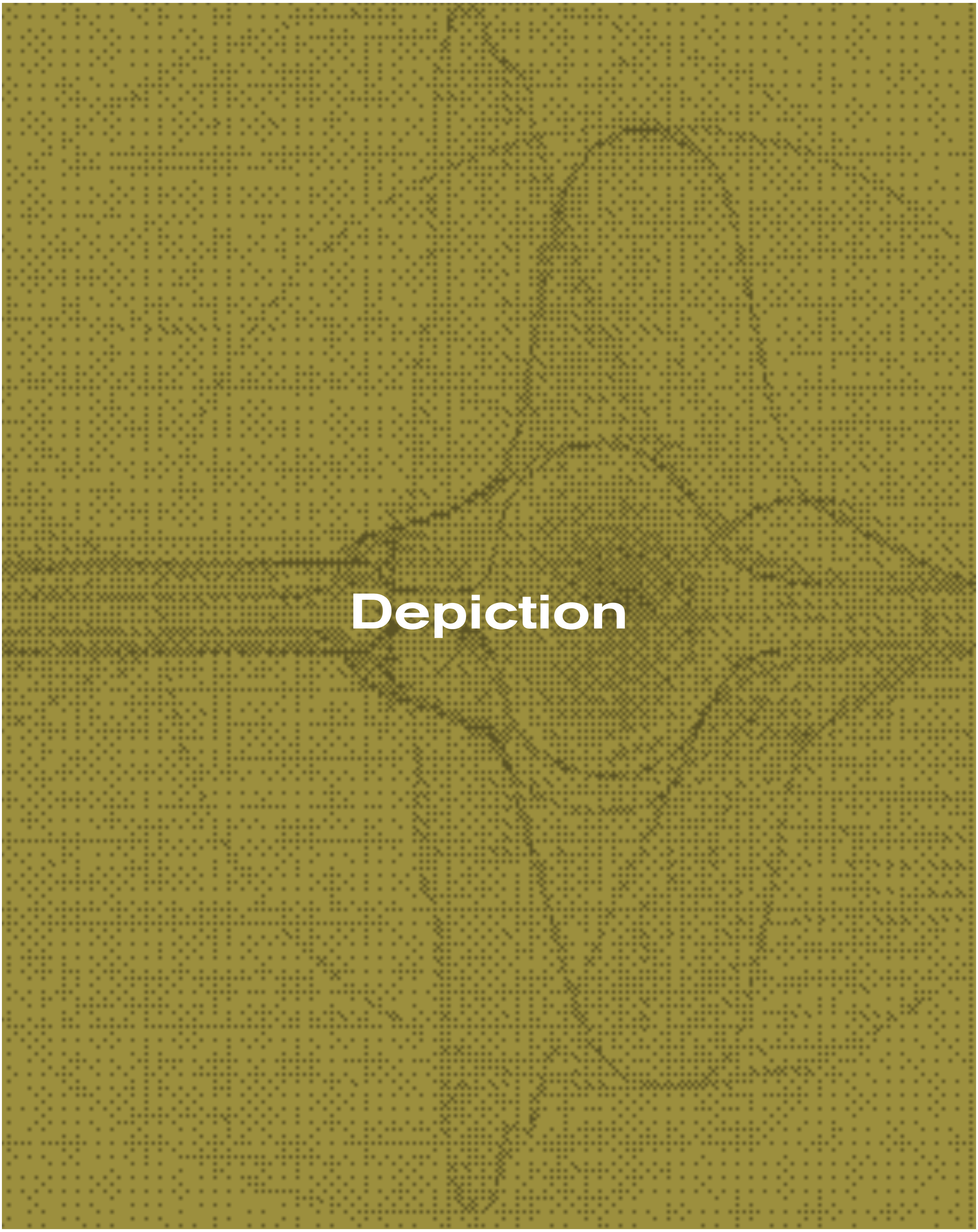

Depiction

The Datafication of Forests? From the Wood Wide Web to the Internet of Trees

Jonathan Gray

HOW CAN DATA and networked digital technologies be used to cultivate collective sensibilities towards the presence of trees?[1] How can the datafication of forests build on or depart from other ways of relating to trees, whether through mythology, mapping, camping, conservation, literature, logging, painting, planting, film, food, art installations, activist occupations, imperial expansion, indigenous stewardship, botany, birthing, or bathing (*shinrin-yoku*)? This piece briefly explores some of the emerging practices, infrastructures, and devices that are used to render trees experiencable, sensible, and relatable through digital data.

