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The effect of contact with natural environments on positive and negative affect: A meta-analysis

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A growing body of empirical research suggests that brief contact with natural environments improves emotional well-being. The current study synthesizes this body of research using meta-analytic techniques and assesses the mean effect size of exposure to natural environments on both positive and negative affect. Thirty-two studies with a total of 2356 participants were included. Across these studies, exposure to natural environments was associated with a moderate increase in positive affect and a smaller, yet consistent, decrease in negative affect relative to comparison conditions. Significant heterogeneity was found for the effect of nature on positive affect, and type of emotion assessment, type of exposure to nature, location of study, and mean age of sample were found to moderate this effect. The implications of these findings for existing theory and research are discussed, with particular emphasis placed on potential avenues for fruitful future research examining the effects of nature on well-being.

Keywords: biophilia; emotion; happiness; meta-analysis; nature; well-being

Many scholars, writers, and scientists from diverse areas of inquiry have recognized the importance of contact with natural environments for physical and mental well-being. For example, nineteenth century author and naturalist Henry David Thoreau referred to the human need for the 'tonic of wilderness,' and John Muir, author and founder of the Sierra Club, noted the power of nature to give strength to the body and the soul. More recently, an impressive body of empirical research has emerged from disciplines such as environmental psychology, urban planning, and landscape aesthetics, among others, which documents the salubrious effects of nature on human health and happiness. This research indicates that even brief contact with natural environments is associated with several positive outcomes, including improved cognition (Berman, Jonides, & Kaplan, 2008; Berto, 2005; Tennessen & Cimprich, 1995), decreased stress (Cole & Hall, 2010; Hartig, Evans, Jamner, Davis, & Gärling, 2003), decreased blood pressure (Lee, Park, Tsunetsugu, Kagawa, & Miyazaki, 2009; Ulrich et al., 1991), increased self-esteem (Barton & Pretty, 2010; Wells & Evans, 2003), and greater emotional well-being (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009; Nisbet & Zelenski, 2011). Taken together, this body of research suggests that contact with the natural environment is likely an important factor contributing to the development of optimal human feeling and functioning.

This meta-analytic review focuses specifically on research examining the effect of brief exposure to natural environments on positive and negative affect. Examining the effect of nature on positive and negative affect is important for several reasons. First, there is considerable theoretical and empirical support for the notion that nature can be a source of happiness (see Bratman, Hamilton, & Daily, 2012), but there exist no systematic reviews that provide a quantitative synthesis of research in this area. Second, many of the theories concerning the effects of nature on well-being, described below, were developed in the mid-to-late twentieth century and have experienced little revision since then (Hartig et al., 2011). A meta-analysis of the relevant empirical research may provide information on the adequacy of these theories and highlight points at which theoretical revision is needed. Third, investigating the factors that contribute to happiness has become the focus of a great deal of research within positive psychology (e.g. Fordyce, 1977; Lyubomirsky, Dickerhoof, Boehm, & Sheldon, 2011; Seligman, Steen, Park, & Peterson, 2005; Sin & Lyubomirsky, 2009), and if it can be established that brief exposure to natural environments enhances emotional well-being, this would suggest that contact with nature may be an additional factor that contributes to happiness.

Theoretical foundations

There exist several explanatory theories that address the positive effects of nature on well-being. For instance, the

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biophilia hypothesis (Kellert & Wilson, 1993; Wilson, 1984) provides the theoretical foundation for a large amount of research on the positive effects of nature. According to this hypothesis, because humans evolved in natural environments and have lived separately from nature only relatively recently in our evolutionary history, people have an innate need to affiliate with other living things. Satisfaction of this need and feeling connected to the natural world are thus predicted to produce broad psychological benefits, including increases in positive affect and decreases in negative affect (Kellert, 1997). In support, research indicates that individual differences in feelings of connectedness to nature are positively associated with positive affect and negatively associated with negative affect (e.g. Mayer & Frantz, 2004; Nisbet, Zelenski, & Murphy, 2011). In addition, brief exposure to natural environments has been found to increase connectedness to nature, which in turn is associated with higher levels of emotional well-being (Mayer et al., 2009). This latter finding suggests that connectedness to nature is one mechanism through which exposure to nature positively impacts well-being.

