How enjoying nature benefits well-being in people's everyday lives

Stefanie Kley[ab]*, Tetiana Dovbischuk[c], Johannes Huinink[d], and Jutta Heckhausen[b]

[a] Department of Social Sciences, University of Hamburg, Germany
[b] School of Social Ecology, University of California at Irvine, CA, USA
[c] Center for Interacting Urban Networks, New York University Abu Dhabi, UAE
[d] Research Center on Inequality and Social Policy, University of Bremen, Germany

Introduction

Numerous studies provide evidence supporting the Stress Reduction Theory (Ulrich et al., 1991; Ulrich, 1983) by showing that exposure to (unthreatening) natural environments elicits a variety of stress-reducing psycho-physiological responses, for instance, decrease in blood pressure and heart rate, as well as lowered perceived arousal and stress (reviews of the literature are provided by Gaekwad et al., 2023; Hartig et al., 2014; James et al., 2015; Kondo et al., 2018; Mygind et al., 2021; Zhang et al., 2020). The underlying mechanism that brings about the beneficial influence of nature exposure on human's psycho-physiological functioning and well-being is likely rooted in the behavioral evolution of primates in their natural habitats (Kaplan & Kaplan, 1989; Ulrich, 1993; Ulrich et al., 1991; Ulrich, 1983). Recent findings about the reduction in amygdala activation associated with walks in nature settings compared to walks in urban environments (Sudimac & Kühn, 2024; Sudimac et al., 2022) might be seen as additional supporting evidence for this *biophilia hypothesis* (Kellert & Wilson, 1993; Wilson, 1984).[1] However, the questions whether beneficial effects of nature exposure are sustainable in the everyday lives of urbanized populations, and in connection with this, whether there is heterogeneity across subgroups of population in this regard, have not been well examined yet. With this study, we are guided by critical appraisals showing that associations found between neighborhood greenspace and psychological well-being are often not consistent (Kabisch, 2019; Lee & Maheswaran, 2010) and may be due more to residual confounding, selection effects, and same-source bias than evidence for a causal effect (Fleckney & Bentley, 2021). The research question is whether and to which extent everyday nature enjoyment directly affects psychological well-being in terms of promoting positive and counteracting negative feelings. In addition, we examine whether the effectiveness of nature enjoyment varies across different parts of the general population, which are diverse in terms of socio-economic status (SES), ethnicity, age and sex. People may employ nature enjoyment strategically to counteract stress and negative feelings (Johnsen, 2013; Pasanen et al., 2018). Therefore, we make use of the Life-Span Theory of Control (Heckhausen & Schulz, 1995) which theorizes such behavior as compensatory control strategies. We are interested in the question to which extent the supposed association between nature enjoyment and affect balance is mediated by both experiences of stressful events and the use of psychological control strategies.

Previous findings about psycho-physiological benefits of nature experience

Effects and associations of nature experience with mental health benefits have been shown in many ways (for systematic reviews of the literature see Bowler et al., 2010; Hartig et al., 2014; Mygind et al., 2021; Roberts et al., 2019; van den Berg et al., 2015; Vitale & Bonaiuto, 2024; Zhang et al.,

[1] For a critical appraisal of the evidence, see Woods, V., & Knuth, M. (2023). The Biophilia Reactivity Hypothesis: biophilia as a temperament trait, or more precisely, a domain specific attraction to biodiversity. *Journal of Bioeconomics*, *25*(3), 271-293. https://doi.org/10.1007/s10818-023-09342-w

2021).[2] In *laboratory experiments,* the subjects were most often exposed to some form of acute stressors, for example, cognitive stress tasks or physical exercise, and were then randomly assigned to be shown photos or videos of either natural or urban scenes. Viewing natural compared to urban and/or control settings was found to reduce physiological stress reactions, most often measured via brain activity, skin conductance levels, blood pressure or heart rates (Grassini et al., 2022; Hedblom et al., 2019; Li et al., 2024; Pretty et al., 2005; Sun et al., 2023; Wood et al., 2020); decreased self-reported stress levels or increased feelings of restoration (Collado & Manrique, 2020; Grassini et al., 2022; Masoudinejad & Hartig, 2020; Wood et al., 2020; Yu et al., 2020); and decreased negative mood states and/or increased positive ones (Collado & Manrique, 2020; Li et al., 2024; Pretty et al., 2005; Sun et al., 2023; Yu et al., 2020).

Field or combined field and laboratory experiments about beneficial effects of nature experience on psycho-physiological and affective well-being typically compared reactions of participants who visited or took a walk in a pleasant natural environment versus in an – often rather unpleasant – urban environment. Several studies found that visiting natural environments was associated with reductions in physiological stress (Abdul Aziz et al., 2021; Kobayashi et al., 2019; Lanki et al., 2017; Saadi et al., 2020; Yin et al., 2023), increased feelings of restoration (Bratman et al., 2015; Gidlow et al., 2016; Hartig et al., 2003; Ojala et al., 2019; Stigsdotter et al., 2017; Tyrväinen et al., 2014; Yin et al., 2023); and a reduction of negative and/or an increase in positive affect or mood (Abdul Aziz et al., 2021; Bratman et al., 2015; Hartig et al., 2003; Saadi et al., 2020; Stigsdotter et al., 2017; Tyrväinen et al., 2014; Vert et al., 2020; Yin et al., 2023). Living in residential areas with high percentages of green space (Dimitrov-Discher et al., 2022), and taking a walk in a natural, but not in an urban environment (Sudimac & Kühn, 2024), were found to be associated with a reduction in stress-related brain activation.

However, some studies found mixed or null-effects regarding positive mood promotion or particular measures of physiological stress recovery (Bowler et al., 2010; Crossan & Salmoni, 2021; Gidlow et al., 2016; Grassini et al., 2022; Hartig et al., 2003; Ojala et al., 2019; Olafsdottir et al., 2020; Stigsdotter et al., 2017; Tyrväinen et al., 2014; Vert et al., 2020; Yu et al., 2020); for critical reviews see Bowler et al. (2010) and Roberts et al. (2019). Besides, whether *everyday* nature experience would yield sizeable and lasting benefits, cannot be concluded from experiments alone.

Observational studies are helpful supplements in this respect. Whereas studies of the health and well-being outcomes of nature experience[3] used to be based on selected and small samples (Kondo et al., 2018), more recent observational studies often aimed for more representative population

[2] There is a growing body of literature dedicated to *virtual* immersion in nature, which we consider less relevant for our study. For recent reviews see Bolouki, A. (2024). The impact of virtual reality natural and built environments on affective responses: a systematic review and meta-analysis. *International Journal of Environmental Health Research*, *34*(1), 73-89. https://doi.org/10.1080/09603123.2022.2130881 , Browning, M. H., Shipley, N., McAnirlin, O., Becker, D., Yu, C.-P., Hartig, T., & Dzhambov, A. M. (2020). An actual natural setting improves mood better than its virtual counterpart: A meta-analysis of experimental data. *Frontiers in Psychology*, *11*, 2200. https://doi.org/10.3389/fpsyg.2020.02200 , Frost, S., Kannis-Dymand, L., Schaffer, V., Millear, P., Allen, A., Stallman, H., Mason, J., Wood, A., & Atkinson-Nolte, J. (2022). Virtual immersion in nature and psychological well-being: A systematic literature review. *Journal of environmental psychology*, *80*, 101765. https://doi.org/10.1016/j.jenvp.2022.101765 .

[3] There is a relatively large body of research linking geographical measures of green space *exposure*, e.g., via vegetation indices, in subjects' residential areas to their psychological well-being or cognitive performance. We do not report on these results here as it often remains unclear to what extent the natural elements are experienced by the subjects. Moreover, as socio-economic status is likely confounded with both residential choice and affect balance, careful controls would be necessary to obtain the net associations between neighborhood greenness and well-being indicators.

samples with relatively high case numbers. Based on such studies, frequent visits of, more time spent in, and higher engagement with natural environments were found related to increased psychological well-being, mental health, and recalled restauration (Hadavi, 2017; Honold et al., 2016; Li et al., 2025; van den Berg et al., 2019; White et al., 2017; Wyles et al., 2019). However, the majority of studies relied on cross-sectional data, while longitudinal designs collecting data via event sampling or diary methods were rare. Notable exceptions that are reviewed underneath are Anderson (2022); Anderson et al. (2018); MacKerron and Mourato (2013); Mascherek et al. (2025); Ryan et al. (2010); Seresinhe et al. (2019).

Making use of smartphone apps or other devices that signaled participants at random moments to fill in a brief questionnaire (i.e., event or experience sampling), while the ecological quality of their location was assessed (objectively via GPS and subjectively), it was found that people were happier in natural and more scenic environments compared to urban and less scenic ones (MacKerron & Mourato, 2013; Seresinhe et al., 2019), and that they felt more active after having spent time outdoors, especially in nature (Ryan et al., 2010). Physical activities and social companionship were additionally significant. Fixed-effects regression was applied to estimate within-person effects net of between-person particularities. However, a similar study found no significant associations of affective well-being with natural surroundings, neither within nor between individuals (Mascherek et al., 2025). Typically, these studies were based on self-selected samples and assessed momentary happiness via single-item questions.

In a diary study targeted at the emotion of 'awe' (Anderson et al., 2018), undergraduate students of a psychology course filled in survey-questions sent by email in 14 consecutive days. Positive emotions were assessed via single-item questions. Nature experience was extracted from a short narrative the subjects were asked to write about an experience of awe they had that day, and if not, alternatively to write about the most positive event of the day. The results indicated positive associations of nature experience with all positive emotions asked for (awe, amusement, contentment, gratitude, and joy), except for 'pride'. Negative emotions and other potential influences on positive affect were not analyzed in this study, and it was restricted to within-person assessments.

In another diary study, Anderson (2022) used data of the Midlife in the United States (MIDUS) refresher sample, where subjects completed surveys across eight consecutive days. He found that enjoying nature *with others* was associated with increased positive and decreased negative affect from day to day (within-person level), while enjoying nature *alone* was not. However, enjoying nature alone did predict both mean positive and mean negative affect levels that the respondents experienced over the week (between-person level). Doing exercise during bouts of nature enjoyment was associated with decreased mean level of negative affect only (i.e., at the between-person level).

