9 Preserving darkness in the wildwood

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Introduction

Global development serves as a harbinger of ever-increasing quantities of artificial light at night (ALAN). The ubiquity of high-pressure sodium bulbs and bright, white LEDs cast a skyglow that extends artificial lighting beyond the concrete bounds of urban and suburban spaces. Problematically, this *light pollution* hinders human psycho-physiological wellbeing, contributes to the loss of aesthetic, intellectual, and cultural values, and inhibits the flourishing of biodiverse organisms and environments (Dill, 2021; Stone, 2018).

Herein, I utilise an environmental ethical framework to analyse how the loss of natural darkness negatively hinders the conservation and restoration of biodiverse *forested* ecosystems, while simultaneously damaging the irreplaceable relationships that we *Homo sapiens* form with them. In addition, as ALAN inhibits a forest's ability to sequester carbon effectively, it thereby contributes to overall climate change (including extreme shifts in weather and rising global temperatures). To explicate these claims, I employ the key philosophical concepts of *wildness* (defined as a lack of toxic, anthropogenic influences below a vague threshold), *eudaemonia* (flourishing), and *relational value* (according to which the wellbeing of both people and forests is inherently intertwined) (Dill, 2021). Altogether, I contend that the preservation of natural darkness should be conceived of as fundamental to forest, human and global health.

Relationalism: a brief history

Ethics and the environment

Broadly, I contextualise and analyse claims about the necessity of dark sky conservation from within a philosophical, ethical framework. More specifically, light pollutant harms to biodiverse, including forested, species, I argue, are ethically problematic both *intrinsically* (that is, in virtue of their value-in-themselves) and *relationally* (that is, insofar as their presence or absence contributes either to the flourishing or declination of their larger, biotic community). This stripe of ethical *relationalism* attributes a kind of value to more-than-human beings which

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transcends yet integrates both intrinsic and instrumental reasons that motivate care. To understand this claim, it is worth noting that relationalism is motivated by two theoretical components: one descriptive (that is, metaphysical and ontological) and the other normative (that is, ethical). Descriptively, relationalism involves a commitment to the idea that life is best understood interdependently—as fundamentally intertwined, interwoven, and entangled (both climatically and at the level of ecosystems). Normatively, relationalism posits that we ought to act in ways that reciprocally maximise the wellbeing of those with whom we stand in relationship (through, for example, acts of care).

Relationalism's ontological and ethical commitments

Today, some biologists, mycologists, and forest ecologists (Kimmerer, 2013; Margulis, 1967; Sheldrake, 2020; Simard, 2021) have argued that the serious consideration of cooperative *symbiosis* necessitates the rejection of biological and ontological atomism—the view that individuals and species are distinct and wholly separable. One consequence of this view is that the identity or definition of an individual organism by necessity (though not completely) refers to organisms or environmental features outside of it. As organisms cannot be understood in isolation, our biotic world is fundamentally and inextricably *entangled* at its roots (Dill, 2021; Sheldrake, 2020). Relationalism thereby takes seriously Ernst Haeckel's (1866) claim that ecology requires a serious "study [of] the relationships between organisms and their environments: both the places where they live and the thicket of relationships that sustain them" (Sheldrake, 2020, p. 71).

This ontological and biological interdependence firmly suggests that we, *Homo sapiens*, also find ourselves inextricably embedded within a web of biotic relationships. Furthermore, this fact, that which Norwegian philosopher and father of deep ecology, Arne Naess (1973), termed the "relational, total-field image", suggests constraints on and recommendations for certain kinds of behaviour. In order to motivate this argumentative move, it is worth clarifying that relationships can be understood along two dimensions: both descriptively (ecologically) and normatively. In this latter sense, relationships at times bear aesthetic or ethical value and so, by extension, carry normative or moral force.

Drawing on the Aristotelian concept of *eudaemonia*—flourishing—I argue that relationships (in addition to individuals) exhibit degrees of more or less wellbeing. To clarify, Aristotle defined *eudaemonia* as the *telos* or ultimate goal toward which all living beings ultimately aspire. A eudaemonistic life is, in short, a life-well-lived: a flourishing life and the source of all goodness. Good actions or objects thereby acquire their value only derivatively, insofar as they instantiate, or fail to instantiate, eudaemonia effectively. The form of relationalism that I endorse here extends this Aristotelian conception of eudaemonia from individuals to *relationships* and *communities*, conceived of holistically. Different kinds of relationships bear and exhibit differing kinds or degrees of value, for they can be healthy and reciprocally rewarding or may at times—and quite tragically—fall irreparably ill.

