2023 BSCES Section and Employer Recognition Award Nominations

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*Denotes BSCES Awards committee recommended recipient

2023 Individual Section Awards

BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

Each year, BSCES presents awards to deserving members and individuals in the community who are nominated by their peers in recognition of their service. Here is your opportunity to nominate a co-worker, friend, or someone who you think deserves special recognition. Please see the following awards descriptions and nomination instructions. Awards reserved for BSCES members are noted as such.

The Nominations Deadline is **Friday, March 31, 2023.** The Awards Committee will review all nominations and present a list of candidates for selection by the Board of Government. Awards will be presented at the 174th BSCES Annual Awards Celebration.

I would like to nominate Kate Duffy **For the:**

_______ **CITIZEN ENGINEER AWARD:** This award is presented to a BSCES member or registered professional engineer for outstanding public involvement in local or national legislation, education (at any level), non-profit volunteer organizations, community activities, or similar activities improving the image of ASCE, BSCES and the civil engineering profession.

__x__ **CLEMENS HERSCHEL AWARD:** This award recognizes an individual who has published a paper, not necessarily published in the BSCES Journal, that has been useful, commendable, and worthy of grateful acknowledgment. If nominating for the Clemens Herschel Award, please attach the name of the paper and names of all authors, if co-authored.

_______ **COLLEGE EDUCATOR AWARD:** This award is presented to a member of the academic community who inspires and encourages civil engineering students through exceptional teaching and mentorship. Educators empower students to realize full potential and exemplify the profession in their classroom. Candidates shall be actively teaching in a classroom setting at a college or university in New England.

_______ **ENGINEER OF THE YEAR AWARD:** This award is presented to a BSCES member, with 15 years or more professional experience, who has exhibited extraordinary leadership in the form of managerial leadership, technical excellence, professional integrity, and mentorship of other engineers.

_______ **GOVERNMENT CIVIL ENGINEER AWARD:** This award is presented to a BSCES member who is serving as a paid public sector engineer at a federal, state, or municipal agency, department, or authority in Massachusetts.

_______ **HORNE/GAYNOR PUBLIC SERVICE AWARD:** This award is presented to a BSCES member or registered professional engineer for unpaid public service in a municipal, state, or federal-elected or appointed post for philanthropic activities in the public interest.

_______ **JOURNALISM AWARD:** This award is presented to a journalist or other author who has published one or more articles, papers, books, social media blogs, or film for a non-technical audience that raises awareness of the contributions of the civil engineering profession.

_______ **PRE-COLLEGE EDUCATOR AWARD:** This award is presented to a member of the K-12 educational community who integrates engineering topics, particularly civil engineering, in a manner that benefits the profession and may promote students to pursue an engineering career. The Public Awareness & Outreach Committee reviews these nominations and recommends the recipient to the Board.

_______ **CHARLES A. STONE AND EDWIN S. WEBSTER PROJECT OF THE YEAR AWARD:** This award is presented to a BSCES member and their project team who has served in a major role on an innovative, challenging, unique, and/or complex project located in the Commonwealth of Massachusetts. The majority of the work should have been completed by engineers located within Massachusetts.

_______ **YOUNGER MEMBER AWARD:** This award is intended to recognize a BSCES member, 35 years of age or younger on February 1 in the year of the award, who has made an outstanding contribution to BSCES and/or the civil engineering profession.

To submit a nomination, complete this form and return it by the nomination deadline via email, fax, or mail to bsces@engineers.org, 617/227-6783, or BSCES Awards Committee, Boston Society of Civil Engineers Section/ASCE, One Walnut Street, Boston, MA 02108-3616, respectively.

Name and Company Address of Nominee(s)*:

Dr. Kate Duffy

Zeus AI (https://myzeus.ai/)

Is this a re-nomination? Yes _______ No __x__

Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.

Your Name: Auroop R. Ganguly Daytime Telephone: 617-373-2444 Email: a.ganguly@northeastern.edu

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

Northeastern

Auroop R. Ganguly — **College of Engineering (COE) Distinguished Professor, Northeastern (NU)**
PhD (MIT), Fellow (American Society of Civil Engineers)
Sr. Member (IEEE), Sr. Member (Association for Computing Machinery)
NU Leadership: — **Co-Director, Global Resilience Institute**
Climate-AI Lead, The Institute for Experiential Artificial Intelligence
Director, Sustainability & Data Sciences (SDS) Lab (https://sdslab.io)
Co-Founder & Chief Scientific Adviser (2014–2021): risQ (www.risq.io): Fortune 500 Acquisition
Chief Scientist, Advanced Computing, Mathematics, and Data Division, Physical and Computational Sciences Directorate, US DOE's Pacific Northwest National Laboratory, Richland, WA
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March 12, 2023

To:
The BSCES Awards Committee: bsces@engineers.org
Boston Society of Civil Engineers Section/ASCE
One Walnut Street, Boston, MA, 02108-3616

Sub: Clemens Herschel Award for Kate Duffy

Dear BSCES Awards Committee,

I am pleased to nominate Kate Duffy for the BSCES Clemens Hershel Award for the following paper:
Duffy, K., Gouhier, T.C., and Ganguly, A.R. (2022): *Climate-mediated shifts in temperature fluctuations promote extinction risk*. **Nature Climate Change**, 12, 1037–1044. https://doi.org/10.1038/s41558-022-01490-7.

Dr. Kate Duffy is the first and corresponding author of the above paper published in the prestigious journal **Nature Climate Change**. The bulk of the work was performed when Kate Duffy was still a Ph.D. student at Northeastern University. The journal highlighted the paper via a Research Briefing.

The work has been recognized by the institutional media, specifically, by Northeastern News, as a NASA Feature, and a PNNL Spotlight, as well as by the US and global media and scientific news outlets, such as Phys.Org in the US, as well as Weather, United Kingdom, and NDTV, India, and India Today.

The impact of projected climate fluctuations on extinction rates of insect populations is a major insight of importance to the environment and ecology, with implications for environmental engineering from sanitation and waste management to agriculture and food security. Furthermore, the climate swings identified in the paper can have significant implications of design, operations, and conservation strategies in ASCE-related disciplines ranging from structural and environmental to transportation and geotechnical engineering.

Sincerely,

Auroop Ratan Ganguly

Auroop R. Ganguly, Professor, Chair of CEE Awards Committee
126 Mass Ave., Northeastern University, Boston, MA 02115, USA
https://en.wikipedia.org/wiki/Auroop_Ratan_Ganguly

SDS
SUSTAINABILITY & DATA SCIENCES LAB
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nature climate change

Article

https://doi.org/10.1038/s41558-022-01490-7

Climate-mediated shifts in temperature fluctuations promote extinction risk

Received: 2 March 2022

Accepted: 31 August 2022

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Check for updates

Kate Duffy[1,2,3] ✉, Tarik C. Gouhier[4] & Auroop R. Ganguly[1,5]

Climate-mediated changes in thermal stress can destabilize animal populations and promote extinction risk. However, risk assessments often focus on changes in mean temperatures and thus ignore the role of temporal variability or structure. Using Earth System Model projections, we show that significant regional differences in the statistical distribution of temperature will emerge over time and give rise to shifts in the mean, variability and persistence of thermal stress. Integrating these trends into mathematical models that simulate the dynamical and cumulative effects of thermal stress on the performance of 38 globally distributed ectotherm species revealed complex regional changes in population stability over the twenty-first century, with temperate species facing higher risk. Yet despite their idiosyncratic effects on stability, projected temperatures universally increased extinction risk. Overall, these results show that the effects of climate change may be more extensive than previously predicted on the basis of the statistical relationship between biological performance and average temperature.

Biodiversity loss has been recognized as one of the top global risks by the World Economic Forum because it could erode or eliminate key ecosystem functions and services[1]. Climate change is expected to surpass habitat loss as the leading threat to global biodiversity by the middle of the twenty-first century[2]. Observed changes in the distribution and phenology of species have already been linked to climate fluctuations in numerous studies[3]. Although conservation actions may ameliorate potential biodiversity loss, the success of these efforts depends on our ability to predict the response of ecological systems to environmental changes.

Most ecological impact studies so far have relied on statistical models, such as bioclimate envelope approaches, to determine how climate change will impact ecological populations[4–7]. Bioclimate envelope models are typically constructed by either mapping the geographical distribution of species to co-located temperature records via regression techniques or by building species' thermal profiles via empirical assessments of their performance across a range of temperatures (that is, thermal performance curves or TPCs)[4,8]. These relationships between organisms and temperature are then used to predict the distribution of species under future thermal conditions projected under various climate change scenarios.

Despite the power and popularity of TPCs, these statistical approaches can yield inaccurate predictions because they typically rely on mean annual conditions and thus ignore the influence of the temporal structure of temperature fluctuations at finer scales. This is problematic because the nonlinear relationship between temperature and most metrics of biological performance essentially guarantees that the average organismal response will not be equivalent to their response to the average condition[9–12]. Specifically, when an organism is exposed to a sequence of temperatures x, its performance at the average temperature $f(\bar{x})$ will differ from the average of its performance $\overline{f(x)}$. Temporal variation in temperature will either magnify $\left(\overline{f(x)} > f(\bar{x})\right)$ or dampen $\left(\overline{f(x)} < f(\bar{x})\right)$ the effects of its mean on organismal performance depending on the curvature of f (that is, whether f is accelerating or decelerating[9]). In many cases, changes in temperature variability can be as or more important than changes in

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the mean value[13,14]. In one study, climate-mediated changes in mean temperature alone were found to broadly promote organismal performance in ectotherms, but accounting for the temporal variability of temperature dampened this effect and led to most species suffering a performance loss[15].

Although the temporal structure of temperature can theoretically be incorporated into bioclimate envelope models by using finer temporal scale data, accounting for its dynamical effects on organisms is much more difficult because of the 'static' nature of these methods and their general inability to account for the cumulative effects of previous temperatures on organismal performance. However, theory has shown that such carryover effects associated with the temporal structure or autocorrelation of temperature can interact with the magnitude of temperature variability to determine population persistence[16]. Specifically, temporally autocorrelated variation tends to reduce extinction risk by decreasing the likelihood of catastrophic conditions under strong variation, whereas temporally autocorrelated variation tends to promote extinction risk under weak variation by increasing the likelihood that organisms will experience long stretches of poor conditions[16]. Prolonged exposure to temperatures above the species' critical thermal maximum is particularly destabilizing as it can reduce population fitness below the replacement rate[17]. Analyses of historical observations and projections from previous generation climate models have found strong temporal trends in the variability and autocorrelation of temperature[18–21], suggesting the potential for a larger impact on ecological populations in the future. Overall, these empirical and theoretical results highlight the importance of quantifying changes in the mean, variability and autocorrelation of temperature projected under climate change to predict their joint influence on ecological systems over the course of the twenty-first century. However, disparities in the scale of models in climate and ecology have hindered impact studies that consider the complexity of both underlying systems[22,23].

We briefly illustrate the potential for complex interactions between climate-mediated changes in the mean, variability and autocorrelation of temperature to influence organismal performance by simulating the effects of synthetic temperature time series on the population growth rate *r* according to a species' TPC (Fig. 1, see Methods for modelling details). Predictably, performance under negligible temperature variation can be inferred directly from the mean of each species' TPC (Fig. 1b,c). However, when temporal variation in temperature is included in the model (that is, standard deviation; shaded region), time-averaged performance can be considerably modified[9], even overturning the identity of 'winning' and 'losing' species based solely on constant temperature conditions (Fig. 1d,e). Temperature autocorrelation, which measures the temporal structure of temperature fluctuations (for example, the persistence of extremes), can also play a pivotal role in determining whether a species' performance and stability will benefit or suffer under different thermal regimes (Fig. 1f,g). To determine the impact of such changes over the course of the twenty-first century, we analysed the latest generation of Earth System Models from the Coupled Model Intercomparison Project Phase 6 (CMIP6) to document spatiotemporal changes in three key aspects of air temperature: statistical distribution, variance and temporal autocorrelation. We then analysed the effects on population stability and extinction risk using simple mathematical models to examine the hypothesis that even under ideal conditions, popular statistical methods can yield incorrect predictions about patterns of organismal performance when dynamical and cumulative temperature effects are ignored.

Regional trends in temperature distribution

We examined changes in the global and regional temperature distributions at each geographical location between 1850 and 2100 under the high emissions scenario, SSP5-8.5[24] (Fig. 2a,b). Quantile regression was used to measure temporal trends in the entire distribution of projected temperatures (that is, across quantiles ranging from $\tau = 2.5\%$ at the low end to $\tau = 97.5\%$ at the high end) in the Northern Hemisphere Extra-tropics (NHEX, 30° N to 90° N), the Southern Hemisphere Extra-tropics (SHEX, 90° S to 30° S), and the Tropics (TROP, 30° S to 30° N). When averaging trends across regions, we found asymmetrical but uniformly positive trends across all quantiles, indicating that the entire temperature distribution is shifting upwards but at rates that vary systematically across the distribution. In NHEX, the lowest quantile of the distribution ($\tau = 2.5\%$, 0.33 *K* per decade) is warming at twice the rate of the uppermost quantile ($\tau = 97.5\%$, 0.16 *K* per decade). The SHEX exhibits a similar pattern of disproportionate warming for the low quantiles ($\tau = 2.5\%$, 0.15 *K* per decade; $\tau = 97.5\%$, 0.10 *K* per decade). Conversely, in the tropics, the upper quantiles of temperature are warming faster ($\tau = 97.5\%$, 0.14 *K* per decade) than the lower quantiles ($\tau = 2.5\%$, 0.10 *K* per decade). The magnitude of trends is greater in NHEX than in SHEX or TROP. The more pronounced extra-tropical decrease in the incidence of cold events may benefit cold-limited species; however, quantile trends also indicate increased positive skewness of the NHEX temperature distribution, which has been associated with declines in long-term ecological performance[15]. Across all eight CMIP6 models that we analysed and in all three latitudinal regions, trends in the tails of the distributions differ from the trends in the central tendencies, thus highlighting the importance of moving beyond mean temperature when predicting organismal performance.

Trends in the variability of temperature between 1850 and 2100 are predicted to exhibit similarly complex regional patterns (Fig. 2c). Variance will generally increase across temperate and tropical land areas below 45° N, with regional exceptions including Asia. The strongest increases in variance are in the northern mid latitudes, including northern Africa, southern Europe, the Middle East and the western United States. Variance is decreasing most rapidly in the high northern latitudes, especially in Canada and Russia[25]. The concurrent decrease in variability at high latitudes and its increase at other latitudes suggests that temperature variation, similar to mean temperature, is becoming more spatially homogeneous in a warming world. These findings are generally consistent with studies of the previous generation of climate models, which suggested increasing temperature variability in tropical countries[26] and decreasing variability in the northern mid to high latitudes[27]. Trends at the regional level are congruent with quantile trends (Fig. 2a), which indicate a widening temperature distribution (increasing variance) in TROP, and a narrowing temperature distribution (decreasing variance) in NHEX and SHEX, as well as large-scale changes in physical climate processes[26–28]. The effects of these trends in temperature variation on ecological systems will depend on the geographical location and physiological properties of each species, with increasing variability either promoting or reducing performance on the basis of its position relative to the inflection point of an organism's TPC[9].

Frequency-resolved temperature changes

To better understand these spatiotemporal patterns, we used time-frequency decomposition via the wavelet transform to resolve changes in the variability of temperature at sub-annual to annual timescales (between 2 d and 2 yr) and multi-annual timescales (between 2 yr and 30 yr; Extended Data Fig. 1). Wavelet transforms resolve a signal in both the time and frequency domains to describe how each frequency or period in the time series contributes to variation over time. We found countervailing trends in scale-specific variability in the mid to high northern latitudes. The magnitude of short-term variability is decreasing, while the magnitude of long-term variability is increasing. Arctic amplification, which is detectable in both observational data and climate simulations, has previously been suggested as the main driver of decreasing sub-seasonal variability at these latitudes[27]. Meanwhile at the mid latitudes, variation in both annual and multi-annual timescales is increasing, consistent with increasing variance at all periodicities.

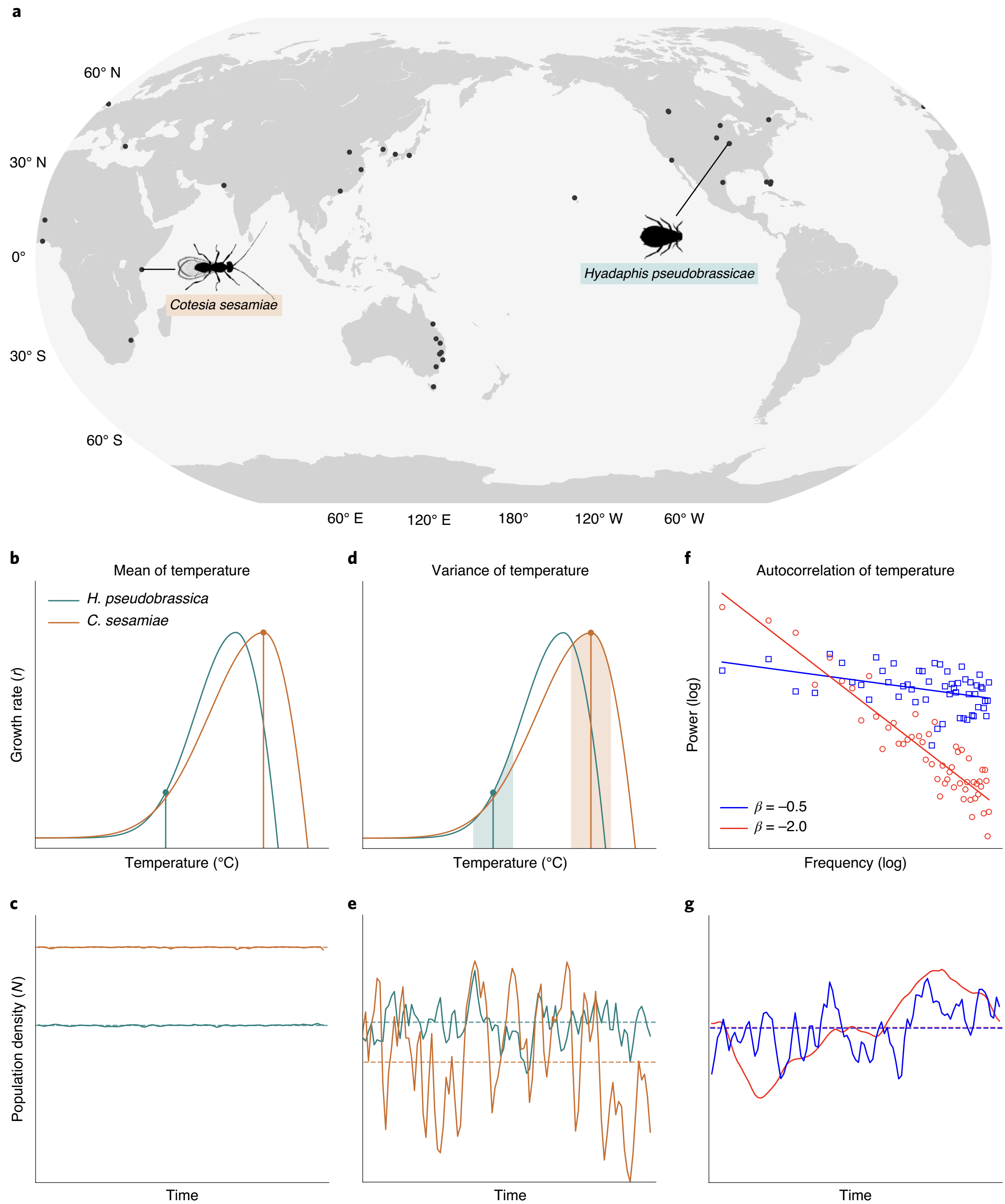

Fig. 1 | Effects of temperature mean, variance and autocorrelation on organismal performance. **a**, Source locations of the 38 species whose thermal performance parameters were obtained from the Deutsch et al.[5] dataset. *Cotesia sesamiae* is a tropical parasitoid wasp and *Hyadaphis pseudobrassicae* is a temperate-zone turnip aphid. **b**,**c**, Thermal performance curves and population dynamics for *C. sesamiae* and *H. pseudobrassicae* under a mean temperature (vertical line) with negligible variation. **d**,**e**, Larger temperature variation (s.d., shaded) alters mean response (dashed horizontal line) and may even overturn predictions of relative performance based on constant temperature conditions. **f**, The power spectrum of temperature with weak ($\beta = -0.5$) and strong ($\beta = -2$) temporal autocorrelation. **g**, Population dynamics of *Hyadaphis pseudobrassicae* under a greater degree of temporal autocorrelation exhibit longer-term fluctuations. Multiple aspects of temperature, such as its mean and variance, can interact to promote or decrease performance.

These scale-dependent changes in the temporal trends of temperature fluctuations could have important ecological implications because the effect of temperature fluctuations depends on the relationship between their period and the generation time of organisms. Indeed, estimating the biological effect of temperature fluctuations by 'nonlinear averaging' of organismal performance under the relevant constant thermal regimes is much more likely to yield accurate results when the period of the temperature fluctuations is larger than the generation time of an organism because such slow variation can more easily be 'tracked' by a population[29].

We computed the spectral exponent of the temperature time series at each geographical location to quantify spatiotemporal trends,

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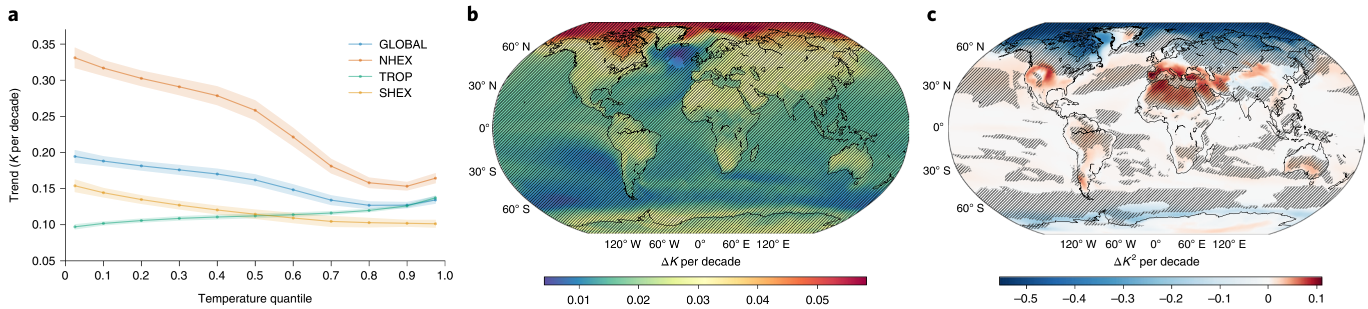

Fig. 2 | Mean trends in the statistical distribution of daily air temperature between 1850 and 2100. a,**b**, Trends in the percentile values of air temperature (**a**, *K* per decade) and mean temperature at each geographic location (**b**, Δ*K* per decade) indicate asymmetrically warming temperature distributions in the Northern Hemisphere Extra-tropics (NHEX, 30° N to 90° N), the Tropics (TROP, 30° S to 30° N), the Southern Hemisphere Extra-tropics (SHEX, 90° S to 30° S), and the full globe (GLOBAL, 90° S to 90° N). Shaded bounds denote the 90% confidence interval based on eight CMIP6 models. **c**, Trends in the variance of daily air temperature (ΔK^2 per decade) exhibit similarly complex regional patterns. The concurrent decrease in variability at high latitudes and increase at other latitudes suggests that temperature variation is becoming more spatially homogeneous in a warming world. Hashed contours indicate statistically significant inter-model agreement on the sign of the trend at the $\alpha = 0.05$ significance level.

with more negative exponents indicating greater temporal autocorrelation over a range of lags from 2 d to 10 yr (Fig. 3a). We found increasing temporal autocorrelation (decreasing spectral exponent) at a majority of sea locations (60%) and land locations (80%), excluding Antarctica where autocorrelation is decreasing. Autocorrelation is increasing most rapidly in equatorial land areas including the Amazon and the Southeast Asian islands, with high inter-model agreement on the sign of the trend. Notable exceptions to the increasing trend in autocorrelation include Greenland, Western Africa, Western Europe and parts of Central Asia. Generally, agreement between models is higher at mid latitudes than in the polar zones or the tropics, where climate model bias and spread have historically persisted[30]. Regional analysis indicates statistically significant increasing trends in temporal autocorrelation in NHEX (-1.12×10^{-3} per decade, $P = 0.010$), TROP (-1.14×10^{-3} per decade, $P = 0.001$) and globally (-0.54×10^{-3} per decade[1], $P = 0.005$), and a statistically significant decreasing trend in temporal autocorrelation in SHEX (0.53×10^{-3} per decade, $P = 0.009$; Supplementary Table 1). The direction and significance of these trends are consistent across land and sea environments, although the spectral exponent is more negative for sea than land, probably due to the buffering effects of the ocean (Fig. 3b–e). In NHEX and TROP, autocorrelation is increasing at a greater rate in land locations than in sea locations, while in SHEX it is decreasing at similar rates between land and sea (Supplementary Table 2). A greater degree of temporal autocorrelation is associated with more gradual changes of state and, even without any changes in variance, results in longer durations spent under extreme conditions. A greater clustering of similar temperatures has been suggested to increase exposure to heat waves and cold snaps while decreasing the incidence of protective temporal refugia[20].