An alternative theory that concerns the effect of nature on well-being is stress-reduction theory (SRT; Ulrich et al., 1991). According to SRT, exposure to environments with water, vegetation, expansive views, and other elements that contributed to the survival of our ancestors produces an unconscious autonomic response characterized by decreased physiological arousal, decreased negative affect, and increased positive affect. In other words, people are less stressed, physiologically and psychologically, when observing or present in the types of natural environments that provided the resources necessary for survival during our evolutionary history. In support of this theory, empirical research indicates lower physiological arousal, less negative affect, and higher positive affect in participants exposed to natural environments when compared to those exposed to urban or built environments (e.g. Hartig et al., 2003; Lee et al., 2011; Park et al., 2007). Further, these effects have been found in participants who are both physically present in nature (e.g. Lee et al., 2009) and those exposed to laboratory simulations of nature (e.g. viewing videos of natural environments; Ulrich et al., 1991).

A third theory that addresses the positive effects of nature is attention restoration theory (ART; Kaplan, 1995, 2001). According to ART, fast-paced urban living taxes attentional capacities and leads to cognitive fatigue. This fatigue may then manifest through difficulties in concentration and higher levels of irritability and negative affect (Kaplan, 1983). In contrast to urban environments, natural environments are suggested to contain elements that are inherently fascinating (e.g. scenic vistas) and draw upon attentional capacities only modestly, thus allowing for the replenishment and restoration of cognitive resources.[1] In result, it is predicted that following exposure to natural environments, individuals will perform better on tasks requiring directed attention (e.g. backwards digit-span tasks) and, importantly, show improved mood. A great deal of research provides empirical support for the predictions of ART, with participants indicating better cognitive functioning and more positive emotions following exposure to both real and virtual natural environments when compared to those exposed to urban or built environments (e.g. Berman et al., 2008; Berman et al., 2012; Hartig et al., 2003).

Moderators of the effect of nature on well-being

As the above literature indicates, there exists ample empirical evidence suggesting that exposure to nature is associated with increased emotional well-being. It should be stressed, however, that there is considerable variation between studies, both in terms of the methods used to assess this effect and the resulting effect sizes. Accordingly, a meta-analysis will provide a synthesis of the available empirical research on this topic. An additional benefit of a meta-analysis is that it allows for the consideration of potential moderating variables that account for variability in the effect of exposure to nature on positive and negative affect. In the current study, we examine whether several study and design-related characteristics (e.g. mean age of sample, instrument used to measure affective well-being) moderate the effect of nature on positive and negative affect.

Of the potential moderators examined, two are of particular interest. First, much of the research conducted on the beneficial effects of nature has been done using laboratory simulations of nature, and it has been argued that nature simulations can serve as effective substitutes for actual exposure to nature (Levi & Kocher, 1999). However, recent research comparing the effects of virtual nature to real nature indicates higher levels of affective well-being in real nature conditions when compared to virtual nature conditions (e.g. Mayer et al., 2009). We therefore examined whether type of exposure – exposure to real nature vs. laboratory simulations of nature – moderates the effect of exposure to natural environments on positive and negative affect across studies included in the meta-analysis. Second, research examining the effects of nature on well-being varies in terms of the types of natural environments participants are exposed to, with some studies utilizing managed and manicured natural environments (e.g. urban green space, arboretums) and others using relatively wild natural environments (e.g. wilderness areas, nature preserves). A provocative question concerns whether exposure to these different types of environments has a differential effect on positive and negative affect, and we therefore examined whether type of natural environment – manicured or wild – moderates the effect of exposure to natural environments on positive and negative affect.

