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Artificial Lightscapes Alter Nocturnal Insect Ecology Through Attraction, Disorientation, Avoidance, and Spillover Beyond Illuminated Sites

Sven Larsson[1]*, Erik Johansson[2], Anna Nilsson[3], Lars Andersson[4]

[1]Department of Artificial Light and Nocturnal Ecology, Faculty of Life Sciences, Swedish University of Agricultural Sciences, Uppsala, Sweden.
[2]Department of Attraction, Disorientation, and Avoidance, Faculty of Biosciences, KTH Royal Institute of Technology, Stockholm, Sweden.
[3]Department of Spillover Beyond Illuminated Sites, Faculty of Sciences, Lund University, Lund, Sweden.
[4]Department of Light Pollution and Insect Behavior, Faculty of Life Sciences, University of Gothenburg, Gothenburg, Sweden.

***E-mail** ✉ sven.larsson@slu.se

ABSTRACT

Artificial light at night is often discussed as though nocturnal insects encounter a lamp, become attracted, and are removed from dark habitat. That sequence captures one pathway but obscures responses operating at different spatial and temporal scales. This article develops a proposed lightscape-effect classification separating physical exposure, immediate behavior, and downstream ecological redistribution. Attraction is treated alongside orientation failure, avoidance, temporal activity displacement, and effects beyond the illuminated footprint. Evidence indicates that lamp aggregation can arise from disrupted flight-control orientation, some taxa avoid illumination, and diffuse skyglow can shift activity without a focal source. Predator, resource, and network consequences therefore cannot be inferred directly from lamp captures or local abundance. Conservation interpretation should move from lamp-centred counts toward spatially explicit lightscapes in which source properties, behavioral state, temporal redistribution, taxonomic context, and scale-transfer uncertainty are evaluated separately. The framework is an organizing hypothesis, not a validated predictive model.

Keywords: Artificial light at night, Nocturnal insects, Phototaxis, Skyglow, Temporal activity, Ecological spillover.

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Introduction

Artificial light at night (ALAN) is pervasive in human-modified environments, yet its biological effects are not directionally uniform. Responses vary with species, behavior, location, exposure configuration, and ecological context [1]. Nocturnal insects make this heterogeneity especially visible because light can alter movement, sensory orientation, communication, foraging, reproduction, and interactions from point sources to diffuse skyglow. The flight-to-light paradigm remains important but is insufficient as a general explanation. Insect-focused synthesis already distinguishes multiple ALAN response pathways [2], while more recent work emphasizes that direct behavioral effects may propagate through interaction networks and community structure [3].

The central inferential problem is which response is measured and what level of consequence that measurement supports. Street lighting can reduce local caterpillar abundance and alter development or feeding behavior [4], whereas long-term moth data show associations between light-related traits and population trends without isolating ALAN as a sole causal driver [5]. Conservation synthesis identifies multiple plausible pathways

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connecting ALAN with insect declines but no universal demographic mechanism [6]. These evidence types are not interchangeable: lamp capture is an encounter outcome, flight trajectory is behavioral evidence, and population trend is a higher-level ecological pattern.

This perspective therefore treats the nocturnal environment as a lightscape rather than isolated lamps. The proposed classification separates exposure geometry, immediate behavioral state, and ecological propagation. Attraction denotes increased source encounter or retention; orientation failure denotes disrupted directional control or signal-guided movement; avoidance denotes reduced use of illuminated space; temporal activity displacement denotes redistribution of when behavior occurs. These states can coexist across species, sexes, life stages, and spatial positions. The aim is to prevent mechanistic and scale-level overreach, not impose a universal taxonomy.

Materials and Methods

Lightscape-effect classification

This perspective applies a conceptual adjudication procedure to the selected 2017–2024 evidence base. Evidence is interpreted along three axes: physical light exposure, immediate biological response, and the highest ecological inference directly supported. The procedure does not convert heterogeneous studies into a quantitative score or assume that experimental settings are commensurable.

