

Supplementary Information

Appendix S1. Methods and results for radiance threshold sensitivity analysis. We tested the sensitivity of the estimated rate of change in lit surface area to the radiance threshold used. For each of a range of darkness thresholds between 0.1 and 1 $\text{nW cm}^{-2} \text{sr}^{-1}$, we used the per-pixel estimated Theil-Sen intercept and slope to sum the pixels that showed a significant increase in brightness or a significant decrease in brightness. A pixel was only noted as having a significant change if its estimated brightness was above the threshold at least some of the time (i.e. a brightness change with both start and end brightness below the threshold was not counted as a change, even if the change was significant). We also summed the number of pixels that did not show a significant change and those that were below the threshold across the whole 2012–2021 period (Table S1). Estimated annual increases in lit surface area showed a hump shape between 2 and 4% over the ranges of the thresholds tested, with a maximum annual change between 0.3–0.4 $\text{nW cm}^{-2} \text{sr}^{-1}$ (Fig. S1; Table S1).

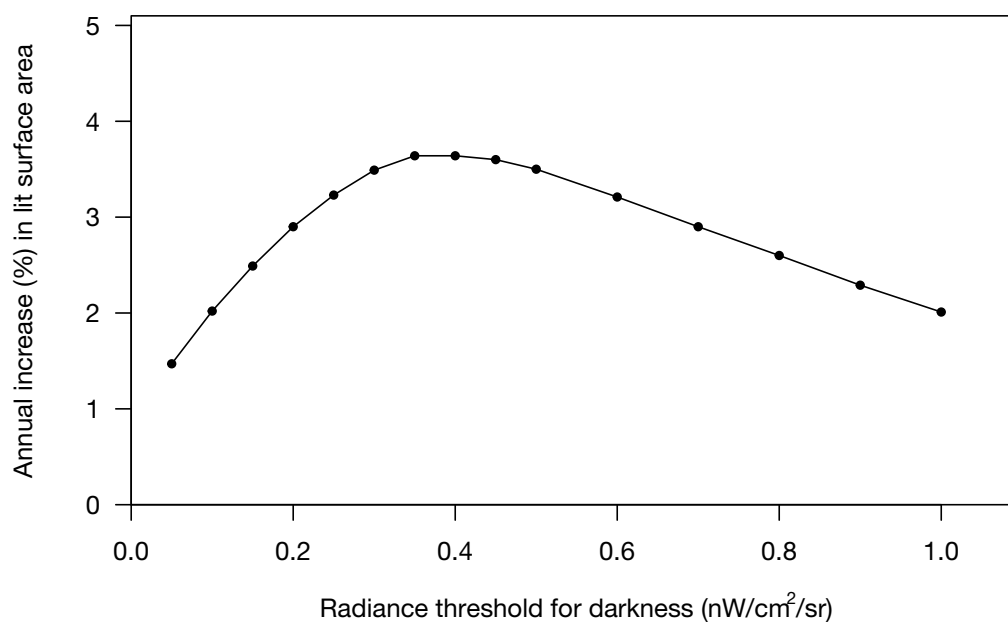
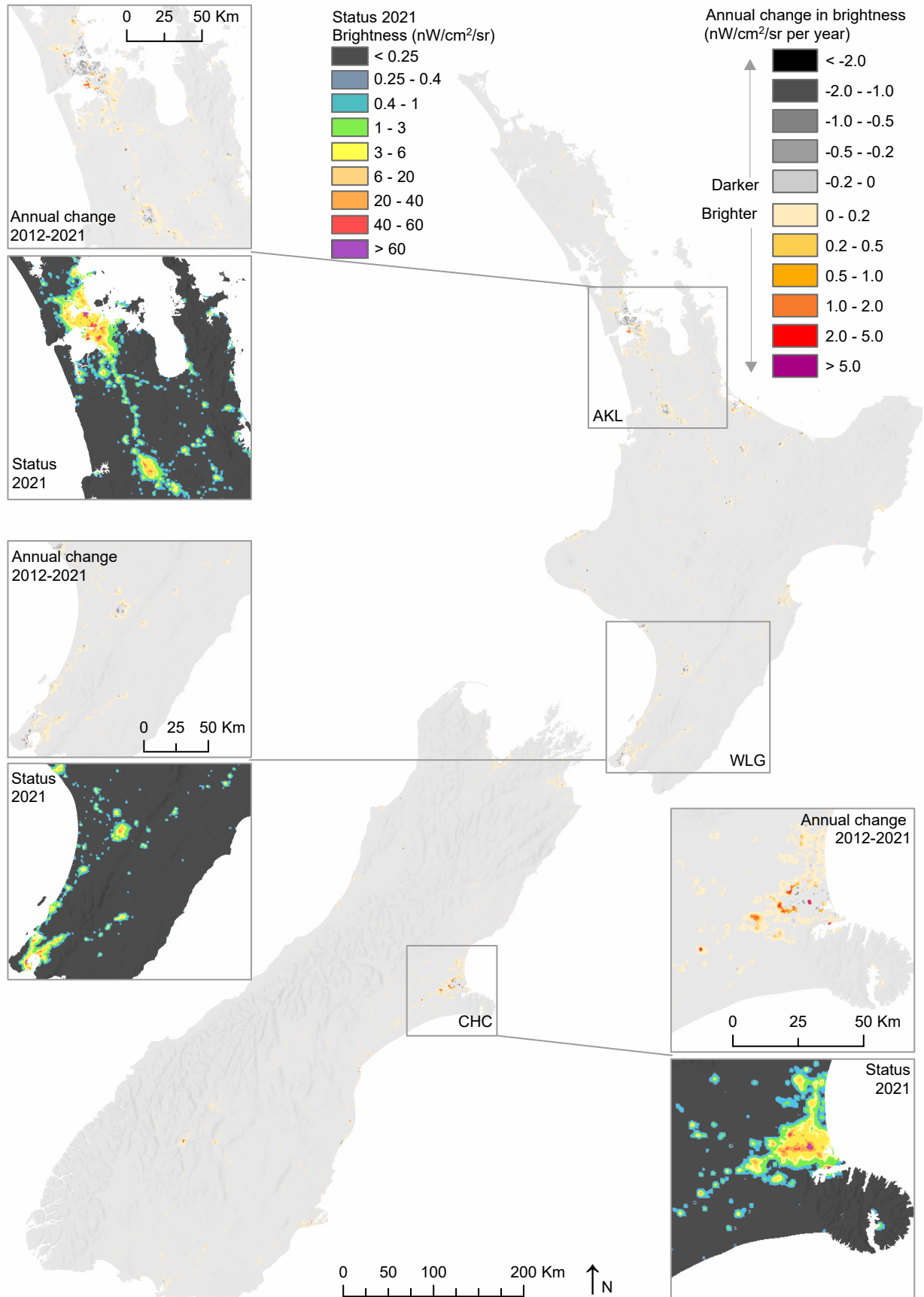