Official statistics about trees have been considered paradigmatic of institutional myopia. For example, James C. Scott's 1998 *Seeing Like a State* contains a parable about how states and empires sought to summarize their interest in forests to "a single number: the revenue yield of the timber that might be extracted annually."[2] The utilitarian's "abstract tree" quantifying wood volume was a spectacular accomplishment insofar as it omitted "nearly everything" considered important by naturalists, anthropologists, and others who studied the life of forests: "Gone was the vast majority of flora: grasses, flowers, lichens, ferns, mosses, shrubs, and vines. Gone, too, were reptiles, birds, amphibians, and innumerable species of insects. Gone were most species of fauna, except those that interested the Crown's gamekeepers. … [The state] typically ignored the vast, complex, and negotiated social uses of the forest for hunting and gathering, pasturage, fishing, charcoal making, trapping, and collecting food and valuable minerals as well as the forest's significance for magic, worship, refuge, and so on."[3]

In contrast to this impoverishing datafication, scientists in the 1990s mobilized computational tropes to characterize the rich social interactions between trees and their neighbors and to suggest affinities between arboreal life and digital networks of information exchange. *Nature* magazine used the notion "Wood Wide Web" to editorialize articles examining how mycorrhizal fungi connect plants, a phrase which has subsequently become common amongst researchers.[4] As though striving to materialize this metaphorical affinity, recent proposals for an "Internet of Trees," inspired by the "Internet of Things," has led to several pilot projects using digital technologies to enable and multiply connections between forests, devices, databases, networks, scientists, institutions, and publics. The United Nations Environment Assembly has made the case for a "global digital ecosystem of environmental data, algorithms, and insights" in order to "build awareness of the state of our planet."[5]

To what extent might digital data practices provide opportunities for not just feats of shortsightedness, but also for multiplying relations and ways of relating to trees? What are the prospects of such developments for Gaia 2.0 and collective encounters with Critical Zones?[6] Can data serve as not just a means to accelerate the marketization and bureaucratization of forests, but also as sites of participatory and inventive approaches for attending to and living with them, for "making forests public"?[7] Might data practices and infrastructures support "chains of transformations" and "sequences of mediators" not just between forests and scientists, but also between forests and broader publics?[8] Might they surface other perspectives on the role of trees in collective life? What is the prospect of incorporating data and digital technologies into "more than human" modes of sensing, sense-making and "becoming planetary," as Jennifer Gabrys puts it?[9] While advocates of "forest therapy" suggest "leaving devices at home," might there also be a case for taking devices with us? The following is a compendium of ways of relating to trees with data, illustrated with various recent projects and techniques, as a prompt for further encounters, experiments, and collective inquiries into the entanglements between trees and digital technologies.[10]

1 This question was prompted by correspondence with Bruno Latour in which he asked: "How can the web be used to enhance sensibilities to the presence of our fellow travellers (trees, bacteria, etc.)?" This line of inquiry was also inspired by discussions with Birgit Schneider, who gave a talk on "Talking Trees: Four Perspectives on Ecological Media and Media Ecologies" at King's College London in March 2019. Conversations with Rina Tsubaki at the European Forest Institute have also provided insights into recent developments in this area. Thanks to Bernard Geoghegan and Liliana Bounegru for their comments on various versions of the text.

2 James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven, CT: Yale University Press, 1998), 11.

3 Ibid., 13.

4 See Thorunn Helgason et al., "Ploughing up the Wood-Wide Web?," *Nature* 394, (1998): 431; Robin Sen, "Budgeting for the Wood-Wide Web," *New Phytologist* 145, no. 2 (2000): 161–3; Suzanne W. Simard et al., "Net Transfer of Carbon between Ectomycorrhizal Tree Species in the Field," *Nature* 388 (1997): 579–82.

5 UN Environment Assembly, "The Case for a Digital Ecosystem for the Environment," March 2019, https://un-spbf.org/wp-content/uploads/2019/03/Digital-Ecosystem-final-2.pdf.

6 See Bruno Latour, *Down to Earth: Politics in the New Climatic Regime*, trans. Catherine Porter (Cambridge: Polity Press, 2018); Timothy M. Lenton and Bruno Latour, "Gaia 2.0: Could Humans Add Some Level of Self-Awareness to Earth's Self-Regulation?" *Science* 361, no. 6407 (2018): 1066–8.