Anishinaabe author and environmental scientist Robin Wall Kimmerer (2013) suggests that loving or healthy relationships by necessity exhibit features of care, respect, and reciprocity. In other words, healthy relationships contribute to the *mutual* flourishing of the *relata* who together comprise them. Understood within this broader ethical framework, healthy relationships of this sort are (what I have elsewhere termed) *synergistic* and regulative (Dill, 2021). Those that detract from the wellbeing of one or more of their *relata*—as a direct result of neglect, abuse or other harms perpetuated by one participant are, by contrast, toxic (Dill, 2021). Altogether, the application of the Aristotelian conception of eudaemonia to relationships and individuals recommends the following prescriptive claim: ethical actions are those that contribute to relational flourishing, while actions that detract from reciprocal wellbeing are, by contrast, morally bereft. We are, thereby, morally obliged to act in ways that demonstrate reciprocal care, in gratitude for the rich abundance that we receive in turn.

Extending relationalism to the more-than-human world

Historically, elements of relationalism have been written into many diverse environmental ethical worldviews, including Norwegian deep ecology (Naess, 1973), Anishinaabe traditional ecological knowledge (Kimmerer, 2013), Daoism (Chinn, 2013), the virtue ethics of Confucianism (Hourdequin and Wong, 2005), Aldo Leopold's land ethic (1949), some forms of eco-feminism (Cuomo, 2002), and some Indian environmental philosophy (Shiva, 1988).

Despite this rather broad taxonomic umbrella, relationalists are nevertheless united by the aforementioned set of descriptive and normative core commitments:

1. *Descriptively*: Given the ecological evidence, *Homo sapiens* are inextricably embedded within—and are not fundamentally distinct from—our more-than-human world.
2. *Ethically*: In virtue of the ecological relationships on which we fundamentally rely, *Homo sapiens* are ethically obliged to act in ways that reciprocally contribute to the flourishing of our more-than-human kin.

In order to justify (2), it is worth emphasising that members of our species *Homo sapiens* existentially rely on the material, psychological, emotional, and spiritual sustenance afforded by more-than-human, ecological beings. At the most basic level we are,

> mere heterotroph[s], feeder[s] on the carbon transmuted by others. In order to live, I must consume. That's the way the world works, the exchange of a life for a life, the endless cycling between my body and the body of the world.
>
> (Kimmerer, 2013)

Our flourishing is thus only made possible through exchanges with the complex web of socio-ecological relationships that together constitute our world. Of course, our knowledge about these relationships, facts about whether we are in them at all, and their corresponding ethical obligations may appear to us as, at times, epistemically opaque, for though all *Homo sapiens* necessarily depend on more-than-human flora and fauna for our sustenance (through the agricultural products we consume, textiles we wear, and materials that structure our homes), not all of us are consciously aware that we do so. Nevertheless, and in light of this fact, Kimmerer suggests an extension of the moral sphere to embrace members of our more-than-human world under its purview. In sum, those actions are good which reciprocally contribute to the wellbeing or flourishing of *both* human and more-than-human beings.

"The Woods Are Lovely, Dark, and Deep" (Frost, 1923)

Human relationships with forests

Within the context of this piece, I am particularly interested in remediating pre-existing relationships between human beings and our sylvan kin. After all, our very lives *qua* human beings are entangled with and made possible through our ancestral and contemporary relationships with the plants, mycelia, soils, and more-than-human animals that compose forested ecosystems.

For the sake of brevity, I will not deeply explicate the multiple ways that we benefit from our ongoing relationships with forests. I will, however, briefly gesture at and make reference to some additional, irreplaceable sylvan gifts: from forests, we enjoy a vast range of building materials for shelter such as wood, as well as foodstuffs and priceless medicinal compounds. Existentially, and most pressingly, old-growth groves provide our Earth with approximately one-third of its overall oxygen (Gilhen-Baker, Roviello and Beresford-Kroeger, 2022), whilst forest floras purify toxins from industrially polluted air (Beresford-Kroeger, 2018).

Psycho-physiologically, the immersive, proprioceptive practice of *shinrin yoku* (forest bathing)—in which subjects inhale phytoncides, the essential oils emitted from trees, such as Japanese cedar (*Cryptomeria*) and Hinoki cypress (*Chamaecyparis obtuse*)—proves demonstrably efficacious. More specifically, these biogenic volatile compounds boost immune-system functioning (Ikei, 2015; Li *et al*., 2007) and the growth of anti-cancerous natural killer and T-cells (Li *et al*., 2007). Intriguingly, the available psychological research also indicates that the experiential fascination induced in subjects exposed to biodiverse and very large tree varietals measurably alleviates symptoms associated with anxiety, depression, ADHD, and autism spectrum disorder (Kaplan, 1995).

Beyond these beneficial effects, forests provide subjects with opportunities to engage in mindful, auditory listening (for instance, to frog and bird song and stargazing) while facilitating the preservation and cultivation of cultural mythos that are contingent on natural darkness. Altogether, it is therefore clear that sylvan groves bear an irreplaceable transformative and restorative power, for immersion in them is psycho-physiologically healing along multiple dimensions.

