**Supplemental Materials**

**Awe in Nature Heals: Evidence From Military Veterans, At-Risk Youth, and College Students**

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Awe in nature heals: Evidence from military veterans, at-risk youth, and college students

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**Section 1: Additional information about Study 1 method**

In this section we provide additional information about the samples of military veterans and youth from underserved communities and show descriptive statistics of the separate measures that make up the well-being composite.

**Participants.** Military veteran and youth participants were recruited via the Military Outdoors and Inspiring Connections Outdoors arms of the Sierra Club Outdoors organization, respectively. Participants that were military veterans were recruited from groups that included: a housing program for homeless veterans in the San Francisco Bay Area; veterans attending a large university; and veterans that applied to attend a four-day white-water rafting trip sponsored by the Sierra Club that was open to veterans from all areas of the United States. Youth participants were recruited from groups including: community outreach programs, high schools, and one middle school in the San Francisco Bay Area.

Data were collected during the 2015 and 2016 summer rafting seasons. Participants in 2015 consisted of 52 youth and 24 veterans. During the 2016 season, 45 veterans were recruited, and included in this sample were three firefighters who were first responders during the September 11th terrorist attacks on the Pentagon. We included them in the sample due to similarities to veterans samples, such as higher incidence of PTSD.

In 2015, age was not measured, but qualitatively ranged greatly. The youngest participant was middle school-aged and the oldest were veterans of the Vietnam War. In 2016 age ranged from 25 to 69 (*M* =38, *SD* = 10.97). Of the 124 people in the sample, 48% identified as White, 27% as Asian, 17% as Latino, 12% as Black, 5% as Native American, and 4% did not respond (participants were able to select more than one category). Twenty-five of the veteran participants and the three firefighters (22.5% of the sample) went on a four-day white-water rafting trip on the on the Green River in Utah, and the remaining veterans and youth attended one-day trips on the South Fork American river in California.

**Measures.** Below is additional information and descriptive statistics for the individual measures that comprise the well-being composite. Items were adapted to use the same scale, which participants used to report the frequency of certain experiences they have had in the recent past from 0 (*never*) to 5 (*every day*). The temporal framing for baseline and follow-up items were in the past month, and since the rafting trip, respectively.

*Satisfaction with Life*. All five items from the Satisfaction with Life Scale (SWLS; Diener, Emmons, Larsen, & Griffin, 1985) were included (baseline *M* = 2.48, *SD* = 1.16, α = .83; follow-up *M* = 2.71, *SD* = 1.30, α = .91). An example item is, *in most ways my life is close to my ideal*.

*Social well-being*. To measure social well-being, participants rated the frequency of five social experiences including three items from the social well-being cluster of the Mental Health Continuum (MHC-SF; Keyes, 2002); *feel that you belonged to a community (like a social group, or your neighborhood)*, *that you had something important to contribute to society*, and *that you had warm and trusting relationships with others*; and two face-valid items, *fight with your friends and family* (reverse scored), and *get along pretty well with your friends and family* (baseline *M* = 3.21, *SD* = .95, α = .70; follow-up *M* = 3.54, *SD* = .99, α = .79).

*Stress*. To measure stress, participants rated the frequency of four experiences related to stress, adapted from the Perceived Stress Scale (Cohen, 1983); *feel that you were unable to control the important things in your life*, *feel difficulties were piling up so high that you could not overcome them*, *feel that things are going your way*, and *feel confident about your ability to handle your personal problems* (baseline *M* = 1.94, *SD* = 1.01, α = .75; follow-up *M* = 1.54, *SD* = .89, α = .67).

*Symptoms of Post-traumatic stress disorder (PTSD)*. Four items were adapted from the PTSD checklist, military version (PCL-M; Blanchard, Jones-Alexander, Buckley, & Forneris, 1996; Wilkins, Lang, & Norman, 2011). All participants rated the frequency of the following three experiences: *being “super alert” or watchful on guard*, *feeling distant or cut off from other people*, and *trouble falling asleep or staying asleep*. Additionally, veterans responded to a fourth item that asked specifically about military-related experience, *repeated, disturbing memories, thoughts, or images, of a stressful military experience*, and youth responded to the item, *feeling jumpy or easily startled*. Participants’ PTSD symptoms were calculated by averaging the four items administered to them (baseline *M* = 2.16, *SD* = 1.08, α = .68; follow-up *M* = 1.54, *SD* = 1.04, α = .68).

