
SMART FOR REST

Considering Forestry,
A Science for Managing the Outside

Jacob Bertilsson, MA Research Architecture,
Goldsmiths University of London, 21/22

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Are we missing a forest of non-knowing for the sparse trees of scientific knowns?

-Sheila Jasanoff (Uncertainty)

0.0 INTRO

0.1 What Vectors are in Place

In response to the “degrading state” of Europe’s forests, the EU has advised a new Forest Strategy for 2030.[1] It advocates for a move away from current clear-cut practices, where all trees are cut down and replaced with even aged stands, towards what is defined as “closer-to-nature forestry”.[2] The Strategy aims to support biodiversity and largely builds on previous practices of “Nature-based Forest management”, characterised by the approach “to follow and support nature”.[3] Alongside this proposed shift towards ‘closer-to-nature forestry’ is an increased emphasis on the role technology will play in future forest management, mainly through data collection and modelling. For example, the 2030 Strategy includes a proposal for an EU-wide integrated forest monitoring framework, building

1 Rep. *State of Europe’s Forests 2020*. Forest Europe, 2020; New EU Forest Strategy for 2030’ (2021), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0572.
2 J. Bo Larsen et al., *Closer-to-Nature Forest Management* (S. l.: European Forest Institute., 2022), https://efi.int/sites/default/files/files/publication-bank/2022/EFI_fstp_12_2022.pdf.
3 Ibid., Larsen et al.

largely on remote satellite imagery.[4] To support the European Green New Deal, the European Space Agency has additionally been tasked with creating a Digital Twin (or replica) of Earth.[5] The Digital Twin is currently in a precursor state, with five sub-twins under development; one of these twins replicates the world's forests.[6] Similar forest models are also being developed on national scales, notably in Finland and Sweden.[7] But while the EU Digital Twin is said to support work toward a green transition, the Swedish and Finish models

4 New EU Forest Strategy for 2030.
5 'Destination Earth – New Digital Twin of the Earth', Text, European Commission - European Commission, accessed 3 August 2022, https://ec.europa.eu/commission/presscorner/detail/en/IP_22_1977.
6 TuomoH, 'Forest DTEP - Part of ESA's Digital Twin Earth - Home', Forest DTEP, accessed 31 August 2022, https://www.foresttwin.org/.
7 'Virtual Forests Are Coming', Metsä Group, accessed 31 July 2022, https://www.metsagroup.com/news-and-publications/others/campaigns/intelligent-forest/virtual-forests-are-coming/.; Visual Sweden Video, *Smart Twins for Forest Environment*, 2021, https://www.youtube.com/watch?v=edM3rWcNvqo.; 'MW Forest Sense AB', MW Forest Sense AB, accessed 25 August 2022, https://mwforestsense.com/. ; 'Digitalisering av hållbart skogsbruk - Mistra Digital Forest', Mistradigitalforest, accessed 25 August 2022, https://www.mistradigitalforest.se/.

are being developed both by and for the forest industry. While often framed in terms of green development, industry priorities chiefly include increasing their own productivity and profitability, excluding biodiversity from the values of forests.[8] As the forest industry adopts this modelling technology, it likewise remains steadfast in continuing business as usual: the industry stands in vocal opposition to the new Forest Strategy (along with closer-to-nature forestry) and plans to retain clear-cutting practices.[9]

8 According to Mistra Digital Forest, the three values in forests are only: the forest as a carbon sink, recreational values, and industrial values. 'Mistra Digital Forest', accessed 31 August 2022, https://www.mistra.org/en/research/mistra-digital-forest/.
9 Swedish Forest Industries, 'Forest Strategy: An Unacceptable Attempt to Regulate Forestry - Swedish Forest Industries Federation', accessed 25 August 2022, https://www.forestindustries.se/news/news/2021/06/forest-strategy/.

0.2 The Root of Forest is Unknown

In this dissertation, I consider what it means to model (and twin) complex systems such as forests environments. I argue that in designing and producing these models, it's necessary to go beyond a focus on exactitude and precision. In developing this argument, I draw from critical cybernetic management theories which emphasise dynamic and experimental responses to complex environments. I draw methodological connections between closer-to-nature forestry and cybernetic planning, regarding both as management approaches that share an aim of creating conditions for system parts to govern themselves. This shared aim of promoting environmental self-governance is crucial to the efficacy of either approach: to deal with the real is to engage with more complexity than what can be fully represented or controlled, necessitating a certain level of trust in intelligences implicit within systems. I argue that taking complexity seriously doesn't render models and knowledge obsolete; rather, models should be designed to communicate their limits and uncertainty to users. In fact, such an inbuilt acknowledgement of limitation should enhance models as navigational tools in an always incompletely known world - rather than be regarded as a defect. Consequentially, this dissertation discusses potential model designs in relation to closer-to-nature forestry that take complexity seriously and embrace the unknown and/or lesser known of complex environments. I begin by foregrounding a critique of the term 'nature' and its double, 'the natural', troubling their preoccupation with nature's static essence (what nature is rather than what it is otherwise or could be). I instead turn to the term 'hypernature', which dynamically approaches nature as always already beyond an established conception of what nature is. I argue that models should cognitively push towards an etymological root of forest, which from Latin 'foris' relate to 'the outside'. I conclude by turning also towards physical roots: I discuss ideas of the outside and un-/lesser known in relation to a model of subterranean fungi lives, a model I'm currently working on with mycologist Anders Dahlberg.

1.0 HYPERNATURAL MODELS

I first problematise the term ***nature*** *(1.0,1.1) – and then discuss the* ***artificial*** *as an alternative to the natural (1.2) – but as the artificial doesn't account for* ***unintentional intelligences*** *within ecosystems (1.3) – I turn to the term* ***hypernatural*** *(1.4) – and highlight the importance of* ***technology*** *when interacting with hypernature (1.5) – and caring for the* ***outside*** *(1.6)*

1.1 Closer to What?

For many, the term 'closer-to-nature' may evoke images of standing in a forest, smelling the rain-damp soil, or hugging a tree while feeling its bark partly crumble to the touch. Such images would assume nature to be a place that one can be physically closer to or further away from. But in its technical definition relating to forestry, 'closer-to-nature' is rather defined as "[l]earning from and permitting natural processes".[10] Importantly, this definition allows for treating nature not as a place put as a series of interrelated processes. As philosopher Ben Woodard, following Schelling, has noted: instead of a place, nature can be considered the "nested physical systems that comprise the cosmos".[11] Woodard's usage is the preferred definition I use throughout this paper: something that can be characterised as always physically close (people in cities materially comprise nature as much as the birds in the forest), but which can be descriptively far away (it's possible to paint a more

10 Larsen et al., *Closer-to-Nature Forest Management*.
11 Ben Woodard, *Schelling's Naturalism: Space, Motion and the Volition of Thought* (Edinburgh: Edinburgh University Press, 2019).1.

or less accurate picture of what constitutes reality). Yet, as a formulation of how things are, nature comes with its troublesome moral accomplice the natural.