Overview of the meta-analysis

The primary objective of this study was to provide a synthesis of the current research on the effect of exposure to natural environments on emotional well-being using meta-analytic procedures. We examined the effect of exposure to nature on both positive and negative affect separately to allow comparisons of the relative strength of the effect for both outcomes. Consistent with the predictions presented above, it was expected that exposure to nature would be associated with increased positive affect and decreased negative affect. A second objective of this study was to investigate potential moderator variables of the effect of nature on emotional well-being. Several of the moderating variables assessed in the meta-analysis reflected study and design-related characteristics, such as year of publication, type of affect assessment, mean age of sample, percent female in sample, and location of study. We also addressed whether type of exposure to nature (real vs. laboratory simulations of nature) and type of natural environment (manicured vs. wild nature) moderated the effect of nature on emotional well-being because these variables were deemed to be of particular interest. Through meeting the present study's objectives, we hope to provide a concise summary of findings regarding the effect of nature on positive and negative affect, while also addressing any limitations of existing theory and research that may provide opportunity for fruitful future work in this area.

Method

Literature search and inclusion criteria

Studies were located using several search strategies. First, we searched for studies using several databases, including PsycINFO, Google Scholar, PsycARTICLES, and SpringerLINK. We used combinations of the following keywords: *affect, affective well-being, biophilia, emotion, emotional well-being, happiness, nature, natural, natural environments, negative affect, negative emotion, positive affect, positive emotion, restoration,* and *well-being*. The earliest study found was conducted in 1974, and these databases were searched through December, 2013. Reference sections of obtained papers were examined for additional studies, and a descendancy search was also conducted for studies that cited the obtained papers. Finally, we contacted colleagues and prominent researchers listed as authors on the obtained studies to request any additional published or unpublished data on this topic, as well as to request other information (e.g. clarifications, additional information on the data reported, etc.) when necessary. This search yielded a total of 389 potentially relevant studies, including published journal articles, book chapters, and unpublished manuscripts, and each was then reviewed for eligibility for inclusion.

There were several criteria for inclusion of studies. First, studies had to examine the effects of exposure to nature through direct physical or sensory contact or through laboratory simulations of nature. Second, studies had to use a randomized controlled design and include a comparison group. Typically, obtained studies compared the effects of exposure to natural environments to exposure to urban or built environments.[2] Studies which did not utilize a randomized control group design, such as those that used a single-group posttest-only design (e.g. Cole & Hall, 2010), were excluded from the review. Third, studies had to include a self-report assessment of current emotional state that was administered following exposure to nature and comparison conditions. These assessments could include measures of positive affect only, negative affect only, or both positive and negative affect. We defined emotion broadly, and included outcomes that, while not referring to emotion specifically, implied a positive or negative emotional state (e.g. vitality, happiness). Studies which did not include an emotion assessment and examined only cognitive (e.g. Berto, 2005) and/or psychophysiological responses (e.g. Chang, Hammitt, Chen, Machnik, & Su, 2008) to nature were excluded from the review. Fourth, studies had to provide an effect size (or sufficient information to calculate an effect size) for the strength and the direction of any differences in positive or negative affect between exposure to nature and comparison conditions.[3]

Overall, 32 studies met inclusion criteria (see Table 1). The majority of the studies examined the effect of nature using a randomized two-group comparison design. For example, Mayer and colleagues (2009, Study 1) examined positive and negative affect in a group of students who spent 15-minute walking in nature vs. a group of students who spent 15-minutes walking in an urban area. Similarly, Berman and colleagues (2008, Study 2) examined positive and negative affect in a group of participants who were exposed to a series of photographs depicting natural environments vs. a group who were exposed to a series of photographs depicting urban environments. For each study, we recorded the sample size and effect size. For moderator analyses, we recorded the mean age of the sample, percent female respondents, and location of study, when provided. We also coded for the instrument used to assess current emotional state, which included the Positive and Negative Affective Schedule (PANAS; Watson, Clark, & Tellegen, 1988), the Zuckerman Inventory of Personal Reactions (ZIPERS; Zuckerman, 1977), the Subjective Vitality Scale (SVS; Ryan & Frederick, 1997), and several other

Table 1. Studies reporting the effect of brief exposure to natural environments on positive and negative affect.