A gift for a gift: restoring natural darkness

Given the wealth of material, psychological, spiritual, emotional, and restorative resources afforded to us by forests, reciprocity suggests that we have a strong relational duty to return their generosity with a gift. The particular recommendation that I here have in mind is by no means flashy or complex. Rather, I suggest that we ought to work toward the restoration or conservation of natural darkness in sylvan ecosystems. Though at times seemingly intangible, forests and their biodiverse constituents *require* natural darkness in order to flourish. Their effective re-darkening therefore serves to “sustain the ones who sustain us, [such that they] will last forever” (Kimmerer, 2013, p. 183).

Dwindling, ecological darkness

Increasingly, white and high-pressure illumination disrupts the flourishing of a range of species, from pollinators and nocturnal mammals to trees and their diverse groves. Consequently, one of the great losses associated with dwindling natural darkness is artificial light’s detrimental impacts on the functioning and wellbeing of forested ecosystems. The flourishing of forest dwellers is impeded, more specifically, for artificial light disrupts circadian rhythms, hinders effective navigation, and removes the cover afforded by natural darkness that some animals require to avoid predation. As the vast majority of invertebrates (60%) and mammal species (an incredible 69%) are nocturnal, the preservation or restoration of biodiverse flora and fauna *requires* the preservation (or restoration) of natural darkness (Bennie *et al*., 2016; Hölker *et al*., 2010).

To illuminate this claim in a useful and measured way, I will spend some time evaluating how light pollution negatively affects a variety of forest-dwelling species: frugivorous and insectivorous (fruit- and insect-consuming) bats, invertebrates (including insects), diverse flora (including trees), and fungi. Curiously, while the effects of artificial lighting on bat species have been extensively covered in the empirical literature, the effects of artificial lighting on trees and fungi in non-urban settings have not. Accordingly, my analysis of ALAN’s detrimental effects focuses on the interdependent interactions betwixt and between the diverse species that dwell therein. More specifically, I analyse how these species positively—and, at times, essentially—contribute to the entangled flourishing of the forested ecosystems they call home. The loss of any one species thereby constitutes a significant harm to the wildwood. Altogether, as we *Homo sapiens* owe a significant debt in reciprocity for the abundance provided by these sylvan zones, we are ethically obligated to work toward their effective re-darkening.

Under cover of darkness: bats, seed dispersal, and reforestation

This exploration begins with an examination of the harmful effects of night-time artificial lighting on one nocturnal, flying mammal, which has been culturally associated with metaphorical and literal darkness. Though at times unnecessarily feared (through e.g., their portrayal in Bram Stoker's *Dracula*), bats play an important ecological role in the creation and maintenance of tropical forests. Serving as seed-dispersing stewards, pollinators, and insect suppressors (Brasileiro, Machado and Aguiar, 2022), bats are indispensable members of and contributors to the health of the wildwood. Light-pollutant harms to bats thus constitute a series of irreparable harms which threaten the wellbeing of the forests in which they dwell.

Given their nocturnal status, bats are particularly sensitive to light. They prefer a cover of darkness *so thick* that even the natural illumination of our moon reduces their hunting and foraging activities (Morrison, 1978; Fleming, 1988). Indeed (and perhaps counter-intuitively), insectivorous bats rarely maximise the potential afforded by artificial lights, which tend to attract a range of invertebrate insects into their glowing field (Stone, Jones and Harris, 2009, 2012). Instead, bats' extreme light shyness prompts them to relinquish these veritable banquets in favour of maintaining an obscured sense of safety. Beyond these, the changes induced by ALAN are vast, including "a delay to leave the nest, decreased sexual activity, changes in flight speed and paths (trajectory, height) as well as significant increases in collisions (~25%) in the presence of lit obstacles" (Falcón *et al*., 2020).

Fruit- and nectar-consuming bats are likewise affected by ALAN. Most avoid well-lit areas, for illumination also renders them vulnerable to predation (Lowery, Blackman and Abbat, 2009). This is particularly worrying, for frugivorous bats provide an array of irreplaceable ecosystem services to the forests in which they dwell. More specifically, frugivorous bats (including *Leptonycteris curasoae*) pollinate flowers and disperse seeds, contributing to the growth and flourishing of a diversity of plant varietals (Ghanem and Voigt, 2012). Even more pressingly, frugivorous bats can withstand habitat disturbances produced when tropical forests are culled to make way for agriculture or livestock grazing. These regions are often later abandoned by farmers due to factors such as soil depletion, so these regions are subject to devastating and alarmingly high rates of biodiversity loss. Given their role as the primary seed-dispersers of pioneering (i.e., first-wave) plant varietals (Muscarella and Fleming, 2007), neotropical frugivorous bats spur the healthy regeneration and reforestation of depleted ecological groves.

