Bright needs, dark desires: understanding public preferences for anthropogenic light and natural darkness at night in Aotearoa-New Zealand

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Bright needs, dark desires: Public preferences and balancing the benefits of artificial light and natural darkness at night in Aotearoa New Zealand

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Abstract

1. While serving many useful functions, artificial light at night (ALAN) also leads to the erosion of natural darkness, and of the various benefits that exposure to darkness provides. Yet, we know little about how people perceive ALAN—where they want it, why and when they prefer darkness.
2. Using an online survey of 1000 participants broadly representative of the New Zealand adult population, we assessed participants' self-declared importance of different benefits derived from ALAN and from natural darkness. For each benefit, we fitted a conditional inference tree with demographic, dark-sky related and built-environment related explanatory variables. For a subset of benefits derived from ALAN, we also assessed what people felt was the most appropriate mode of delivery (i.e. always on at night, on-when-needed (using sensors) or bring-your-own).
3. Benefits derived from ALAN were generally rated as more important than those derived from darkness, especially for safety functions and orientation—however ratings were poorly described by the explanatory variables. Darkness benefits rated lower overall, showed less variability and were relatively well explained. Across the subset of ALAN benefits assessed, the preferred mode of delivery for at least 31% of respondents was 'on only when needed' (e.g. using sensors).
4. This nationally representative study exploring public perceptions of both artificial light and natural darkness at night is the first of its kind in Aotearoa New Zealand, and possibly globally. We contribute to reframing the discourse around ALAN to consider both light and dark as essential yet countervailing resources. Our findings advocate for a more balanced and nuanced approach to nighttime lighting policy—one that recognises artificial light and darkness as coexisting, interdependent resources and that actively supports a recalibration of their respective benefits to achieve preferred future states.

KEYWORDS
ALAN, artificial light at night, common pool resource, dark sky, light pollution, natural darkness, preferences, survey, valuation

1 | INTRODUCTION

Over the last 150 years or so, the nighttime environment has changed dramatically, courtesy of the advent of public and commercial electric lighting. These lights have allowed us to extend our day into the night, which has paved the way for work and play after dark. Artificial light at night (ALAN) can also improve road safety, personal safety and reduce property crime (although these benefits depend on lighting quality, placement and context; Fotios & Gibbons, 2018; Trop et al., 2023).

This widespread and increasing use of ALAN, while serving many useful functions, also leads to the erosion of natural darkness and the various benefits that exposure to darkness provides. The benefits of natural day–night cycles include healthy circadian rhythms for humans (Martinez-Nicolas et al., 2014), plants and animals (Seymoure et al., 2025). Under the cloak of a natural night sky, people can feel a sense of peace and solitude (Stone, 2018), and observe stars or other celestial bodies for personal enjoyment/well-being, science and cultural connection (Harris et al., 2013; Stone, 2018). Hence, the emission of nighttime light well above natural levels is resulting in negative impacts for human health and well-being (Cho et al., 2015; Zielinska-Dabkowska et al., 2023), the physiology and behaviour of plants and animals around us (Sanders et al., 2021), astronomy (Green et al., 2022) and cultural practice (Hamacher et al., 2020; Zielinska-Dabkowska & Xavia, 2021).

The continued and ever-increasing use of ALAN has resulted in rapid change in our nighttime environment (Cox & Gaston, 2023; Kyba et al., 2023). The societal challenge of reducing the unintended consequences of ALAN must consider both the benefits of nighttime lighting, and those of exposure to natural darkness. However, there is a lack of knowledge regarding how people perceive ALAN, where and for what reasons they feel it is important to have the surroundings lit, and when/where would they prefer to have it dark. The few studies to date that have attempted to understand the public perception and attitude to ALAN (Besecke & Hänsch, 2014; Coogan et al., 2020; Lyytimäki & Rinne, 2013; Schulte-Römer et al., 2019) were all framed from an ALAN as pollution perspective. Without neutral framing, responses may be biased, and without acknowledgement of artificial light as a provider of a multitude of benefits, such approaches cannot attend to the trade-offs between light and dark that are necessary to reduce the unintended consequences of ALAN, while maintaining access to the core benefits of artificial light. Moreover, these studies did not use samples that were representative of the broad population—which hampers the generalisation of results and the incorporation of results into socially relevant and broadly acceptable mitigation measures.

Using a representative population survey, we assessed the importance of different functions/purposes of ALAN and natural darkness (Table 1), and determined to what extent importance is driven by potential explanatory variables (including demographics, nighttime related variables and contextual/location information). We then assessed, for a subset of lighting purposes, how declared importance affects people's attitudes towards the availability or the delivery mode of ALAN (i.e. always on at night, motion-sensed or bring-your-own). Part of a larger project aiming to assess the extent of situational dependency in the way people value ALAN and darkness at night, this study sets a baseline for attitudes to natural darkness and artificial light at night in Aotearoa New Zealand. This will be a foundation upon which we can build to develop policy focusing on trade-offs between the benefits of ALAN and the benefits of natural darkness, and the implementation of principles of sustainable lighting.

TABLE 1 'Benefits' derived from (or functions of) artificial light at night (ALAN) and natural darkness at night used in the study. The column 'specific benefit' uses the same wording used in the survey, while 'abbreviation used' refers to the short-hand terms used in this paper.

	Generic benefit	Specific benefit	Abbreviation used
Light	Safety and security	Light for traffic safety (lamp posts/streetlights)	Traffic safety
		Light to prevent crime around public and commercial facilities (e.g. carpark lighting)	Property crime
		Light for personal safety/security (e.g. lighting in parks)	Personal safety
	Utilitarian	Light to orientate and find your way (e.g. lighting along pathways)	Orientation
		Light to extend time for recreation (e.g. lit outdoor sports facilities)	Recreation
		Light to extend time for productivity (e.g. at ports, industrial areas)	Production
	Discretionary	Light for advertising (e.g. billboards, lit shop fronts)	Advertising
		Light for decoration (e.g. illuminated buildings, trees)	Decoration
Darkness	Access to night sky	Darkness for visibility/vibrancy of the night sky	Visibility
		Darkness to experience the night	Experience
	Connection	Darkness for peace, solitude	Peace
		Darkness for spiritual/cultural connection	Spirituality
		Darkness for connection to nature	Nature
	Health	Darkness for the natural rhythm of plants and animals	Rhythm organisms
		Darkness for the natural rhythm of people	Rhythm people

2 | METHODOLOGY

2.1 | Survey instrument design

The quantitative online anonymous survey consisted of a series of quantitative questions related to respondents' rating of the importance of the different benefits derived from artificial light and natural darkness at night, their preference for the delivery of artificial light, and their behaviour after dark, supplemented by background and open response questions. The survey instrument was informed by studies on attitudes to ALAN, including surveys conducted in Switzerland (Guenat et al., unpublished), Finland (Lyytimäki & Rinne, 2013), Scotland (Coogan et al., 2020), as well as contributions from lighting professionals and light pollution experts (Schulte-Römer et al., 2019).