Study	N	*Positive affect r* (lower, upper)	*Negative affect r* (lower, upper)	Mean age	Percent female	Location	Emotion measure	Exposure type	Environment type
Berman et al. (2008)	36	0.47 (0.16, 0.69)	–	22.62	64	United States	PANAS	REAL	M
Study 2	12	0.00 (−0.57, 0.57)	–	24.25	67	United States	PANAS	LAB	W
Berman et al. (2012)	20	0.72 (0.41, 0.88)	−0.38 (−0.70, 0.08)	26.00	60	United States	PANAS	REAL	M
Hartig et al. (1991, Study 2)	34	0.21 (−0.14, 0.51)	−0.10 (−0.42, 0.25)	20.00	50	United States	ZIPERS	REAL	M
Hartig et al. (1996)	102	0.17 (−0.03, 0.35)	0.07 (−0.13, 0.26)	21.40	62	Sweden	ZIPERS	LAB	W
Study 2	18	0.49 (0.03, 0.78)	–	27.40	33	Sweden	OTHER	LAB	W
Hartig et al. (1999, Study 1)	100	0.02 (−0.18, 0.22)	−0.20 (−0.38, −0.00)	20.10	50	United States	ZIPERS	LAB	W
Study 2	90	0.05 (−0.16, 0.25)	0.00 (−0.21, 0.21)	23.10	50	Sweden	ZIPERS	LAB	W
Study 3	101	0.16 (−0.03, 0.35)	−0.07 (−0.26, 0.13)	20.60	61	United States	ZIPERS	REAL	M
Hartig et al. (2003)	112	0.33 (0.16, 0.49)	−0.10 (−0.28, 0.09)	20.80	50	United States	ZIPERS	REAL	W
Johansson et al. (2011)	20	0.19 (−0.28, 0.58)	−0.05 (−0.48, 0.40)	23.00	50	Sweden	OTHER	REAL	M
Lee et al. (2009)	12	0.52 (−0.07, 0.84)	–	21.30	0	Japan	OTHER	REAL	W
Lee et al. (2011)	12	0.63 (0.09, 0.99)	−0.67 (−0.90, −0.16)	21.20	0	Japan	OTHER	REAL	W
Lohr and Pearson-Mims (2006)	206	0.22 (0.08, 0.34)	−0.22 (−0.34, −0.08)	–	–	United States	ZIPERS	LAB	M
Mayer et al. (2009)	76	0.26 (0.04, 0.46)	0.00 (0.23, 0.23)	–	67	United States	PANAS	REAL	W
Study 2	92	0.69 (0.57, 0.78)	−0.28 (−0.46, −0.08)	–	66	United States	PANAS	REAL	M
Nisbet and Zelenski (2011)	150	0.18 (0.02, 0.33)	−004 (−0.20, 0.12)	20.80	57	Canada	PANAS	REAL	M
Study 2	80	0.30 (0.09, 0.49)	−0.03 (−0.25, 0.19)	–	–	Canada	PANAS	REAL	M
Park et al. (2007)	12	0.39 (−0.24, 0.79)	–	22.80	0	Japan	OTHER	REAL	W
Ryan et al. (2010)	171	0.28 (0.14, 0.41)	–	20.16	72	–	SVS	LAB	M
Study 2	80	0.28 (0.07, 0.47)	–	20.00	83	–	SVS	REAL	M
Study 3	97	0.35 (0.16, 0.51)	–	20.00	72	–	SVS	LAB	W
Sheets and Manzer (1991)	168	0.31 (0.17, 0.44)	–	–	53	United States	OTHER	LAB	M
Study 2	69	0.28 (0.05, 0.49)	–	–	56	United States	OTHER	LAB	M
Tennessen and Cimprich (1995)	72	–	−0.01 (−0.24, 0.22)	20.00	58	United States	OTHER	VIEW	M
Tsunetsugu et al. (2007)	11	0.46 (−0.20, 0.83)	–	22.00	0	Japan	OTHER	REAL	W
Ulrich (1979)	46	0.29 (0.00, 0.54)	−0.12 (−0.39, 0.18)	–	–	United States	ZIPERS	LAB	W
Ulrich et al. (1991)	120	0.28 (0.11, 0.44)	−0.15 (−0.32, 0.04)	–	50	United States	ZIPERS	LAB	W
Valtchanov et al. (2010)	22	0.41 (−0.01, 0.71)	−0.14 (−0.53, 0.30)	–	55	Canada	ZIPERS	LAB	W
Valtchanov and Ellard (2010)	69	0.23 (−0.01, 0.44)	−0.16 (−0.38, 0.08)	–	54	Canada	ZIPERS	LAB	W
van den Berg et al. (2003)	106	0.28 (0.10, 0.45)	−0.29 (−0.43, −0.07)	21.90	65	Netherlands	OTHER	LAB	W
White et al. (2010)	40	0.66 (0.44, 0.81)	–	28.50	70	England	OTHER	LAB	W