1.2 Exit Nature

Lorraine Daston has framed the problem with nature and the natural as the confusion of 'what is' with 'what ought to be'.[12] Grounding morals in essentialist conceptualisations of nature is often used to legitimise social injustices by deeming certain practices or people unnatural. Such morality serves to uphold ruling orders by conversely presenting them as natural (e.g. racism, gender essentialism and economic injustices have all been, in various historical moments, legitimised through their branding as 'natural'). This tendency has led anti-essentialist thinkers to try to rid theory of the concept of nature all together or articulate 'anti-naturalist' positions.[13] Among

12 Lorraine Daston, *Against Nature: 17*, Illustrated edition (Cambridge, Massachusetts: The MIT Press, 2019).
13 Timothy Morton, *Ecology without Nature* (Cambridge, Mass.: Harvard University Press, 2009).; Laboria Cuboniks, 'Xenofeminism: A Politics for Alienation | Laboria Cuboniks',

the most explicit articulations is perhaps by the Xeno-feminist collective Laboria Cuboniks, who proclaim: "If nature is unjust, change nature!"[14] By emphasising that 'is' and 'ought' mustn't be confused and that what is considered to be is always a partial view, often dictated from a place of power, these positions complicate the static concept of nature and the natural in productive ways. This wariness is also applicable in the context of forest management in Sweden as the industry often justifies their practices as natural, pointing to essentialist notions about the ways things have been, are and always will be.[15] Conversely, and equally worthy of wariness, critics of the industry may deem industrial practices 'unnatural', which feeds on old romantic ideas of nature as an 'unspoiled place', where mechanical society is a

accessed 30 July 2022, https://laboriacuboniks.net/manifesto/xenofeminism-a-politics-for-alienation/.

14 Laboria Cuboniks, 'Xenofeminism: A Politics for Alienation | Laboria Cuboniks'

15 Consider the promotional video 'The forest – changes and remains the same' by Swedish Cellulose Company 'We Are Driven by the Force of the Forest', accessed 28 August 2022, https://www.sca.com/en/.

malaise that “learning from nature must cure”.[16]

1.3 the Artificial

In relation to ecosystem management and climate change governance, design theorist Benjamin Bratton has proposed a conceptual turn towards ‘the artificial’. In opposition to revamped ideas of the natural, Bratton emphasises that any response to anthropogenic climate change needs to be equally anthropogenic, in the sense of being deliberately brought about and thus artificial.[17] Commenting on the idea ‘Earth needs half’, campaigned by biologist E.O. Wilson, Bratton further concludes that the two halves - (1) the half composed of human and machine populated mega cities and (2) the rewilded park where ecosystems are allowed to recover - mirror each other in their artificiality.[18] This conceptual move toward the artificial points to the reality that any act of setting areas aside (e.g.

16 Raymond Williams, *Keywords: A Vocabulary of Culture and Society*, New edition (Oxford ; New York: Oxford University Press, 2014).
17 Benjamin Bratton, *The Terraforming* (Strelka Press, 2019). eBook, The Artificial Plan.
18 Bratton. eBook, Planning the Parks.

conservation areas, rewilding zones) are still forms of governing and management. These practices involve cultural and technological interventions just as much as moving dirt or planting trees directly reshapes the land. Excluding people is in no way a natural act.

1.4 Intending the Unintentional

While the idea of the artificial is productive for clarifying that acts such as rewilding are indeed anthropogenic, it does not parse the difference between e.g. planting trees in neat rows and minimising contact to let forests, more or less, grow back in their own shape and pace. Following Bratton, the artificial should be identified "as a trace of intention and design", and leaving forests to recover mostly by themselves would require minimising indications of intention.[19] While I'm sympathetic towards anti-naturalist and artificial conceptualisations as developed by thinkers such as Laboria Cuboniks and Bratton, I nonetheless wish to emphasise that environments such as

19 Benjamin Bratton, *The Terraforming* (Strelka Press, 2019). eBook, The Artificial Plan/The Artificial.

forests are complex systems that have modes of self-regulation calibrated over long periods of time and on such a fine level that it's likely (not essentially) damaging to reduce their variety by managing them based on what can neatly be moulded in human form. As I know of no fitting term to describe this non-human, non-deliberate feature once nature is abandoned, I will instead, for the sake of argument, turn to an always expanded (and never untroubled) version of it.

1.5 Hypernatural

Importantly, this troubled version is not nature as a blueprint for what morally ought to be -socially or materially- but as processes which might know things humans don't. Seeing nature as a process that is always only partially revealed means to never take it as a stable given. This approach hinges not so much on a refusal of nature, but an active engagement with it, because as Woodard points out "attempting to know what nature is expands the distant boundary of what we thought it was".[20]

20 Woodard, *Schelling's Naturalism*.

Cultural theorist Mark Fisher has defined the term hypernaturalism as “an expanded sense of what the material cosmos contains”.[21] Thus, the point of reference in hypernature is always already beyond the established conception of nature, and thus constantly denaturalises anything currently known.

1.6 Closeness by way of Remoteness

When deliberating on her concept of xeno-solidarity -the ability to exercise care for the other and be hospitable to difference- the Xenofeminist theorist Helen Hester references philosopher Alexis Shotwell’s notion of ‘hobby naturalism’.[22] Exemplified through activities such as recognising birdsongs or certain traits of trees, hobby naturalism becomes a “method of training people to be attentive to their environment in a way they

21 Mark Fisher, *The Weird and the Eerie*, 3rd Edition (London: Repeater, 2016).

22 ‘Helen Hester on Xeno-Solidarity and the Collective Struggle for Free Time’, Strelka Mag, accessed 6 July 2022, https://strelkamag.com/en/article/helen-hester-on-xeno-solidarity-and-the-collective-struggle-for-free-time.: Helen Hester, ‘Sapience + Care’, Angelaki 24, no. 1 (2 January 2019): 75, https://doi.org/10.1080/0969725X.2019.1568734.

