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REVIEW AND SYNTHESIS

Green fields, ugly ducklings and black swans: Aesthetic dimensions of ecological science

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Abstract

1. Despite its relative infancy, ecological science plays a pre-eminent role in current environmental decision-making globally and has, over recent decades, permeated a broad range of academic disciplines. Developments in two areas of philosophical thought in particular, environmental aesthetics and the aesthetics of science, beg an exploration of their intersection with respect to the role of aesthetics in ecological science.
2. Here, we provide a contemporary synthesis of both environmental aesthetics and aesthetics of science to explore aesthetic dimensions of contemporary ecological science, highlighting three main areas of convergence: (1) the influence of aesthetic experiences and judgements of nature by ecologists on ecological science and our contemporary understanding of nature; (2) the development and role of ecological 'taste' among ecologists; and (3) moral, cultural and political implications of the ecological imagination as underpinned by current ecological science.
3. We identify a risk for feedback mechanisms to perpetuate a relatively homogeneous ecological aesthetic as a result of reciprocal influences between ecological science and society which may further promote inadvertent policy advocacy and stifle scientific innovation.
4. We suggest ecological science would benefit from increased aesthetic literacy and reflection by broadening the ecological imagination and intentionally facilitating more diverse and equitable science to inform policy outcomes. Our argument should be of interest to philosophers of science, ecologists and those that draw on their outputs.

KEYWORDS
beauty, ecocriticism, ecology, environmental aesthetics, nature, philosophy of science, scientific method

1 | INTRODUCTION

Ecological science, despite being a relatively young discipline, has become enormously influential in contemporary society, shaping the way we understand both nature and ourselves, as well as our interactions with the environment. Ecological knowledge occupies a privileged position in environmental decision-making and has provided a rationale for significant environmental and social control globally (Trisos et al., 2021). Ecological insights have also triggered extensive developments in a wide range of other disciplines, including economics, sociology, literary studies and philosophy, often resulting in entirely new disciplinary branches of thought, for example, eco-criticism. Surprisingly, however, philosophers have paid relatively little attention to scrutinising ecological science itself (Brown et al., 2011; Colyvan et al., 2009; Lefkaditou & Stamou, 2006) with the philosophy of ecological science that does exist focusing largely on metaphysical and ontological concerns (e.g. Donhauser, 2016). Given growing public distrust of science across a range of disciplines (Kabat, 2017), greater reflection on the philosophical dimensions of ecological science is long overdue to improve its transparency and equitability and to identify more robust and defensible approaches to its practice and application.

One area of thought in which ecological science has had a substantial impact is philosophical aesthetics, particularly in relation to the aesthetics of nature and the environment. While environmental aesthetics can encompass a broad range of places, things and events that are typically considered to be beyond the realm of 'art' (Parsons & Carlson, 2024), here we focus on a narrower interpretation of the term, that is, that concerning natural environments or natural components of anthropogenic environments. Major schools of thought within environmental aesthetics, especially scientific cognitivism, place considerable weight on ecological knowledge and its bearing on aesthetics, arguing that scientific knowledge is essential for 'correct' aesthetic experiences and judgements of the natural world (Brady & Prior, 2020). While there remains considerable debate in the field of environmental aesthetics between cognitivists and non-cognitivists (i.e. those that argue for and against the necessity of ecological knowledge in aesthetic appreciation of nature), a range of pluralist models have also emerged emphasising the importance of, for example, imagination, emotion and myth in addition to scientific knowledge (Brady, 2019). More recently, a philosophical branch of environmental aesthetics, ecological aesthetics, has been proposed, claiming to be directly and explicitly informed by key principles of ecological science, for example, dynamic balance and complementarity (Berleant, 2016).

Recent years have also seen aesthetics garner greater attention in the philosophy of science with a growing recognition of the role that aesthetic factors play in scientific practice, understanding and knowledge production (Ivanova & French, 2020). Particular attention has been given to the influence of aesthetic values and judgements on the selection by scientists of objects of study, methodological approaches and scientific theories (Arcangeli & Dokic, 2020; Breitenbach, 2018; Ivanova, 2022). The relationship between beauty and scientific 'truth' or 'facts' has also been widely explored (Elgin, 2020; McAllister, 1998), as have comparisons between works of art and scientific products including theories, models and scientific 'non-art', for example, images generated by electron microscopes (Ivanova & French, 2020; Nadin, 1991). Importantly, aesthetic factors are often viewed as epistemic 'gatekeepers' (Elgin, 2020), heuristically guiding scientists through complex decision-making such as theory selection or experimental design (Colless, 2020).