However, given their light-shyness, frugivorous bats *require* the cover afforded by natural darkness to successfully produce their "copious seed rain . . . in deforested habitats" (Lewanzik and Voigt, 2014). ALAN thus hinders reforestation and spurs further biodiversity loss by dissuading frugivorous bats from engaging in their integral stewardship efforts.

Artificial light's effects on plant and tree species

Perhaps surprisingly, few studies have been conducted on how ALAN affects plants in non-urban or suburban settings. Due to variances in lighting intensities (compare, say, the diffuse illumination of skyglow to the direct illumination shone by white-LED streetlamps), it has been difficult to isolate and measure the particular effects of different lighting kinds, levels, and intensities. Instead, the bulk of research has so far focused on artificial light's effects on either plants in urban settings or more broadly, on plant-pollinator relationships (Giavi, Fontaine and Knop, 2021). With this in mind, Bennie *et al*. (2016, p. 612) call on ecologists to "define ecologically meaningful measures of artificial light in the natural environment [in order to] develop understanding of the thresholds and dose-response relationships of light-sensitive processes in plants".

It is clear, nevertheless, that biological beings in general—from bats and human beings to bees *and* trees—have evolved circadian rhythms that track transitions from day to night. More precisely, circadian rhythms serve as internal clocks, which regulate an organism's sleep-wake cycles, influence their behaviour, and determine overall metabolic growth.

Briggs (2006) provides a thorough and compelling review of the available research into the physiological effects of artificial light on the circadian rhythms of urban and suburban plant varietals. Altogether, the empirical evidence summarised demonstrates that artificial light has measurable and sometimes detrimental effects on the season-relative timing of leafing, bud-burst, and flowering in trees and plants more generally, which is (under naturally dark conditions) determined relative to day length and seasonality (Falcón, 2020). In other words, as artificial lighting mimics well-lit days and emulates longer, brighter seasons, it prompts plants to bud earlier and lose their leaves later in the year. This is worrisome, for shifts in seasonal cycles could result in the potential desynchronisation between plants and the pollinator populations on which they rely for successful reproduction, dispersal, and gene flow.

Last but certainly not least, plants, like humans, need rest. Natural darkness provides them with the proper conditions under which to recover from physiological stress and strain (Futsaether *et al*., 2009). This is crucial, for rest stimulates successful carbon metabolism through photosynthesis, respiration, and photorespiration, which enables plants to synthesise sunlight into food, produce oxygen, and sequester carbon (Gaston *et al*., 2017). By contrast, the strain of enduring continuous artificial lighting inhibits this process by inducing necrosis (cell injury) and chlorosis (the yellowing of leaves) (Velez Ramirez *et al*., 2011).

Artificial light, moths, and night-blooming flowers

The bulk of our planet's biodiversity is comprised of invertebrates, including a mind-numbing variety of insect species. Familiarly, insects are highly attracted to artificial illumination, for it emulates the white glow of luminous moonlight. This is problematic, for in some cases it renders insects vulnerable to predation by owls, reptiles, spiders, and amphibians. Highly reflective surfaces only magnify this concern, for their twinkle attracts pollinators (including moths) and disrupts the lifecycles of aquatic insects by drawing them out of and away from water (Bruce-White and Shardlow, 2011). As this chapter seeks to recommend strategies that contribute to the flourishing of the wildwood, I evaluate the threats posed by ALAN to nocturnal, *pollinating insects* in particular. After all, the flourishing of flowering plants, including their successful reproduction and the maintenance of their genetic diversity, requires the pollinating labours of moths, bees, nectarivorous bats, and flies. Indeed, nectarivorous insects are responsible for the bulk of this entomophily.

One nocturnal species is primarily responsible for the pollination of night-blooming flowers: the ethereal, illustrious, and elusive moth (Lepidoptera). Over the course of their adult lifecycles, the relationship between flora and moth grows and deepens, for the nectar that once served as their primary source of sustenance then eventually feeds their young (MacGregor *et al*., 2015). Reciprocally, the flourishing of white varietals with sweet, heavy fragrances, including jasmine (*Jasminum*) and bog orchids (*Platanthera leucostachys*), require the distributive ecosystem services afforded by moths. Indeed, from tropical rainforests to coniferous forests, moths, including Sphingidae, Noctuidae, and Geometridae, contribute indispensably to the wellbeing and functioning of the complex, varied, and entangled ecosystems in which they dwell (Winfree, Bartomeus and Cariveau, 2011). Accordingly, their loss would constitute an irreparable series of harms to biodiverse, night-blooming plants.