weren't before".[23] Hester notes that these practices of becoming aware of critters and flora which were previously imperceptible does not need to be inhospitable towards technology, nor towards the human capacity for abstract reasoning.[24] Hester instead advocates "that it is as crucial to any ability to deprioritize ourselves and our immediate concerns in favour of recognizing wider obligations to the environmental networks of which we are a part".[25] The human body is an exceptional environmental sensor, but its bandwidth is limited to the scale of human perception. Forests exceed humans both downwards (for instance as microscopic mycorrhizae hypha crawling in the soil) and upwards (for instance as technologies implicated in planetary carbon cycles). Forests are simultaneously too large and too small to experience as immediate places. The process of getting closer to (hyper)nature and engaging with environments beyond the local scale of the body is largely premised on technologies, and abstractions

23 Hester, 'Sapience + Care', 74. ibid.
24 Hester, 'Sapience + Care', 75. ibid
25 'Helen Hester on Xeno-Solidarity and the Collective Struggle for Free Time'.

produced by them can bring people closer to, rather than further away from, canopy covers and microbes.

1.7 Care for the Not Yet Known

Hobby naturalism, as proposed by Shotwell, can be a hypernaturalism but it doesn't have to be. Learning to recognise birdsongs can attune people to their surroundings in important ways, it can broaden the scope of how to access the world but without necessarily challenging the idea of what composes it. People might already know of the birds whose songs they learn to recognise, which, as an example, can be valuable for identifying species known to be endangered in order to protect them. But limiting the capacity for care to what is known privileges the 1.2 million species that are so far identified and leaves out the estimated 6.5 million unidentified species.[26] Caring for the hypernatural must also include caring for the not yet known, and that which remains unknown.

26 'How Many Species on Earth? About 8.7 Million, New Estimate Says', ScienceDaily, accessed 30 July 2022, https://www.sciencedaily.com/releases/2011/08/110823180459.htm.

1.8 Designing Wildness

Regarding ecosystem management, practices of rewilding interestingly allude to a framework capable of including the unidentified in the plan. Whereas traditional conservation practices focus on finetuning interventions by focusing on individual species (which are already known), rewilding takes a landscape and system-based approach to allow both known and unknown species to create liveable habitats for each-other.[27] To continue this track, which considers effective management and freedom (for the known and unknown) to be integral to one another, - I will turn to discuss cybernetics.

27 'Rewilding and Conservation', Rewilding Britain, accessed 28 August 2022, https://www.rewildingbritain.org.uk/explore-rewilding/what-is-rewilding/rewilding-and-conservation.

2.0 DESIGNING FREEDOM

Care for the outside cannot wait for ***knowledge*** *(2.1) – so how to care for the* ***unknown?*** *(2.2) – by allowing it to* ***care for itself*** *instead of controlling it (2.3) – but importantly to allow something to care for itself also* ***requires management*** *(2.4)*

2.1 Useful Imperfection

Care for the unknown cannot be postponed to the moment when it becomes known. To continue the topic of biodiversity, species risk going extinct whether they are identified or not. So, while it's helpful to expand the knowledge about the world, both to better know it and to unsettle current convictions about it, there's a need to manage it without mapping every corner and opening every black box. On the face of it, this reality may seem obvious: models are often non-exhaustive simplifications of the worlds they model and are often helpful in informing operative decisions precisely because of their simplifying quality. Yet, as sociologist Andrew Pickering notes, although conventional information systems are occasionally drawn upon for action, they are mostly detached from real world performance.[28] Data collection is often treated as an end in itself; improving models risks being reductively equated with increasing resolution, instead of how well they manage to

28 Andrew Pickering, 'The Science of the Unknowable: Stafford Beer's Cybernetic Informatics', *Kybernetes* 33, no. 3/4 (1 March 2004): 499–521, https://doi.org/10.1108/03684920410523535.

inform action upon and within the worlds they model.

2.2 the Science of the Unknowable

Pickering, who has written vastly on British cybernetics, frames the distinction between mainstream and cybernetic informatics as one of ontology. Conventional informatics he says, is representational; that is, it is all about accumulating knowledge and data. Conventional informatics believes that “the world is a regular, law-like place that can be known more or less exhaustively. It is a place that can therefore be controlled and dominated through knowledge.”[29] In contrast, cybernetics, or “the science of the unknown” as Pickering calls it, treats the world as filled with objects and processes that needs to be dealt with without knowledge of how each internal lever functions.[30] Rather than being about what the system is - deciphering its code - cybernetics ask how it performs.[31] This might sound strange,

29 Pickering.
30 Pickering.
31 Pickering.

as cybernetics is often defined as the science of control, originating from Norbert Wieners work during the second world war on anti-aircraft systems. Wieners' systems predicted the movement of approaching enemy planes in order to fire not at where they were, but at where they would be. In this imaginary, there is little or no room for freedom or creativity; these systems focus on programmed execution based on calculated trajectories, rather than dynamic and engaged responses. In contrast, British cybernetician Stafford Beer, in his small book Designing Freedom, reformulates the definition from Wiener's "science of control and communication in the animal and the machine" to his preferred "science of effective management".[32]

2.3 Steersmanship

While discussing Beer's approach to management, Pickering also recalls the etymology of cybernetics, derived from Greek 'kybernetics', or 'steersmanship'. Evoking the image of a ship in an ocean of waves, steering is not about controlling

32 Stafford Beer, *Designing Freedom* (Toronto (Canada), 1993).6.

the environment, such as the direction of the waves, but to dynamically react to it.[33] In the case of forestry, the waves of Pickering's analytic can be analogised to trees, moss, wildlife and so on. And for Beer's cybernetic organisation, it's less about steering each level of the system from a central control room as it is about enabling the different sections to steer themselves; it's premised on trust in all levels of the system.[34] In contrast, under current orders of neoliberalism, management has, as Fisher has argued, largely been equated with managerialism, characterised by its emphasis on ubiquitously monitoring everything.[35]

2.4 Neither Full nor No Control

Before discussing cybernetics in relation to emerging systems for ecosystem management, I'd like to clarify two conceptions of cybernetics

33 Pickering.

34 PodBean Development, '018 - The Cybernetic Brain, Part 1: Ontological Theatre', accessed 30 July 2022, http://generalintellectunit.net/e/018-the-cybernetic-brain-part-1-ontological-theatre/.

