Landscape Research

ISSN: 0142-6397 (Print) 1469-9710 (Online) Journal homepage: www.tandfonline.com/journals/clar20

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To cite this article: Chris Fremantle, Jo Vergunst, Louise J. Barwell, Anne Bevan, Stephen Cavers, Jennifer Clarke, Timothy M. Collins, Reiko Goto Collins, Malcolm M. Combe, Joan Cottrell, Anne Douglas, David Edwards, Aaron M. Ellison, Deirdre Heddon, Wallace Heim, Petra Tjitske Kalshoven, Glenn Marion, Seth Oliver, Vadim Saraev & Sietske Veenman (21 Aug 2025): What do indeterminacy and uncertainty mean in landscape research? Perspectives from natural sciences, social sciences, and arts, Landscape Research, DOI: 10.1080/01426397.2025.2537772

To link to this article: https://doi.org/10.1080/01426397.2025.2537772

Published online: 21 Aug 2025.

LANDSCAPE RESEARCH
https://doi.org/10.1080/01426397.2025.2537772

What do indeterminacy and uncertainty mean in landscape research? Perspectives from natural sciences, social sciences, and arts

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ABSTRACT

Landscapes, intentionally or otherwise, are often planned and managed in ways that create determined outcomes involving production, conservation, and aesthetics. While the focus of much research is on how to plan landscapes more effectively, this article explores how uncertainty and indeterminacy are inevitably also part of the research process. We present the results of discussions among a multidisciplinary group of researchers across the arts, humanities, social and natural sciences. We articulate discipline-specific understandings of indeterminacy and uncertainty and synthesise points of similarity and difference between them. Common concerns are with the limits of knowledge; conceptions of futures; the role of chance and change; and the dichotomy of action or 'doing nothing' in landscapes. We highlight arts research that works distinctively to develop subjectivities and create different relations with control and management. We emphasise the challenge of research to manage risks versus the need for indeterminacy to enable adaptation and promote novelty.

ARTICLE HISTORY
Received 17 January 2024
Accepted 7 July 2025

KEYWORDS
Indeterminacy; uncertainty; multidisciplinary; environment; arts; knowledge; futures; chance; innovation; risk; landscape decisions

Introduction

Landscapes are often planned by people, and we can think of planning as a process of bringing different kinds of knowledge and values together that determine the present and future of

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landscapes. Our common experience of the modern world is one in which our surroundings are affected by human action whether intentionally or otherwise, and this is well evidenced by scholarship from the humanities (e.g. Tsing et al., 2017) to ecology (e.g. Ellis & Ramankutty, 2008). However, landscapes are also the product of much that is unplanned (Davis, 1999). Factors beyond human control can result in change, even if still under some human influence, which means that the ways we make decisions about landscapes are never fully controlled and there is always an element of uncertainty and contingency. Tensions arise in research from plans and expectations rooted on the one hand in the knowledge and cultures of specific disciplines and on the other hand in the uncertainty embedded in the reality of landscape research.

This article presents results from a series of three discursive, multidisciplinary events where 20 contributors shared and discussed their disciplinary concerns with indeterminacy and uncertainty. Our aim is to collectively present ways of working in a range of disciplines, including the arts, and explore what these different fields of expertise can bring to discussions about landscape, ecological processes, and decision-making. We highlight the potential for the arts to work with, or alongside, other disciplines on challenges in making decisions about landscapes. Approaches include methods of control that attempt to define and limit indeterminacy and uncertainty whilst also recognising that indeterminacy is necessary for the emergence of new subjectivities and values, a key concern for the arts.

Scientific discourse distinguishes between 'aleatory' uncertainty (natural randomness or indeterminacy), and 'epistemic' uncertainty (uncertainty about what is true or knowable) (Van Der Bles et al., 2019, p. 2). Whilst uncertainty in both senses may appear to reduce public trust, in reality, it is an inevitable part of the scientific enterprise. Is it, therefore, correct to see uncertainty and indeterminacy as obstacles to planning and management? Pragmatist philosopher John Dewey argued that logic and science in the Western tradition have involved a search for universal truths, in contrast to the uncertain world of practice: 'The distinctive characteristic of practical activity, one which is so inherent that it cannot be eliminated, is the uncertainty which attends it' (Dewey, 2008, pp. 5–6). He continues: 'The realm of the practical is the region of change, and change is always contingent; it has in it the element of chance that cannot be eliminated' (Dewey, 2008, p.16). The ideals of science, by contrast, have 'glorified the invariant' (Dewey, 2008, p.17). However, as Lennard (2022) argues, we must also recognise that the use of the term 'uncertain' can also be political, strategically operationalising 'not-knowing' to evade responsibilities and maintain discriminations for instance concerning disease and environmental pollution. Lennard develops this argument with reference to Ludwig Wittgenstein, who in his work 'Certainty' (1969/2008) (Wittgenstein, 2008) shows that (un)certainties are socially constructed and dependent on context.

Major intergovernmental environment programmes have developed specific guidance on uncertainty, showing how scientists are engaging with this theme (IPBES Secretariat, n.d.; IPCC, 2005; Mastrandrea et al., 2010; UN Environment Program, 2019, pp. 625–628). The IPCC argues that 'There is a growing recognition that today's policy choices are highly sensitive to uncertainties and risk associated with the climate system and the actions of other decision-makers (Kunreuther et al., 2014, p. 155). Their guidance is focused on quantifying uncertainty in terms of 'confidence' in predictions based on a set of calibrations created specifically to support communications between scientists and policymakers (IPCC, 2005). This model of trying to delimit uncertainty is important but is not the only approach that emerged in our events.

Different disciplines and practices across arts, humanities, natural and social sciences have distinct quantitative, qualitative, aesthetic, experiential, and embodied approaches to indeterminacy and uncertainty. Some disciplinary practices seek to control outcomes through thought, dexterity, tools, and technologies. However, arts and design practices generally work intentionally with uncertainty, indeterminacy, and chance to generate novelty and produce ambiguous outcomes open to differing interpretations (Díaz, 2011; Hutter & Farías, 2017; Klarskov, 2022). Approaches can include sharing authorship, seeking minimum intervention, and needing to respond to the unexpected. In the visual arts exhibitions have provided an analysis of different

approaches (Malone et al., 2009). In the case of the early 20th century movement 'Dada', this was precisely to counter the 'academic arts' values associated with excellence and mastery, and in the case of Surrealism, to release the intuitive and unconscious (Brecht, 1966). Artists who used chance and indeterminacy include Marcel Duchamp, Man Ray, Yoko Ono, Alison Knowles, and John Cage. Many of these were associated with, or inspired, the Fluxus Art Movement of the 1960s and 1970s. More recently artists have adopted ideas on subjectivity from philosophers including Félix Guattari (2000) and Michel Serres (2007), in order to question human exceptionalism and control.