These previous studies framed the impacts of (and attitudes to) ALAN as 'light pollution'. The term 'pollution' is universally applied to human impacts upon a 'natural' state, with the inherent value statement that the natural state is 'good' and necessarily favourable, whereas the human-modified state is 'bad' and unfavourable; as such, adopting pollution framing positions ALAN as an explicitly 'negative' influence/presence. Therefore, to avoid introducing conformity bias through pre-sensitising respondents with a negative framing of ALAN (see also Stone, 2017), we instead adopted a positive framing by characterising *both* ALAN *and* darkness as each providing numerous benefits.

An earlier version of the instrument was used in a 400-respondent survey (Breukel & Cieraad, 2024). Based on feedback, the questions were amended, and additional questions were added for this study. Our study and survey instrument were approved by the Nelson-Marlborough Institute of Technology Research and Ethics Committee (B2023-04). The full survey instrument is available on FigShare (Cieraad & Dalley, 2025, https://doi.org/10.6084/m9.figshare.28801235).

The instrument comprises a selection of mainly matrix-type ordinal rating questions. Unipolar rating scales were chosen for their simplicity, low respondent burden, reliability and ease of analysis. Table 2 provides more details of the explanatory variables that were included in this study.

In summary, the sections in the instrument relevant to this study included:

- Background questions (including age, sex, ethnicity and location of the respondent's usual current place of residence along the urban–rural gradient, and where they spent most time growing up)—as these may affect the response to ALAN and darkness at night (Lapostolle & Challéat, 2020; Trop et al., 2023).
- Nighttime-related questions:
  - To capture a respondent's potential exposure to or experience with the night sky, we asked how often they participated in a range of outdoor activities after dark;
  - To capture respondents' potential interest in the night sky, we determined the maximum frequency across different 'reasons' for look up to observe the night sky, the moon, stars, satellites or any celestial objects;
  - To incorporate potential limitations to experiencing or functioning in low-light conditions, we asked respondents whether they had difficulties seeing, walking or other difficulties that might affect this.
- Attitude-related questions:
  - Attitudes towards darkness and ALAN may be relatively primal, and predispositions may affect people's rating of importance of natural darkness and artificial light. While darkness may be negatively associated with 'the dark side' and 'forces of darkness', artificial light at night may be conceptualised positively with 'enlightenment' (Edensor, 2013). We asked respondents the extent to which they agreed with statements whether darkness and ALAN relate with economic poverty and prosperity (respectively), underdeveloped and developed (respectively) communities/countries, and bad and good things, respectively. We also asked the extent to which participants agreed that darkness or ALAN enhances human well-being.
- Importance ratings of different benefits derived from ALAN and darkness at night at the respondent's usual place of residence (see response variable section below) and at a natural setting (not used in this study).
- Most appropriate delivery mode for a subset of benefits derived from ALAN at the respondent's usual place of residence (see response variable section below) and at a natural setting (not used in this study).

2.2 | Response variables

- To gather people's importance ratings of the various functions of ALAN and darkness at night, respondents were asked whether 'Thinking about being outside where you live after dark—How important to you are the following different functions of artificial light at night?'. Responses were provided on a 5-point scale ranging from 'Not at all important' to 'Extremely important'. Definitions of the different benefits derived from ALAN and darkness at night were informed by existing studies (Meier, 2018; Silver & Hickey, 2020, respectively).
- For a subset of benefits derived from ALAN, respondents also selected the most appropriate delivery mode for this type of lighting on a 3-point ordinal ALAN availability scale; specifically, should this lighting be provided (1) installed and continuously lit (i.e. permanently on all night), (2) installed but only on when needed (hereafter referred to as 'on-when-needed', for example, using a motion sensor) or (3) as portable, personal temporary lighting ('bring-your-own-device', e.g. torch/flashlight). To keep the survey concise and reduce repetition, this question set was limited to the benefits derived from ALAN that were rated most important and for which all three modes of light delivery are relevant. For example, 'bring-your-own-device' is not a relevant delivery mode to reduce property crime, hence this was not tested. This question was included for the following subset of benefits: traffic safety, personal safety/security, orientation and recreation.

TABLE 2 Explanatory variables used in this study (short terms used in main text in brackets). See Cieraad & Dalley, 2025 for the full survey instrument.

Group	Explanatory variable	Description	Type
Demographic	Age	Age in years (18 and over)	Numeric
	Ethnicity	The 21 levels of the Ethnicity New Zealand Standard Classification (Stats NZ 2005V2.1.0) used in the survey were simplified to six categories	Binary (0/1) for each of: NZ European, Māori, Pacific, Other European, Asian and Other
	Sex	Male, Female	Categorical (Male, Female)
Nighttime-related	Gazing up after dark (Gazing up)	Maximum frequency across the different reasons for gazing up to the night sky (sky general, moon, stars, satellites, other celestial objects)	Ordinal (5-point—frequency from never < sometimes < often < almost always < always)
	Activity after dark (Activity)	Maximum frequency of various outdoor activities after dark over the last 6 months (including walking, biking, stargazing, other outdoor activities in unlit locations or in dedicated lit facilities)	Ordinal (6-point frequency scale: never < 6-monthly < 3-monthly < monthly < weekly < nightly)
	Impairment after dark (Impairment)	Maximum level of impairment that affects respondent's experience/function in low-light conditions, across difficulties regarding (1) seeing in low-light conditions (even when wearing glasses or contact lenses), (2) walking in low-light conditions or (3) other difficulty/impairments that affect experience/functioning in low-light conditions	Ordinal (4-point ordinal scale of severity: No, no difficulty < Yes, some difficulty < Yes, a lot of difficulty < No, cannot do at all)
Built-environment context	Urban–rural now	Location of current place of residence along the urban–rural gradient	Ordinal (city centre, suburban, peri-urban, rural settlement, rural other)
	Urban–rural growing up	Location along the urban–rural gradient where respondent spent most time growing up	Ordinal (city centre, suburban, peri-urban, rural settlement, rural other)
Attitude/Beliefs	Dark/light ~ well-being	Agreement to the statements 'Darkness at night enhances human well-being' or 'Artificial light at night enhances human well-being'	Ordinal (5-point agreement scale: Not at all < slightly < moderately < strongly < totally)
	Dark/light ~ prosperity	Agreement to the statements 'Darkness at night is a sign of economic poverty' or 'Artificial light at night is a sign of economic prosperity'	
	Dark/light ~ developed	Agreement to the statements 'Darkness at night is a sign of an underdeveloped community/country' or 'Artificial light at night is a sign of a developed community/country'	
	Dark/light ~ bad/good	Agreement to the statements 'Darkness at night is associated with bad things' or Artificial light at night is associated with good things'	