35 Mark Fisher, "Accelerate Management," PARSE, accessed August 31, 2022, https://parsejournal.com/article/accelerate-management/.

which I find to be unproductive avenues. The first is as mentioned that of full control. This is the faith of the military and the police state. The second is that of no control at all; the belief that if all forms of management are abandoned systems will self-organise in desirable ways. In relation to forest management the regime of control is easily recognisable in the straight rows of trees imposed in grid like formation on the land. On the other hand, the ones that advocate for no control at all, to let forests completely be in order to let them care for themselves. This is also easily a misconception about rewilding, that it's all about not interfering, to simply "let nature do its thing".[36] But although this is to a large extent the ambition of the dispersed movement - to one day "step back and allow nature to manage itself"[37] - it is also internally acknowledged that to accomplish this involves active management, whether by introducing

36 'Rewilding Britain: Letting Nature "Do Its Thing" Could Help Solve Climate Change', One Earth, accessed 3 August 2022, https://www.oneearth.org/rewilding-britain-letting-nature-do-its-thing-could-help-solve-climate-change/.
37 'What Is Rewilding?', Rewilding Europe, accessed 3 August 2022, https://rewildingeurope.com/what-is-rewilding-2/.

species, planting trees, or vitally restricting human access or investment.

3.0 PRECISION FORESTRY

*While **forest management** is becoming increasingly **digital** (3.1) – it's important to not confuse ecosystems with spaceship **engines** (3.2) – that is, systems that can be controlled with **military precision** (3.3) – yet much ecosystems management **polices environments** (3.4) – regulations **legitimise interventions** as much as they prohibit them (3.5)*

3.1 Smart Forests Twins

Forests are increasingly being both accounted for through and populated with technology. As emerging technologized sites of data production, they are sometimes referred to as smart forests.[38] And like their urban counterpart 'Smart Cities', Smart Forests are likewise about automatization and optimisation through data collection and algorithmic planning; for the forest industry this chiefly concerns the supply chain to increase productivity and profitability.[39] Sensors are mounted on tree trunks and in the soil, satellites monitor canopies from space and drones prepared with LiDAR scanners fly over and through forests to produce high resolution three-dimensional virtual representations.[40] A key component of smart environments, cities and forests, enabled by

38 Jennifer Gabrys, 'Smart Forests and Data Practices: From the Internet of Trees to Planetary Governance', *Big Data & Society* 7, no. 1 (1 January 2020): 2053951720904871, https://doi.org/10.1177/2053951720904871.

39 'Tieto Forest Hub | Tietoevry', accessed 29 August 2022, https://www.tietoevry.com/en/industries/forest-pulp-paper-and-fibre/forest-solutions/wood-and-fibre-ecosystem-and-integration/tieto-forest-hub/.

40 Gabrys, 'Smart Forests and Data Practices'.

the surge in data collection, are so called Digital Twins. Digital Twins are commonly referred to as digital representations of physical assets –objects or systems.[41] Often, it's included in the definition that there should be a feedback loop between the virtual representation and the physical counterpart, they should inform and dynamically respond to each other. Moreover, as the term gives away, there's a fixation on exactitude. Digital Twins are often said to both "look like and behave identically to [their] real-world counterpart".[42]

3.2 From Spaceship to Earth

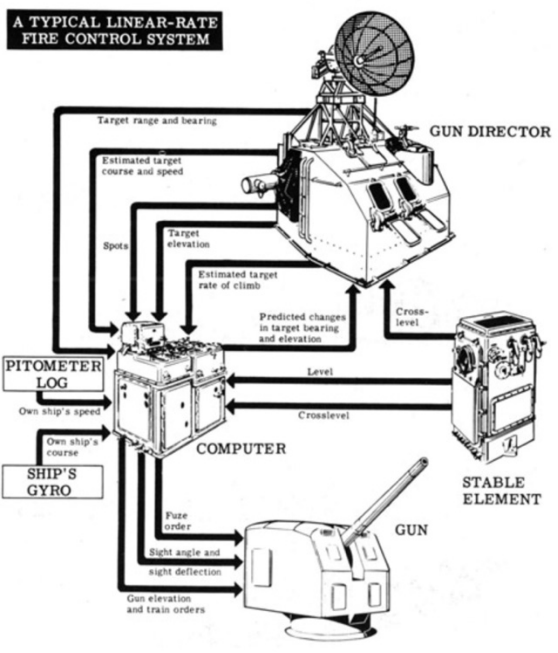
The first use of Digital Twins to study and manage distant physical objects is often attributed to NASA in the 60's. The technology was dramatically demonstrated during the Apollo 13 emergency when the spaceship suffered an explosion. NASA digitally replicated the spaceship system on the ground to

41 The financial term 'asset' is common when Digital Twins are discussed as they are most often implemented to optimise systems in order to maximise profits.
42 Unity Technologies, 'What Is a Digital Twin and How Does It Work? | Unity', accessed 26 July 2022, https://unity.com/solutions/digital-twin-definition.

run diagnostic simulations and instruct the crew onboard how to safely navigate back to Earth.[43] While the term Digital Twin wasn't popularised until early in the 21st century, there are important legacies from this period to consider.[44] The Apollo missions spurred the idea that planet Earth itself was a spaceship in need of care, afforded through monitoring and optimisation. Recalling Pickering's analogy of the steersman, the model of the ship was erroneously transposed to the waves. As historian Sabine Höhler has argued, the spaceship analogy not only portrayed the planet as a fragile system in need of care, but also as a closed system that could be mastered through knowledge.[45] The emphasis on exactitude may have grounding in systems such as car engines or spaceships, while they arguably fall short when applied to what Beer has called "exceedingly complex systems" - systems that cannot be fully known and therefore

43 Unity Technologies.
44 'The Mysterious History of Digital Twin Technology and Who Created It', Challenge Advisory, accessed 26 July 2022, https://www.challenge.org/insights/digital-twin-history/.
45 Sabine Höhler, *Spaceship Earth in the Environmental Age, 1960-1990*, History and Philosophy of Technoscience, number 4 (London: Pickering & Chatto, 2015).

not dealt with purely through knowledge. In other words, the well-known ontology of mainstream informatics, which aspires to exhaustively know the world through ever larger databases and faster information systems is not enough when dealing with systems that are too large and complex to model.