At the convergence of environmental aesthetics and the aesthetics of science, significant implications for ecological science emerge. For example, the products of ecological science are, according to the many cognitivist and pluralist models of environmental aesthetics, likely to play a pivotal role in determining how people perceive and value their environment and nature, with implications for environmental policy and action. At the same time, insights from the aesthetics of science suggest that ecological knowledge generation itself is subject to considerable influence and bias due to aesthetic values, experiences and judgements of ecological scientists. The aesthetic sensibilities of ecologists, in turn, can be shaped by a range of factors including formal scientific training as well as cultural and socioeconomic influences. Consequently, a potential arises for feedback mechanisms in which a relatively homogeneous ecological aesthetic is perpetuated as a result of these reciprocal influences between ecological science and society, propagating inadvertent policy advocacy (Lackey, 2001; Wilhere, 2012) and stifling scientific innovation. For environmental management, this could promote hegemonic decision-making based on a particular aesthetic 'picture' of the environment to the exclusion of others and consequently disregarding the values and ways of interacting with the environment that these alternative perspectives entail. For example, First Nations Australians do not perceive the fundamental distinction between the terrestrial and marine realms that pervades ecological science, and which has constrained Indigenous aspirations for ownership and management of sea country (Jackson, 1995).

For much of the latter half of the 20th century, the role of aesthetics in ecological science was rarely acknowledged by ecologists (Kovacs et al., 2006). More recently, the importance of public perceptions of ecosystems and landscapes to conservation endeavours has been increasingly recognised by ecologists, although misalignment and conflict between ecological values and public aesthetic values have also been widely reported (e.g. Arsenio et al., 2020; Shapshay et al., 2018). Arsenio et al. (2020), for example, report on significant discrepancies between scientific ecological condition assessments and visual preferences for restored riparian ecosystems, noting how the latter vary considerably among stakeholder groups. Furthermore, reflection by ecologists on how their own aesthetic preferences might influence their scientific practices and outputs remains lacking—as evidenced by the conspicuous dearth of explicit aesthetic considerations in the ecological scientific literature.

We argue that ecological science, rather than overtly or covertly disregarding, denying or minimising the influence of aesthetics, can benefit from explicit consideration of aesthetic factors in relation to its scientific practices and products through, for instance, the stimulation of creativity, transparency and diversity. Indeed, given its pre-eminent role in much contemporary decision-making, ecological science might be seen as having a responsibility to not only generate epistemologically robust and defensible knowledge but also to acknowledge and tend to the aesthetics which underpin it as well as that which it facilitates or endorses.

Here, we provide a contemporary synthesis of environmental aesthetics and the aesthetics of science to investigate the role of aesthetics in contemporary ecological science and discuss the implications for the future of ecological research and its applications. We assume a relatively narrow definition of ecological science as referring largely to the Western academic discipline concerned with biophysical relationships between living organisms and their environments, as typified by its use in university science departments. We therefore exclude from our definition the environmental humanities, which we instead perceive as being informed by and engaging with, both positively and negatively, ecological science. While aesthetic influences on ecological science have been discussed previously (see Kovacs et al., 2006), a general lack of awareness persists among ecologists and their audiences regarding the influence of aesthetics on ecological research and its applications. Additionally, where aesthetics is considered by ecologists, there is often a perception that aesthetic concerns detract from conservation practice, for instance, by prioritising attractive species and landscapes over others assigned less positive aesthetic values (Gobster et al., 2007; Shapshay et al., 2018).

This paper seeks to spark renewed interest in this topic among philosophers of science, ecologists and users of ecological knowledge (e.g. conservation decision makers, natural resource managers etc.) and to advocate for improved aesthetic literacy in ecological science, as well as establishing a research agenda at the intersection of environmental aesthetics and the aesthetics of science. We initially provide a brief overview of these two fields—(1) aesthetics of nature and the environment and (2) the aesthetics of science. We then discuss the implications of both for ecological science, identifying three main areas of convergence for further investigation: (1) the influence of aesthetic experiences and judgements of nature by ecologists on ecological science and our contemporary understanding of nature; (2) the development and role of ecological 'taste' among ecologists; and (3) the moral, cultural and political consequences of the ecological imagination as underpinned by current ecological science. Finally, we consider the challenges posed to ecological science as a result of these implications and identify ways that ecologists may respond through improved aesthetic awareness and reflexivity.

2 | AESTHETICS OF NATURE AND THE ENVIRONMENT

2.1 | Early philosophical aesthetics of nature

Philosophical aesthetics has its roots in ancient philosophy but burgeoned in the 18th century when thinkers such as Kant, Hume and Shaftesbury, responding to predominantly rationalist accounts of beauty as a property of objects, drove a shift in focus to the examination of the aesthetic experiences and 'tastes' of subjects (Brady & Prior, 2020). Aesthetic experiences are distinguished from simply acquiring knowledge via the senses by the role played in the generation of such experiences by feelings and imagination (Brady & Prior, 2020), as well as, according to Kant, the subject's feeling of themself being affected by the sensed representation (Breitenbach, 2018). The notion of 'disinterested' pleasure in beauty was popularised during this period, particularly by Kant, to describe the contemplative, non-utilitarian character of aesthetic judgements (Shelley, 2022).