2.3 | Participant recruitment

We used IPSOS Ltd. FastFacts online market research platform to deliver the anonymous online questionnaire to a representative sample of the population of Aotearoa New Zealand. The $n = 1000$ sample was quota-based according to region, sex and age demographic variables, which were determined by the 2018 New Zealand census (the most recent data available at the time, Stats NZ, 2019). The resulting sample was broadly representative of the adult New Zealand population in 2023 (see Table S1, Stats NZ, 2024). No post-stratification weights were applied due to constraints in accounting for multi-dimensional demographic variation across ethnicity, age and region. As is implicit with online surveys, the most used current tool for national representative surveys, there was no representation of the offline population (Scherpenzeel & Bethlehem, 2018). The reported results are thus based on unweighted data. The survey had a maximum margin of error of 3.1% (at a 95% confidence level).

2.4 | Terminology

In this study, ALAN denotes permanently installed outdoor artificial lighting; moving or portable sources are excluded, except where a bring-your-own-device option is explicitly tested. For readability, we use the term 'artificial light' and ALAN interchangeably. When referring to 'darkness', we mean 'natural darkness', that is, the dark part of the natural light–dark daily and seasonal cycles where only celestial objects (including moon, stars and planets) provide illumination; that is, without any artificial light sources.

3 | ANALYSIS

3.1 | Importance of benefits derived from natural darkness and ALAN

We used conditional inference trees (Zeileis et al., 2008) to explore the importance of the different functions of natural darkness and ALAN (Table 1). Conditional inference trees (hereafter refered to as 'trees') are a simple non-parametric classification (or regression) analytical tool. The space spanned by all predictor variables is recursively partitioned into groups of observations with similar response values. In contrast to linear regression models, which combine predictors linearly, classification trees consider the range of possible combinations, including non-linear associations and multiple splits in the same variable. At each node, the predictor that is most strongly associated with the response variable is selected for the next binary branch. No pruning or cross-validation of trees is needed, as this approach uses permutation tests at each split to assess whether an added branch would add to predictive accuracy, thus reducing overfitting (Strobl et al., 2009).

Our response variables were presented on a 5-point unipolar ordinal rating scale, where 0 equals total absence of the variable of interest and 4 equals total presence (e.g., ranging from 'Do not at agree at all' to 'Agree totally', see *response variables* section). For each benefit derived from natural darkness and artificial light separately, we fitted a tree with the demographic, dark-sky-related and context-related explanatory variables (see Table 2 for details).

To construct the trees for each response variable, we used the 'ctree' function in the *partykit* package in R (Hothorn & Zeileis, 2015). We set the minimum bucket size to 20 (each terminal node must contain at least 20 respondents), and did not constrain the depth of the tree, nor the complexity of the interactions. Our variable selection was based on the maximum of the absolute values of the standardised T statistic (teststat='max'), with a Bonferroni corrected p-value to account for multiple assessments of the addition of each branch. The *EasyTreeVarImp*() function in the *moreparty* package was used to assess predictor importance for each tree, represented by the area under the curve AUC, using 100 Monte Carlo replications (Robette, 2023). To compare and visualise the relative importance of the predictors across functions (trees), we ranked the predictor importance for each tree.

We used the ordinal weights Scott's π (pi) metric to evaluate the classification performance while accounting for the ordinal nature of the importance rating, imbalance in the number of respondents in each class and heterogeneous performance across classes. Scott's π is a chance-corrected agreement coefficient for ordinal classification, which, when using weighted scores has been found useful and reliable for this type of data (Yilmaz & Demirhan, 2023). For example, if the importance class as provided by a set of respondents was 3, and the tree predicts an importance of class 2, weighted Scott's π would consider the model to perform better than if the predicted class was 1 for the same respondents. To calculate this, we used the *scott2.table*() function with ordinal weights in the irrCaC package (Gwet, 2019).

3.2 | Mode of delivery of ALAN

For the subset of ALAN functions ('Traffic safety', 'Personal safety', 'Orientation' and 'Recreation') for which respondents specified the most appropriate delivery mode, we followed the same approach to explore the delivery mode of ALAN for each type of lighting that respondents deemed most appropriate. With the response variable on a 3-point ordinal scale, the tree input included the above predictor variables, as well as the respondents' importance rating of that use of light.

4 | RESULTS

4.1 | Importance of benefits derived from natural darkness and ALAN

The median importance rating for all benefits derived from natural darkness was 'Moderately important', except for the 'Rhythms of organisms', which had a higher median rating of 'Very important' (Figure 1a,b). Median importance ratings for the benefits of ALAN related to safety ('Property crime', 'Personal safety' and 'Traffic safety') and 'Orientation' were all 'Very important', while the other utilitarian benefits ('Production', 'Recreation') rated 'Moderately important', and discretionary functions of ALAN ('Decoration' and 'Advertising') were 'Slightly important' (Figure 1c,d).