Both the sciences and the arts, therefore, have directly addressed indeterminacy and uncertainty, and as these are key issues in today's world of rapid environmental change (Bartolini & DeSilvey, 2021), we argue that conversations on this topic across disciplines are increasingly needed. Although the means of relating to them seem different—the sciences seeking to identify indeterminacy and uncertainty while recognising the impossibility of ever eliminating them, and the arts seeking to represent, inhabit and learn directly from them—commonalities and novelty may be found through interdisciplinary interaction. Given the imperative to work across disciplines to engage with complex or 'wicked' problems (Rittel & Webber, 1973), this surfacing of differences and commonalities seems a vital starting point to collaborative scholarship. The definition of wicked problems provided by Rittel & Webber encompasses both uncertainty (problems related to knowledge) and also indeterminacy (problems related to unfixed outcomes) (1973, p. 160ff). Three issues were suggested to our event participants: the ways in which artists engage with indeterminate authorship; how both science and the arts offer means to intervene in landscapes; and the consequences of uncertainty in adapting to changing conditions. Participants responded in ways appropriate to their discipline and practice. 486044.

A multi-disciplinary approach

During three 2.5-hour online workshops in 2021 and 2022, participants were invited to share disciplinary perspectives on indeterminacy and uncertainty and explore how the arts can be brought into a discourse with the natural and social sciences around this topic. Our approach was underpinned by the principle of 'epistemological equality' (Hawkes et al., 2022, p. 82) and participants were initially drawn from two multidisciplinary projects funded by UKRI that focused on the ecological adaptation of trees and arts and humanities approaches to landscape decision-making.[1] No approach was understood to have particular authority. Participants were encouraged to situate their research and disciplinary practices in relation to indeterminacy and uncertainty, highlighting the forms and limits of disciplinary methods. In keeping with Dewey's pragmatic perspective, fixed definitions of indeterminacy and uncertainty were avoided, which allowed participants to explain how the concepts were used in practice. This made for an unusually open set of conversations with insights being found across disciplinary boundaries. The results do not provide a comprehensive summary of indeterminacy and uncertainty research but instead show how a group of researchers understand the limits and potentials of their own disciplines from this perspective. The results also highlight some of the forms of contributions contemporary art practices and research could make. The collaborative nature of much of the arts research presented in this paper (Heim and Kalshoven [10[2]], Collins and Goto Collins [11] and Veenman and Oliver [12]), as well as Ellison's [5] discipline-spanning approach, suggest a way to open up conversations in this area, which we pick up on in the discussion.

Summaries of the 14 presentations from the events were subsequently prepared as short texts by their authors. Here these are grouped according to discipline starting with two population geneticists (Cottrell [1] and Cavers [2]), two ecological modellers (Marion [3] and Barwell [4]), and an interdisciplinary ecologist (Ellison [5]), all of whom focus on aspects of tree and forest management. The next four contributions develop historical, economic, legal, and anthropological perspectives from social science (Edwards [6], Saraev [7], Combe [8], and Vergunst [9]).

The third grouping of arts researchers and collaborations (as above, plus Clarke [13] and Douglas [14]) present diverse case studies and reflections on ways of inhabiting, rather than overcoming, uncertainty and indeterminacy.

Perspectives

1. Genetics and adaptation: Complex intervention or woodland adaptation in the face of new threats? (Joan Cottrell, Forest Research)

Forests and woodlands provide a vital resource for a range of ecosystem services including construction timber, biodiversity, and social wellbeing which is under threat due to hazards caused by predicted climate change, including risks of wind, flooding, drought, wildfires, frost, and the arrival of exotic pests and diseases (Forest Research, 2023). Policymakers and forest managers aim to develop and follow clear measures for safeguarding the delivery of such services. It is often very difficult to provide clear guidelines because of the uncertainties behind any statement. The broad character of change is known: there will be climate change and outbreaks of exotic and native pests and diseases, but the extent of the changes, for instance what will arrive and when, might be modelled but not known. The options available to foresters to prepare ahead of these changes include introducing new tree species; breeding resistant individuals; predicting pest and disease outbreaks and using pesticides. Another way to prepare for climate change is to practice predictive provenancing (planting material sourced from areas which currently experience the climate predicted for the planting site in the future, also known as 'climate matching'). The alternative is to work with native species or well tested exotics and adopt a nature-based solution; allowing natural selection to favour particular individuals; manage woods to maintain high genetic diversity and encourage adaptation to changing growing conditions via turnover of generations to provide material for natural selection to work on. Both these strategies are subject to uncertainty. The significant difference is in the extent of control envisaged: on the one hand rigorous management regimes and on the other promoting processes that enable woodlands to adapt to any new threat that appears.

2. Uncertainty and the importance of defining samples in population genetics (Stephen Cavers, UK Centre for Ecology & Hydrology)

In population genetics, researchers work with estimates of natural systems. Perfect knowledge, such as the genotype of every individual of a species, is never available. There isn't the time, budget, or capacity to gather complete information, so data are estimates based on limited sampling, from a moment in time. One Europe-wide study of genetic diversity in oak (Petit et al., 2002) is accepted to represent patterns formed by oak's post-glacial migration. Although a large study, it still only sampled about 1% of the natural oak population of Europe and used one type of genetic marker. A different sampling scheme (e.g. plantations rather than natural forests) would have shown a different pattern of genetic structure, whilst an alternative genetic marker would have given a different pattern of genetic diversity. The study was designed to uncover a specific part of oak's history in Europe and is robust in disciplinary terms, but knowing the limitations of the data is crucial, as other, equally valid, representations of the population are possible.

3. Limits to modelling: intrinsic indeterminacy and uncertain knowledge (Glenn Marion, Biomathematics & Statistics Scotland)

Indeterminacy is a central issue in constructing and using mathematical models of natural and human systems. What is included ('known unknowns' and 'unknown unknowns—the latter

sometimes called 'black swans') impacts interpretation of a model. Three aspects of indeterminacy are especially relevant:

- complexity in composition and behaviour including adaptive change (although there might be simple underlying causes in particular cases);
- intrinsic variation in ecosystems (at the level of individuals and of landscapes);
- and 'uncertainty', i.e. limits in knowledge, including absolute limits on information contained in available observations and technical limits on inferring information from these, with less or lower quality data leading to greater uncertainty.

Failures to account for intrinsic variation in modelling may lead to inaccurate assessment of population or ecosystem stability. Examples include demographic variation in space and time, and phenotypic and genetic diversity within populations, each of which can be associated with greater resilience. Whether intrinsic variation is hard-wired (exogenous) or is endogenously generated by model dynamics changes model interpretation; maintenance of stability being typically more convincing for the latter. This highlights the general need to consider where model boundaries have been set when interpreting results. There is an ethical dimension which requires consideration of multiple perspectives in modelling, including decision-makers and those affected by decisions, in thinking through potential for hard-to-anticipate problems arising from their use (Boden & McKendrick, 2017).

