Biodiversity Data as Environmental Media: Databases, Interfaces and Visualisations

Abstract
Through a combination of scientific and community activity our living environment is increasingly registered and documented as data. Given the expanding breadth of this digital domain, it is crucial that scholars consider the problems it presents as well as its affirmative potential. This article critically examines biodiversity data through a close reading of public-facing databases, citizen science platforms, and data visualisations. It integrates perspectives from screen and media studies, digital design and environmental studies, reflecting the authors' disciplinary backgrounds. Our aim is to evaluate whether and how biodiversity data on-screen has the capacity to convey the complexities of a more-than-human world in ways that can amplify understanding, connection and attention amongst interested publics. We develop a critical analysis of the emerging visual languages of digital biodiversity, in order to better understand how these forms operate as environmental media: designed representations of the living world.

Digital screen media has the capacity to convey the complexities of a more-than-human world in ways that can amplify understanding, connection and attention amongst interested publics. The difficulty of this project presents a crucial challenge for digital media practitioners, while its urgency, in a time of environmental crisis, provides ample motivation. In this context, this essay evaluates the rich arena of interactive web platforms deployed to gather, share and represent data about species and ecosystems, including databases, interfaces and data visualisations.

Through a combination of scientific and community activity our living environment is increasingly registered and documented as data. The past decade has seen the large-scale digitisation of natural history collections and literature (Biodiversity Heritage Library no date), the aggregation of diverse data at national scale (Atlas of Living Australia no date a), and the emergence of international platforms such as iNaturalist (Seltzer 2019), along with a wave of activity in digitally-enabled citizen science (Dickinson *et al.* 2012). These projects promise to advance scientific research, enhance public knowledge, and galvanise public engagement. They operate in a media ecosystem increasingly characterised by the real-time data flows of the smartphone app and the social media platform, where the screen-based mediations of web pages, interfaces and visualisations are ubiquitous components of a digital everyday.

In this paper we undertake a close reading of these forms, including online databases, citizen science platforms, and data visualisations, where the scale, diversity and complexity of the living world comes to us through chains of technological mediation and the genres and conventions of the screen. We develop a critical analysis of the emerging visual languages of digital biodiversity, in order to better understand how these forms operate as environmental media: designed representations of the living world. This close analysis is informed by our own practical experience, and seeks to inform practice in visualisation, web and interface design; it also leads us into the contexts and constituencies in which biodiversity data is published and produced, considering the ways in which data both forms and is formed by mediated representations.

Like all forms of documentation, these visual artefacts are, first and foremost, interpretations. In this point lies a problem for the graphical display of data — it is often posed as a transparent presentation of an *a priori* world. Johanna Drucker describes this as a 'realist' approach to information:

> So naturalized are the Google maps and bar charts generated from spread sheets that they pass as unquestioned representations of "what is". [...] Realist approaches depend above all upon an idea that phenomena are *observer-independent* and can be characterized as *data*. Data pass themselves off as mere descriptions of a priori conditions. Rendering *observation* (the act of creating a statistical, empirical, or subjective account or image) as if it were *the same as the phenomena observed* collapses the critical distance between the phenomenal world and its interpretation, undoing the basis of interpretation on which humanistic knowledge production is based. (Drucker 2011)

For Drucker, a core problem revolves around a lack of critical scrutiny—the limitations of data are suppressed in a 'rush to visualization' (ibid). Offering an evaluation more specifically focused on 'environmental visualisations,' Heather Houser describes the allure of, in particular, 'infovis' imagery (such as maps, line graphs, flowcharts and time series displays) which 'not only pleases through astonishment but also promises to hone attention and instantaneously generate knowledge' (Houser 2014: 320). Thus, Houser critiques the assumed transparency of the data as well as what is entailed in the move from complex datasets to simple visualisation. She questions, moreover, the efficacy of its reception, suggesting that the allure of well-crafted data representation may only produce a 'quick fix' (333) for environmental engagement. Both Drucker and Houser draw attention to the question of representational transparency, a question that ultimately impacts on how users navigate the graphical display of data and the knowledge it might engender.

Given that data and its representations are never immediate, we must come to grips with the mediated translation between data and the visual. This is what Lev Manovich (2002) terms 'data mapping': the selection and transformation of abstract, intangible data features into concrete visual forms. As Manovich argues this mapping is contingent, not given; a matter of design: 'designers and their clients have to choose which dimensions to use and which to omit, and how to map the selected dimensions.' (Manovich 2002: 3) These decisions are not simply issues of appearance: 'This is the new *politics of mapping* of computer culture. Who has the power to decide what kind of mapping to use, what dimensions are selected; what kind of interface is provided for the user – these new questions … are now as important as more traditional questions about the politics of media representation' (Ibid).

With these frames in mind, we take another look at the presentation of biodiversity data online, considering again how it might function as environmental media. For example, what would be required for data representation to embrace the limits of transparency and to postulate partial perspectives, or offer design modalities that eschew the 'quick fix' of user understanding? Which dimensions of biodiversity data are selected, how are they made visual, and how do these choices condition our view of a living environment? How might the aesthetics and techniques of visualisation draw us more richly into multispecies worlds? We undertake close readings of four examples to support a comparative analysis, revealing their differential contexts of use and production as well as specific visual strategies and their affordances.

This paper is the result of a collaboration between a practitioner and theorist in digital design, and a film and screen scholar with expertise in documentary studies and animal/environmental studies. Our dual perspectives draw out the interplay between the capture and visualisation of data and the address to the user *as a form of popular environmental media*. To achieve this, we focus on the affordances of particular design decisions. The analysis is divided into three sections which align with three key affordances--the relationality of data, the formation, source and scope of data, and observation and species specificity. The four examples we consider include The *Atlas of Living Australia* (ALA), Australia's umbrella national biodiversity database, is a collaborative project that pulls together and publishes a wealth of data from multiple sources (Atlas of Living Australia, no date a). By contrast *Canberra Nature Map* (CNM) is a community platform and database produced by members as they upload sightings of species from parkland areas around the greater Canberra region (Canberra Nature Map, no date a). The first data visualisation we examine, *Local Kin*, is an experimental visualisation created by one of the authors that draws on data produced by Canberra Nature Map, and aggregated by the ALA (Whitelaw 2016). The second, which we will refer to as *Insects*, is published by the City of Melbourne, based on a research collaboration investigating urban insect biodiversity (City of Melbourne 2018).