7 See Bruno Latour and Peter Weibel, eds., *Making Things Public: Atmospheres of Democracy* (Cambridge, MA: The MIT Press, 2005); Celia Lury and Nina Wakeford, eds., *Inventive Methods: The Happening of the Social* (London: Routledge, 2012); Noortje Marres, *Material Participation: Technology, the Environment and Everyday Publics* (London: Palgrave Macmillan, 2012).

8 See Bruno Latour, "Circulating Reference: Sampling Soil in the Amazon Forest," in *Pandora's Hope: An Essay on the Reality of Science Studies* (Cambridge, MA: Harvard University Press, 1999), 24–79.

9 Jennifer Gabrys's work offers a rich set of perspectives on forest sensing practices, including "Sensing an Experimental Forest: Processing Environments and Distributing Relations," *Computational Culture* 2 (September 2012); *Program Earth: Environmental Sensing Technology and the Making of a Computational Planet* (Minneapolis: University of Minnesota Press, 2016); and "Becoming Planetary," in *Accumulation*, ed. Daniel Barber, *e-flux Architecture* (October 2, 2018).

10 These prompts are intended to be illustrative and certainly not comprehensive or mutually exclusive. In the spirit of Wittgenstein's *Philosophical Investigations*, the aim is to show that data, like language, do not do only one type of thing. This is not to imply a metalanguage of practices, but is rather intended as an encouragement to "take a wider look around" at how relations with trees are organized with and through data.

ADDRESSING. The concept of addressability is said to be a central aspect of networked technologies and cybernetic imaginaries, from geographical coordinates to hardware numbers to digital traceability.[11] Making a person or thing addressable means they can be identified, located, and communicated with on digital networks. In 2013 the city of Melbourne not only assigned trees unique ID numbers, but also email addresses to enable citizens to report issues — unexpectedly giving rise to a surge of questions, reflections, and letters of admiration, a selection of which were shown in 2018 at *The Future Starts Here* exhibition at the Victoria and Albert Museum in London.[12]

Trees have also been issued with social media accounts: the Swedish multinational Ericsson's @connectedtree uses a combination of sensors and an "analysis engine" to "reflect" the trees' "mood" in posts to the Twitter platform.[13] Researchers at the *TreeWatch* platform of Ghent University, Belgium, used sensors as the basis for Twitter accounts for individual trees posting about diameter variation and sap flow: "My sap is finally starting to flow!".[14] (*See figs.* 1 *a*, *b*) Individual trees have been issued with barcodes, QR codes, and "phytosanitary passports" to enable them to be tracked and have information associated with them. Conversely, the village of Xilinshu in China organized 130,000 juniper trees into a giant QR code, an address visible from the air (*see fig.* 2).

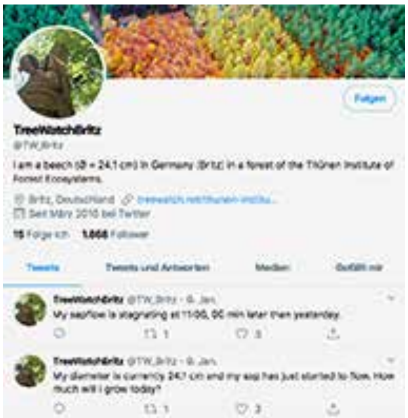

Fig. 1 a: TreeWatch.net. Tweets of a beech from Thünen, Germany.
Fig. 1 b: TreeWatch.net. Sap flow sensor and dendrometer, Schovenhorst Estate, Putten, Netherlands.

DASHBOARDING. Dashboards are an increasingly prominent way to provide interfaces with information, with a history that spans the controls of vehicles, radar, financial transactions, management, and real-time data flows.[15] This visual form has been repurposed to display tree data such as total numbers of trees in a given area, comparisons of tree types, tree sizes, and percentage canopy coverage.

Fig. 2: Aerial view on the giant QR code built of juniper trees, Xilinshui, China, 2017.