Regional differences in warming patterns

In the northern latitudes, variance and autocorrelation exhibit opposite temporal trends. The decreasing variance may be attributed to a decrease in high-frequency variability and more rapid warming of the lower than the upper quantiles of the temperature distribution. Studies of reanalysis data and observations have also implicated decreasing cold-season sub-seasonal variability and rapidly warming cold days in decreasing temperature variability in mid to high northern latitudes[20,24,29]. Meanwhile, temporal autocorrelation in NHEX is increasing—a finding that has also been detected in the previous generation of climate models[20], weather station observations[31] and monthly reanalysis data[19]. As a result, variation at 2 d to 10 yr periodicities is decreasing while temperature fluctuations are becoming more persistent, suggesting the increased probability of a series of homogeneous conditions. In contrast to the mid to high northern latitudes, variance and temporal autocorrelation show similar trends at most latitudes, that is, both variance and autocorrelation are increasing.

Implications for global ectotherm populations

To better understand the independent and joint effects of these projected trends in the mean, variance and autocorrelation of temperature on ecological systems, we used empirical thermal performance information from invertebrate ectotherms compiled by Deutsch et al.[5]. We extracted temperature time series from the eight CMIP6 climate models at geographical point locations corresponding to the source sites of the 38 species (Fig. 4a). A dynamical population simulation using species-specific temperature-dependent growth rates yielded time series of population abundance for the historical period (1950–2000) and the latter half of the twenty-first century (2050–2100). We used a dynamical logistic growth model whose carrying capacity $K = r_t/\alpha$ is determined by the temperature-dependent growth rate r_t and the self-regulation parameter α. Importantly, the model captures the effects of temperatures above the critical thermal maximum and extinction propensity under autocorrelated variation by allowing growth rates to become negative (see Methods for details). Using the eight climate simulations as replicates, we compared the historical and future periods to detect statistically significant temperature-driven changes in population abundance, stability (mean/standard deviation of abundance) and extinction probability (proportion of simulations where a species did not have a strictly positive final abundance).

Under the high emissions scenario (SSP5-8.5), population abundance increased for the plurality of species (16 of 38) because the mean temperature grew closer to their thermal optimum and thus boosted equilibrium abundance, but it decreased for 9 species (Supplementary Table 3). Population abundance increased significantly for 3 of 5 TROP species and for the majority (5 of 8) of SHEX species. In NHEX, outcomes were mixed, with approximately equal proportions of species experiencing an increase in abundance, a decrease in abundance, and no significant change. NHEX population abundance followed latitudinal patterns, generally decreasing between 30° N and 45° N, and increasing above of 45° N. Under the high emissions scenario, population stability increased for the 12 out of 38 and decreased for 9 species (Fig. 4b). Population stability increased or underwent no significant change for TROP species, while in the mid latitudes (NHEX and SHEX), changes in stability were mixed. Additional analyses showed that the trends in stability were mainly due to the emergence of two distinct dynamical regimes under climate change, with species either moving to a low-mean/low-variance mode or a high-mean/high-variance mode,

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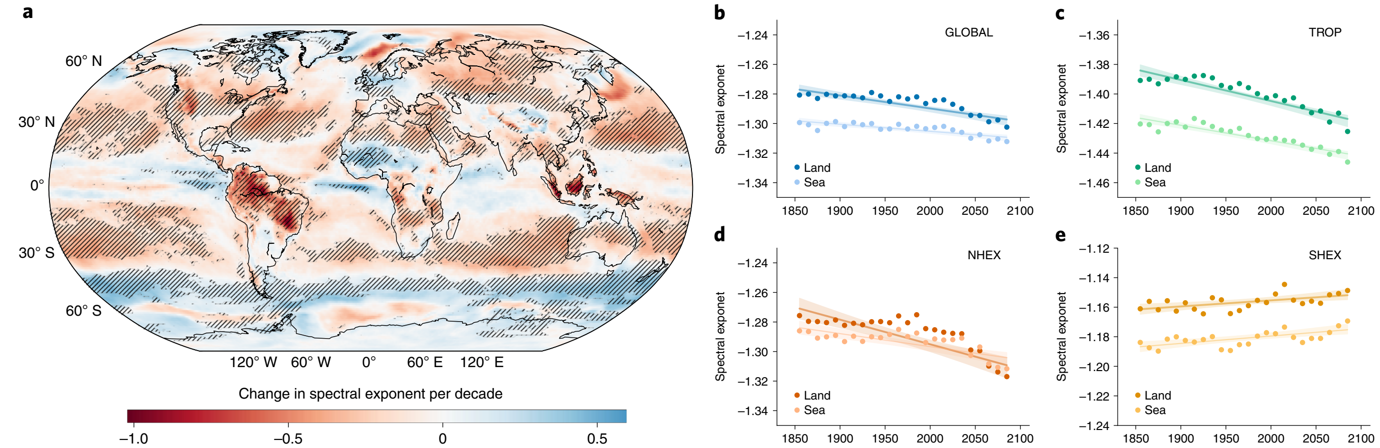

Fig. 3 | Increasing temporal autocorrelation in daily air temperature between 1850 and 2100. a, Spatiotemporal trends in temporal autocorrelation suggest changes in the chronological sequence of temperature conditions, with increasing temporal autocorrelation (decreasing spectral exponent) at 80.04% of global land locations, excluding Antarctica. Hashed contours indicate statistically significant inter-model agreement on the sign of the trend at the $\alpha = 0.05$ significance level. **b**–**e**, Regional analysis indicates statistically significant increasing trends in temporal autocorrelation in NHEX and TROP, and a statistically significant decreasing trend in temporal autocorrelation in SHEX. While sea environments generally exhibit a greater degree of temporal autocorrelation than land, in NHEX autocorrelation is increasing at a greater rate on land locations as to overturn this relationship by the end of the twenty-first century.

particularly in the extra-tropics (Extended Data Figs. 2 and 3). These results were robust to orders of magnitude changes in the growth rate r_t and self-regulation parameter α (Extended Data Figs. 4 and 5).

Many SHEX and NHEX species suffered performance losses (negative growth rates) during summers in their respective hemispheres, as they are generally less tolerant of hot temperatures than tropical species. For some temperate species, longer growing seasons and warmer winter temperatures offset the negative effect of the warmest part of the year, while others suffered an overall performance loss[32]. This is consistent with the suggestion that increases in summer heat stress would reduce overall fitness and increase fitness variation for many mid-latitude species. Our results suggest that temperate species may be at greater risk than tropical species as a result of warm days, even when annual mean temperature remains below the thermal optimum. The results contrast with those of previous studies, which suggested on the basis of hourly temperature records and monthly temperature anomalies that warming in the tropics would be more deleterious than warming in the mid latitudes[5,33]. This discrepancy may be due to the fact that growth rates were allowed to become negative when temperatures exceeded the critical thermal maximum in our simulations but assumed to converge to zero (that is, were not allowed to be negative) in previous studies[4]. Our results are more consistent with studies that predict a greater risk of performance loss for temperate species when accounting for negative performance values in response to climate-mediated changes in the mean and the variance of temperature[15].

To tease apart the dynamical effects of climate change on population stability from its effects on mean performance as inferred by measuring average growth rate using each species' TPC, we replicated previous efforts by comparing changes in the average growth rate under historical and future climatic conditions with vs without negative growth rates (Extended Data Fig. 6). Our results show that although allowing negative growth rates predictably leads to greater reductions in performance overall, the regional patterns in performance are similar to the trends in population stability observed in the dynamical simulations, with tropical species generally enjoying performance gains and temperate species—particularly in NHEX—suffering performance losses (Extended Data Fig. 6).

Our simulations indicated mean warming as the dominant driver of ecological impacts. Changes in temporal autocorrelation alone (mean temperature and variance held at historical levels) had no significant effects on population abundance and a significant destabilizing effect on just 1 NHEX species. Changes in temporal autocorrelation and variance (mean temperature held at historical levels) led to an increase in population abundance in 2 NHEX species and a decrease in population stability in 2 NHEX species. These results suggest that NHEX species are more susceptible to changes in temperature variability than TROP or SHEX species. Finally, changes in mean and temporal autocorrelation (variance held at historical levels) led to increased population abundance in 18 global species and increased stability in 14 global species, versus 16 and 12 under the high emissions scenario-projected changes in all three aspects of temperature. Thus, projected changes in temperature variability have a weak moderating effect on the positive effects of mean warming on population abundance and stability.

To determine how these complex changes in population abundance and stability translate to persistence, we quantified extinction risk as the proportion of the 8 CMIP6 models for which population abundance declined below an arbitrarily small threshold of 1×10^{-9} at any point during the 50 yr simulation (Fig. 4c). In our simulations under the high emissions scenario, extinction risk increased significantly under future climate conditions relative to historical baselines for 18 species, increased (but not significantly) for 6 species, decreased for 1 species, and did not change for 13 species. We found statistically significant increases in extinction risk globally (Mann–Whitney $U = 423$, $n_1 = n_2 = 38$, $P = 8 \times 10^{-4}$) and in NHEX (Mann–Whitney $U = 166$, $n_1 = n_2 = 25$, $P = 3 \times 10^{-3}$). These findings suggest that temperature changes promote extinction risk, despite having a largely positive or neutral effect on population abundance and idiosyncratic impacts on stability. Hence, although variability among climate models produces a wide range of changes in stability across species and geographical locations, uncertainty at the climate level yields consistent biological impacts in the form of systematically higher extinction risks (Extended Data Fig. 7).

Conclusion

By forcing simple strategic and dynamical models of population growth with fine temporal scale temperature projections from the latest generation of Earth System Models, we demonstrated increased extinction risk under climate change across globally distributed ectotherm populations. Unfortunately, using more complex tactical dynamical

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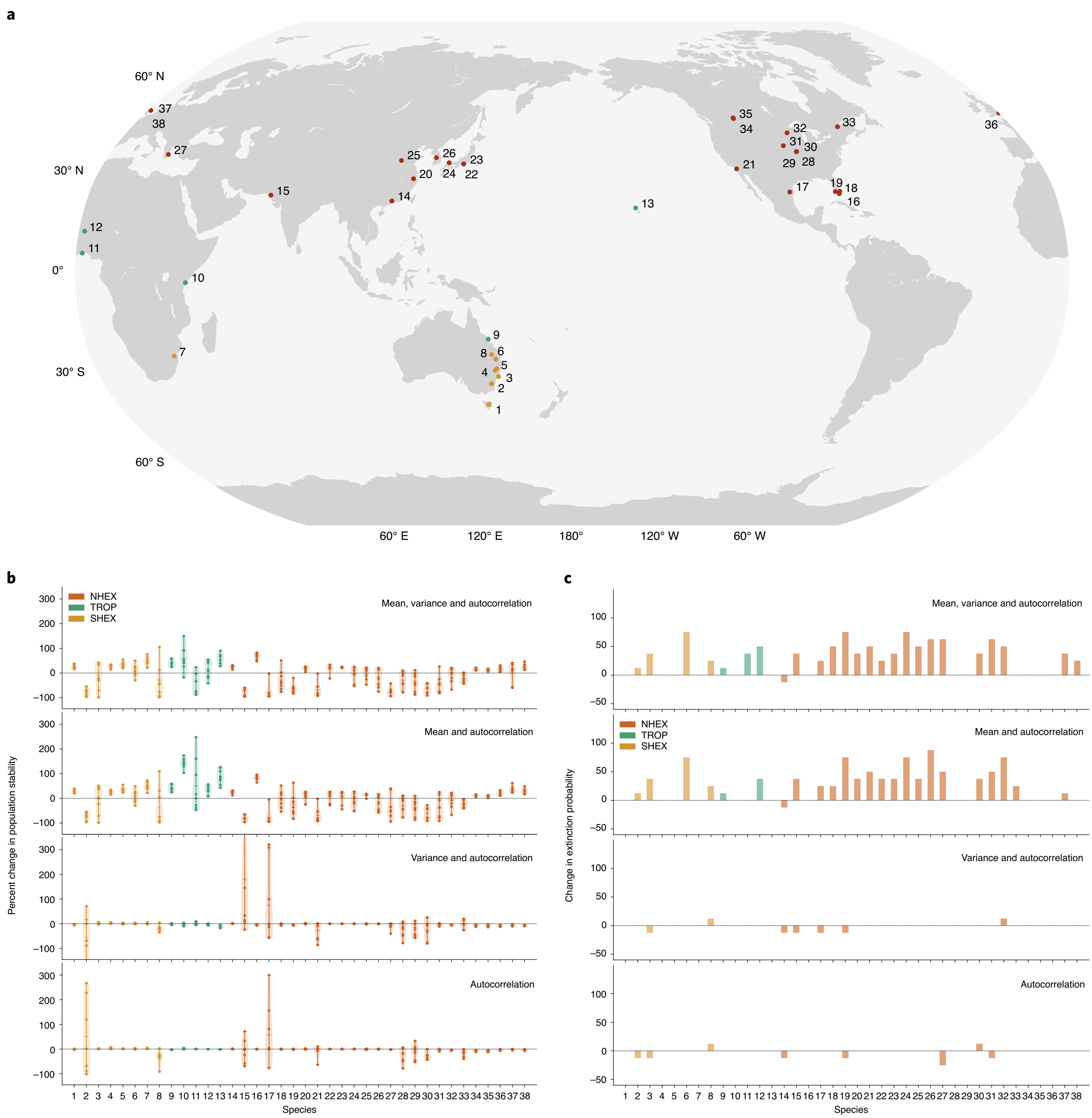

Fig. 4 | Temperature has idiosyncratic effects on stability but increases extinction risk globally. a, Source locations of the terrestrial ectothermic invertebrate species, numbered 1 (southernmost latitude) to 38 (northernmost latitude). Species are colour-coded according to latitudinal region (orange, SHEX; green, TROP; red, NHEX). **b**, Percent changes in population stability (mean ÷ s.d.) between a historical reference period (1950–2000) and a future period (2050–2100) under multiple aspects of temperature change indicate greater risk to temperate than to tropical species. Under a high emissions scenario, stability shows a statistically significant increase for 12 of 38 species and a statistically significant decrease for 9 species. Points in the violin plots represent the 8 climate model outputs. **c**, Extinction probability shows a quasi-universal increase globally between the historical period (1950–2000) and a future period (2050–2100) under high emissions scenario changes in temperature.

models would require extensive species-, age- and life-stage-specific information about the effects of temperature fluctuations on population growth rates that is simply not available at the relevant scales. Tactical models would also need to consider thermoregulation[34], the effects of microclimates[35], acclimatization or adaptation[36], partitioning of activity periods[37] and synecological processes such as predator-prey interactions that could affect ectotherm population dynamics. Additionally, due to their 1° spatial resolution, the climate projections used in this study are much coarser than the microclimates experienced by individual organisms and may thus lead to underestimates of organismal performance due to the presence of thermal refugia in the real world[23,34]. Hence, our results should be viewed as a qualitative baseline prediction of how the spatiotemporal distribution of extinction risk is likely to shift due to climate change rather than a quantitative forecast of when each species is likely to be extirpated from each geographical location.

Despite the limitations of TPCs in accounting for temporal carryover and dynamical effects, the lack of obvious alternatives calls for strategies to make these approaches more robust to real-world conditions[38], such as by integrating more realistic, fine-scaled temperature variation into our predictive models than previous studies. Although bioclimate envelope approaches have been criticized for not accounting for important ecological factors, such as species interactions and dispersal, when attempting to predict the ecological effects of climate change[39–42], we have shown that even under ideal conditions when the influence of such factors can be assumed to be negligible, statistical frameworks that ignore the dynamical consequences of temperature variation are likely to yield inaccurate forecasts of the impact of climate change on organisms. Our results show that accounting for shifts in the entire statistical distribution of temperature over time via dynamical models can better capture the cumulative effects of climate-mediated changes in thermal stress on extinction risk.

By bringing together climate data and a minimal dynamical model from ecology, we demonstrated a strong and systematic amplification of extinction risk in ectotherms due to projected changes in fine-grained temperature variability. Furthermore, our finding of greater risk to sub-tropical than tropical species highlights the importance of accounting for the dynamical effects of projected changes in the mean as well as the variance of temperature over the course of the twenty-first century to accurately predict the response of ecological systems around the globe.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41558-022-01490-7.

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Methods

CMIP6 simulations

We obtained CMIP6 climate simulations for the historical forcing period (1850–2014) and future emissions scenario SSP5-8.5 (2015–2100) via the CMIP6 data portal (https://esgf-node.llnl.gov/search/cmip6/). Eight models from CMIP6 (AWI-CM-1-1-MR, BCC-CSM2-MR, CESM2, EC-Earth3, INM-CM5-0, MPI-ESM1-2-HR, MRI-ESM2-0 and NorESM2-MM) were selected on the basis of availability of daily air temperature at surface ('tas') at a 100 km nominal resolution at the time of download. While 'tas' at sub-daily frequencies is available for some models, daily data was selected to maximize the ensemble size. We resampled all datasets to a common 1° by 1° grid spanning −90° to 90° latitude and 0° to 360° longitude, and to a standard calendar without leap years. Spatial regions were defined on the basis of latitude as Northern Hemisphere Extra-tropics (90° S to 30° S), Tropics (30° S to 30° N) and Southern Hemisphere Extra-tropics (30° N to 90° N).

Statistical analyses of climate data

Quantile regression. Trends in the percentile values of global and regional temperature distributions were computed via quantile regression. Quantile regression can comprehensively model heterogeneous conditional distributions, where the relationship between the quantiles of the dependent variable and the independent variable is different from the relationship between the means of the dependent variable and the independent variable. We applied quantile regression to analyse trends with respect to time at various percentile values ($P_{2.5}$, P_{10}, P_{20}, P_{30}, P_{40}, P_{50}, P_{60}, P_{70}, P_{80}, P_{90}, $P_{97.5}$). Analyses were performed using the R package quantreg, with significance level $\alpha = 0.1$ and the default Barrodale and Roberts method to return confidence intervals for the estimated parameters. To obtain the ensemble mean trends, we calculated the mean slope, upper bound and lower bound across the eight climate models at each geographical location, then computed spatial averages for the full globe and three latitudinal regions.

Variance. Trends in the magnitude of temporal variation of air temperature were examined at each geographical location using a moving window approach. First, temperature was detrended by fitting a piecewise linear regression against time with Python package pwlf at each geographical location and extracting the residuals. Then, the temperature time series were divided into 10 yr windows starting in years 1855 through 2085 so as not to combine historical and future simulations (pre- and post-01-01-2015), and the variance of daily air temperature was calculated for each window. Windows were selected with no overlap to avoid statistical issues due to non-independence of estimates taken from partially overlapping time windows[20].

Scale-specific variability. Scale-specific variability was quantified using time-frequency decomposition. Specifically, at each geographical location, wavelet analysis was conducted on multi-model mean temperature using the R package biwavelet[43]. Wavelet analysis resolves both the time and frequency domains of a signal (here a time series) via the wavelet transform. This is achieved via the convolution of a mother wavelet function and a time series across a set of windows τ and scales s. We chose to use the Morlet wavelet, which represents a sine wave modulated by a Gaussian function:[44]

$$\psi_0(t) = \pi^{-1/4} e^{i\omega_0^t} e^{-t^2/2}$$

where i is the imaginary unit, t represents non-dimensional time, and $\omega_0 = 6$ is the non-dimensional frequency[3]. The continuous wavelet transform of a discrete time series $x(t)$ with equal spacing δt and length T is defined as the convolution of $x(t)$ with a normalized Morlet wavelet:[44,45]

$$W_x(s,\tau) = \sqrt{\frac{\delta t}{s} \sum_{t=0}^{T-1} x(t)\, \psi_0 * \left(\frac{(t-\tau)\delta t}{s}\right)}$$

where * indicates the complex conjugate. By varying the wavelet scale s (that is, dilating and contracting the wavelet) and translating along localized time position τ, one can calculate the wavelet coefficients $W_x(s,\tau)$ across the different scales s and positions τ. These wavelet coefficients can be used to compute the bias-corrected local wavelet power, which describes how the contribution of each frequency or period in the time series varies over time:[44,46,47]

$W_x^2(s,\tau) = 2^s\,|W_x(s,\tau)|^2$ where 2^s is the bias correction factor[46]. The scale s of the Morlet wavelet is related to the Fourier frequency f:[47,48] $\frac{1}{f} = \frac{4\pi s}{\omega_0 + \sqrt{2+\omega_0^2}}$.

When $\omega_0 = 6$, the scale s is approximately equal to the reciprocal of the Fourier frequency f, so period $p \approx s$. The local wavelet power spectrum can then be visualized via heat maps and contour plots[45,47]. From the resulting local wavelet power spectrum heat map with time on the x axis, period (scale) on the y axis and power on the z axis, scale-averaged wavelet power was computed at annual (between 3 d and 2 yr) and multi-annual (between 2 yr and 30 yr) periodicities. This was achieved by taking the weighted sum of the local wavelet power across all scales for each time location τ:[44,47]

$$W_x^{-2}(\tau) = \frac{\delta j \delta t}{C_\delta} \sum_{j=0}^{J} \frac{|W_x(s_j,\tau)|^2}{s_j}$$

where $C_\delta = 0.776$ for the Morlet wavelet, δJ represents the spacing between successive scales and δt represents the spacing between successive time locations[44]. Scale-averaged power was then regressed against time using Generalized Least Squares (GLS) regression for the period 1850–2100 at each geographic location. To determine the robustness of results to the choice of period for scale averaging, we also performed analysis of trends separately at interannual (between 2 yr and 7 yr) and multi-annual (between 7 yr and 30 yr) scales and found qualitatively similar results.

Temporal autocorrelation. The temporal autocorrelation of air temperature was quantified by calculating the spectral exponent at each geographical location[20]. As described above, temperature was detrended by fitting a piecewise linear regression at each geographical location and extracting the residuals. The detrended temperature was divided into 10 yr windows starting in years 1855 through 2085. Fourier transforms of each time series were computed via fast Fourier transform using the Python package NumPy. Periodograms were prepared with frequency on the x axis and power spectral density on the y axis. The spectral exponent, β, was calculated as the slope of the regression line relating log-transformed power to log-transformed frequency. β expresses the relative contributions of frequencies to the power spectrum. In the case of equal contribution from all frequencies, $\beta = 0$. Greater contribution from low frequencies than from high frequencies results in a more negative value of β and indicates greater temporal autocorrelation in the time domain.

