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Biodiversity data as public environmental media: Citizen science projects, national databases and data visualizations

ABSTRACT

Through a combination of scientific and community activity, our 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, arising from collaboration between a practitioner and theorist in digital design and a film and screen scholar with expertise in documentary and environmental studies, critically examines biodiversity data through an ecocritical reading of public-facing databases, citizen science platforms and data visualizations. We examine the Atlas of Living Australia*;* Canberra Nature Map*; the City of Melbourne's* Insects*; and the experimental visualization* Local Kin*. Integrating perspectives from screen studies, design*

KEYWORDS

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data
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multispecies
Australia
citizen science

and the environmental humanities, including multispecies studies approaches in anthropology, we examine how digital representations reflect the way biodiversity data is produced and structured. Critically analysing design choices – what is shown, and how it is shown – we argue that biodiversity data on-screen provides specific affordances: allowing, encouraging or discouraging certain insights and possibilities that condition our knowledge of and engagement with living things. An interdisciplinary approach allows us to ask new questions about how users might experience multispecies worlds in digital form, and how biodiversity data might convey the complexities of an entangled biosphere, amplifying understanding, connection and attention amongst interested publics. We examine the visual rhetorics of digital biodiversity in order to better understand how these forms operate as environmental media: designed representations of the living world.

Through a combination of scientific labour and community activity, our complex biosphere is increasingly registered and documented as digital data. The past decade has seen the large-scale digitization of natural history collections (Biodiversity Heritage Library), the aggregation of diverse data at national scale (*Atlas of Living Australia*) and the emergence of international platforms such as iNaturalist (Seltzer 2019), along with a wave of activity in digitally enabled citizen science apps (Dickinson et al. 2012). These projects promise to advance scientific research, enhance public knowledge and galvanize public engagement. Setting aside professional scientific uses of this data, we focus in this study on platforms that appeal to a general audience, where biodiversity data is emerging as a significant form of public environmental media. The non-expert audience for the examples we discuss is diverse and might include school students, tourists, art practitioners and consumers, amateur naturalists, gardeners, bird watchers or any other group motivated by an engagement with a place or the ecosystems it sustains. These platforms operate in a system of networked digital media increasingly characterized by the real-time data flows of the smartphone app and the social media platform, where the screen-based mediations of websites, interfaces and visualizations are ubiquitous components of a digital everyday.

In this article we undertake an ecocritical review of these visual forms, including online databases, citizen science platforms and data visualizations, instances where the scale, diversity and complexity of the living world comes to us through chains of technological mediation and the genres and conventions of screen culture. We examine the visual languages of digital biodiversity in order to better understand how these formal practices shape acts of environmental media: designed representations of the living world. We follow these visual forms into the contexts and constituencies in which biodiversity data is published and produced, considering how data both forms and is formed by mediated representations. We draw attention to the specific design choices at work here – what is shown and how it is shown. These visual forms render digital biodiversity through different lenses: as mobile or static, singular or multiple, orderly or chaotic. They emphasize some features, and omit others. We aim to show how these choices shape our increasingly digital view of the living world, demonstrating their significance for both the analysis and production of these emerging forms of environmental media. This article 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

environmental studies. Our dual perspectives draw out the interplay between the capture and visualization of data and the address to the user *as a form of public environmental media*. To achieve this, we focus on the affordances of particular design decisions. As Davis and Chouinard (2016) argue, technological artefacts 'afford' by allowing, encouraging or discouraging certain lines of action. Biodiversity data online similarly affords certain insights, understandings and possibilities. Our investigation revolves around the hypothesis that design decisions condition user engagement with and understanding of the living world through digital media. The analysis is divided into three sections, aligned with key themes: (1) the relationality of data, (2) the formation, source and scope of data and (3) observation and species specificity as it is presented by data.

We undertake this analysis by drawing together approaches from our respective disciplines. Media studies provides methods for interpreting the screen in its cultural and institutional contexts; digital design focuses on the conventions and experimental potential of visualization. We also draw on approaches in anthropology that have, under the umbrella of 'multispecies studies', explored how humans might experience multispecies worlds in ways that are both attentive and ethical, perhaps even entailing renewed consideration of what it is to be human. Our analysis is also informed by our own practical experience. This novel interdisciplinary approach allows for us to ask new questions about how users might experience multispecies worlds in digital form, thus contributing crucial new knowledge to practice in visualization, web and interface design, as well as the environmental humanities. This study and the media artefacts it deals with constitute a pivotal development in the history of exchanges between the sciences and forms of mediation. Whether for the purposes of dissemination or as a method of inquiry, science has always advanced through an association with visual culture, whether botanists' illustrations, anatomical drawing, micro-cinematic experiments, atlases or photography (see, e.g., Daston and 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.