First, exposure is separated into source geometry, spectrum, intensity, temporal pattern, and diffuse background illumination. Close-range gathering can arise from disruption of normal flight-control orientation rather than active long-range steering toward a lamp [7]. Field experiments further show that shielding and tailoring road-light emission can reduce insect attraction, making spatial emission geometry biologically relevant [8]. Spectral composition can alter aquatic and terrestrial invertebrate communities and subsidy patterns [9], while laboratory moth behavior changes across light doses without establishing a universal field threshold [10].

Second, the measured response is assigned to the narrowest defensible class. Attraction requires evidence of increased source encounter or retention; orientation failure requires disrupted directional control or signal-guided movement; avoidance requires reduced use of illuminated space; and temporal displacement requires altered timing or temporal distribution. An increased insect count near a lamp can reflect attraction, failed escape, retention, or changed timing, so mechanism remains unresolved unless the relevant process is measured directly.

Third, ecological propagation is considered separately. A synthesis of ALAN-mediated species interactions found that interaction direction can increase or decrease among systems [11]. The proposed classification therefore does not infer predation, reproductive loss, population decline, or community change directly from individual behavior; such outcomes require evidence at the corresponding organizational level.

Results and Discussion

Attraction is the most visible insect response to artificial light, but near-source concentration can be produced by different processes. Insects may approach a source, fail to maintain stable flight near it, remain in repeated trajectories, or encounter it because activity shifts into an illuminated zone. Three-dimensional flight analyses show that many insects orient the dorsal body axis toward artificial light, producing orbiting, stalling, and inversion near sources rather than simple direct steering consistent with universal positive phototaxis [7]. This supports a close-range flight-control interpretation, not a claim that all nocturnal insects detect and approach lamps from long distances.

Source design modifies encounter. Shielding and tailoring road lighting reduced attraction in field experiments [8], while dose-dependent laboratory behavior in Galleria mellonella shows that response type and magnitude can vary with intensity [10]. Attraction is therefore better treated as an exposure-dependent outcome than a fixed taxonomic trait.

Ecological interpretation becomes harder when illumination changes prey availability through the night. Experimental forest-edge lighting altered diel activity of insect prey and pipistrelle bats, with white and red treatments differing [12]. This supports temporal redistribution of prey availability and predator activity, not a necessary increase in insect mortality, predator benefit, or population decline.

Orientation failure

Orientation failure is distinct from attraction because directional control can be lost without long-range approach to a source. Nocturnal moths can use natural celestial information: in Sphinx ligustri, moon position and elevation affected flight orientation and mate finding under relatively dark field conditions [13]. This provides a natural-light comparator but does not establish a common cue system across moths.

Artificial light can also disrupt movement acutely. Pulsed nighttime illumination altered moth flight across multiple species, including erratic movement and flight-to-light responses [14]. Because pulse exposure differs from continuous street lighting in duration and geometry, those effects should not be transferred directly to chronic lightscapes.

Signal-guided movement provides another form of orientation failure. Male common glow-worms showed wavelength-dependent changes in attraction to luminous female surrogates, with shorter-wavelength lighting causing stronger disruption in the tested system [15]. The defensible inference is interference with visually mediated reproductive approach, not that any spectral band is universally safe or that altered approach proves population-level reproductive decline.

Avoidance

Artificial light does not universally increase local insect presence. Field experiments with New Zealand weta showed avoidance of illuminated stations, with male tree weta reducing visitation whereas females lacked the same detectable response [16]. Avoidance therefore belongs alongside attraction as a distinct behavioral state whose occurrence can depend on taxon and sex.

Repeated exposure should not be interpreted as evolutionary adaptation. Experimental comparison of Yponomeuta cagnagellus populations did not support expected local adaptation of feeding and calling behavior to ALAN [17]. Population exposure history is therefore not a surrogate for demonstrated adaptation; plasticity, acclimation, selection, and local adaptation remain separate hypotheses unless directly tested.

Temporal activity displacement

Artificial light can alter nocturnal ecology by changing when activity occurs even without source accumulation or avoidance. Under semi-natural conditions, ALAN disrupted the timing and rhythmic organization of male Gryllus bimaculatus stridulation [18]. This is best interpreted as temporal desynchronization of behavior, not attraction, habitat avoidance, or demonstrated fitness loss.