Analysis of decadal trends. For each climate model, GLS regression was used to detect statistically significant trends ($P < 0.05$) in variance and temporal autocorrelation with respect to time in the presence of potentially autocorrelated residuals. To measure inter-model agreement, we calculated the multi-model mean trend as the mean of trends calculated for each of the 8 models at each geographic location, then assessed the proportion of models that agreed with the sign of the multi-model mean trend. Inter-model agreement was considered as statistically significant at the $\alpha = 0.1$ level on the basis of a binomial test. ANCOVA was used to quantify the relationship between temporal autocorrelation and time while accounting for potential differences between land and sea environments. Statistically significant main effects and interactions were reported for $P < 0.05$.

Modelling temperature impacts on ecology

Thermal tolerance data. We obtained experimentally derived thermal tolerance parameters for a set of terrestrial ectotherms ($n = 38$) published by Deutsch et al.[5] and used them to predict physiological response to CMIP6-simulated temperature. Deutsch et al.[5] gathered data from 31 thermal performance studies published between 1974 and 2003 based on a collection of insects from 35 different locations. For each species, experimental intrinsic growth rates at multiple temperatures were used to fit a TPC, yielding least-squares estimates of key parameters such as critical thermal maximum (CT_{max}), optimum temperature (T_{opt}), and sigma (σ). We used a numerical scheme to reconstruct the curves whereby the rise in performance up to T_{opt} was modelled as Gaussian and the decline beyond T_{opt} was quadratic[5,49]:

$$P(T) = \begin{cases} \exp\left[-\left(\frac{T-T_{opt}}{2\sigma}\right)^2\right] & \text{for } T \leq T_{opt} \\ 1-\left(\frac{T-T_{opt}}{T_{opt}-CT_{max}}\right)^2 & \text{for } T > T_{opt} \end{cases}. \quad (1)$$

This allowed negative growth rates to arise at high temperatures, but growth rates were bound at zero at low temperatures. Negative performance values indicate that mortality surpasses reproduction rates. Because $P(T)$ is capped at 1 under this numerical scheme, $P(T)$ represents the relative fitness of each species based on its normalized maximum growth rate. However, scaling this relative or normalized maximum growth rate by two orders of magnitude (that is, by a factor of 0.1 or 10.0) had limited quantitative and no qualitative impact on our results (Extended Data Fig. 4). Overall, increasing the growth rate scaling factor had no impact on population stability but promoted extinction risk.

Isolation of temperature aspects. To isolate projected changes in mean temperature and variability, we transformed the future (2050–2100) time series using z-score normalization. Using this approach, we modified projected time series to match the historical (1950–2000) mean and/or standard deviation. Working in 10 yr moving windows between 2050 and 2100, each series x_i with mean m_1 and standard deviation s_1 was transformed to series y_i with mean m_2 and standard deviation s_2:

$$y_i = m_2 + (x_i - m_1)\frac{s_2}{s_1}. \quad (2)$$

According to the scenario, m_2 and s_2 were alternatively defined as (1) high emissions scenario mean and standard deviation ('Mean, variance and autocorrelation'), (2) high emissions scenario mean and historical standard deviation ('Mean and autocorrelation'), (3) historical mean and high emissions scenario standard deviation ('Variance and autocorrelation') and (4) historical mean and standard deviation ('Autocorrelation'). High emissions scenario statistics refer to the properties of future series x_i and confer no change to that aspect of the time series.

Population dynamical modelling. To model the effects of temperature change on the stability and extinction probability of global ectotherm populations, temperature dependence was integrated in the growth rate term of a population dynamical model[50]. While more complex synecological models can capture a range of community-level effects including competition and predation, we chose to model first order autecological dynamics to produce foundational insights about the role of temperature fluctuations on single-species population dynamics. Specifically, we used the $r - \alpha$ logistic growth model to simulate temperature-dependent growth and negative density-dependence:

$$\frac{dN}{dt} = N(r_t - \alpha N) \quad (3)$$

with population size N, time t, temperature-dependent growth rate r_t, and self-regulation in the form of intraspecific competition α. This $r - \alpha$ logistic model is easily interconvertible with the classical $r - K$ formulation ($r/\alpha = K$), but has the advantage of handling negative values of r without issues[51]. This approach is sensitive to the effects of temperatures at and above the critical thermal maximum, which can yield negative growth rates that are important for determining population dynamics as well as long-term fitness.

We extracted time series of daily temperature at the source locations for each species from the ensemble of eight climate simulations. Daily intrinsic growth rates were computed from temperature using equation (1), incorporated into the $r - \alpha$ logistic growth model depicted in equation (3), and the model was then numerically solved using the explicit Runge-Kutta method of order 5(4) implemented in the Python SciPy package to obtain daily population densities. Rather than delineating active periods, which may shift under climate change, we considered the full year to account for potential changes in fitness due to shifts in activity.

The sensitivity of the results to strong ($\alpha = 1$) and weak ($\alpha = 0.1$) self-regulation was examined and found to be extremely limited (Extended Data Fig. 5). We also assessed the sensitivity of our results to absolute rather than relative or normalized growth rates by scaling r_t by a factor of 0.1 or 10 in our simulations. Scaling r_t by two orders of magnitude in this manner had very little quantitative and no qualitive impact on our results. This suggests that the effects of temperature fluctuations on changes in the spatiotemporal distribution of population abundance, stability and extinction were not contingent upon the use of relative fitness (that is, normalized growth rate) versus absolute fitness (that is, growth rate scaled by a factor of 0.1 or 10). These sensitivity analyses also showed that our results are robust to temperature-mediated changes in the maximum instantaneous growth rate[52,53].

Analysis of population changes. To quantify temperature-driven changes in ecological stability and extinction probability, we compared population sizes and dynamics between a historical period (1950–2000) and a future period (2050–2100). Here we defined latitudinal regions according to traditional delineations in ecology: Northern Hemisphere Extra-tropics, 60° S to 23° S; Tropics, 23° S to 23° N; and Southern Hemisphere Extra-tropics, 23° N to 60° N.

Population abundance was computed as the mean population size (N) for a time period. Population stability was computed as the inverse of the coefficient of variation, or mean population divided by population standard deviation. Percent changes in population size and stability were computed for each of the climate models as $(\text{future} - \text{historical})/\text{historical} \times 100\%$ and plotted without outliers in Fig. 4. Statistically significant changes in population abundance and stability between the historical and future periods were identified via the Mann–Whitney U-test, with the eight models as replicates.

Extinction probability was quantified as the proportion of ensemble simulations for which the population declined to zero during a 50 yr simulation. Changes in extinction probability were calculated as the difference between future and historical extinction probabilities. Statistically significant changes in extinction probability were identified on a regional basis via the Mann–Whitney U-test.

Reporting summary

Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

The CMIP6 simulation data used in this paper are available via the data portal https://esgf-node.llnl.gov/search/cmip6/. The ecology data are available for download at https://doi.org/10.1073/pnas.0709472105.

Code availability

The code can be accessed on GitHub at https://github.com/KateDuffy/climate-change-ecology[54].

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Author contributions

K.D., T.C.G. and A.R.G. conceived, designed and refined the project. K.D. performed the data analysis and modelling. K.D., T.C.G. and A.R.G. interpreted the results. K.D. wrote the manuscript with contributions from T.C.G. and A.R.G.

Competing interests

The authors declare no competing interests.

Additional information

Extended data is available for this paper at https://doi.org/10.1038/s41558-022-01490-7.

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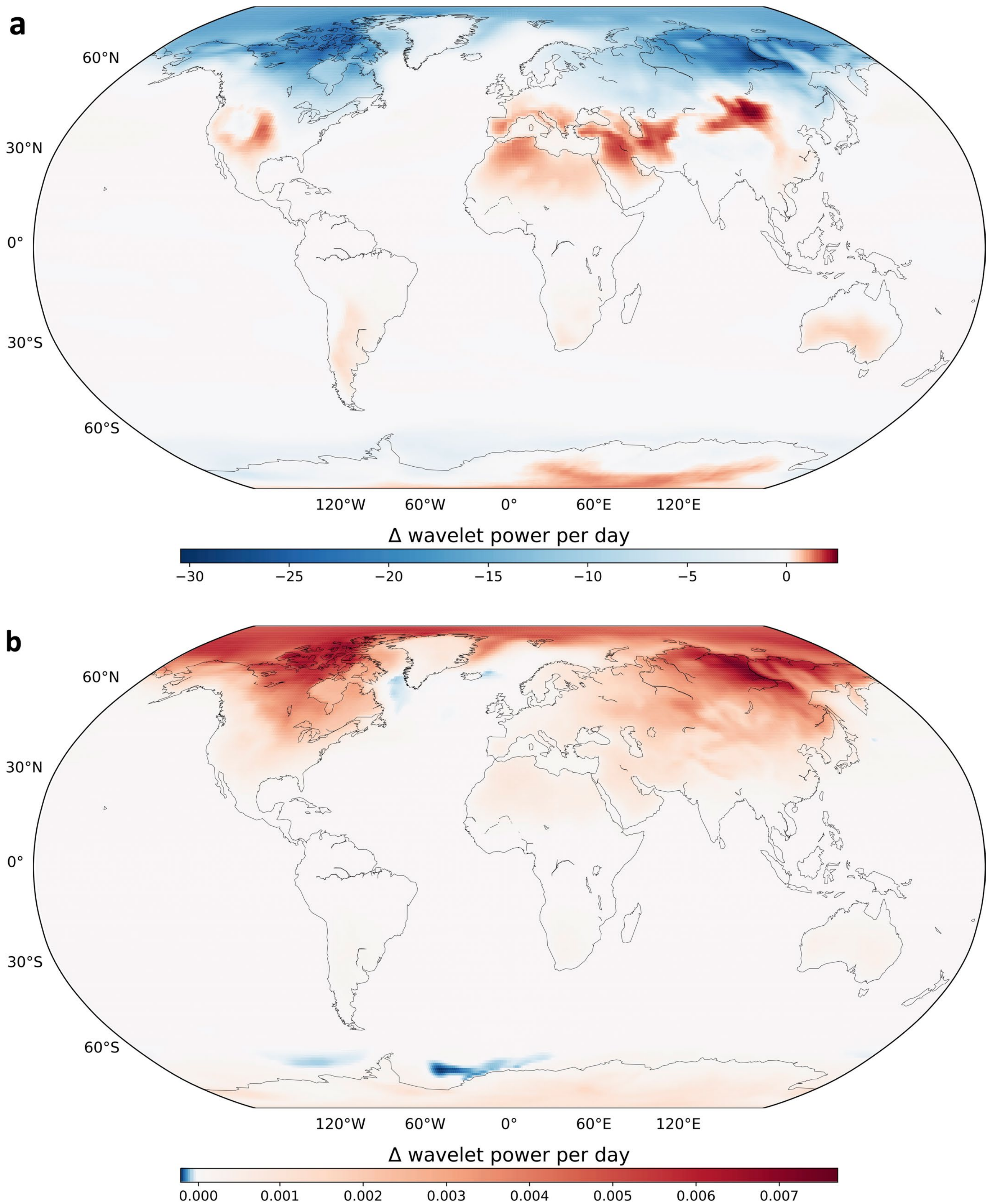

Extended Data Fig. 1 | Temperature variation at multiple timescales contributes to trends in overall variance. a-b Temporal trends in the power of variation at sub-annual to annual periodicities (3-days to 2-years) (**a**) and multi-annual periodicities (2-30 years) (**b**). Trends represent the slope obtained by regressing wavelet power at each geographical location against time. Countervailing trends are found in the Arctic, where the power of short term, high-frequency fluctuations is decreasing and the power of more persistent, low-frequency fluctuations is increasing.

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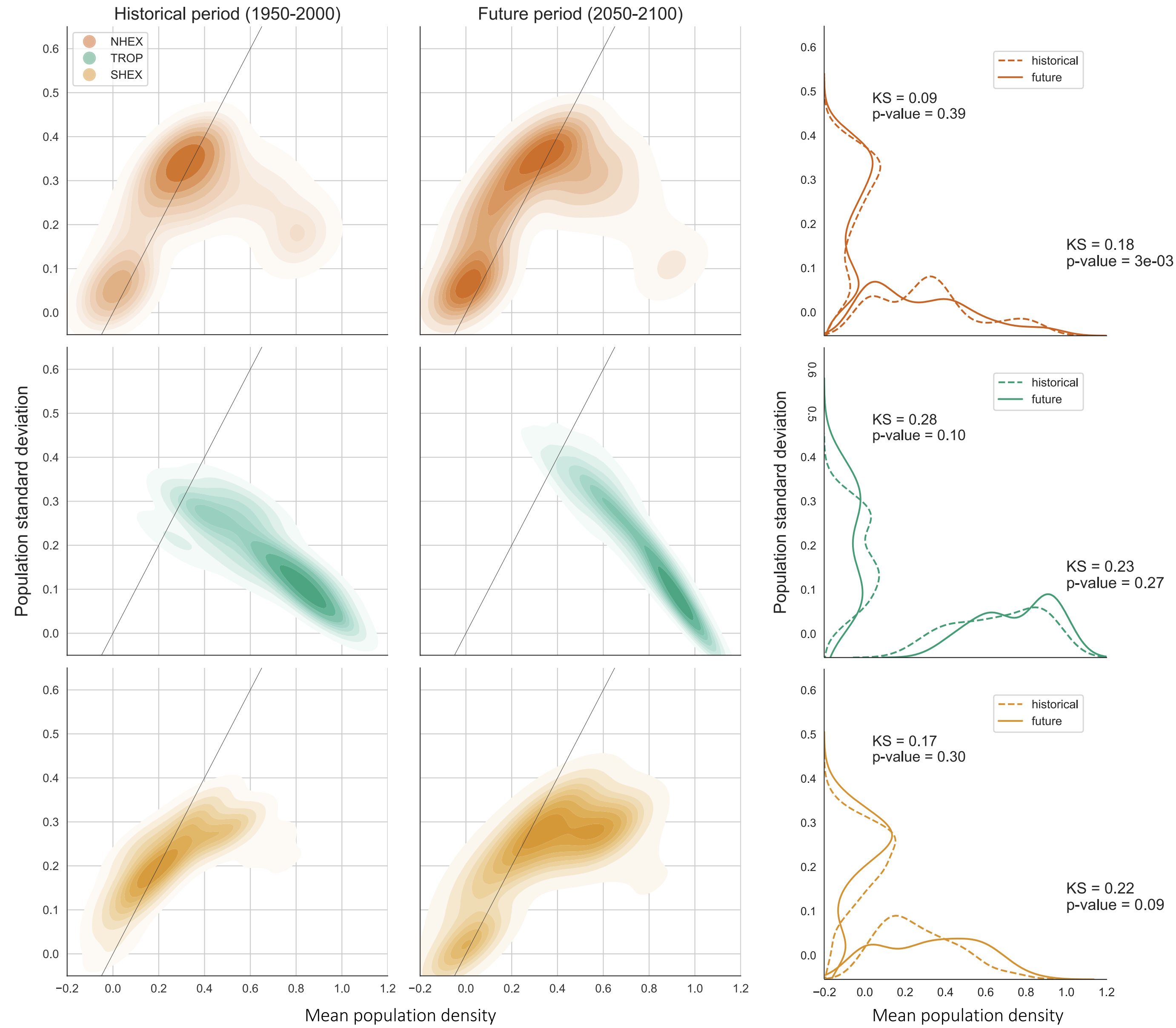

Extended Data Fig. 2 | Drivers of changes in stability (analysis includes both pre- and post-extinction period). Kernel density plots illustrate the relationships between population mean and population standard deviation in the historical period and the future climate change period. The grey 1:1 line divides the more stable regime (high-mean/low-variance; below line), and the less stable regime (low-mean/high-variance; above line). Bimodal distributions emerge in the extra-tropics, with some species at low abundance and standard deviation, and a larger cluster of species at high abundance and standard deviation.

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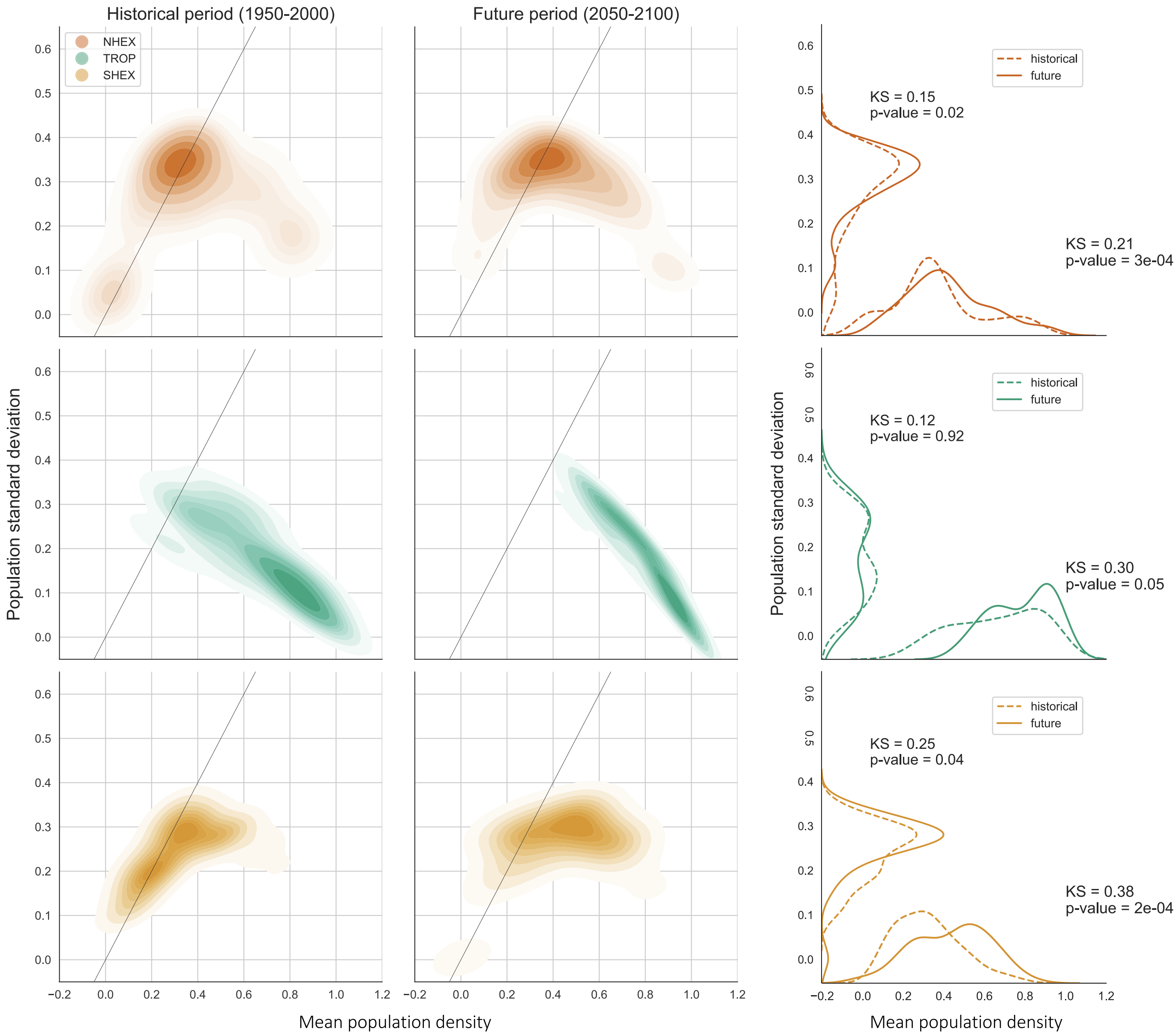
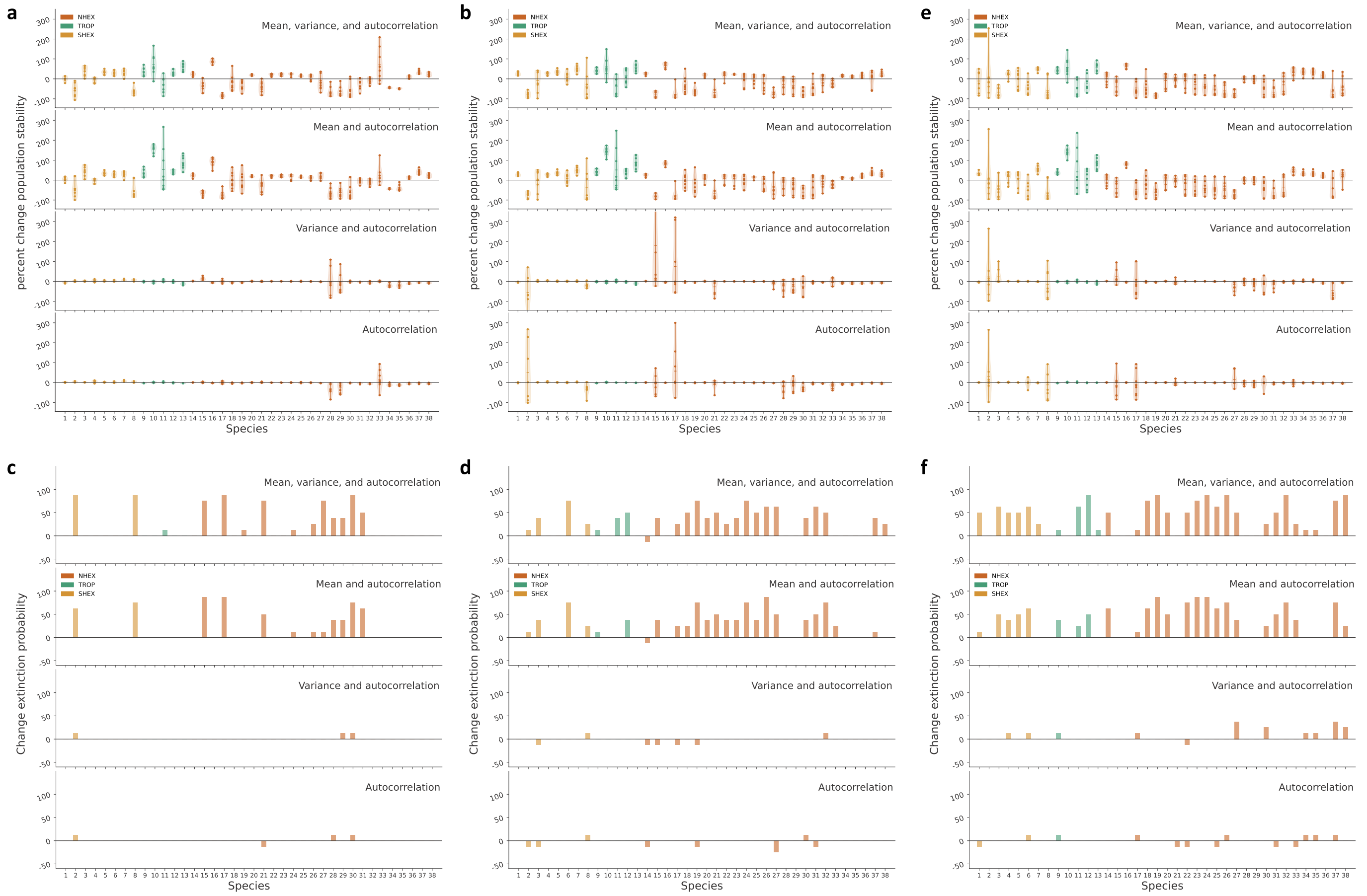
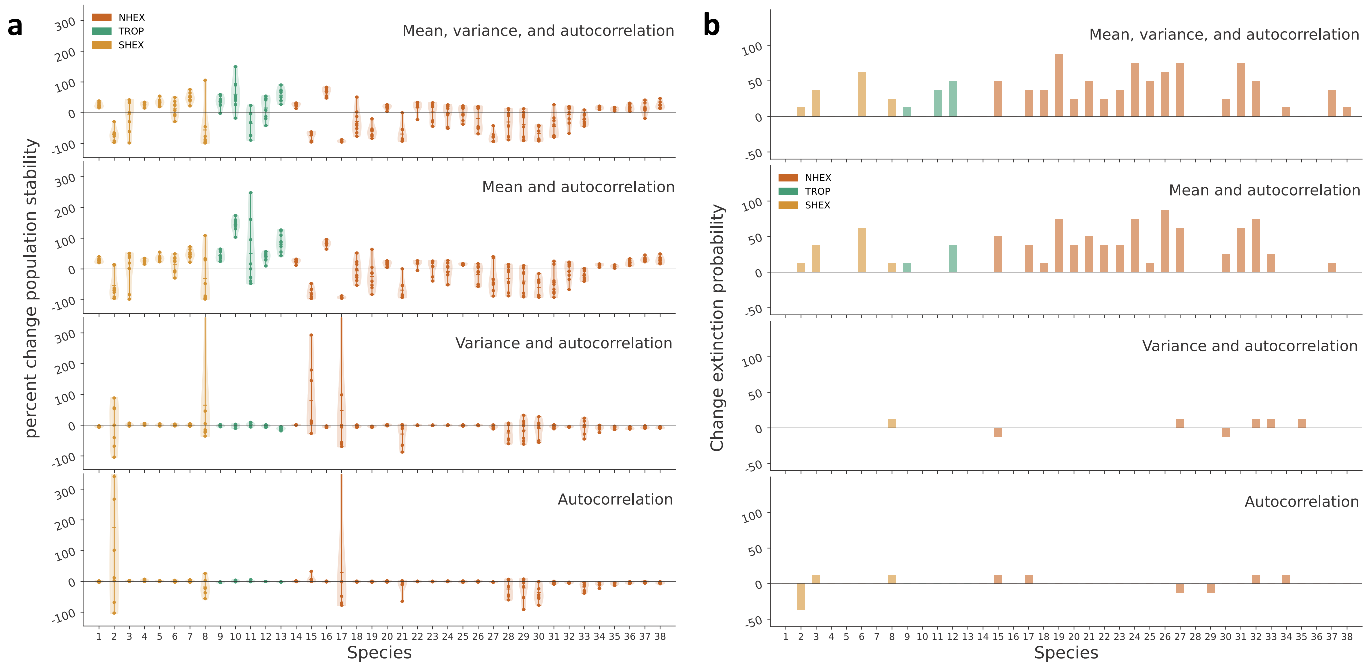