*Happiness*. Guided by work demonstrating that a single happiness item strongly correlates with established multi-item measures of happiness (Abdel-Khalek, 2006), we measured happiness with a single item asking participants to specify how often in the recent past did they *feel happy* (baseline *M* = 3.22, *SD* = 1.22; follow-up *M* = 3.47, *SD* = 1.20)

**Section 2: Tests of Study 1 Hypotheses using individual measures of well-being and stress-related symptoms**

For ease of presentation in the main text our analyses focused on a composite of all the well-being items that were assessed. In this section, we have conducted analyses of each well-being and stress-related measure separately, testing the hypotheses that 1) people would show improvements in well-being from baseline to follow-up and 2) awe assessed in the rafting diary, above and beyond the other positive emotions measured, would predict improvements in well-being.

*Hypothesis 1.* Table S1 contains the results of repeated measures ANOVAs with the well-being and stress-related measures specified as a within-subject factor and participants status (veterans = 1, youth = 0) as a between subjects factor, which we used to test the significance of changes in these measures. As Table S1 indicates, consistent with our first hypothesis, all of the individual well-being and stress-related symptoms measures showed improvements from baseline before the rafting trip to follow-up one week after the rafting trip. In the case of the stress outcome, we found that there was a significant interaction with participant status, *F*(1,95) = 7.30, *p*  = .008, ηp2 = .07 such that youth showed a greater reduction in stress than veterans from baseline to follow-up. No other measures showed this interaction.

*Hypothesis 2*. To test if awe reported in the rafting diary uniquely predicted improvements in each of the well-being and stress-related measures, we conducted a series of regressions that specified follow-up time point as the outcome, with participant status and baseline time point as predictors, as well as the six emotions measured in the rafting diary: awe, amusement, contentment, gratitude, joy, and pride. The results shown in Table S2 largely support our hypothesis. When controlling for participant status and baseline, awe but not the other five emotions significantly predicted follow-up levels in the PTSD, social well-being, and happiness measures. Awe showed a similar trending pattern for the SWLS. However, the stress outcome did not show the expected effect. In light of the interaction we found in tests of Hypothesis 1 with this measure, we further explored this effect by testing if the amount of awe reported in the diary interacted with participant status and change in well-being. We found a significant three-way interaction *F*(2,90) = 3.71, *p* = .028, ηp2 = .08, such that in youth, awe was consistently related to improvements in stress levels, but in veterans only those who reported high levels of awe reported improvements in stress levels.

In sum, this overall pattern is consistent with the second hypothesis we tested in Study 1. However, the exploratory interaction we found suggests that the effects of nature experiences on certain outcomes may be different for different kinds of people, a possibility that should be confirmed by future work.

**Section 3: Additional information about Study 1 daily life satisfaction measure**

In Study 1, participants reported their daily life satisfaction by responding to the item *How satisfied with your life were you today?* on a scale from 0 (*Not at all*) to 10 (*Completely or Totally*). Responses to this item ranged from 1 to 10; however, the modal response was 10 and the mean was high (M = 8.12, SD = 2.12).

In Study 1, when we entered daily life satisfaction as a predictor in a regression along with participant status and baseline well-being, daily life satisfaction did not significantly predict changes in well-being, b = .009, *t*(94) = .29, *p* = .29, 95% CI [-.05, .07], β = .02. Possible reasons this relationship was observed in Study 2 but not in Study 1 are that that the follow-up well-being measurement is further temporally removed from the diary in Study 1 than in Study 2, and the modal response to the item in Study 1 was the scale maximum, reducing the power of the relevant analyses. The relationship between the emotion and life satisfaction items in the rafting diary are displayed in Table S3.

**Section 4: Additional information about Study 2 method**

In this section we provide additional information about the demographics of the sample, as well as descriptive statistics for the individual measures that made up the longitudinal well-being composite.

**Participants.** In terms of racial and ethnic composition of the sample, 47.9% of participants identified as White, 42% identified as Asian, 16% identified as Latino/Hispanic, 7.6% as Middle Eastern, 3.4% as Black, 2.5% as Native American, and 2.5% as Pacific Islander.

**Measures.**

***Satisfaction with Life Scale***. As in Study 1, the entire five-item scale was assessed in Study 2 (baseline *M*  = 4.73, *SD* = 1.40; follow-up *M* = 4.83, *SD* = 1.38) on a scale from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*).