4. The paradox of modelling cost-effective intervention to mitigate impacts of tree pathogens (Louise Barwell, UK Centre for Ecology & Hydrology)

Horizon-scanning is the process of identifying and prioritising future threats. A major challenge for tree health is that forest pathogens are often not known to science until their impacts are felt (Grünwald et al., 2012). The optimal time for cost-effective intervention is early in the spread of a pathogen, when there is little awareness of the threat and insufficient understanding to support evidence-based decision-making (Jones & Kleczkowski, 2020). By the time the pathogen receives widespread attention, the costs of control have increased, and the effectiveness of intervention has reduced. In this situation, the problem may be unresolvable: it isn't possible to act before the threat is recognised, yet it is too late to influence the outcome once the knowledge becomes available for robust model predictions.

Policymakers are increasingly interested in predicting what might have happened if no action had been taken, to justify previous and future interventions. For example, without eradication, how far might an invasive species or emerging tree pathogen have spread (Hassall et al., 2025)? Integrating alternative scenarios into ecological models can provide tools that better reflect how people make decisions about the costs and benefits of intervention, allowing users to experiment with future climate, land-use or management changes, but more discourse around uncertainty and indeterminacy is needed at the science-policy interface to contextualise and validate these ecological models.

5. Embracing indeterminacy and uncertainty in forest management (Aaron M. Ellison, Harvard University Herbaria)

In managing and restoring ecological systems we assume a simple solution to achieving a pre-determined endpoint—'we are restoring to…' 'we are conserving as…' and 'make it the way it was'—albeit mostly without defining when 'it' was (Botkin, 2012). Whilst most restoration and conservation efforts set fixed, unchanging endpoints, real ecosystems are dynamic and constantly changing. Ecological systems are of 'intermediate dimensionality'—perhaps

counter-intuitively, they have insufficient variables for 'simple' physical models but too many variables for comprehensible statistical ones. Rather, managing ecological systems is an insoluble 'wicked' problem—an incomplete, contradictory problem with changing requirements that are difficult to recognise. Statistician George Box suggested that we should 'not worry about the mice if there are tigers abroad' and identify the 'important' variables and their uncertainty (Box, 1976, p. 792).

The 19th-century Hudson River School artists reified a sublime vision of 'natural' landscapes whose preservation in perpetuity defines the mission of the US National Parks Service (Ellison, 2013). Thomas Cole's paintings of the New England (USA) landscape cast a strange light on this mission. Cole painted New England landscapes following nearly 200 years of deforestation. In the subsequent two centuries, New England's forests regenerated, without any 'management' or other human intervention; 2020 forest cover is four times that of 1830. Which landscape should we preserve? Is 'doing nothing' a more successful approach for scientifically managing a process of constant change (Foster & Orwig, 2006)? Can contemporary art provoke a move from managing for preservation to embracing a process?

6. Forestry responding to uncertainty through spreading risks (David Edwards, Forest Research)

Uncertainty runs throughout the history of British forestry, with the threat of war, economic crises, and wavering political support—but the emergence of climate change represents a new challenge, bringing extreme weather events and unpredictable outbreaks of pests and diseases. By the 2000s a contested debate took hold about how best to respond. Many foresters pursued interventions in line with the simplified, utilitarian view of nature that had underpinned productive forestry since WWII (Scott, 1998), which sought to predict and control the resilience of forests, e.g. by 'assisted migration' of provenances from southerly latitudes that may be suited to future climates. Others saw forests as complex adaptive systems, and worked with organic processes to enable forests themselves to adapt to changing conditions through natural regeneration and continuous cover forestry (Puettmann et al., 2008). It is tempting to take sides in this debate in line with our own interests and worldviews (Aubin et al., 2011). Yet evidence of the risks and benefits of each approach is inconclusive. A third response has been to experiment with a portfolio of options to spread risks, monitor effects, and adapt accordingly. Not every forest is large enough for this approach to be feasible, but networks of land managers, each addressing the problem in different ways (in accordance with their perceptions of the benefits, risks, and uncertainties involved) can share their experiences, and act as 'stewardship scientists'. Researchers can help ensure their interventions are robustly designed, following agreed protocols to monitor resilience and performance. Such an approach could offer an effective combination of creative experimentation and collaborative learning at the scale required to respond effectively to an uncertain future.

7. Economic theory, risk and uncertainty (Vadim Saraev, Forest Research)

Modern portfolio theory in economics can be applied to analyse risks and benefits of wood and forest landscapes. Planting a tree is a risky business in an increasingly uncertain world, whether due to climate change or pathogens.

The distinction between risk and uncertainty in economics was established by Frank Knight and John Maynard Keynes. Risk is defined as an event that is not certain but for which probabilities or likelihoods can be assigned. True uncertainty is harder to deal with and results from variability of natural systems (aleatory) and a lack of information or knowledge (epistemic) about system dynamics.

Leach et al. (2010) use two axes of uncertainty: 'Knowledge of outcomes' and 'Knowledge about likelihoods' to explore relative relationships among the concepts of risk, ambiguity, uncertainty, and ignorance. In the associated graphic 'unproblematic outcomes' and 'unproblematic likelihoods' are characterised as 'risk', i.e. manageable risk. When both are problematic one is in the midst of ignorance also commonly named as unknown unknowns, including 'Black Swans'.

Generally, scientific processes aim to move issues into the category of risk, which could be handled with mathematical tools. Economics aspires to do the same. However, being much closer to social than to natural sciences it faces a significant, potentially unsolvable challenge because its constituent actors are humans rather than particles and physical objects whose properties are stable and predictable with sufficient observation data.

8. Intentional uncertainty in landscape law (Malcolm Combe, University of Strathclyde)

Different constructions of the law have different relationships with indeterminacy. Roman Law—which influenced Scots Law—is traditionally less accepting of uncertainty whereas the law (and equity) in England and Wales is perhaps more tolerant. However, legal systems contend with areas where a rule is simply needed, e.g. which side of the road we drive on.

Landowners have significant agenda setting roles in relation to landscape, which are constrained by the law and by binding undertakings. An example of the latter might be the former Common Agricultural Policy system of Set Aside, where degrees of indeterminacy and uncertainty in creating more 'wild' land were facilitated.

The regulation of public access to land for recreational, educational, or in some instances commercial activities varies across the UK. Scotland has a more extensive 'right to roam' than England. England also has a more specific definition of an exclusion zone around houses (20 m) whereas in Scotland there is no set distance. This gives a contextual zone for reasonable privacy without reference to the specific occupier, characterised as the 'Property Specific Objective Test' (Lovett, 2011), meaning that each location is evaluated specifically (Combe, 2018).

Legal structures can have areas of clear determinacy—'bright lines'—but can also have significant areas of intentional uncertainty which require contextual decision-making.