Extended Data Fig. 3 | Drivers of changes in stability (analysis only includes pre-extinction period). When only pre-extinction dynamics are analyzed, significant changes in population abundance persist in the extra-tropics; changes in population standard deviation become significant for NHEX and TROP and remain non-significant for SHEX.

https://doi.org/10.1038/s41558-022-01490-7

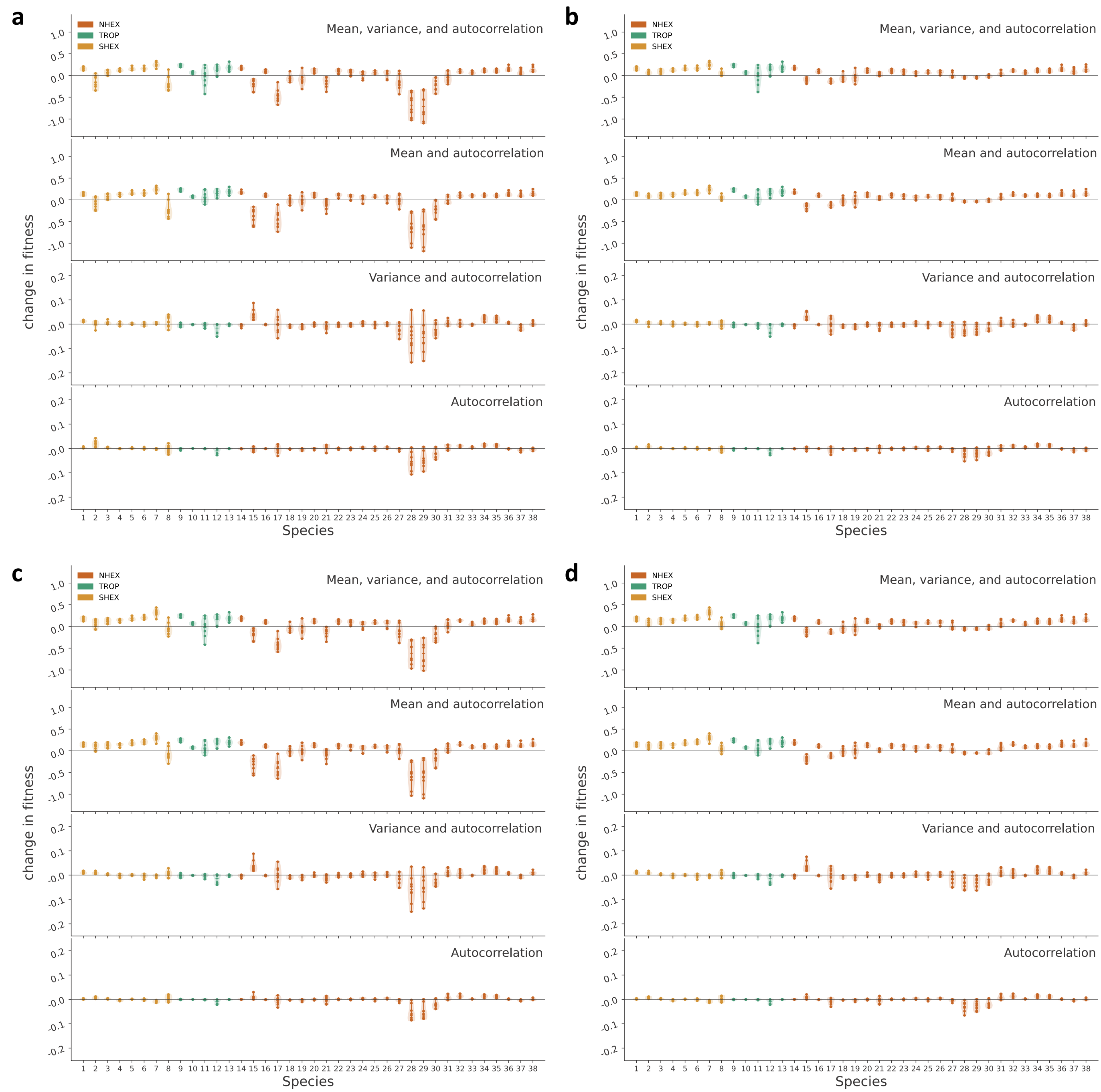


Extended Data Fig. 4 | Scaling of the intrinsic growth rate has moderate effects on temperature-driven impacts on population stability and extinction risk. Results exhibited limited sensitivity to the choice of smaller (scaling factor = 0.1; **a,b**) and larger (scaling factor = 10.0; **e,f**) intrinsic growth rates. Although larger growth rates were more strongly associated with deceased stability and increased extinction risk than smaller growth rates, the latitudinal patterns and effect sizes were consistent with the changes in population stability, **c**, and extinction probability, **d**, observed under normalized growth rates.



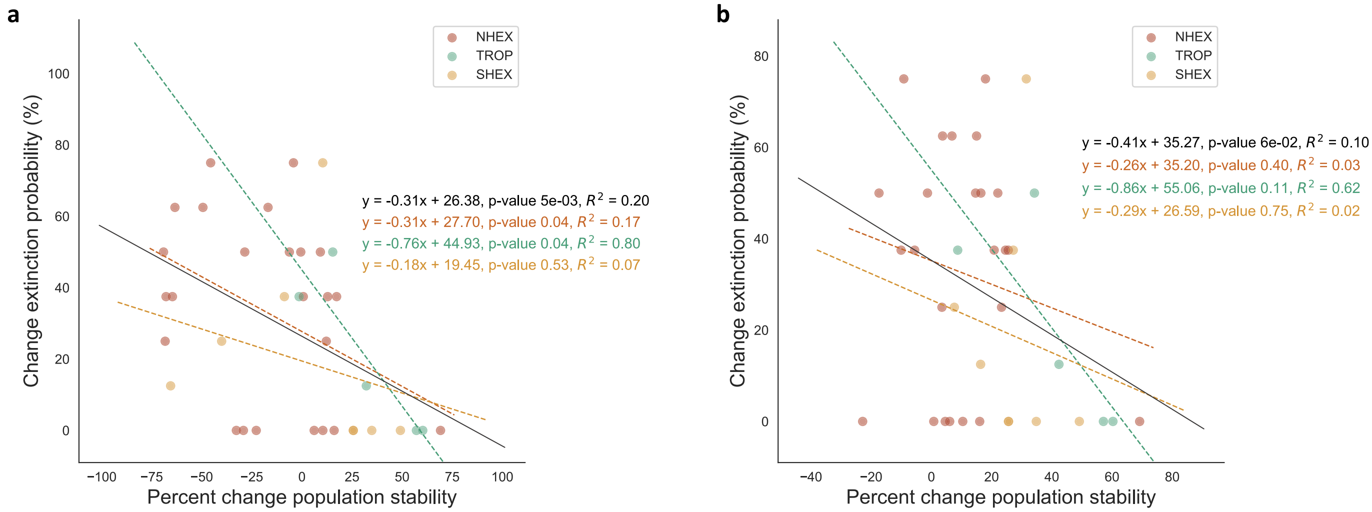
Extended Data Fig. 5 | Temperature-driven effects on population stability and extinction risk are robust to the degree of population self-regulation. Results exhibited limited sensitivity to strong ($\alpha = 1$; Fig. 4) and weak ($\alpha = 0.1$; above) self-regulation in the form of crowding effects. Latitudinal patterns and effect sizes were consistent for changes in population stability, **a**, and extinction probability, **b**.

https://doi.org/10.1038/s41558-022-01490-7



Extended Data Fig. 6 | Patterns of species risk are sensitive to treatment of high-temperature performance. Change in the average fitness (growth rate) driven by daily temperature between the historical period (1950-2000) and future period (2050-2100) when allowing negative growth rates above CTmax as in Vasseur et al. 2014 (**a**) and when performance values are bounded by 0 above CTmax as in Deutsch et al. 2008 (**b**). Change in the average fitness (growth rate) driven by monthly mean temperature between the historical period and future period when allowing negative growth rates above CTmax (**c**) and when performance values are bounded by 0 above CTmax (**d**).

https://doi.org/10.1038/s41558-022-01490-7



Extended Data Fig. 7 | Increased stability is negatively related to extinction probability. Regression relationships in our simulations are presented **a**, when considering only the pre-extinction time period and **b**, when taking into account the full 50-year periods. Regardless of largely positive (**b**) or mixed (**a**) changes in stability, there is generally a weak but significant negative relationship between stability and extinction probability globally (p-value < 0.05).

nature portfolio

Corresponding author(s): Kate Duffy

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Reporting Summary

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For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

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☐	☒	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☐	☒	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	No software was used for data collection in this study.
Data analysis	Open source codes were used to analyze the data, including R package quantreg v5.88 and R package biwavelet v0.02.21. Custom codes for analysis are available in our public GitHub repository at https://github.com/KateDuffy/climate-change-ecology

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

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The CMIP6 simulation data used in this paper is available via the data portal https://esgf-node.llnl.gov/search/cmip6/. The ecology data is available for download at https://doi.org/10.1073/pnas.0709472105.

Human research participants

Policy information about studies involving human research participants and Sex and Gender in Research.

Reporting on sex and gender	Not applicable
Population characteristics	Not applicable
Recruitment	Not applicable
Ethics oversight	Not applicable

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Using simulations from the latest generation of earth system models, we applied quantile, spectral, and wavelet analyses of temperature projections to study the way that temperatures will increase over time. We integrated temperature projections into empirically-parameterized mathematical models that simulate the dynamical and cumulative effects of thermal stress on the performance of 38 global ectotherm species.
Research sample	We obtained experimentally derived thermal tolerance parameters for a set of terrestrial ectotherms of the phylum arthropoda (n = 38) published by Deutsch et al. (2008). Deutsch gathered data from 31 previously published thermal performance studies, which were published between 1974 and 2003 based on a collection of insects from 35 different locations. For each species, experimental intrinsic growth rates at multiple temperatures were used to fit a thermal performance curve yielding least-squares estimates of the the curve's parameters. This dataset was selected to represent a globally distributed set of arthropod species.
Sampling strategy	Not applicable to study. We analyzed existing data as described in the data availability statement.
Data collection	Not applicable to study. We analyzed existing data as described in the data availability statement.
Timing and spatial scale	Not applicable to study. We analyzed existing data as described in the data availability statement.
Data exclusions	No data were excluded from the analysis.
Reproducibility	Our study consists of fully reproducible data analysis.
Randomization	Not applicable.
Blinding	Not relevant to study.

Did the study involve field work? ☐ Yes ☒ No

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

BSCES

Boston Society of Civil Engineers Section
American Society of Civil Engineers

2023 Individual Section Awards

Each year, BSCES presents awards to deserving members and individuals in the community who are nominated by their peers in recognition of their service. Here is your opportunity to nominate a co-worker, friend, or someone who you think deserves special recognition. Please see the following awards descriptions and nomination instructions. Awards reserved for BSCES members are noted as such.

The Nominations Deadline is **Friday, March 31, 2023.** The Awards Committee will review all nominations and present a list of candidates for selection by the Board of Government. Awards will be presented at the 174th BSCES Annual Awards Celebration.

I would like to nominate Nasser Yari, **For the:**

_______ **CITIZEN ENGINEER AWARD:** This award is presented to a BSCES member or registered professional engineer for outstanding public involvement in local or national legislation, education (at any level), non-profit volunteer organizations, community activities, or similar activities improving the image of ASCE, BSCES and the civil engineering profession.

X **CLEMENS HERSCHEL AWARD:** This award recognizes an individual who has published a paper, not necessarily published in the BSCES Journal, that has been useful, commendable, and worthy of grateful acknowledgment. If nominating for the Clemens Herschel Award, please attach the name of the paper and names of all authors, if co-authored.

_______ **COLLEGE EDUCATOR AWARD:** This award is presented to a member of the academic community who inspires and encourages civil engineering students through exceptional teaching and mentorship. Educators empower students to realize full potential and exemplify the profession in their classroom. Candidates shall be actively teaching in a classroom setting at a college or university in New England.

_______ **ENGINEER OF THE YEAR AWARD:** This award is presented to a BSCES member, with 15 years or more professional experience, who has exhibited extraordinary leadership in the form of managerial leadership, technical excellence, professional integrity, and mentorship of other engineers.

_______ **GOVERNMENT CIVIL ENGINEER AWARD:** This award is presented to a BSCES member who is serving as a paid public sector engineer at a federal, state, or municipal agency, department, or authority in Massachusetts.

_______ **HORNE/GAYNOR PUBLIC SERVICE AWARD:** This award is presented to a BSCES member or registered professional engineer for unpaid public service in a municipal, state, or federal-elected or appointed post for philanthropic activities in the public interest.

_______ **JOURNALISM AWARD:** This award is presented to a journalist or other author who has published one or more articles, papers, books, social media blogs, or film for a non-technical audience that raises awareness of the contributions of the civil engineering profession.

_______ **PRE-COLLEGE EDUCATOR AWARD:** This award is presented to a member of the K-12 educational community who integrates engineering topics, particularly civil engineering, in a manner that benefits the profession and may promote students to pursue an engineering career. The Public Awareness & Outreach Committee reviews these nominations and recommends the recipient to the Board.

_______ **CHARLES A. STONE AND EDWIN S. WEBSTER PROJECT OF THE YEAR AWARD:** This award is presented to a BSCES member and their project team who has served in a major role on an innovative, challenging, unique, and/or complex project located in the Commonwealth of Massachusetts. The majority of the work should have been completed by engineers located within Massachusetts.

_______ **YOUNGER MEMBER AWARD:** This award is intended to recognize a BSCES member, 35 years of age or younger on February 1 in the year of the award, who has made an outstanding contribution to BSCES and/or the civil engineering profession.

To submit a nomination, complete this form and return it by the nomination deadline via email, fax, or mail to bsces@engineers.org, 617/227-6783, or BSCES Awards Committee, Boston Society of Civil Engineers Section/ASCE, One Walnut Street, Boston, MA 02108-3616, respectively.

Name and Company Address of Nominee(s)*:

Nasser Yari, Assistant Professor, Civil Engineering Wentworth Institute

55 0Huntington Ave. Boston, MA 02115

Is this a re-nomination? Yes _______ No X

***Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.**

Your Name: Ronald Burns Daytime Telephone: 508-561-1611 Email: rburns@arcadia-tec.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

BSCES 2023 Individual Section Award – Clemens Herschel Award

Nominee: Nasser Yari

Nominator: Ronald Burns

Nominee Qualifications for Clemens Herschel Award

I want to nominate Dr. Nasser Yari for the Clemens Herschel Award. Dr. Yari published a paper entitled "Bridge Repair Priority Ranking System" in the Summer 2022 edition of the BSCES Civil Engineering Practice Journal. This paper presented a Bridge repair ranking system based on a number of critical criteria. It can be integrated with GIS Bridge Management system. See attached paper.

Dr. Yari is a seasoned professional engineer with over 30 years of professional experience in civil engineering and construction management roles. He worked for New Hampshire Department of Transportation for over 33 years in various positions including Construction Engineer, Project Manager and Bridge Maintenance Engineer.

Volume 30, Number 1

Bridge Repair Priority Ranking System

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Abstract

DOTs, cities, and towns in the United States have limited or constrained funding to maintain their bridges and improve the transportation infrastructure as desired by the public. Bridge Repair Priority Ranking System (BRPRS) prepares a network bridge project management strategy within management specified budget limits. The objective is to refine the decision-making process to attain the maximum network service life, at the lowest possible cost to sustain a bridge network at the highest possible network condition index. Subsequently, the BRPRS provides data to network managers for presentation to respective government budget approval process as well as the voting public. Bridge prioritization is based on ranking all the available bridges in a network, with an overall score developed using the pre-defined set of criteria pertinent to individual bridge site conditions selected by a network manager. Bridge network managers face the challenge of having many bridges in the same relative condition with limited funding sufficient to rehabilitate one or two bridges per fiscal year. BRPRS will justify bridge management decisions which result in improved budget decision making while improving the network bridge condition index. Bridge engineers or bridge owners using BRPRS can specify the selection and prioritize repair schedules based on factors such as condition, criticality, risk, functionality, type, size, and age. Priority ranking techniques are based on calculating a value for each bridge and then sorting all bridges in descending order of their parameters.

Keywords: BMS, Bridge Management, Priority Ranking

1. Introduction

Traditionally, maintenance, rehabilitation, and replacement (MR&R) projects are selected on a "worst first" approach. This method is acceptable if an unlimited budget is available to provide sufficient funding to sustain the bridge network at a high level of performance (Rashidi et al, 2016). This is typically not the case--municipalities and state transportation agencies have a limited resource to manage their infrastructure. Consequently, there is a need for prioritization to utilize available funds to assure the highest network level of performance as evaluated by bridge infrastructure managers' specified parameters. The bridge owners are confronted with major challenges to improve and maintain the aging bridge infrastructure (Allah Bukhsh et al, 2018).

Figure 1 illustrates the age distribution of New Hampshire Department of Transportation (NHDOT) bridges. About 95% of NHDOT bridges require some type of maintenance or rehabilitation. New bridges could use some type of proper preventive maintenance to extend their service life.

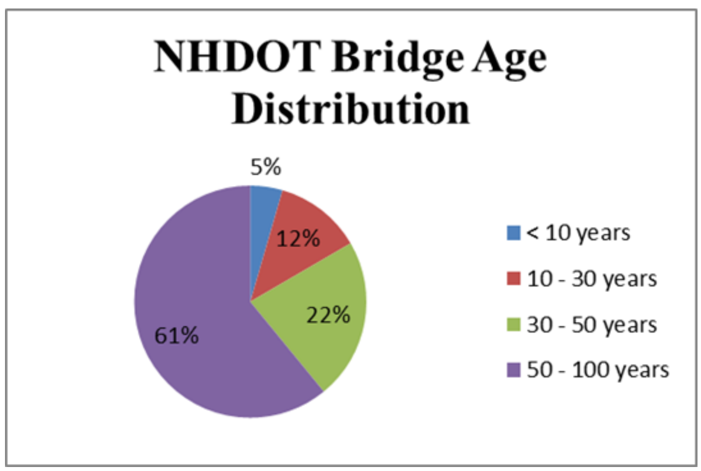

Figure 1. NHDOT bridge age distribution.

The goal for BRPRS is to extend the useful life of bridges in the most cost-effective manner by evaluating financial plans to identify funding levels required to sustain bridge networks at selected service levels. Bridge Repair Priority Ranking System (BRPRS) prepares a network bridge project management strategy within management specified budget limits. The objective is to refine the decision-making process to attain the maximum network service life, at the lowest possible cost to sustain a bridge network at the highest possible network condition index. Subsequently, the priority ranking system provides data to network managers for presentation to respective government budget approval process, as well as the voting public. The BRPRS presents the site-specific bridge parameters, weighting factors, and cost comparative factors to provide a bridge network priority ranking system that includes preservation, general maintenance, rehabilitation, and replacement projects.

2. Background

Project priority ranking systems have been used by several state departments of transportations to evaluate and select bridge projects for their preservation, rehabilitation, capital improvement programs, and replacement projects in preparing long and short term budget plans. (Kulkarni et al, 2004). Most BMS programs provide some type of ranking system on a network level. BrM (Pontis) provides bridge ranking based on benefit-to-cost ratio, the average health index, or the sufficiency rating for each project (Cambridge, 2005).

The sufficiency-rating (SR) approach is still used by some state DOTs for ranking bridges. Sufficiency rating (SR) was developed by the Federal Highway Administration (FHWA, 1995) to rate and rank bridge inventories. The SR is used by FHWA as of priority-ranking technique to determine the eligibility of bridges for MR&R activities and overall assessment of a bridge's condition. A SR calculation scale is expressed as a percentage from 0 to 100, with 0 representing a completely deficient bridge and 100 a new or rehabilitated bridge. SR categorizes bridges into three groups for MR&R recommendation. (1) bridges with SR ratings between 80 and 100 should receive preservation treatments and no additional maintenance, (2) bridges with SR between 50 and 80 are eligible for rehabilitation and (3) bridges with SR between 0 and 50 are eligible for replacement. Bridge deficiencies are described in one of two categories: structurally deficient or functionality obsolete (Xanthakos, 1996).

The drawbacks of the SR method are (Sianipar et al, 1997): (1) overlooks the Average Daily Traffic (ADT), (2) SR is determined on the basis of a single standard, and (3) the method provides no room for optimization. Based on the SR method, narrow bridges that have a low capacity are subjected to low sufficiency ratings, although these bridges may be in good or better condition. (Elbehairy et al, 2006). The SR is not capable of providing MR&R strategy for each bridge.

Benefit-to-Cost Ratio: The benefit-to-cost ratio (B/C) considers all the benefits and costs associated with a project. Agency benefits are defined as "the present worth of future cost savings to the agency bridge expenditures" (FHWA, 1989b). Benefit/cost ratios are used to compare the use of fundings between projects. Numerous projects on the network level may be prioritized by evaluating the B/C ratio for each project. In comparing all the projects, those projects with the highest B/C ratio would be ranked as the most efficient (Sallman et al, 2012). Farid et al (1993) reported that the B/C ratio is difficult to use for assessing user costs and forecasting future conditions. The B/C ratio assumes the benefits gained from improvement projects are constant. However, this is not always correct; this assumption does not take into account project timelines within the limits of the analysis period.

Health Index: The Bridge Health Index was developed by the California Department of Transportation (CALTRANS). The purpose was to create a unified condition index that would solely reflect the structural condition of the bridge (Roberts et al, 2000). The Heath Index determines the remaining bridge asset value and compares it to its replacement value or to its best possible condition versus the current condition.