Researchers at KU Leuven, Belgium, created an "Internet of Trees," a system to "remotely monitor the health of your tree" using a combination of open source sensor kits and an IoTree Dashboard with real-time graphs of temperature, movement, and sap flow.[16] The Dutch-Portugese startup 20tree.ai combines satellite data and machine learning algorithms to provide a "forest intelligence platform" with a dashboard containing insights on tree health, threats, sustainability, soil, and water.[17]

IDENTIFYING. "What's that?" Building on centuries of botanical literature, arboreal field guides, and vegetation maps, there are now many digital and web-based projects to identify trees and plants. Citizen science apps such as TreeSnap, LeafSnap, iNaturalist and Pl@ntNet help to guide users to identify trees, in the process creating data which can be used by scientists. Many of these apps are using machine learning algorithms in order to assist with identification as well as to check plant health, including stress from various sources. Databases of images classified by experts and crowdsourcing volunteers are used to train algorithms to recognize different features.

Machine learning assisted identification has also been used to identify trees from satellite imagery. Building on a study that estimates there to be three trillion trees on Earth and a database from the Global Forest Biodiversity Initiative, a Swiss research group used machine learning to map the Wood Wide Web.[18] Training datasets based on ground inventories were thus used to create

11 See Florian Sprenger, "The network is not the territory: On capturing mobile media," *New Media & Society* 21, no. 1 (2018): 76–96, https://doi.org/10.1177/1461444818787351.

12 *The Future Starts Here*, Victoria and Albert Museum, May 12 — November 4, 2018; see Rory Hyde and Mariana Pestana, eds., *The Future Starts Here* (London: Victoria and Albert Museum, 2018).

13 Ericsson, "Connected Tree: The Tree That Speaks to the World," 2012, https://web.archive.org/web/20120724144033/http://www.ericsson.com/connectedtree.

14 See https://treewatch.net/. Birgit Schneider has written about this project as a new form of "nature writing": Birgit Schneider, "Entangled Trees and Arboreal Networks of Sensitive Environments," *Zeitschrift für Medien- und Kulturforschung*, no. 9, 107–26.

15 See Nathaniel Tkacz, *Dashboard Visions* (London: Polity Press, forthcoming).

16 See https://www.dramco.be/projects/iotree/.

17 See https://www.20tree.ai.

Fig. 3: Descartes Labs.
Tree canopy layer around Baltimore Bay.

algorithmically mediated renderings of symbiotic communities. Other research groups, such as Descartes Labs, have created detailed maps of tree canopy layers in cities, using machine learning to distinguish between trees and other greenery (*see fig. 3*).

Inventorizing. Tree inventories are a common aspect of community forestry, whereby local communities participate in the management, use and governance of a forest. Many citizen science and civic ecology initiatives incorporate tree inventorising, not only through paper forms, but also using apps, websites and online databases. For example, the Casey Trees initiative in Washington, D.C., works with community groups to gather data on "species, height, diameter, tree health, and canopy characteristics," which enables the production of maps, ecosystem analyses, and "tree report cards."[19] They use the i-Tree system from the USDA Forest Service which templatizes data collection as well as facilitates the calculation of carbon storage, stormwater runoff, air quality, and other aspects.

What aspects of trees are recorded in such inventories? Just as surveys and polls are understood to contribute to the production and stabilization of human populations, tree inventories facilitate dealing with trees as collectives with certain characteristics. The data fields and attributes which are included in such inventories may be understood as a "parameterization" of trees. How such inventories participate in the rendering of forests may be elucidated by looking over time in the form of "data historiographies" comparing the evolution of different fields (e.g., looking beyond the bottom line of timber measurements) or through comparisons across inventories (e.g., the presence of fields such as the legal designation of "exceptional trees" in Hawaii or indigenous data projects such as the *Heiltsuk Culturally Modified Tree Database* in British Columbia, Canada).

Mapping. Many tree data projects use maps to show the locations of trees and other associated information (*see fig. 4*). As well as using maps for forest conservation and research, public maps are used to draw attention to different aspects of forests. An interactive animated map from Global Forest Watch uses different colors to show "tree cover gain" and "tree cover loss" around the world over time.[20] The Trees and Health app displays a map with sliders to overlay data such as "% tree canopy cover" and "traffic-related air quality" as well as to "assess, prioritize, and plan" tree planting initiatives in response. The collaborative mapping project OpenStreetMap uses tags such as "natural=tree", "natural=wood," and "landuse=forest" to mark and provide information about the coordinates of forests. The proliferation of tree mapping data has given rise to websites and apps with user features such as to "find a forest near you," as well as other projects such as a three-dimensional wooden map of tree volumes in Manhattan, New York (*see figs. 5a, b*).

Figs. 4: The New York City Street Tree Map. Online map of every street tree in New York, launched with the data of TreesCount!, 2015–2016.