Typical Anti Aircraft Fire Control Systems: https://maritime.org/doc/firecontrol/partg.php

3.3 Fire-Control System

The idea of precision is integral to the digital transformation in forest management, and the industry usually refers to the new set of technology-enabled practices as precision forestry.[46] Its aspiration for control is suggestive of military cybernetics. In a conference on "Smart Twins for Forest Fires" hosted by Visual Sweden earlier this year, discussions of fire-control systems features were reminiscent of Wieners' predictive anti-aircraft systems. There, one of the project managers explained to a fire brigade representative that with the new Smart Twin technology, it will be possible to predict where fires will occur both in advance and with such precision that fire fighters will have the capacity to pre-emptively extinguish them.[47] Elsewhere, but in a similar vein,

46 'The Precision Forestry Revolution | McKinsey', accessed 26 August 2022, https://www.mckinsey.com/industries/paper-forest-products-and-packaging/our-insights/precision-forestry-a-revolution-in-the-woods.

47 The military connection is not coincidental, the person who explained the pre-emptive potentials of Smart Twins to the fire fighter has a long-standing background as a director at the Swedish Defence Research Agency. Today he's heading the project 'Smart Twins for forests environments' at Visual Sweden together with the head of research at the Swedish National

another fire suppression technology by the name of ‘smart dust’ has been under discussion. Based on nanotechnology, the idea underpinning smart dust is that sensors, barely larger than a grain of sand, could be sprayed from planes over forests to turn whole landscapes into fire detectors.[48] The complete and granular mapping of forests could allow for high-precision early interventions, targeting sparks immediately before they grow into sizable fires, as opposed to engaging with the landscape more holistically (e.g. by allowing smaller fires to burn more frequently).[49]

Police Authority. While Visual Sweden is a university affiliated research project there’s the two main companies in Sweden that commercially produce Digital Twins of forests are MW group, previously Military Works Group, and Deep Forestry, where the founder and CEO has a background in the Australian Navy: Unrecorded webinar attended by the author “Smart forest twins and forest fires” April 2022.

48 I. Chatzigiannakis and S. Nikoletseas, ‘A Sleep-Awake Protocol for Information Propagation in Smart Dust Networks’, in *Proceedings International Parallel and Distributed Processing Symposium* (International Parallel and Distributed Processing Symposium (IPDPS 2003), Nice, France: IEEE Comput. Soc, 2003), 8, https://doi.org/10.1109/IPDPS.2003.1213413.

49 ‘What Turned California Forests into a Tinderbox? Fire Suppression, Paradoxically’, *The Guardian*, 14 September 2020, sec. Opinion, https://www.theguardian.com/commentisfree/2020/sep/14/california-fire-suppression-forests-tinderbox.

3.4 Forensic Warehouse

When asked about the importance of resolution, the program manager at the research program for Smart Forest Twins stated that they worked in the interests not only of forest owners, but also of the digital forensics department at the Swedish police. The forest is a potential crime scene, and when looking for evidence, accuracy is everything; as the program manager notes, "[W]e want to be able to see every individual leaf."[50] Thanks to drone captured LiDAR scans, this resolution is largely attenable. And while the police wish to use these models to let machine vision spot blood or weapons in forests, commercial companies targeting the forest industry focus on utilising the same models for capturing and visualising productivity data.[51] Advertised as allowing owners to "know everything about [their] forest," these Digital Twins reduce 'everything' to "tree species,

50 Unrecorded interview with Lena Klasén from Visual Sweden, October 2021.

51 Vreta Kluster, *Möte i Den Digitala Skogen – Smarta Skogstvillingar*, 2022, https://www.youtube.com/watch?v=XmH4fEeydzQ.

height, diameter, curvature and trunk volume”.[52] The models are essentially framed as more detailed stock inventories.[53] This stock-taking approach to forests finds its metric both in data such as timber volume, as well as biodiversity indexes; ironically, the work to optimise profits also benefits from greater ease in proving that environmental market certification requirements are met.[54]

3.5 Exactitude What?

It’s important to note that environmental standards, such as impact assessments, are supposed to impose limits to ecosystem disturbances; however, in practice some of these standards risk enabling industrial interventions more than holding them to account. For instance, prohibiting damages to environments above certain thresholds also

52 And will soon include ‘tree age, soil moisture, soil fertility class, wood imperfections, and wood quality class’ Pickering, ‘The Science of the Unknowable’.
53 Visual Sweden Video, *Smart Twins for Forest Environment*.
54 ‘Lovande resultat för ny metod att bedöma biodiversitet’, Mistradigitalforest, 21 June 2022, https://www.mistradigitalforest.se/nyheter/lovande-resultat-for-ny-metod-att-bedoma-biodiversitet/.

implicitly endorses anything below them.[55] To illustrate, biodiversity maps recently produced by Mistra Digital Forest, the industry's research institute, show a forest where the colour red is used to mark areas of conservation concern (Image 1), while the surrounding areas are inversely classified as low priority. On Mistra's website, a testimony from an ecologist employed by the forest company Södra is provided, praising the model for its precision.[56] But while this model is lauded for its supposedly improved precision, it remains a crude representation of what is holistically taking place on the ground. Arguably, this selective distribution of precision and crudeness in representation is in fact, highly calculated: the data that the model is exact about - its capacity to pinpoint defined biodiversity proxies such as fallen trees (Image 2) - is precisely what bestows the model with its value to the industry. For a forest owner who wants to

55 Nicolas Baya-Laffite, 'Black-Boxing Sustainable Development: Environmental Impact Assessment on the River Uruguay', in *Knowing Governance*, ed. Jan-Peter Voß and Richard Freeman (London: Palgrave Macmillan UK, 2016), 237–55, https://doi.org/10.1057/9781137514509_11.
56 'Lovande resultat för ny metod att bedöma biodiversitet'.

tick the conservation box on an eco-certificate, the level of precision is celebrated as the model helps legitimise profit- and productivity-driven interventions falling outside the red areas - those zones that programmatically exceed the model's logic for conservation concern.