The results of these longitudinal studies go beyond earlier findings which suggested that exercise and social interaction, which often co-occur with nature experience, might explain the relationship between enjoying nature and emotional well-being to a large extent (e.g., Hartig et al., 2014; Kuo, 2015). They resonate well with the idea that physical activity and social interaction might be mediators between nature experience and emotional well-being (van den Berg et al., 2019). Studies that have investigated whether people consciously seek out nature to regulate their emotions are also rare. The few studies we found suggest that employing such "environmental strategies" might increase the benefits of nature experience. It was found that self-reported emotion regulation in nature was related to restorative outcomes of nature visits (Johnsen, 2013). Another study found that self-reported stress reduction was the motive for nature visits that was most strongly related to well-being after the visit (Pasanen et al., 2018). Both studies were based on cross-sectional data. In summary, there is some initial evidence for the claim that nature experience generally has

positive effects on individuals' well-being in everyday settings that is worth further investigation. Individual agency may play an important role but has not been examined so far. Therefore, drawing on the Motivational Theory of Life-Span Development (Heckhausen et al., 2010) is a promising avenue for advancing this field of research.

The present study

With this study, we will add to the literature based on more comprehensive survey data from the 3rd wave of the Midlife in the United States survey (MIDUS III) (Ryff et al., 2019), which has been enriched by oversampling of black and metropolitan residents and by including repeated measurements across one week from daily-diary assessments (Ryff & Almeida, 2022a). The longitudinal and multilevel-structure of these data allows to assess whether people's affective well-being is generally influenced by preceding nature experience, that is whether there is a *within-person* effect. In addition, we will systematically analyze *between-person* associations that might come about because people differ in their reactions to nature experience due to socio-demographic, economic, or other factors that differentiate individuals. As affective well-being refers to the experience of pleasant and unpleasant feelings (Tov, 2018), research on happiness and psychological well-being typically refers to the affect balance between these two types of feelings (Veenhoven, 2017), which we follow in this study. Nature experience was measured as *nature enjoyment*. The exclusion of negative connotations of nature experience is in line with an established definition of nature in this field of research (Hartig et al., 2011) and leads to a more precise measurement. We will also consider both stressors and positive experiences more comprehensively than in previous studies. This will allow us to more rigorously test our hypotheses that are presented at the end of this chapter.

Regarding potential 'mechanisms' that might bring about the positive effects of nature experience on well-being, we want to test two pathways. First, in line with the biophilia hypothesis and the evidence described above, nature enjoyment can be expected to counteract stress. Therefore, we want to test whether the supposed positive impact of nature enjoyment on affect balance is enhanced in times of stress experiences (within-persons). Moreover, the benefits of nature enjoyment could be more pronounced in persons with high stress levels (between-persons). Second, people have individual agency in coping with stressors. The "Coming of Age of Sociogenomics" (Mills & Tropf, 2020) has opened the view for more agency-based explanations of individual's traits. For instance, the socio-genomic model of personality traits suggests that many character traits, although heritable to some degree, are not as stable across the life course as widely thought (Damian et al., 2019; Roberts, 2009). Individuals might use nature enjoyment strategically to enhance their affective well-being, for example, to distract themselves from excessive demand and concern. It was suggested that experiencing nature is particularly effective for restoring depleted resources via generating feelings of 'being away' from everyday worries (Kaplan & Kaplan, 1989; Kaplan, 1995). Based on the Motivational Theory of Life-Span Development (Heckhausen et al., 2010) we hypothesize that nature enjoyment is particularly effective when combined with *compensatory secondary control strategies* of action motivation. When individuals experience obstacles in everyday life, compensatory secondary control strategies are used to support and secure the basic motivation to devote effort, time, and skills into reaching (feasible) goals (Heckhausen, 1997; Heckhausen & Schulz, 1993, 1995; Wrosch et al., 2000). For example, individuals might adjust their goals so that they remain achievable (goal adjustment), they might give up commitment to a goal that is perceived as not realizable (disengagement), and/or they might convince themselves of their self-worthiness despite of the difficulties (self-protection).

We expect that individuals from lower socio-economic status (SES) groups are in greater need of stress relief through nature enjoyment, because they are more likely to encounter financial or family worries, to be employed in tedious and underappreciated jobs, and to live in small apartments and unattractive environments. On the other hand, nature enjoyment may be less accessible for low SES individuals than more affluent individuals, who can afford to live closer to parks or in more pricey neighborhoods at the outskirts of big cities. The intra-individual investigation of nature effects allows us to differentiate between these two potential differences between lower and upper SES groups. Another potentially relevant demographic variable could be age. Older people may have health-related mobility restrictions and therefore less access to nature settings, but still may be able to enjoy nature from a window that looks into a green vista (for a literature review on the health and well-being benefits of green window views see Velarde et al., 2007). In addition, green and airy neighborhoods are often a privilege of the affluent whereas those with fewer economic resources and ethnic minorities tend to live in neighborhoods with less tree cover, fewer parks, and more environmental pollution (Abercrombie et al., 2008; Ash & Fetter, 2004; de Vries et al., 2020; Estabrooks et al., 2003; Heynen et al., 2006; Jünger, 2022; Landry & Chakraborty, 2009; Ruttenauer, 2018). Those most in need of restoration through nature experience might have few opportunities. Interestingly, selective studies found *stronger* associations between nature exposure and well-being outcomes in deprived groups, for example, in the mobility-constrained elderly, the youth, the less educated and the working class (Coppel & Wüstemann, 2017; De Vries et al., 2003; Groenewegen et al., 2018; Kley & Dovbischuk, 2024; Maas et al., 2006; Moran et al., 2021; Ruijsbroek et al., 2017; Silveira & Junger, 2018; Wei et al., 2023). However, conflicting with these findings, some studies found similarly strong or even weaker associations for elderly respondents (Coppel & Wüstemann, 2017; Ruijsbroek et al., 2017) and similarly strong associations for people with low SES (Ruijsbroek et al., 2017; Sugiyama et al., 2016; Wang et al., 2022), with few exceptions for particular cities or city areas, where people with low SES profited more from green space exposure (Ruijsbroek et al., 2017; Silveira & Junger, 2018). A main reason for inconsistent results might be that most studies relied on characteristics of people's physical environment (i.e., green space data around people's dwellings) rather than actual self-exposure to natural settings. Therefore, it remained unclear to which extent people experienced natural elements in the course of everyday life. Moreover, since the associations between well-being and exposure to green space were analyzed cross-sectionally, the risk of bias due to omission of important variables is high.

As we rely on survey data, comprehensive assessment of all potential confounders is essential to obtain valid results. Individuals' affective well-being was found to be subject to socio-structural characteristics and personality traits. Regarding age, older adults have been shown to have increased subjective well-being (Charles et al., 2023; Mroczek & Kolarz, 1998; Wrosch et al., 2000), a trend accompanied by decreased time spent in unpleasant emotional states (Kahneman & Krueger, 2006) and increased time spent in positive ones (Mroczek & Kolarz, 1998). More highly educated individuals were normally found happier, but with notable variation across sex, age, and income levels (Wilson Fadiji & Lomas, 2024). Additionally, positive social relationships were found to correlate strongly with affective well-being. For example, social support and feeling respected are strong predictors of emotions (Tay & Diener, 2011). While socio-economic characteristics and ethnic group likely influence a person's baseline affect-level (Kahneman & Krueger, 2006; Tov, 2018), we do *not* expect them to moderate influences of nature enjoyment on daily affect balance. Accordingly, we hypothesize that the supposed association between nature experience and affective well-being remains stable across groups with different socio-structural characteristics.

Personality traits, in particular extraversion – which describes sociable, outgoing individuals – and neuroticism – marked by frequent worry and reduced relaxation – were also found to correlate

strongly with affective well-being (Schimmack et al., 2008). Extraverts may attend to positive stimuli more than introverts (Derryberry & Reed, 1994; Lou et al., 2016), and they may actively seek out pleasant social situations (Emmons et al., 1986). Moreover, extraversion and neuroticism are the only two Big Five personality traits that are considered biological dispositions (Schimmack et al., 2008). These traits, therefore, reflect stable, underlying biological mechanisms in the brain that shape individuals' emotional responses to the world (Conley, 1984; Schimmack et al., 2008). Again, we do not expect extraversion or neuroticism to moderate the impact of nature enjoyment on individual's daily affect balance (within-persons), but extraverts might seek positive nature experience more often compared to other persons, leading to increased well-being levels of extraverts due to nature enjoyment (between-persons). Therefore, these two personality traits will be controlled for in the analyses.

In conclusion, we hypothesize that:

(H1a) Nature enjoyment *on a given day* has positive effects on individual's affect balance (i.e., within persons), and (H1b) an individual's *frequent* nature enjoyment is positively related to it (i.e., between persons).

(H2) The beneficial effect of nature enjoyment on affect balance is robust against variation in age, sex, ethnic group, educational level, partnership status, and social status (i.e., it is not moderated by these characteristics to a significant extent).

(H3a) Nature enjoyment *on a given day* particularly benefits individual's affect balance after experiencing stressful events (i.e., within persons), and (H3b) *frequent* nature enjoyment is more positively related to affect balance in persons with high mean stress levels (i.e., between persons).

(H4) The beneficial effect of nature enjoyment on affect balance is subject to individual differences in readiness to use compensatory secondary control strategies.

Method

Procedures and participants

The data come from the 3rd wave of the Midlife in the United States survey (MIDUS III) (Ryff et al., 2019), enriched by a daily-diary study in which respondents completed telephone interviews in up to 8 days in a row (Ryff & Almeida, 2022a). Making use of the Day Reconstruction Method (Ryff & Almeida, 2022b), n=1,236 respondents aged 47 to 94 were interviewed by telephone about their physiological and psychological well-being and about what has happened since yesterday. The daily-diary study was fielded throughout the years 2017–19, in succession of the main data collection of MIDUS III and its enrichment with non-white participants via the 'Milwaukee'-oversample of people identifying as black (Ryff et al., 2023). This compensation for the underrepresentation of blacks is advantageous for our goal of researching effect heterogeneity.

At the onset of the MIDUS I survey, participants aged 25 to 74 had been recruited via a national Random Digit Dialing (RDD) sample. This sample was enlarged by recruiting siblings of individuals from the RDD sample; by the drawing of another national RDD sample of twin pairs; and by oversamples from five metropolitan areas in the U.S. (Ryff et al., 2019). The recruitment of an oversample of African Americans aged between 35 and 85 in the Milwaukee metropolitan area was part of the follow-up MIDUS II study (Ryff et al., 2023). All eligible participants were non-institutionalized, English-speaking adults in the United States. The data used in this study stem from interviews by telephone and mail-in self-administered questionnaires.

To form the estimation sample, information of respondents who did report on less than 14 out of 27 items measuring positive and negative affect, and those who did not report on nature enjoyment were excluded (63 individuals in sum). Another 26 individuals were excluded because they were only interviewed once during the eight days of the diary study. After applying these criteria that result in an exclusion of 7.2% of the respondents, the estimation sample comprises n=1,147 individuals, providing N=8,741 observations. Individuals were observed on average at 7.7 days, and only 5.7% of individuals were observed fewer than six days.