While these examples represent differing orientations and institutional and disciplinary contexts, all four focus their attention on specific bioregions, albeit at differing scales from the urban to the regional and continental. We consider localised examples in part as a counterpoint to critical work (such as Heise (2016) and Houser (2014)) that has focused on global scopes. Additionally, our aim in this respect is to grapple with Yanni Loukissas' assertion that 'all data are local' (2019), recognising 'data settings' as much as data sets. We do so by acknowledging the specific ways in which data is produced through localised practices and knowledge. As Antonello and Morgan argue, environmental knowledge is situated:

> Where bodies of knowledge are formed (and how) influences the very nature of that particular knowledge. [. . .] Wherever such bodies of knowledge develop, those are specifically local sites—positions in which humans experience and comprehend the more-than-human world, whether directly or in mediated ways. (Antonello & Morgan 2018: 62)

Our selection of examples is shaped, moreover, by our own situations, in the Australian cities of Melbourne and Canberra, and this analysis is informed by our membership of the civic and more-than-human constituencies that these examples present.

Enlivening Information: Narrative and Relationality

Landing on a website, whether a database or visualisation, the user's first task is to make sense of the relationships between data and within data points (single, unique pieces of information). These relationships structure the documentation of species and their interactions (including the categorical structures of taxonomic classification). The relationships between data also determine how the user might navigate the site, from organising information on a single page, to determining its overall architecture. Relationality, in this sense, is representational: the depiction of species is bound up with the organisation of information on a given platform. Thus, following Manovich's question (2002: 3) of which dimensions are selected, we might investigate which relations are shown: if the living environment is characterised by an unthinkable mass of ecological and phylogenetic connections, which are encoded in data and which are shown in visualisations? How are these

relations shown, and how does their rendering condition or modulate their role in orchestrating encounters with biodiversity data? We propose that the way relationships are posed within graphical display, moreover, has the potential to encourage narrative as a mode of interpretation, composing phenomena into stories. Narrative is a key avenue for heightening understanding of species ontology and interactions. In the interests of offering detail about the organisation of the analysis, we note that we have chosen two examples for each affordance, one data visualisation and one database. Particular examples are paired up because they offer vivid contrasts that draw out the problems and possibilities of these key affordances as we have identified them. The *Atlas of Living Australia* (ALA) and Local Kin are the two examples that elucidate our exploration of relationality. Not only do they present a compelling contrast, but *Local Kin* (a visualisation produced by one of the authors) is also a creative work that deploys and thus responds to the data aggregated on the ALA database.

A public biodiversity database, ALA aggregates and publishes millions of data points, from across the Australian continent, echoing Ursula Heise's characterisation of biodiversity databases as both epic and encyclopaedic (Heise 2016: 65). It is an expansive work of public environmental media which aims to 'create a more detailed picture of Australia's biodiversity for scientists, policy makers, environmental planners and land managers, industry and the general public' (Atlas of Living Australia no date a). The Atlas' core data points are occurrence records, which document an identified species, observed or collected in a specific place, at a specific time. The rendering of occurrences and their relations plays a significant role in mediating and conditioning our view of the data. Taxonomic features of the data are emphasised, and a hierarchical relationship, between occurrence and species, is key. Occurrence records, in the site architecture, *belong to* a given species (and in turn to its genus, family, and so on). This structure reifies the singularity of a species, rather than revealing how they are entangled with other species and environments. Occurrences in the Atlas also have spatial and temporal dimensions, and in presenting these it again offers specific affordances and represented relations. The Atlas enables the user to explore their local area, loading observations within a small radius into a map and list-based interface (Atlas of Living Australia no date b) (Figure 1). This interface promises to place the user in a localised ecosystem, with a navigable hierarchy of taxa which filter the central list of species as well as the map. This is a powerful display; among other things it quickly reveals the range and diversity of nearby lifeforms, and leads us into the unfamiliar nomenclature of arthropods and reptiles alongside the charismatic and familiar birds and mammals. However, this multispecies awareness is obstructed by contingencies of interface and information design. The interface is laden with text, and scientific names dominate. Occurrences are represented as dots on the map; the images linked to many records are not visible by default. The hierarchical pairing of species and occurrences dominates, and it does so at the expense of showing relationships between species.

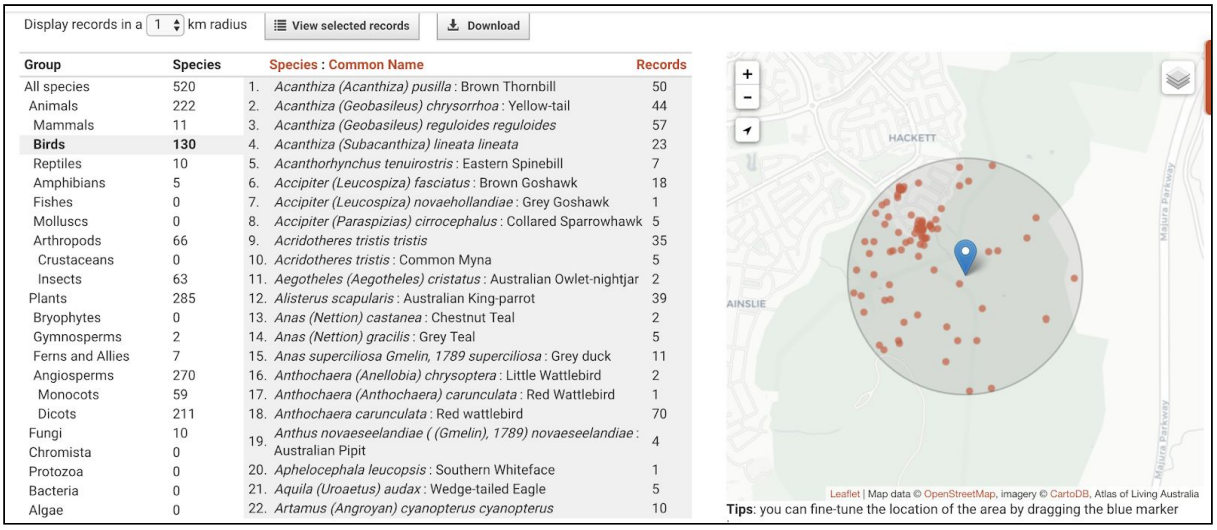

Figure 1: Atlas of Living Australia, *Explore Your Area interface (screen capture)*. Copyright Atlas of Living Australia, reproduced under a Creative Commons CC BY 3.0 AU license https://creativecommons.org/licenses/by/3.0/au/