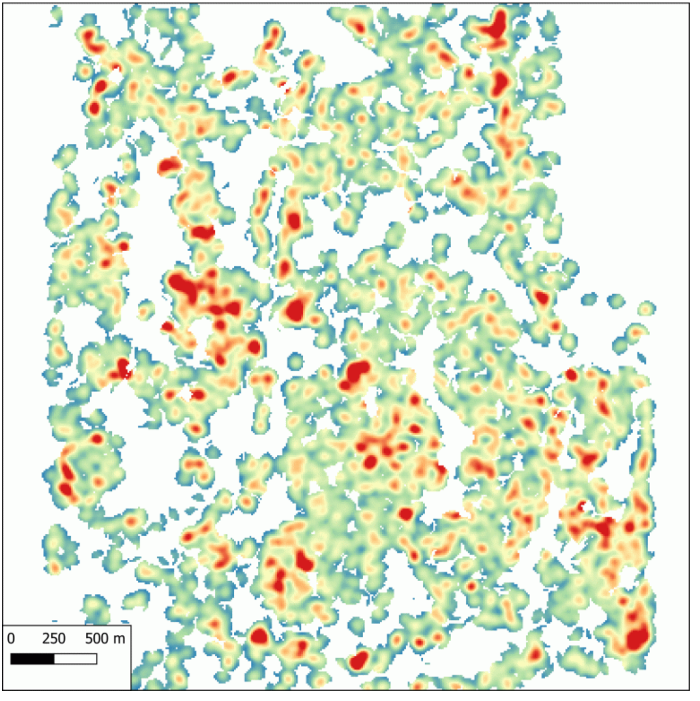


Image 1. This images shows a forest where red marks areas of intrest for conservation.https://www.mistradigitalforest.se/nyheter/lovande-resultat-for-ny-metod-att-bedoma-biodiversitet/

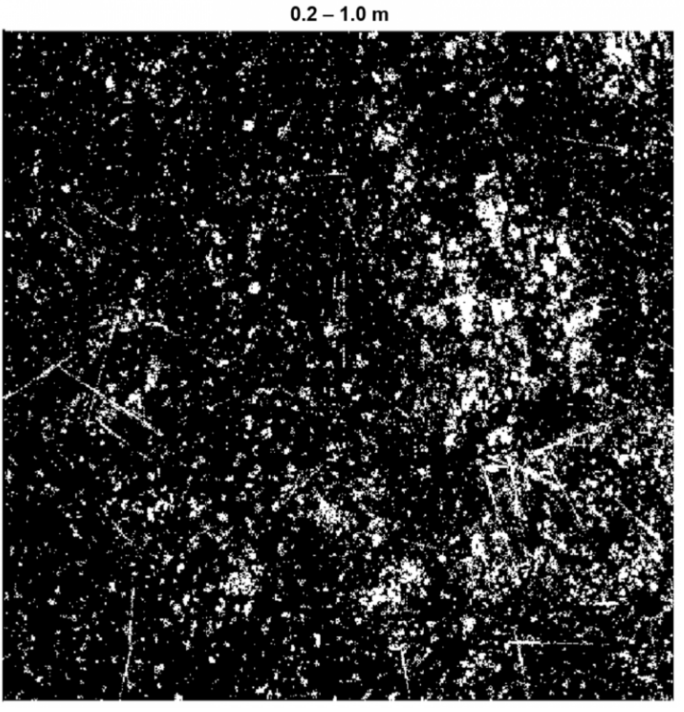


Image 2. This image shows how fallen trees (lines in the image) can be detected by means of remotesensing which help indicate areas of conservation https://www.mistradigitalforest.se/nyheter/lovande-resultat-for-ny-metod-att-bedoma-biodiversitet/

4.0 THE HUMAN IN THE SYSTEM

Forestry requires ***complex managers*** *(4.1) – which can mean* ***people****. (4.2) –While considering* ***small landowners,*** *(4.3) –how they* ***interface forests*** *digitally (4.4) –and how their experience is becoming* ***immersive*** *(4.5) –it's in place to question* ***verisimilitude*** *(4.6) –and ask if models should challenge* ***reality*** *instead of merely depicting it (4.7)*

4.1 Complex Systems Need Complex Care

A central principle in cybernetic theory is Ashby's law of requisite variety, which states that any system deployed for management needs to have more possible system outputs (have a larger variety) than the system it manages.[57] Often though, management operates by means of decreasing the amount of complexity in the environment rather than amping up the complexity of the system which manages it. The industrial plantation system is obvious in this regard: to control the environment, wildlife is fenced out, crops or trees are planted in neat rows, and weeds, insects and microbes are eradicated with chemicals. The environment is reformatted to be no more complex than the manager's ledger. The rise of Smart Forestry seems to be trending toward creating more complex management systems; but when considered in a landscape of abstract environmental standards decoupled from on-the-ground complexity, the success of these optimised systems remains. This

57 M. Boisot and Bill Mckelvey, 'Complexity and Organization–Environment Relations: Revisiting Ashby's Law of Requisite Variety', 2011, 279–98, https://doi.org/10.4135/9781446201084.n16.

is not to say that technologies such as sensor and artificial intelligence cannot be useful; but rather - even as early cybernetics had already recognised - the efficacy of complex management systems should not rely purely and unequivocally on the newest forms of technology. It's instead possible to leverage complexity already present in the world. To a degree, this means engaging with the environment itself, but it can also mean human operators, which in themselves are highly intelligent systems, able to digest information and dynamically respond to their environment.

4.2 more Experts less Machines

The Natural Forest Academy, a German institute which carries out research and publishes best practices, states as their primary advice: "Natural forest management requires qualified decisions. This is why the principle applies: more forestry experts instead of more machinery."[58] Echoing Ashby's law, as nature-based forest management tries to avoid flattening ecosystems by reducing

58 'Forestry', *Naturwald Akademie* (blog), accessed 29 August 2022, https://naturwald-akademie.org/en/forestry-2/.

their variety, it needs to increase the variety internal to the managing system. And while contrasting experts with machines mainly speaks to the poor capacity for dynamic responses that machines such as harvesters or woodchippers possess, imagining experts should not have to be hostile to technology writ large. Technology, as mentioned earlier, can help augment the capacity to sense forests; through highly considered models, technology can assist caretakers in making informed decisions.

4.3 Small Landowners and their Forests

In Sweden, almost 50% of forests are owned by small landowners, and since the early 20th century companies are prohibited from acquiring private land which means this is unlikely to change.[59] Because of this, the wood and pulp industry are highly dependent on forest owners to provide cheap timber to the mills. Leif Öster, previous head of communication at the national forest company

59 ‘Norrländska förbudslagen’, in *Wikipedia*, 16 May 2021, https://sv.wikipedia.org/w/index.php?title=Norrl%C3%A4ndska_f%C3%B6rbudslagen&oldid=49245194.

in Sweden, Sveaskog, and now vocal critic of the current forestry system, told me in an interview that forest owners who own smaller areas of land harvest rarely and have thus less knowledge about the procedures. They are therefore very dependent on industry advisors with interest to buy timber in the moment or in the future. According to Öster there's a sly saying within the industry: "The advice is a door opener, the timber contract is the goal", to which he added, "they always want to give the advice to continue with clearcuts. They never mention that there are other more modern methods available". [60]