Eighteenth-century philosophical aesthetics embraced both art and nature with the latter prompting the development of new aesthetic categories such as the 'picturesque' and 'sublime' (Carlson, 2017), these being differentiated from beauty by the character of the associated experience—the picturesque similarly inducing pleasure but also provoking imaginative reinterpretation and engagement with the landscape, while the sublime is associated with discordant, unsettling and overwhelming feelings, albeit from a position of safety (Paden et al., 2012). Theorising of nature appreciation in Western philosophical aesthetics significantly diminished during the 19th century, despite the flourishing of North American nature writing, as epitomised by Aldo Leopold and his land ethic (Brennan & Lo, 2016). This hiatus is typically attributed to Hegel's claim that only art is a suitable object for theorising since it is only art, not nature, that is the product of reason and therefore deserving of reason's attention (Tafalla, 2011).

2.2 | Contemporary environmental aesthetics

Contemporary environmental aesthetics in Western philosophy has since developed largely in parallel with growing environmental concerns from the mid-20th century and the development of ecological science (Brady & Prior, 2020). Also important during this period has been the growing influence of pragmatism, leading to a broadening in the scope of environmental aesthetics to encompass everyday environments as well as 'pristine' nature (Mikkonen, 2022). Both subjects and objects of aesthetic judgements have been explored by contemporary environmental aesthetics as well as attempts to dissolve this dichotomy though phenomenological approaches which highlight the inherently immersive way in which we experience nature (Berleant, 2016). Aesthetic theory during this period has tended to emphasise the influence of perception on a subject's aesthetic responses and, in turn, the role of imagination, feeling and emotion (Brady & Prior, 2020).

Reflecting trends in philosophical aesthetics overall, contemporary environmental aesthetics has focused predominantly on positive aesthetic experiences and values including, but not limited to, judgements of beauty (Figure 1). Characterised by qualities such as balance, harmony and unity, beauty is often presented as a property of nature (Paden et al., 2012). Indeed, some authors have argued that all of nature is beautiful and that failing to recognise this is due to poor understanding rather than a lack of any

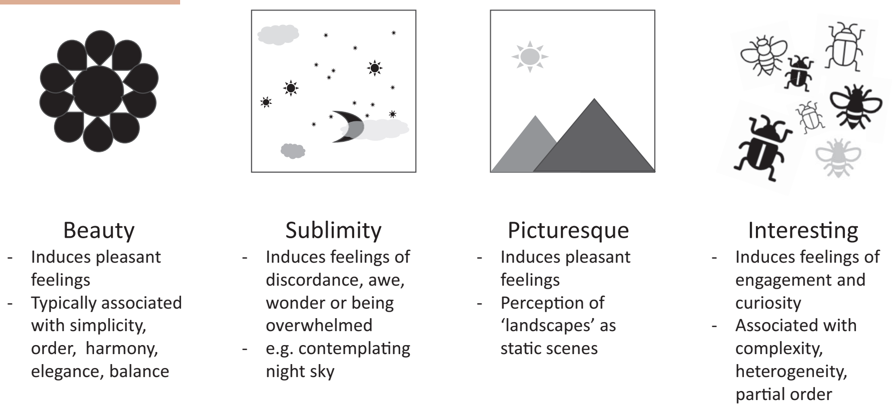

FIGURE 1 Key categories in philosophical aesthetics framing aesthetic experiences of nature.

TABLE 1 Key features of cognitivist and non-cognitivist models of environmental aesthetics.

	Cognitivism	Non-cognitivism
Definition	Proper aesthetic appreciation of nature requires ecological knowledge	Aesthetic appreciation of nature does not rely on ecological/ scientific understanding
Key proponents	Carlson, Holmes Rolston III	Cheng, Mikkonen, Gandy, Iared
Appeal	Provides a basis for objective judgement of aesthetic value vs. disvalue	Considers emotional and imaginative responses; multisensory perception of nature
Object of aesthetic evaluation	Nature, seen as separate to self	Self-in-nature or self-and-nature
Example	Positive aesthetics (Carlson, 1984)—all 'pristine' nature is beautiful, judgements of 'ugliness' due to incorrect knowledge or human degradation	Phenomenology (e.g. Berleant, 2016)—no subject–object distinction when aesthetically experiencing nature, immersed in nature, reflective self-consciousness, 'being in the world' (Berleant, 2016)