Posing these aspects of interface and information design as problems of readability, or user orientation, opens out onto the storytelling capacity of data representation. They may not be concerns for specialist users of the site (scientists, policy makers and other researchers) but they do impact on how the site functions as a public resource or tool for encouraging more quotidian engagement. Story, or narrative, are useful concepts because they have relevance across scholarship concerning both databases and animal studies. Lev Manovich expands on the relationship between narrative and database, positing that digital media forms privilege and materialise the database, while dematerialising narrative, rendering it a set of multiple, virtual potentials; latent paths between the database entries (Manovich 2001: 231). Drawing on Manovich's formulation, however, Heise writes: 'the data assembled in a database can be mobilized for a variety of cultural forms and aesthetic, administrative, or scientific genres—narrative among them' (Heise 2016: 66). Making a case for employing narrative as a way to comprehend the phenomena of extinction, Thom Van Dooren suggests taking a 'lively' approach to telling stories about life and death (Van Dooren 2014: 8). For Van Dooren, extinction is not a single phenomenon, but rather 'a distinct unravelling of ways of life, a set of changes and challenges that require situated and case-specific attention' (7). Importantly, extinction is not the only significant lively narrative that might be read from databases such as the ALA. There is value in noticing the 'changes and challenges' (Van Dooren 2014: 8) across multispecies assemblages, whether they register species depletion, or adaptation as ecologies transform due to a range of factors. Governed by scientific interests and genres of representation, the ALA tells a story of atomised species, rather than the broader lively story of a data point. While it places the user in the environment, potentially showing how the human might be embedded in the more than human web of relations, these associations (perhaps even narrative associations) remain buried in the composition of the site.

By contrast the shifting mosaics of *Local Kin* show how the digital screen might reveal other relations, and render them differently, even with the very same data structures (Whitelaw 2016). *Local Kin* draws on a dataset of occurrences harvested from the Atlas of Living Australia, where they were contributed by citizen science platform Canberra Nature Map.

Local Kin is a mashup or remix, taking the ALA's occurrence data structure — species, location, time, and images — as material for creative reinterpretation.

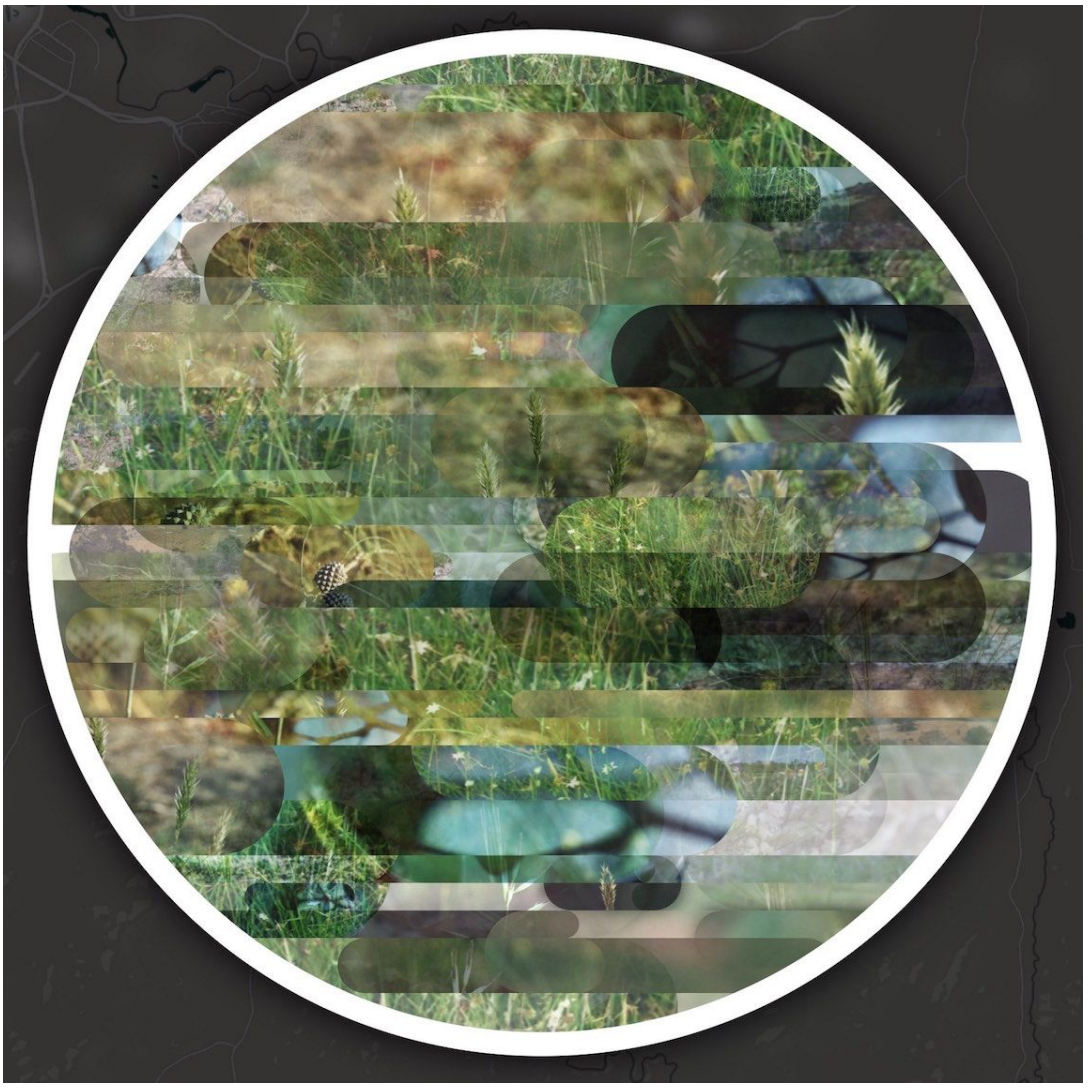

Figure 2. Mitchell Whitelaw, *Local Kin* (screen capture). Copyright the artist, used with permission.

Within a map view centred on the city of Canberra, *Local Kin* displays a visual mosaic, composed of hyper-local samples: occurrences from within one kilometer of the chosen site. Thus, like the ALA's map interface, spatial proximity is a determining relationship; however unlike the ALA, here taxonomic relationships (between species or family) are completely undetermined — *Local Kin* shows a random sample across all taxa in a given local patch of data. In showing these local samples, the interface uses fragmentation and recombination as speculative visual strategies that transform the underlying data. ALA occurrences represent the environment as a set of distinct and independent individual entities: in response *Local Kin* makes these entities indistinct, fragmenting and dissolving them to the point of interpenetration. The visualisation questions the status of the observation as singular and self-sufficient by actively combining observations with their neighbours, making a visual argument that what is distinct and separate in the data is more properly joined. In emphasising this view *Local Kin* draws on the ecological notion of community or (as Anna Tsing prefers) the more contingent 'assemblage'. Assemblage loosens the 'fixed and bounded

connotations' of ecological community, Tsing points out: 'The question of how the varied species in a species assemblage influence each other—if at all—is never settled: some thwart (or eat) each other; others work together to make life possible; still others just happen to find themselves in the same place' (Tsing 2015: 22). In combining random sampling with a hyper-local spatial scope, *Local Kin* seeks to render exactly the happenstance of coexistence that Tsing outlines here.