Individual trees for the different benefits of darkness and ALAN are displayed in the Supporting Information, and summaries are provided in Figure 2. Trees for all benefits of darkness described the variation in importance ratings fairly well (Scott's π agreement coefficient between 0.34 and 0.42; Figure 2b). Scott's π for the benefits of ALAN was overall lower and more variable, ranging between fair for Production (0.26) and the discretionary uses of ALAN (Decoration and Advertising, 0.36 and 0.25, respectively), and lower for Traffic safety and Property crime (0.12–0.13), whereas the trees for Personal safety and Recreation were barely better than by chance (0.03), and the one for Orientation did not perform better than chance (Scott's π 0.0, p-value <0.05; Figure 2d).

Trees for all darkness benefits consistently contained two top explanatory variables: Frequency of gazing up to the night sky and agreement with the statement 'Darkness enhances human well-being', with higher ratings in either or both variables leading to higher importance ratings of all benefits. The trees explaining the importance of the three well-being benefits derived from darkness ('Peace', 'Experience' and 'Spirituality') contained Frequency of activity after dark (with increased activity being related to higher importance ratings). Trees for 'Experience', 'Spirituality' and 'Visibility' also included the association of ALAN with human well-being, developed communities and/or good things (Figure 2a). In all cases, for a subset of the respondents, an increased strength of these associations with artificial light described an increased importance of the *darkness* benefit. Trees explaining darkness-derived natural rhythms

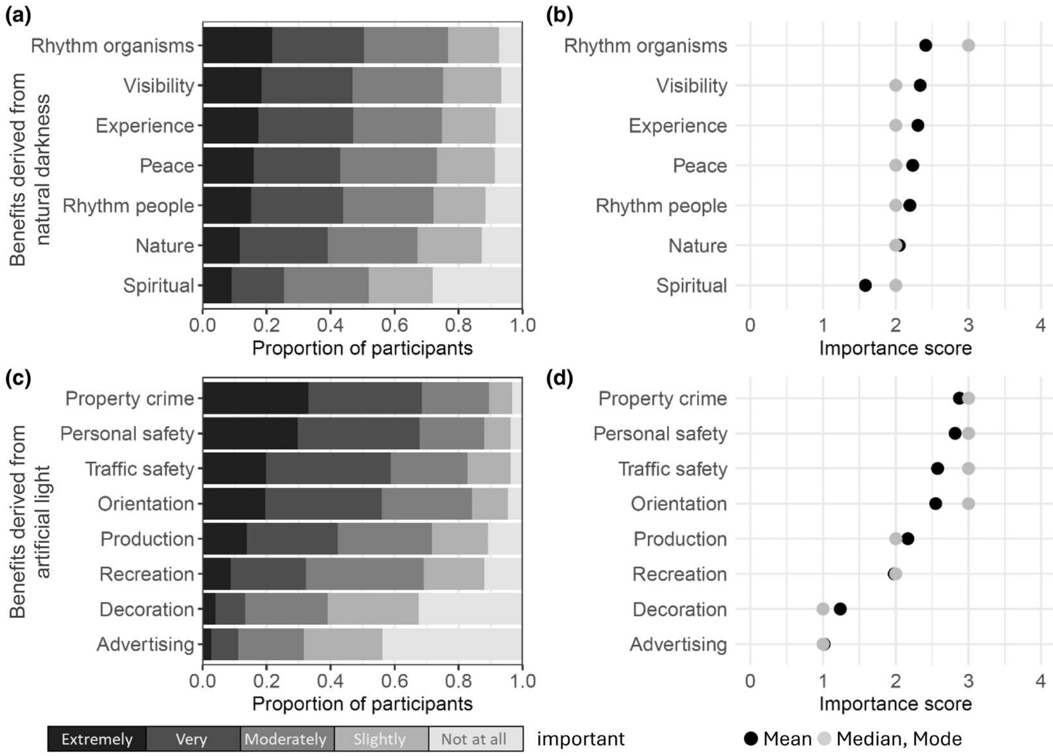

FIGURE 1 Summary of respondents' importance ratings for the different benefits derived from natural darkness (top: a, b) and artificial light (bottom: c, d) at night. Stacked bars (a, c) represent the proportion of the 1000 respondents within the five different importance ratings (indicated by decreasing dark grey bars from 'extremely important', score 4, to 'not at all important', score 0). Right figures (b, d) show the raw mean (in black; the standard errors fall entirely within the symbol shape in all cases) and median (grey) importance scores for each benefit; in all cases median ratings equalled the mode (category with most responses). Benefits are ordered by decreasing mean importance rating.

of organisms also included 'Age' and 'Sex' (Figure 2a). While darkness trees contained overall few variables, they often contained many splits along the same variable (see Supporting Information S2).

Trees for the benefits of ALAN contained more variables, but fewer splits along the same variable. All trees, except the one for Advertising, included the location of the respondent's residence along the urban–rural gradient as an explanatory variable (Figure 2c, for full trees, see Supporting Information S1). In general, respondents living further away from urban areas rated benefits derived from artificial light less importantly. All trees also included one or more attitudes toward artificial light (i.e. to what extent respondents agreed that artificial light at night was associated with enhancing human well-being, good things, economic prosperity, and with well-developed communities). In all cases, an increased agreement with the positive association with artificial light was associated with an increased importance rating of the benefits. Trees of several benefits also included respondents' attitudes toward darkness, also in a predictable (but opposite) direction: respondents with a stronger negative association with darkness (in terms of poverty, underdeveloped communities or bad things), also rated the importance of ALAN for Decoration, Advertising and Property crime more highly , and those with a stronger association between darkness and human well-being rated the benefit of Decoration lower. Several benefits were also partially explained by demographic variables, including 'Ethnicity' (whether of Asian descent—for Decoration, Advertising, Traffic safety—or NZ European descent—for Advertising and Recreation) and Age (for Advertising and Property crime). Production was also associated with where along the urban–rural gradient the respondent spent most time growing up, with a subset of the respondents currently residing in rural areas rating light for Production more importantly if they had also grown up in a rural area. Personal safety was partially explained by 'Sex', 'Frequency of gazing up' and 'Impairment'—although the overall performance of the tree was barely better than chance (Figure 2d).