Measures

The outcome was coded as *affect balance*, based on 13 items of positive and 14 items of negative affect (Watson et al., 1988). Positive affect items were, for example, cheerful; full of life; close to others; attentive; confident. Negative affect items were, for example, worthless; lonely; afraid; ashamed; angry. The respondents were asked how much of the time today they felt in this way, on a scale from (0) none of the time, (1) a little of the time, (2) somewhat of the time, (3) most of the time, (4) all of the time. Affect balance was calculated as a mean score of positive minus negative items, demanding 14 items at a minimum (Cronbach's alpha=0.93). It ranges from –1.74 to 2.08. As this is a rather narrow span, we do expect small effect sizes. **Table A1** in the appendix depicts the unstandardized distribution of the individuals' characteristics in the estimation sample.

Nature enjoyment was assessed with the question (Ryff & Almeida, 2022b): *"Since this time yesterday did you spend any time enjoying or viewing nature? Please do not include any events you have previously mentioned".* Valid answers were "yes" and "no". We think that this question targets nature experience well, as it explicitly asks for *additional* nature experience that was not mentioned as part of the positive events reported before. Respondents reported nature enjoyment in 9.3% of the daily observations.

Positive events (Almeida et al., 2002) that respondents experienced during the day referred to interactions with other people; experiences at work or volunteer positions; experiences at home; experiences of close friends or relatives that turned out to be positive for the respondent; anything else that happened. The items were summed up to the number of positive events (0–5).

Stressors were assessed with regard to seven forms of negative experiences, each surveyed on a scale from (3) very stressful, (2) somewhat, (1) not very, and (0) not at all stressful (Almeida et al., 2002). The items referred to an argument or disagreement with someone; anything that happened that the respondent could have argued about but decided to let pass in order to avoid disagreement; anything that happened at work or school (other than already mentioned); anything that happened at home (other than already mentioned); experience of discrimination on the basis of, for example, race, sex, or age; anything that happened to a close friend or relative (other than already mentioned) that turned out to be stressful for the respondent; anything else that happened. Each of the items were multiplied with the scale value of severity and then summed up to form stressor severity, ranging from 0–15.

Physical health symptoms were assessed with 28 items, whereas the respondents were asked to rate each of the symptoms on a scale from (1) very mild to (10) very severe (Larsen & Kasimatis, 1991). They included, for example, headache; nausea; chest pain; skin, eye, and teeth related symptoms. Again, each of the health items were multiplied with the scale value of severity and then summed up to form a scale ranging from 0–68.

Additional predictors of affect balance stem from the main study projects of MIDUS III and are therefore constant across the daily assessments.

Control strategies included multi-item measures of two forms of primary control strategies, that is selective and compensatory primary control, and two forms of secondary control strategies, that is disengagement and self-protection. Each of them was averaged to form scales from 1 to 4 (Heckhausen & Schulz, 1993, 1995; Wrosch et al., 2000).

Socio-economic status (SES) was analyzed in two forms: educational level and perceived status. *Educational level* was measured with a 12-point scale ranging from (1) no school or some grade school to (12) postgraduate studies completed. In line with other studies using the same dataset (Boylan et al., 2015), the items were combined to form three categories:[4] 'high school or less'; 'some college'; and 'tertiary' ranging from 'grad. from 2-year college, vocational' to 'Ph.D., Ed.D., MD, DDS, LLB, LLD, JD'. *Social status* was measured with the MacArthur Scale of Subjective Social Status (Adler et al., 2000) as perceived rank with respect to one's community with a ladder from (1) top rung to (10) bottom rung. It was reversely coded so that high numbers reflect high perceived social status and treated as metric (O'Leary et al., 2021).

Ethnic background was coded based on multiple questions about respondents' descent and 'racial' origin, following the procedures of the U.S. Census Bureau and the Pew Research Center[5]. When respondents named more than one group, their answers to the question about which ethnic group best described their background was used instead. The coding resulted in the categories 'white (non-hispanic)', 'hispanic', 'black', and 'other'. *Partnership* status indicates married or cohabiting individuals and was coded with (1) yes or (0) no. *Sex* was assessed with the question "What is your sex?". The two response options were coded with (1) female and (0) male. The *personality traits* 'extraversion' and 'neuroticism' were measured with multiple items each and summarized to form scales from 1 to 4 (Mroczek & Kolarz, 1998).

Analysis strategy

To test our hypotheses, we start with a fixed-effects regression but then conduct two-level regression analyses with full information maximum likelihood estimation (Muthén & Muthén, 2017). The repeated observations across the daily-diary assessments constitute level 1; they are nested in individuals that constitute level 2. In addition to the daily measured values for enjoyment of nature, positive events, stressors, and physical health symptoms, their means over the observation period are also included.[6] This allows the separation of influences that might occur within the individual, for example, because of a daily experience, from those that might occur across individuals, for example, because individuals react differently to experiences (Hamaker & Muthen, 2020). As this approach is well suited to isolate the influences nature enjoyment might have on the affect balance *within* individuals, the resulting 'fixed-effect' coefficients on level 1 correspond to those one gets in fixed-effects regression and might be interpreted as causal effects (Brüderl & Ludwig, 2015). Fixed-effects estimation has emerged as the gold standard in life-course research based on longitudinal observational studies (Huinink & Brüderl, 2021). To account for greater homogeneity in unobserved characteristics between siblings compared to single persons in the sample, we estimate robust standard errors.[7]

---

[4] For sensitivity analyses, the original 12 categories of educational attainment were used as a quasi-metric scale. The results were similar in either way of coding.

[5] https://www.pewresearch.org/short-reads/2024/09/12/who-is-hispanic/

[6] Therefore, at the individual level the incremental between-person main effects of enjoyment of nature, positive events, stressors, and physical health symptoms are estimated Hoffman, L. (2014). *Longitudinal analysis: Modeling within-person fluctuations and change*. Taylor & Francis.

[7] A relatively high share of 24.0% of the respondents have 1 to 4 siblings in the estimation sample, forming 'families'. Preparatory analyses showed smaller variances within than across families in affect balance (Levene's

First, it is estimated whether nature enjoyment is associated with improved affect balance at the within- and between-person levels, and whether this is still the case when positive events during that day, stressor severity and health symptoms are controlled for. Then, we test for interactions between nature enjoyment, SES, and demographic characteristics. With these analyses of possible moderators, the stability of the relationship between nature enjoyment and affect balance across population groups is assessed. Finally, we test interactions between nature enjoyment and both, stressor severity and compensatory control strategies. All metric variables were standardized.[8] A quadratic term for age was not significant in the multivariate models.

Results

Applying fixed-effects regression to estimate the effects of nature experience on the affect balance *within* individuals yields a significant bivariate association (b=0.029, se=0.009, p=0.001; not shown in the Tables). In contrast, the null-model suggests that a high proportion of the variance in affect balance is based in differences between individuals (Intraclass Correlation Coefficient=0.749). Therefore, estimating a multilevel model with daily assessments on the first and individual assessments on the second level, is appropriate.

Model 1a in **Table 1** shows parameters based on a two-level regression analysis with random intercepts with full information maximum likelihood estimation and robust standard errors. At the within-person level, nature enjoyment is again significantly related to affect balance (b=0.031, sd=0.008, p<0.001). This effect is additive to other positive events that the respondents might have experienced that same day, additive to the number and severity of stressful events, and additive to health symptoms severity. As expected, nature enjoyment and other positive experiences are positively related to affect balance, whereas stress and health symptoms are negatively related to it. At the between-person level, we find no additional association of mean nature experience with affect balance. Therefore, H1a stating that nature enjoyment on a given day has positive associations with an individual's affect balance (i.e., within persons) is supported by these data, whereas H1b that frequent nature enjoyment is positively related to it (i.e., between persons) is not.

test of equal variances, f =1.172 (df=6640, 2099), p=0.000), stressor severity (f=1.100 (df=6640, 2099), p=0.005), and disengagement (f=1.144 (df=6361, 2052), p=0.000), which are key variables in this analysis.

[8] Standardization of the within-person slope with the within-person standard deviations, and standardization of the between-person slopes with the between-person standard deviations, is implemented in MPLUS (Hamaker, E. L., & Muthen, B. (2020). The fixed versus random effects debate and how it relates to centering in multilevel modeling. *Psychol Methods*, *25*(3), 365-379. https://doi.org/10.1037/met0000239).

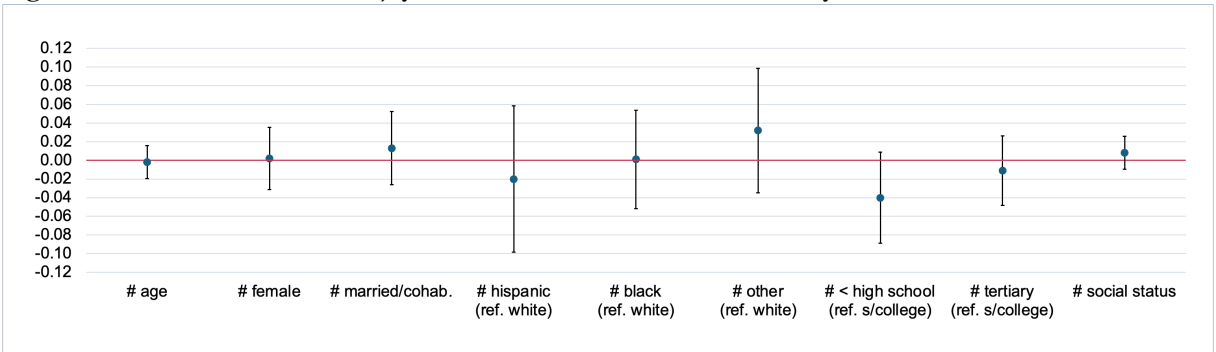
Table 1: Affect balance regressed on nature enjoyment and other predictors