As noted the ALA data used here does not explicitly encode relationships or interactions between species. The random and fragmentary all-to-all assemblage shown here is thus synthetic or speculative: simple computational techniques are used here to synthesise or simulate features absent in the data. As outlined below the animated mobile data-points of *Insects* echo this approach, showing how computation can play a generative role in orchestrating and staging lively encounters. This approach is informed by what Drucker and Nowviskie (2004) term 'speculative computing', a perspective that recognises the generative role of computation and the power of aesthetic provocation to shape interpretation and mediate data. We might consider this a parafictional narrative, concerned with the aesthetics of relationality.

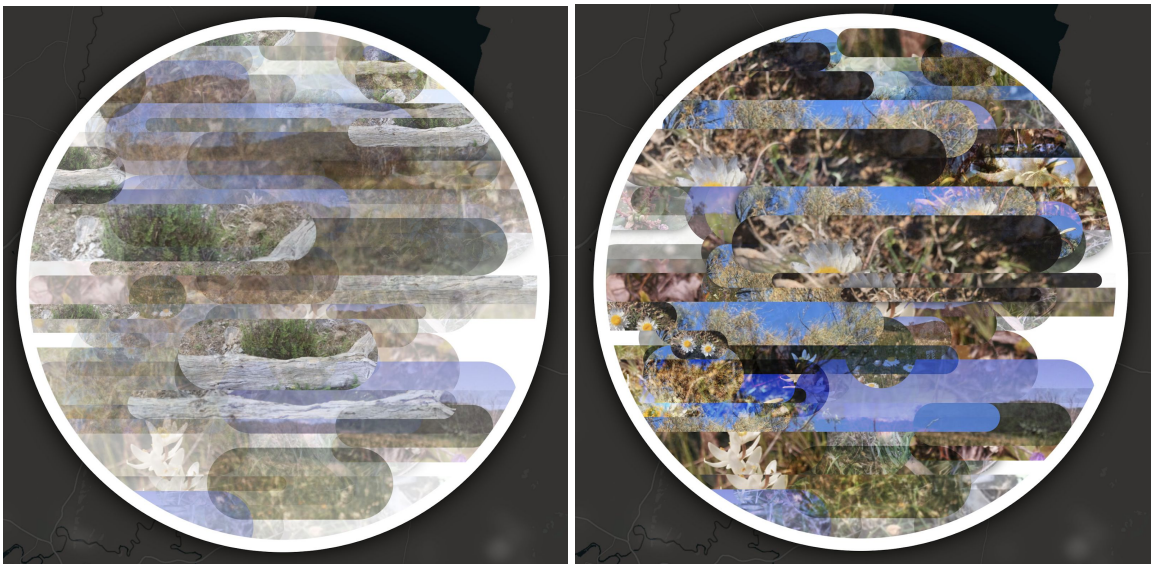

Figure 3. Mitchell Whitelaw, *Local Kin (detail showing seasonal variation. Left: winter; right: spring)*. Copyright the artist, used with permission.

As well as reconstituting visual assemblages, *Local Kin* strategically addresses temporal relations within biodiversity data. ALA occurrences include detailed time data, though this is not emphasised in the ALA's own interface. *Local Kin* selectively reintroduces temporal variation by way of a seasonal cycle. Visual fragments are animated based on the month of the observation; as a result the mosaic as a whole changes character, with pale and sparse winter months followed by a characteristic bloom of colour and activity in spring. As Tsing observes, assemblages harbor 'patterns of unintentional coordination' characterised by temporal rhythms and a polyphonic multiplicity (Tsing 2015: 24). Rendering temporal data reveals patterns of coordination within the data that are otherwise latent: a seasonal sequence of overall variation, and specific temporal affinities and contrasts between individual observations and species. As this approach shows, some of the temporal liveliness latent in biodiversity data can be rendered in digital form, in the web browser.

As these examples show, digital representations of biodiversity data select and visualise specific relations and structures within that data; and they do so differentially, in line with distinct interests and audiences. These sites and interfaces provide legible evidence of differing views of what might be shown of this data; and thus, of what is valuable or significant about it. Data repositories such as ALA emphasise the scientific value of data and its hierarchical taxonomy; but its interface leaves many stories tacit within its database logic. *Local Kin*, a mashup or revisualisation of ALA data, demonstrates the contingency of this emphasis, as it samples and scatters digital traces in search of the vibrant polyphony of Tsing's assemblage.

Valuing the Scope and Structure of Data

Another consideration that sits at the centre of the tension between the transparency of data practices and the productive mapping that Manovich refers to concerns how data points are devised, their scope and how their abundance or limitations are translated into, in this case, online design. Biodiversity data is a complex mass of *things* structured by ontological categories and attributes. These are formal structures and fields within specific data structures, and so are technically identifiable in both data and visualisations. Data points and organisms may be individuated or aggregated, grouped into communities, geographical areas or, the most common aggregation, a single ontological category – a species (taxa). These all necessarily constitute choices in the way data is selected and mapped. We are interested in how these processes might convey data in ways that enhance what Anna Tsing refers to as 'the arts of noticing' and 'passionate immersion in the lives of the nonhumans being studied' (Tsing 2011: 19). Tsing's investigation explores practices of encounter between humans and wild mushrooms. For Tsing, the arts of noticing the diversity of life involve the mediated abstractions of representation and classification, as well as direct immersion in more than human worlds. The two examples discussed in this section offer two interesting and contrasting options for structuring and sourcing data: the *Canberra Nature Map* (CNM), is a community platform (a form of co-created database), and *Insects* is a data visualisation.

Canberra Nature Map deploys data to maximise its potential as an evolving community artefact. Within this, its initial aim was to map rare plants for conservation purposes. As stated on the website, this purpose has mushroomed into mapping 'the location and abundance of most types of wildlife in the Canberra region, in a way that is useful to science and researchers as well as easy and enjoyable for members' (Bedingfield 2019). Users of Canberra Nature Map contribute data by reporting sightings of nonhuman species, uploading photographs and logging the time and place of the observation. These can be uploaded to the site through the custom designed mobile app, which also serves as a portable field guide to aid observation. The development of the site is interesting in that it does not simply visualise a pre-existing data set – it is in an ongoing and dynamic formation. This is evident in a particular aspect of the history of the CNM recounted on the site. While the project originated in order to map the rare Canberra Spider Orchid (*Caladenia actensis*), the scope grew to include all rare plants and then as more amateur naturalists became involved (who often did not know the difference between common plants and rare ones), the focus was broadened to all plants and eventually fauna as well. As the founder, Michael Bedingfield, also an amateur naturalist, writes it was decided that the unanticipated move from rare to all plants was ultimately useful because it was 'very valuable to know about the complex flora communities

that rare plants were part of' (Bedingfield 2019). The type of data considered relevant and therefore aggregated on the site, is not a fixed, top-down concern, but an unpredictable part of the process of non-expert community building and data gathering.