The four case studies we consider include the *Atlas of Living Australia* (ALA), Australia's umbrella national biodiversity database, a collaborative project that pulls together and publishes a wealth of data from multiple sources (Atlas of Living Australia n.d.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. The first data visualization we examine, *Local Kin*, is an experimental visualization created by one of the authors that draws on data produced by the CNM and aggregated by the ALA (Whitelaw 2016). The second, *Insects*, is published by the City of Melbourne, based on a research collaboration investigating urban insect biodiversity (City of Melbourne 2018). While they can be grouped into similar pairs – two database platforms and two visualizations – we juxtapose these categories in order to draw out the problems and possibilities of each. While these examples demonstrate 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 localized 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), recognizing 'data settings' as much as data sets. We do so by acknowledging the specific ways in which data are produced through localized practices and knowledge. As Antonello and Morgan argue, environmental knowledge is situated

> [w]here 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.
>
> (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 multispecies constituencies that these examples present. This focus is also motivated by what is at stake on our continent: Australia has one of the highest rates of extinction in the world and is experiencing an ongoing biodiversity crisis (Kearney et al. 2019).

Like all forms of documentation, the visual artefacts we have described 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' (Drucker 2011). Offering an evaluation more specifically focused on 'environmental visualizations', Heather Houser describes the allure of, in particular, 'infovis' imagery (such as maps, line graphs, flowcharts and time series displays) that 'not only pleases through astonishment but also promises to hone attention and instantaneously generate knowledge' (2014: 320). Thus, Houser critiques the assumed transparency of the data as well as what is entailed in the move from complex data sets to simple visualization. She questions, moreover, the efficacy of its reception, suggesting that the allure of well-crafted data representation may only produce a 'quick fix' (2014: 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 questions 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.
>
> (Manovich 2002: 3)

With these frames in mind, we take another look at the designed affordances of biodiversity data online in order to consider how it might function as environmental media. Which dimensions of biodiversity data are selected, how are they made visual and how do these choices condition our view of a given environment? How might the aesthetics and techniques of visualization draw us into a richer understanding of our multispecies world? 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.

ENLIVENING DATA: STORY AND RELATIONALITY

Landing on a website, whether a database or visualization, the user's first task is to make sense of the relationships between data and within data points (single, unique pieces of information). How they do this is a direct result of the design decisions that convey the structure of the relations, in these cases 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 organizing 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 organization 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 selected environment is characterized by an unthinkable mass of ecological and phylogenetic connections, which are encoded in data and which are shown in visualizations? 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. Conventionally, stories are produced by events ordered into causal chains that infer meaning. Narrative is a key avenue for heightening the public understanding of species as situated in contexts of cause and effect that influence not only the relationship between species but also their very existence. The ALA and *Local Kin* elucidate our exploration of relationality. They present a striking contrast and an apt pairing, as *Local Kin* (a visualization produced by one of the authors) deploys and thus responds to the data aggregated on the ALA database.

A public biodiversity database, the ALA aggregates and publishes millions of data points, from across the Australian continent, echoing Ursula Heise's characterization of biodiversity databases as both epic and encyclopaedic (2016: 65). It is an expansive work of public environmental media that 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 n.d.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 affords us a particular view of the data. Taxonomic features of the data are emphasized, 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 allows the user to explore their local area, loading observations within a small radius into a map and list-based interface (Atlas of Living Australia n.d.b) (Figure 1). This interface promises to place the user in a localized ecosystem, with a navigable hierarchy of taxa that 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 that of 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.