Diffuse illumination extends the problem beyond lamp-centred behavior. In experimental insect communities, skyglow induced temporal and spatial movement shifts across fragmented grassland habitat, while the same experiment showed no overall predation response [19]. Altered movement can therefore be observed directly even when a commonly predicted ecological consequence is absent.

For analytical use, the manuscript proposes four temporal-displacement states: activity-window redistribution, rhythmic desynchronization, spatiotemporal redistribution, and apparent local activity amplification caused by changed timing rather than demonstrated population increase. These are not universal categories or mutually exclusive states. They are interpretive checkpoints intended to prevent timing changes from being misclassified as attraction or converted prematurely into demographic claims.

Because similar local activity patterns can arise from different temporal processes, a comparative adjudication matrix keeps observation, interpretation, and required validation separate.

Table 1. Distinguishing temporal activity displacement from apparent attraction and demographic change

	Within-night timing	
Temporal response dimension	**Activity-window redistribution**	**Rhythmic desynchronization**
Observed temporal signature	Activity shifts or concentrates within the night	Normal timing or periodic organization is disrupted
Interpretation permitted	Light can change when insects are locally available	ALAN can alter temporal organization without source approach
Biological context	Nocturnal flying insects and consumers	Calling male crickets under semi-natural ALAN
Full-window test	Measure full-night activity against dark temporal profiles	Link timing to mating, survival, or performance
Alternative	Higher local activity need not mean higher abundance	Behavioral disruption does not demonstrate fitness cost

Standing	Evidence-supported pattern; label proposed	Evidence-supported pattern; classification use proposed

Spatiotemporal redistribution		
Temporal response dimension	**Spatiotemporal redistribution**	**Apparent local activity amplification**
Observed temporal signature	Movement changes jointly across habitat and time	Local detections rise during particular intervals
Interpretation permitted	Diffuse light can reorganize movement beyond a focal lamp	Timing, concentration, or retention can elevate local counts
Biological context	Experimental insect communities under skyglow	Insects detected near illuminated edges or concentrated resources
Full-window test	Validate under field light gradients and natural habitat structure	Pair time-resolved activity with independent abundance or movement measures
Alternative	Ecotron patterns may not transfer directly to landscapes	Sampling window can confound attraction with temporal concentration
Standing	Evidence-supported pattern; label proposed	Proposed adjudication state

The temporal states also alter how later spatial inference should proceed: a response may remain local, couple to habitat redistribution, or change interaction opportunity without passing through attraction. **Figure 1** compresses these alternatives while preserving the boundary between observed behavioral change and higher-level ecological inference.