CNM shows how the scope and formation of biodiversity data can develop around a constituency already engaged with the arts of noticing more-than-human life. The site also shows how aggregation — the grouping and clustering that makes the unruly mass of biodiversity data tractable — reflects the scope and formation of data, and functions to both support and condition mediated encounters. Take for example the categorical structure CNM introduces, evident both in the visual interface (Figure 4) and the site organisation. While based on hierarchical scientific classification, it adapts this structure using common names and small illustrations; these representational choices reflect the site's amateur naturalist community, as well as using visual (and aesthetic) cues to convey the diversity and character of these lifeforms more vividly than the usual Linnaean taxonomy. CNM also aggregates data by geographical site, with a set of defined spatial locations (boundary polygons) that denote sites of particular significance, including national and local parks and reserves, urban parklands, even state forests and parks in neighbouring New South Wales, as well as private properties (Canberra Nature Map no date b). This list has expanded from an initial focus on Canberra Nature Reserves, reflecting the genesis of CNM, to sprawl across public and private sectors. These sites provide tractable groupings of observation data, but they also constitute lenses or views, showing how CNM's data coexists with different stakeholders and administrative domains.

Figure 4. Canberra Nature Map, interface detail. Copyright Canberra Nature Map, reproduced under a Creative Commons Attribution 3.0 Australia license.

The CNM database is conceived of in ways that offer useful evidence for scientific investigation. It is also, however, a compelling example of the interplay between expert and non-expert, digital affordances and direct encounters with more than human phenomena. Houser critiques modes of infovis that stand 'to make us ethical actors by proxy while keeping us at our laptops and smartphones, following trending hashtags and Instagram photos' (Houser 2014: 334). CNM differs from the visualisations critiqued by Houser, in that it is not simply interactive, it is co-created by users who also play a role in determining its scope. In this respect it offers an example of an important counter point in discussions of the utility of data. CNM posits and demonstrates a hybrid form of engagement that integrates online and offline encounters — it urges us into the living environment, smartphone in hand.

In her discussion of biodiversity and databases Ursula Heise confronts the problem of how data points are conceived by questioning what is 'recordable' as data. She considers how databases might also function as archives, preserving information about ecology and taxonomy as well as cultural memory about the natural world. She argues that 'what is recordable' is 'a matter of principle, and [that] these structural inclusions and exclusions shape the available information and cultural memory' (Heise 2016: 67). While Heise focuses mainly on the problem of exclusions, CNM provides an example of a database produced

inclusively at the intersection of scientific inquiry and culturally held knowledge (or what can be remembered and not remembered, in Heise's words). The non-expert collection of data also makes visible the contingent status of the data. Not only is it confined to small bio-regions, but because sightings are serendipitous rather than the product of a systematic study they are more clearly only partial or indicative accounts of particular ecosystems. This signals an evidently subjective engagement rather than what Val Plumwood refers to as the 'new scientific fantasy of mastery' that offers the illusion of fully cataloguing or representationally aggregating an ecosystem, even if only by omitting information about the scope of data collection (Plumwood 2010: 118).

The next example we discuss differs from CNM in that it is a visualisation of a pre-existing data set. Contributing to the City of Melbourne's "Nature in the City" initiative, *Insects* and *Butterflies* are connected pages produced as part of an urban biodiversity project focused on insect/plant interactions (City of Melbourne 2018). Designed by OOM Creative, the site visualises research data through an engaging portrayal of insect biodiversity, cultivating attention to these tiny species in numerous parks in central Melbourne. Here we focus on *Insects*, an example that maps data through two visualisations: the first conveys the location of parks studied in Melbourne and the volume of insect taxa in vertical layers of park habitat. In the second, the emphasis is on the interaction between vegetal species and insects in different parks, according to insect type, function and habitat. *Insects* shows how the scope of biodiversity data constitutes both a limit and an affordance for engagement. *Insects* presents a limited number of parks, insects and plants. In doing so it omits the other species, such as birds, flying foxes, fungi and microbes, and of course humans, that are integral to the bios of these parks. It also omits the life that no doubt thrives beyond these park boundaries across the city at large. But in adopting this narrower scope, *Insects* directs our attention emphatically, and invites us to focus on the detailed data it re-presents.

For our purposes, the scope and treatment of each park is important. Clicking on the map reveals the capacity to zoom out to view the city within the state of Victoria, or to zoom in to almost street view. A photographic aerial view offers a Google Earth style aesthetic; richer and more textural than the crisp outlines and flat shapes of digital cartography most familiar to us now. The function of the map becomes clear to the user as small sections of the city are outlined and overlaid with a coloured filter—these sections are city parks of varying sizes. A matrix visualisation below the map responds each time a different park is chosen (Figure 5). This matrix offers a symbolic representation of insects, showing the fifteen parks featured in the map and a vertical axis showing the four structural layers of vegetation: lawn, grass, mid-story and trees. Each cell of the graph is stippled with dots showing the volume of insects in each park and habitat. This display shows how visualisation techniques condition and characterise data through its aggregation and ontologies. The grouping of vegetation into structural layers asserts a distinction that might otherwise go unnoticed; this aggregation (of plant species into spatial layers) calls attention to a specific feature of park habitat. This feature is particularly significant for, as the data makes clear, it is the mid-storey that plays a key role as insect habitat. Visual representations of parks, especially in popular culture, often deem this mid-storey invisible. The use of dots to denote quantity in this matrix is both unconventional and noteworthy. Aggregated quantities such as this are elsewhere conventionally shown in graphs as columns or bars. These shapes are blank and homogeneous, with only a single salient dimension (such as height) encoding quantity. By contrast this pointillist matrix shows us quantity as many tiny things, and the use of colour

here also conveys diversity; it reveals these aggregates as *hetergeneous aggregates of individuals*, rather than simply numerical values.

Figure 5. City of Melbourne, *Insects (map and matrix visualisations)*. Copyright City of Melbourne, reproduced with permission.

Moreover, these are not simply a homogenous notion of species or insects. Attending to each species group, offering photographic representation and naming the insect species at hand, *Insects* also seeks to differentiate taxa and attributes. This differentiation, and its interplay with the functionality of aggregation, is most striking in the visualisation design of the 'Who works on what?' interactive. This panel groups insects, represented as small coloured, jostling dots, into clusters (Figure 6). We can see insects by type (bees, beetles, ants, flies), by habitat layer, by ecological function (herbivore, parasitoid, detritivore) as well as by park site. As with the habitat matrix, these aggregations draw us into the ecological detail of their lifeworlds, while carefully maintaining a sense of lively differentiation. Animation is crucial here: this irregular jostling immediately creates an impression of autonomy and agency — though in truth this movement is programmed and algorithmic, a computational *simulation* of life. This movement is also striking in that unlike the rest of this dense visualisation, it does not represent data. This digital synthesis is in excess of the data; it is an aesthetic or design decision, a kind of scenography, but it is in no sense superficial. In choosing to render data in this way, the designer goes to great lengths to imbue the visualisation with life, and orchestrate an engaging digital encounter.