Tragically, nocturnal moth populations have declined by an overwhelming *two-thirds* since the early 1970s (Fox *et al*., 2013). In addition to climate change and habitat degradation, the available evidence strongly suggests that ALAN may be driving population decreases in Great Britain, the Netherlands, and Finland (Hölker *et al*., 2010; Fox, 2013; MacGregor *et al*., 2015). Like other nocturnal animals, ALAN affects moth populations along a few dimensions. Illumination poses a threat to nocturnal moths, for it both renders them highly vulnerable to predation and impedes their capacity to reproduce successfully. Even "low levels of artificial light [have been shown to] inhibit the release of sex pheromones in female moths of the Geometridae species" (Sower, Shorey and Gaston, 1970), while simultaneously disrupting the healthy development and growth of moth larvae. Furthermore, moth navigation is partially driven by their sensitive vision, a function of their combined simple and compound eyes (Frank, 2006). As bright light obscures the UV markings on flowers, these nectar-foragers are thereby unable to successfully locate and land on their preferred sources of sustenance (Davies, Bennie and Inger, 2013). By extension, ALAN hinders their successful pollination efforts. In some cases, it delays their nocturnal, foraging activities altogether (for, long after the sunsets, moths continue to sense their still-bright world as "still day").

Given their integral ecological role, ALAN's deleterious effects on moth species are potentially momentous, detracting from the functional wellbeing and functioning of their biodiverse ecosystems (MacGregor *et al*., 2015). The loss of nocturnal moths thereby constitutes a significant harm to the flourishing of the wildwood.

ALAN, mycelial health, and water pollution

Fungi play a variety of crucial roles in forested ecosystems. In their capacity as decomposing saprobes, they indispensably recycle litter (including leaves, wood, and needles) into nutrient-dense soil. Fungi, furthermore, participate in a complex web of nutrient and chemical exchanges with diverse tree species. For example, mycorrhizal fungi carry excess nitrogen from alder to pine trees through an interwoven and mutualistic underground network. Alder, more specifically, are especially nitrogen-rich, yet in a spectacularly cooperative fashion, contribute this excess abundance to their nitrogen-poor plant neighbours, including pine trees (Simard, 2021). The exchange between alder and pine, however, requires an intermediary, a role fulfilled and facilitated by the mycorrhizal fungi that colonise the roots of both species. In terms of their reciprocal flourishing, fungi benefit from their participation in this mutualistic, forested exchange through the carbohydrates that they in turn receive. Thus, this symbiotic process contributes to the growth and *eudaemonia* of all three, entangled beings.

Relatively little empirical work has been conducted on the relationship between increases in ALAN and forest-dwelling fungi. Nevertheless, we can (with a reasonably high degree of accuracy) infer its effects in the proverbial wild, for ALAN demonstrably stunts the growth of fungal fruiting bodies such as mushrooms and mycelia, while simultaneously impeding fungi's capacity to engage in efficacious litter decomposition (Pu *et al*., 2020). Controlled laboratory studies have shown, for example, that light hinders mycelial growth in jack-o'-lantern (*Omphalotus olearius*), bitter oyster (*Panels stipticus*), honey fungus (*Armillaria mellea*), and *Mycena citricolor* mushrooms. More precisely, Weitz *et al*. (2001) observed that all four species underwent a decreased period of growth when placed under (artificially bright) light for a 24-hour period. Worryingly, *A. melea* failed to produce rhizomorphs (that is, hyphae strands) under *any* artificial light whatsoever. By contrast, a 24-hour period of total darkness proved optimal for mycelial growth across all four species. Generalising from these studies, it is reasonable to infer that ALAN will have measurable (and potentially detrimental) effects on the growth of wild fungi in forested settings, too.

In addition to stunting fungal growth, the presence of ALAN affects and alters "fungal community composition and the correlations between fungi species" while simultaneously over-stimulating or inhibiting their capacity to engage in efficacious litter decomposition (Pu *et al*., 2020). Furthermore, when fungi are overly stimulated by artificial light, they engage in the hyper-decomposition of litter. As a result, toxic quantities of arsenic (Pu *et al*., 2020) and cadmium are released into aquatic streams. In one study, ALAN stimulated fungal litter decomposition to such an extent that cadmium toxicity in nearby aquatic stream-beds increased by an overwhelming 71% (Liu *et al*., 2020). The effects of this process are, of course, deleterious, for "fungi . . . play key roles in the carbon and nutrient dynamics of stream ecosystems" yet "are more sensitive to pollutants than bacteria" (Liu *et al*., 2020).

Altogether, the presence of artificial lighting clearly affects fungal, forested communities along (at least) two dimensions: it hinders their healthful growth and impedes their capacity to engage in the efficacious and measured decomposition of forest detritus. Given the crucial role that fungi play in forested ecosystems, harms to fungi constitute a series of both direct and indirect harms to forests, conceived of as wholes.

Conclusions

Ecological networks and entangled flourishing

Throughout this conceptual foray into the wildwood, assessments of diverse beings have made explicit reference to the indispensable and entangled ecosystem services that each species provides. These community structures, including "the occurrence (and frequency) of interactions between species, such as plants and pollinators", are best described as *ecological networks* (Montoya, Pimm and Solé, 2006). In addition, their robustness or resiliency refers to each network's ability to withstand drastic changes or perturbations to their overall composition, through, for instance, extirpation or species loss (Evans, Pocock and Memmott, 2013).