9. Recognising indeterminacy as an ethical position in anthropology (Jo Vergunst, University of Aberdeen)

Anthropology offers some interesting resources for thinking about environmental uncertainty and indeterminacy. For much of its history anthropology often had a determinant or cause-and-effect approach to human relations with the environment that might broadly be stated as an adaptation model, where humans adapt to and in turn modify their environments. In this way anthropology explored society as a stable system of inter-related parts, mirroring ecological models of equilibria and climax vegetation (e.g. Frederic Clements's hypothesis of forest growth). But things have changed. In ecology, non-equilibrium theory challenged the notion that environments tend towards a balance of natural processes, and complexity and uncertainty are now understood as core aspects of socio-ecological systems (Scoones, 1999, 2019). In anthropology, a range of theoretical approaches no longer take for granted the stability or 'naturalness' of human-environment relations, from political ecology (exploring the dynamics of power) to the posthumanities and New Materialism (where science and the act of knowing itself are scrutinised). Paul Nadasdy argues that engaging with indeterminacy also supports an anti-colonial politics, recognising that the material and semiotic practices through which settler-colonialism dominated lands and peoples cannot be taken as simply an equivalent ontology to that of the indigenous people affected (Nadasdy, 2021, p. 65). 'If,' Nadasdy writes, 'reality is indeterminate

and all knowledge of it necessarily incomplete, then we all have a reason to question our own knowledge of the world'.

10. Art-anthropology collaborations around nuclear waste management (Petra Tjitske Kalshoven, the University of Manchester; Wallace Heim, Artist and Philosopher)

The transformation taking place at Sellafield in West Cumbria (UK) from active nuclear operations to nuclear waste management is expected to be a century-long process full of uncertainties and unknowns (Kalshoven, 2022). Intrigued by such prolonged indeterminacy, anthropologist Kalshoven and artist-philosopher Heim collaborated in a series of interdisciplinary, semi-public workshops in summer 2019, asking what the site might become post-decommissioning.

Drawing on the workshops, on Kalshoven's West Cumbrian ethnography, and on conversations with scientists, Heim created a series of different 'fonts' that held transformative materials, including sediments and scientific images. The resulting exhibition 'x = 2140'[3] was meant as a provocation encouraging visitors to imagine caring for a post-industrial landscape into the far future. For Heim, indeterminacy was an aesthetic strategy, tying in with her intention to 'afford' or provoke, with the form of the font indicating, and forming, a place of transformation. Reflecting on the work, she highlighted the importance of keeping indeterminacy moving, rather than calcifying or settling it (Heim, 2021). For Kalshoven, indeterminacy remains a central focus of experimentation with 'futuring' in areas where nuclear decommissioning takes place. She explores mimesis as the human urge to capture and tame uncertainties by drawing on existing models, projecting ideas, images, experiences, infrastructures, and landscapes forwards and backwards through practice and imagination.[4] Ironically, such modelling is bound to throw up new questions, and uncertainties.

11. Defining ecocide and indeterminant/emergent subjectivity in Irish peatlands (Timothy Collins and Reiko Goto Collins, Collins and Goto Studio)

To address the questions of indeterminacy (not fixed, not leading to any definite end) and determinacy (to identify or fix or settle an outcome or issue), we consider the term 'ecocide' in relation to a specific place. Fifty years of industrial-scale mining of peatlands for Irish energy production has resulted in destruction on a significant scale. This raised the speculative question: are there ways to determine if ecocide has actually occurred (Collins & Goto-Collins, 2023)?

We have considered three approaches to ecocide through deliberative and philosophical perspectives. Stop Ecocide International (SEI) starts with spontaneous judgements that industrial agriculture, fishing, mining, chemical etc enterprises are ecocidal. This can be argued to be weakly 'determinant' because of its generality. Using strongly determinate language, the solicitor Polly Higgins stated 'Ecocide is the extensive damage to, destruction of, or loss of ecosystem(s) […], to such an extent that peaceful enjoyment of the inhabitants of that territory has been severely diminished' (Higgins et al., 2013, p. 263). A determinant position arguing that ecosystem loss undermines the practical interests of proximate communities provides clear cause-and-effect grounds for litigation. However, our reference population, both generally and in the vicinity, probably did have 'peaceful enjoyment' (as well as employment and electrification) and therefore the strip mining of peat would not constitute ecocide under the Higgins' definition. The third alternative based on the work of Félix Guattari might be understood as a strongly indeterminate philosophical position. Without using the term ecocide, he describes a 'period of intense techno-scientific transformation' (2000, p. 27). This results in a level of disequilibrium and imminent threat to all life on earth. His approach is to rethink the philosophical interrelationships of the social, the ecological, and the techno-scientific aspects of culture, as a means of initiating an ecosophical evolution of subjectivity. In conclusion we have argued that the moralist, legal,

and philosophical positions are all helpful as we reconsidered perception, value, and meaning, as the basis for a new ethical and ecological relationship with peatland.

12. Responding to Dutch media discourses and the imaginary power of artists on future environments (Sietske Veenman, Radboud University Nijmegen, and Seth Oliver, artist)

Research on dominant and desired futures in Dutch newspapers reveals embedded assumptions, sparking imagination of alternatives. A total of 401 Dutch newspapers were scanned, 265 of which featured future narratives, explicitly or implicitly. Fifty-three mentioned 'future', while 212 treated futures only implicitly (hinted at futures). Of those 212, three-quarters portrayed 'dominant' futures, with 'expected' and 'desired' futures prevalent within. 'Plausible' futures were less frequent. The 'near' future often focuses on the economy and technology, while 'desired' environmental stories are placed further ahead (Veenman et al., 2021). Art and collaborative community action can flip these two dynamics, making them perceptible and prompting questions:

- What if the economic future prioritised the 'desired' and the 'long-term' for its citizens?
- What if short-term plausible actions became the focus of environmental futures (instead of long-term desires)?

Artworks, ancient or contemporary, trigger nuanced pre-verbal responses, each one distinct. Art embraces cognitive and linguistic limitations, challenging assumptions and birthing new ideas. As time unfolds, art cleaves rhythms and forges new perspectives that happily dwell beyond definite conclusions. The creative act, when collaborative, challenges present stasis, making ways for future movements. Becoming entwined with uncertainty opens doors to community action and relational co-design, where more landscape inhabitants become considered.

Engaging thoroughly with the land and its inhabitants encourages sustainable collective actions. By embodying reciprocal care with the land, we nurture and are nurtured, fostering a deep connection with the landscape and its biome. Grounded in this substantiated contact, words in newspapers and landscape plans bridge the gap between plausible long-term futures and short-term economic ideals.

Through harnessing uncertainty's full potential, futures become less overwhelming for citizens and their increasingly complex environment.

13. Learning from Michel Serres' 'The Parasite' for art and anthropology (Jen Clarke, Gray's School of art)

In landscape research, uncertainty and indeterminacy are not boundaries to be crossed, but generative spaces to work within, where the planning and crafting of futures unfold. Drawing on Michel Serres' *The Parasite* (2007), I explore the figure of the parasite as a methodology that embraces disruption, transformation, and creative interference. A parasite, in its Greek sense, 'eats at the table of another,' and in French, it also signifies 'noise'—a disturbance that reshapes the system from within. [5] This parasitic noise, as I understand it, is not merely an interruption, but an opening, a space where new relations can emerge.