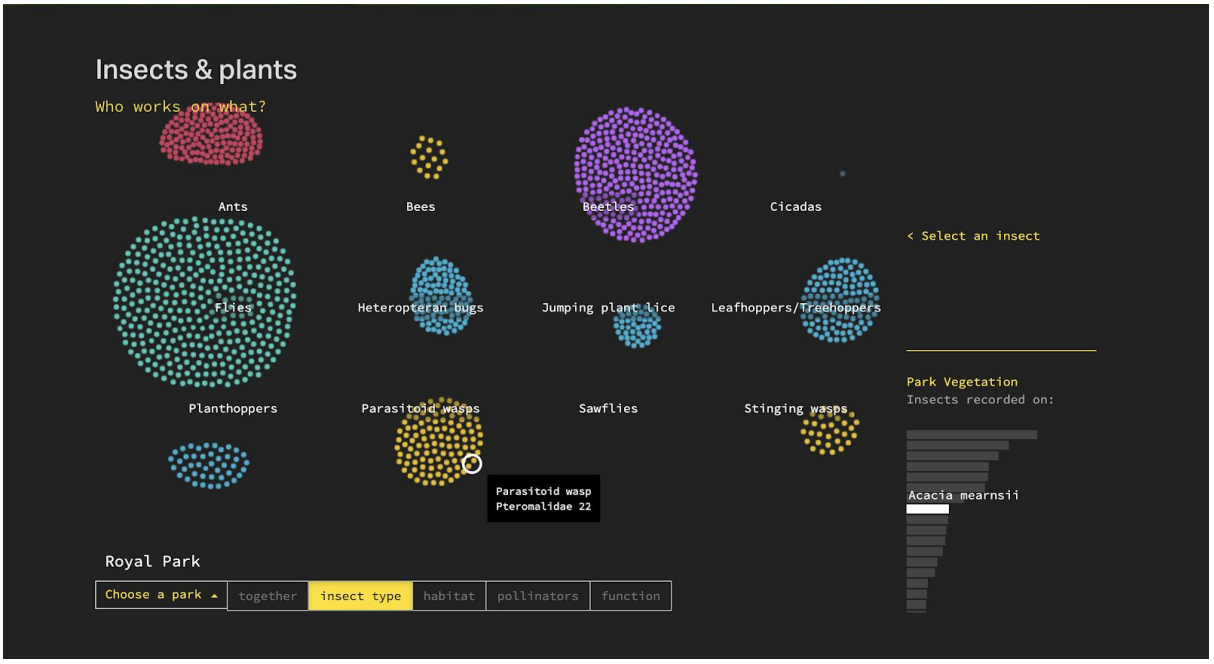

Figure 6. City of Melbourne, *Insects (Who works on what? visualisation)*. Copyright City of Melbourne, reproduced with permission.

The city-location presented by the map speaks to another crucial way this visualisation engages the user. It asks the Melbourne resident to acknowledge that the city grid is not only a familiar home for themselves, humans (or even humans and domestic pets), it is also a zone inhabited by more than human species. As Houston et al. eloquently state 'We are after all but one species among many inhabiting diverse urban worlds, and any presumed exclusive human "right to the city" and the biosphere is increasingly untenable' (Houston et al 2018: 191). The parks are delineated by hard edges. It would be intriguing to consider a design that depicted these boundaries as more porous, indicating the difficulty of delineating which spaces wildlife should and do live in. Such a question aligns with the fluidity of what Sarah Whatmore (2002) refers to as 'wild topologies'. Nevertheless, the clear placement of the fifteen parks in the Melbourne environment remains important—it alerts the user to how they might navigate the city (through the aerial view), while simultaneously using photography, text and graphical symbols to reveal the complex multispecies and inter-species systems that contribute to the urban community. This indicates the broader ethical stance of the page—research has shown that entomofauna are in rapid decline in many locations, which may lead to the extinction of 40% of the world's insect species over the next few decades. (Sánchez-Bayo & Wyckhuys: 2019). The ecological impact of this cannot be clearly known.

Placing the user, and the parks, in Melbourne brings a recognition of place to the art of noticing and extends the city's existential boundaries (and perhaps the user's home) to include species that seldom gain the attention of humans, and if they do they are deemed pests or threats. The design of the page organises information, both photographic images of insects (discussed further below) and parks and graphical display, in ways that require the user to reorient their relationship with insect life and the rendering of the cityscape as they navigate through the page vertically. In contrast, CNM privileges the observation of actual individual organisms. The serendipitous collection of these observations constitutes the scope and depth of data pertaining to specific bioregions. This data is also aligned with the location

of the users who gather data in the field; in this respect aggregation and value is a product of community.

Observation and Species Specificity

In this section we focus on *observation* in a dual sense—as a necessary part of gathering data in the field and as the visual engagement with the aesthetics of data online. Combining approaches from digital design and media studies we consider traces of biological specificity, how these relate to symbolic representational proxies such as pins on a map or points in a cloud *as well as* how photographic images are used, framed and sometimes circulated. In this sense, we look beyond generic quantitative forms of graphical representation to ask how biodiversity data might be conveyed in ways that are specific to multi-species formations. The notion of identification offers a more granular approach to understanding the modes of observation offered to the user, whether in the sense of the classification of species or in terms of measuring one's own relationship with the other. We return to *Insects* and *Canberra Nature Map* for a discussion of observation because they again offer rich contrasting examples, each including multiple aesthetic modes.

One of the most important ways *Insects* organises user engagement is through the deployment of scale. A key concept in ecology and human geography, scale is frequently understood as *relational*—it is not an absolute or discrete measurement of size or duration but rather it offers a way to understand the relations among phenomena (Sayre 2009: 105). The scale of observation determines the configurations and phenomena that appear. *Insects* uses cartography, photography and data visualisation to purposefully bring the user down to city scale, and then to park scale (sometimes only a few square metres) and then to the Lilliputian scale of insect life. Thus, we extend our consideration of relationality above to more fully account for the ontological relation between organisms, one of which is the user.