	Model 1a				Model 1b			
Affect balance	Coef.	Std. Dev.	p-value	Sig.	Coef.	Std. Dev.	p-value	Sig.
Level 1: daily assessments								
Nature enjoyment	.031	.008	.000	***	.031	.008	.000	***
Positive experiences	.029	.004	.000	***	.029	.004	.000	***
Stressor severity	-.075	.004	.000	***	-.075	.004	.000	***
Health symptoms severity	-.022	.005	.000	***	-.022	.005	.000	***
Level 2: individuals' mean assessments and traits								
Mean nature enjoyment	-.003	.011	.817		-.016	.010	.110	
Mean positive experiences	.077	.012	.000	***	.030	.011	.005	***
Mean stressor severity	-.141	.014	.000	***	-.098	.012	.000	***
Mean health symptoms severity	-.041	.012	.000	***	-.046	.011	.000	***
Age					.017	.010	.076	*
Sex: female					.025	.020	.210	
Married/cohabiting					.087	.020	.000	***
Ethnic group: ref. white								
hispanic					.023	.048	.640	
black					-.003	.037	.938	
other					-.078	.035	.039	**
Educ. level: ref. some college								
high school or less					.014	.028	.625	
tertiary degree					-.078	.024	.001	***
Social status					.024	.011	.033	**
Extraversion					.086	.011	.000	***
Neuroticism					-.061	.011	.000	***
Selective primary control					.041	.011	.000	***
Compensatory prim. control					.046	.010	.000	***
Disengagement					-.008	.010	.411	
Self-protection					.043	.012	.000	***
Survey year: ref. 2017								
2018	-.005	.024	.845		-.003	.020	.886	
2019	.058	.033	.080	*	.060	.029	.038	**
Constant	1.187	.019	.000	***	1.159	.030	.000	***
Residual variance within individuals	.050	.002	.000	***	.050	.002	.000	***
Residual variance between individuals	.120	.007	.000	***	.083	.005	.000	***
Number of observations			8741				8741	
Chi^2			4136.4				4875.9	
Prob > Chi^2			0.000				0.000	
R_m^2			0.20				0.37	
R_c^2			0.76				0.76	

**** p<.01, ** p<.05, * p<.1* Intraclass Correlation Coefficient (ICC) of affect balance = 0.749.
Two-level regression analyses with random intercept; full information maximum likelihood estimation; robust standard errors; metric predictors are standardized.
Data: Midlife in the United States (MIDUS) III

Based on Model 1a, cross-level interaction terms with nature enjoyment and individual characteristics on affect balance are estimated (**Figure 1** and Table A2 in the appendix). None of the interaction terms is statistically significant, lending support to H2: The beneficial effect of nature enjoyment on affect balance within persons is robust against variation in age, sex, ethnic group, educational level, partnership status, and social status.

Figure 1: Moderation of nature enjoyment's influence on affect-balance by socio-structural characteristics



95% confidence intervals; number of observations = 8741
Two-level regression analyses with random intercept and random slope of daily nature enjoyment; full information maximum likelihood estimation; robust standard errors.
# denotes interaction with daily nature enjoyment; metric predictors are standardized.
Other variables as in Table 1, Model 1a.
Data: Midlife in the United States (MIDUS) III

Including all socio-economic characteristics and personality traits in Model 1b depicted in Table 1 leaves the coefficients at the within-person level unchanged. However, some notable adjustments of predictors are found at the individual level. The influences of mean levels of positive experiences and stressor severity across the week of the daily-diary assessments on affect balance are attenuated. However, they are still significantly related to affect balance, as is mean health symptoms severity. Other socio-economic characteristics and personality traits are additionally significant. Marriage or cohabiting, high social status, and scoring high on extraversion are positively related to affect balance, whereas tertiary educational degrees and scoring high on neuroticism are negatively related to it. Individuals scoring high on selective and/or compensatory primary control strategies show a more positive affect balance, as do those who employ self-protection as a compensatory secondary control strategy.

As an indicator of the model fit, we calculated the marginal R_m^2, which indicates the variance explained by the fixed factors (Nakagawa et al., 2012). The value is 0.20 for Model 1a and 0.37 for Model 1b, which indicates a good fit. In addition, we report that the conditional R_c^2, which represents the explained variance by the fixed and the random factors, is 0.76 for both models.

Following Anderson's (2022) findings about the beneficial effects of experiencing nature with others, we also tested whether the relationship between nature enjoyment and affect balance depends on whether one experiences it in the company of other people. In our data, this was not the case. When added to the full Model 1b, enjoying nature in company was not additionally significant, neither at the within-person level (b=0.017, sd=0.018, p=0.332) nor at the between-person level (b=0.012, sd=0.011, p=0.264), and the main coefficients of nature enjoyment remained stable (not shown in the tables).

In the last step, interaction effects between nature enjoyment and both stressor severity and employing compensatory strategies of control were tested (**Table 2 and Figure 2**). As preparatory analyses revealed that only disengagement showed significant effects, we concentrate on displaying this control strategy. Hypothesis 3a stating that nature enjoyment particularly benefits individual's affect balance after experiencing stressful events (i.e., within-person) is not supported, as neither the within-person interaction nor the cross-level interaction with stressor severity is significant (see Table 2). However, frequent nature enjoyment is more positively related to affect balance in persons with high mean stress levels (i.e., between-persons, $p<0.05$), corroborating H3b.

Table 2: Interactions of nature enjoyment with stress and disengagement

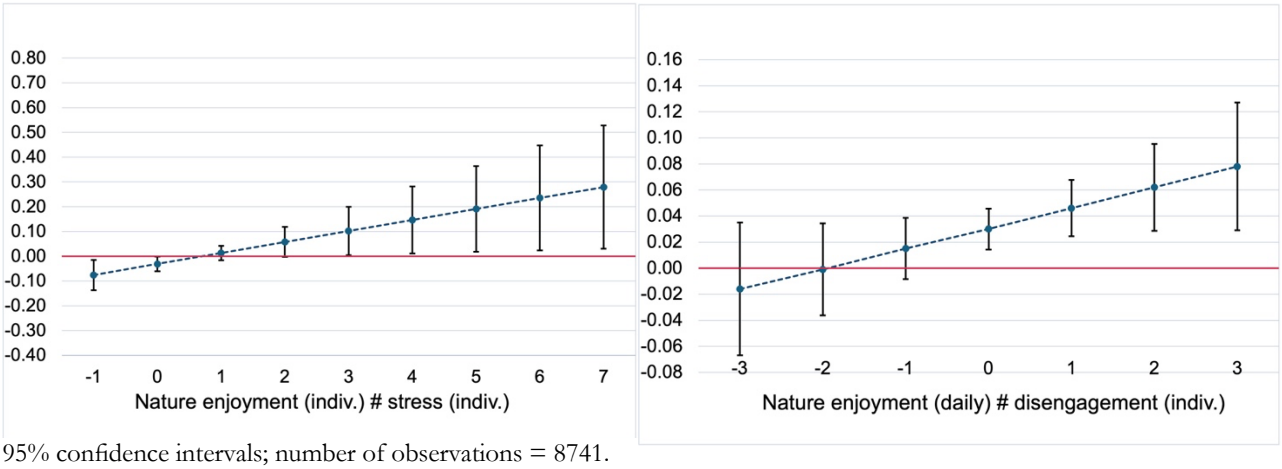
Affect balance	Coef.	Std. Dev.	p-value	Sig.
Nature enjoyment, daily				
# stress (daily)	-.004	.006	.530	
# mean stress (cross-level.)	.005	.010	.623	
# disengagement (cross-level.)	.016	.008	.049	**
Mean nature enjoyment, indiv.				
# mean stress	.044	.019	.023	**
# disengagement	.074	.062	.238	

*** p<.01, ** p<.05, * p<.1; number of observations = 8741
Two-level regression analyses with random intercept and random slope of daily nature enjoyment; full information maximum likelihood estimation; robust standard errors.
Single models per interaction (#) with nature enjoyment; metric predictors are standardized.
Other variables as in Table 1, Model 1a.
Data: Midlife in the United States (MIDUS) III

Moreover, the beneficial effect of nature enjoyment on affect balance is subject to variation in secondary control ($p<0.05$), supporting H4. Particularly, individuals, who are able to disengage from the perseverance of goal achievement when they encounter obstacles, seem to profit more from daily nature enjoyment (see Table 2).

Marginal effect plots in Figure 2 reveal that nature enjoyment particularly benefits the affect balance of individuals with high individual stress levels (left-hand panel 2a; coef.=0.044, p=0.023), and of those who employ disengagement as a secondary control strategy (right-hand panel 2b; coef. 0.16, p=0.049). Nature enjoyment seems to have a slightly negative association at the left-hand end of the distribution of individuals who are not at all stressed but further analyses reveal a non-linear form of the interaction coefficient that approaches zero in individuals with very low stress levels.

Figure 2: Average marginal effects of nature enjoyment on affect balance by stress and disengagement



95% confidence intervals; number of observations = 8741.
Two-level regression analyses with random intercept (2a, left panel) and with random intercept and random slope of nature enjoyment (2b, right panel); full information maximum likelihood estimation; robust standard errors.
Single models per interaction (#) with nature enjoyment; metric predictors are standardized. Other variables as in Table 1, Model 1a.
Data: Midlife in the United States (MIDUS) III

Discussion

In a world characterized by rapid urbanization and high shares of time spent indoors (Klepeis et al., 2001; United Nations, 2019), we need to know, whether and to which extent nature experience might help to reduce the global burden of disease attributable to mental illness (Bratman et al., 2019; Frumkin et al., 2017). Numerous previous studies have shown that positive and negative affect has important associations with overall physical health (Boehm & Kubzansky, 2012). We analyzed people's affective responses to experiencing or viewing nature on a day-to-day basis. So far, only a handful of studies investigated longitudinally whether everyday contact with nature relates to affective well-being. We used daily-diary data of the study Midlife in the United States (MIDUS) III and employed multilevel regression to separate within-person effects from between-person associations. This allowed us to systematically explore differences and similarities between state and trait measures of well-being in connection with nature experience, which has been little studied to date (Tov, 2018). Moreover, compared to most previous observational studies, the database of our analyses was larger (n>1,100 respondents, N>8,700 observations) and richer in well-established psychological instruments, and, thanks to oversamples of black and metropolitan residents, more diverse regarding socio-economic characteristics. Furthermore, measuring 'nature experience' with one item from a list of positive experiences (Ryff & Almeida, 2022a) was in line with the established definition of Hartig and colleagues (2011), who refer to seemingly natural features and processes that people perceive directly via their own senses (sight, hearing, touch, and smell) and in their everyday environment.

The results showed that everyday nature enjoyment increased within-person affect balance to a similar extent as other positive experiences that were mainly of a social nature, and that nature enjoyment counteracts stressors and health symptoms. Eventual effect-moderation through socio-economic and demographic characteristics was explicitly tested. Very small coefficients, which were not significant, supported our expectation that the positive influence of nature enjoyment on within-person affect balance remains stable across population groups. To our best knowledge, this is the first study that has systematically tested moderation of nature enjoyment on affect balance.[9]

Our finding of a universal positive influence of nature enjoyment on within-person affect balance is in some contrast to Anderson's (2022) finding that nature enjoyment was only beneficial when experienced together with others. Additionally, we found in contrast to Anderson's (2022) study that frequent nature enjoyment had no significant association with mean affect balance between-persons. This means that people who enjoy nature frequently differ not systematically from those who do this seldom regarding their affect balance. These findings consistently support the interpretation that individuals' affective well-being benefits from nature irrespective of their differences in individual characteristics and habits.