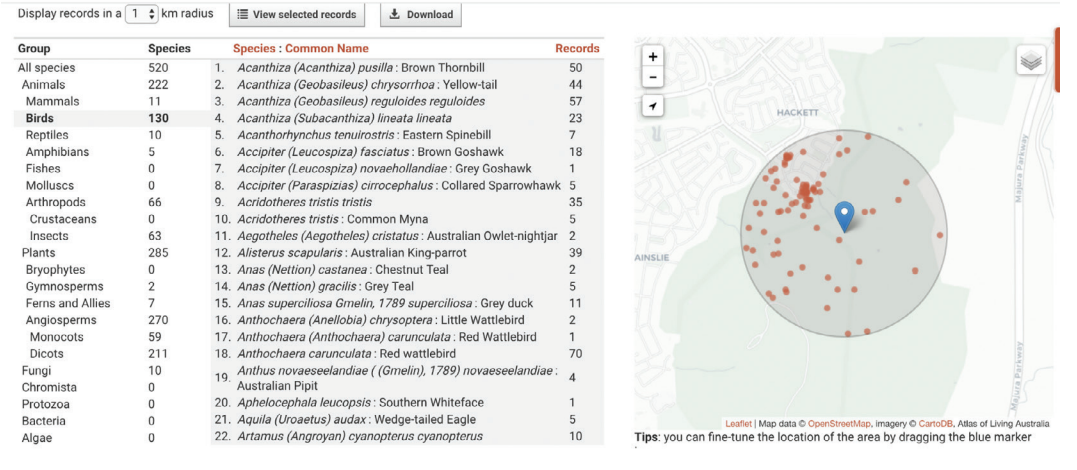

Figure 1: Atlas of Living Australia, *'Explore Your Area' interface (screen capture). Copyright Atlas of Living Australia, reproduced under a Creative Commons CC BY 3.0 AU license, https://creativecommons.org/licenses/by/3.0/au/. Accessed 22 February 2021.*

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 how the site functions as a public resource or tool for wider lay audiences. *Story* and *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 materialize the database while dematerializing 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' (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 (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' (2014: 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. In focusing by default on the identification and representation of species and the occurrence as a geospatial point, the ALA interface says little about the broader liveliness of this data. While its design affords us a sense of our place in the environment, potentially showing how the human might be embedded in a larger web of species relations, these associations (perhaps even narrative associations) remain latent, concealed in the information architecture 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 observations harvested from the ALA, where they were collected by citizen scientists on the platform CNM. *Local Kin* is a mashup or remix, taking the ALA's occurrence data structure – species, location, time and images – as material for creative reinterpretation.

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 kilometre 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 select specific features in 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 visualization 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.

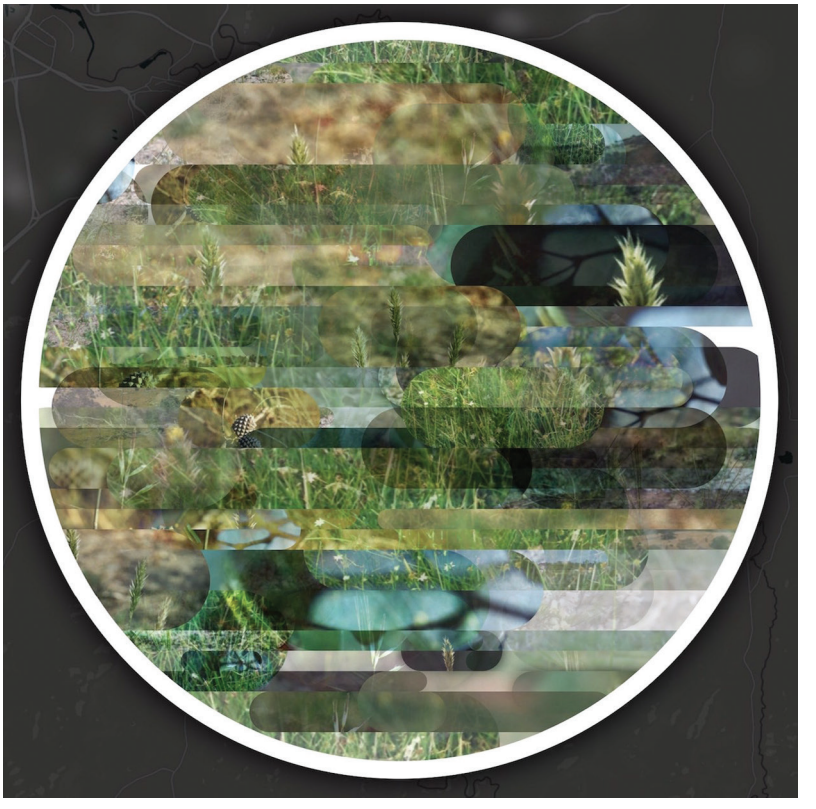

Figure 2: Mitchell Whitelaw, Local Kin *(screen capture). Copyright the artist, used with permission.*