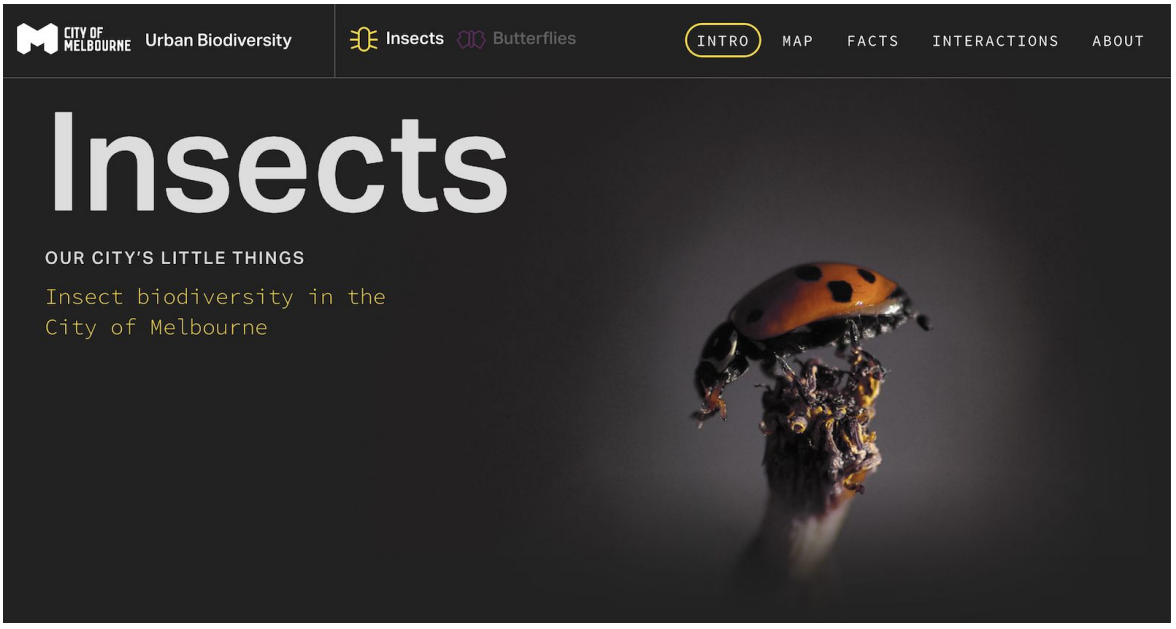

Figure 7. City of Melbourne, *Insects (detail)*. Copyright City of Melbourne, reproduced with permission.

Landing on the *Insects* page, the eye is drawn to Luis Mata's photographic image of a beetle perched on a twig alongside the title of the page. Magnified many times, the image presents a striking rendering of the texture and shape of the black and red insect (Figure 7). Scrolling down, the user sees visualisations of insect populations (many of these are registered symbolically as dots, as noted above) interspersed with more macro-photographic images. Here the user is offered an indexical image, one that deploys scale to promote beauty rather than the disgust sometimes associated with insects; this individual also functions as a placeholder, standing in for the many other insects presented within the dataset. The effect is to pose the insect (and insects in general) as, potentially, charismatic species. The contrast between the dots and macro-photography is an interesting study in the use of scale.

Identifying with insects poses a particular challenge for humans: the valuation of the human/nonhuman encounter privileges, as Hustak and Myers observe, 'organisms that humans can "hold in regard," that is, those animals with whom we can lock eyes' (Hustak & Myers 2012: 81). From the perspective of human perception, entomofauna do not have a recognisable faciality and, moreover, they are seemingly not individuated, reinforcing the difficulty of identification, and indeed, anthropomorphism. Describing the impact of this lack of individuation, Jaimie Lorimer writes, 'many people find it difficult to understand taxa where the individual is so radically subsumed by the many, where the subject is unimportant' (Lorimer 2007: 920). The bounded human subject, in this respect, is easily threatened by the sheer multiplicity of insect ontology. The perceived lack of individuation and their tiny scale means that encounters with insects are likely to be characterised by negative affect or indifference.

Insects' different aesthetic modalities offers a mix of scale and texture of representation. While the photography asks for close attention to light and surface, countering potential indifference, the dots evoke swarming insects. Indeed, *Insects'* 'creepy-crawly' aggregations of symbolic dots suggest a certain abject multiplicity; yet in their interactivity each dot reveals an appealing, macro-photographic composite portrait. Interaction here connects the scale of the data point (one among many) with the scale of the specimen or individual. While the mobile masses here might remind us of insect swarms, we quickly find that this (simulated) movement is entirely under our control, as selecting different groupings sends the dots flying into new ordered, labelled clusters. Through these devices *Insects* balances the functional demands of visualisation with a strategic articulation of symbolic data point and photographic image. It asks the user to look again at insects, their distinctive properties, and to recognise their status beyond anthropocentric assumptions about insect ontology.

Canberra Nature Map (CNM) offers a very different example, where indexical traces of specificity are pivotal within a community process of observation and identification. Unlike *Insects*, which uses a relatively small set of pre-existing data, CNM hosts a continually growing collection, where photographs play a large part. The identification of organisms sighted by users is a deliberative process, emphasising the role of both the photographic image, captured at the scene of the original sighting, and online discussion. In this instance, it is the specificity of a living organism and the human/nonhuman encounter, rather than the graphical symbolism of *Insects*, that is key. Layers of encounter are in play, including the sighting in the field and the social interchange between CNM members that is prompted by the very richness of the observation.

In one observation of a black-shouldered kite the contributor RodDeb writes ‘saw 3 of them today, every now and then they would all fly out over Kelly's Swamp and 2 of them would do a short tussle. May be another male coming into the pair's territory’ (Canberra Nature Map, 2019a). Multiple images show these raptors sparring, claws out and beaks gaping in a hazy blue sky. The sparse occurrence record seen in *ALA* (and remixed in *Local Kin*) is enriched here — not only a species with a location, but a drama along with a suggested narrative of invasion and defence. In confirming the species identification, moderator Illilanga also comments, ‘Nice photos.’ The personal encounter is authorised and validated by way of species identification, but at the same time a social interchange between CNM members takes place, prompted by both the specificity of the encounter and the aesthetic and indexical value of the photographic evidence.