aesthetic quality (Carlson, 2002). Relatively little attention has been given to experiences of the ugly, spoilt or human-dominated environments (Maskit, 2007; Mikkonen, 2022). In particular, there has been a broad emphasis in Western environmental aesthetics on the scenic value of nature, arising from the picturesque aesthetics of the 18th century, by which nature (especially that comprising landscapes) is largely appreciated as a series of static pictures (Figure 1; Saito, 1998). Although, as Saito (1998) discusses, numerous authors including Leopold, Rolston III and Carlson have presented cases for appreciating the positive aesthetic values of more mundane or even repulsive aspects of nature such as bare plains, rotting carcasses or the 'tragic beauty' of predation (Hettinger, 2010).

In a recent review of environmental aesthetics, Brady and Prior (2020) identify three major interrelated focal areas in the field: First, the differentiation of environmental aesthetics from that concerning art; second, cognitivist versus non-cognitivist models of nature appreciation; and third, the multisensory nature of aesthetic experiences of the environment. In particular, the debate between cognitivists and non-cognitivists regarding the relevance of scientific knowledge to environmental aesthetics remains one of the most prominent in the field (Table 1; Mikkonen, 2018, 2022). Spearheaded by Carlson and Holmes Rolston III, cognitivists claim that scientific, especially ecological, knowledge is critical to proper environmental appreciation with correct aesthetic judgements of nature dependent upon the appropriate designation of aesthetic objects to scientifically informed categories within which they can be accurately judged (Carlson, 2002). Furthermore, under Carlson's 'positive aesthetics' (Carlson, 1984), all of 'pristine' nature is beautiful with judgements of 'ugliness' therefore associated with either environmental degradation or destruction, or else incorrect classification, the latter well exemplified by the tale of the ugly duckling. According to this model, for example, a treeless floodplain landscape might be judged as 'ugly' if it is assumed that the lack of trees is due to anthropogenic land clearing rather than frequent flooding.

A major appeal of cognitivist models of environmental appreciation is the potential for an objective aesthetics and a persuasive account of aesthetic value versus disvalue (Brady & Prior, 2020). Arguments against cognitivist and positivist aesthetics, however, often reject the possibility of an objective environmental aesthetics, particularly one which is underpinned by an outmoded concept of ecological science which relies on notions of a 'balance of nature' rather than a more contemporary, dynamic conception of nature informed by evolutionary biology (Paden et al., 2012). Non-cognitivists argue that aesthetic environmental appreciation, as a 'perceptual counterpart of ecology' (Cheng, 2022), does not rely on reductive scientific understanding but rather comprises the emotional and imaginative responses triggered by aesthetic experience of nature (Mikkonen, 2018). Non-cognitivist models of environmental aesthetics highlight the importance of our multisensory perception of nature which always occurs from a position immersed within nature

(Gandy, 2013; Iared et al., 2016). Phenomenological approaches to environmental aesthetics further suggest that the subject–object distinction is irrelevant in aesthetic experiences of nature which, rather than involving a human subject passively perceiving a separate and external environment, are instead characterised by immersive self-consciousness and 'being in the world' (Berleant, 2016; Iared et al., 2016). Nature, like art, therefore, represents an invitation to engage in a 'game' in which aesthetic experiences may facilitate new approaches to understanding the (self in the) world (Grun, 2005).

Aesthetic experiences of the environment, especially those of non-human nature, can be seen as providing an invisible background to human lives, affecting people's well-being (Kuisma, 2019) and potentially influencing their values and actions. Environmental aesthetics can also have significant political ramifications by influencing public awareness of environmental concerns and fostering political action (Brady & Prior, 2020; Gandy, 2013). Aesthetic protectionism, for example, holds that aesthetic, rather than moral, criteria best underpin decisions regarding nature conservation (Godlovitch, 1989; Hettinger, 2010), a perspective that has become increasingly shared by many ecologists working in biodiversity conservation (Mikkonen & Raatikainen, 2024). Numerous empirical studies suggest that people frequently hold aesthetic preferences for landscapes which are also deemed to be ecologically healthy, with an evolutionary basis and sociocultural context often implicated (Arsenio et al., 2020; Cottet et al., 2013; Tribot et al., 2018). However, this is not always the case as highly modified urban and rural landscapes with little ecological value are also widely perceived as beautiful (Gobster et al., 2007). Additionally, aesthetically perceived biodiversity tends to align poorly with biodiversity described by various scientific means, suggesting that a reliance on aesthetic values to defend and promote conservation may be insufficient or even detrimental (Mikkonen & Raatikainen, 2024).