In the Treescapes project 'Agroforestry Futures', and across my work in anthropology, art, and forestry, the parasitic becomes a way of working through the entanglements of image and text, abstract concepts and lived experience. It is a methodology that navigates the flux of landscapes—human, ecological, and conceptual. By interrupting the dominant narratives of control and certainty, the minor figure of the parasitic invites us to reimagine our relationship with

landscapes, as Tsing et al. (2017) suggest, not as objects to be mastered but as co-creations of countless, often conflicting forces.

Through interventions in image-making, writing, and the materiality of the world itself, I seek to uncover how uncertainty and indeterminacy can be generative. Like the parasite, my practice thrives on the in-between spaces, where the unknown can shift our understanding of landscapes and their futures, always unfinished, always in process. In this, I ask: How can we, too, learn to live with and within uncertainty, as a source of possibility?

14. John Cage and the celebration of uncertainty and indeterminacy (Anne Douglas, Gray's School of Art)

John Cage (1912–1992), avant-garde composer, musician, poet, essayist, and visual artist, explored indeterminacy as key to composition. In his view. indeterminacy was a key factor in enabling a piece to live (or die) as a musical experience. This 'life', Cage posited, was an outcome of a series of decisions made in the creative process of composition and performance, around what was determined and what was left indeterminate, to compose in such a way that could bring about an unforeseen situation.

For Cage, uncertainty is a condition of life. He therefore made serendipity a core function of a work of art, by experimenting with approaches to the creative process that consciously eschewed the mindset of control, particularly the tendency to fall back on taste and habit that are frequently mistaken for truth or authenticity. He used the term 'chance operations' for this approach.

4'33" (a piece composed in 1952 which involves no playing of instruments) formally frames the uncertainty of life. The score creates a specific time frame whilst not providing any 'content' in the conventional form of note-to-note notation. The only sounds heard are those of the audience, who effectively compose the piece, inverting what is conventionally shut out, foregrounding ambient sound including the audience's coughs and sneezes. The audience co-creates the experience rather than having an experience created for them by the composer/performers (Douglas, 2018).

Cage's essay 'Indeterminacy: Composition as Process' (Cage 1995) describes the elements of music as structure (the division of the whole into parts), method (point to point procedure), materials (sounds and silences through timbre and amplitude), and form (the morphology of the continuity). The essay analyses the ways in which certain composers have determined or left indeterminate different elements of compositions.

Cage's analysis and method are different from conventional approaches in other disciplines where the focus is on reducing uncertainty to increase confidence in decision-making. His processes of control seek to release and celebrate uncertainty.

Discussion

More progress towards genuine interdisciplinarity is needed. Two joint presentations demonstrated interdisciplinary working in the arts (Kalshoven and Heim [10], and Veenman and Oliver [12]). These explored how the arts can provide metaphorical or framing approaches, and open up discourse and sensory ways of knowing that a number of the authors and contributors have been concerned with previously (Douglas & Fremantle, 2016; Edwards et al., 2016; Heim, 2003; Vergunst, 2017). However, interdisciplinarity requires mutual understanding and recognition of the different forms of uncertainty and indeterminacy between disciplines. A better awareness of disciplinary approaches to what is uncertain and indeterminate could provide entry for the arts in future research in support of landscape decision-making. The issues arising in our contributing disciplines are summarised below.

Amongst the scientists, Cottrell [1] frames expectations of certainty amongst decision-makers, while Cavers [2], Marion [3], and Barwell [4] address issues of sampling and estimation within scientific field, lab, and modelling work, including the relation between knowledge and action. The limits of these approaches were consistently highlighted including the effect of sampling schemes as well as the small scale of samples in relation to the numbers of trees and the size of the genome. Both the timing of intervention and the ethical issues in modelling (relating back to the problem of certainty raised by Lennard) were highlighted. Ellison [5] further develops the challenge of modelling in terms of landscape restoration, highlighting the role of art in fixing an 'idea' of a landscape which then becomes an objective for landscape management. Ellison also made the case for considering 'do nothing', a strategy used in Harvard Forest in relation to Eastern Hemlock and the threat of hemlock woolly adelgid (Barnett, 2025). Shifting back from science and modelling towards policy questions, Edwards [6] provides a framework for thinking about historical changes in forestry indicating changing assumptions about certainty, while Vergunst [9] locates indeterminacy as an ethical position rather than just an academic problem in anthropological research. Law and economics, as key interfaces between research and policy, have specific relations with uncertainty—Saraev [7] arguing that economics faces similar problems to the ecological modellers, and Combe [8] that law can intentionally create indeterminacy and uncertainty by instigating open-ended processes and avoiding tight definitions in access to the landscape. Saraev [7] shows that moving uncertainty (and indeterminacy) into the scope of 'risk' provides an important way of understanding the forms of translation that occur between research and decision-making. This suggests that 'epistemological equity' needs to acknowledge processes of translation, not just mutual respect.

The artist contributors also offered a diversity of approaches but included ones which perhaps focus more on indeterminacy. Veenman, Oliver, Kalshoven, and Heim focus on futures. Veenman and Oliver [12] problematise environmental constructions in the media and look to the arts for alternative visions to connect the short and long term. This is also an issue for Kalshoven and Heim [10] in relation to nuclear decommissioning—where duration creates uncertainty as the norm. Collins and Goto Collins [11] consider ecocide on a cutaway Irish peat bog, highlighting that for legal purposes, determinacy is useful, whereas to affect subjectivity (a key role of the arts) indeterminacy is necessary. Clarke [13] provides a reading of Serres' *The Parasite* that is distinct from the spectrum of controlled/uncontrolled. The analogies to third positions such as parasites might be discomfiting, however they conceptually challenge the binary of 'control' versus 'do nothing'. Drawing on the work of John Cage, Douglas [14] also questions what is normally controlled in the arts and other disciplines and what is left indeterminant. This exploration through composition of which aspect of a process to leave indeterminant is provocative in relation to 'adaptive management' approaches where *all* aspects are subject to evidence-based decision-making. In practice foresters may be making judgements about what to focus on in terms of decision-making and what to leave to chance.