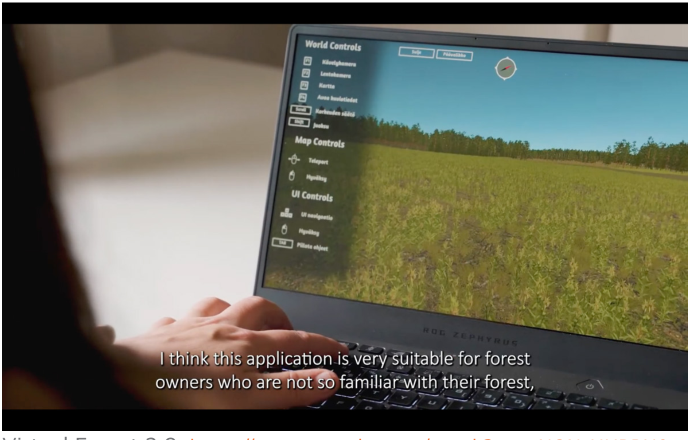
4.4 Digital Forest Plans

Besides personal contact with local industry advisors, forest owners usually have a forest management plan which informs them about what actions needs to be taken when. Management plans used to be analogue documents but are today almost exclusively digital. Most companies

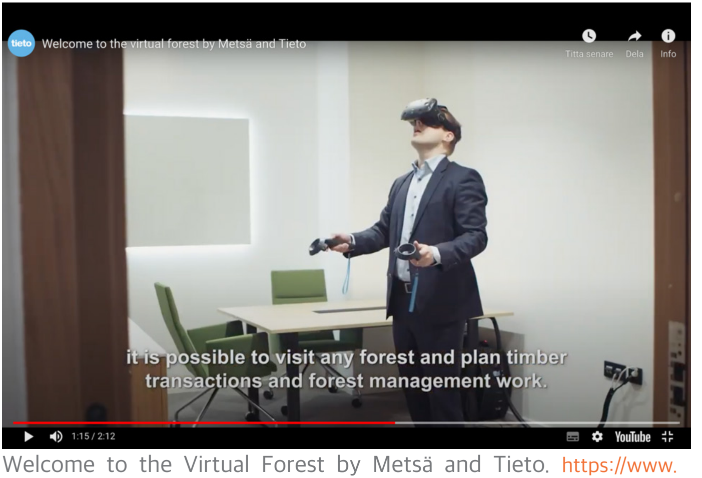
60 . Saying translated from Swedish 'rådgivningen är dörröppnaren, virkeskontraktet är målet', Untranscribed interview with the author, September 2021.

develop forestry apps that they encourage associated owners to use, while outside the private sector, the Swedish Forest Agency also provide their own. Plans commonly show felling category (e.g. K2 'newly planted', S2 'ready for final harvest'), age, site index (stand productivity), volume, tree species distribution and suggested actions, alongside information demarcating areas used for timber production versus areas earmarked for other purposes, such as conservation.[61] One objective with the digital planning apps is to encourage forest owners to undertake active forest management, since the industry relies on owners to provide them with timber. Active management becomes especially important as more and more forest owners live far away from their forests, often in cities, and are also reliant on other sources of income.

61 'Skogsbruksplanen – ett viktigt verktyg', accessed 26 August 2022, https://www.skogsstyrelsen.se/aga-skog/du-och-din-skog/skogsbruksplanen/.



Virtual Forest 2.0. https://www.youtube.com/watch?v=pnNQNsHHRRU&t=3s&ab_channel=ROSEWOOD4.0Network



Welcome to the Virtual Forest by Metsä and Tieto. https://www.tietoevry.com/en/success-stories/2018/metsa-group-virtual-forest/

4.5 Virtual Forest

In a promotional video from 2017 titled "Welcome to the virtual forest by Metsä and Tieto," the Executive Vice President of the Finnish forest company states that "in the future, working urban citizens will own increasingly more forests and progressively fewer of those will have the time, know-how and skills required for professional forest management." He then proceeds to put on a VR headset to demonstrate the company's virtual forest prototype, which visually expands their current mobile forest apps (or 'pocket forests' as they call them). One of the videos key takeaways is that these forest apps make it "possible to conduct forest business anytime and anywhere".[62] Similarly, in 2020, the EU funded project "Virtual Forest 2.0", developed by researchers at Lapland University and game designers at FrostBit Software Lab, published a public version of their virtual forest application, which allows forest owners to walk or fly through their forest from the comfort of their own homes.

62 Tietoevry.com, 'Metsä Group's Virtual Forest', accessed 29 August 2022, https://www.tietoevry.com/en/success-stories/2018/metsa-group-virtual-forest/.:'Virtual Forests Are Coming'.

It is also promoted as a tool for owners to simulate different logging scenarios and their effects on the landscape before deciding on an intervention. On the face of it, these tools offer owners increased financial control over their forests; but in omitting uncertainty and complexity from these simulated landscapes, these tools also risk evoking a false sense of ecological mastery.

4.6 From photorealism

Digital Twins and virtual environments created in game software such as Unity and Unreal Engine often strive towards photorealism in order to more 'faithfully' reference the objects or environments they model.[63] Although they might seem visually complex, virtual forest environments actually include only a handful of tree models which are subsequently cloned thousandfold to cover the landscape. A few individual broken twigs, moss and rocks might be added to lessen the impression of homogeneity.[64] It's important to remember that

63 'Virtual Forests Are Coming'.
64 Alenda Y. Chang, *Playing Nature: Ecology in Video Games*, Electronic Mediations 58 (Minneapolis: University of Minnesota Press, 2019), 115.

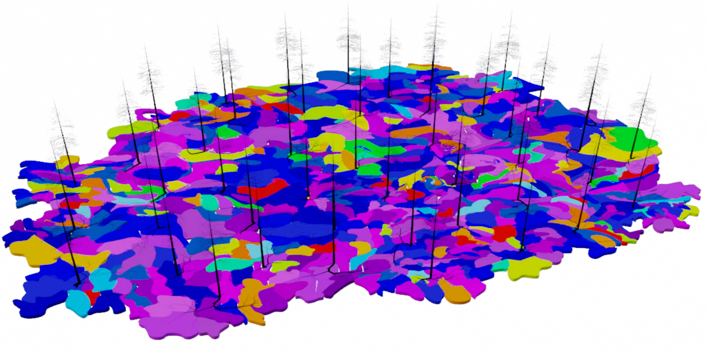
Unreal Engine 4 Model, Mawi United GmbH, 2016 https://www.unrealengine.com/marketplace/en-US/product/conifer-forest-collection

photorealistic is not the same as realistic; it's easy to overlook that photorealism pertains to a realistic reproduction of a photo, not reality. As composites of numerous, layered images and scripted effects, three-dimensional models still don't capture the richness of reality. Virtual forests are made up only of object surfaces; trees are hollow with only a pixel thick layer of bark, no water travels through their stem and below the ground there are no roots.