3 | AESTHETICS OF SCIENCE

3.1 | Aesthetic influences on objects of science

According to Arcangeli and Dokic (2020), aesthetics influences science in three broad but interrelated areas—in relation to the *objects* of scientific enquiry, the *products* of scientific activities and *scientific practices* themselves (Table 2). In the first instance, for example, the beauty of a scientific object can provide significant motivation for research (Breitenbach, 2013). While beauty has often been considered an objective property of natural systems, especially under a theologically informed view (Garcia-Rivera et al., 2009), philosophical aesthetics has come to focus more on the perceiver. As such, aesthetic tastes, experiences and judgements of scientists are likely to be crucial in the definition, description and prioritisation of scientific objects. According to the phenomenologist, Merleau-Ponty, scientific objects are akin to 'maps' of the natural world, representing an abstract sign language (Heelan, 1991).

3.2 | Aesthetic influences on products of science

Many of the products of science, including scientific models, theories and even datasets (e.g. series of images), may be considered as 'non-art', although their artistic worth is often devalued, particularly where this is perceived to detract from 'real' scientific work and achievements. Sommerlund (2004), for example, describes how a group of microbial ecologists expressed concern with being recognised for the aesthetic value of their scientific products (i.e. a picture of bacterial biofilm published in the journal *Nature*) rather than their 'hard' scientific contributions. Aesthetic considerations, however, can clearly play a role in the generation of scientific outputs. For example, choices regarding the style of graphs or pictorial diagrams which extend beyond solely those associated with clear communication may involve multiple aesthetic judgements. Vanderplas et al. (2020), for instance, distinguish between 'purely utilitarian' and 'purely artistic' charts, for example, some infographics, although even a decision to produce the former could be influenced by aesthetic preferences. Furthermore, a growing number of studies have investigated relationships between the history of science and art, demonstrating how scientists have drawn extensively on artistic practices, and vice versa, to produce scientific representations of the world (Hendriksen & Wragge-Morley, 2022).

3.3 | Aesthetic influences on scientific practices

There is a clear role for imagination in scientific practice, apparent in the development of research questions, scientific theories

TABLE 2 Key areas of aesthetic influence on science (Arcangeli & Dokic, 2020).

Areas of influence	Examples of mechanisms of influence
Objects of scientific enquiry	Motivation for research Selection and definition of study objects Description of study objects
Products of scientific activity	Generation of 'non-art', e.g. scientific images (e.g. microscope imagery) Design of scientific models and theories Selection of modes of data presentation, e.g. graph type
Scientific practices	Hypothesis generation Selection among competing scientific theories Use of pictures and narratives in scientific training

and even methodological approaches, conflicting with conventional notions of epistemic progress (Murphy, 2022). Many of these activities may involve aesthetic aspects, for example, innovative ways of perceiving and delineating study objects and their interactions, choices regarding the presentation of scientific information etc. Aesthetics is also often assigned epistemic value with the beauty of a theory, as exemplified by its simplicity or elegance for example, often associated with its 'truth' (Ivanova, 2022). More recently, however, aesthetics has come to be seen as an epistemic 'gatekeeper', providing scientists with a non-epistemic heuristic for selecting among theories and aiding understanding, rather than signifying truth (Elgin, 2020; Ivanova, 2022). Judgements made by scientists regarding the 'fit' of scientific theories may thus be seen as having an aesthetic 'flavour' (Todd, 2020). Pictures, for instance, are widely recognised as supporting understanding more than propositions (Meynell, 2020) and their aesthetic qualities may therefore either support or impede their informational intent. Written presentation of scientific propositions may also have an aesthetic quality, for example, elegance. On this view, the epistemic role of aesthetics is not to indicate truth but rather to guide understanding, which is underpinned by aesthetic experiences and judgements of coherence, harmony and 'fit' (Kosso, 2002), and to shape decisions regarding which theories are good or bad. Aesthetic appreciation of a scientific theory will inevitably involve an evaluation of its harmony with our existing intellectual approach to making sense of the world, reflecting a Kantian conception of aesthetic judgements (Breitenbach, 2013).

Long before current philosophical interests in the influence of aesthetics on science, Da Vinci and Descartes both highlighted the significance of the aesthetic sensibilities of European scientists (Nadin, 1991). Scientific training typically comprises significant time spent studying, the epistemic labour of which, rather than solely developing knowledge of theoretical truths, can be seen as providing knowledge-based aesthetic experiences (Currie, 2023). The aesthetic sensibility of scientists is therefore developed, refined and attuned to epistemic purposes through education and, presumably, ongoing involvement in scientific communities (Currie, 2023). Similarly, scientific training and practice will influence and attune the imagination of scientists, shaping their aesthetic tastes (Murphy, 2022). Since different perceptions and tastes may arise from different theoretical frameworks and scientific paradigms, progress in science likely depends not only on changes in knowledge but also on changes in aesthetic standards (Currie, 2023). Just as favourable aesthetic properties, such as harmony and simplicity, likely favour preferences for, and success of, a scientific theory, greater empirical power of a theory may similarly elevate its aesthetic characteristics (McAllister, 1998).