The National Bridge Inventory (NBI) is the aggregation of structure inventory and appraisal data which was initially developed in 1971 to observe bridge operations and safety. The NBI inventory data consisting of 116 items provides information for each bridge. These items are specified in the Recording and Coding Guide for the structure inventory and appraisal of the Nation's Bridges (FHWA-PD-96-001). The National Bridge Inspection Standards (NBIS) were established in 1971 to require that all bridge inspection processes, frequency of inspections, qualification of the bridge inspectors, bridge inspection reports and the maintenance of bridge inventories meet the National Bridge Inspection Standards (Rossow, 2012). All bridges longer than 20 feet (6.1 meters) must be inspected per (NBIS; 23 CFR 650 subpart C) and reported by the states and federal agencies to the Federal Highway Administration.

3. Bridge Repair Priority Ranking System

The bridge prioritization process is based on a set of criteria for performance measures which will be used to prioritize projects in the ranking system. These criteria are based on fundamental values and concepts in the following categories:

1. Condition
2. Criticality
3. Risk
4. Functionality
5. Type
6. Age
7. Size

The rating scoring system includes user specified site conditions pertaining to a respective individual bridge in a network. The priority ranking index is from 0 (least candidate for rehabilitation and replacement) to 100 (most preferred candidate for rehabilitation and replacement).

The priority ranking points for rehabilitation are calculated as:

$$PRPR = \alpha C + \beta CT + +\gamma R + \delta F + \varepsilon BT + \theta A + \mu S \quad (1)$$

where

PRPR - priority ranking points for rehabilitation (ranging from 0 to 100)

C - condition rating points based on NBI rating system

CT - criticality based on traffic volume, road class, detour length, border bridge, utility, and impact

R - risk based on scour critical, flood, ice, fracture critical member, and bridge rail type

F - functionality based on load limit, vertical clearance, lane width, shoulder width, waterway adequacy, and mobility

BT - bridge type: girder, movable, culvert, timber, truss

S - size

A - age

The weighting variables (α, β, γ, δ, ε, θ, μ) are a percentage of each criterion in the rating equation and are agency specified. It is recommended that the rating score total 100 points to denote the highest priority. Bridge managers can adjust the weighting factors of each category and their respective parameters based on their highway network. Table 1 shows the recommended range of category weighting factors. The sum of the weighting factors must not exceed 1.

Table 1. Ranking Criteria Weighting Factors

Criteria	Weighting Variable	Recommended Range	Default Value
Condition	α	0.40 – 0.60	0.40
Criticality	β	0.10 – 0.30	0.18
Risk	δ	0.10 – 0.30	0.15
Functionality	γ	0.10 – 0.20	0.12
Type	ε	0.0 – 0.10	0.05
Age	θ	0.05 – 0.15	0.05
Size	μ	0.05 – 0.10	0.05
Total			1.00

3.1 Condition:

The bridge condition criteria are worth 40% to 60% of the total PRPR. A bridge condition assessment is normally divided into three sections or components: (1) Deck, (2) Superstructure, and (3) Substructure. In this study, the default condition weighting factor is 40% (α = 40%) in which the Deck Condition score accounts for 20% of the rating, while the Superstructure and Substructure Condition score account for 40% each. NBI condtion rating shown in Table 2.

C = 0.2 k(Deck)+0.4 k(Superstructure)+0.4 k(Substructure)

Where

k = (9-N)/(100/9) (3)

N = NBI condition rating of bridge component

Table 2 NBI condition rating

NBI Condition Rating	
9	Excellent Condition
8	Very Good Condition
7	Good Condition
6	Satisfactory Condition
5	Fair Condition
4	Poor Condition
3	Serious Condition
2	Critical Condition
1	Imminent Failure Condition
0	Failed Condition

The NBI condition rating for Bridge #216/112 Spaulding Turnpike over NH 75 based on NHDOT's inspection report is:

Deck: 6 Satisfactory
Superstructure: 8 Very Good
Substructure: 7 Good

From equation 3 the scoring numerical value for each bridge component can be calculate as:

k(deck)=(9-6)(100/9)=33.3
k(superstructure)=(9-8)(100/9)=11
k(substructure)=(9-7)(100/9)=22

From equation 2 the condition score is

C=0.2(33.3)+0.4(11)+0.4(22)=20

The condition of this bridge is worth 20 out of 100. The maximum points in this category (bridge condition) will not exceed 100 points (i.e. the worst condition).

3.2 Criticality

Criticality is based on a set of criteria that is important to the public. These criteria include traffic volume (T), road classification (RC), detour length when bridge is closed to traffic (D), border bridge (if a bridge is connecting two states) (B), utilities on the bridge (U), and the economic, environmental, societal impact caused by a bridge closure (I). Table 3 describes the percentage of each section of criticality. Criticality recommended weighting factor is 10% to 30% of PRPR (β=10% to 30%)

$$CT = 0.3T+0.2RC+0.15D+0.05B+0.1U+0.2I \quad (4)$$

Table 3. Criticality Recommended Scoring

Annual Average Daily Traffic	**Points**
> 50,000	100
25,000 – 49,999	75
10,000 – 24,999	50
1,000 – 9,999	25
0 to 999	12.5
Road Class	**Score**
Interstates & Turnpikes	100
Other Freeways & Expressways	75
Collector	50
Local	25
Detour Length (miles)	**Score**
>20	100
10 – 20	75
5 – 10	50
0 – 5	25
Utilities	**Score**
Contains utilities	100
No utilities	0
Criticality	**Score**
Economic	25
Environmental	25
Societal	25
School Bus Route	25

Table 4 shows the scoring of criticality for Bridge #216/112 Spaulding Turnpike over NH 75.

Table 4. Criticality Scoring of Bridge 216/112 on Spaulding Turnpike

Parameter	**Criteria**	**Value**
Traffic Volume	35,000	22.5
Road Class	Turnpikes	20
Detour Length	9 miles	11
Border Bridge	No	0
Utilities	No	0
Impact		
Economic	Yes	5
Environmental	No	0
Societal	Yes	5
School Bus Route	Yes	5
		68.5

From equation 4 the traffic volume is 30% of criticality. In this bridge example the traffic volume of 35000 AADT based on table 3 will result with the total score of 75 points. Applying the weighting factor of 0.3 will result in the value of 22.5 as shown in table 4.

3.3 Risk

The bridge risk criteria are factors that may cause bridge failure. In the United States, bridge scour has been the number one cause of bridge failures. The risk criteria for this study are scour critical (SC), flood (FL), ice (IC), fracture critical member (FC), bridge rail types (BR), and impact damage (I). A fracture critical bridge is defined by the FHWA as a steel member in tension, or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse.

$$R = 0.3\,SC + 0.1\,FL + 0.2\,BR + 0.3\,FC + 0.1\,IC$$

Table 5. Risk Recommended Scoring

Scour Critical	**Score**
Yes	100
No	0
Flood	
Yes	100
No	0
Bridge Rail	
Does not meet standard	100
Meets standard	0
Fracture Critical Member	
Yes	100
No	0
Ice	
Yes	100
No	0

Table 6 shows the risk value scoring of Bridge 216/112 on Spaulding Turnpike. total risk value is 20 points since this bridge is not over water and bridge rail does not meet the current standard.

Table 6. Risk Value Scoring of Bridge 216/112 on Spaulding Turnpike

Parameter	Value	Score
Scour Critical	No	0
Flood	No	0
Bridge Rail / Barrier	Does not meet standard	20
Fracture Critical Member	No	0
Ice	No	0
Total		20

3.4 Functionality

Functionally obsolete bridges are those that do not have adequate vertical clearances, lane widths, shoulder widths, or those that may be occasionally flooded or fail to meet current traffic demand or current geometric standards. The Federal Highway Administration defines functionality obsolete as, does not meet current design standards (for criteria such as lane width), either because the volume of traffic carried by the bridge exceeds the level anticipated when the bridge was constructed and/or the relevant design standards have been revised.

In this study, the functionality criteria is based on load limit (LL), vertical clearance (VC), lane width (LW), shoulder width (SW), waterway adequacy (WA), and mobility (MB). The scoring detail is shown in Table 7.

The recommended weighting factor is 10% to 20% of PRPR (γ=10% to 20%) with default setting of 12%.

$$F = 0.2\,LL + 0.2\,VC + 0.1\,LW + 0.1\,SW + 0.2\,MB + 0.2\,WA$$

Table 7. Functionality Recommended Scoring

Load Limit	**Score**
< 3 tons	100
3 – 10 tons	70
< HS-20	50
HS 20	0
Lane Width (ft)	**Score**
< 12	100
≥12	0
Mobility (vehicles/hour)	**Score**
>1400	100
1100-1400	75
900 – 1100	50
700-900	25
<700	0
Vertical Clearance (ft)	**Score**
<14	100
14 – 16	50
>16	100
Shoulder Width (ft)	**Score**
<4	100
4 – 10	50
≥10	0
Waterway Adequacy	**Score**
Flood Overtopping	100
Clearance < 12 ft	50

Table 8 shows the scoring of functionality for Bridge 216/112 Spaulding Turnpike over NH 75.

Table 8. Functionality Value Scoring of Bridge 216/112 on Spaulding Turnpike

Parameter	Value	Points
Load Limit	HS-20	0
Lane Width	12 ft	0
Mobility	1400	20
Vertical Clearance	16.8 ft	0
Shoulder Width	10	0
Waterway Adequacy	N/A	0
Total		20

3.5 Bridge Type, Size and Age

The recommended weighting factors for bridge type, size, and age are 5% each as described in Table 9

Table 9. Bridge Type, Size, and Age Recommended Scoring

Type	**Score**
Girder	80
Movable	100
Culvert	20
Timber	50
Truss	100
Cable Supported	100
Arch	75
Size (deck area sq-ft)	**Score**
>30,000	100
20,000 – 30,000	80
10,000 – 19,999	60
5,000 – 9,999	40
< 5000	20
Age (years)	**Score**
> 50	100
40 – 50	80
30 – 39	60
20 – 30	40
< 20	20

Table 10 shows the scoring of bridge type, size, and age for Bridge #216/112 Spaulding Turnpike over NH 75.

Table 10. Bridge Type, Size, and Age Scoring of Bridge 216/112 on Spaulding Turnpike

Parameter	Value	Points
Type	Girder	80
Size	6,500 ft^2	40
Age	42 years	80

The total PRPR score for Bridge 216/112 on the Spaulding Turnpike may be calculated using the default weighting variable values from Table 1 and the individual category scores from Tables 4, 6, 8, and 10. These results are shown in Table 11.

Table 11. Composite Score Calculation of Bridge 216/112 on Spaulding Turnpike

Category	Score	Weight	Weighted Score
Condition	20	0.4	8.0
Criticality	68.5	0.18	12.3
Risk	20	0.15	3.0
Functionality	20	0.12	2.4
Type	80	0.05	4.0
Size	40	0.05	2.0
Age	80	0.05	4.0
Total			35.7

4. Case Study

A sample network consisting of 170 New Hampshire Turnpikes bridges has been chosen to demonstrate the application of the developed priority ranking method. Table 12 shows some of the calculated BRPR scores. In order for BRPRS (Bridge Repair Priority Ranking System) to be effective, there needs to be a fine balance between the condition of the bridge and the other criteria that affect the traveling public. The BRPRS, in altering the distribution rate outside of the recommended range, should not compromise the condition of the bridge, nor should it be solely based on the condition.

The current method of bridge management is insufficient to meet the demands of the traveling public; the “worst first” routine is no longer being viewed as the best option. The BRPRS is most effective when the condition range is between 40% and 60% which allows other user factors to be considered. The criteria such as traffic volume, detour length, bridge rail, fracture critical member, lane width, and mobility that interrupt the nation’s economy, lifestyle, and the safety of motorists should be a significant part in decision making.

The two other criteria that should remain constant are toll plaza bridges and emergency vehicle route bridges. These two criteria should receive an additional 5 to 10 points in the priority rating. The detour bypass around toll plazas can be costly due to revenue loss. Emergency vehicle route bridge closure can have a significant impact on the community and can be costly to the bridge owner in providing a safe reliable detour.

Table 12. NH Turnpike BRPR Scores

Town	Description	BRPR Score
Portsmouth	I-95 over Piscataqua River Road	63
Dover / Newington	SB Spaulding Turnpike over Little Bay	60
Dover / Newington	NB Sp. Turnpike over Little Bay	58
Hampton	I-95 over Taylor River	51
Manchester	F.E. Everett Turnpike NB over Black Brook	47
Nashua / Hudson	WB Connector over B&M RR and Merrimack River Sagamore Bridge	45
Dover	Sp. Turnpike NB over Cocheco River	44
Dover	Sp. Turnpike SB over Cocheco River	434
Manchester	F.E. Everett Turnpike SB over Black Brook	43
Merrimack	Baboosk Road over F.E. Everett Turnpike	43
Merrimack	F.E. Everett Turnpike SB over Pennichuck Brook	41
Merrimack	F.E. Everett Turnpike NB over Pennichuck Brook	41
Concord	F.E. Everett Turnpike SB over Hall Street	40
Milton	Spaulding Turnpike over Route 75	36
Nashua	F.E. Everett Turnpike NB over Nashua River	34
Concord	F.E. Everett Turnpike NB over B&M Railroad	34
Portsmouth	I-95 over Hodgson Brook	33
Nashua	F.E. Everett Turnpike SB over Canal Road	29
Nashua	F.E. Everett Turnpike NB over Canal Road	27
Bow	F.E. Everett Turnpike over Dow Road	26
Hooksett	I-93 over Ramp A and B	25

5. Summary

The prioritization is based on multi-criteria type of analysis, a priority ranking is computed for each bridge, the ranking index is expressed as a number from 0 (least candidate for rehabilitation and replacement) to 100 (most preferred candidate for rehabilitation and replacement) which enables project managers and decision-makers to understand and compare the overall health of a various bridges in the network. This ranking system has been tested through case study and experienced professional engineers and asset managers from municipalities and NHDOT. The advantage of this system is that it provides flexibility to the bridge owners to adjust the weighing factor based on their own interest. However, the adjustment must be within recommended weighing factor and the changes must be on the network level. This priority ranking system is designed to integrate with the proposed GIS Based Bridge Management System. The drawback of this system is the weighing factor is based on engineering experience and judgment which can be bias.

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2023 Individual Section Awards

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The Nominations Deadline is **Friday, March 31, 2023.** The Awards Committee will review all nominations and present a list of candidates for selection by the Board of Government. Awards will be presented at the 174th BSCES Annual Awards Celebration.

I would like to nominate Annalisa Onnis-Hayden **For the:**

_______ **CITIZEN ENGINEER AWARD:** This award is presented to a BSCES member or registered professional engineer for outstanding public involvement in local or national legislation, education (at any level), non-profit volunteer organizations, community activities, or similar activities improving the image of ASCE, BSCES and the civil engineering profession.

_______ **CLEMENS HERSCHEL AWARD:** This award recognizes an individual who has published a paper, not necessarily published in the BSCES Journal, that has been useful, commendable, and worthy of grateful acknowledgment. If nominating for the Clemens Herschel Award, please attach the name of the paper and names of all authors, if co-authored.

___x___ **COLLEGE EDUCATOR AWARD:** This award is presented to a member of the academic community who inspires and encourages civil engineering students through exceptional teaching and mentorship. Educators empower students to realize full potential and exemplify the profession in their classroom. Candidates shall be actively teaching in a classroom setting at a college or university in New England.

_______ **ENGINEER OF THE YEAR AWARD:** This award is presented to a BSCES member, with 15 years or more professional experience, who has exhibited extraordinary leadership in the form of managerial leadership, technical excellence, professional integrity, and mentorship of other engineers.

_______ **GOVERNMENT CIVIL ENGINEER AWARD:** This award is presented to a BSCES member who is serving as a paid public sector engineer at a federal, state, or municipal agency, department, or authority in Massachusetts.

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_______ **JOURNALISM AWARD:** This award is presented to a journalist or other author who has published one or more articles, papers, books, social media blogs, or film for a non-technical audience that raises awareness of the contributions of the civil engineering profession.

_______ **PRE-COLLEGE EDUCATOR AWARD:** This award is presented to a member of the K-12 educational community who integrates engineering topics, particularly civil engineering, in a manner that benefits the profession and may promote students to pursue an engineering career. The Public Awareness & Outreach Committee reviews these nominations and recommends the recipient to the Board.

_______ **CHARLES A. STONE AND EDWIN S. WEBSTER PROJECT OF THE YEAR AWARD:** This award is presented to a BSCES member and their project team who has served in a major role on an innovative, challenging, unique, and/or complex project located in the Commonwealth of Massachusetts. The majority of the work should have been completed by engineers located within Massachusetts.

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Name and Company Address of Nominee(s)*:

Prof. Annalisa Onnis-Hayden

Northeastern University, Civil and Environmental Engineering

360 Huntington Avenue, Boston, MA 02115

Is this a re-nomination? Yes _______ No ___x___

***Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.**

Your Name: Auroop R. Ganguly Daytime Telephone: 617-373-2444 Email: a.ganguly@northeastern.edu

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

Northeastern

Auroop R. Ganguly — **College of Engineering (COE) Distinguished Professor, Northeastern (NU)**
PhD (MIT), Fellow (American Society of Civil Engineers)
Sr. Member (IEEE), Sr. Member (Association for Computing Machinery)
NU Leadership: **Co-Director, Global Resilience Institute**
Climate-AI Lead, The Institute for Experiential Artificial Intelligence
Director, Sustainability & Data Sciences (SDS) Lab (https://sdslab.io)
Co-Founder & Chief Scientific Adviser (2014–2021): risQ (www.risq.io): Fortune 500 Acquisition
Chief Scientist, Advanced Computing, Mathematics, and Data Division, Physical and Computational Sciences Directorate, US DOE's Pacific Northwest National Laboratory, Richland, WA
Email: a.ganguly@northeastern.edu Internet: https://coe.northeastern.edu/people/ganguly-auroop/

Department of Civil and Environmental Engineering
400 Snell Engineering Ctr.
360 Huntington Ave.
Boston, MA 02115
617.373.2444
f 617.373.4419

March 12, 2023

To: The BSCES Awards Committee: bsces@engineers.org
Boston Society of Civil Engineers Section/ASCE
One Walnut Street, Boston, MA, 02108-3616

Sub: College Educator Award for Annalisa Onnis-Hayden

Dear BSCES Awards Committee,

I am pleased to nominate Annalisa Onnis-Hayden, Teaching Professor at Northeastern University (NU) in Boston, MA, for the BSCES College Educator Award.

Prof. Annalisa Onnis-Hayden is a college educator par excellence, as evidenced by her numerous awards ranging from the NU Civil and Environmental Engineering (CEE) Teaching Excellence Award in 2014 and the NU College of Engineering (COE) Martin W. Essigmann Outstanding Teaching Award in 2016 to the Clair N. Sawyer Award from the New England Water Environment Association in 2017 and the Ralph Fuhrman Medal for Outstanding Water Quality Academic-Practice Collaboration from the Water Environment Federation in 2019. Her student mentees have won numerous research awards based on publications and presentations in top journals and conferences.

Dr. Annalisa Onnis-Hayden has been teaching several undergraduate courses in the classroom on-campus ranging from Water Treatment System Design, Environmental Biological Processes, and Introduction to Environmental Classroom, a Senior Design (Capstone) project course, as well as two courses abroad, specifically, Resource Recovery and Waste Treatment Technology and Waste Management and Policy. In each of these courses, on an average, students consistently rate her well above departmental, college, and university averages, which are very high to start with at a university like Northeastern which prides itself on its experiential heritage.

Based on her classroom teaching both on-campus and abroad, her string of teaching awards, as ell as her accomplishments as a student mentor, I cannot think of a more suitable candidate for the BSCES College Educator Award than Prof. Annalisa Onnis-Hayden of NU CEE.

Sincerely,

Auroop R. Ganguly, Professor, Chair of CEE Awards Committee
126 Mass Ave., Northeastern University, Boston, MA 02115, USA
https://en.wikipedia.org/wiki/Auroop_Ratan_Ganguly

SDS
SUSTAINABILITY & DATA SCIENCES LAB
https://sdslab.io/

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I would like to nominate JESSICA ORMSBY **For the:**

_______ **CITIZEN ENGINEER AWARD:** This award is presented to a BSCES member or registered professional engineer for outstanding public involvement in local or national legislation, education (at any level), non-profit volunteer organizations, community activities, or similar activities improving the image of ASCE, BSCES and the civil engineering profession.

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X **COLLEGE EDUCATOR AWARD:** This award is presented to a member of the academic community who inspires and encourages civil engineering students through exceptional teaching and mentorship. Educators empower students to realize full potential and exemplify the profession in their classroom. Candidates shall be actively teaching in a classroom setting at a college or university in New England.

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Name and Company Address of Nominee(s)*:

Jessica Ormsby, Assoc. Co-op Coordinator Northeastern University
Holmes Hall 5th Floor, 360 Huntington Ave. Boston, MA 02115

Is this a re-nomination? Yes _______ No X

***Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.**

Your Name: Ronald Burns Daytime Telephone: 508-561-1611 Email: rburns@arcadia-tec.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

BSCES 2023 Individual Section Award – College Educator Award

Nominee: Jessica Ormsby

Nominator: Ronald Burns

Nominee Qualifications for College Educator Award

I want to nominate Ms. Ormsby for the College Educator Award. Ms. Ormsby joined Northeastern's faculty as coordinator with the Department of Civil and Environmental Engineering (CEE), Cooperative Education team. In her role she helps to educate and support students as they search for and carry out their co-op experiences. She is passionate about helping students identify career goals and enjoys assisting them as they navigate the job search and interview process.

Ms. Ormsby received the COE Department's 2019 Excellence in Teaching Award. Also of note is Jessica's multi-year involvement with Engineers without Border Northeastern Student Chapter. Jessica has served as faculty advisor many years. She has provided valuable support to help the chapters complete their overseas engineering projects. In 2019 the chapter received the EWB USA's Premier Chapter Award.

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I would like to nominate Marc Veletzos, Ph.D., P.E. **For the:**

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Name and Company Address of Nominee(s)*:

Marc Veltzos, Ph.D., P.E.

Merrimack College, 510 Turnpike Street, Suite 2020

North Andover, MA 01845

Is this a re-nomination? Yes _______ No X _______

Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.

Your Name: Richard A. Matson, P.E. (MA, NY) Daytime Telephone: 978-394-6310 Email: richard.matson@aecom.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

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03/31/2023

BSCES
One Walnut Street
Boston, MA 02108-3616

Subj: Marc Veletzos, Ph.D., P.E. Nomination for the BSCES 2023 College Educator Award

To whom this may concern:

This letter is in support of nominating Mr. Marc Veletzos, Ph.D., P.E. (MA, CA) for the BSCES 2023 College Educator Award. I have had the pleasure to personally know Marc over the last 13+ years, first as a student of his from 2009 to 2011 and secondly as an alumnus through my involvements with Merrimack College. Marc has received a B.S. (1994), M.S. (1997), and Ph.D. (2007) all in Structural Engineering from the University of California, San Diego.

Marc began his career first in consulting by working as a bridge engineer/resident engineer at Buckland & Taylor Ltd., in Walnut Creek, CA from 1996 to 2001. He then worked as a bridge engineer for Parsons in San Francisco, CA from 2002 to 2003. Marc then returned to academics in 2003 as a graduate student to pursue his doctorate degree. It was during this time that Marc found his passion for a career in higher education by serving many roles such as:

- Graduate student researcher from 2003 to 2007 at UC, San Diego in the Structural Engineering department.
- Senior teaching assistant from 2004 to 2006 at UC, San Diego in the Structural Engineering department.
- Adjunct assistant professor from 2006 to 2007 at San Diego State University in the civil engineering department.
- Post-doctorate researcher from 2007 to 2008 at UC, San Diego.