Regarding the 'mechanisms' that bring affective well-being about, we built on the Stress Reduction Theory regarding nature experience (Ulrich et al., 1991; Ulrich, 1983) that has been repeatedly supported through findings form laboratory and field experiments. Correspondingly, we hypothesized that nature enjoyment is particularly beneficial when individuals are highly stressed. However, contrary to our expectation, nature enjoyment was not found to be moderated by stressor severity within- but only between-persons. We think that the within-persons null-moderation might not reflect the true effect but could be based in the observational design of our study. The temporal sequence of stressor experience and nature enjoyment was not taken into account, as several hours could have passed between stressor experience, nature enjoyment, and

[9] For a meta-moderation-analyses of short-term nature exposure on depression see Roberts, H., van Lissa, C., Hagedoorn, P., Kellar, I., & Helbich, M. (2019). The effect of short-term exposure to the natural environment on depressive mood: A systematic review and meta-analysis. *Environmental research*, *177*, 108606. https://doi.org/10.1016/j.envres.2019.108606 .

recording of the responses. However, empirical support for the acute stress-reducing effect of immersion in natural environments is generally weak due to methodological challenges (Mygind et al., 2021). At the between-person level we found that respondents who were at average burdened by higher stress profited more from regular nature enjoyment, as their affect balance was more improved compared to less stressed individuals. This finding is consistent with the Theory of Stress Reduction (Ulrich et al., 1991; Ulrich, 1983).

However, it could also be that highly stressed individuals are motivated to seek nature enjoyment more frequently. To probe deeper into the question whether people make use of "environmental strategies" (i.e., selecting a beneficial environment) for affect regulation, as suggested by earlier studies (Johnsen, 2013; Pasanen et al., 2018), we studied motivational control strategies in connection with nature enjoyment, based on the Motivational Theory of Life-Span Development (Heckhausen et al., 2010). We found that nature enjoyment particularly benefited the affect balance of respondents who were capable of disengaging from goals perceived as too difficult or costly to pursuit further. This finding supports the idea that individuals employ "environmental strategies" by using everyday nature enjoyment for motivational and affect regulation. To our best knowledge, this is the first study that explicitly tested moderation of nature enjoyment based on a general motivational theory. We conclude from this finding that a better integration of control striving into theoretical models that address the relationship between nature experience and affective well-being, or psychological functioning, would be promising to further advance this field of research.

The recommendations resulting from the findings of this study regarding public health policies are obvious. Neighborhood structures that enable everyday nature enjoyment are important for health outcomes and should be prioritized in public-health policies. Good access to everyday nature enjoyment in city dwellers' neighborhoods might be a cost-effective strategy to support public health (Hartig et al., 2014). On average, people tend to underestimate the mood benefits of brief contact with nature (Nisbet et al., 2011). Therefore, individuals might not be aware of the more subtle health benefits and threats of their surroundings. For those who have to cope with mobility restrictions, opportunities of nature enjoyment in the close surroundings are particularly important. After all, for efficiently counteracting the adverse effects of health-threats on emotional distress, control strategies have to be well adjusted to the individual's opportunities (Heckhausen et al., 2010; Wrosch & Heckhausen, 2024).

A limitation regarding the generalizability of our findings could lie in the relatively high age of respondents (47 to 94 years). It might be the case that the effective connection between nature enjoyment and goal disengagement on enhanced affect balance found in this study might not be found in younger populations. After all, effective goal *engagement* has primacy for affective well-being, whereas goal *disengagement* and other compensatory control strategies are downstream and come into play out of necessity, particularly when people age (Barlow et al., 2016; Heckhausen et al., 2010; Heckhausen et al., 2019; Wrosch & Schulz, 2008). However, as we found a sizeable coefficient of nature enjoyment on affect balance within-persons that was robust across population groups, this main finding remains substantial. Future studies might want to probe deeper into the question how people's everyday environments could be improved in a way that supports nature enjoyment and its strategic use for maximizing psychological well-being.

References

Abdul Aziz, N. A., Shian, L. Y., Mokhtar, M. D. M., Raman, T. L., Saikim, F. H., Chen, W., & Nordin, N. M. (2021). Effectiveness of urban green space on undergraduates' stress relief in tropical city: A field experiment in Kuala Lumpur. *Urban Forestry & Urban Greening*, *63*, 127236. https://doi.org/10.1016/j.ufug.2021.127236

Abercrombie, L. C., Sallis, J. F., Conway, T. L., Frank, L. D., Saelens, B. E., & Chapman, J. E. (2008). Income and racial disparities in access to public parks and private recreation facilities. *Am J Prev Med*, *34*(1), 9-15. https://doi.org/10.1016/j.amepre.2007.09.030

Adler, N. E., Epel, E. S., Castellazo, G., & Ickovics, J. (2000). Relationship of Subjective and Objective Social Status With Psychological and Physiological Functioning: Preliminary Data in Healthy White Women. *Health Psychology*, *19*, 586-592. https://doi.org/10.1037/0278-6133.19.6.586

Almeida, D., Wethingtone, E., & Kessler, R. (2002). The daily inventory of stressful events. An interview-based approach for measuring daily stressors. *Assessment*, *9*, 41-55. https://doi.org/10.1177/1073191102091006

Anderson, A. R. (2022). Enjoying nature, exercise, social interaction, and affect: A daily diary study. *Journal of Health Psychology*, *27*(4), 890-900. https://doi.org/10.1177/1359105320977642

Anderson, C. L., Monroy, M., & Keltner, D. (2018). Awe in nature heals: Evidence from military veterans, at-risk youth, and college students. *Emotion*, *18*(8), 1195-1202. https://doi.org/10.1037/emo0000442

Ash, M., & Fetter, T. R. (2004). Who Lives on the Wrong Side of the Environmental Tracks? Evidence from the EPA's Risk-Screening Environmental Indicators Model*. *Social Science Quarterly*, *85*(2), 441-462. https://doi.org/10.1111/j.0038-4941.2004.08502011.x

Barlow, M., Wrosch, C., Heckhausen, J., & Schulz, R. (2016). Control Strategies for Managing Physical Health Problems in Old Age: Evidence for the Motivational Theory of Life-Span Development. In J. W. Reich & F. J. Infurna (Eds.), *Perceived control: Theory, research, and practice in the first 50 years*. Oxford University Press.

Boehm, J. K., & Kubzansky, L. D. (2012). The heart's content: the association between positive psychological well-being and cardiovascular health. *Psychol Bull*, *138*(4), 655-691. https://doi.org/10.1037/a0027448

Bolouki, A. (2024). The impact of virtual reality natural and built environments on affective responses: a systematic review and meta-analysis. *International Journal of Environmental Health Research*, *34*(1), 73-89. https://doi.org/10.1080/09603123.2022.2130881

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*, *10*(1), 456. https://doi.org/10.1186/1471-2458-10-456

Boylan, J. M., Lewis, T. T., Coe, C. L., & Ryff, C. D. (2015). Educational Status, Anger, and Inflammation in the MIDUS National Sample: Does Race Matter? *Annals of Behavioral Medicine*, *49*(4), 570-578. https://doi.org/10.1007/s12160-015-9687-2

Bratman, G. N., Anderson, C., Berman, M. G., Cochran, B., & al., e. (2019). Nature and mental health: An ecosystem service perspective. *Science Advances*, *5*(eaax0903), 1-14. https://doi.org/10.1126/sciadv.aax0903

Bratman, G. N., Daily, G. C., Levy, B. J., & Gross, J. J. (2015). The benefits of nature experience: Improved affect and cognition. *Landscape and Urban Planning*, *138*, 41-50. https://doi.org/10.1016/j.landurbplan.2015.02.005

Browning, M. H., Shipley, N., McAnirlin, O., Becker, D., Yu, C.-P., Hartig, T., & Dzhambov, A. M. (2020). An actual natural setting improves mood better than its virtual counterpart: A meta-analysis of experimental data. *Frontiers in Psychology*, *11*, 2200. https://doi.org/10.3389/fpsyg.2020.02200

Brüderl, J., & Ludwig, V. (2015). Fixed-effects panel regression. In H. Best & C. Wolf (Eds.), *The Sage handbook of regression analysis and causal inference* (pp. 327-357). SAGE.

Charles, S. T., Rush, J., Piazza, J. R., Cerino, E. S., Mogle, J., & Almeida, D. M. (2023). Growing old and being old: Emotional well-being across adulthood. *Journal of Personality and Social Psychology*, *125*(2), 455-469. https://doi.org/10.1037/pspp0000453

Collado, S., & Manrique, H. M. (2020). Exposure to awe-evoking natural and built scenes has positive effects on cognitive performance and affect. *Environment and behavior*, *52*(10), 1105-1132. https://doi.org/10.1177/0013916519868733

Conley, J. J. (1984). The hierarchy of consistency: A review and model of longitudinal findings on adult individual differences in intelligence, personality and self-opinion. *Personality and Individual Differences*, *5*(1), 11-25. https://doi.org/10.1016/0191-8869(84)90133-8

Coppel, G., & Wüstemann, H. (2017). The impact of urban green space on health in Berlin, Germany: Empirical findings and implications for urban planning. *Landscape and Urban Planning*, *167*, 410-418. https://doi.org/10.1016/j.landurbplan.2017.06.015

Crossan, C., & Salmoni, A. (2021). A Simulated Walk in Nature: Testing Predictions From the Attention Restoration Theory. *Environment and behavior*, *53*(3), 277-295. https://doi.org/10.1177/0013916519882775

Damian, R. I., Spengler, M., Sutu, A., & Roberts, B. W. (2019). Sixteen going on sixty-six: A longitudinal study of personality stability and change across 50 years. *J Pers Soc Psychol*, *117*(3), 674-695. https://doi.org/10.1037/pspp0000210

de Vries, S., Buijs, A. E., & Snep, R. P. H. (2020). Environmental Justice in The Netherlands: Presence and Quality of Greenspace Differ by Socioeconomic Status of Neighbourhoods. *Sustainability*, *12*(15). https://doi.org/10.3390/su12155889

De Vries, S., Verheij, R. A., Groenewegen, P. P., & Spreeuwenberg, P. (2003). Natural Environments—Healthy Environments? An Exploratory Analysis of the Relationship between Greenspace and Health. *Environment and Planning A: Economy and Space*, *35*(10), 1717-1731. https://doi.org/10.1068/a35111

Derryberry, D., & Reed, M. A. (1994). Temperament and attention: orienting toward and away from positive and negative signals. *J Pers Soc Psychol*, *66*(6), 1128-1139. https://doi.org/10.1037//0022-3514.66.6.1128

Dimitrov-Discher, A., Wenzel, J., Kabisch, N., Hemmerling, J., Bunz, M., Schöndorf, J., Walter, H., Veer, I. M., & Adli, M. (2022). Residential green space and air pollution are associated with brain activation in a social-stress paradigm. *Scientific reports*, *12*(1), 10614. https://doi.org/10.1038/s41598-022-14659-z

Emmons, R. A., Diener, E., & Larsen, R. J. (1986). Choice and avoidance of everyday situations and affect congruence: two models of reciprocal interactionism. *Journal of Personality and Social Psychology*, *51*(4), 815-826. https://doi.org/10.1037/0022-3514.51.4.815

Estabrooks, P., Lee, R., & Gyurcsik, N. (2003). Resources for Physical Activity Participation: Does Availability and Accessibility Differ by Neighborhood Socioeconomic Status? *Annals of Behavioral Medicine*, *25*(2), 100-104.