Drivers of ecological change, including global warming and dramatic increases in light pollution, have measurable effects on network resiliency. When, for example, considering the important networks that emerge from interrelationships between plants and pollinators, it is clear that the loss of one has dramatic and, at times, irreparable consequences on the flourishing of the other.

As an isolated phenomenon, the effects of light pollution on ecological networks has not yet been holistically and explicitly studied (MacGregor *et al.*, 2015). Nevertheless, the available empirical data *does* clearly demonstrate that nocturnal moths, plant and tree populations, mycelia, and insectivorous and frugivorous bats are threatened by expanding urbanisation and the artificial light-at-night that it heralds. It is thus reasonable to infer that ALAN's detrimental impacts on the species outlined herein will, by extension, spur a set of cascading consequences for the ecological networks in which they dwell. In sum and most pressingly, the flourishing of the wildwood is threatened by ever-increasing quantities of ALAN.

Darkness and the mitigation of climate change

Interwoven into this analysis has been an implicit gesture toward the climate impacts of light pollution, an indirect yet problematic product of its detrimental effects on biodiverse, forested ecosystems. More specifically, forests demonstrably serve as carbon sinks, for they lock overabundant atmospheric CO_2 into the trees, grasses, shrubs, and mycelial networks that together comprise them. Old-growth forests account for about 10% of carbon sequestration globally (Gilhen-Baker, Roviello and Beresford-Kroeger, 2022) and rely on their healthy mycelial networks in order to flourish. However, the available empirical evidence strongly suggests that ALAN hinders both the mycelial and radial (fruiting-body) growth of fungi. As such, ALAN also poses a threat to the continued growth of old-growth trees while simultaneously preventing fungi from fulfilling their carbon-sequestering role.

We have seen, in addition, that an overabundance of artificial lighting in the tropics dissuades nocturnal keystone species, including bats, from engaging in their efficacious pollination and seed-dispersal efforts. As a result, deforested regions, more specifically those that have been clear-cut to make way for mono-agriculture plantations, are slower to regenerate through fresh growth. This implies that light pollution also *indirectly* contributes to climate change, for it hinders the regeneration of forests which under naturally dark conditions would be successfully seeded and could thereby serve as efficacious carbon sinks.

A relational duty to re-darken forests

Altogether, relationalism recommends a set of duties: epistemically to learn about and ethically to invest in the renewal of healthy, regulative, and synergistic ecological relationships. The particularities of environmental ethical prescriptions should take the contextual features of the flora and fauna that are endemic to each sylvan space into account, for their varying needs will motivate varying constraints on anthropogenic behaviour. Nevertheless, one recommendation can be generalised across forested ecosystems: in reciprocal gratitude for the multiplicity of sylvan gifts received, we *Homo sapiens*, quite simply, are ethically obligated to restore their natural darkness.

Practically, this can be achieved by diverse measures including employing only soft, warm-toned, motion-activated, and low-pressure sodium bulbs, constructing widespread and well-networked wildlife corridors, and devising local policies that constrain lighting trespass near sylvan zones (Dill, 2021; Lewanzik and Voigt, 2014). The construction of interconnected and naturally dark wildlife corridors is particularly efficacious, for they exhibit low degrees of toxic anthropogenic influence and consist of “interspersed [and] peri-urban spaces, which blend [the] barriers between developed and more-than-human realms” (Dill, 2021, p. 16). Even when relatively small, these regions demonstrably allow for the unimpeded migration of more-than-human beings, including bats, between fragmented afforested zones. Furthermore, as darkness corridors utilise motion-activated lighting along their borders, their construction ensures that illuminative trespass remains minimal and limited. Thus, by preserving or re-instating natural darkness in these cordoned-off regions, we will by extension successfully *re-wild* them.

All things told, the cultivation of relational *eudaemonia* between humans and forested ecosystems requires the implementation of wise and considerate boundaries, which ultimately contribute to the wellbeing of those complex eco-relationships in which we find ourselves embedded. Toward this end, we are called on to mindfully sacrifice our diurnal preconceptions of comfort and a global addiction to hyper-illumination in favour of the deep, dark, and flourishing *wild*wood.

References

Bennie, J., Davies, T., Cruse, D. and Gaston, K. (2016) ‘Ecological effects of artificial light at night on wild plants’, *Journal of Ecology*, 104(3), pp. 611–620.

Beresford-Kroeger, D. (2018) ‘The medicine of trees’, The Ninth Haig Brown Memorial Lecture, Campbell River Community Arts Council, Campbell River, British Columbia.

