018) emphasise how scientific knowledge infrastructures need to both multiply the sensors and open pathways to participation:

> This is where the scientific establishment will play a crucial role in multiplying the sensors, improving their qualities, speeding the dissemination of their results, improving models, and proposing alternative explanations to phenomena. Such an infrastructure cannot, however, be limited to scientists. (Lenton and Latour, 2018: 1068)

I suggest that recognising distributed experience in the biodiversity science-base adds a collective sensing to the sensing infrastructures. Amongst the many elements of the biodiversity science-base, some re-distribute infrastructure for multiplying, accelerating and monitoring experiences, and for restoring phenomena to experience. The mixture of topics and their associations suggests that in some ways this is already happening. The question is whether their co-occurrence there actually can be assembled as an experienced situation.

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References

Adams WM and Hutton J (2007) People, parks and poverty: political ecology and biodiversity conservation. *Conservation and society* 5(2): 147–183.

Benoit K (2018) Quantitative Analysis of Textual Data for Social Sciences. *Impact* 2018(4): 22–24.

Blei DM and Lafferty JD (2007) A correlated topic model of science. *The Annals of Applied Statistics* 1(1): 17–35.

Bonebrake TC, Brown CJ, Bell JD, et al. (2018) Managing consequences of climate-driven species redistribution requires integration of ecology, conservation and social science. *Biological Reviews* 93(1): 284–305. DOI: 10.1111/brv.12344.

Bowker GC (2000a) Biodiversity Datadiversity. *Social Studies of Science* 30(5): 643–683. DOI: 10.1177/030631200030005001.

Castro P and Mouro C (2016) "Imagining ourselves' as participating publics: An example from biodiversity conservation. *Public Understanding of Scienec* 25(7): 858–872. DOI: 10.1177/0963662515581303.

CBD Secretariat (2011) What is Biodiversity? Available at: https://www.cbd.int/2011-2020/about/biodiversity (accessed 9.11.2021).

CBD Secretariat (2020) Global Biodiversity Outlook 5 | Convention on Biological Diversity. Available at: https://www.cbd.int/gbo5 (accessed 9.11.2021).

Chakrabarty D (2019) The Planet: An Emergent Humanist Category. *Critical Inquiry* 46(1): 1–31.

Dempsey J (2016) *Enterprising Nature: Economics, Markets, and Finance in Global Biodiversity Politics*. Hoboken, NJ: John Wiley & Sons.

Devictor V and Bensaude-Vincent B (2016) From ecological records to big data: the invention of global biodiversity. *History and Philosophy of the Life Sciences* 38(4): 13. DOI: 10.1007/s40656-016-0113-2.

Dewey J (1957) *Reconstruction in Philosophy*. Boston, MA: Beacon Press.

Dewey J (1958) *Experience and Nature*. New York: Dover Publications.

Faith DP (2019) Biodiversity. In: Zalta EN (ed.) *The Stanford Encyclopedia of Philosophy*. Fall 2019. Metaphysics Research Lab, Stanford University. Available at: https://plato.stanford.edu/archives/fall2019/entries/biodiversity/(accessed 15.12.2021).

Gordon TAC, Radford AN and Simpson SD (2019) Grieving environmental scientists need support. *Science* 366(6462): 193–193. DOI: 10.1126/science.aaz2422.

Greenfield P (2020) World fails to meet a single target to stop destruction of nature – UN report. *The Guardian*, 15 September. Available at: https://www.theguardian.com/environment/2020/sep/15/every-global-target-to-stem-destruction-of-nature-by-2020-missed-un-report-aoe (accessed 9.11.2021).

IPBES (2019) *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn, Germany: IPBES Secretariat. Available at: www.ipbes.net (accessed 9.11.2021).

James W (1976) *Essays in Radical Empiricism*. Cambridge, MA: Harvard University Press.

Jockers ML (2013) *Macroanalysis: Digital Methods and Literary History*. Champaign, IL: University of Illinois Press.

Kelty C and Landecker H (2009) Ten thousand journal articles later: ethnography of» The literature» in science. *Empiria: Revista de metodología de ciencias sociales* (18): 173–192. Available at: http://dialnet.unirioja.es/servlet/articulo?codigo=3130617 (accessed 9.11.2021).