3.4 | Sublimity and science

While there is an emphasis on beauty in recent discussions concerning the aesthetics of science, the role of sublimity in science has also been explored (Figure 1; e.g. Arcangeli & Dokic, 2020). In contrast to considerations of beauty, which often focus on an object's properties, the emphasis in theorising the sublime is typically on the experience of the perceiver, for example, feelings of awe, wonder or an uncomfortable awareness of our cognitive limits (Arcangeli & Dokic, 2021). Consequently, there are interesting avenues for exploration regarding how such aesthetic experiences may influence scientists and their work. The range of aesthetic values relevant to science may also be broadened by considering properties of scientific objects and products beyond those typically associated with beauty, for example, irregularity and complexity. Chaos theory, for example, might be perceived as enabling unpredictable patterns to be positively perceived (Biswas et al., 2018).

4 | IMPLICATIONS FOR ECOLOGICAL SCIENCE

At the intersection of these two burgeoning areas of philosophical aesthetics lies the aesthetic dimension of ecological science itself (Figure 2). Here, we identify three main areas of convergence that warrant further exploration. First, aesthetic experiences and judgments of nature by ecological scientists, as theorised in environmental aesthetics, are likely to have a significant influence on ecological research, knowledge and, therefore, our contemporary understanding of nature (Furia, 2020). Second, aesthetic sensibilities or tastes will be developed by ecologists through their professional training and scientific practices, including social activities, supporting the development and perpetuation of both aesthetic and empirical paradigms. Third, there is a responsibility for ecological scientists to reflect on and acknowledge the role of aesthetics in their scientific

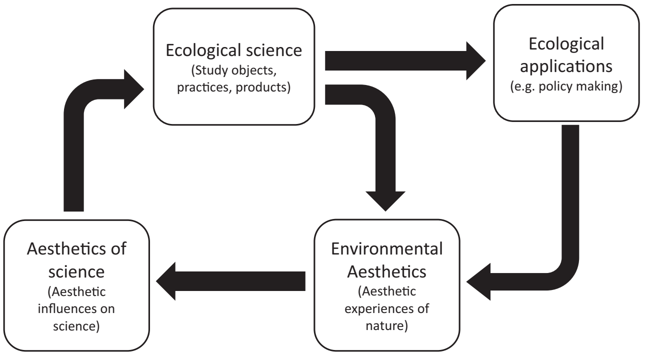

FIGURE 2 Conceptual diagram illustrating key influences (arrows) between environmental aesthetics, aesthetics of science and ecological science and its applications as discussed here. In this model, environmental aesthetics is both *influenced by* ecological science (as per cognitive and pluralist models) and *influences* ecological science through aesthetic influences on science, for example, preferences for certain study objects, methods or theories. In turn, the aesthetic tastes and biases of ecological science will *influence* ecological applications, such as policymaking and other decision making, with direct and indirect implications for society's broader appreciation of nature.

endeavours and the possible consequences for moral, cultural and political reception of scientific outputs.

4.1 | Aesthetic influences on ecological research

There has long been recognition, especially among non-cognitivists, that subjectivity and cultural bias are present in the sciences (Godlovitch, 1994; Mikkonen, 2018). According to Berlant, for instance, conceptual understanding and knowing must be viewed in relation to perceptual experience (Berleant, 2016). Aesthetic experiences, including those of natural beauty, play a significant role in driving ecologists to train in the discipline as well as in the selection of study objects, for example, species, ecosystems or field sites (Kovacs et al., 2006). Furthermore, the ecological scientific literature abounds with aesthetic terminology, for example, ecological integrity, stability, diversity, complexity etc. Aesthetics may further shape the definition and spatial and temporal bounds of a study object which, in ecology, may be commonly influenced by a visual, static and scenic model of environmental perception (Brady & Prior, 2020). Many ecological phenomena, however, exceed the scales of human perception (Gobster et al., 2007) and are highly dynamic or chaotic (Drouin, 2012). In such cases, pre-existing aesthetic biases could be expected to be even more significant in scoping research framings.

Data collection in ecological science also has an aesthetic dimension, sensing and measuring information typically involving both perception and feeling (Otálora-Luna & Aldana, 2017). Furia (2020) further suggests that aesthetics contributes to a blurring of the subject–object distinction, emphasising the importance of field experiences for researchers in facilitating the recognition of a 'symphonic or dissonant' quality in landscapes. Deeper scientific understanding is also aided by aesthetic appreciation of landscapes through, for example, perceiving connectivity of their different components (Furia, 2020).