Brasileiro, L., Machado, R. and Aguiar, L. (2022) ‘Ecosystems services provided by bats are at risk in Brazil’, *Frontiers of Ecological Evolution*, 10, p. 852177. https://doi.org/10.3389/fevo.2022.852177.

Briggs, W. R. (2006) 'Physiology of plant responses to artificial night lighting', in Rich, C. and Longcore, T. (eds) *Ecological consequences of artificial night lighting*. Washington, DC: Island Press, pp. 389–411.

Bruce-White, C. and Shardlow, M. (2011) *A review of the impact of artificial light on invertebrates*. Peterborough: Buglife—The Invertebrate Conservation Trust.

Chinn, M. (2013) 'Sensing the wind: The timely music of nature's memory', *Environmental Philosophy*, 10(1), pp. 25–38.

Cuomo, C. (2002) 'On ecofeminist philosophy', *Ethics and the Environment*, 7(2), pp. 1–11. https://doi.org/10.1353/een.2002.0016.

Davies, T., Bennie, J. and Inger, R. (2013) 'Artificial light pollution: Are shifting spectral signatures changing the balance of species interactions?' *Global Change Biology*, 19, pp. 1417–1423.

Dill, K. (2021) 'In defense of wild night', *Ethics, Policy, and Environment*, 25(2), pp. 153–177. https://doi.org/10.1080/21550085.2021.1904496.

Evans, D., Pocock, M. and Memmott, J. (2013) 'The Robustness of a network of ecological networks to habitat loss', *Ecology Letters*, 16(7), pp. 844–852.

Falcón, J., Torriglia, A., Attia, D., Viénot, F., Gronfier, C., Behar-Cohen, F., Martinsons, C. and Hicks, D. (2020) 'Exposure to artificial light at night and the consequences for flora, fauna, and ecosystems', *Frontiers of Neuroscience*, 14, p. 602796. https://doi.org/10.3389/fnins.2020.602796.

Fox, R. (2013) 'The decline of moths in Great Britain: A review of possible causes', *Insect Conservation and Diversity*, 6, pp. 5–19.

Frank, K. (2006) 'Effects of artificial night lighting on moths', in Rich C. and Longcore, T. (eds.) *Ecological consequences of artificial night lighting*. Washington, DC: Island Press, pp. 305–344.

Frost, R. (2002 [1923]) *The poetry of Robert Frost: The collected poems*. Lathem, E. C. (ed.), New York, NY: Holt Paperbacks.

Fleming, T. (1988) *The short-tailed fruit bat: A study in plant-animal interactions*. Chicago, IL: University of Chicago Press.

Futsaether, C., Vollsnes, A., Kruse, O. M. O., Otterholt, E., Kvaal, K. and Eriksen, A. B. (2009) 'Effects of the Nordic photoperiod on ozone sensitivity and repair in different clover species studied using infrared imaging', *Ambio,* 38, pp. 437–443.

Gaston, K., Davies, T., Nedelec, S. and Holt, L. (2017) 'Impacts of artificial light at night on biological timings', *Annual Review of Ecology, Evolution, and Systematics*, 48(1), pp. 49–68.

Ghanem, S. and Voigt, C. (2012) 'Increasing awareness of ecosystem services provided by bats', in *Advances in the Study of Behavior*, 44, pp. 279–302.

Giavi, S., Fontaine, C. and Knop, E. (2021) 'Impact of artificial light at night on diurnal plant-pollinator interactions', *Nature Communications*, 12, p. 1690. https://doi.org/10.1038/s41467-021-22011-8.

Gilhen-Baker, M., Roviello, V. and Beresford-Kroeger, D. (2022) 'Old growth forests and large old trees as critical organisms connecting ecosystems and human health', *Environmental Chemistry Letters*, 20, pp. 1529–1538. https://doi.org/10.1007/s10311-021-01372-y.

Hölker, F., Wolter, C., Perkin, E. and Tockner, K. (2010) 'Light pollution as a biodiversity threat', *Trends in Ecology and Evolution*, 25(12), pp. 681–682. https://doi.org/10.1016/j.tree.2010.09.007.

Hourdequin, M. and Wong, D. (2005) 'A relational approach to environmental ethics', *Journal of Chinese Philosophy*, 32, pp. 18–33.

Ikei, H., Song, C. and Miyazaki, Y. (2015) 'Physiological effect of olfactory stimulation by Hinoki Cypress (Chamaecyparis obtusa) leaf oil', *Journal of Physiological Anthropology*, 34(1), p. 44. https://doi.org/10.1186/s40101-015-0082-2.

Kaplan, S. (1995) 'The restorative benefits of nature: Toward an integrative framework', *Journal of Environmental Psychology,* 15(3), pp. 169–182. https://doi.org/10.1016/0272-4944(95)90001-2

Kimmerer, R. (2013) *Braiding sweetgrass*. Minneapolis, MN: Milkweed Editions.