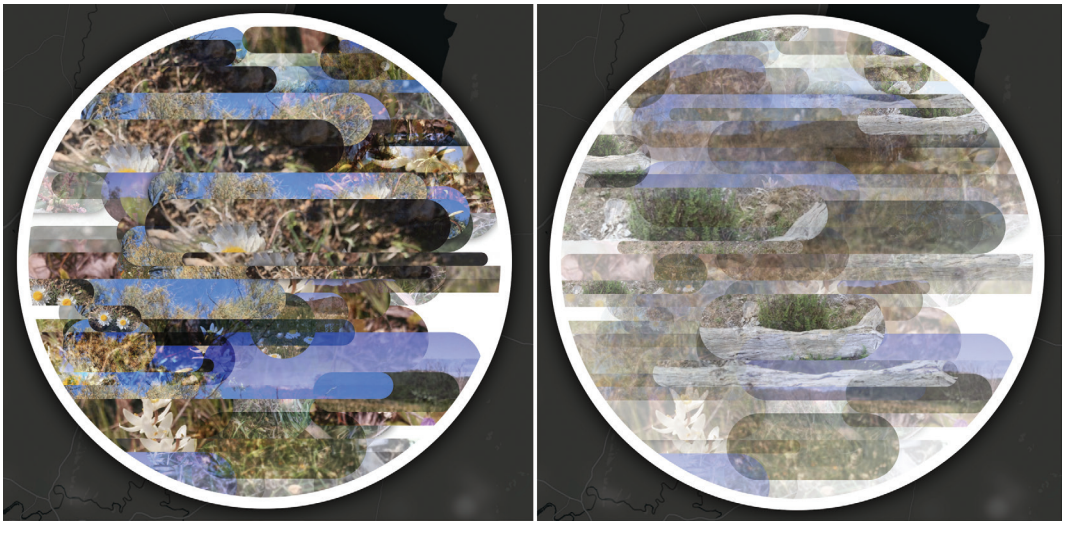

Figure 3: Mitchell Whitelaw, Local Kin *(detail showing seasonal variation; left: winter; right: spring). Copyright the artist, used with permission.*

Local Kin applies simple computational techniques to visualize the co-occurrence of living things through an aesthetics of shifting relatedness, creating spatial and temporal variation from a static data set. 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 recognizes the generative role of computation and the power of aesthetic provocation to shape interpretation and mediate data.

As well as reconstituting visual assemblages, *Local Kin* affords a view of temporal relations within biodiversity data. ALA occurrences include detailed time data, though these features are not emphasized 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. 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. This variation also reflects increased human data gathering in the temperate Canberra spring, demonstrating Drucker's argument for the dependence of data upon observation. As this approach shows, visualization can afford a view of the temporal liveliness latent in biodiversity data and a sense of its production through human activity.

As these examples show, decisions about the digital design of biodiversity data emphasize (by the choice of data selection) and visualize specific relations and structures within that data; and they do so differentially in line with distinct interests and aims. These sites and interfaces provide differing views of what might be shown of identical data and, thus, of what is valuable or significant about it. Data repositories such as the ALA encourage a focus on the scientific value of data and its hierarchical taxonomy; but its interface leaves many stories tacit within its database logic. In contrast, *Local Kin* selects and mobilizes the ALA data in a way that privileges spatial proximity, visual texture and temporal variation; these design choices afford narratives of site specificity, coexistence and seasonal change.

ENVISIONING BIODIVERSITY IN RESERVES AND URBAN SPACES: VALUING THE SCOPE AND STRUCTURE OF DATA

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 visualizations. 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' (2011: 19), practices that cultivate multispecies awareness and connection. For Tsing, the arts of noticing the diversity of life involve the mediated abstractions of representation and classification, as well as direct immersion in complex multispecies contexts. The two examples discussed in this section offer two interesting and contrasting options for structuring and

sourcing data: the CNM is a community platform (a form of co-created database), and *Insects* is a data visualization.

The CNM demonstrates the relationship between the scope of biodiversity data and its constituency. The users of CNM contribute data by reporting sightings, uploading photographs and logging the time and place of the observation. These can be uploaded to the site through a mobile app, which also serves as a portable field guide. The platform aims to record '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). Notably the scope of this project is an ongoing and dynamic formation: while it 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, this broadening 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.