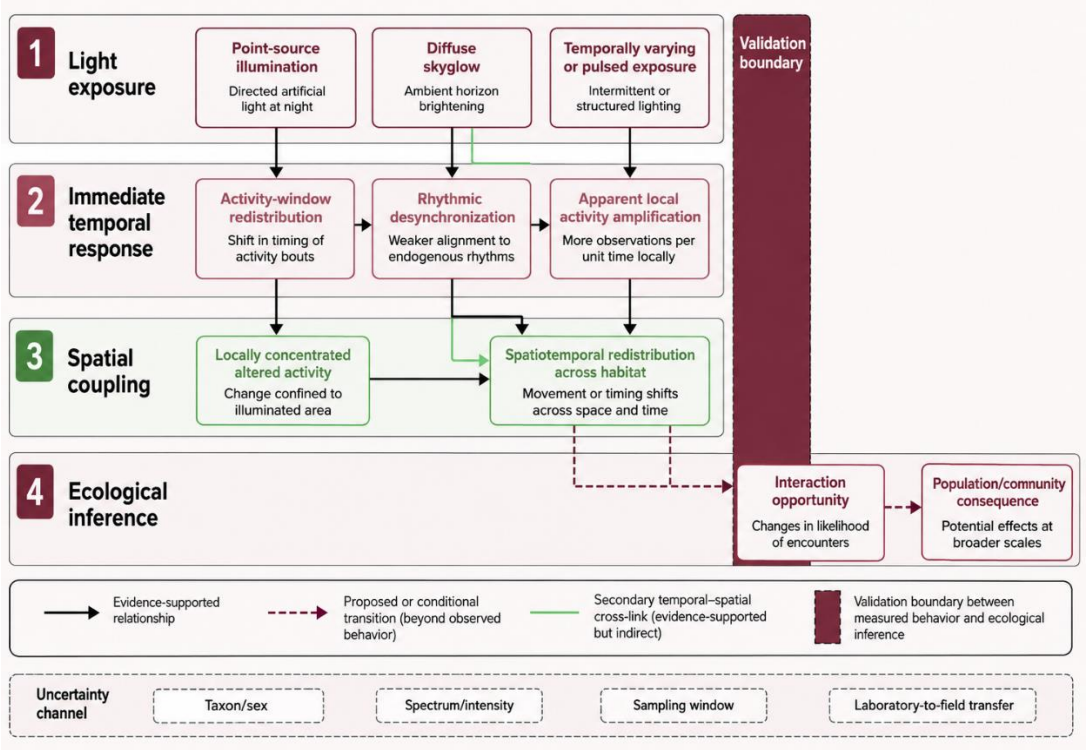


Figure 1. Temporal displacement separates behavioral timing from attraction and downstream ecological consequence

Predator and resource spillover

Behavioral redistribution becomes ecologically consequential when artificial lighting changes where predators, prey, or resources overlap. Yet increased abundance near light cannot by itself demonstrate increased predation. In Swiss forest experiments, LED characteristics altered the functional composition of ground-dwelling invertebrates, with predators and omnivores responding differently from detritivores [20]. Such guild-specific accumulation is consistent with altered trophic opportunity, but realized consumption must be measured independently.

The direction of predator effects is particularly uncertain. A field experiment using insect-containing substitutes found lower predation nearer brighter streetlights, opposing the common expectation that illumination necessarily increases insect predation [21]. Because substitute prey do not reproduce the behavior, detectability, or escape capacity of living insects, this result does not establish a protective effect. It instead demonstrates that a one-direction predation rule is untenable.

Spillover also includes movement of energy and ecological function. Artificial lighting in aquatic–riparian environments was associated with altered invertebrate food-web structure and aquatic-derived energy pathways [22]. In meadow communities, illumination reduced nocturnal flower visitation and impaired reproductive output of focal plants [23]. Moth studies further show why sampling position matters: illuminated sites can have fewer moths at ground level while concentrating activity nearer lamp height and simultaneously altering pollen transport [24]. Thus, local aggregation, trophic opportunity, resource movement, and ecological function represent different response dimensions. None can be inferred reliably from lamp catches alone.

Effects beyond the light source

A lamp-centred framework becomes incomplete when biologically relevant illumination extends into habitat that appears visually dark to a human observer. Diffuse skyglow can modify movement without direct source encounter, and point-source effects can interact with vegetation, habitat structure, wavelength, and sampling method. In macromoth communities, skyglow was associated with changes in abundance, richness, and composition, whereas local artificial-light effects differed and depended partly on collection method [25]. This distinction reinforces the earlier experimental evidence that diffuse illumination can shift insect movement across habitat rather than simply draw individuals toward a luminous object.

The proposed lightscape interpretation therefore separates three spatial states. A source-proximal state concerns direct encounter with a luminaire and includes attraction, orientation failure, or local avoidance. A spill-light state concerns behavior within illuminated habitat surrounding the source, where activity can be displaced without physical contact with the lamp. A diffuse-lightscape state concerns broader background illumination such as skyglow, for which ecological effects can occur beyond the obvious illuminated footprint. These states describe exposure geometry rather than fixed insect phenotypes.

Spatial inference is also constrained by measurement. A trap positioned at lamp height may record concentrated activity even when ground-level abundance is lower, and community patterns estimated with light traps can differ from those obtained with alternative sampling methods. Consequently, “distance from lamp” is not a sufficient exposure metric unless it is accompanied by biologically relevant measures of illumination and habitat context.

The distinction between point-source encounter, spill-light redistribution, and diffuse-lightscape exposure is compacted in **Table 2** because those states differ not only spatially, but also in what can legitimately be inferred from a positive observation.