Connecting back to themes we identified in existing art and design practice; Collins and Goto Collins [11] and Veenman & Oliver [12] articulate the co-production of place and subjectivity. Clarke's [13] conceptualisation of a third position, different to both uncertainty and control, is also a form of 'sharing authorship', as is Douglas' [14] framing of Cage's 4'33". The latter is also an example of 'least intervention' that Ellison [5] considers in landscape ecology. In addition, Heim's [10] fonts bring to mind a way to value the inevitability of the unexpected. These are all experiments that could have a range of outcomes for landscapes, as shown in Collins and Goto Collins 'deep mapping' of the peat bog that opens up the value of an extractivist landscape in new ways (Collins & Goto-Collins 2020). Experimentation, as Bartolini and De Silvey note, 'offers opportunities in moments of loss or upheaval' (2021, p. 17). We show here that experimental approaches in a broader sense are not limited to the sciences. Arts experiments may not test hypotheses or use a 'control' as part of the method, but they do aid the imagination of different kinds of landscape futures. The range of arts approaches

evidenced correlates with literature on arts and arts research in relation to environment and climate change research, including in particular, attention to futures (Galafassi et al., 2018, p. 74), framing issues (such as ecocide) (Saratsi et al., 2019, p. 21), and sharing agency (Douglas, 2018).

Notably, the possibility of arts experiments that we explored in these discussion events in 2021 and 2022 have been taken forward in the two research projects they were organised by—'newLEAF' and 'Creative Landscape Futures' (see endnote 1). In 'newLEAF', a new verbatim theatre production was developed based on 30 interviews with practitioners involved in woods and the forestry industry. This work opens up experiences of uncertainty and indeterminacy from the perspective of practitioners and models a 'dramaturgy of uncertainty'. In 'Creative Landscape Futures', small-scale landscape arts activities included kite aerial photography and improvised choreographic practices in a forest.[6] These enabled different perspectives to be explored within a critical framing—not art for its own sake or for a narrow aesthetic purpose, but as contributions to understanding landscape change and decision-making.

Our project work has also helped us to reflect on these discussion events in new ways. To summarise our insights, we can distinguish four areas of concern across the contributions, all of which offer alternatives to our initial dichotomy of science as delimiting indeterminacy and uncertainty and art as inhabiting them.

1. *Knowledge* is articulated in terms of estimation and sampling in field and lab work, in factors to consider in modelling, and in conflicting knowledge vs. action trajectories in landscape decision-making. In all of these, the distinction between practical and theoretical knowledge described by Dewey seems to merge.
2. *Futures*, both near and distant, are projected through landscape research in different ways in science and art. Participants found that discussing indeterminacy (in the sense of unclear cause and effect) opened new perspectives on temporality, while recognising that policymakers make decisions on short timescales. Art can imagine ways of living in an enduring uncertain and indeterminate world.
3. *Chance* was a particular concern of some of the artists whether engaging with indeterminacy through experience, noise and parasitism, or selecting a dimension to open to 'chance operations' in order to enable creativity and emergence rather than repetition. As Ellison [5] and Edwards [6] showed, this has, to some extent, been mirrored in changing priorities and paradigms in forest landscape management. Recent work on the cultural history of chance explores the long relationship between chance and causality (Duprat et al., 2024).
4. *Action* and the question of how to act—the apparent alternatives of management and control versus letting nature get on with it—were explored. Barwell's [4] case of action against pathogens being most effective when conditions of uncertainty still prevail is also instructive. Action is required despite the lack of formal knowledge, and this shows how important accepting uncertainty and indeterminacy can be.

Conclusions

Two conclusions can be drawn. Firstly, whilst the sciences and the arts place different values on uncertainty and indeterminacy—the former focused on developing knowledge and understanding and the latter characterised by imagining life with uncertainty and indeterminacy, there are also shared challenges. The context of increasing complexity (wicked problems) might benefit from the adoption of a wider range of ways to think about, on the one hand, uncertainty and indeterminacy, and on the other, 'control'. The translation of landscape research to meet the needs of policy-makers could usefully focus not just on scientific concepts of

uncertainty and indeterminacy (Hawkes et al., 2022), but also on the way that the arts contribute to this discourse.

Secondly, our four areas of shared concern in knowledge, futures, chance, and action can provide a focus for developing better mutual understanding in multi-disciplinary landscape and environment research. Future research might usefully address ways in which these translations of uncertainties and indeterminacies are conceptualised and articulated both in terms of knowledge and understanding, and also with regard to subjective experiences and ways of being. The aim is not to reconcile the differences, but to allow the differences, the grit that provides the traction, to productively reorient ways of collective thinking and doing.

Notes

1. 'Learning to adapt to an uncertain future: linking genes, trees, people and processes for more resilient treescapes (NewLEAF)' NE/V019813/1, and 'Creative landscape futures: Making decisions with the arts and humanities' AH/T006102/1.
2. Contributions are numbered for the purposes of the paper – this was not the order they were presented in during the workshops.
3. Exhibited at Florence Arts Centre, Egremont, Cumbria, see https://wallaceheim.com/sculpture/(accessed 11 March 2025) and https://www.facebook.com/nuclearsitefutures (accessed 11 March 2025). Heim's work was a commission as part of the Sellafield Site Futures project funded by the UK Energy Research Centre and The University of Manchester's Dalton Nuclear Institute.
4. See Kalshoven's 'Mimesis in Action' project, funded by the UK's Economic and Social Research Council, https://www.mimesis-in-action.org/(accessed 11 March 2025).
5. For a useful unpacking of the importance of 'noise' see the podcast on the Future of Indeterminacy Research project site (Malaspina, 2020).
6. https://creativelandscapefutures.wordpress.com/.

Ethics statement

No new research was undertaken and all participants are also contributors to the paper. Therefore, no ethics approval has been sought.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

UK Research and Innovation awards NE/V020080/1 and Natural Environment Research Council (AH/T006102/1).

Data availability statement

No new data were collected or synthesised for the work presented in this paper.

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Chris Fremantle's research focuses on the role and contribution of artists and designers in environmental research. He is currently a Research Fellow and Lecturer at Gray's School of Art, Robert Gordon University and is Co-I for the Arts work package, a large Future of UK Treescapes project, as well as PI on a Royal Society of Edinburgh network focused on the role of artists in woodland creation. He is a Curatorial Research Associate with the US Forest Service's Urban Field Station Arts programme and Arts Advisor to the European Marine Board's Embracing the Ocean initiative. Chris has co-authored policy notes on the role of arts and humanities in net zero landscapes.

Key themes in Chris' work include systems aesthetics, indeterminacy and uncertainty, and theories of change. Chris has written extensively on the work of pioneering ecological artists Helen Mayer Harrison (1927–2018) and Newton Harrison (1934–2022) including the recently published 'Thinking with the Harrisons: Re-imagining the Arts in the Global Environment Crisis' (2024) co-authored with Professor Emerita Anne Douglas. Chris and Anne launched the book in California in association with the four-venue retrospective of the Harrisons' work which formed part of the Getty's PST in 2024.

Jo Vergunst is a Senior Lecturer in the Department of Anthropology, University of Aberdeen. His research is about people's relationships with their environments. Most of his ethnographic fieldwork has been in Scotland, focusing particularly on the intersection between everyday experience and wider political circumstances. His early work was on farming and rural development, and over recent years he has worked on themes ranging from walking in rural and urban areas, to landscape history and heritage, and wood as a craft material and landscape. He is especially interested in anthropology that works with artists and through creative practice.