The CNM shows how the scope and formation of biodiversity data can develop around a constituency already engaged with observing flora and flora (Tsing's 'arts of noticing'). The site also shows how decisions about 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 organization. While based on hierarchical scientific classification, it adapts this structure using common names and small illustrations. It reflects the site's amateur naturalist community in its avoidance of technical terms, and uses visual (and aesthetic) cues to convey the diversity and character of these lifeforms more vividly than the usual Linnaean taxonomy. The 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 n.d.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 easily understandable 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 might 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 flora and fauna. 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' (2014: 334). The CNM differs from the visualizations critiqued by Houser, in that it is not simply interactive but is co-created by users who also play a role in determining its scope. In this respect it offers an important counterpoint, positing and demonstrating a hybrid form of crowdsourced engagement that integrates online and offline encounters – it urges us into the 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, the 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 accounts of particular ecosystems. The CNM interface affords a certain scope, and its open-ended design accommodates the changes in that scope over time, emphasizing that the data is inclusive, partial and dynamic. This is evident in the taxa navigation (Figure 4) and the accumulating lists of spatial locations. The site shows how biodiversity data can operate as co-produced environmental media, whose scope is bound up with an ongoing community process that celebrates living diversity while acknowledging that the complexity of the ecosystem is beyond complete capture.

The next example we discuss differs from the CNM in that it is a visualization 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 and plant interactions (City of Melbourne 2018). Designed by OOM Creative, the site visualizes research data through an engaging portrayal of insect biodiversity, cultivating attention to these tiny invertebrate species in numerous parks in central Melbourne. Here we focus on *Insects*, an example that maps data through two visualizations: 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 ecosystems 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 design 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 visualization 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 ordered by height: lawn, higher 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 visualization techniques condition and characterize 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

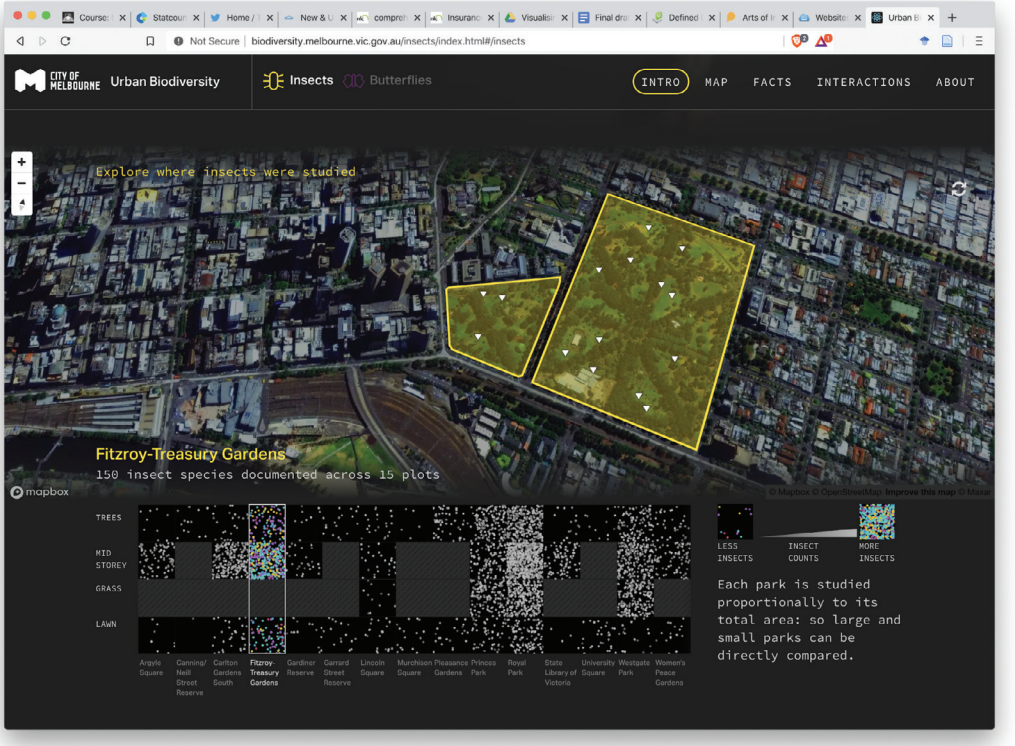

Figure 5: City of Melbourne, Insects *(map and matrix visualizations). Screen capture by Whitelaw.*

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 *heterogeneous aggregates of individuals*, rather than simply numerical values.