Owning. An 1890 newspaper article from Athens, Georgia, reported about a "tree which owns itself," through a deed from its former owner who stated his intention to "convey unto the said oak tree entire possession of itself and of all land within eight feet of it on all sides."[21] The tree was thus said to enter into a state of legal self-ownership, raising questions about property, the law, the status of trees in society, and the uncertain fate of the land after the tree's death.

Over a century later, the art project *terra0* (2016) raises similar questions through its proposals and digital prototypes of a "self-owning, self-exploiting forest," which operates through "meshes of interacting decentralized autonomous organizations." The project envisages "a scenario whereby a forest is able to sell licences to log trees through automated processes, smart contracts, and blockchain technology,"[22] raising questions about what it means for property-centric forms of social and economic organization to extend to nonhuman actors and about extending the agential capacities of bots, algorithms, databases, and blockchain technologies to forests through the sale of "woodtokens."

Performing. How are trees performed with data? In a sense

18 See Brian S. Steidinger et al., "Climatic Controls of Decomposition Drive the Global Biogeography of Forest–Tree Symbioses," *Nature* 569 (2019): 404–8.

19 See https://caseytrees.org/.

20 See https://www.globalforestwatch.org/. The project is discussed in Birgit Schneider and Lynda Walsh, "The Geopolitics of Environmental Global Mapping Services: An Analysis of Global Forest Watch," in *A Research Agenda for Environmental Geopolitics,* ed. Shannon O'Lear, (Cheltenham: Edward Elgar Publishing, 2020).

21 See E. Merton Coulter, "The Story of the Tree That Owned Itself," *The Georgia Historical Quarterly* 46, no. 3 (1962): 237–49.

22 Paul Seidler, Paul Koling, and Max Hampshire, *terra0: Can an augmented forest own and utilise itself?* (Berlin: University of the Arts, May 2016), https://terra0.org/assets/pdf/terra0_white_paper_2016.pdf, 1.

all of the tables, lists, numbers, maps, apps, and media examined in this chapter can be considered performances, or ontological renditions of forests.[23] Many artists and others integrate tree data into various other kinds of restagings of forests. *The Singing Trees of Tremough* (2008) by the British artist Stanza uses a bank of forty sensors to create "a singing networked tree which can be heard in the park" or *Tree + Field + Lake + Park* (2009) where data are collected and visualized in realtime in the internet (*see* fig. 6).[24] *Hello Tree* (2011) by arts collective Active Ingredient collects data from trees in Sherwood Forest in the UK and Mata Atlantica in Brazil to facilitate a "conversation" between them using 3D visualizations.[25] *Arboretum* (2015) by Australian creative agency APositive uses an augmented reality app to show both information about trees in the National Arboretum, Canberra, as well as virtual animals that would have traditionally lived amongst them.[26] For his *Sentient Forest* (2016) in the Forest of Dean, UK artist Andrea Roe uses sensor banks to simulate the "network of information and nutrients" between fungi and trees (*see* fig. 7).[27] Tree data may thus schematize the participation of trees in various kinds of cultural production.

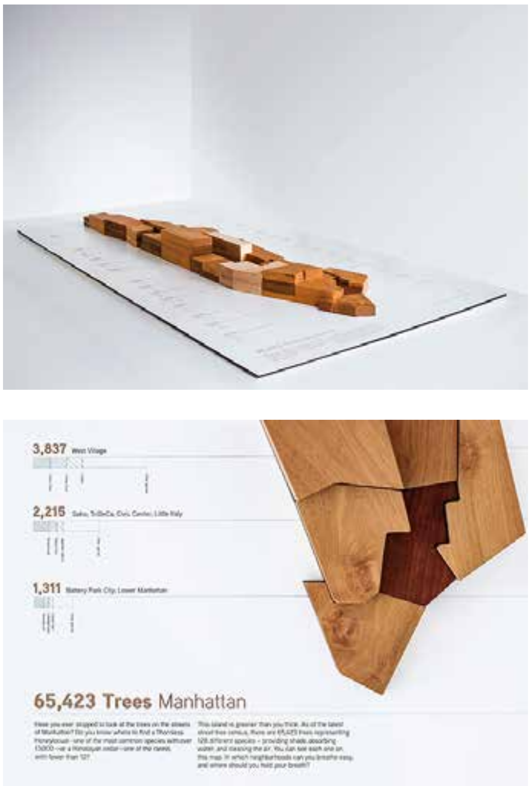

Fig. 5 a, b: TWO-N, *Manhattan Tree Topography Map*. 2018. Visualization of the street tree population of NYC through data driven, wooden map.