Louise Barwell's research aims to understand insect populations and plant pathogens using statistical modelling of spatial data at regional to global scales. Barwell is especially interested in how species' ecological traits and evolutionary history interact with socio-environmental factors to drive the success or failure of biological invasions. Barwell has developed trait-based and phylogenetic comparative models of pests and pathogen host ranges and introduction through trade pathways to support horizon-scanning and risk assessment activities, funded through the Living with Environmental Change (Phyto-threats), TREESCAPES (NewLEAF) and Future-Proofing Plant Health programmes. Projects funded by Scotland's Plant Health Centre and the Welsh Government involve co-development of model outputs with cross-sectoral stakeholders to support preparedness in these regions. Barwell is actively engaged with UK stakeholders in the forestry and nursery sectors and plant health policy to understand how these data and models could be translated into web-based tools adapted for end-users. Other ongoing work includes the development of indicators for measuring pressure from non-native species entering and establishing in Britain to assess the effectiveness of biosecurity measures and recent abatement.

Anne Bevan is a visual artist and works as a part-time Lecturer with the UHI Archaeology Institute at the University of the Highlands and Islands Orkney. Her interdisciplinary research and art practice engage with water, the sea, energy and issues around environmental change. She was Co-Investigator for the Creative Landscape Futures network.

Stephen Cavers works on genetic diversity, gene flow and adaptation in plants. Together with UK and international partners, he studies how genetic variation is organised in populations and how this diversity arises from demographic and evolutionary forces. He uses a combination of molecular and quantitative genetic approaches to assess genetic diversity, and in particular to characterise forest genetic resources for conservation and use. Stephen is currently working on projects on European temperate tree species (Pinus sylvestris, Juniperus communis, Taxus baccata, Quercus spp, Betula spp) and African dryland tree species (Acacia senegal & A. tortilis, Melia volkensii, Moringa oleifera & M. stenopetala, Osyris lanceolata), and has worked on several Neotropical tree species in the past. As well as primary research, Stephen works to communicate and make scientific findings accessible to policymakers in various sectors. He obtained his Ph.D. from the University of Edinburgh in 2002 and M.Sc. from the University of Wales, Bangor in 1998.

Jennifer Clarke, Associate Professor at Gray's School of Art, is an anthropologist, artist, and transdisciplinary researcher. Her work addresses environmental and social issues, by combining art and anthropology. Jen currently leads artistic research for the UKRI-funded Agroforestry Futures Treescapes project, reimagining our relationships with forests and farming futures. Grounded in feminist approaches, her work challenges existing narratives and creates opportunities for alternative perspectives. Jen also collaborates on transnational projects in the UK and Japan, where she has lived and researched since 2003. In 2022, she held a Visiting Professorial Research Fellowship at Tohoku University to develop her project Feminist Hospitalities. Her practice spans analogue, digital, and social art forms, as well as public engagement producing diverse artworks and texts, including moving image, installation, and socially engaged projects that work across languages to create spaces for reflection and action. She writes both academically and creatively, contributing to broader discourses related to her artistic and research practice. Since 2018, she has chaired the Board of the Scottish Sculpture Workshop and co-chaired ANTART, EASA's Anthropology and the Arts Network (2020–2022).

Timothy M. Collins is an artist whose research examines aesthetic and ethical conditions of environmental change, exploring how art can shift values in response to new ideas, technologies, and experiences. Based in Glasgow, Scotland, he is a principal at the Collins + Goto Studio. With collaborator Reiko Goto, Collins investigates the cultural meaning of nature in an age of environmental change. Recent works—HAKOTO: Portach | Bog and Artificial-Bog-Intelligence—were developed during a year-long research residency at Leitrim Sculpture Centre, culminating in an exhibition and research report (2025). This work was built on two years of research for Deep Mapping | Lough Boora Sculpture Park (2020). Other projects include deep mapping a Caledonian pine forest in

Future Forest: The Blackwood, Rannoch, Scotland, as well as Sylva Caledonia (2016) and Caledonian Decoy (2017). The sculptural instrument PLEIN AIR signifies photosynthesis, transpiration, and carbon exchange, and has been presented in Belgium (2022), North Carolina (2019), Glasgow (2017), and Cologne (2016). Collins has been a Distinguished Research Fellow at the Studio for Creative Inquiry, Carnegie Mellon University, since 2005, and is an international associate of the RMIT Arts and Ecologies Research Network (AEGIS) in Melbourne, Australia.

Reiko Goto Collins is an environmental artist whose work explores relationships between humans, other living beings, and the environment. Her practice is informed by ideas of empathic connection with more-than-human others, drawing on the philosophy of Edith Stein, Charles Sanders Peirce, and others. Her current project, HAKOTO, is a sculptural instrument that reveals the relationship between greenhouse gas removal and the life signs of trees and peatland. In 2025, theory, practice, and fieldwork with HAKOTO were presented at the *Art & Ecoart Communities in Ireland* seminar at Université Paul-Valéry Montpellier, France, and at *Art & Ecology: Uniting Creativity with Sustainable Practices* at Damer Galleries, Roscrea, Ireland. In 2024, HAKOTO was performed and exhibited in Düsseldorf and Cologne, Germany; in Vienna, Austria; and at the Glasgow International Festival. Alongside this, Goto Collins has spent a decade working with a horse, developing a body of work on interspecies time and presence. In 2025, as artist-in-residence at Hospitalfield, she is editing journals and creating a series of drypoint prints about time spent by *Darkness, and with Darkness*. This work has been presented at the Institute for Advanced Studies in the Humanities, University of Edinburgh, and published in Arts (Special Issue, MDPI, Basel, 2022).

Malcolm Combe is a senior lecturer in Scots private law at the University of Strathclyde. Before moving to academia, he was a solicitor in private practice in a Scottish law firm (qualifying as a solicitor in Scotland in 2008 and in England and Wales in 2009). As an academic, Malcolm's work has tended to have a property law focus, with particular interests being land law reform, public access to land, and landlord and tenant law. He also has an interest in access to justice. He is the author of 'The ScotWays Guide to the Law of Access to Land in Scotland' (2018) and a co-editor of 'Land Reform in Scotland: History, Law and Policy' (2020)

Joan Cottrell is a Senior Scientist and Head of Forest Genetics at Forest Research, an agency of the Forestry Commission. Her research is mainly focused on genetic diversity, geneflow and adaptation in woodlands. She is also experienced in working at the research/policy interface and in explaining the implications of her research to policy makers.

Anne Douglas is Professor Emerita, Gray's School of Art, Robert Gordon University, Scotland, who explores the changing place of the artist in public life. Her research has increasingly focused on art and the environmental crisis from a practice-led perspective. She co-produced the Harrisons' work 'On the Deep Wealth of this Nation: Scotland' (2017) in collaboration with Newton Harrison and the Centre for the Study of the Force Majeure, University of California Santa Cruz and co-authored 'Thinking with the Harrisons: Re-imagining the Arts in the Global Environmental Crisis' with Chris Fremantle (Leuven University Press 2024).