Table 2. Spatial lightscape states that separate source encounter from nonlocal ecological redistribution

Exposure field			Inference beyond behavior		Evidence required	
Lightscape exposure	**Spatial signature**	**Sampling context**	**Ecological interpretation**	**Boundary**	**Validation**	**Standing**
Point-source encounter						
Source-proximal encounter	orbiting, retention, increased capture, erratic flight, or departure failure	Flying insects immediately around luminaires	Direct light can alter near-source movement	Encounter does not identify long-range attraction or demographic loss	Combine trajectories with source geometry and independent abundance measures	Evidence-supported state; synthesis label proposed
Spill and diffuse fields						
Spill-light redistribution	changed local activity, vertical redistribution, habitat use, or functional-group composition	Habitat illuminated around but not at the source	Light can reorganize use of adjacent habitat	Local concentration may reflect timing or redistribution rather than population increase	Sample illuminated and matched dark habitat across height and time	Proposed spatial state

Diffuse-lightscape exposure	shifts in movement, abundance, richness, or composition along background-light gradients	Habitat under skyglow without an obvious nearby source	Ecological response can extend beyond visible lamp footprints	Skyglow covaries with urbanization and habitat structure	Pair biological data with spatial light measurements and habitat covariates	Evidence-supported pattern; synthesis label proposed
Cross-boundary propagation						
Cross-boundary spillover	altered subsidies, visitation, resource flux, or interaction opportunity	Aquatic–riparian, pollination, or predator–prey interfaces	Behavioral redistribution can propagate across ecosystem or interaction boundaries	Interaction change does not establish population consequence	Measure the downstream interaction or function directly	Evidence-supported pattern; organizing state proposed

These spatial states also determine where the manuscript's inferential boundary should sit. **Figure 2** therefore treats movement through a lightscape as a set of trajectories that may terminate at behavioral redistribution or continue, conditionally, toward ecological interactions and community consequences.

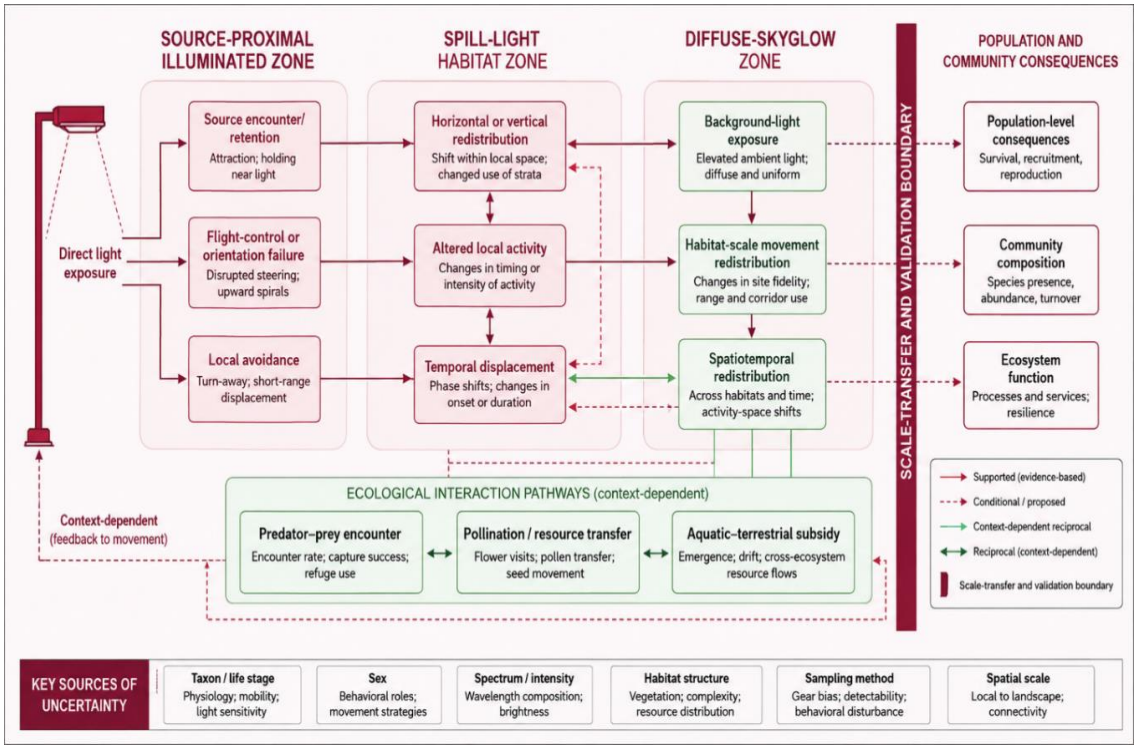


Figure 2. Lightscape trajectories distinguish lamp encounter, habitat redistribution, and cross-boundary ecological propagation