Moreover, this interface does not offer 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 visualization 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 diet and ecological roles (herbivore, parasitoid, detritivore) as well as by park site. As with the habitat matrix, these aggregations draw us into the ecological detail of their diverse ways of life. 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 animation is an aesthetic or design decision, a kind of scenography, but one that offers crucial affordances, showing these insects as active, mobile individuals.

The city location emphasized by the map speaks to another crucial way this visualization 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 many other

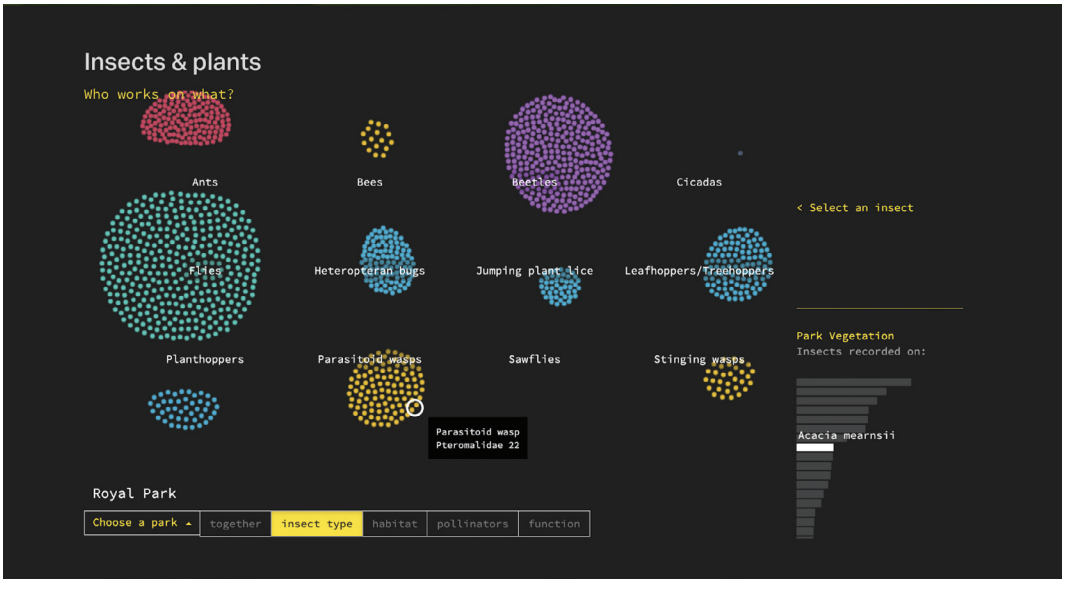

Figure 6: City of Melbourne, Insects *('Who Works on What?' visualization). Screen capture by Whitelaw.*

species. As Houston et al. eloquently state, '[w]e are after all but one species among many inhabiting diverse urban worlds, and any presumed exclusive human "right to the city" and the biosphere here is increasingly untenable' (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 interspecies systems that contribute to the urban community. Research has shown that entomofauna are in rapid decline in many locations, and some projections estimate the extinction of 40 per cent of the world's insect species over the next few decades (Sánchez-Bayo and Wyckhuys 2019). Promoting greater awareness of insect species, the site contributes to intensifying recognition of the relevance of insect populations at a time when insect biodiversity is under threat globally.

The design affords a sense of shared city and site; for the Melbournian, it 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 such as jumping plant lice that seldom gain human attention. The design of the page organizes visual information 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 to this systematic spatial organization, traversing scales within the urban realm, the CNM privileges the serendipity of the individual observation within an accumulating list of sites and locales. The CNM affords its users an architecture that supports and celebrates their data gathering, even as this architecture reflects the values and activity of that same 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 data online. Combining approaches from digital design and media studies, we consider the design affordances of 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 the materiality of species. The notion of identification offers a more granular approach to understanding the modes of observation offered to the user, whether it is identification *of* (the classification of observations) or identification *with* (measuring one's relation to another organism). We return to *Insects* and the CNM for a discussion of observations because they again offer rich contrasting examples, each including multiple aesthetic modes.

One of the most important ways *Insects* organizes or affords 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 mapping, photography and data visualization 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.