4.2 | Mode of delivery of ALAN

The proportion of respondents who felt permanently lit was the most appropriate delivery mode was dependent on the function, varying from highest ratings of 63.6% for Traffic safety to 27.3% for Recreation (Figure 3). There was strong support for lights that were only on when needed (e.g. through sensors), ranging from 30.9% for Traffic safety to 58.2% for Recreation and intermediate values for Personal safety and Orientation (38.7% and 45.5%, respectively). Fewer respondents felt that bringing your own device (e.g. torch, flashlight) was the most appropriate mode of delivery of lighting (5.5% Traffic safety, 10.9% Orientation, 13.1% Personal safety and 14.5% Recreation; Figure 3).

The coefficient of agreement of the conditional inference trees for the delivery mode were relatively low (Scott's π of 0.25, 0.19

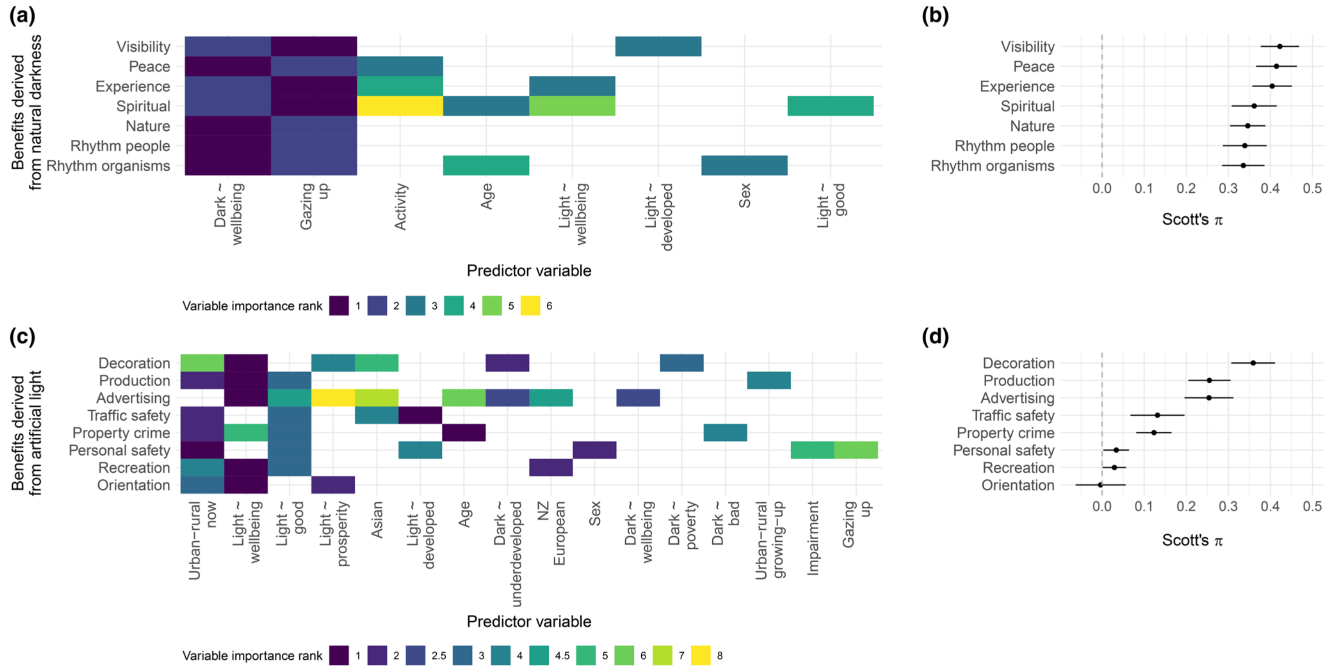

FIGURE 2 Summary of the conditional inference trees for the importance rating of the different benefits derived from natural darkness (a, b) and artificial light (c, d) at night. Left panels (a, c) show the predictors and their relative importance used in the trees for each benefit. Predictor variables (*x*-axis) are ordered by the number and importance of benefits that contained each variable. The colour indicates the rank of variable importance for each benefit. Only those variables selected in one or more of the trees for dark (a) or artificial light (c) are shown. Benefits (*y*-axis) are ordered by decreasing Scott's π. Right panels (b, d) show the chance-corrected ordinal agreement coefficient Scott's $\pi \pm 95\%$ confidence interval (CI) for each benefit. Trees for which the CI of Scott's π intersects zero (dashed vertical line) are not different from chance. The individual trees for each benefit are provided in Supporting Information S2. Refer to Tables 1 and 2 for explanations on the benefits and explanatory variables used, respectively.

and 0.17 for Personal Safety, Orientation and Traffic Safety, respectively) to very poor (with the tree for Recreation performing worse than chance, Scott's π −0.07; Figure 4b). In each case, the importance rating for a given benefit was the top-ranking explanatory variable in describing the most appropriate lighting delivery mode (Figure 4a), with higher importance ratings generally being associated with a more permanent (less transient) type of lighting. Those respondents living further from the city centre and those with stronger associations of darkness with human well-being more often indicated that more transient forms of lighting were most appropriate (individual trees are provided in Supporting Information S3).

5 | DISCUSSION

This paper reports a nationally representative study exploring public perceptions of both ALAN and natural darkness. This is the first study of its kind in Aotearoa New Zealand, and possibly globally. We sought to assess declared importance of various functions of ALAN and darkness, identify explanatory variables and examine preferences for different lighting delivery modes. This study sets a foundation for understanding how to sustainably manage ALAN and the required trade-offs between the benefits of ALAN and the benefits of darkness.

5.1 | Importance of benefits derived from natural darkness and artificial light at night

Overall, benefits derived from ALAN were rated as more important than benefits from darkness, especially for benefits related to safety and orientation. The lower importance ratings of darkness benefits could be interpreted as a lower awareness of these benefits overall. However, the mean and median importance of all benefits of darkness were higher than the importance of artificial lighting for decoration or advertising, suggesting that there is indeed an awareness of the relative benefits.

The importance ratings of the different benefits derived from darkness were very similar, compared with more varying importance ratings for benefits derived from ALAN (Figure 1b,d). This suggests that the public may readily differentiate between the different benefits of darkness. Describing the different benefits derived from ALAN, which are represented mainly as functional and extrinsic benefits, may be easier than understanding and articulating the less tangible benefits that can be derived from natural darkness. These results corroborate Stone (2018), who posited that the 'intrinsic valuations associated with the night sky [...] are much more closely intertwined' than those of ALAN. It suggests that people may think of benefits derived from natural darkness in more holistic terms, consistent with human well-being models (Schramme, 2023).