Figure S1. Changes in annual increase in lit surface area with varying radiance thresholds for darkness. For visualisation purposes, the line connects the annual increases in lit surface area estimated at the thresholds detailed in Table S1.

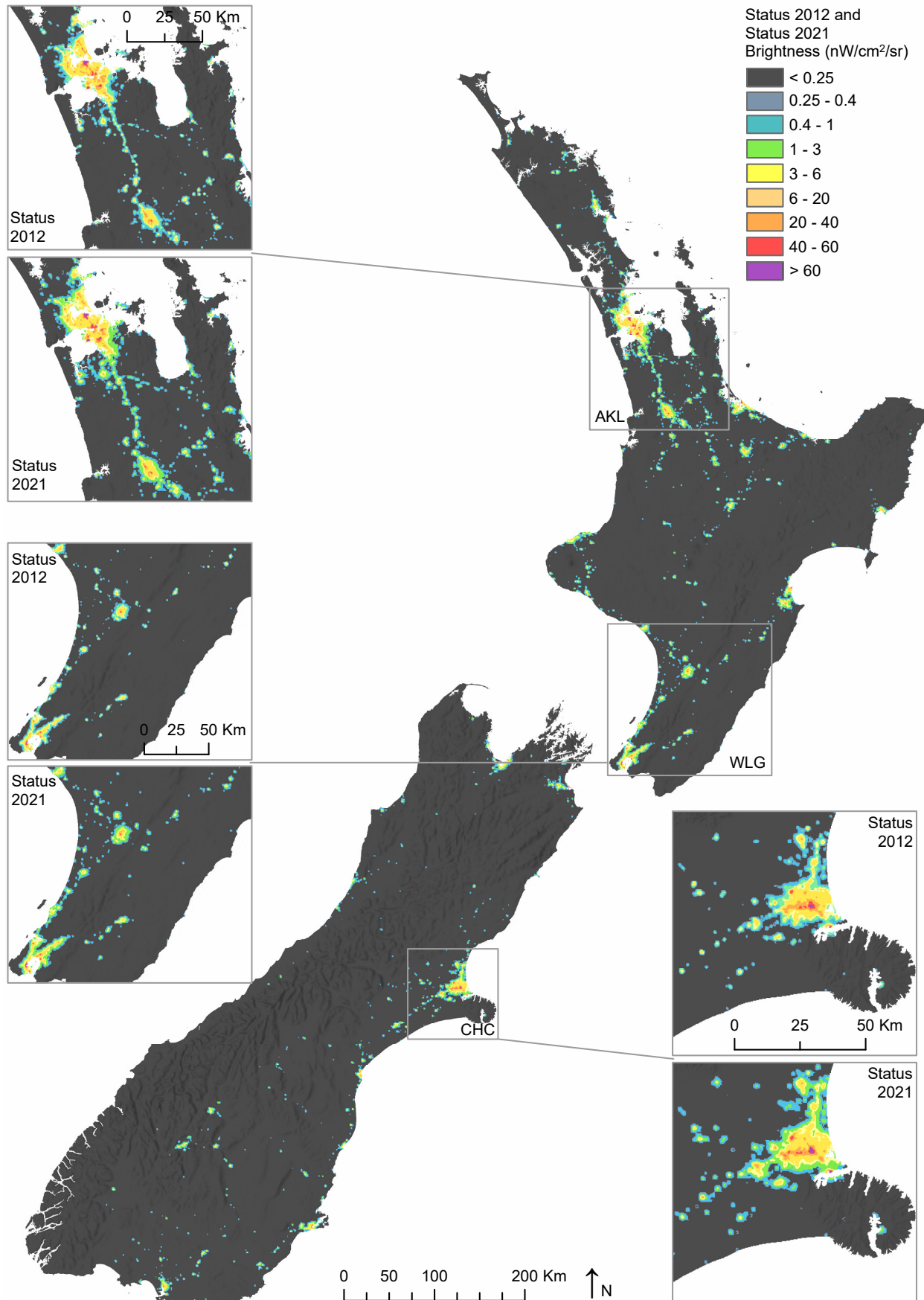
Table S1. Results of the sensitivity analysis showing how varying the radiance threshold (used to determine whether a pixel is classified as dark or lit) affects the surface area with significant changes in brightness and the rate of change over the 2012–2021 study period. Alternative models (log-linear, linear, and exponential) of trend in lit surface area over the 2012–2021 period were compared using Akaike Information Criterion (AIC). The results presented in the main text use the $0.25 \text{ nW cm}^{-2} \text{ sr}^{-1}$ radiance threshold for darkness, and the linear estimate of trend in lit surface area (in bold).