Note: Dash (–) indicates information could not be found. N = number of participants included in effect size estimate; r = effect size estimate; PANAS = Positive and Negative Affective Schedule; ZIPERS = Zuckerman Inventory of Personal Reactions; OTHER = other measure of emotion; SVS = Subjective Vitality Scale; REAL = exposure to real nature; LAB = exposure to laboratory simulation of nature; VIEW = exposure to window view of nature; M = managed nature; W = wild nature.

measures that were used relatively infrequently and thus grouped into a single 'OTHER' category. We also coded for whether participants were exposed to real nature (i.e. being physically present in a natural environment) or laboratory simulations of nature (e.g. viewing photographs of natural environments). Finally, we coded for whether participants were exposed to managed or manicured natural environments (e.g. urban green space) vs. relatively unmanaged and wild natural environments (e.g. wilderness areas).

Analytic approach

We used Pearson's product-moment correlations (r) to provide an estimate of the magnitude and direction of the effect of exposure to nature on positive and negative affect. In nearly all cases, the r effect size for positive or negative affect was computed from Cohen's d, t, F, p, or descriptive statistics. If a result was reported as significant but did not provide an exact probability, the one-tailed p value was assumed to be 0.025. If a result was reported as nonsignificant and no data were provided to calculate an exact probability, we conservatively assigned p (one-tailed) = 0.50 and $r = 0$. In situations where multiple measures of positive or negative affect were used in a single study, the r for each measure was computed and then transformed into its corresponding Fisher Z_r. These scores were then averaged to form a single composite score. This procedure produces a conservative estimate of effect size (Rosenthal & DiMatteo, 2001). Effect sizes with an absolute value of 0.50 or greater are assumed to be large, effect sizes of 0.30–0.49 are moderate, and effect sizes of 0.00–0.29 are considered small (Cohen, 1992).

Comprehensive Meta-analysis (Version 2.2.064; Borenstein, Hedges, Higgins, & Rothstein, 2011) was used for all analyses. Consistent with the Hedges and Olkin (1985) method of meta-analysis (see also Borenstein, Hedges, Higgins, & Rothstein, 2009), we used the Fisher Z transformation ($z = \tanh^{-1}(r)$) of the Pearson correlation coefficients for the analysis. Random-effects models were used to calculate mean effect sizes. In the random-effects model, each study is weighted by the inverse of its variance, which includes both within-studies variance and between-studies variance (Borenstein et al., 2009). Random-effects models were used instead of fixed-effects models because the studies included in the meta-analysis were conducted independently using different methods in different populations, and thus, we did not assume a common effect size (Hedges & Vevea, 1998).

Heterogeneity was assessed using Cochran's heterogeneity statistic (Q), which tests the null hypothesis that the effect sizes from the individual studies are similar enough that they share a common effect size (Cochran, 1954). A significant value for Q thus indicates significant heterogeneity among effect sizes. Given the low power of Q to detect heterogeneity in meta-analyses with relatively few studies (Dickersin & Berlin, 1992; Higgins, Thompson, Deeks, & Altman, 2003), a Q with an associated p value of less than 0.10 is considered significant. Degree of heterogeneity was assessed using the I^2 statistic, which assesses the proportion of total variance due to between-study variability in the effect sizes. For this metric, a score of 0 indicates no heterogeneity, values from 1 to 49 indicate low heterogeneity, 50–74 indicate moderate heterogeneity, and 75–100 indicate high heterogeneity (Higgins et al., 2003). We also report 95% confidence intervals reflecting the precision of our estimate of the mean. In the case of significant heterogeneity, univariate moderator analyses were conducted to determine whether the variables coded in the current study moderated the effect of exposure to nature on the outcome variable. Mixed effects models were used for all categorical moderator analyses. Random-effects metaregression with method of moments estimation was used for all continuous moderator analyses.