Leopold, A. (1949 (1986)) *A sand county almanac (outdoor essays and reflections)*. New York, NY: Ballantine Books.

Lewanzik, D. and Voigt, C. (2014) 'Artificial light puts ecosystem services of frugivorous bats at risk', *Journal of Applied Ecology*, 51, pp. 388–394. Available at: https://besjournals.onlinelibrary.wiley.com/doi/epdf/10.1111/1365-2664.12206 (Accessed: 29 April 2023).

Li, Q., Morimoto, K., Nakadai, A., Inagaki, H., Katsumata, M., Shimizu, T., *et al*. (2007) 'Forest bathing enhances human natural killer activity and expression of anti-cancer proteins', *International Journal of Immunopathology and Pharmacology*, 20, pp. 3–8.

Liu, Z., Lv, Y., Ding, R., Chen, X. and Pu, G. (2020) 'Light pollution changes the toxicological effects of cadmium on microbial community structure and function associated with leaf litter decomposition', *International Journal of Molecular Science*, 21(2), p. 422. https://doi.org/10.3390/ijms21020422.

Lowery, S., Blackman, S. and Abbate, D. (2009) *Urban movement patterns of lesser long-nosed bats (Leptonycteris curasoae): Management implications for the habitat conservation plan within the city of Tucson and the town of Marana*. Phoenix, AZ: Arizona Game and Fish Department.

MacGregor, C., Pocock, M., Fox, R. and Evans, D. (2015) 'Pollination by nocturnal Lepidoptera, and the effects of light pollution: A review', *Ecological Entomology*, 40, pp. 187–198. https://doi.org/10.1111/een.12174.

Margulis (Sagan), L. (1967) 'On the origin of mitosing cells', *Journal of Theoretical Biology*, 14(3), pp. 225–274.

Montoya, J., Pimm, S. and Solé, R. (2006) 'Ecological networks and their fragility', *Nature*, 442, pp. 259–264. https://doi.org/10.1038/nature04927.

Morrison, D. (1978) 'Foraging ecology and energetics of the frugivorous bat Artibeus Jamaicensis', *Ecological Society of America*, 59(4), pp. 716–723.

Muscarella, R. and Fleming, T. (2007) 'The role of frugivorous bats in tropical forest succession', *Biological Reviews*, 82(4), pp. 573–590.

Naess, A. (1973) 'The shallow and the deep, long-range ecology movement. A summary', *Inquiry*, 16, pp. 95–100.

Pu, G., Zeng, D., Mo, L., Liao, J., Chen, X., Qiu, S. and Lv, Y. (2020) 'Artificial light at night alter the impact of arsenic on microbial decomposers and leaf litter decomposition in streams', *Ecotoxicology and Environmental Safety*, 191, p. 110014. https://doi.org/10.1016/j.ecoenv.2019.110014

Sheldrake, M. (2020) *Entangled life*. New York, NY: Random House.

Shiva, V. (1988) *Staying alive: Women, ecology, and survival in India*. London: Zed Books Ltd.

Simard, S. (2021) *Finding the mother tree*. New York, NY: Random House.

Sower, L., Shorey, H. and Gaston, L. (1970) 'Sex pheromones of noctuid moths. XXI. Light-dark cycle regulation and light inhibition of sex pheromone release by females of *Trichoplusia ni*', *Annals of the Entomological Society of America*, 63, pp. 1090–1092.

Stone, E., Jones, G. and Harris, S. (2009) ‘Street lighting disturbs commuting bats’, *Current Biology*, 14(19), pp. 1123–1127. https://doi.org/10.1016/j.cub.2009.05.058.

Stone, E., Jones, G. and Harris, S. (2012) ‘Conserving energy at a cost to biodiversity? Impacts of LED lighting on bats’, *Global Exchange Biology*, 18(8), pp. 2458–2465.

Stone, T. (2018) ‘Re-envisioning the nocturnal sublime: On the ethics and aesthetics of nighttime light’, *Topoi*, 40, pp. 1–11. https://doi.org/10.1007/s11245-018-9562-4.

Velez Ramirez, A., van Ieperen, W., Vreugdenhill, D. and Millenaar, F. (2011) ‘Plants under continuous light’, *Trends in Plant Science*, 16(6), pp. 310–318. https://doi.org/10.1016/j.tplants.2011.02.003.

Weitz, H., Ballard, A., Campbell, C. and Killham, K. (2001) ‘The effect of culture conditions on the mycelial growth and luminescence of naturally bioluminescent fungi’, *FEMS Microbiology Letters*, 202(2), pp. 165–170. https://doi.org/10.1111/j.1574-6968.2001.tb10798.x.

Winfree, R., Bartomeus, I. and Cariveau, D. (2011) ‘Native pollinators in anthropogenic habitats’, *Annual Review of Ecology, Evolution, and Systematics*, 42, pp. 1–22.