***Social well-being.*** In Study 2, social well-being was measured with the full social well-being cluster from the MHC-SF (Keyes, 2002, 2009¸ baseline *M*  = 3.15, *SD* = .92; follow-up *M* = 3.41, *SD* = 1.03). Consisting of five items, the social well-being cluster assesses the frequency that people feel social connection on a five-point scale from 0 (*never*) to 5 (*every day*). An example item is, *during the past month how often did you feel that you belonged to a community (like a social group, your school, or your neighborhood)?*

***Psychological well-being.*** In Study 2, psychological well-being was measured with the psychological well-being cluster from the MHC-SF (Keyes, 2002, 2009, *M*  = 4.13, *SD* = 1.01; follow-up *M* = 4.13, *SD* = 1.06). Consisting of six items, this instrument assesses components of well-being such as self-acceptance, (e.g., *in the past month how often did you feel that you liked most parts of your personality?*), and purpose in life (e.g., *in the past month how often did you feel that your life has a sense of direction or meaning to it*?) on a scale from 0 (*never*) to 5 (*every day*).

**Section 5: Alternative models of Study 2 sequential mediation**

In the main text we described a significant indirect effect via a sequential mediation such that the effect of days that people experienced nature on changes in longitudinal well-being was carried through awe and daily life satisfaction in sequence. In this section we report the results from alternative models calculated by the PROCESS macro (Hayes, 2013, Model 6) such as testing each mediator alone and the opposite sequence of mediators (i.e., daily life satisfaction then awe).

The indirect effects of the alternative models that examined each mediator separately were not significant: daily awe, *b* = -.002, *SE* = .04, 95% CI [-.04, .04]; daily well-being, *b* = .02, *SE* = .02, 95% CI [-.03, .06]. Furthermore, when we tested the mediators in the opposite sequence (see Figure S1) there was not a significant indirect effect of daily nature experience on change in longitudinal well-being through serial mediation, *b* = -.0007, *SE* = .01, 95% CI [-.03, .03]. These results further support the sequence of relationships between nature experience, awe, and well-being that we proposed by ruling out alternative possibilities.

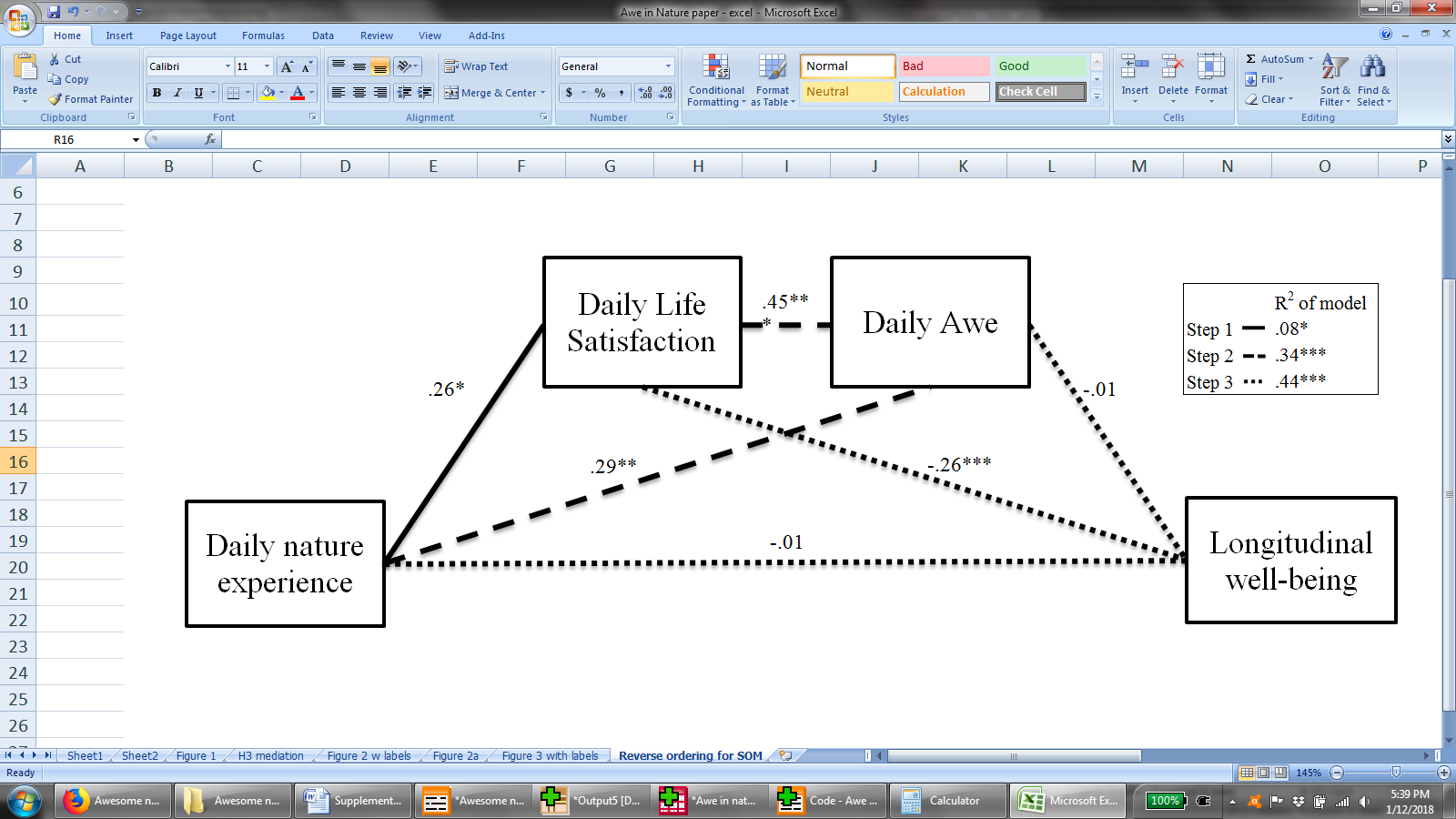
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| Table S1 |  | | |
| *Effect sizes of changes in well-being and stress related symptoms from baseline to follow-up* | | | |
| Measure | Within-subjects contrast | | |
|  | *F* | *p* | ηp2 |
| Satisfaction with life | 11.19 | .001 | .11 |
| PTSD | 53.36 | >.001 | .36 |
| Social well-being | 19.75 | >.001 | .17 |
| Stress | 22.71 | >.001 | .19 |
| Happiness | 4.35 | .040 | .045 |
| *Note*. Baseline was assessed in the morning before the rafting trip began, and follow-up was assessed at least one week after the rafting trip. | | | |