| Radiance threshold for darkness ($\text{nW cm}^{-2} \text{ sr}^{-1}$) | Area in different brightness/change categories (sum of pixels, expressed in km^2) | | | | Rate of change in lit surface area 2012–2021 | | AIC of alternative models of trend in lit surface area between 2012–2021 | | |
|---|---|---------------------------------------|----------------------------|--|---|---------------------------------------|---|--------------|--------------|
| | Significant increase in brightness | Significant decrease in brightness | No change in brightness | Dark area (below threshold) for whole period | Estimated average annual change (%) | Cumulative change 2012–2021 (%) | Linear | Log-linear | Exponential |
| 0.05 | 5612 | 1 017 | 260 844 | 251 857 | 1.5 | 15.8 | 145.0 | 145.3 | 149.2 |
| 0.1 | 5363 | 966 | 261 144 | 252 720 | 2.0 | 22.2 | 150.7 | 150.9 | 154.0 |
| 0.15 | 5131 | 933 | 261 409 | 253 465 | 2.5 | 27.9 | 153.7 | 153.9 | 156.6 |
| 0.2 | 4915 | 907 | 261 651 | 254 142 | 2.9 | 33.1 | 155.5 | 155.7 | 158.1 |
| 0.25 | 4694 | 887 | 261 892 | 254 800 | 3.2 | 37.4 | 156.7 | 156.8 | 158.9 |
| 0.3 | 4477 | 870 | 262 126 | 255 462 | 3.5 | 41.0 | 157.0 | 157.1 | 159.0 |
| 0.35 | 4257 | 857 | 262 359 | 256 146 | 3.6 | 43.0 | 156.7 | 156.7 | 158.4 |
| 0.4 | 4018 | 847 | 262 608 | 256 837 | 3.6 | 43.0 | 155.5 | 155.5 | 157.1 |
| 0.45 | 3776 | 838 | 262 859 | 257 499 | 3.6 | 42.5 | 153.8 | 153.8 | 155.3 |
| 0.5 | 3540 | 830 | 263 103 | 258 138 | 3.5 | 41.0 | 151.7 | 151.6 | 153.3 |
| 0.6 | 3089 | 816 | 263 568 | 259 239 | 3.2 | 37.1 | 147.1 | 147.1 | 148.9 |
| 0.7 | 2688 | 804 | 263 981 | 260 119 | 2.9 | 33.1 | 142.5 | 142.5 | 144.5 |
| 0.8 | 2345 | 792 | 264 336 | 260 830 | 2.6 | 29.2 | 138.2 | 138.3 | 140.6 |
| 0.9 | 2052 | 780 | 264 641 | 261 401 | 2.3 | 25.4 | 134.1 | 134.2 | 136.7 |
| 1 | 1795 | 769 | 264 909 | 261 858 | 2.0 | 22.0 | 130.2 | 130.3 | 133.2 |

Appendix S2. Average annual rates of brightness change across Aotearoa New Zealand 2012–2021. Map showing the estimated average annual rates of change for pixels with a significant change in brightness level of direct emissions of artificial light at night (ALAN) ($\text{nW cm}^{-2} \text{sr}^{-1}$), as represented by VIIRS satellite data between 2012–2021. Inserts show details around Auckland (AKL), Wellington (WLG), and Christchurch (CHC) for annual change in brightness and the brightness status in 2021.



Appendix S3. Brightness map of Aotearoa New Zealand in 2021. Map detailing the brightness level of direct emissions of artificial light at night (ALAN) in 2021, as represented by VIIRS satellite data. Inserts show brightness around Auckland (AKL), Wellington (WLG), and Christchurch (CHC) in 2012 and 2021.



Appendix S4. Ratio of brightness 2021:2012. Violin plots depicting the distribution of the ratio of brightness in 2021 compared to 2012 for pixels with a significant trend in brightness (increase or brighter: ratio > 1, in grey, and decrease or darker: ratio < 1, in black). For example, a ratio of 2 indicates that the artificial light at night (ALAN) emission detected by satellite imagery was twice as bright in 2021 compared with 2012 (which equals a 100% increase). The dashed horizontal line indicates a 2021:2012 ratio brightness of 1, indicating no change. The width of each density curve of the violin plot corresponds to the relative frequency of data points. The horizontal line within each violin plot indicates the median value. For pixels that started off in 2012 as dark (i.e. $0 \text{ nW cm}^{-2} \text{ sr}^{-1}$ or close) and then became brighter, ratios were infinite or artificially high. To counteract this, we set these values to the selected darkness threshold ($0.25 \text{ nW cm}^{-2} \text{ sr}^{-1}$), which resulted in conservative estimates of the brightness ratio for these pixels. Pixels that started dark and became brighter but to only just at, or just above, the darkness threshold, showed a brightness ratio of 1 or close to 1, respectively. For visualisation purposes, ratios were truncated at 10.