PLANTING. Tree planting has a long and contested history, from the greening of cities to timber for shipbuilding to failed colonial afforestation.[28] The *Greening of Detroit* project, founded in 1989, met unexpected resistance from residents who issued "no tree requests," partly because they did not trust local authorities to help maintain them.[29] More recent enthusiasm about the potential of massive tree planting to combat climate change has met with concerns about neglecting the comparative importance of protecting old-growth forests as well as overlooking the urgent need to reduce emissions.

The popularity of tree planting for carbon and paper offsetting has given rise to initiatives which connect the fate of trees to the media logics of apps, platforms, and other online devices. A noted post from the sustainable clothing brand TenTree urged Instagram users to "double tap to plant a tree," harnessing the viral dynamics of the platform for both advertising and planting (*see* fig. 8). The Ecosia search engine also funds planting through advertising, suggesting it takes "roughly 45 searches to plant a tree."[30] The Forest app encourages users to "stay focused, be present," and plants trees to reward them for time spent away from their phones, thus quantifying and gamifying non-screen time.

QUANTIFYING. Creating inventories and maps of trees also enables their quantification. Some projects foreground quantification as a focus, such as the *TreesCount!* census in New York, which in 2015–16 entailed 2,241 volunteers mapping 666,134 street trees and estimating $151.2 million of "benefits" to the city.[31] The Treemetrics' *Forest HQ* platform promises analyses of the "most productive areas" of forests as well as "accurate forest valuations."[32] The *OpenTreeMap* project aims to collect, manage, model, and analyze tree data, including the calculation of "ecosystem benefits" and the quantification of the value of "green infrastructure."[33] The i-Tree software which it runs on (and which powers tree inventories around the world) contains a number of built-in metrics and analytical capabilities for the quantification and valuation of trees. Such practices give rise to the production of "enumerated entities,"[34] from the three trillion global count to city and country level estimates of tree-totals and tree-values.

REMEMBERING. Data can be used to elicit and encode memories

23 See Annemarie Mol, "Ontological Politics. A Word and Some Questions," *The Sociological Review* 47, (1999): 74–89.

24 See http://www.stanza.co.uk/tree/index.html.

25 See https://web.archive.org/web/20151012124058 or even http://www.hello-tree.com/.

26 See http://www.a-positive.com.au/project/arboretum/.

27 See https://www.forestofdean-sculpture.org.uk/sentient-forest/.

28 See Diana K. Davis and Paul Robbins, "Ecologies of the Colonial Present: Pathological Forestry from the *taux de boisement* to Civilized Plantations," *Environment and Planning E: Nature and Space* 1, no. 4 (2018): 447–69.

29 See Christine E. Carmichael and Maureen H. McDonough, "Community Stories: Explaining Resistance to Street Tree-Planting Programs in Detroit, Michigan, USA," *Society & Natural Resources* 32, no. 5 (2019): 588–605.

30 See https://ecosia.zendesk.com/hc/en-us/articles/201657341-How-does-the-personal-counter-work-.

31 See https://www.nycgovparks.org/trees/treescount.

32 See http://www.treemetrics.com/ourtechnology/measure/.

33 See https://www.opentreemap.org/.

34 See Helen Verran, "Enumerated Entities in Public Policy and Governance," in *Mathematics, Substance and Surmise*, ed. Ernest Davis and Philip J. Davis (New York: Springer, 2015), 365–79.

Fig. 6: Stanza, *Tree*, 2009.
Data visualization of live data from light, temperature,
humidity, noise, and gps.

Fig. 7: Andrea Roe with Al Bennett, Sentient Forest, 2016.
Solar powered LEDs mimic mycelial networks
and communicate the presence of walkers to surrounding trees.

of living with trees. The *Árboles de Botogá* project by Datasketch sought to create a "collaborative tree catalog," which included memories and stories about the trees in the city.[35] They advocated for the release of the official tree inventory, which they published in full and used as the basis for interactive projects. Readers could call a WhatsApp number and leave voice notes, which included "stories of trees where they had their first kiss, trees that taught them how to climb, that protected them from thieves, or that were missed because they were cut down."[36] The project thus sought to foreground the role and presence of trees in urban life.