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| Table S2 |  | | | | | |  |  | |  |  | |
| *Influences of positive emotions during the rafting trip on changes in well-being and stress-related symptoms* | | | | | | | | | | | | |
| Emotion | Well-being measures | | | | | | | | | | | |
|  | Satisfaction with life | | PTSD symptoms | | Social  well-being | | Stress | | | Happiness | | |
|  | *β* | *p* | *β* | *p* | *β* | *p* | *β* | | *p* | *β* | | *p* |
| Awe | .17 | .099 | **-.29** | **.008** | **.42** | **.001** | -.09 | | .53 | **.27** | | **.04** |
| Amusement | -.15 | .15 | -.05 | .68 | .07 | .62 | .21 | | .14 | .14 | | .31 |
| Contentment | .07 | .42 | .06 | .55 | -.07 | .54 | -.04 | | .75 | .15 | | .22 |
| Gratitude | .08 | .42 | -.02 | .82 | .11 | .34 | -.10 | | .42 | -.01 | | .93 |
| Joy | .07 | .56 | .16 | .20 | -.22 | .12 | -.15 | | .33 | -.18 | | .22 |
| Pride | -.02 | .89 | -.02 | .87 | -.23 | .09 | .04 | | .80 | -.20 | | .15 |
| *Note.* Results are displayed from multiple regressions with all six emotions and the baselines measure entered as predictors with the follow-up measure as the outcome. Effects significant at the p < .05 level are bolded. | | | | | | | | | | | | |