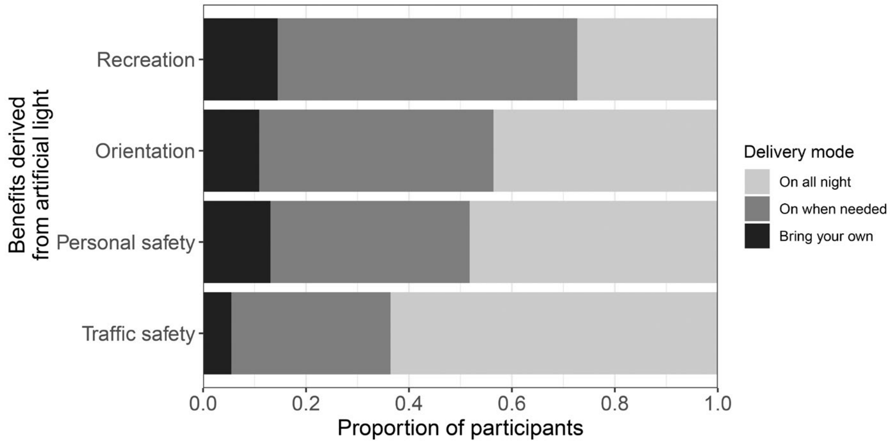

FIGURE 3 Summary of respondents' ratings for the most appropriate delivery mode for four benefits of artificial light at night. Stacked bars represent the proportion of the 1000 respondents and the three modes of ALAN delivery (indicated by increasing dark grey bars from lights being permanently on all night, only on when needed and bring your own). Benefits are ordered by decreasing mean rating.

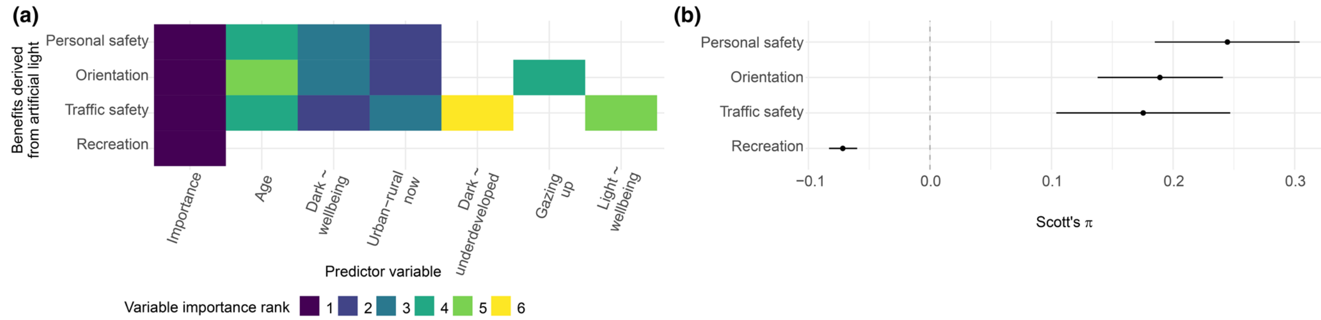

FIGURE 4 Summary of the conditional inference trees for the delivery mode of four benefits derived from artificial light at night, including variable importance (a) and Scott's π (b). The benefits are ordered by Scott's π, and in (a) the explanatory variables are ordered by the number of benefits that contained each variable and their ranking. The colour indicates the rank of variable importance for each benefit. Panel (b) show the chance-corrected ordinal agreement coefficient Scott's $\pi \pm 95\%$ confidence interval (CI) for each benefit. Trees for which the CI of Scott's π intersects zero (vertical dashed line) are not different than chance. The predictor 'Importance' refers to the respondents' importance rating for each benefit derived from artificial light. For other explanatory variables, please refer to Table 2. Only those variables selected in one or more of the trees are shown. The individual trees are provided in the Supporting Information (S3).

Respondent importance ratings were better explained for the benefits derived from darkness than those derived from ALAN (Figure 2b,d). Strong predictors for darkness benefits included the belief that darkness is associated with human well-being and the frequency of night-sky gazing. The benefits derived from ALAN were correlated with a wider variety of predictors, but the variability in responses was fairly poorly explained and particularly so for highly rated benefits related to safety (Figures 1 and 2). This suggests that our predictors did not effectively capture the drivers of declared importance for these benefits, and perhaps are related to more situational or emotional contextual variables that were not contained in our instrument, including the attributes of outdoor lighting and place-related factors (e.g. Boomsma & Steg, 2012; Portnov et al., 2020; Trop et al., 2023).

5.2 | Contextual influences

Where people live along the urban–rural gradient affected the importance of the benefits of ALAN, but did not change the importance ratings of the benefits of darkness. Despite the overall poor performance, urban dwellers rated almost all light-derived benefits more highly than respondents residing in more rural areas. This corroborates other studies showing the contextual dependence of the perceptions of 'light pollution' (Coogan et al., 2020; Guenat & Bauer, 2025), and of the perception of safety and 'pleasantness' of light (see review Trop et al., 2023). The lower importance placed on ALAN benefits by the non-urban population is non-trivial: more than half of the direct emissions of ALAN are from non-urban areas, and this part of the population is disproportionately exposed to sky-glow (Cox et al., 2022). There was no equivalent built environment gradient for darkness benefits, indicating that appreciation of natural darkness may be universal rather than specific to a location along the urban–rural gradient. This suggests that, regardless of whether someone lives in a city or in a rural area, New Zealanders feel similarly about the importance of access to natural darkness at night.

This finding, together with the generally lower rating of natural darkness benefits compared with benefits from artificial light, may also indicate an under-recognition of these benefits. More than 97% of the New Zealand population lives under skies that are at least somewhat affected by ALAN (Falchi et al., 2016), and the rate of increase in light emissions is faster than the global average

(Cieraad & Farnworth, 2023). Still, Aotearoa New Zealand is one of the OECD countries least exposed to the emission of artificial light into the night sky (Falchi et al., 2016). While the extent of artificially lit areas is mostly associated with urban development (Cieraad & Farnworth, 2023), these areas are still surrounded by large expanses of unlit landscape, allowing much of the public relatively easy access to natural darkness. This may lead to broad acceptance of artificially lit environments at places of residence, and complacency regarding easy access to natural darkness - even though access is increasingly challenging given the high rates of change of ALAN extent and brightness in non-urban areas (Cieraad & Farnworth, 2023). Testing this assertion will require comparable studies in countries with varying levels of access to natural darkness.