Spatial lightscape model

The evidence above motivates a proposed spatial lightscape model in which ecological interpretation depends on both response state and exposure field. Network modeling indicates that shifts in diel activity can alter temporal overlap among interacting species and thereby change network structure or persistence under specified assumptions [26]. That modeling establishes plausibility rather than field validation of the present architecture.

The proposed model therefore contains three analytically separate layers. The first is physical exposure: source-proximal light, spill light, and diffuse background illumination. The second is behavioral redistribution: attraction or retention, orientation failure, avoidance, and temporal displacement. The third is ecological propagation through predator–prey encounters, resource transfer, pollination, or other interactions. A transition between layers is not automatic. Each requires evidence appropriate to the receiving level.

This structure resolves a recurrent ambiguity. An insect captured at a lamp demonstrates presence at the source, not necessarily a population sink. A temporally shifted calling rhythm demonstrates altered behavior, not reproductive failure. A changed predator abundance demonstrates redistribution, not realized predation. The model's principal function is therefore inferential discipline: it identifies where additional measurements are required before moving from observation to ecological consequence.

Conservation predictions

Mitigation should be formulated as conditional predictions rather than universal prescriptions. Existing synthesis indicates that reducing unnecessary light, modifying timing, direction, intensity, and spectrum, and considering ecological interactions can reduce biologically disruptive exposure in appropriate settings [27]. Field evidence that shielding reduces attraction supports a prediction that limiting source visibility and lateral spill should benefit taxa for which direct source encounter is important. It does not show that shielding eliminates diffuse light effects or restores populations.

Similarly, spectral modification should be matched to the relevant sensory system and ecological process rather than treated as a universally safer color. Reducing short-wavelength content may lessen disruption in some systems, while other taxa or interactions respond differently. Timing interventions are most defensible where temporal displacement is a principal pathway; spatial shielding is most defensible where source encounter dominates.

The proposed conservation rule is therefore response-matched mitigation: identify the biologically relevant exposure field, establish the dominant measured response, and choose an intervention that modifies that exposure without assuming a demographic benefit. Successful conservation inference ultimately requires post-intervention evidence at the population or ecological-function level.

Artificial light alters nocturnal insect ecology through more than attraction. Recent synthesis confirms substantial effects on species interactions and communities while emphasizing persistent taxonomic and ecological gaps [28]. The cited evidence is particularly rich for moths and other flying nocturnal insects, whereas responses of many orders, developmental stages, tropical assemblages, subterranean taxa, and poorly sampled habitats remain uncertain.

The central contribution of this perspective is a proposed separation among exposure field, behavioral response, and ecological propagation. Attraction, orientation failure, avoidance, and temporal displacement are not mutually exclusive labels for species. Different individuals or sexes may occupy different states, and the same insect may shift state as intensity, spectrum, time, habitat, or distance from the source changes. That conditionality explains why lamp counts, ground-level abundance, activity timing, and interaction outcomes can apparently conflict without being logically inconsistent.

The strongest mechanistic evidence concerns close-range flight control around artificial sources, yet even this should not be generalized to every insect or spatial scale. Avoidance evidence shows the opposite directional response in particular taxa. Temporal experiments demonstrate redistribution without source approach, while diffuse-skyglow studies extend exposure beyond discrete luminaires. Predator studies provide an especially important warning: aggregation of prey or predators does not guarantee increased predation, and observed direction can reverse depending on system and method.

Three validation priorities follow. First, field studies should measure biologically relevant light exposure rather than classify habitat solely as lit or unlit. Second, movement and activity measurements should be paired with independent estimates of abundance or demographic performance where population inference is intended. Third, tests of mitigation should measure the response pathway that motivated the intervention and then separately assess whether higher-level ecological outcomes follow.