Fleckney, P., & Bentley, R. (2021). The urban public realm and adolescent mental health and wellbeing: A systematic review. *Social science & medicine*, *284*. https://doi.org/10.1016/j.socscimed.2021.114242

Frost, S., Kannis-Dymand, L., Schaffer, V., Millear, P., Allen, A., Stallman, H., Mason, J., Wood, A., & Atkinson-Nolte, J. (2022). Virtual immersion in nature and psychological well-being: A systematic literature review. *Journal of environmental psychology*, *80*, 101765. https://doi.org/10.1016/j.jenvp.2022.101765

Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Kahn, P. H., Jr., Lawler, J. J., Levin, P. S., Tandon, P. S., Varanasi, U., Wolf, K. L., & Wood, S. A. (2017). Nature Contact and Human Health: A Research Agenda. *Environmental Health Perspectives*, *125*(7), 075001. https://doi.org/10.1289/EHP1663

Gaekwad, J. S., Sal Moslehian, A., & Roös, P. B. (2023). A meta-analysis of physiological stress responses to natural environments: Biophilia and Stress Recovery Theory perspectives. *Journal of environmental psychology*, *90*, 102085. https://doi.org/10.1016/j.jenvp.2023.102085

Gidlow, C. J., Jones, M. V., Hurst, G., Masterson, D., Clark-Carter, D., Tarvainen, M. P., Smith, G., & Nieuwenhuijsen, M. (2016). Where to put your best foot forward: Psycho-physiological responses to walking in natural and urban environments. *Journal of environmental psychology*, *45*, 22-29. https://doi.org/10.1016/j.jenvp.2015.11.003

Grassini, S., Segurini, G. V., & Koivisto, M. (2022). Watching nature videos promotes physiological restoration: evidence from the modulation of alpha waves in electroencephalography. *Frontiers in Psychology*, *13*, 871143. https://doi.org/10.3389/fpsyg.2022.871143

Groenewegen, P. P., Zock, J. P., Spreeuwenberg, P., Helbich, M., Hoek, G., Ruijsbroek, A., Strak, M., Verheij, R., Volker, B., Waverijn, G., & Dijst, M. (2018). Neighbourhood social and physical environment and general practitioner assessed morbidity. *Health & Place*, *49*, 68-84. https://doi.org/10.1016/j.healthplace.2017.11.006

Hadavi, S. (2017). Direct and Indirect Effects of the Physical Aspects of the Environment on Mental Well-Being. *Environment and behavior*, *49*(10), 1071-1104. https://doi.org/10.1177/0013916516679876

Hamaker, E. L., & Muthen, B. (2020). The fixed versus random effects debate and how it relates to centering in multilevel modeling. *Psychol Methods*, *25*(3), 365-379. https://doi.org/10.1037/met0000239

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of environmental psychology*, *23*(2), 109-123. https://doi.org/10.1016/S0272-4944(02)00109-3

Hartig, T., Mitchell, R., De Vries, S., & Frumkin, H. (2014). Nature and Health. *Annual review of public health*, *35*(1), 207-228. https://doi.org/10.1146/annurev-publhealth-032013-182443

Hartig, T., van den Berg, A. E., Hagerhall, C. M., Tomalak, M., Bauer, N., Hansmann, R., Ojala, A., Syngollitou, E., Carrus, G., van Herzele, A., Bell, S., Podesta, M. T. C., & Waaseth, G. (2011). Health Benefits of Nature Experience: Psychological, Social and Cultural Processes. In *Forests, Trees and Human Health* (pp. 127-168). https://doi.org/10.1007/978-90-481-9806-1_5

Heckhausen, J. (1997). Developmental regulation across adulthood: primary and secondary control of age-related challenges. *Developmental Psychology*, *33*(1), 176-187. https://doi.org/10.1037//0012-1649.33.1.176

Heckhausen, J., & Schulz, R. (1993). Optimisation by selection and compensation: balancing primary and secondary control in life span development. *International Journal of Behavioral Development*, *16*(2), 287-303. https://doi.org/10.1177/016502549301600210

Heckhausen, J., & Schulz, R. (1995). A Life-Span Theory of Control. *Psychological review*, *102*(2), 284-304. https://doi.org/10.1037/0033-295X.102.2.284

Heckhausen, J., Wrosch, C., & Schulz, R. (2010). A motivational theory of life-span development. *Psychol Rev*, *117*(1), 32-60. https://doi.org/10.1037/a0017668
Heckhausen, J., Wrosch, C., & Schulz, R. (2019). Agency and Motivation in Adulthood and Old Age. *Annual Reviews of Psychology*, *70*, 191-217. https://doi.org/10.1146/annurev-psych-
Hedblom, M., Gunnarsson, B., Iravani, B., Knez, I., Schaefer, M., Thorsson, P., & Lundström, J. N. (2019). Reduction of physiological stress by urban green space in a multisensory virtual experiment. *Scientific reports*, *9*(1), 10113. https://doi.org/10.1038/s41598-019-46099-7
Heynen, N., Perkins, H., & Roy, P. (2006). The political ecology of uneven urban green space. The Impact of Political Economy on Race and Ethnicity in Producing Environmental Inequality in Milwaukee. *Urban Affairs Review*, *42*(1), 3-25. https://doi.org/10.1177/1078087406290729
Hoffman, L. (2014). *Longitudinal analysis: Modeling within-person fluctuations and change*. Taylor & Francis.
Honold, J., Lakes, T., Beyer, R., & van der Meer, E. (2016). Restoration in Urban Spaces: Nature Views From Home, Greenways, and Public Parks. *Environment and behavior*, *48*(6), 796-825. https://doi.org/10.1177/0013916514568556
Huinink, J., & Brüderl, J. (2021). Editorial on the Special Issue "The identification of causal mechanisms in demographic research". *Comparative Population Studies*, *46*. https://doi.org/10.12765/CPoS-2021-17
James, P., Banay, R. F., Hart, J. E., & Laden, F. (2015). A Review of the Health Benefits of Greenness. *Current epidemiology reports*, *2*(2), 131-142. https://doi.org/10.1007/s40471-015-0043-7
Johnsen, S. Å. K. (2013). Exploring the use of nature for emotion regulation: Associations with personality, perceived stress, and restorative outcomes. *Nordic Psychology*, *65*(4), 306-321. https://doi.org/10.1080/19012276.2013.851445
Jünger, S. (2022). Land use disadvantages in Germany: A matter of ethnic income inequalities? *Urban Studies*, *59*(9), 1819-1836. https://doi.org/10.1177/00420980211023206
Kabisch, N. (2019). The Influence of Socio-economic and Socio-demographic Factors in the Association Between Urban Green Space and Health. In M. R. Marselle, J. Stadler, H. Korn, K. N. Irvine, & A. Bonn (Eds.), *Biodiversity and Health in the Face of Climate Change* (pp. 91-119). Springer.
Kahneman, D., & Krueger, A. (2006). Developments in the Measurement of Subjective Well-Being. *Journal of Economic Perspectives*, *20*, 3-24. https://doi.org/10.1257/089533006776526030
Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge University Press.
Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of environmental psychology*, *15*(3), 169-182. https://doi.org/10.1016/0272-4944(95)90001-2
Kellert, S., & Wilson, E. (1993). *The Biophilia Hypothesis*. Island Press.
Klepeis, N. E., Nelson, W. C., Ott, W. R., Robinson, J. P., Tsang, A. M., Switzer, P., Behar, J. V., Hern, S. C., & Engelmann, W. H. (2001). The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *Journal of Exposure Science & Environmental Epidemiology*, *11*(3), 231-252. https://doi.org/10.1038/sj.jea.7500165
Kley, S., & Dovbischuk, T. (2024). The equigenic potential of green window views for city dwellers' well-being. *Sustainable Cities and Society*, *108*, 105511. https://doi.org/10.1016/j.scs.2024.105511
Kobayashi, H., Song, C., Ikei, H., Park, B.-J., Kagawa, T., & Miyazaki, Y. (2019). Combined effect of walking and forest environment on salivary cortisol concentration. *Frontiers in Public Health*, *7*, 376. https://doi.org/10.3389/fpubh.2019.00376
Kondo, M. C., Jacoby, S. F., & South, E. C. (2018). Does spending time outdoors reduce stress? A review of real-time stress response to outdoor environments. *Health & Place*, *51*, 136-150. https://doi.org/10.1016/j.healthplace.2018.03.001
Kuo, M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Front Psychol*, *6*, 1093. https://doi.org/10.3389/fpsyg.2015.01093
Landry, S. M., & Chakraborty, J. (2009). Street Trees and Equity: Evaluating the Spatial Distribution of an Urban Amenity. *Environment and Planning A: Economy and Space*, *41*(11), 2651-2670. https://doi.org/10.1068/a41236
Lanki, T., Siponen, T., Ojala, A., Korpela, K., Pennanen, A., Tiittanen, P., Tsunetsugu, Y., Kagawa, T., & Tyrväinen, L. (2017). Acute effects of visits to urban green environments on cardiovascular physiology in women: A field experiment. *Environmental research*, *159*, 176-185. https://doi.org/10.1016/j.envres.2017.07.039
Larsen, R. J., & Kasimatis, M. (1991). Day-to-day physical symptoms: individual differences in the occurrence, duration, and emotional concomitants of minor daily illnesses. *Journal of Personality*, *59*(3), 387-423. https://doi.org/10.1111/j.1467-6494.1991.tb00254.x
Lee, A. C. K., & Maheswaran, R. (2010). The health benefits of urban green spaces: a review of the evidence. *Journal of Public Health*, *33*(2), 212-222. https://doi.org/10.1093/pubmed/fdq068