Previous experiences also shape our perceptions of the current context (Trop et al., 2023). The shifting baseline syndrome poses that the perceived norm for the darkness of the night sky changes due to a lack of exposure to natural darkness. For example, in a stratified survey in Switzerland, those who previously lived in the countryside (less exposed to ALAN) were more likely to perceive ALAN as an environmental issue than those who grew up in a city (Guenat & Bauer, 2025). Our study did not directly test the presence or extent of a shifting baseline syndrome. Respondents were not asked about acceptance of darkness or brightness levels, but instead about the importance of different benefits derived from ALAN and darkness at their place of residence. We used respondents' residential setting on the urban–rural gradient as an indirect measure of their current exposure to ALAN; similarly, the setting along this gradient where they spent most of their time growing up was used as a measure of previous exposure. We found that overall, the *importance* of the benefits of ALAN in current settings along the urban–rural gradient was not affected by the predominant setting where people grew up. Still, our results cannot determine whether people living in urban areas consider artificial light more important because their setting genuinely demands it, or whether their sense of importance reflects an acceptance of ALAN in those settings. However, it does raise an important question: have community preferences for current levels of ALAN been shaped by the functional benefits artificial lighting brings, or have community preferences been shaped by persistent and/or increasing exposure to ALAN? More work is needed to determine whether urban residents perceive artificial light as intrinsically more important than people residing in non-urban settings, or whether they accept higher levels of ALAN as 'normal'—or even preferential—regardless of the setting that is being lit.

5.3 | Influences of attitudes to artificial light and natural darkness

Respondents' attitudes related to ALAN and darkness shaped how important they rated benefits. Positive associations with artificial light (ALAN is associated with good things, well-being, prosperity, developed communities, see Table 2) predicted higher importance ratings of ALAN. Also, negative associations with natural darkness at night (bad things, poverty, undeveloped communities) elevated importance ratings for the decoration and crime prevention functions of ALAN. In contrast, respondents who saw darkness as more strongly associated with human well-being rated discretionary or 'non-essential' uses of artificial lighting (decoration and advertising) as less important. This suggests a willingness of these respondents to trade-off discretionary ALAN in order to restore natural darkness (Figure 5). Similarly, positive associations with natural darkness at night were also related to the night sky connectedness of New Zealanders (Cieraad & Dalley, in press).

In addition, a stronger positive association of ALAN (with human well-being, developed communities or good things) was related to an increased importance of the natural darkness benefits of spiritual connection and experience and visibility of the night sky. The mechanisms and validity of these, apparently counterintuitive, associations require more study, as, to our knowledge, this has not been described elsewhere and was only present for a small subset of respondents. Nevertheless, this finding may be indicative of a more pragmatic perspective that incorporates the concept of trade-offs: preferring a specific set of benefits of ALAN in a specific context does not ergo constitute a corresponding devaluation of the benefits of darkness.

Previous work has started to present the value of natural darkness as a moral framework for evaluating urban nighttime lighting (Stone, 2017, 2018). Our results highlight that the public rates many of the benefits provided by ALAN as important, and support Stone's assertion that the challenge is to 'incorporate darkness back into our nights without marginalizing other values inherent to (…) our nighttime lighting' (Stone, 2018). Natural darkness is a 'common pool resource' (Millet, 2025), with everyone free to draw down stocks through the introduction of artificial light. ALAN provides many benefits; however, it also depletes the pool of benefits that can be derived from darkness. Hence, it is crucial to frame the challenge around mitigating the unintended consequences of ALAN in terms of trade-offs with natural darkness. The question *how much artificial light at night is appropriate*? (Stone, 2017) *and for which purpose* for any given setting, should be juxtaposed with *how much darkness is preferred*? That is, do the benefits of ALAN outweigh the loss of benefits of darkness (the costs)? Trade-offs between ALAN and darkness benefits are already incorporated in dark-sky initiatives and related guidance; however, they are often implicit rather than explicit. To arrive at an agreed balanced state in any given context, the reality of the trade-off should be explicitly addressed within the discourse.

5.4 | Mode of delivery of ALAN

We cannot obtain all benefits of darkness and artificial lighting simultaneously. Adoption of responsible lighting guidelines (CIE, 2017; Dark Sky International, Illuminating Engineering Society, 2020; DCCEEW, 2023; Science for Environment Policy, 2023)