4.7 to hypernaturalism

One possible response to the complexity-depleted virtual forests the industry is creating could be to visualise site-specific biodiversity, such as squirrels, rare birds and worms. Such additions could arguably be considered a more accurate representation of a place, but the approach also risks falling into the trap of equating more accurate models with more data. While not being antithetical to such approaches - mapping and communicating species distribution is valuable work- the role of models is not to fully capture reality. Rather than striving to reproduce images of natural environments to serve as substitutes for static nature, models can be explored as sketches for managing the hypernatural. Instead of reconstructing experiences of physical forests - plantations or old growths- how can models unsettle current conceptions of what forests are? Models of the hypernatural can be considered epistemological tools that dynamically challenge the conception of what constitute reality. As such, two design avenues can be conceived: (1) Modelling the lesser known: A model that presents something unfamiliar to a person can challenge their conception of the world, even though this something is already acknowledged elsewhere. (2) Modelling the unknown: While, this is largely an oxymoron, designs can emphasise the incompleteness of models, they can be suggestive of the outside to knowledge.

5.0 MODEL UNGROUNDING



Model sketch by Author, 2022

5.1 Intro

Before concluding I will discuss how uncertainty and hypernatural qualities can be imagined in ecosystem management models by example of a model I'm working on, with assistance from mycologist Anders Dahlberg. At the time of writing, this model exists as sketches; discussing it at this stage allows me to share certain questions and ideas I have explored when designing the model.

5.2 Objective

The model is aimed towards forest owners rather than scientist and my objective is primarily two-fold: to show the spatial distribution of mycorrhiza[65] to highlight its otherwise hidden presence and to show the effect different forestry practices have on it.

65 Mycorrhizae are fungi that live in symbiosis with plant roots; trees provide sugar to the fungi who in turn provide nutrients such as phosphorus and nitrogen to the trees.

5.3 the Scientific Ground

Without discussing the science in detail, the three building blocks for the model are:

(1) the linear correlation between how many trees are cut down and how much mycorrhiza is lost;
(2) knowledge from previous studies of the relative occurrence of species in different environments - with this information it's possible to hypothesise the risk of rare species being lost if x number of trees are cut down; and
(3) a database that Dahlberg and others at the Swedish University of Agriculture have compiled from nationwide soil inventories, which gives an estimate to what species exist where, and to what extent, which allows us to make site specific estimates across the country.

5.4 Unstable Image

Importantly, all estimates are rough, and the model can only show possible presences and absences of species. As mycorrhizae is hidden from view by being underground, the act of verifying the specific effect of a particular felling - i.e. what certain species are lost when a tree is logged - becomes impossible. As such, it's inconceivable to cut down trees in exception to their relationship to endangered species. To visually emphasise this inextricability, I propose avoiding presenting a stable and/or static image. Instead, a randomly generated species distribution map (from the approximated list of possible species present) would be spatially mosaiced along the forest floor, regenerated with a different outcome each time the model loads.

5.5 Complexity as Information

Moreover, I plan to visualise all species at once, with the aim of displaying an overwhelming amount of data that privileges complexity over clarity. This aesthetic effect is potentially undesirable, as users may be inundated by the knotty and oversaturated information presented, which in turn may prevent them from deriving meaningful information from the model. But in the case of this mycorrhiza model, I consider complexity itself part of the meaningful information, even if the information may not be of immediate use as defined by existing industry metrics. Yet, as I consider it important to be able to discern what species are possibly present, I am working towards allowing each species to be presented as a layer, enabling users to toggle the amount of information presented at any given moment.

5.6 false precision

The physical forms of mycorrhiza pose a problem for representation. Living underground, mycorrhiza are difficult to study, and even if they were visible, they don't have well-defined shapes; mycorrhiza are moulded by their environment to be long, thin, small or large. Dahlberg therefore insisted on taking precaution to not create false precision when depicting the relative shapes and sizes of different species. As not enough information is available for all mycorrhiza species, even the ones that are known to be generally smaller versus generally larger will all be represented along the same size scale. In this instance, greater abstraction is a tool for dealing with uncertainty.

5.7 general vs more precise models

Different models do different things. Dahlberg first proposed that I should make a more precise model by using a test site where more accurate data exists. Such a model might be helpful for scientists studying fungi distributions and their relationships. However, for use in forestry, a more general and less precise model that can be scaled and used in different locations is potentially more useful. As I've argued throughout this essay, there are problems with striving for precision in management. Instead, the quality of models should also be judged by how well it acts back on what it models, which is directly dependent on its capacity to be applied as a tool for management.

6.0 CONCLUSION

6.1 Smart for Rest

In this dissertation, I have critiqued the emphasis on precision in models, which is particularly evident in Digital Twins. I also argue that this focus on precision is over-reliant on finding certainty, and thereby tends to favour conceptions of the known at the expense of the unknown. In response, I have considered two levels of designs of management models that include and rely on the unknown. (1) The level of interfaces to complex systems. I here argue that they should avoid communicating images of totality. As the unknown cannot rely on regimes of representation, representations should remind users of their incompleteness and allude to the outside. I have in this dissertation focused on interfaces' need to encourage attitudes of curiosity towards the unknown, not how or where encounters with the unknown takes place. (2) The level of management systems. I have here drawn upon critical cybernetic theory, which equates effective management with the enablement of systems to steer themselves. In other words, by drawing on cybernetic management systems while discussing forms of ecosystem management, I have argued that effective management should allow ecosystems time and space to activate their known and unknown capacities for intelligent self-governance. Importantly, I've highlighted that the capacity for self-governance is not opposed to management but rather facilitated by it. Yet, as ecosystem management moves forward, it should not simply need to mean increased monitoring in search of expanding datasets. Instead of Smart Forests, that celebrate precision by investing in ever more sensors, is it possible to conceive of management as 'Smart for Rest'? Where forests are acknowledged as already intelligent and, enabled by management systems with respect for the unknown, capable of effective self-governance.

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In place of managers who inundate us with micro-demands, can't we imagine managers who see their role as providing us with a space to think?

-Mark Fisher (Accelerate Management)

Considering Forestry,
A Science for Managing the Outside

Jacob Bertilsson, MA Research Architecture
Goldsmiths University of London, 21/22