The proposed spatial lightscape model is therefore not a predictive algorithm. It is a falsifiable organizing architecture. Its value lies in exposing where an inference changes level: from photons to behavior, from behavior to redistribution, and from redistribution to interaction or population consequence. Future comparative work can test whether these transitions recur across taxa, landscapes, and life stages or require substantially different architectures.

Conclusion

Artificial lightscapes should not be interpreted as ecological point sources surrounded by unaffected darkness. Nocturnal insects may gather near lights, lose directional control, avoid illuminated habitat, shift the timing of activity, or redistribute across diffuse light fields. These responses can alter predator encounters, resource transfer, pollination, and cross-ecosystem subsidies, but behavioral change does not by itself demonstrate demographic harm.

The proposed classification separates physical exposure, behavioral state, and ecological propagation so that each inference remains matched to the evidence that supports it. This perspective replaces a single attraction-centred pathway with a spatially and temporally conditional lightscape view while preserving uncertainty about taxa, mechanisms, scale transfer, and conservation outcomes. Its principal prediction is methodological: stronger inference will come from measuring the response pathway and spatial exposure directly before attributing population or community consequences.

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References

1. Jägerbrand AK, Spoelstra K. Effects of anthropogenic light on species and ecosystems. Science. 2023;380(6650):1125-30. doi:10.1126/science.adg3173
2. Owens ACS, Lewis SM. The impact of artificial light at night on nocturnal insects: A review and synthesis. Ecol Evol. 2018;8(22):11337-58. doi:10.1002/ece3.4557
3. Kehoe R, Sanders D, van Veen FJF. Towards a mechanistic understanding of the effects of artificial light at night on insect populations and communities. Curr Opin Insect Sci. 2022;53:100950. doi:10.1016/j.cois.2022.100950
4. Boyes DH, Evans DM, Fox R, Parsons MS, Pocock MJO. Street lighting has detrimental impacts on local insect populations. Sci Adv. 2021;7(35):eabi8322. doi:10.1126/sciadv.abi8322
5. van Langevelde F, Braamburg-Annegarn M, Huigens ME, Groendijk R, Poitevin O, van Deijk JR, et al. Declines in moth populations stress the need for conserving dark nights. Glob Chang Biol. 2018;24(3):925-32. doi:10.1111/gcb.14008
6. Owens ACS, Cochard P, Durrant J, Farnworth B, Perkin EK, Seymoure BM. Light pollution is a driver of insect declines. Biol Conserv. 2020;241:108259. doi:10.1016/j.biocon.2019.108259
7. Fabian ST, Sondhi Y, Allen PE, Theobald JC, Lin HT. Why flying insects gather at artificial light. Nat Commun. 2024;15(1):689. doi:10.1038/s41467-024-44785-3
8. Dietenberger M, Jechow A, Kalinkat G, Schroer S, Saathoff B, Hölker F. Reducing the fatal attraction of nocturnal insects using tailored and shielded road lights. Commun Biol. 2024;7(1):671. doi:10.1038/s42003-024-06304-4
9. Parkinson E, Tiegs SD. Spectral composition of light-emitting diodes impacts aquatic and terrestrial invertebrate communities with potential implications for cross-ecosystem subsidies. Philos Trans R Soc Lond B Biol Sci. 2023;378(1892):20220361. doi:10.1098/rstb.2022.0361
10. Jägerbrand A, Andersson P, Nilsson Tengelin M. Dose-effects in behavioural responses of moths to light in a controlled lab experiment. Sci Rep. 2023;13(1):10339. doi:10.1038/s41598-023-37256-0
11. Seymoure B, Dell A, Hölker F, Kalinkat G. A framework for untangling the consequences of artificial light at night on species interactions. Philos Trans R Soc Lond B Biol Sci. 2023;378(1892):20220356. doi:10.1098/rstb.2022.0356
12. Hermans C, Litovska I, de Pastors M, Visser ME, Spoelstra K. Artificial light at night drives diel activity patterns of synanthropic pipistrelle bats and their prey. Sci Total Environ. 2024;940:173699. doi:10.1016/j.scitotenv.2024.173699