4.2 | Ecological taste

This discussion also raises the notion of a distinctive 'ecological taste'. Commonly and historically viewed in opposition to science's objectivity, judgements of taste are usually seen as being beyond scientific explanation and dependent on individual, subjective factors (Hendriksen & Wragge-Morley, 2022). Taste can also be understood, however, as 'an embodied form of knowledge production' which arises through one's collective experiences of the external world including through 'ingestion' and 'destruction' of sensory material, both physical and otherwise (Hendriksen & Wragge-Morley, 2022). For ecologists, taste will be developed and shaped by scientific training and ecological fieldwork (Kovacs et al., 2006). Many ecologists also exhibit a preference for simple, 'elegant' scientific explanations and ordered theories, perhaps reflecting a purported envy of physicists (Kovacs et al., 2006). Such aesthetic preferences are important as they may, for instance, constrain conceptualisations of ecological complexity (Kovacs et al., 2006), including temporal dynamism, self-organisation and agency, potentially blinkering ecologists to other phenomena or explanations—the possibility, for example, of 'black swans'.

Aesthetic factors may contribute, as epistemic gatekeepers for instance, to scientific paradigm shifts or, by impeding these, to the maintenance of 'normal science' (Currie, 2023). In ecology, a potentially ongoing epistemic paradigm shift from a balance of nature/successional model to one centred on non-equilibrium and patch dynamics (Fiedler et al., 1997) has arguably been accompanied by a change in the perception of the temporal structure of ecological phenomena, that is, from cycles to organic growth, unpredictability and chaos (Drouin, 2012). Simus (2008) suggests that an emphasis on ecological processes in this new epistemic paradigm necessitates a cognitive model in which aesthetic appreciation is approached more theoretically, given the new conceptualisation of nature as dynamic and more chaotic than previously assumed. Aesthetic factors are therefore likely to contribute, along with epistemic aspects, to challenges posed by incommensurability, such as disagreements and misunderstandings regarding research questions and results (Kuhn, 1970).

4.3 | Broader implications

In the quest for un-biased, objective science, ecologists, like many other scientists, have engaged in many practices which might be construed as an attempt to remove or limit any influences of aesthetic factors on their scientific endeavours, for example, by using random number tables to select field sites. Nevertheless, there is widespread recognition of the inherent aesthetic biases of ecologists in their selection of study objects towards, for instance, 'charismatic' species (e.g. birds and mammals), reflected by the relative volume of scientific literature concerning these taxa (Tribot et al., 2018). Such biases are very likely to influence priorities for conservation investment and action, as explored by Lorimer (2006), for example, with regard to 'non-human charisma' (Lorimer, 2007). Many wetland ecologists, for example, have historically been birdwatchers and the criteria and listing of wetlands under the Ramsar Convention on Wetlands of International Importance strongly reflects such preferences (Stroud et al., 2022).

Ecologists often exhibit a general suspicion of the link between aesthetic and ecological value, as evidenced by the 'aesthetics-ecology debate' which emphasises the lack of any necessary positive correlation between aesthetic and ecological quality (Gobster et al., 2007). There is, however, broad and growing acknowledgement that aesthetic experiences, values and judgements are significant sources of motivation for conservation action, representing the most intimate connections between people and nature (Tribot et al., 2018). For example, aesthetic factors may be particularly significant in determining people's responses to climate change since these afford more personalised and in-depth reflection than science (Mikkonen, 2022). Communication of ecological science widely capitalises on such emotional connections by using beautiful images of species or ecosystems to accompany calls for conservation action, for example, conservation marketing (Ryan et al., 2020). Some subdisciplines of ecology have also sought to effect attitudinal shifts by changing terminology to that with a more positive aesthetic flavour. For example, urban ecologists have taken to replacing the term 'brownfields' with 'open mosaic habitat' (Gandy, 2013).

The relationship between environmental aesthetics and environmental ethics, for example, a moral imperative to protect nature on the basis of its capacity to provide aesthetic experiences, is not straightforward (Shapshay et al., 2018). Non-cognitive accounts of nature appreciation are widely viewed as being too subjective to enable the standardised approach seen as necessary, from a Western philosophical perspective, to underpin this connection. On the other hand, cognitivist approaches face the obstacle of the supposed fact–value gap (Shapshay et al., 2018), a gap which might be at least partially bridged by an acknowledgement from ecologists of the role both aesthetics and ethics inherently play in the production and dissemination of ecological knowledge. Aesthetic choices made by ecologists regarding the presentation of their work to others, for example, as textual propositions or illustrations, may have a significant influence on emotional responses to ecological objects, especially when these objects are not discernible by an untrained or naked eye.