David Edwards is the Research Impact Coordinator at Forest Research (FR), the research agency of the Forestry Commission in Britain, and an environmental social scientist with 30 years' experience of research and consultancy in the UK and internationally. Working in FR's Chief Scientist's Office, he supports dialogue and collaboration with FR's customers and stakeholders to increase the impact of its research, evidence, and advice. He is also conducting historical research on policies and practices of diversification in Twentieth Century British forestry. Previously, David was a member of FR's Senior Management Team, leading five Science Groups. As a Senior Social Scientist, he led teams on several EU-funded projects, and published widely on the interfaces between science, policy and practice, social and cultural values, and environmental arts research. David originally trained in biology (University of Durham) and then forestry (University of Oxford) and worked for the UK government on community forestry and rural development programmes in West Africa and South Asia. He has an MSc and PhD in African Studies from the University of Edinburgh with a doctoral thesis exploring changes in land-use and ethnic and religious identities in southern Tanzania.

Aaron M. Ellison is a Boston (USA)-based photographer, sculptor, writer, and Senior Research Fellow Emeritus in Ecology at Harvard University. His research and artistic practice focus on the disintegration and reassembly of ecosystems following natural and anthropogenic disturbances; the relationship between the Dao and the Intermediate Disturbance Hypothesis and the critical and reactionary stance of Ecology relative to Modernism. Whenever he can, he works with wood. Find him online at https://unbalancedecologist.net.

Deirdre Heddon holds the James Arnott Chair in Drama at the University of Glasgow. She is the author of many publications and other outputs, including creative research, and has an enduring interest in creative walking practices, alongside environmental/ecological theatre. She is co-editor of the book series, Performing Landscapes. Most recently, she has been a Co-Investigator on the Future of UK Treescapes project, newLEAF, contributing to the verbatim play, Three Words for Forest. This drew on 30 interviews with professionals from across the forestry sector, to explore uncertainty and decision-making in the context of climate change.

Wallace Heim writes, researches and makes art in the field of ecology and culture. Her exhibition of sculpture, X = 2140, explored what it means to care for contaminated land in West Cumbria. She writes audio fiction, including 'the sea cannot be depleted', about the military, uranium and the Solway Firth. She devises events on the changing climate in Cumbria for the national project, 'When the Future Comes'. Her academic slant is philosophical (PhD, environmental ethics/methods of change in social practice art). She has written on how a place can learn; on 'slow activism'; on sensing extinction; on ecological conflict and theatre. She co-edited Nature Performed (2003) and Landing Stages (2014). She has published in Performance Research; in Performance and Ecology. What Can Theatre Do? (2018); Readings in Performance and Ecology (2012); and Performing Nature (2006). She was awarded the CIWEM Awe-Inspiring Award for her work editing the Ashden Directory of Environment and Performance. She co-curated the conference/event BETWEEN NATURE (2000). She is an associate of the Nuclear Cultures Research Group, the PLACE Collective and the Centre for the Study of Environmental Change. Her first career was as a set designer in theatre, establishing The Gate, London.

Petra Tjitske Kalshoven is a cultural anthropologist with the University of Manchester who draws on both the Humanities (M.A. Classical Languages and Cultures, Leiden University) and the Social Sciences (Ph.D. Cultural Anthropology, McGill University) to explore skilled manifestations of human curiosity, play, and rhetoric. She is the author of 'Crafting 'the Indian': Knowledge, Desire, and Play in Indianist Reenactment' (Berghahn Books, 2012), an ethnographic study of the social and performative dynamics of a contemporary amateur practice in Europe predicated on expert replication of Native American life worlds from the past. More recently, her research agenda has centred on the engagement with and emulation of nature that underpins skilled practices of hunting and taxidermy. Since 2017, Kalshoven has pursued her interest in expertise, materials, and more-than-human landscapes with ethnographic and experimental research on 'futuring' in habitats of nuclear decommissioning. Practices of modelling and mimesis remain central foci: Kalshoven conceives of human life as a series of repetitions and rehearsals for things that never quite come to pass.

Glenn Marion aims to show and extend the power of mathematical modelling to impact on societal challenges through multi- and inter-disciplinary research, real-world application, and via the development of improved methods. He has published more than 100 refereed articles and book chapters on the development and application of statistical techniques for spatio-temporal stochastic processes (including Markov chain Monte Carlo, model diagnostics and model comparison) and stochastic modelling techniques (including individual- and agent-based modelling) applied to epidemiology and population dynamics in ecological interactions. These tools and approaches are needed to understand complex adaptive systems including, sometimes unanticipated, responses to policy interventions. They aim to extract maximum value from observational and experimental data to quantify uncertainty and estimate quantities of interest that are impractical or too costly to measure directly and to provide actionable insights to guide better management and policy.

Seth Oliver is an artist, innovator and improviser. He is the director of the Event and Film Production company FIZZI Productions Ltd, an entrepreneurial and motivational mentor and advocate for Young People, and a pioneering consultant in the emerging field of 'Relational Activism' through Four Bars. Central to his work is the search for a language and way of becoming as close to experience as possible. Oliver's artistic interventions are being applied in academia, policy circles and the world of business. Seth has just completed a 20-year book collaboration with Barbara Adam: Drawing Futures, Parallel Substances, Domains, Processes in which his drawings sit beside Barbara's distilled theory on social futures. Seth seeks out artists and policy makers whose focus is on hope in hopeless situations, attempting to collaborate on practical approaches where hope can transform into promise through authentic collaboration.

Vadim Saraev conducts economic research at Forest Research, focusing on the valuation of ecosystem services and the benefits provided by Britain's forests. He has extensive experience managing research projects and currently oversees a team of assistant economists. He holds a PhD from Queen Mary, University of London, where he investigated monetary issues in the transition economies of Central and Eastern Europe. Prior to joining Forest Research in December 2007, Vadim worked at the Bank of Finland Institute for Economies in Transition (Helsinki), analysing macroeconomic developments in transition countries. He also held a research fellow position in the Department of Economics at the University of Stirling, contributing to applied economic studies on topics such as returns to education, the cost of elderly care, and income dynamics in later life. His current research interests encompass the physical and mental health benefits of woodlands, payments for ecosystem services and their valuation, optimal rotation length modelling, economic benefits of green infrastructure, natural capital assessment, modern robust portfolio optimisation, risk and uncertainty modelling, econometrics, dynamic optimisation, numerical analysis, and simulation. He is proficient in programming with Python and R.

Sietske Veenman currently works at the Chair Group of Environmental Governance and Politics at Radboud University Nijmegen. She teaches courses on scientific methods and futures framing in sustainability issues, amongst others. Her research focuses on environmental governance from a futures and/or anticipation perceptive. Although Sietske addresses a wide range of environmental issues, recently, her research focuses on the energy

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