Upon completing his post-doctorate research, Marc accepted a position as Assistant Professor in 2009 with Merrimack College. From 2009 to present, Marc has taken on many roles at Merrimack that includes:

- Assistant Professor (2009-2013)
- Associate Professor (2013-present)
- Interim Department Chair of Civil & Mechanical Engineering (2014-2015)
- Department Chair of Civil Engineering (2019-present)
- Program director for the MS in Civil Engineering (2019-present)
- Program director for the MS in Engineering Management (2020-present)

In Marc's 14 years at Merrimack College, he has taught 10 different courses from the sophomore level to the graduate level. Marc continues to teach two courses per semester while serving as Department Chair and Program Director for the graduate programs.

I can personally say that Marc is a true inspiration in the classroom having fueled my thirst for a career in structural engineering when he first came to Merrimack in 2009 and taught my structural engineering I, concrete analysis and design, and a mechanics recitation course during my junior and senior years. Marc has a way of teaching very complex problems appear simple and easy to understand. Marc is a great listener, has a calm approach to his conversations and lessons, and is very direct when it comes to problem solving. Marc certainly understands students wants and needs and having served in his many roles, also understands the wants and needs at the institutional level. Marc has found a way to balance his desires for career growth, while still maintaining to teach to students every semester.

In addition to the many hats Marc wears at the Merrimack College campus, Marc has been a big advocate for assisting Haiti and Nepal in repairing systems after earthquake damage as follows:

AECOM

Haiti (2011-2015):
Marc Veletzos was the Civil Engineering lead of the Haiti Service Learning Initiative. - This was a multidisciplinary initiative between civil engineering, athletic training and campus ministry. He worked with Project Medishare for Haiti (a medical non profit) to improve the gravity fed water system for the community of Marmont in central Haiti. The water system was damaged during the 2010 earthquake and Marc led 6 teams of students for 4 years to work with the members of the Marmont water committee. Typically, Marc brought three civil engineering students on each trip. Each trip was a week long. During their time there, they repaired many leaks and were able to triple the water reaching their storage cistern. One CE student, Maggie Laracy (née Jacques) who participated on these trips was named an ASCE 2013 New Faces of Engineering College Edition.

Nepal (2015-present):
Following the 2015 earthquake Marc Veletzos was invited to participate on a team to the Thame Valley to provide technical advice on how best to rebuild their homes. This region is at an elevation of over 10000 feet and is accessible only by a 3 day walk from the local airport (there are no vehicular roads in this region). Marc conducted a 2 day workshop, where he explained the origin of earthquakes, identified common damage to their buildings and offered advice on how they can reduce the chance of these failures in future earthquakes for a small increase in the cost of construction.

In the summer of 2016, Marc led a team of 6 undergraduate students on a three week trip to the Thame Valley region and they repaired a 55 foot long pedestrian bridge that was damaged during the 2015 earthquake. The community continued to use this bridge in it's severely damaged condition because the next closest river crossing added 3-4 hours of walking to their trip. Marc published a conference paper about this project that provides a good description (see attached).

In 2018 Marc was awarded a Fulbright Award and he has been working with colleagues at Kathmandu University to build their research infrastructure so that they will be able to conduct physical experiments on structures with details and materials common to the region and affordable to the population. As part of this project he conducted a building survey of the Khumbu region (mountain region that includes the Thame Valley and the Everest Base Camp Trek) to quantify building type, building material and to document the seismic details used if any. They surveyed over 1500 structures in 30 villages (>90% of structures in the region). Marc continues to work with colleagues at Kathmandu University and he is co-advising MS and PhD students.

As documented in this nomination, Marc Veletzos is a worthy candidate for the BSCES 2023 College Educator Award. He continues to excel both in and outside the classroom. March is also a licensed professional engineer in California (C-59796) and Massachusetts (54838). In addition to his deep involvement with Merrimack College, Marc has been on the Board of Directors for the EERI New England Chapter from 2021 to present and he is a Structures Specialist on the MA Task Force 1, FEMA US&R from 2017 to present.

If any additional information is needed in support of this nomination, please let me know.

Sincerely,

Richard A. Matson, P.E. (MA, NY)
Structural Engineer
Team Leader, Bridge & Tunnel Inspections
Cell: 978-394-6310
richard.matson@aecom.com

Repairing the Yullajung Pedestrian Suspension Bridge: Service Learning in the Nepal Himalaya

By Marc J. Veletzos[1], Robert K. Dowell[2], Cynthia Carlson[3]

[1] Marc J. Veletzos, Associate Professor, Dept. of Civil Engineering, Merrimack College, North Andover, MA.
[2] Robert K. Dowell, Associate Professor, Dept. of Civil, Construction and Environmental Engineering, San Diego State University, San Diego, CA.
[3] Cynthia Carlson, Assistant Professor, Dept. of Civil Engineering, Merrimack College, North Andover, MA.

ABSTRACT

The paper describes how a severely damaged pedestrian suspension bridge located in a remote valley in the Nepal Himalaya was strengthened by repurposing the existing main cables and anchorages to support expected pedestrian and yak loads. A repair scheme was designed and implemented over a seven day period during a service learning trip in the summer of 2016. The strengthened bridge functions as a cable-stayed bridge without compressing the deck. Surveying showed that the main cable tensioning operation raised the deck three inches at midspan which reduced loads on the abutment anchor bolts. Any additional live loading would go directly into the modified structural system and not overload the deck or bolts.

YULLAJUNG BRIDGE DESCRIPTION

The Yullajung pedestrian bridge crosses the Bhote Koshi River in the Thame Valley of the Nepal Himalaya (see Figure 1 and Figure 2). The bridge is 55-foot-long and six feet wide and is the primary access route to the community of Yullajung in Sagarmatha (Mount Everest) National Park. The bridge was built in the late 1980s after the previous bridge was washed out by a historic flood. This remote Sherpa village resides at an elevation of 12,500 feet and is accessed by way of a 24 mile hike from the local airport at Lukla (elevation 9380 feet). There are no roads in this region of Nepal so vehicular transportation is not possible. This bridge is very important to the Yullajung community because it provides access to medical services, schools, monasteries, neighboring communities and the market in Namche Bazar.

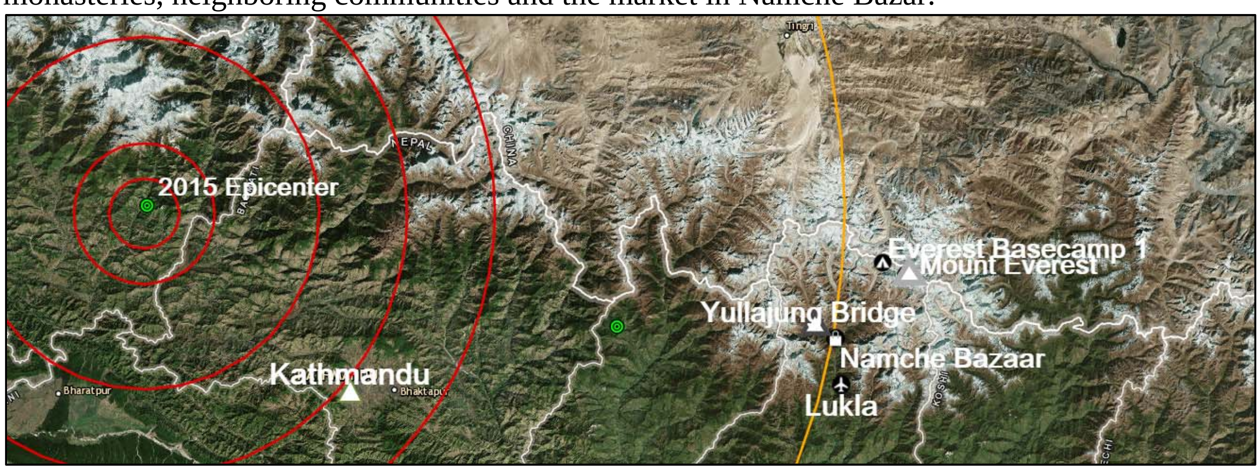


Figure 1 Bridge location with respect to 2015 earthquake epicenters, Mount Everest, and Lukla Airport.

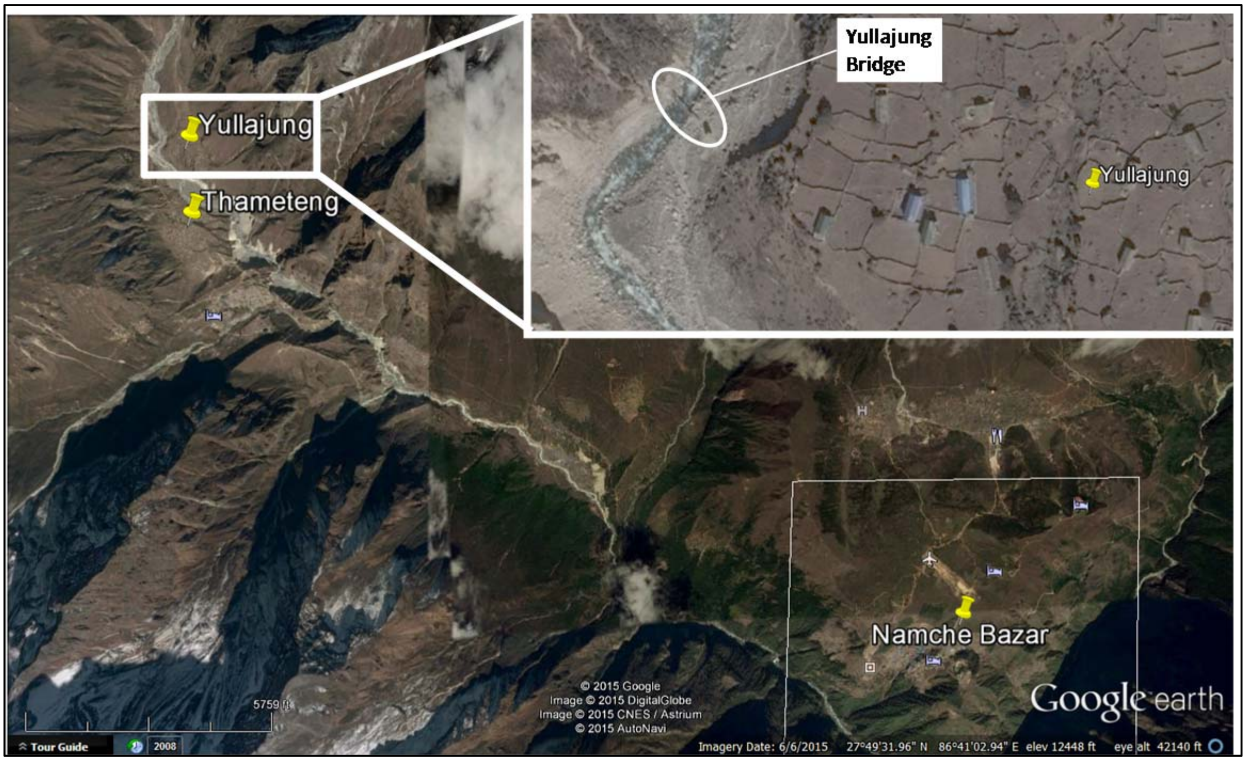


Figure 2 Google Map of Thame Valley, including Thameteng, Yullajung and the Yullajung Bridge (inset)

The original configuration was a suspension bridge with a single unreinforced stone tower on the Yullajung side of the river (see Figure 3). The anchorage on the Thameteng side of the river is at the top of an adjacent hill. The bridge deck consists of two channels with a steel plate bolted to the top flange. Each channel is attached to the abutments with four 7/8" diameter anchor bolts. Vertical hanger rods connect the deck to the main cables.

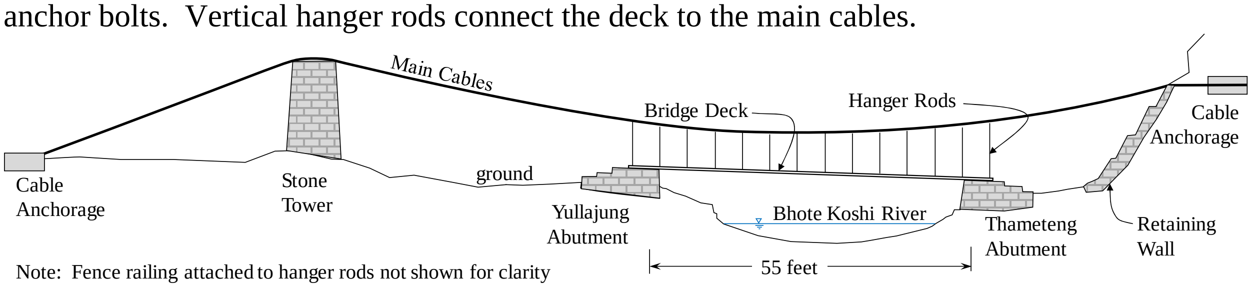
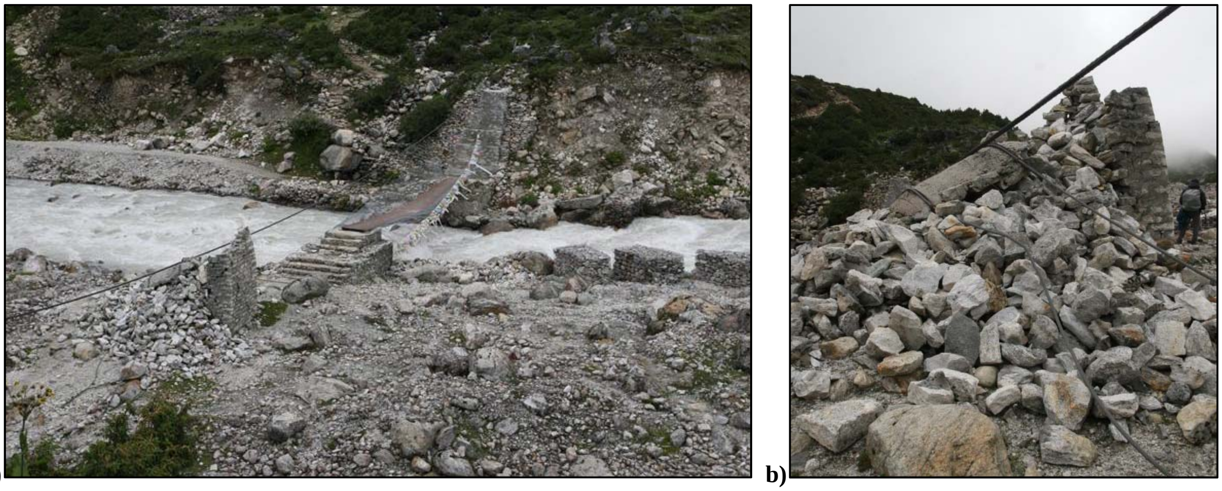


Figure 3 Schematic of original bridge configuration. (Note: Not to scale)

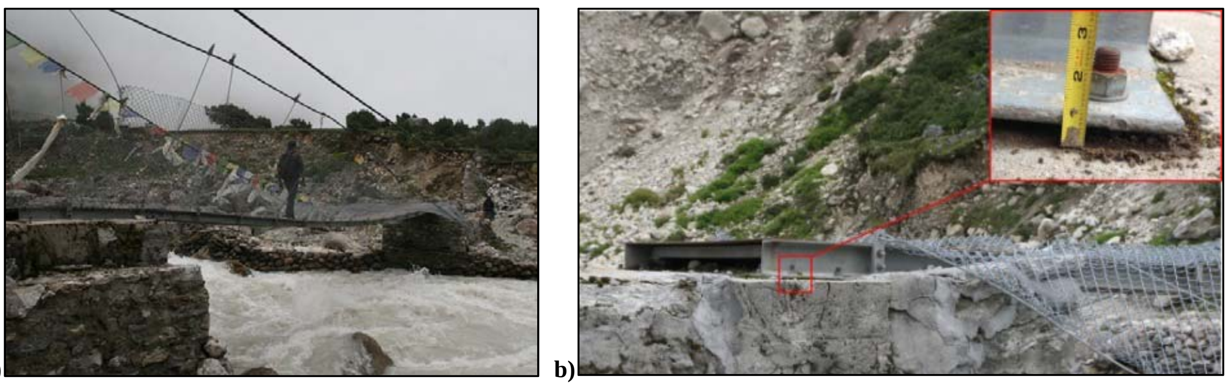
DAMAGE FROM THE GORKHA EARTHQUAKE

The 2015 Gorkha earthquakes destroyed the stone suspension tower and completely detensioned the main suspension cables (see Figure 4). Lack of support from the main cables resulted in an eighteen inch sag at the midspan of the deck and a structure that functioned as a stress ribbon bridge rather than as a suspension bridge (see Figure 5a). Eight anchor bolts connected the steel deck to the abutments and prevented complete collapse of the bridge (see Figure 5b). This bridge has been scheduled for replacement in 2018 by the Nepal Trail Bridge Program, however the community has little choice but to continue to use it, as their alternatives are to either walk an additional 3-4 hours to the next river crossing or to use the old trail across active landslides.



a) b)

Figure 4 a) Overview of bridge site from the Yullajung side of the river. Note the riprap protection on the right of the photo which protects against erosion and scour of the Yullajung abutment. b) Remains of the Tower on the Yullajung side of the river. Note the water pipe on the top right and the cable saddle at the top of the rubble pile.



a) b)

Figure 5 a) Elevation view of the bridge from the Thameteng side of the river. Note the bending of the bridge deck. b) Thameteng abutment. Note the four anchor bolts on each channel and the gap between the anchor plate and the abutment which indicates the anchor bolts are beginning to pull out of the abutment.

DESIGN CRITERIA AND REPAIR CONCEPT

Upon inspection of the current condition of the bridge and consultation with community members to understand their concerns and wishes, our team decided on the following design criteria.

- Strengthen the bridge to last approximately three to five years until a replacement can be designed and constructed.
- Utilize existing material as much as possible.
- Minimize maintenance requirements.
- Ensure the bridge can support loading from pedestrians, livestock, snow, and yak trains weighed down with mountaineering equipment. Yak loading provided the governing load case.
- Grade 36 steel for the hanger rods. This was determined based on field measurements using elementary mechanics principles and a luggage scale.
- Repairs must be accomplished using available hand tools (i.e. pocket knives, multi-tools and few hand wrenches).
- Only make changes that improve the bridge

- Design concept must allow structural analysis calculations to be conducted by hand due to lack of relevant computer software at the site

Our team considered several possible strengthening concepts, including a traditional asymmetric cable-stay configuration, but decided that the most feasible concept was a modified cable-stayed bridge layout. This strengthening concept repurposed the existing main suspension cables and threads them through the hanger rod–to-deck padeye connections and attaches the main cable to the existing undamaged Yullajung anchorage (see Figure 6). The benefits of this concept are that it utilizes numerous undamaged portions of the bridge (i.e. main cables, cable anchorages and deck connections), provides uplift forces at the midspan of the bridge, and eliminates compression loading in the bridge deck. It was important in the modification of the bridge to not induce axial load in the deck (cable-stayed bridges typically do result in large deck compression from the horizontal components of the diagonal cable forces) due to significant permanent vertical deformation of the deck, even after modification, possibly resulting in global buckling of the structure. As a suspension bridge, the original structure carried no compression loading in the deck, and it was critical that any modifications to the structure not make the bridge worse. Due to the stiffness of a cable-stayed system, any additional live load on the bridge is supported directly by the modified structure and does not overload the deck and its abutment details. Our team presented this repair concept to community leaders for their input and approval. Community leaders then discussed the proposed repairs with the community, and our team received approval to implement the repairs the following day with the full support of the community.

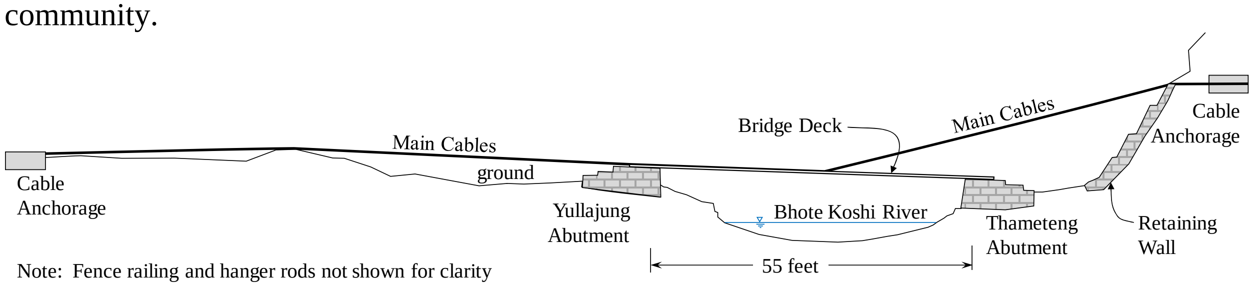


Figure 6 Schematic of strengthened bridge configuration. (Note: Not to scale)

CONSTRUCTION

Construction of the approved repair concept occurred over the course of three days and included assistance from all available community members, as well as soldiers from the nearby Nepal army outpost. Construction occurred in nine stages as follows.

1. Remove stone rubble from the destroyed suspension tower to make way for new main cable alignment (see Figure 7) and salvage the main cable saddles.
2. Detach the main cable from the Yullajung anchorage.
3. Detach the main cable from the top of the hanger rods. This required pulling the main cables completely away from the tops of the hanger rods, which were bent and twisted following collapse of the tower, off of the bridge and onto the Thameteng side of the river.
4. Support the fence railing out of the construction area and prevent it from falling into the rushing river.
5. Feed each main cable through two or more padeye loops (for redundancy) at the hanger rod-to-deck connection (see Figure 8).
6. Feed the main cable through the Yullajung anchorage connection.

7. Hand tighten the main cables and secure them to the Yullajung anchorage (see Figure 9).
8. Secondary tensioning of the main cables using leverage. The cables were propped up and apart with large stones near the old tower location (see Figure 10a). The cables were then pinched together near the midpoint between the old tower location and the anchorage (see Figure 10b). The pinched location was secured with galvanized wire. All of these methods shortened the cables and increased their tension forces which provided a resultant upward load at midspan of the deck, where the angle change of the cables occur.
9. Secure the fence railing to protect pedestrians during normal operation.

a) 
b) 

Figure 7 a) Clearing away the tower stones and releasing the main cables from the Yullajung anchorage b) Positioning large stones with the assistance of the Nepal Army.

a) 
b) 

Figure 8 a) Threading the main cables through the hanger padeye loops at the deck b) Pulling the main cables through the hanger padeye loops.

a)  b) 

Figure 9 a) View of main cable alignment from Yullajung anchorage. b) Preparing to hand tighten a main cable.

a)  b) 

Figure 10 Secondary tensioning of cables. a) Using large stones to prop the cables. b) Securing pinched location with galvanized wire.

STRENGTHENED BRIDGE

The strengthened and modified bridge is shown in Figure 11, 12 and 13 below. Fence railing is supported with mountaineering rope that deteriorates with exposure and will require replacement by the community every six to twelve months. Note the addition of signage to restrict loading on the bridge. The signage is in three languages, Nepali, English and symbolism, to communicate to as many people as possible.

Figure 11 a) Overall view of the strengthened bridge. b) View of strengthened bridge from the Thameteng anchorage.