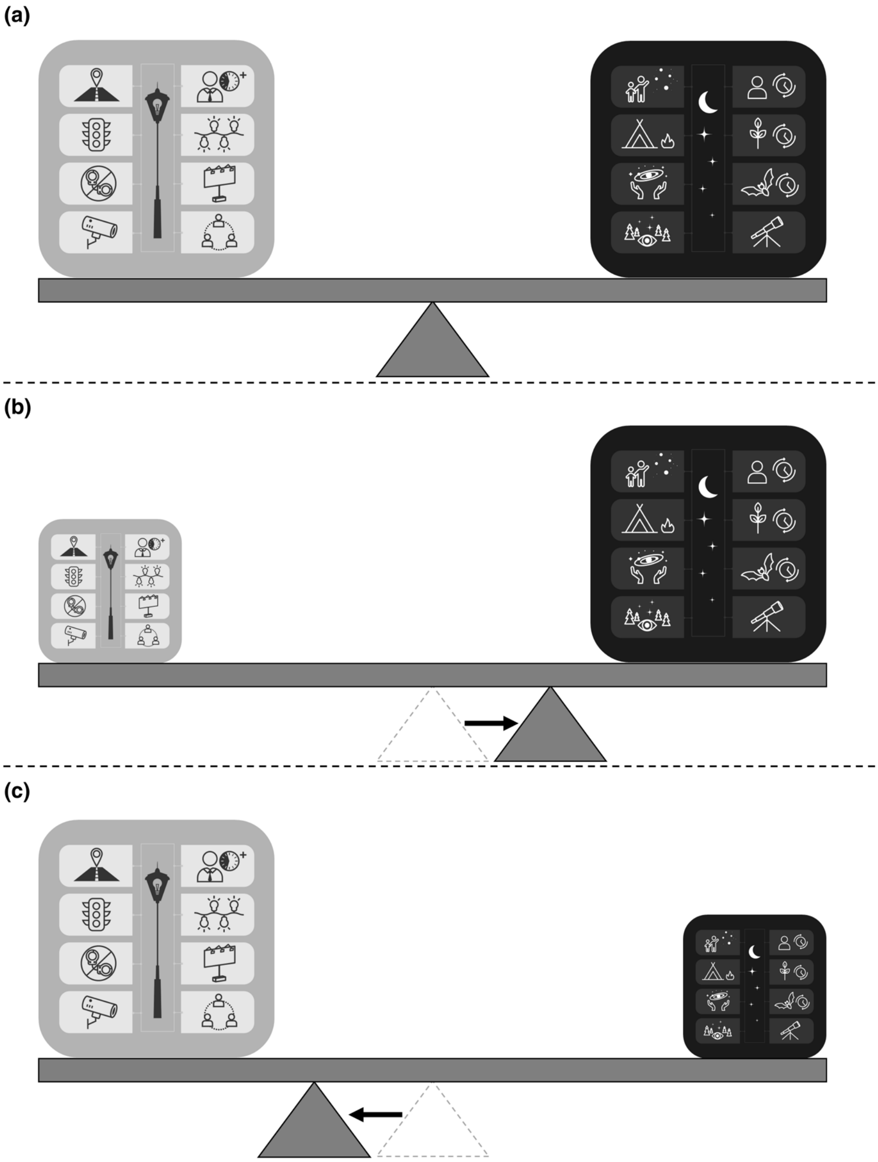

FIGURE 5 In an ideal state, all benefits of artificial light at night (ALAN) and natural darkness would coexist simultaneously, represented by a balance (a). Benefits of ALAN (grey box, from top right clockwise) include productivity, aesthetics, advertising, recreation, perceptions of security, traffic safety and wayfinding. Benefits of darkness (black box) include maintaining natural rhythms for humans and other organisms and visibility of the night sky, (including benefits for astronomical research, cultural/personal connectedness and experiencing the night sky). In practice, both sets of benefits cannot be fully realised at the same time and place. Trade-offs are therefore required, with weight placed on specific benefits derived from ALAN or darkness depending on cultural, ecological or situational contexts. The shifting fulcrum in (b, c) represents this intentional re-balancing across different contexts. For example, in protected areas, ALAN benefits are sacrificed to preserve natural darkness (b). In urban settings, a reduction in darkness benefits may constitute an acceptable balance (c).

will necessarily retain the benefits of ALAN while increasing access to the benefits of darkness, but never to the full extent (e.g. natural rhythms of organisms near the light source will be compromised even at low-light levels, Seymoure et al., 2025). Currently, almost all public lighting in Aotearoa New Zealand is provided through permanent installations that are continuously on through the night. Technological mitigation options that have become available since the transition to Light Emitting Diodes now allow a more bespoke approach to delivering 'the right light in the right place at the right time'; that is, only when someone is present to accrue a specific set of benefits. Our results indicate broad support for situational, adaptive lighting. For example, for each of the benefits tested, at least 31% of respondents preferred on-when-needed delivery. For light for recreation and orientation, 78% and 58% of respondents, respectively, preferred either on-when-needed or bring-your-own delivery, rather than continuous lighting. This is similar to levels of support for motion-detecting street lighting in Switzerland (Guenat & Bauer, 2025). Possibly reflecting current practice in Aotearoa New Zealand, respondents who rated a benefit as highly important also preferred all-night street lighting for this purpose over on-when-needed systems. For survey brevity purposes, we did not test preference for part-night dimming options, as others have found variable preferences across scenarios related to the exact timing of dimming (Beaudet et al., 2022). However, we hypothesise that, if options of part-night dimming (rather than more extreme only on-when-needed) had been presented, the proportion of respondents preferring continuous delivery would be lower.

5.5 | Implications for policy and research

Every policy embodies a desired future state. For ALAN, guidelines and policy to date typically refer to managing the energy efficiency or negative consequences (Yakushina, 2025). Yet managing ALAN does not equate to creating access to natural darkness. We propose that policy goals should explicitly acknowledge both the benefits of ALAN and the benefits of natural darkness, and focus on the balance of benefits that is preferred. The appropriate balance, and the associated trade-offs will vary with any situational, cultural and/or ecological context. Future research should investigate how different contexts shape perceptions and attitudes towards ALAN and natural darkness—and how to leverage these insights for more balanced ALAN policy and practice. Further research into the public acceptance of various mitigation options (including levels of dimming, part-night lighting and delivery of light based on motion-sensing) across contexts is also paramount for successful implementation.

6 | CONCLUSIONS

In conclusion, humanity has 'conquered' darkness, but in so doing has lost access to many of its benefits. This study contributes to reframing the ALAN discourse to consider both artificial light and natural darkness as essential yet countervailing resources offering a multitude of benefits. It is therefore important that the management of ALAN and related decision-making is anchored in the reflection that to gain access to the benefits of one resource involves a consequential loss of access to the benefits of the other. Any purposeful re-balancing of the two benefit sets relative to each other can effectively result in a shift towards a desired future state. Furthermore, this study strongly suggests that any imagining of alternative future states is more likely to receive broad societal support if the benefits derived from both artificial lighting and from natural darkness are considered as being interdependent variables that are subject to trade-offs.

AUTHOR CONTRIBUTIONS

Ellen Cieraad and Jeff Dalley contributed to the study conception and design. Ellen Cieraad analysed the data and wrote the first draft of the manuscript. Both authors contributed to the final manuscript, and approved the final manuscript for publication.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they do not have any conflicts of interest.

DATA AVAILABILITY STATEMENT

The survey instrument and data associated with this manuscript are available on Figshare (instrument: https://doi.org/10.6084/m9.figshare.28801235; data: https://doi.org/10.6084/m9.figshare.30225580).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Supporting Information S1. Summary of population demographics.

Supporting Information S2. Conditional inference trees for the importance rating of each benefit derived from ALAN and natural darkness.

Supporting Information S3. Conditional inference trees for the mode of delivery for four selected benefits derived from ALAN.

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