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Supplemental Material

Lyme Disease Risks in Europe under Multiple Uncertain Drivers of Change

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Figure S1. Deer population as a linear regressive function of habitat suitability in different regions. Deer (habitat) suitability indicates the capability of the cell to support the full carrying capacity, and was estimated as a multiplication of species presence, climate suitability and extent of suitable habitats. Individual data points refer to cell-level projections of deer density at the baseline and the regression lines indicate their linear relationship to deer suitability.

Figure S2. Projected monthly variation of the density of infected nymphs for (A) baseline and by the 2050s under the SSP1 x RCP2.6 (B) using the MPI-ESM-LR/REMO coupled climate model (B) and SSP4 x RCP4.5 using the HadGEM2-ES/RCA4 coupled climate model (C).

Figure S3. (A) Projected rates of active questing ticks under different temperatures in different European countries (Box plots = distributions of cell-level projections at different temperatures; blue line = mean value). (B) Projected monthly rates of active questing ticks in different European countries (Green line = larvae; Blue line = nymphs; Black line = female adults). (C) Projected monthly density of active questing ticks in different European countries (Green line = mean density of larvae/100; Blue line = mean density of nymphs/10; Black line = mean density of female adults). Country abbreviations are explained in Table S1.

Figure S4. Monthly average daily mean temperature for (A) baseline based on the WATCH-WFDEI data, and the 2050s under RCP2.6 using the MPI-ESM-LR/REMO coupled climate model (B) and RCP4.5 using the HadGEM2-ES/RCA4 coupled climate model (C).

Figure S5. Patterns of habitats for (A) baseline and by the 2050s under the SSP1xRCP2.6 (B) and SSP4xRCP4.5 (C) scenarios.

Figure S6. Density and distribution of deer (represent reproduction hosts) for (A) baseline and by the 2050s under the SSP1xRCP2.6 (B) and SSP4xRCP4.5 (C) scenarios. For species distribution: grey area refers to baseline observed presence (source: IUCN); pink area refers to the predicted presence.

Figure S7. Projected density and distribution of rodents (represent transmission hosts) for (A) baseline and by the 2050s under the SSP1xRCP2.6 (B) and SSP4xRCP4.5 (C) scenarios. For species distribution: grey area refers to baseline observed presence (source: IUCN); pink area refers to the predicted presence.

Figure S8. Comparison between the projected distribution of *Ixodes ricinus* nymphs (coloured areas) and the *I. ricinus* tick occurrence dataset (red dots) produced in Estrada-Peña et al. (2013). Country abbreviations are explained in Table S3.

Figure S9. Comparison between the projected distribution of infected *Ixodes ricinus* nymphs in Spain (left panel) with the Lyme disease incidence distribution map generated based on Bonet Alavés et al. (2016) (right panel).

Figure S10. Comparison between the projected infection prevalence of nymphal and adult ticks with observed data in a literature review (Rauter and Hartung, 2005) in different European countries. The violin plots in Fig. S9D show the probability density at different predicted values of infection prevalence of combinations of adults and nymphs (grey). Red symbols (pies and lines) refer to the observed infection prevalence in the combined population of nymphs and adults from the articles reviewed in Rauter and Hartung (2005). Subplots without red pies or lines reflect that the observed data for the counties are missing from the review.

Table S1. Reproduction host (cervidae) population estimation in the European countries (in thousands).

Table S2. Selected GCMs and RCMs for modelling climate change impacts.

Table S3. Projected changes in overall DON (density of nymphs) and DIN (density of infected nymphs) under different scenarios. The greatest decrease and increase are highlighted in blue and red respectively.

Table S4. Projected changes in the drivers and risk indicators of Lyme disease for the European countries considered. Projections under the six combined scenarios of socio-economic (SSPs) and climate changes (RCPs) are summarised for different countries. Country abbreviations are explained in Table S3. Sub-regions of European regions are according to the Eurovoc, the EU's multilingual thesaurus. Risk drivers include: ΔT – increase in temperature ($^{\circ}C$); ΔF – change in forest coverage (%); ΔD – change in deer density (%); ΔH – change in transmission host density (%). Risk indicators include: ΔMD – change in infected nymphal tick density (ticks/km²); ΔwL – change in range of low risk area in winter (Dec-Jan) (%); ΔpH – change in range of high risk area in peak season (May-Jun) (%).