5 | CHALLENGES AND RESPONSES FOR ECOLOGICAL SCIENCE

The intersection of aesthetics, especially environmental aesthetics, and ecological science highlighted here raises many questions which warrant detailed investigation, such as 'what characterises contemporary ecological taste?', 'how have ecological tastes shifted through time and do they currently vary culturally and/or geographically?' and 'how might ecological tastes have inadvertently influenced policy choices?'. Some of the challenges posed to ecologists, however, may begin to be addressed through increased aesthetic awareness and reflection. For example, with improved training in aesthetics and promotion of a 'reflective praxis' (Colless, 2020), ecologists could become more open to assessing when experiences and judgements of beauty (or sublimity) occur in their scientific practice as well as what influence these might be having on their work and its outputs (Paden et al., 2012). With respect to avoiding possible colonial bias, Trisos et al. (2021) propose that an author's 'gaze' (i.e. imagined audience) and 'pose' (i.e. standpoint) be identified by, for example, including 'positionality statements' in publications. Ecologists may similarly promote attitudinal, behavioural and political change through their work by recognising the value-ladenness of the terminology and concepts they use, including those associated with aesthetic value (Elliott, 2020).

Ecologists could further benefit from embracing aesthetic, along with epistemic, curiosity. Iared et al. (2016) suggest that adoption of a critical-reflective interpretive position can deepen the meaning and appreciation of naïve aesthetic curiosity. Aesthetically aware ecologists might seek to develop new aesthetic framings or concepts to guide their endeavours and present their results. 'Evolutionary aesthetics', for example, presents an opportunity to recognise bad design in nature as well as the value of disorder and dysfunction in which nature's tangled complexity is 'interesting' rather than beautiful (Figure 1; Paden et al., 2012). Appreciation of the perceptions and aesthetic experiences of non-human species through new fields such as sensory ecology are also emerging (Otálora-Luna & Aldana, 2017). Additionally, ecologists can engage with environmental art projects, such as eco-art which seeks to raise awareness or trigger behaviour change regarding environmental concerns (Cucuzzella, 2021), or sustainable architecture and landscape design initiatives including that of green infrastructure (Muller, 2014). Such involvement may both broaden the aesthetic horizon of ecologists and facilitate greater exchange with the broader community of ideas and knowledge—presenting 'green fields' for fruitful intellectual dialogue and innovation.

Finally, we urge ecologists to better acknowledge and tend to their societal role as pre-eminent, if not ideal, aesthetic judges of nature, especially given their opportunity to observe ecological phenomena which may be difficult to experience or are hidden from most people. Accordingly, we assert that ecologists have a duty to be cognisant of their influence on broader societal understanding of nature and the planet as an integrated system (Furia, 2020) through aesthetic, as well as epistemic, drivers. This has particular import given the current climate and biodiversity crises and the action these necessitate.

6 | CONCLUSION

Environmental aesthetics and the aesthetics of science are two burgeoning areas of philosophical thought, both of which have significant implications for the practice and application of contemporary ecological science. Environmental aesthetics explores aesthetic values, experiences and judgments of nature, including the influence of ecological science on these, while the aesthetics of science is concerned with the influence of aesthetic considerations on the objects, practice and outputs of science. At their intersection, ecological science emerges as both a product of societal aesthetic preferences and a generator and adjudicator of these. These reciprocal influences, as depicted in Figure 2, therefore present the possibility of a feedback loop within which ecological aesthetic preferences are constrained by dominant scientific and aesthetic paradigms, such as the balance of nature metaphor.

We suggest that greater awareness of, and reflection on, aesthetic influences on ecological science by ecologists is likely to generate multiple benefits for the practice and application of ecological science, contributing, for example, to a more nuanced framing of human–nature relationships that recognises the significance of cultural and institutional factors (e.g. Mace, 2014). By increasing transparency and promoting creativity, incorporating stronger aesthetic literacy in the training and practice of ecological science may facilitate a broadening of the ecological imagination, permitting new ways of seeing, understanding and engaging with nature. We urge further research in this field to facilitate such reflexivity among both ecologists and the many groups who employ and engage with ecological science and knowledge to inform their thinking and decision-making. We see fruitful avenues in the exploration of trends and drivers of ecological 'taste' and how this implicitly and explicitly shape the objects and practice of ecological science as well as the production of ecological knowledge. We also encourage further work to examine relationships between epistemic and aesthetic paradigms and potential paradigm shifts in ecological science, including the effects of recent concepts such as rewilding and novel ecosystems.

AUTHOR CONTRIBUTIONS

Samantha J. Capon conceived the ideas and methodology for the paper and led the writing of the manuscript; Robyn Bartel, Sandy Boucher, Felicity Joseph and Anthony Lynch contributed to the writing and revisions of the manuscript.

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