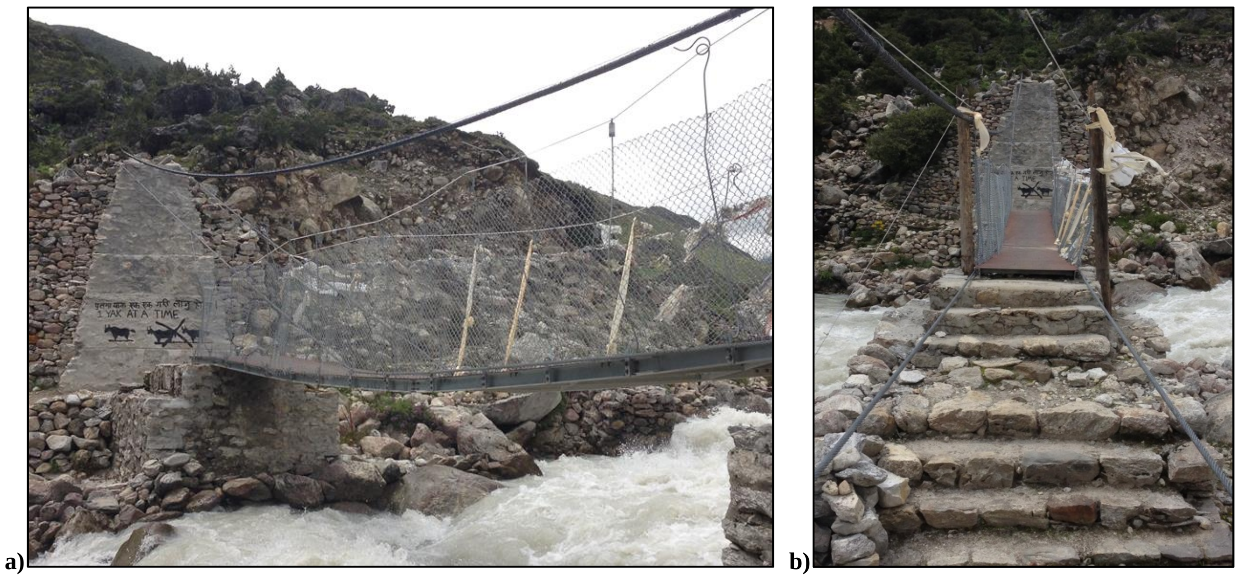


Figure 12 a) View of strengthened bridge and Thameteng abutment. b) Strengthened bridge at Yullajung abutment.

Figure 13 a) New signage near entrance to bridge. b) Detail of main cable at deck level. Note the threading of the main cables through the padeye loops of the hanger rods.

CONCLUSIONS

This project demonstrates the importance of basic mechanics and structural analysis techniques in bridge design and construction. A small group of civil engineering faculty and undergraduates students on a service learning trip to a remote bridge site in the summer of 2016 were able to work with a community and modify a severely damaged pedestrian suspension bridge into a cable-stayed bridge. The bridge was nearly destroyed following the 2015 Gorkha earthquakes however the community has little choice but to continue to use it, as their alternatives are to either walk an additional 3-4 hours to the next river crossing or to use the old trail across active landslides.

The modifications implemented resulted in no deck compression while still providing the desired upward force at midspan. Surveying of the bridge indicated that the main cable tensioning operations utilized leverage and raised the midspan of the bridge three inches which reduced loads on the abutment anchor bolts. Any additional live loading on the bride would go directly into the modified structural system and not overload the deck or bolts. The structural design calculations were completed by hand without the aid of structural analysis software and all modifications to the existing bridge were implemented using simple hand tools.

ACKNOWLEDGMENTS

This project could not have been completed without the hard work and dedication of numerous individuals. Our incredible guides, Kami Temba Sherpa, Mingma Temba Sherpa and Mingma Rita Sherpa, shepherded us up and down the trails and impressed us with their humor, compassion, work ethic, and ability to walk endlessly with pace and significant loads while maintaining a smile. We offer special thanks to our lead guide, Kami Temba Sherpa, who also facilitated food and lodging along the trail, and four yaks to transport our equipment. Board members of the Thame Sherpa Heritage Fund provided support for our team while in Nepal. Dr. Lhakpa Sherpa facilitated discussion with the Nepal Trail Bridge Program and Dr. Kami Temba Sherpa hosted our team in Thame and provided medical advice when needed. Jiban Ghimire of Shangri-La Nepal Trek facilitated air travel between Lukla and Kathmandu. Travel costs for a large portion of our team were supported by the Merrimack College School of Science & Engineering and the Merrimack College ASCE-Student Chapter. We offer sincere thanks to the undergraduate students (Giovanna Dowell, Sophia Dowell, Peter Foltz, Sean Krause, Brad Picard, and Leyna Tobey) who surveyed the bridge site and performed much of the physical labor. Last, but by no means least, we thank the soldiers at the Nepal army outpost in Thameteng for a full day of hard work positioning large stones and tightening the main cables and the Yullajung community for trusting us with your bridge and allowing us the opportunity to work with you and for inviting us into your homes for some of the best tea we have ever enjoyed.

REFERENCES

Nepal, Ministry of Federal Affairs and Local Development, Local Bridge Section. "*Short Span Trail Bridge Standard – Technical Handbook: How to Build a Short Span Trail Suspended Bridge*". Retrieved from: http://www.nepaltrailbridges.org.np/2015/manuals

APPENDIX – ADDITIONAL PHOTOS

a)  b) 

Figure 14 a) Yullajung community members showing their appreciation b) Enjoying the strengthened bridge.

a)  b) 

Figure 15 a) Surveying the bridge. b) View of underside of the bridge deck. Note cross bracing

a)  b) 

Figure 16 a) Detail of web connection of deck channels. b) Detail of anchor bolts at abutment.

a)  b) 

Figure 17 a) Attachment detail of pulling rope to main cable b) Hand tightening the main cable

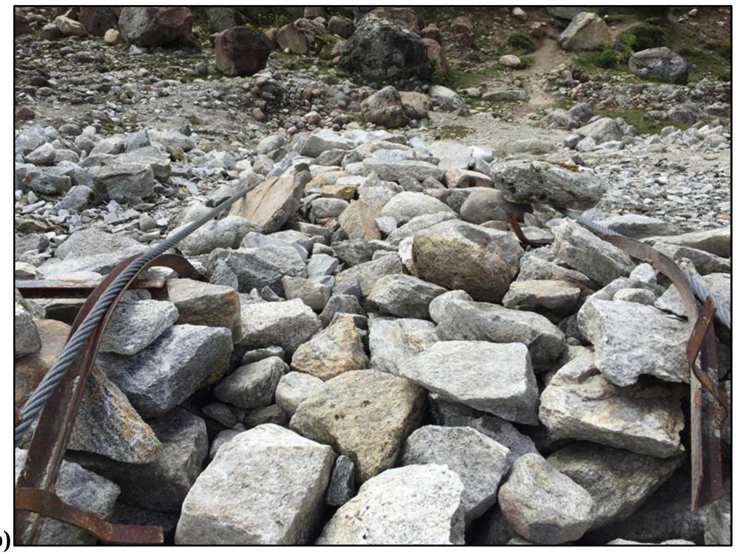
a)  b) 

Figure 18 a) View of main cables between Yullajung anchorage and old tower location. Note the pinching of the main cables. b) Main cables at the old tower location. Note the reuse of the steel cable saddle from the old tower to ensure a large radius bend in the cables.

Figure 19 Group photo after completion of strengthening operations.

BSCES

Boston Society of Civil Engineers Section
American Society of Civil Engineers

2023 Individual Section Awards

Each year, BSCES presents awards to deserving members and individuals in the community who are nominated by their peers in recognition of their service. Here is your opportunity to nominate a co-worker, friend, or someone who you think deserves special recognition. Please see the following awards descriptions and nomination instructions. Awards reserved for BSCES members are noted as such.

The Nominations Deadline is **Friday, March 31, 2023.** The Awards Committee will review all nominations and present a list of candidates for selection by the Board of Government. Awards will be presented at the 174th BSCES Annual Awards Celebration.

I would like to nominate Matt A. Card, PE **For the:**

_______ **CITIZEN ENGINEER AWARD:** This award is presented to a BSCES member or registered professional engineer for outstanding public involvement in local or national legislation, education (at any level), non-profit volunteer organizations, community activities, or similar activities improving the image of ASCE, BSCES and the civil engineering profession.

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_______ **COLLEGE EDUCATOR AWARD:** This award is presented to a member of the academic community who inspires and encourages civil engineering students through exceptional teaching and mentorship. Educators empower students to realize full potential and exemplify the profession in their classroom. Candidates shall be actively teaching in a classroom setting at a college or university in New England.

x_______ **ENGINEER OF THE YEAR AWARD:** This award is presented to a BSCES member, with 15 years or more professional experience, who has exhibited extraordinary leadership in the form of managerial leadership, technical excellence, professional integrity, and mentorship of other engineers.

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To submit a nomination, complete this form and return it by the nomination deadline via email, fax, or mail to bsces@engineers.org, 617/227-6783, or BSCES Awards Committee, Boston Society of Civil Engineers Section/ASCE, One Walnut Street, Boston, MA 02108-3616, respectively.

Name and Company Address of Nominee(s)*:

Matt A. Card, PE Alfred Benesch & Company 50 Redfield Street, Suite 102 Boston, MA 02122

Is this a re-nomination? Yes _______ No x_______

Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.

Your Name: Ed Baumann Daytime Telephone: 508-631-4493 Email: ebaumann@benesch.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

Matt A. Card, PE - Nomination for 2023 BSCES Engineer of the Year Award

Education and Beginning of Professional Career

Matt Card graduated with his BS Civil Engineering from UMass Dartmouth in 1978. After graduation, he started his professional career with General Dynamics at the Fore River Shipyard in Quincy, MA. Matt received 6 months of general management training and then served as foreman in the #1 Steel Fabrication Shop where they fabricated steel plates and members for sub-assemblies for LNG tankers. Matt gained hands-on experience of steel fabrication, management skills and many “shipyard stories” to share throughout his career.

Civil-Structural Engineering Career

In 1980, Matt left the ship building industry to join Walter J. Hickey Associates in Quincy/Boston, MA where he worked on a variety of bridge, roadway and building projects. Matt continued this work after Hickey Associates merged with Purcell Associates in 1984. After several years of night classes, Matt earned his MS Civil Engineering from Northeastern University in 1987.

Leadership Role at a Young Age

In 1991, at the age of 35, Matt took over as Purcell’s Boston Office Manager. Matt found mentors and the trainings available through both BSCES/ASCE and ACEC helpful in managing an office at such a young age. In 2012 Purcell Associates merged with Alfred Benesch & Company and Matt continued to serve as Vice President and the Massachusetts Division Manager.

Noteworthy Projects

Matt has managed the design of many notable bridge replacement and rehabilitation projects including the $177m replacement of the N. Washington Street Bridge in Boston, the $85m rehabilitation of the Braga Bridge in Fall River/Somerset and the $28m Route 128 Add-A-Lane/Bridge I replacement in Canton/Dedham. Matt has managed hundreds of other assignments including many bridge and culvert replacements, rehabilitations, repairs, load ratings and inspections. He also managed and performed many bridge design reviews for major projects throughout Massachusetts including the $290m rehabilitation of the Longfellow Bridge over the Charles River, the MassDOT’s bridges over MBTA’s GLX, the Long Island Bridge over Boston Harbor and the New Northern Avenue Bridge over Fort Point Channel.

Matt enjoyed working on several large building projects such as the Garner Correctional Institution in Newton, CT, the N. Attleboro and Plymouth Middle Schools as well as several smaller building projects in Massachusetts. Matt was involved in the MassDOT Tunnel Inspections performed immediately after the ceiling collapse in 2006 in order to allow the reopening of I-90 and since that time, he has managed several subsequent tunnel inspection contracts.

Contributions to Professional Societies

Matt is a long-time member and supporter of BSCES/ASCE. In 2007, he received the Ralph Horne Award that is given for unpaid public service for philanthropic activities in the public interest. He served as Co-Chair of the Local Planning Committee for the ASCE/SEI Structures Congress held in Boston in 2014. Matt is also a long-time member and supporter of ACEC/MA. He served on the Board and on the Transportation Agency Liaison Committee (TALC) for several years and much of his focus was on the MassDOT Partnering Committee helping to build the partnership between the state agency and the consulting community.

Managerial Leadership

Matt managed the Boston office for Purcell and Benesch for over 30 years with a friendly and approachable demeanor, leading by example and always willing to provide advice or jump in to help on any assignment. He handles stress and pressure with calmness and poise. When challenges arise, Matt immediately starts looking for the best path forward.

Matt remains heavily involved at the project level: from understanding client needs to using his extensive experience to properly scope projects, efficiently solve design and construction challenges, all in service of producing a quality result for the client and travelling public.

Technical Excellence

Matt has always made sure that he and his team were up to date on the latest codes and practices in the civil and structural engineering industry. This included maintaining an extensive (first in print, then virtually) library of codes, past project design materials, manufacturer's catalogs, and software resources. He is always up for a new challenge: from designing a large truss structure to working through constructability obstacles in an urban environment. Matt has trained his team to always consider the big picture: is the complex model giving a result to the simplified analysis based on first principles.

Professional Integrity

Matt is a model of integrity for all engineers who dedicate their professional careers to protect the health, safety and welfare of the public and work to improve the quality of life for all. Matt builds partnerships among owners and industry partners to efficiently meet project needs. He works with honesty and integrity and makes decisions based on providing the best value of private and/or public funds.

Mentorship of Other Engineers

Matt mentors and provides both managerial and technical guidance to all who works with him. He puts collaborating and mentoring of others in the profession above competition. He is always happy to provide his ideas and opinions to clients and colleges at other firms on project challenges that they are faced with and is a sounding board for most people who have worked with him.

Summary

Matt Card is an ideal candidate for the BSCES Engineer of the Year based on his 45-year career summarized above, his managerial leadership, technical excellence, professional integrity and openness to mentoring co-workers and piers alike.

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Name and Company Address of Nominee(s)*:

Chris Cole
Department of Public Works, 16 Lowell Street, Town Hall
Reading, MA 01867

Is this a re-nomination? Yes ________ No X________

Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.

Your Name: Richard A. Matson, P.E. (MA, NY) Daytime Telephone: 978-394-6310 Email: richard.matson@aecom.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

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03/31/2023

BSCES
One Walnut Street
Boston, MA 02108-3616

Subj: Christopher Cole Nomination for the BSCES 2023 Government Civil Engineer Award

To whom this may concern:

This letter is in support of nominating Mr. Christopher Cole for the BSCES 2023 Government Civil Engineer Award. I have had the pleasure to personally know Chris over the last 15+ years through our involvement with Merrimack College, and more specifically through Merrimack College's civil engineering alumni organization. Chris graduated in 2004 from Merrimack College with a Bachelor of Science degree in Civil Engineering.

Upon graduation, Chris began his career with the Town of Reading, Massachusetts in the Public Works Engineering Division as a civil engineer from June 2004 to December 2018. During this 14 ½ year span, Chris has performed a magnitude of tasks, some of which includes:

- Managed and planned complex public works projects related to road resurfacing; sidewalk and curb construction; water, sewer, and stormwater sub-surface utilities; parks; cemeteries; and other municipally owned properties including school properties
- Prepared contract documents, design calculations, plan sets, and budgets for public works projects
- Managed Reading's annual Pavement Management Program, including all State (MassDOT) issued annual funding sources
- Supervised multiple contractors on public works related projects
- Coordinated various Town projects with outside agencies (MassDOT, MassDEP, MWRA, etc)
- Responsible for maintaining proper operation of all traffic signals within the Town of Reading
- Assisted other Town Departments and residents in resolving engineering related problems

From December 2018 to Present, Chris has taken on the role of Reading Assistant Director of Public Works. In this role, Chris has expanded his repertoire of tasks, some of which includes:

- Oversee operations for a Department of 60 employees, consisting of 10 divisions which include: Administration, Engineering, Highway, Vehicle Maintenance, Stormwater, Water, Sewer, Parks, Forestry, and Cemetery
- Assist with the preparation of the annual budget for the Department
- Review and approve all weekly vendor invoicing for the Department
- Create Department policies, regulations, and procedures
- Research and prepare grant applications to acquire external funding from various organizations for Town projects and equipment
- Prepare and deliver presentations to Reading Town Meeting, Town Boards and Committees pertaining to Department initiatives being discussed or proposed
- Review employment applications and conduct interviews of potential new employee hires
- Represent the Town at meetings with Federal, State, and local agencies

Chris has spent the entirety of his first 19 years in the civil engineering profession working for the Town of Reading and he continues to challenge himself and excel in his many tasks that he takes on. In addition to his various involvements within the Department of Public Works, Chris has taken on many volunteer roles with Merrimack College that include:

- CE Alumni Organization President (April 2013 to April 2015); also held past positions of recording secretary and Vice President; currently serve on CE Alumni Organization Executive Board
- Organize annual CE Alumni Golf Outing (16 years) to benefit annual CE Alumni Student Scholarships

AECOM

- Advisor to the ASCE student steel bridge team since graduating from Merrimack in 2004 (former steel bridge captain in 2004 - 1st place regionals) - 19 years as advisor
- One of the lead planners/organizers when Merrimack College hosted the ASCE/AISC New England regional student steel bridge competition in 2015
- Part of the select CE alumni group that has met with the ABET accreditation board to discuss the CE Department curriculum and operations
- Past guest speaker with ASCE student groups and CE classes on "what it is like working in municipal government and what I do for the Town of Reading"

Having known Chris through his various involvements at Merrimack College, I can attest that Chris is everything you are looking for in a candidate. He has demonstrated the ability to have a long-lasting career in a municipal government, while giving back his time and efforts to his Alma mater, Merrimack College. Chris is patient, eager to learn, and loves to share his wealth of knowledge. In addition, Chris is a current dues paying member of ASCE & BSCES (ASCE Member # 362237), which qualifies him for this award.

If any additional information is needed in support of this nomination, please let me know.

Sincerely,

Richard A. Matson, P.E. (MA, NY)
Structural Engineer
Team Leader, Bridge & Tunnel Inspections
Cell: 978-394-6310
richard.matson@aecom.com

BSCES

Boston Society of Civil Engineers Section
American Society of Civil Engineers

2023 Individual Section Awards

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I would like to nominate Jason A. Santos, PE **For the:**

_______ **CITIZEN ENGINEER AWARD:** This award is presented to a BSCES member or registered professional engineer for outstanding public involvement in local or national legislation, education (at any level), non-profit volunteer organizations, community activities, or similar activities improving the image of ASCE, BSCES and the civil engineering profession.

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x --> **GOVERNMENT CIVIL ENGINEER AWARD:** This award is presented to a BSCES member who is serving as a paid public sector engineer at a federal, state, or municipal agency, department, or authority in Massachusetts.

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Name and Company Address of Nominee(s)*:

Jason A. Santos, PE; Director of Transportation

Massachusetts Department of Conservation and Recreation (DCR)

251 Causeway St., Suite 700; Boston, MA 02114

Is this a re-nomination? Yes x No ________

Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.

Your Name: Shanta Keller Daytime Telephone: 207-468-3766 Email: skeller@vhb.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

BSCES Award Nomination

Government Civil Engineer Award

Nominee: **Jason A. Santos, PE**; Director of Transportation at DCR

Nominated by: Shanta Keller on 3/27/2022

At a recent NOI hearing with the Boston Conservation Commission, I fully realized the respect that Jason has earned while serving as Director of Transportation at DCR. In a break from the formality of the hearing, a member of the Commission said, “Jason, we really appreciate how you, as an owner, are thoroughly involved with your projects and so actively participate in these hearings.” During the second hearing, I heard the same sentiment. This particular project ended up with an unusual condition. Within a week of the draft conditions coming out, Jason had gotten an opinion from his legal department, set up a meeting to discuss the condition with the commission, and called me, his design engineering consultant, to discuss our response over the phone. The next week, the condition was settled, to the satisfaction of the commission. This is just one small example of many that makes Jason a special government civil engineer. He’s respected among other governmental agencies, and he makes being a consultant for him and DCR a pleasure.

Jason has a hand in overseeing a wide range of projects at DCR, from major parkway re-designs such as the Arborway Improvement Project, to intersection projects such as the Soldiers Field Road Allston intersection and bridge crossings project, Shared Use Path projects such as the Blackstone Greenway project, sidewalk improvement projects throughout the commonwealth, and much more. DCR’s Traffic Section, Structural Section, Parkway Section, as well as DCR’s newly formed Green Transportation are all disciplines that fall under Jason. He is currently serving as the project manager for the new Mystic River Pedestrian Bridge connecting Everett and Somerville.

Jason has been with DCR for nearly 10 years, moving up from a civil engineer and project manager to director of transportation 3 years ago. Before joining DCR he worked in the private sector, both on the contracting side for a heavy civil contractor on primarily large state projects and in engineering consulting focusing on both civil and environmental engineering. This background gives him a unique perspective amongst government employees. As illustrated in my opening story, he’s very proactive, and he knows how to make civil engineering projects move forward. And while he’s primarily managing or overseeing projects these days, his keen understanding of civil engineering and sense for constructability is invaluable with his work at DCR across is wide array of projects. His passion for public infrastructure is clear.

Jason is a true civil engineer. He enjoys talking about all aspects of science and engineering, especially with those he is mentoring. He volunteers yearly as a judge for MA State Science and Engineering Fair held at MIT. He is currently serving his second term as an elected member of his local Planning Board in Holliston, MA. He takes the mission of public service very seriously and he never seems to stop moving. Jason is professional, always positive and personable in his work. He calls and texts often to touch base. He’s always asking about my family and sharing stories about his. He’s a great example of a government civil engineer, and he deserves recognition for his outstanding work.

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I would like to nominate Al Fordiani **For the:**

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Name and Company Address of Nominee(s)*:

Al Fordiani

Is this a re-nomination? Yes _______ No X

***Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.**

Your Name: Becky Weig Daytime Telephone: 978-760-2772 Email: rweig@kleinfelder.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

NOMINATION FOR ALFRED FORDIANI FOR THE PRE-COLLEGE EDUCATOR AWARD 2/27/23

Al Fordiani received his Bachelor of Science degree in Biology from the Massachusetts Institute of Technology (MIT) in 1982 and his Master of Education degree from Harvard University in 1994. He has been a Science Teacher at Nashoba Regional High School in Bolton, MA, since September 1994. After his MIT graduation, Al worked in horticulture at the Arnold Arboretum and Harvard's Case Estates. In 1985, he moved to New York City (NYC) and managed a greenhouse in the South Bronx for Glie Farms, growing culinary herbs for NYC restaurants and substitute taught high school. Glie Farms provided jobs to residents of a blighted urban area and provided an opportunity to teach them about food production and distribution. In Al's free time, he took NYC youth hiking to learn about the outdoors.

After moving to Jamaica Plain, MA, in 1987, Al worked in horticulture and soon began his landscape design business and began assistant coaching baseball at MIT. Upon moving from Jamaica Plain to Sudbury, MA, in 1991, Al began coaching baseball from youth through high school ages, eventually becoming the Lincoln-Sudbury High School Junior Varsity coach and Varsity hitting coach, where they won 3 state championships over his 20+ years as coach.

In 1993, Al realized his love and aptitude for teaching and went to Harvard to obtain his graduate degree in education. After graduating from Harvard, Al began teaching Science at Nashoba and became the primary Physics teacher (teaching levels from College Preparatory through Advanced Placement). During summers, Al coached baseball but also developed an intensive Electronics and Music Program at the University of Lowell Future Engineers Center where high school kids built audio speakers, amplifiers, and instruments such as electric pianos and electric guitars. Seeing a need for understanding physics at an early age and the power of using engineering projects to teach science concepts, Al developed the very popular Freshman Physics and Engineering curriculum at Nashoba working with the Tufts University Center for Engineering Education. The concept was to introduce many hands-on projects where students could design, build, and test various machines and predict outcomes.

In 2006, Al got introduced to FIRST© (For Inspiration and Recognition of Science and Technology) Robotics Competition by his students requesting a mentor and Team 1768 was founded. Al has been Director of the Nashoba FIRST Robotics Team 1768 to date where Team 1768 has become one of the most technically awarded teams in the New England District.

FIRST Robotics takes up an enormous amount of extracurricular time starting with afterschool practice in the fall to 7-day per week engagement during the season which begins the first week of January and concludes with world championships in the spring. There are off-season events over the summer for additional practice. About 30 students (freshman through seniors) work in teams to develop, design, manufacture parts, build, code, repair, advertise, and fundraise for the robot which is typically just under 120 pounds and limited to about 9 cubic feet. Each season approximately $30,000 is required to fund the robot and competition season. His students, particularly those from the Robotics Team, have received scholarships at many engineering schools including MIT, Northeastern, Lowell, and Carnegie Mellon and have secured employment at prestigious engineering companies including assignments at SpaceX and working on the Mars Rover.