Langton M (2003) The 'wild', the market and the native: Indigenous people face new forms of global colonization. In: Adams W and Mulligan M (eds) *Decolonizing Nature: Strategies for Conservation in a Post-Colonial Era*. London & New York: Routledge, pp. 79–107.

Latour B, Jensen P, Venturini T, Grauwin S and Boullier D (2012) The Whole is Always Smaller than its Parts. How Digital Navigation May Modify Social Theory. *British Journal of Sociology* 63(4): 590–615.

Lenton TM and Latour B (2018) Gaia 2.0. *Science* 361(6407): 1066–1068.

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

MacArthur RH (1965) Patterns of species diversity. *Biological reviews* 40(4): 510–533.

Mackenzie A (2020) How to make ANT concepts more real? In: Blok A, Farias I, and Roberts C (eds) *The Routledge Companion to Actor-Network Theory*. London & New York: Routledge, pp. 14–23. DOI: 10.4324/9781315111667.

Marres N (2017) *Digital Sociology: The Reinvention of Social Research*. 1 edition. Malden, MA: Polity.

McAfee K (1999) Selling nature to save it? Biodiversity and green developmentalism. *Environment and Planning D-Society & Space* 17(2): 133–154. DOI: 10.1068/d170133.

Miller JR (2005) Biodiversity conservation and the extinction of experience. *Trends in Ecology & Evolution* 20(8): 430–434. DOI: 10.1016/j.tree.2005.05.013.

Mittelbach GG (2012) *Community Ecology*. 1st Edition. Sunderland, Mass: Sinauer Associates is an imprint of Oxford University Press.

Mohr JW and Bogdanov P (2013) Introduction—Topic models: What they are and why they matter. *Poetics* 41(6): 545–569. DOI: 10.1016/j.poetic.2013.10.001.

Mohr JW, Wagner-Pacifici R and Breiger RL (2015) Toward a computational hermeneutics: *Big Data & Society*. DOI: 10.1177/2053951715613809.

Moretti F (2013) *Distant Reading*. London: Verso.

Ovaskainen O and Abrego N (2020) *Joint Species Distribution Modelling: With Applications in R*. Ecology, Biodiversity and Conservation. Cambridge: Cambridge University Press. Available at: https://www.cambridge.org/core/books/joint-species-distribution-modelling/0D9FA93EA1DD408332A17266449668B3 (accessed 9.11.2021).

Prévot A-C, Cheval H, Raymond R and Cosquer A (2018) Routine experiences of nature in cities can increase personal commitment toward biodiversity conservation. *Biological Conservation* 226: 1–8. DOI: 10.1016/j.biocon.2018.07.008.

Roberts ME, Stewart BM and Airoldi EM (2016) A Model of Text for Experimentation in the Social Sciences. *Journal of the American Statistical Association* 111(515): 988–1003. DOI: 10.1080/01621459.2016.1141684.

Selivanov D (2020) *Text2vec: Modern Text Mining Framework for R*. Available at: https://CRAN.R-project.org/package=text2vec (accessed 9.11.2021).

Sodhi NS and Ehrlich PR (eds) (2010) *Conservation Biology for All*. Oxford: Oxford University Press. Available at: https://conbio.org/publications/free-textbook/ (accessed 9.11.2021).

Steffen W, Grinevald J, Crutzen P and McNeill J (2011) The Anthropocene: conceptual and historical perspectives. *Philosophical transactions. Series A, Mathematical, physical, and engineering sciences* 369(1938): 842–867. DOI: 10.1098/rsta.2010.0327.

Stenseke M and Larigauderie A (2018) The role, importance and challenges of social sciences and humanities in the work of the intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES). *Innovation-The European Journal of Social Science Research* 31(1): S10–S14. DOI: 10.1080/13511610.2017.1398076.

Subramaniam B (2014) *Ghost Stories for Darwin: The Science of Variation and the Politics of Diversity*. Urbana, IL: University of Illinois Press.

Tsing AL (2015) *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton: Princeton University Press.

Turnhout E, Bloomfield B, Hulme M, Vogel J and Wynne B (2012) Listen to the voices of experience. *Nature* 488(7412): 454–455. DOI: 10.1038/488454a.