An intense form of observation and attention is applied to the photographic image. The materiality of the individual organism is remediated online to become a locus of group deliberation in a way that would not have been possible without its registration as a data-point within the platform. This parallels Tsing’s discussion of the creative interventions that are encouraged by wild mushroom advocates: ‘the wild mushroom economy, in its open opportunity for eccentrics, also creates the possibilities of vernacular science, that is, knowledge production in which ordinary citizens can participate’ (Tsing 2011: 19). Yet, while contributors to CNM may propose a species identification with their sighting, identification is confirmed or contested by expert moderators, so in this case the role of the expert is embedded in the social exchange and the process of vernacular science. Here there is a tension between the productive indeterminate encounter described by Tsing (an openness to the uncertain or unknowable), and the definitive classification central to CNM (as well as ALA and *Insects*). Tsing also notes however that while ‘taxonomy is not very popular these days [. . .] through naming, we *notice* the diversity of life’ (Tsing 2011: 6). Similarly, while classification is important for CNM the deliberation that precedes it is perhaps more crucial. This is a process through which the encounter is made meaningful for users and attention is honed. While in most cases consensus is reached, it is the group deliberation over evidence and the encounter that brings the most intense observation. In a sighting of Brown Toadlets debate and discussion reveals both a close attentiveness and an underlying indeterminacy around identification (Canberra Nature Map 2019b). On the question of whether this observation is *Pseudophryne dendyi* or *Pseudophryne bibronii* one commenter observes, ‘I have always considered them colour variations of the same species.’ As Tsing proposes, classification here drives noticing — but this social attentiveness also extends to questioning the distinctions that classification enforces. Significantly, as a data platform CNM is characterised by a passionate and open-ended curiosity rather than a form of mastery that revolves around an anthropocentric use-value.

If observation, in the case of CNM, is concerned with deliberation and the richness of a single encounter aggregated across the site, *Insects* is able to explore specificity in deep ways and attend to the ontological qualities of insects, their scale, and their otherness in relation to humans. Sean Cubitt suggests that data can reveal what other forms of representation cannot, including phenomena that does not appear ‘in humanly perceptible scales or timeframes’ (Cubitt 2012: 280). Both of the examples discussed here demonstrate how the mediation of human observation as data, can enable modes of understanding and attention that would not be possible without mediation.

Conclusions: Building on Slight Acquaintance

Through close attention to the mediated forms of online biodiversity data, we have sought to balance the critical with the prospective in these case studies. Bearing in mind the justified critiques that warn against taking data as given, or its presentation as transparent, we read the politics of mapping of these visual forms in a way that also draws us into a consideration of the scope and formation of biodiversity data, and its social and institutional contexts. We show how formations and representations of biodiversity data online often reify normative regimes such as scientific classification and quantitative aggregation; but also how more imaginative mappings can render vibrant complexity, intensify attention and modulate scale in ways that can enrich our view of the living world.

We show how the relations within datasets are rendered differentially across contexts and audiences, and how specific choices in interface and visualisation design select, omit, celebrate or elide certain features even within the same data structure. The *Atlas of Living Australia* privileges a determinate hierarchy of species and occurrence, while *Local Kin* redeploys the same data structure to emphasise seasonal temporality, variation and the visual textures of the digital image. In doing so *Local Kin*, like the swarming dots of *Insects*, shows how computational techniques for generating screen media can exploit the scale and complexity of biodiversity data to create lively depictions and intensify aesthetic engagement. The scope and structure of biodiversity data is both reflected in and shaped by its mediated representations. *Canberra Nature Map* shows how the formation of data is bound up with place and constituency, as well as being enabled by the affordances of the web site and mobile app. Similarly, *Insects* shows how limitations in the scope of biodiversity data — specific species, in very specific sites — can be a powerful and productive constraint, calling the attention of Melburnians to fellow city-dwellers, and enabling us to zoom in, visually and informationally, on small but significant lives. *Insects* also shows how the digital screen enables a blending of representational strategies, from macro photography to cartography and data-graphics, which modulates scale and directs our attention. The observations that constitute biodiversity data are replayed here in a strategically mediated form, staging an encounter with curiously lively data-points. Conversely in *Canberra Nature Map*, we see how digital platforms can enrich and complicate the observational data-point itself, enabling a social setting for narrative context and reflection on the limits of classification.

Across these four examples we have attended to not only the organisation of data, but how and why these interfaces might invite meaningful user engagement. At the heart of this is the power of the potential encounter with tangible multispecies worlds. These encounters are mediated, often through a double remove from the living materiality presented—first through the capture of data, then through the mapping of data into visual form. As such they are easily dismissed as lower-order echoes of unmediated encounters. We suggest there is a more complex set of considerations in play. Firstly, the user encounter with the architecture of the site and the data it re-presents is also an encounter with the traces of other human/nonhuman encounters and these offer a valuable collective form attentiveness and care. We refer here not only to the way users might upload data (a very visible indication of encounter) but also the less visible personal labour and scientific expertise that goes into the collection of data deployed in a visualisation such as *Insects*. These examples also transmit and aggregate data in way that would not otherwise be possible—one can browse thousands of observations on databases such as ALA and CNM. As noted above, the audience for this mode of digital

culture is *already* interested in the knowledge practices associated with multispecies domains. These sites seek to enhance that interest, while also demonstrating the democratisation of scientific expertise and information. As Sharma et al. (2019) also show, citizen science platforms can enable potent forms of environmental attachment and engender action for species conservation. Indeed, rather than the 'quick fix' of environmental engagement Houser refers to (2014: 333), these examples are designed to be part of an ongoing process of user engagement. In contrast to the 'globalist' visualisations critiqued by Houser (2014: 327) this engagement is a matter of situated and site-specific concern.

Secondly, it is important to note that science and citizen science has always affirmed a productive mix of direct observation and transmedia activity. Tsing's 'arts of noticing' include intricate botanists drawings and a website produced by a 'mushroom eccentric' for public knowledge exchange (2011: 13). Her account points to a broader paradigm—science has always advanced through an association with visual culture, whether botanists' illustrations, anatomical drawing, micro-cinematic experiments, atlases and photography (see for example Daston & Galison 2007). These activities have engaged a broader community of makers and artisans for centuries. Rather than a digital break, work with data should be seen as a next phase in the way noticing and interspecies relations are supplemented by media. Equally, the databases and visualisations discussed here are as likely to send users into multispecies domains, whether as students, educators or enthusiasts.

Focusing our critical attention on the affirmative potential of the digital culture of biodiversity is important, moreover, because this domain is only expanding, as demonstrated by the growing user base and international reach of platforms such as iNaturalist (Seltzer 2019). There is much at stake in understanding how to deploy technology in ways that enhance public engagement with the living world. Referring specifically to multispecies awareness, Tsing asks how we might practice the 'arts of inclusion', saying: 'In these times of extinction, when even slight acquaintance can make the difference between preservation and callous disregard, we might want to know' (Tsing, 2011: 6). In examples such as the *Atlas of Living Australia*, *Local Kin*, *Canberra Nature Map*, and *Insects*, biodiversity data becomes environmental media; we have shown how it might harness and build on the 'slight acquaintance' Tsing describes. The importance of these Australian examples is especially stark: this continent has one of the highest rates of extinction in the world and is experiencing an ongoing biodiversity crisis (Kearney et al 2019). The fires of 2019 and 2020, still underway at the time of writing, have only worsened this. Individuals are increasingly mobilised to respond to the climate crisis, raising the stakes around digital engagement with a more-than-human world, and demanding further critical and practical research.

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