Li, Y., Zhao, B., Jiang, B., Jia, X., Li, H., & Zhang, J. (2025). Beyond visits: Investigating the restorative pathways and cumulative effects of park engagement and sustained exposure on psychological well-being with park type as a moderator. *Environmental research*, *276*, 121520. https://doi.org/10.1016/j.envres.2025.121520

Li, Z., Zhang, W., Cui, J., Liu, H., & Liu, H. (2024). Beneficial effects of short-term exposure to indoor biophilic environments on psychophysiological health: Evidence from electrophysiological activity and salivary metabolomics. *Environmental research*, *243*, 117843. https://doi.org/10.1016/j.envres.2023.117843

Lou, Y., Meng, X., Yang, J., Zhang, S., Long, Q., & Yuan, J. (2016). The impact of extraversion on attentional bias to pleasant stimuli: neuroticism matters. *Exp Brain Res*, *234*(3), 721-731. https://doi.org/10.1007/s00221-015-4492-5

Maas, J., Verheij, R. A., Groenewegen, P. P., de Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: how strong is the relation? *Journal of epidemiology and community health*, *60*(7), 587-592. https://doi.org/10.1136/jech.2005.043125

MacKerron, G., & Mourato, S. (2013). Happiness is greater in natural environments. *Global Environmental Change*, *23*(5), 992-1000. https://doi.org/10.1016/j.gloenvcha.2013.03.010

Mascherek, A., Luong, G., Wrzus, C., Riediger, M., & Kühn, S. (2025). Meadows or asphalt road – Does momentary affective well-being vary with immediate physical environment? Results from a geographic ecological momentary assessment study in three metropolitan areas in Germany. *Environmental research*, *264*, 120283. https://doi.org/10.1016/j.envres.2024.120283

Masoudinejad, S., & Hartig, T. (2020). Window View to the Sky as a Restorative Resource for Residents in Densely Populated Cities. *Environment and behavior*, *52*(4), 401-436. https://doi.org/10.1177/0013916518807274

Mills, M. C., & Tropf, F. C. (2020). Sociology, Genetics, and the Coming of Age of Sociogenomics. *Annual Review of Sociology*, *46*(1), 553-581. https://doi.org/10.1146/annurev-soc-121919-054756

Moran, M. R., Bilal, U., Dronova, I., Ju, Y., Gouveia, N., Caiaffa, W. T., Friche, A. A. L., Moore, K., Miranda, J. J., & Rodriguez, D. A. (2021). The equigenic effect of greenness on the association between education with life expectancy and mortality in 28 large Latin American cities. *Health & Place*, *72*, 102703. https://doi.org/10.1016/j.healthplace.2021.102703

Mroczek, D., & Kolarz, C. (1998). The effect of age on positive and negative affect: A developmental perspective on happiness. *Journal of Personality and Social Psychology*, *75*(5), 1333-1349. https://doi.org/10.1037/0022-3514.75.5.1333

Muthén, L., & Muthén, B. (2017). *Mplus User's Guide* (8 ed.). Muthén & Muthén.

Mygind, L., Kjeldsted, E., Hartmeyer, R., Mygind, E., Stevenson, M. P., Quintana, D. S., & Bentsen, P. (2021). Effects of Public Green Space on Acute Psychophysiological Stress Response: A Systematic Review and Meta-Analysis of the Experimental and Quasi-Experimental Evidence. *Environment and behavior*, *53*(2), 184-226. https://doi.org/10.1177/0013916519873376

Nakagawa, S., Schielzeth, H., & O'Hara, R. B. (2012). A general and simple method for obtaining R2 from generalized linear mixed-effects models. *Methods in Ecology and Evolution*, *4*(2), 133-142. https://doi.org/10.1111/j.2041-210x.2012.00261.x

Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2011). Happiness is in our Nature: Exploring Nature Relatedness as a Contributor to Subjective Well-Being. *Journal of Happiness Studies*, *12*(2), 303-322. https://doi.org/10.1007/s10902-010-9197-7

O'Leary, D., Uysal, A., Rehkopf, D. H., & Gross, J. J. (2021). Subjective social status and physical health: The role of negative affect and reappraisal. *Social science & medicine*, *291*, 114272. https://doi.org/10.1016/j.socscimed.2021.114272

Ojala, A., Korpela, K., Tyrväinen, L., Tiittanen, P., & Lanki, T. (2019). Restorative effects of urban green environments and the role of urban-nature orientedness and noise sensitivity: A field experiment. *Health & Place*, *55*, 59-70. https://doi.org/10.1016/j.healthplace.2018.11.004

Olafsdottir, G., Cloke, P., Schulz, A., van Dyck, Z., Eysteinsson, T., Thorleifsdottir, B., & Vögele, C. (2020). Health Benefits of Walking in Nature: A Randomized Controlled Study Under Conditions of Real-Life Stress. *Environment and behavior*, *52*(3), 248-274. https://doi.org/10.1177/0013916518800798

Pasanen, T. P., Neuvonen, M., & Korpela, K. M. (2018). The Psychology of Recent Nature Visits: (How) Are Motives and Attentional Focus Related to Post-Visit Restorative Experiences, Creativity, and Emotional Well-Being? *Environment and behavior*, *50*(8), 913-944. https://doi.org/10.1177/0013916517720261

Pretty, J., Jo, P., Martin, S., & and Griffin, M. (2005). The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research*, *15*(5), 319-337. https://doi.org/10.1080/09603120500155963

Roberts, B. W. (2009). Back to the future: Personality and Assessment and personality development. *Journal of Research in Personality*, *43*, 137-145. https://doi.org/10.1016/j.jrp.2008.12.015138

Roberts, H., van Lissa, C., Hagedoorn, P., Kellar, I., & Helbich, M. (2019). The effect of short-term exposure to the natural environment on depressive mood: A systematic review and meta-analysis. *Environmental research*, *177*, 108606. https://doi.org/10.1016/j.envres.2019.108606

Ruijsbroek, A., Droomers, M., Kruize, H., van Kempen, E., Gidlow, C. J., Hurst, G., Andrusaityte, S., Nieuwenhuijsen, M. J., Maas, J., Hardyns, W., Stronks, K., & Groenewegen, P. P. (2017). Does the Health Impact of Exposure to Neighbourhood Green Space Differ between Population Groups? An Explorative Study in Four European Cities. *International Journal of Environmental Research and Public Health*, *14*(6). https://doi.org/10.3390/ijerph14060618

Ruttenauer, T. (2018). Neighbours matter: A nation-wide small-area assessment of environmental inequality in Germany. *Soc Sci Res*, *70*, 198-211. https://doi.org/10.1016/j.ssresearch.2017.11.009

Ryan, R. M., Weinstein, N., Bernstein, J., Brown, K. W., Mistretta, L., & Gagné, M. (2010). Vitalizing effects of being outdoors and in nature. *Journal of environmental psychology*, *30*, 159-168. https://doi.org/10.1016/j.jenvp.2009.10.009160

Ryff, C. D., & Almeida, D. (2022a). *Midlife in the United States (MIDUS 3) Daily Diary Project, 2017-2019* (ICPSR 38529.

Ryff, C. D., & Almeida, D. (2022b). *MIDUS 3 Project 2: National Study of Daily Experiences. Daily Diary Instrument* (

Ryff, C. D., Almeida, D., Ayanian, J., Binkley, N., Carr, D. S., Coe, C., Davidson, R., Grzywacz, J., Karlamangla, A., Krueger, R., Lachman, M., Love, G., Mailick, M., Mroczek, D., Radler, B., Seeman, T., Sloan, R., Thomas, D., Weinstein, M., & Williams, D. (2019). *Midlife in the United States (MIDUS 3), 2013-2014* (Inter-university Consortium for Political and Social Research [distributor]. https://doi.org/10.3886/ICPSR36346.v7

Ryff, C. D., Almeida, D., Ayanian, J. Z., Binkley, N., Carr, D. S., Coe, C., Davidson, R. J., Grzywacz, J. G., Karlamangla, A., Krueger, R. F., Lachman, M. E., Love, G., Seltzer, M. M., Mroczek, D. K., Radler, B., Seeman, T. E., Sloan, R. P., Thomas, D., Weinstein, M., & Williams, D. R. (2023). *Midlife in the United States (MIDUS 3): Milwaukee African American Sample, 2016-2017* (Inter-university Consortium for Political and Social Research [distributor]. https://doi.org/10.3886/ICPSR37120.v4

Saadi, D., Schnell, I., Tirosh, E., Basagaña, X., & Agay-Shay, K. (2020). There's no place like home? The psychological, physiological, and cognitive effects of short visits to outdoor urban environments compared to staying in the indoor home environment, a field experiment on women from two ethnic groups. *Environmental research*, *187*, 109687. https://doi.org/10.1016/j.envres.2020.109687

Schimmack, U., Schupp, J., & Wagner, G. G. (2008). The Influence of Environment and Personality on the Affective and Cognitive Component of Subjective Well-being. *Social Indicators Research*, *89*(1), 41-60. https://doi.org/10.1007/s11205-007-9230-3

Seresinhe, C. I., Preis, T., Mackerron, G., & Moat, H. S. (2019). Happiness is Greater in More Scenic Locations. *Scientific reports*, *9*(1). https://doi.org/10.1038/s41598-019-40854-6

Silveira, I. H. D., & Junger, W. L. (2018). Green spaces and mortality due to cardiovascular diseases in the city of Rio de Janeiro. *Rev Saude Publica*, *52*, 49. https://doi.org/10.11606/s1518-8787.2018052000290

Stigsdotter, U. K., Corazon, S. S., Sidenius, U., Kristiansen, J., & Grahn, P. (2017). It is not all bad for the grey city – A crossover study on physiological and psychological restoration in a forest and an urban environment. *Health & Place*, *46*, 145-154. https://doi.org/10.1016/j.healthplace.2017.05.007

Sudimac, S., & Kühn, S. (2024). Can a nature walk change your brain? Investigating hippocampal brain plasticity after one hour in a forest. *Environmental research*, 119813. https://doi.org/10.1016/j.envres.2024.119813

Sudimac, S., Sale, V., & Kühn, S. (2022). How nature nurtures: Amygdala activity decreases as the result of a one-hour walk in nature. *Molecular Psychiatry*, *27*, 4446-4452. https://doi.org/10.1038/s41380-022-01720-6

Sugiyama, T., Villanueva, K., Knuiman, M., Francis, J., Foster, S., Wood, L., & Giles-Corti, B. (2016). Can neighborhood green space mitigate health inequalities? A study of socio-economic status and mental health. *Health & Place*, *38*, 16-21. https://doi.org/10.1016/j.healthplace.2016.01.002

Sun, Y., Li, F., He, T., Meng, Y., Yin, J., Yim, I. S., Xu, L., & Wu, J. (2023). Physiological and affective responses to green space virtual reality among pregnant women. *Environmental research*, *216*, 114499. https://doi.org/10.1016/j.envres.2022.114499

Tay, L., & Diener, E. (2011). Needs and subjective well-being around the world. *J Pers Soc Psychol*, *101*(2), 354-365. https://doi.org/10.1037/a0023779

Tov, W. (2018). Well-being concepts and components. In E. Diener, S. Oishi, & L. Tay (Eds.), *Handbook of well-being* (pp. 1-15). DEF Publishers.