Turnhout E, Waterton C, Neves K and Buizer M (2013) Rethinking biodiversity: from goods and services to 'living with'. *Conservation Letters* 6(3): 154–161.

Whittaker RH (1972) Evolution and Measurement of Species Diversity. *Taxon* 21(2/3): 213–251. DOI: 10.2307/1218190.

Wikipedia (2020) Biodiversity. *Wikipedia*. Available at: https://en.wikipedia.org/w/index.php?title=Biodiversity&oldid=974767406 (accessed 9.11.2021).

Wilson EO (ed) (1988) *Biodiversity*. National Academy of Sciences. Washington, DC: The National Academies Press. DOI: 10.17226/989.

Wyborn C, Davila F, Pereira L, et al. (2020) Imagining transformative biodiversity futures. *Nature Sustainability* 3: 670-672 DOI: 10.1038/s41893-020-0587-5.

Wyborn C, Montana J, Kalas N, et al. (2020) *Research and Action Agenda for Sustaining Diverse and Just Futures for Life on Earth. Biodiversity Revisited.* DOI: 10.13140/RG.2.2.12086.52804/2

Notes

1   Code and data supporting our analysis can be found at [https://github.com/rian39/aibiodiversity/tree/scilit/analysis]. The full dataset of Web of Science records derives from a single word query 'biodiversity'. The data was exported from the "Web of Science Core Collection" database. A search for "biodiversity" in the field "topic" on the 24th May 2020 returned 133664 records ranging in publication year from 1987 to 2020. This search was then split into a search from 1987-2013 and a search from 2014-2020 because Web of Science prevents the export of records beyond the 100000th record returned by a single search. The dataset containing all 133664 records is accessible here: Biodiversity dataset Each record contains 67 fields. Key fields used in this project are TI - Document Title, DE - Author Keywords, AB - Abstract, PY - Year Published, SO - journal title, CR - cited references, TC - times cited, AU - author name. A full list of fields can be found at: Web of Science Core Collection. I rely on the quanteda (Benoit,2018) text analysis, Structured Topic Model stm (Roberts et al., 2016) and text2vec (Selivanov et al., 2020) R packages in the analysis, combining close reading with quantitative text analysis approaches.

2   Here Dewey echoes what William James in *Essays on Radical Empiricism* had called 'pure experience' or the 'instant field of the present' James (1976: 23). James analyzed the conditions under which things and thinking can separate out into processes that can followed "along entirely different lines" (James, 1976: 12) towards, to name two salient endpoints, thinking or things. Like Dewey and indeed various contemporary thinkers, James saw this separation as a limited variety of experience, useful in some situations, obstructive in others.

3   Author-supplied keywords are more often missing in the early years of biodiversity science, but occur consistently from the mid-1990s. The plots of keywords use a yearly-weighted publication count to normalise the counting of occurrences, unless otherwise mentioned. This is to take account of the generally increasing volume of scientific publication in the last few decades. It also allows relative proportions of different concerns to become more visible.

4   The span of these keywords hint that biodiversity threads back through major ecological theories, studies and models of diversity, particularly, species diversity (Whittaker, 1972; MacArthur, 1965) dating from the mid-20th century. Textbooks of ecology and conservation biology have more technical framings, sometimes focused on measurement or modelling within specific conceptual framings. The *Stanford Encyclopedia of Philosophy* article on biodiversity, written by a museum-employed taxonomist defines biodiversity economically: 'estimating and quantifying the largely unknown variation that makes up biodiversity is one and the same as quantifying corresponding option values of biodiversity' (Faith, 2019). Regulatory instruments such as the *Convention on Biological Diversity* (CBD Secretariat, 2011). In all these settings, the underlying question of diversity or why lives vary or differ so much on earth, of why microbes leave in hot undersea vents or trees grow to different heights persist, along with the questions of significance or meaning of these differences.

5   I also sampled records in order to manage to fit topic models with computational resources readily available to us. Computers with more memory and CPUs would alleviate this problem. Records were cleaned using standard quantitative textual analysis techniques of removing very common terms ('the', 'of', 'it'), numbers and other symbols (Benoit, 2018).