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. This image offers a human viewer a highly magnified view, enhancing our capacity for observation with a striking rendering of the texture and shape of the black and red insect (Figure 7). Scrolling down, the user sees visualizations of insect populations (many of these are registered symbolically as dots, as noted above) interspersed with more close-up 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 data set. The effect is to pose the insect (and insects in general) as, potentially, charismatic species. The contrast between the symbolic dots and these insect portraits offers an interesting study in scale.

Identifying with insects poses a particular challenge for humans: the valuation of interspecies encounters privileges, as Hustak and Myers observe, 'organisms that humans can "hold in regard", that is, those animals with whom we can lock eyes' (2012: 81). Again, from the perspective of human perception, entomological fauna do not have a recognizable 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' (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 characterized by negative affect or indifference.

Insects' different aesthetic modalities offer 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 interactive affordances, each dot reveals an appealing photographic 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 visualization with a strategic articulation of symbolic data point and photographic image. The design asks the user to look again at insects, their distinctive properties, and to recognize their status beyond anthropocentric assumptions about insect ontology.

The 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, the CNM hosts a continually growing collection, where photographs play a large part. The identification of organisms sighted by users is a deliberative process,

Figure 7: City of Melbourne, Insects *(detail). Screen capture by Whitelaw.*

emphasizing 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 encounter with other species, 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 forms around these observations.

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 the 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, '[n]ice photos'. The personal encounter is authorized 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 in this activity. 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. Thus, data here supports a socially inclusive form of knowledge production, what Tsing terms 'vernacular science' (2011: 19). Yet, while contributors to the 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; if classification is important for the 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; group deliberation over evidence and the encounter brings 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'. Classification here drives noticing – but this social attentiveness also extends to questioning the distinctions that classification enforces. Significantly, as a data platform, the CNM is characterized by a passionate and open-ended curiosity. The architecture and interface design of the site supports this, with pages devoted to individual sightings, emphasizing deliberative observation. A collection of photographs and threaded discussion afford close attention to the organism under discussion.

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 a focused way, attending to the scale and otherness of insects 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 relies upon how information, including images, is made available to users. Digital design affords modes of understanding and attention that would not be possible without its 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. In exploring digital affordances, we show how the relations within data sets are rendered differentially across contexts and audiences and how specific choices in interface and visualization design select, omit, celebrate or elide certain features even within the same data structure. The ALA privileges a hierarchy of species and occurrence, while *Local Kin* redeploys the same data to emphasize 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 potentially intensify user engagement through aesthetic strategies. The scope

and structure of biodiversity data is both reflected in and shaped by its mediated representations. The CNM shows how the formation of data is bound up with place and constituency, as well as being enabled by the affordances of the website 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 datagraphics, 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 the CNM, 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 how website and app design and visualization affords 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 might be dismissed as lower-order echoes of unmediated encounters. We suggest there is a more complex set of considerations in play. First, 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 encounters with wildlife, and these offer a valuable collective form of 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 visualization such as *Insects*. While these visualizations are not co-created with users, they transmit and aggregate data in a way that would not otherwise be possible – one can browse thousands of observations on databases such as the ALA and CNM. 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 interaction that is also anchored to a specific bioregion rather than 'globalist' (Houser 2014: 327). Second, and as we note at the outset, science and citizen science have always affirmed a productive mix of direct observation and transmedia activity. Tsing's 'arts of noticing' include intricate botanical drawings and a website produced by a 'mushroom eccentric' for public knowledge exchange (2011: 13). Rather than simply replacing direct encounters with attention to a digital form, we have shown how the databases and visualizations discussed are as likely to send users into multispecies domains, whether as students, educators or enthusiasts. Our evaluation of design choices functions as a new reference point for the creation of web interfaces, one that is informed by ecocritical concerns. This is a first step in a wider endeavour to understand the impact of digital design and visual culture on environmental awareness and action.

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. Tsing asks how we might foster multispecies awareness:

'[i]n these times of extinction, when even slight acquaintance can make the difference between preservation and callous disregard, we might want to know' (2011: 6). In examples such as the ALA, *Local Kin*, CNM and *Insects*, biodiversity data becomes environmental media; we have shown how it might harness and build on the 'slight acquaintance' Tsing describes. This potential is timely: in Australia, the fires of 2019 and 2020, still underway at the time of writing, have compounded threats to biodiversity. Individuals are increasingly mobilized to respond to the climate crisis, raising the stakes around digital engagement with biomes and ecosystems, and demanding further critical and practical research.

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