Witnessing. The use of data infrastructures to attend to forests may be construed as a form of "data witnessing."[37] Drawing on both notions of witnessing from media studies ("media witnessing") and science and technology studies ("virtual witnessing"), data witnessing examines how situations of injustice can be accounted for and responded to through data, affirming the often collective, distributed character of witnessing as well as the participation of nonhuman actors.

For example, Conservation Drones has captured footage in Southeast Asia, which is intended not just as legal evidence, but also in order to multiply public witnessing of environmental injustice through orthomosaic maps (stitched together from drone footage) and machine learning to identify illegal logging.[38] Rainforest Connection provides a "scalable, real-time logging detection system" with solar-powered, recycled smartphones and machine-learning to remotely identify sounds, such as chainsaws, and to send text messages to local authorities and indigenous communities.[39] The ARTiVIS group has prototyped a DIY *Forest Surveillance Kit* with open source hardware and software for live video streaming from forests to support environmental activism.[40] The *Forest Watcher* app enables users to participate in "dynamic online forest monitoring" and highlights "#PlacesToWatch" for "threats to global forests."[41] All of

35 See contributions and project results at http://especiales.datasketch.co/arboles-bogota/.

36 Maria Isabel Magaña, "Multiplying Memories While Discovering Trees in Bogota," in *The Data Journalism Handbook 2: Towards a Critical Data Practice*, ed. Jonathan Gray and Liliana Bounegru (Amsterdam: Amsterdam University Press, forthcoming)

37 See Jonathan Gray, "Data Witnessing: Attending to Injustice with Data in Amnesty International's Decoders Project," *Information, Communication & Society* 22, no. 7 (2019): 971–91.

38 See https://conservationdrones.org/ and https://interactive.aljazeera.com/aje/2016/lungs-of-the-earth/index.html.

39 https://rfcx.org/.

these projects aim to gather not only data or input for scientists or policy-makers, but also for data witnessing collectives which are capable of articulating care, concern and solidarity for and with their fellow travellers.

CONCLUSION. The practices and projects above are intended to illustrate the many different ways of organising relations between trees, people, practices, cultures, environments, devices, creatures, and infrastructures with and through data. Sensing and making sense of trees through these practices tells us not only about trees, of course, but about ourselves and the transposition, translation and circulation of methods, devices, and approaches for composing collective life. As Jennifer Gabrys points out in her above mentioned research, attending to the many ways in which these relations can be figured and configured may suggest different ways of "being human" and "being planetary," including "other pre- or post-accumulative modalities."

That arboreal life can perhaps be construed as a kind of "strange intermediate being," as John Ruskin put it,[42] can be further elaborated by unpacking the changing uses of the long-standing notion of "witness trees." This phrase was originally applied to how trees marked the borders of land, before being expanded to include their role in observing historic events ("silent witnesses") and more recently used to explore their

Fig. 8: TenTree. Post on Instagram, April 10, 2019.

role in analyzing colonial settlement patterns and environmental history.[43] Recent publications — such as Richard Powers's *The Overstory* and Lynda V. Mapes *Witness Tree* — explore the perspective of trees as witnesses by focalizing their narratives in "more-than-human" registers and temporalities.[44] A material and relational sensibility towards forest data practices and public data cultures may suggest further ways in which trees may be involved in processes of the "progressive composition of a common world"[45] and of reorienting and resituating ourselves in the Critical Zones in which we dwell.

40 http://diy.artivis.net/.

41 See https://forestwatcher.globalforestwatch.org/.

42 John Ruskin, *Modern Painters: Volume V* (London: Smith, Elder and Co, 1860), 2.

43 See https://green.blogs.nytimes.com/2012/09/18/the-witness-trees/; Christiana Payne, *Silent Witnesses: Trees in British Art 1760–1870* (Bristol: Sansom & Co, 2017); Bryan A. Black and Marc D. Abrams, "Influences of Native Americans and Surveyor Biases on Metes and Bounds Witness-Tree Distribution," *Ecology* 82, no. 9 (2001): 2574–86.

44 See, for example, Richard Powers, *The Overstory* (London: Penguin Random House, 2018) and Lynda V. Mapes, *Witness Tree: Seasons of Change with a Century-Old Oak* (New York: Bloomsbury USA, 2017).

45 Bruno Latour, *Politics of Nature: How to Bring the Sciences into Democracy*, trans. Catherine Porter (Cambridge, MA: Harvard University Press, 2004).