Al has truly dedicated his adult life to teaching and applying STEM competencies to everyday needs and for children at all levels and aptitudes.

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The Nominations Deadline is **Wednesday, April 26, 2023.** The Awards Committee will review all nominations and present a list of candidates for selection by the Board of Government. Awards will be presented at the 174th BSCES Annual Awards Celebration.

I would like to nominate Crescent Street Over Millers River Bridge Replacement Project **For the:**

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Name and Company Address of Nominee(s)*:

Michael Cruz, PE, Project Manager, Green International Affiliates, Inc., 100 Ames Pond Drive, Suite 200, Tewksbury, MA 01876

Is this a re-nomination? Yes _______ No x

***Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.**

Your Name: Dawn Connelly Daytime Telephone: (978) 843-5220 Email: dconnelly@greenintl.com

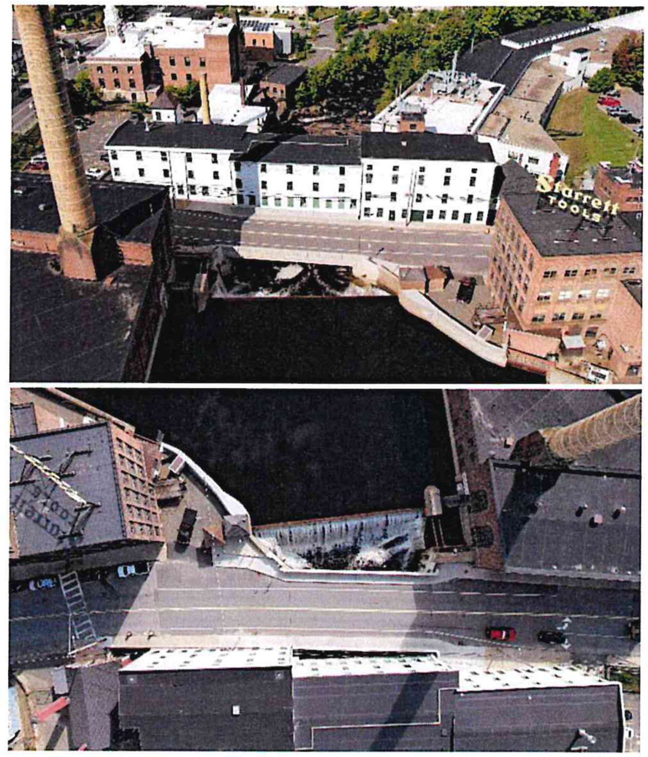
NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

Crescent Street Over Millers River Bridge Replacement: Solving Engineering Challenges Through Successful Stakeholder Partnerships

GREEN INTERNATIONAL AFFILIATES, INC.

Green International Affiliates, Inc. (Green) is nominating our Crescent Street Over Millers River Bridge Replacement project in Athol, Massachusetts for the Charles A. Stone and Edwin S. Webster Project of the Year Award because it meets all the evaluation criteria. The incredible number of physical constraints present at the site drove the need to incorporate unique and innovative design and construction techniques and made the project very challenging and highly complex, as you will see from the description that follows. The project was managed by Michael Cruz, PE and completed by our team of engineers who are all located in our Massachusetts headquarters office.



The bridge abuts Starrett facilities on all sides

The Crescent Street Over Millers River Bridge, which is under the jurisdiction of the Massachusetts Department of Transportation (MassDOT), is nestled within feet of the L.S. Starrett Company, the leading employer in Athol and the reason Athol has the nickname "Tool Town". Starrett has been at the heart of business in Athol since its founding in 1881 and over time, the Crescent Street Over Millers River Bridge became deeply woven into its operations and therefore vital to the Company and Town.

While Starrett's business grew, the bridge aged. Wear and tear from decades of use combined with the upstream dam's spillway creating harsh environments due to water spray and ice flows caused the bridge to deteriorate to the point where a full replacement was needed. Given the importance of this bridge, it was crucial to approach its replacement with exceptional care and communication within the team itself and with stakeholders.

Replacing the bridge posed many seemingly impossible design and construction challenges. The abundance of physical constraints presented by the site included Starrett-owned buildings, wall structures, utilities, tunnels, the dam, and Millers River. Existing building foundations that date back to the 1800s directly abut the bridge abutments on the west side and support a Starrett building spanning over the Millers River. There is less than 3 feet of clear space between the edge of the bridge and the edge of the building. On the east side, the bridge wingwalls tie directly into the retaining walls for the upstream dam structure. At the northeast corner there is an existing splash block to mitigate the flow over the dam spillway mid height of the bridge wall. At the southeast corner the bridge walls connect to the dam walls which support an electrically powered metal head gate. The head gate structure controls water flow through Starrett's 6 foot-diameter steel penstock which sits directly behind the existing south abutment, within 1 foot at the closest point. There was also an existing sewer manhole wedged between the penstock and partially built into the south abutment concrete wall. This sewer manhole connects to the sewer line carried by the bridge.

The south and north roadway approaches contained multiple structures and water, sewer, and storm drain utilities. Additionally, overhead wires run along the west side of the bridge with utility poles on either side within the sidewalk. These overhead utilities include telephone, communication, and electrical services for the Starrett buildings. A utility tunnel crosses the south approach roadway between Starrett buildings carrying a critical steam line, buried less than 3 feet below the existing pavement. Within the north approach roadway is an underground pedestrian tunnel enabling Starrett employees to move between buildings. This tunnel has less than 3 feet of cover at the shallowest point.

Our team, comprised of us, MassDOT, Starrett, the Town, and the Contractor, tackled all of these design challenges together and also responded quickly to additional, unforeseen conditions during construction to deliver the replacement bridge and even address additional scope items, ahead of schedule. Despite the small footprint, we were able to widen the bridge to accommodate two sidewalks to meet the pedestrian needs of the Town and the business. All this was done in one construction season so as to avoid prolonged impacts to Starrett and the local community. The project's success was achieved thanks to Green's design ingenuity and ability to develop a highly effective partnership among all stakeholders. The new bridge surpasses the function of the previous bridge, matching the previous bridge span while also widening it. The new superstructure is also designed to combat the constant water spray and icing issues which will help this new bridge stand the test of time and continue to be a reliable structure for the Town and Starrett for decades to come.

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I would like to nominate John T. Brooks **For the:**

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Name and Company Address of Nominee(s)*:

John T. Brooks
31 Saint. James Ave., Suite 300
Boston, MA 02116

Is this a re-nomination? Yes ________ No ___X___

Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.

Your Name: James Gayle Daytime Telephone: (713) 517-6471 Email: jgayle@lafp.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.*

L.A. FUESS PARTNERS
Structural Engineers

March 29, 2023

BSCES Awards Committee
Boston Society of Civil Engineers Section/ASCE
One Walnut Street
Boston, Massachusetts 02108

BSCES Awards Committee,

I am writing to recommend John Brooks for the BSCES Younger Member Award. John has continuously held BSCES to the highest standard throughout his time within the Younger Member Group, all the while exemplifying his efforts as Chair of YMG. As Chair, he has effortlessly conditioned the team to be efficient and collaborative, while bringing the initiative required to steer a post-pandemic world. For these reasons, it gives me great pleasure to nominate John for this award.

The number of active members within the Younger Member Group dropped significantly from the beginning of 2020 to the end of 2021. Virtual calls, virtual events, virtual happy hours; you know the story - nothing was the same. However, by the start of 2022, it seemed that our "new normal" was short lived, and a transition to find balance between the old and new world was becoming more desirable. And so, John's term as Chair was watermarked with a challenge: how can YMG reinvent itself while staying true to its core mission? John response - a focus on collaboration, teamwork, and efficiency to bring about the changes necessary for a successful YMG. Through his leadership, he was able to guide the team by encouraging creative thinking with an emphasis on increased member interaction. This was especially true when planning new events; for example, the team broke from tradition at last year's holiday party by incorporating candlepin, which promoted members to mingle with other engineers outside of their peers. Moreover, this year's Billiards Tournament was hosted at a new venue, which served as a refresh to YMG's most popular event and to address concerns from years prior regarding the quantity and quality of food served. These careful considerations were discussed freely among the team, with John at the head of the conversation.

Another strategy John incorporated was pushing for greater collaboration between YMG and other young professional organizations, such as SEAMASS, and TD&I. John would jump at any opportunity to collaborate with these organizations and has consistently encouraged the team to reach out to other groups about hosting a joint event. The upcoming Charles River Cleanup with SEAMASS YMG is just one example of these efforts. The cleanup not only allows our members to give back to the local community, but also provides members of both parties the opportunity to network and trade ideas, which align perfectly with John's core philosophy. BSCES YMG has always emphasized teamwork and collaboration, it's engrained into its mission; however, it's one thing to promote, it's another to actually do it.

John has efficiently focused on teamwork and collaboration throughout his term as Chair at YMG with both his team and active members. I personally find his efforts noteworthy and inspiring, and I hope the effects of his hard work carry on at YMG for many years to come. Once again, with the highest of praises, I recommend John Brooks for this year's BSCES Younger Member Award.

Yours truly,

James Gayle

BSCES

Boston Society of Civil Engineers Section
American Society of Civil Engineers

2023 Employer Recognition Awards

As a means of fostering the members of the civil engineering profession, the Boston Society of Civil Engineers Section/ASCE has established an award to recognize those employers who commit to providing exceptional opportunities to their engineers. Special recognition will go to those organizations who exhibit exemplary support as evidenced by:

1. Encouraging technical and professional growth through continuing education/training, mentoring, project experience, participation in development of technical papers or presentations, and other means.
2. Tackling staff quality-of-life issues in the modern workplace.
3. Contributing to the community to make a positive impact.
4. Encouraging active participation in professional societies such as ASCE/BSCES.

Members who want their organization to be considered for recognition should provide a letter demonstrating their firm's commitment to their engineers. Firms nominated shall be actively participating in BSCES. Such active participation may be sponsorship, employee membership, contributions to the newsletter, or participation in other forms. Letters shall include the total number of employees in the firm, number of BSCES members, and cite specific examples of their employees being actively involved in BSCES.

The Awards Committee will review the nominations and select an exemplary small employer and a large employer in the Section. Organizations with less than 50 employees are eligible for the Small Employer Award. Awards will be presented during the 174th BSCES Annual Awards Event. Successful recipients will be considered for endorsement as potential (future) applicants for the ASCE Employer Recognition Award. No organization will be eligible to receive the award in consecutive years.

Complete and return this nomination form and your letter to the BSCES Awards Committee no later than Friday, March 31, 2023, to be eligible for the award.

Nominated Organization: Collins Engineers, Inc.

Type of Award (check one): ☒ Small Employer ☐ Large Employer

Nominator/Title: Irena Svetieva, PE - Project Engineer II; Edwin Mena, PE - Group Manager - Inspection

Address: 685 Canton Street, Suite 102 Norwood, MA 02062

Telephone: (339) 204-1056; (781) 819-2075 Email: isvetieva@collinsengr.com ; emena@collinsengr.com

Signature: Irena Svetieva Edwin Mena Date: 03/28/2023

Nominated Organization Contact Person: Alex Tetreault, PE

Title: Regional Manager

Office Address: 685 Canton Street, Suite 102 Norwood, MA 02062 Website: www.collinsengr.com/

Telephone: 781-205-2018 Email: atetreault@collinsengr.com

Please attach a brief (no more than two pages) narrative describing why the organization meets the criteria described in this nomination form.

Please complete this form and the additional pages and return it via email, fax, or mail to bsces@engineers.org, 617/227-6783, or BSCES Awards Committee, Boston Society of Civil Engineers Section/ASCE, One Walnut Street, Boston, MA 02108-3616, respectively. For questions, contact BSCES Awards Committee Chair at Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.

Thank you for your continued support of ASCE and BSCES.

COLLINS ENGINEERS INC.

BSCES Awards Committee
Boston Society of Civil Engineers Section/ASCE
One Walnut Street,
Boston, MA 02108-3616

March 30, 2023

Attn: Antonios Vytiniotis, PhD, PE
Chair – BSCES Awards Committee

Subject: BSCES 2023 Employer Recognition Award, Small Employer

Dear Mr. Vytiniotis,

We are writing to recommend Collins Engineers, Inc. (Collins) for the 2023 Small Employer Recognition Award. Collins employs 326 engineering professionals, technicians, and administrative staff located in 28 offices across the country. The Norwood, MA office opened its doors in 2012 and currently employs 20 engineering professionals and technicians in the Commonwealth.

During our years of employment with Collins, we have witnessed and experienced the outstanding care of Collins leadership to support engineers participating in volunteer activities to promote STEM and support their communities, attending and providing educational and technical seminars and lectures to improve their expertise, and involvement with the engineering community organizations including BSCES, ASCE, WTS, ACEC, local schools, and universities.

Encouraging the technical and professional growth of its employees, the company provides opportunities for engineers to collaborate within the engineering disciplines and to benefit through mentorship from colleagues with extensive expertise in their professional field of practice. Examples include:

- Collins diverse engineering expertise offers young engineers the opportunities to work closely and learn from senior engineers who set examples in their fields of practice.
- Collins promotes coaching and mentorship opportunities within the company, which is a mutually beneficial process that provides improvement of skills and technical knowledge and generates a positive energy in the working process.
- Collins conducts lessons learned briefings pertaining to safety and technical observations made from projects around the company.
- Collins has developed an in-house Project Management Program that provides professional development to engineers aspiring to become Project Managers.

Furthermore, the company encourages and provides different opportunities for engineers to participate in company and community social events and professional societies such as BSCES, WTS, and ACEC.

- A majority of Collins' 40+ employees over four New England offices are current BSCES Members.
- Collins has multiple engineers in recent years in BSCES leadership roles who provide their time to actively collaborate with their peers for the society including, Irena Svetieva – SEI Chapter Chair; Dan O'Connor COPRI Chapter (past); Edwin Mena – EMG Group (temporary hiatus).

- Collins has published many articles in the BSCES Newsletter over the last several years – Alex Tetreault – Jan. 2021; Dan O'Connor - June 2022; Irena Svetieva – Oct. 2022; Barritt Lovelace – Jan. 2023.

- Collins hosted and presented an SEI Chapter technical event in February 2023.

- Collins has many active engineers in the BSCES YMG group and routinely attend meetings, events, and activities.

- Collins has been a BSCES Program Sponsor, WTS Supporter-level Sponsor, and ACEC Gold Sponsor for many years.

As a family-owned business, Collins management understands the needs of their employees and the importance of quality-of-life in the workplace. Therefore, Collins also offers a variety of health and wellness benefits.

- Collins employs the "Chill" program (Chill Anywhere), which helps support employees with tailored mental health and wellbeing programs in the workplace.

- Collins offers employees Volunteer Time Off, which is time for employees to support STEM related programs of their choice in their communities.

- Collins implements and manages a Safety Program, which establishes health and safety guidelines and a support system for teams working in the office and field.

- Collins promotes social team building events within the offices throughout the year such as various holiday gatherings, summer outings, and birthday celebrations.

In summary, Collins supports the professional development of its employees with a mix of internal training and learning opportunities and by encouraging and supporting participation in professional and technical societies. Collins is a recognized leader in the industry and supports professional and technical societies by hosting technical seminars and sharing Subject Matter Expertise locally and around the country. It is our opinion that such dedication to the industry and the support of their employees' professional development merits recognition with this award.

Thank you for your time and in considering Collins as a proud candidate for the BSCES 2023 Small Employer Recognition Award.

Sincerely,

Irena Svetieva

Irena Svetieva, PE
Chair - BSCES SEI Chapter

Edwin Mena

Edwin Mena, PE
Member - BSCES

BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

2023 Employer Recognition Awards

As a means of fostering the members of the civil engineering profession, the Boston Society of Civil Engineers Section/ASCE has established an award to recognize those employers who commit to providing exceptional opportunities to their engineers. Special recognition will go to those organizations who exhibit exemplary support as evidenced by:

1. Encouraging technical and professional growth through continuing education/training, mentoring, project experience, participation in development of technical papers or presentations, and other means.
2. Tackling staff quality-of-life issues in the modern workplace.
3. Contributing to the community to make a positive impact.
4. Encouraging active participation in professional societies such as ASCE/BSCES.

Members who want their organization to be considered for recognition should provide a letter demonstrating their firm's commitment to their engineers. Firms nominated shall be actively participating in BSCES via sponsorship, employee membership, contributions to the newsletter, etc. Letters shall include the total number of employees in the firm, number of BSCES members, and cite specific examples of their employees being actively involved in BSCES.

The Awards Committee will review the nominations and select an exemplary small employer and a large employer in the Section. Organizations with less than 50 employees are eligible for the Small Employer Award. Awards will be presented during the 174th BSCES Annual Awards Event. Successful recipients will be considered for endorsement as potential (future) applicants for the ASCE Employer Recognition Award. No organization will be eligible to receive the award in consecutive years.

Complete and return this nomination form and your letter to the BSCES Awards Committee no later than Monday, February 27, 2023, to be eligible for the award.

Name of Organization: BETA Group, Inc.

Nominator/Title: Mark Gershman, PE
Address: 315 Norwood Park South, Norwood, MA 02062
Telephone: 781-255-1982 Email: MGershman@beta-inc.com
Signature: [signature] Date: 2/16/23

Organization: BETA Group, Inc.
Contact Person: Christine King
Title: Vice President
Office Address: 315 Norwood Park South, Norwood, MA 02062 Website: www.beta-inc.com
Telephone: 781-255-1982 Email: cking@beta-inc.com

Please attach a brief (no more than two pages) narrative describing why the organization meets the criteria described in this nomination form.

Please complete this form and the additional pages and return it via email, fax, or mail to bsces@engineers.org, 617/227-6783, or BSCES Awards Committee, Boston Society of Civil Engineers Section/ASCE, One Walnut Street, Boston, MA 02108-3616, respectively. For questions, contact BSCES Awards Committee Chair at Antonios Vytiniotis at 978/893-1224 or Awards.Comm@bsces.org.

Thank you for your continued support of ASCE and BSCES.

IMPROVING COMMUNITIES TOGETHER

February 14, 2023

Antonios Vytiniotis, BSCES Awards Committee Chair
BSCES Awards Committee
Boston Society of Civil Engineers Section/ASCE
One Walnut Street
Boston, MA 02108-3616

Re: 2023 Employer Recognition Award

Dear Mr. Vytiniotis,

BETA Group, Inc. proudly celebrated its 40th year of business in 2022. Over the last four decades, the firm has grown in both workforce numbers and service offerings. However, the foundation of our mission has remained unchanged: *improving communities together*.

To achieve this mission, BETA not only produces high quality work for our clients but also encourages our employees to be engaged with their local governmental boards and committees, as well as professional organizations. We believe that to truly make an impact in the communities in which we work and live, we must play an active role. We are pleased to provide the following evidence in support of choosing BETA Group, Inc. for the 2023 Employer Recognition Award. With nearly 160 employees in six office locations throughout New England, and three of those offices in Massachusetts, we have 8 employees who are members of ASCE with seven of those also members in good standing with BSCES.

1. *Encouraging technical and professional growth through continuing education/training, mentoring, project experience, participation in development of technical papers or presentations, and other means.*
   Promoting and supporting our employees' development, knowledge, and experience is one of the most important things we can do as a company. Our employees' growth and development are directly tied to our ability to provide quality services to our clients. Any employee may request to attend training, seminars, professional events, or obtain advanced degrees or further education that is applicable to their position and career development. BETA also strongly encourages all eligible employees to take their respective discipline's licensing and certification examinations. Becoming licensed or certified shows their commitment to their profession and our commitment to provide our clients with staff that are qualified in their respective fields.

   BETA is fortunate to provide a full-service range of in-house capabilities – from visioning to design to construction administration and oversight. With these resources and well-rounded approach to providing client services, we train our entry level engineers to gain a fuller understanding of the many facets of civil engineering. Senior staff are required to mentor and train younger staff and are encouraged to prepare and present technical papers. In the past year, employees presented at events such as the National Brownfields Conference, the Northeast Arc Users Group (NEARC), MassDOT's Moving Together Conference, New England APWA Fall Conference, and several Highway Association meetings. Additionally, BETA offers tuition reimbursement up to $5,000 per employee per calendar year. Employees have utilized this excellent benefit to take additional courses in their area of interest as they pursue Bachelor's and Master's level college degrees.

2. *Tackling staff quality-of-life issues in the modern workplace.*
   BETA has always strived to be understanding and flexible in allowing our employees to find a work/life balance that best fits their individual needs. In 2021, BETA adopted a flexible "work from home" policy which allows employees to work from home up to two days per week. This has significantly improved the quality of life for staff who now have more time in their days due to the reduction of their commuting time. Additionally, BETA

has been approached by employees to reduce their schedules to deal with child and elder care issues, or to change their primary office location. BETA always looks to accommodate these requests to provide our employees with the additional flexibility to meet their daily demands and individual situations.

3. *Contributing to the community to make a positive impact.*
One key initiative that BETA focused on during our 40th anniversary year was to positively impact the future of the A/E/C industry by supporting the education of the next generation of engineers. With six offices throughout New England, BETA felt it would be appropriate to make donations towards scholarships in the school systems for each of those six communities (Lincoln, RI; Chicopee, Worcester, and Norwood, MA; Hartford, CT; and Manchester, NH). The selected students are all pursuing degrees in majors such as civil engineering, environmental engineering, marine biology, and other STEM fields at institutions of higher education.

Additionally, BETA selected several national organizations that support our diversity, equity, and inclusion goals. Donations were made towards the scholarship programs at the National Society of Black Engineers, the Society of Asian Scientists and Engineers, the Society of Women Engineers, and the Society of Hispanic Professional Engineers. These organizations share similar missions, and we are thrilled that our donations will make a positive impact to support minority students looking to pursue a career in the AEC industry.

BETA's employees have always been active in community service roles as well, including participation in the local Conservation Commissions, Transportation Advisory Committees, Permanent Building Committees, and Town Councils. In addition, we have employees that volunteer and serve on the boards of various non-profit and community organizations for purposes and causes that are important to them personally. These include The iQuilt Partnership who are working to transform the City of Hartford, CT; the United Cerebral Palsy of Boston which provides programs and services for people with disabilities and their families; and the Neponset River Advisory Council.

As a firm, it is important that we give back in ways that make a positive impact to the community. In 2022, BETA was proud to volunteer and/or make donations to the following organizations: UMass Amherst ASCE Student Chapter; MathCounts RI Society of Professional Engineers; Girls on the Run RI; Save Bristol Harbor; Century Dragon Boat Club; Buzzard's Bay Coalition; the RI Basketball Officials Association; United Cerebral Palsy MetroBoston; TEMPO of Tiverton; the Asian American Civic Association; UConn Graduate Society of Hispanic Professional Engineers; the Trevor Project; and the Hispanic Federation.

4. *Encouraging active participation in professional societies such as ASCE/BSCES.*
BETA encourages and supports our employees to become members and be active in professional organizations geared to their specific disciplines and areas of interest. Of our current seven members in BSCES, one is the past Chair of the Transportation & Development Institute Boston Chapter and two are past Chairs of the Structural Engineering Institute (SEI) Boston Chapter. In addition, we have an employee that is the President of New England Section of the Institute of Transportation Engineers; another that is Chair of the Licensed Site Professionals Technical Practices Committee, and another that is 2nd Vice President of the Providence Engineering Society.

We appreciate the opportunity to provide evidence of our firm's commitment to our employees, to mentor and develop their professional careers, and to encourage them to lend their talents, time, and expertise in promoting the civil engineering profession while improving the communities in which we live and work.

Very truly yours,

Mark Gershman, PE – Senior Vice President & COO

BETA