13. Storms M, Jakhar A, Mitesser O, Jechow A, Hölker F, Degen T, et al. The rising moon promotes mate finding in moths. Commun Biol. 2022;5(1):393. doi:10.1038/s42003-022-03331-x
14. Fabusova M, Gaston KJ, Troscianko J. Pulsed artificial light at night alters moth flight behaviour. Biol Lett. 2024;20(11):20240403. doi:10.1098/rsbl.2024.0403
15. Kivelä L, Elgert C, Lehtonen TK, Candolin U. The color of artificial light affects mate attraction in the common glow-worm. Sci Total Environ. 2023;857(Pt 3):159451. doi:10.1016/j.scitotenv.2022.159451
16. Farnworth B, Innes J, Kelly C, Littler R, Waas JR. Photons and foraging: Artificial light at night generates avoidance behaviour in male, but not female, New Zealand weta. Environ Pollut. 2018;236:82-90. doi:10.1016/j.envpol.2018.01.039
17. Cieraad E, van Grunsven RHA, van der Sman F, Zwart N, Musters KJM, Strange E, et al. Lack of local adaptation of feeding and calling behaviours by Yponomeuta cagnagellus moths in response to artificial light at night. Insect Conserv Divers. 2022;15(4):445-52. doi:10.1111/icad.12568
18. Levy K, Wegrzyn Y, Moaraf S, Barnea A, Ayali A. When night becomes day: Artificial light at night alters insect behavior under semi-natural conditions. Sci Total Environ. 2024;926:171905. doi:10.1016/j.scitotenv.2024.171905
19. Dyer A, Ryser R, Brose U, Amyntas A, Bodnar N, Boy T, et al. Insect communities under skyglow: Diffuse night-time illuminance induces spatio-temporal shifts in movement and predation. Philos Trans R Soc Lond B Biol Sci. 2023;378(1892):20220359. doi:10.1098/rstb.2022.0359
20. van Koppenhagen N, Haller J, Kappeler J, Gossner MM, Bolliger J. LED streetlight characteristics alter the functional composition of ground-dwelling invertebrates. Environ Pollut. 2024;355:124209. doi:10.1016/j.envpol.2024.124209
21. Eckhartt GM, Ruxton GD. Artificial light at night may decrease predation risk for terrestrial insects. Biol Lett. 2022;18(11):20220281. doi:10.1098/rsbl.2022.0281
22. Sullivan SMP, Hossler K, Meyer LA. Artificial lighting at night alters aquatic-riparian invertebrate food webs. Ecol Appl. 2019;29(1):e01821. doi:10.1002/eap.1821
23. Knop E, Zoller L, Ryser R, Gerpe C, Hörler M, Fontaine C. Artificial light at night as a new threat to pollination. Nature. 2017;548(7666):206-9. doi:10.1038/nature23288
24. Macgregor CJ, Evans DM, Fox R, Pocock MJO. The dark side of street lighting: Impacts on moths and evidence for the disruption of nocturnal pollen transport. Glob Chang Biol. 2017;23(2):697-707. doi:10.1111/gcb.13371
25. Grenis K, Nufio C, Wimp GM, Murphy SM. Does artificial light at night alter moth community composition? Philos Trans R Soc Lond B Biol Sci. 2023;378(1892):20220365. doi:10.1098/rstb.2022.0365
26. Sanders D, Hirt MR, Brose U, Evans DM, Gaston KJ, Gauzens B, et al. How artificial light at night may rewire ecological networks: Concepts and models. Philos Trans R Soc Lond B Biol Sci. 2023;378(1892):20220368. doi:10.1098/rstb.2022.0368
27. Evans DM. Mitigating the impacts of street lighting on biodiversity and ecosystem functioning. Philos Trans R Soc Lond B Biol Sci. 2023;378(1892):20220355. doi:10.1098/rstb.2022.0355
28. Grubisic M, van Grunsven RHA. Artificial light at night disrupts species interactions and changes insect communities. Curr Opin Insect Sci. 2021;47:136-41. doi:10.1016/j.cois.2021.06.007