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| Table S3 |  | |  | |  | |  | |  | |  | |  |  | | | | | |  |  |  |  |  |  |  |
| *Influences of individual emotions on well-being measures and intercorrrelations among measures (Study 1)* | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Emotion | | Effect on daily life satisfaction | | | | | | | | | | |  | Effect on follow-up well-being | | | | | |  | Intercorrelations | | | | | |
|  | | B | | SE | | B | | p | | LCI | | HCI |  | B | SE | B | p | LCI | HCI |  | 1 | 2 | 3 | 4 | 5 | 6 |
| 1. Awe | | .46 | | .07 | | .53 | | <.001 | | .33 | | .60 |  | .05 | .02 | .18 | .012 | .01 | .10 |  | - | .60 | .50 | .47 | .60 | .54 |
| 2. Amusement | | .67 | | .07 | | .66 | | <.001 | | .53 | | .81 |  | .02 | .03 | .05 | .46 | -.03 | .07 |  |  | - | .53 | .50 | .65 | .62 |
| 3. Contentment | | .49 | | .07 | | .53 | | <.001 | | .35 | | .64 |  | .04 | .02 | .11 | .13 | -.01 | .08 |  |  |  | - | .51 | .55 | .47 |
| 4. Gratitude | | .49 | | .08 | | .50 | | <.001 | | .33 | | .64 |  | .06 | .03 | .14 | .053 | -.001 | .12 |  |  |  |  | - | .47 | .51 |
| 5. Joy | | .44 | | .08 | | .46 | | <.001 | | .29 | | .60 |  | .02 | .02 | .07 | .32 | -.02 | .07 |  |  |  |  |  | - | .60 |
| 6. Pride | | .71 | | .07 | | .67 | | <.001 | | .56 | | .85 |  | .03 | .03 | .07 | .32 | -.03 | .08 |  |  |  |  |  |  | - |
| *Note*. The effects displayed in this table are of each individual emotion without controlling for other emotions. Effects of individual emotions on well-being measures are presented as regression coefficients obtained when controlling for participant status (i.e. veteran or youth), and in the case of follow-up well-being, controlling for baseline well-being. The upper (UCI) and lower (LCI) limits indicate the 95% confidence interval of effects. All correlations in the table are significant at *p* < .001 level. | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| Table S4 | | |
| *Number of diary narratives that were coded as nature experiences (Study 2)* | | |
|  | Frequency | Percent |
| 0 | 36 | 30.8 |
| 1 | 34 | 29.1 |
| 2 | 21 | 17.9 |
| 3 | 12 | 10.3 |
| 4 | 6 | 5.1 |
| 5 | 5 | 4.3 |
| 6 | 1 | .9 |
| 7 | 1 | .9 |
| 8 | 1 | .9 |
| *Note.* Total n = 115 participants | | |

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| Table S5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Relationship of individual emotions measured in the daily diary with nature experience and well-being measures, and their intercorrrelations (Study 2)* | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | Effect of coded nature experience | | | | |  | Effect on daily life satisfaction | | | | |  | Effect on follow-up well-being | | | | | |  | Intercorrelations | | | | | |
|  | *B* | *SE* | *p* | LCI | ULI |  | *B* | *SE* | *p* | LCI | ULI |  | *B* | *SE* | *B* | *p* | LCI | ULI |  | 1 | 2 | 3 | 4 | 5 | 6 |
| 1. Awe | 2.08 | .18 | <.001 | 1.71 | 2.44 |  | .32 | .02 | <.001 | .28 | .36 |  | .13 | .04 | .32 | .001 | .05 | .20 |  | - | .46 | .42 | .46 | .49 | .39 |
| 2. Amusement | .43 | .20 | .027 | .05 | .82 |  | .50 | .02 | <.001 | .47 | .53 |  | .19 | .03 | .49 | <.001 | .12 | .25 |  |  | - | .55 | .57 | .73 | .45 |
| 3. Contentment | 1.03 | .18 | <.001 | .67 | 1.39 |  | .46 | .02 | <.001 | .42 | .50 |  | .18 | .04 | .39 | <.001 | .10 | .26 |  |  |  | - | .51 | .58 | .39 |
| 4. Gratitude | .65 | .19 | <.001 | .29 | 1.01 |  | .46 | .02 | <.001 | .42 | .49 |  | .16 | .03 | .43 | <.001 | .09 | .22 |  |  |  |  | - | .56 | .46 |
| 5. Joy | .39 | .18 | .027 | .04 | .73 |  | .58 | .02 | <.001 | .54 | .62 |  | .21 | .03 | .52 | <.001 | .15 | .28 |  |  |  |  |  | - | .50 |
| 6. Pride | .06 | .20 | .77 | -.33 | .45 |  | .36 | .02 | <.001 | .32 | .39 |  | .23 | .04 | .54 | <.001 | .16 | .30 |  |  |  |  |  |  | - |
| *Note*. The effects displayed in this table are of each individual emotion without controlling for other emotions. Effects of coded nature experience on emotions, and emotions on daily life satisfaction are fixed effects generated using multilevel modeling with participant as a random intercept from day-level data. Effect of individual emotions on follow-up well-being are regression coefficients with baseline well-being as a covariate and the emotion independent variables aggregated across the diary. The upper (UCI) and lower (LCI) limits indicate the 95% confidence interval of effects. The correlations are all significant at *p* < .001 level, and were generated from day-level data | | | | | | | | | | | | | | | | | | | | | | | | | |



*Figure S1.* Study 2 sequential mediation model where the order of mediators is switched. As described in Section 4 of these Supplementary Materials, there is no significant indirect effect with this ordering of mediators. Distinct line styles represent different steps in the model. Numbers above lines are unstandardized coefficients of that path. \*\*\* *p* < .001.