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., & Kagawa, T. (2014). The influence of urban green environments on stress relief measures: A field experiment. *Journal of environmental psychology*, *38*, 1-9. https://doi.org/10.1016/j.jenvp.2013.12.005

Ulrich, R. (1993). Biophilia, biophobia, and natural landscapes. In S. Kellert & E. Wilson (Eds.), *The Biophilia Hypothesis* (pp. 73-137). Island Press.

Ulrich, R., Simons, R., Losito, B., Fiorito, E., Miles, M., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of environmental psychology*, *11*, 201-230. https://doi.org/10.1016/S0272-4944(05)80184-7

Ulrich, R. S. (1983). Aesthetic and Affective Response to Natural Environment. In *Behavior and the Natural Environment* (pp. 85-125). https://doi.org/10.1007/978-1-4613-3539-9_4
United Nations, D. o. E. a. S. A., Population Division. (2019). *World Urbanization Prospects. The 2018 Revision*. U. Nations. https://digitallibrary.un.org/record/3833745
van den Berg, M., Wendel-Vos, W., van Poppel, M., Kemper, H., van Mechelen, W., & Maas, J. (2015). Health benefits of green spaces in the living environment: A systematic review of epidemiological studies. *Urban Forestry & Urban Greening*, *14*(4), 806-816. https://doi.org/10.1016/j.ufug.2015.07.008
van den Berg, M. M., van Poppel, M., van Kamp, I., Ruijsbroek, A., Triguero-Mas, M., Gidlow, C., Nieuwenhuijsen, M. J., Gražulevičiene, R., van Mechelen, W., Kruize, H., & Maas, J. (2019). Do Physical Activity, Social Cohesion, and Loneliness Mediate the Association Between Time Spent Visiting Green Space and Mental Health? *Environment and behavior*, *51*(2), 144-166. https://doi.org/10.1177/0013916517738563
Veenhoven, R. (2017). Measures of happiness: which to choose? In G. Brulé & F. Maggino (Eds.), *Metrics of Subjective Well-Being: Limits and Improvements* (Vol. Measurement Issues, pp. 65-84). https://doi.org/10.1007/978-3-319-61810-4
Velarde, M. D., Fry, G., & Tveit, M. (2007). Health effects of viewing landscapes – Landscape types in environmental psychology. *Urban Forestry & Urban Greening*, *6*(4), 199-212. https://doi.org/10.1016/j.ufug.2007.07.001
Vert, C., Gascon, M., Ranzani, O., Márquez, S., Triguero-Mas, M., Carrasco-Turigas, G., Arjona, L., Koch, S., Llopis, M., Donaire-Gonzalez, D., Elliott, L. R., & Nieuwenhuijsen, M. (2020). Physical and mental health effects of repeated short walks in a blue space environment: A randomised crossover study. *Environmental research*, *188*, 109812. https://doi.org/10.1016/j.envres.2020.109812
Vitale, V., & Bonaiuto, M. (2024). The role of nature in emotion regulation processes: An evidence-based rapid review. *Journal of environmental psychology*, *96*, 102325. https://doi.org/10.1016/j.jenvp.2024.102325
Wang, R., Feng, Z., & Pearce, J. (2022). Neighbourhood greenspace quantity, quality and socioeconomic inequalities in mental health. *Cities*, *129*. https://doi.org/10.1016/j.cities.2022.103815
Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and Validaton of Brief Measures of Positive and Negative Affect: The PANAS Scales. *Journal of Personality and Social Psychology*, *54*(6), 1063-1070. https://doi.org/10.1037/0022-3514.54.6.1063
Wei, D., Lu, Y., Wu, X., Ho, H. C., Wu, W., Song, J., & Wang, Y. (2023). Greenspace exposure may increase life expectancy of elderly adults, especially for those with low socioeconomic status. *Health & Place*, *84*, 103142. https://doi.org/10.1016/j.healthplace.2023.103142
White, M. P., Pahl, S., Wheeler, B. W., Depledge, M. H., & Fleming, L. E. (2017). Natural environments and subjective wellbeing: Different types of exposure are associated with different aspects of wellbeing. *Health Place*, *45*, 77-84. https://doi.org/10.1016/j.healthplace.2017.03.008
Wilson, E. O. (1984). *Biophilia*. Harvard University Press. https://www.degruyter.com/document/doi/10.4159/9780674045231/html
Wilson Fadiji, A., & Lomas, T. (2024). Understanding the Association Between Education and Wellbeing: An Exploration of the Gallup World Poll. *Applied Research in Quality of Life*, *19*(5), 2467-2501. https://doi.org/10.1007/s11482-024-10335-8
Wood, C., M., F., R., L., J., N., & and Smyth, N. (2020). The effect of the visual exercise environment on the response to psychological stress: a pilot study. *Anxiety, Stress, & Coping*, *33*(6), 716-729. https://doi.org/10.1080/10615806.2020.1770231
Woods, V., & Knuth, M. (2023). The Biophilia Reactivity Hypothesis: biophilia as a temperament trait, or more precisely, a domain specific attraction to biodiversity. *Journal of Bioeconomics*, *25*(3), 271-293. https://doi.org/10.1007/s10818-023-09342-w
Wrosch, C., & Heckhausen, J. (2024). Control strategies for managing health threats in older adults. *Current Opinion in Psychology*, *55*, 101750. https://doi.org/10.1016/j.copsyc.2023.101750
Wrosch, C., Heckhausen, J., & Lachman, M. E. (2000). Primary and secondary control strategies for managing health and financial stress across adulthood. *Psychology and Aging*, *15*(3), 387-399. https://doi.org/10.1037//0882-7974.15.3.387
Wrosch, C., & Schulz, R. (2008). Health-engagement control strategies and 2-year changes in older adults' physical health. *Psychological Science*, *19*(6), 537-541. https://doi.org/10.1111/j.1467-9280.2008.02120.x
Wyles, K. J., White, M. P., Hattam, C., Pahl, S., King, H., & Austen, M. (2019). Are Some Natural Environments More Psychologically Beneficial Than Others? The Importance of Type and Quality on Connectedness to Nature and Psychological Restoration. *Environment and behavior*, *51*(2), 111-143. https://doi.org/10.1177/0013916517738312
Yin, J., Ramanpong, J., Chang, J., Wu, C.-D., Chao, P.-H., & Yu, C.-P. (2023). Effects of blue space exposure in urban and natural environments on psychological and physiological responses: A within-subject experiment. *Urban Forestry & Urban Greening*, *87*, 128066. https://doi.org/10.1016/j.ufug.2023.128066

Yu, C.-P., Lee, H.-Y., Lu, W.-H., Huang, Y.-C., & Browning, M. H. E. M. (2020). Restorative effects of virtual natural settings on middle-aged and elderly adults. *Urban Forestry & Urban Greening*, *56*, 126863. https://doi.org/10.1016/j.ufug.2020.126863

Zhang, R., Zhang, C. Q., & Rhodes, R. E. (2021). The pathways linking objectively-measured greenspace exposure and mental health: A systematic review of observational studies. *Environmental research*, *198*, 111233. https://doi.org/10.1016/j.envres.2021.111233

Zhang, Y., Mavoa, S., Zhao, J., Raphael, D., & Smith, M. (2020). The Association between Green Space and Adolescents' Mental Well-Being: A Systematic Review. *International Journal of Environmental Research and Public Health*, *17*(18). https://doi.org/10.3390/ijerph17186640

- Appendix –

Table A1: Descriptive statistics

Variable	Obs.	Mean	Variance	Min	Max
Level 1: daily assessments					
Affect balance (dependent)	8741	1.199	.213	-1.741	2.080
Nature enjoyment	8741	.093	.084	0	1
Positive experiences	8741	1.373	.979	0	5
Stressor severity	8741	1.017	3.127	0	15
Health symptoms severity	8735	2.631	7.760	0	68.333
Level 2: individuals' mean assessments and traits					
Mean nature enjoyment	8741	.093	.020	0	.875
Mean positive experiences	8741	1.373	0.436	0	3.571
Mean stressor severity	8741	1.017	1.055	0	8.500
Mean health symptoms sev.	8741	2.632	3.803	0	14.167
Age	8741	67.498	103.195	47	94
Sex: female	8741	.575	.244	0	1
Married/cohabiting	8741	.657	.225	0	1
Ethnic group					
white	8725	.815	.151	0	1
hispanic	8725	.033	.032	0	1
black	8725	.100	.090	0	1
other	8725	.051	.048	0	1
Educational level					
high school or less	8733	.225	.174	0	1
some college	8733	.208	.165	0	1
tertiary degree	8733	.567	.246	0	1
Social status	8293	6.481	3.523	1	10
Extraversion	8439	3.119	.321	1	4
Neuroticism	8439	2.029	.379	1	4
Selective primary control	8390	3.201	.292	1	4
Compensatory prim. control	8415	2.410	.369	1	4
Disengagement	8415	2.498	.240	1	4
Self-protection	8422	3.004	.312	1	4

Data: Midlife in the United States (MIDUS) III

Table A2: Moderation of nature enjoyment's influence on affect-balance by socio-structural characteristics

Affect balance	Coef.	Std. Dev.	p-value
Nature enjoyment, daily			
# age	-.002	.009	.858
# female	.002	.017	.928
# married/cohab.	.013	.020	.525
Ethnicity: ref. white			
# hispanic	-.020	.040	.611
# black	.001	.027	.973
# other	.032	.034	.342
Educ. level: ref. some college			
# high school or less	-.040	.025	.109
# tertiary degree	-.011	.019	.552
# social status	.008	.009	.374

Number of observations = 8741

Two-level regression analyses with random intercept and random slope of daily nature enjoyment; full information maximum likelihood estimation; robust standard errors.

# denotes interaction with daily nature enjoyment; metric predictors are standardized.

Other variables as in Table 1, Model 1a.

Data: Midlife in the United States (MIDUS) III