A serious concern for any meta-analysis is the possibility that the data contain a selection or publication bias (Rosenthal, 1995; Rothstein, Sutton, & Borenstein, 2005). To address this possibility, Duval and Tweedie's (2000) trim and fill approach was used to estimate the number of missing studies that might exist and the unbiased effects size. In addition, we tested funnel plot asymmetry using Egger's weighted regression test (Egger, Smith, Schneider, & Minder, 1997).

Results

Overall analyses

Effect sizes for the effect of exposure to natural environments on positive and negative affect along with study characteristics of each study included in the meta-analysis are listed in Table 1. As shown, after collapsing nonindependent effect sizes, 31 effect sizes for the effect of exposure to nature on positive affect ($N = 2284$) and 20 effect sizes for the effect of exposure to nature on negative affect ($N = 1630$) were included. The distributions for these effect sizes are displayed in Table 2. For positive affect, the median effect size was 0.28, and the distribution had a slight positive skew (skewness = 0.51) and minimal kurtosis (kurtosis = −0.05). For negative affect, the median effect size was −0.11, and the distribution was negatively skewed (skewness = −1.79) and leptokurtic (kurtosis = 4.43). With the exception of one effect size for the effect of exposure to nature on negative affect, all effects were in the predicted directions.

As shown in Table 3, a random-effects meta-analysis indicated a moderately sized effect of exposure to nature

Table 2. Back-to-back stem-and-leaf display of all effect sizes.

Positive affect (k = 31)		Negative affect (k = 20)
Leaf	Stem	Leaf
2	0.7	
9, 6, 3	0.6	
2	0.5	
9, 7, 6, 1	0.4	
9, 5, 3, 1, 0	0.3	
9, 8, 8, 8, 8, 8, 6, 3, 2, 1	0.2	
9, 8, 7	0.1	
5, 2, 0	0.0	7
	−0.0	0, 0, 1, 3, 4, 5, 7
	−0.1	0, 0, 2, 4, 5, 6
	−0.2	0, 2, 6, 8
	−0.3	8
	−0.4	
	−0.5	
	−0.6	7

Note: k = the number of studies included for each outcome indicator.

on positive affect across studies, $r = 0.31$, 95% confidence interval (CI) lower limit (LL) = 0.24, upper limit (UL) = 0.37. Thus, higher levels of positive affect were found among those exposed to natural environments when compared to those in comparison conditions. There was significant heterogeneity among effect sizes, $Q(30) = 69.68$, $p < 0.001$, and a substantial portion of the total variance was due to between-study variability in effect sizes ($I^2 = 56.95$). Duval and Tweedie's (2000) trim and fill approach (with random effects) was then used to address whether the found effect size estimate is the result of publication bias. One effect size was added below the estimated average effect size, resulting in an adjusted estimated effect size slightly smaller than the initial average effect size, $r = 0.30$, 95% CI LL = 0.23, UL = 0.36. Zero effect sizes were added above the estimated average effect size. These analyses thus indicate a possible bias in the data to overestimate the effect of exposure to nature on positive affect. However, Egger's regression coefficient was nonsignificant, intercept = 1.22, $t(29) = 1.83$, $p = 0.08$, indicating a lack of bias in the data. Taken together, the results of these analyses suggest that this sample either lacks a publication bias or includes a slight publication bias by underrepresenting small effect sizes.

Also shown in Table 3, a second random-effects meta-analysis indicated a small effect of exposure to nature on negative affect across studies, $r = -0.12$, 95% CI LL = −0.17, UL = −0.07. This indicates that lower levels of negative affect were observed among those exposed to natural environments when compared to those in comparison conditions. Analyses further indicated that there was not significant heterogeneity among effect sizes, $Q(19) = 21.86$, $p = 0.29$, and only a small portion of the total variance was due to between-study variability in effect sizes ($I^2 = 13.08$). To address the possibility of publication bias, Duval and Tweedie's (2000) trim and fill approach (with random effects) was again used. Zero effect sizes were added above or below the estimated average effect size, indicating a lack of bias in the data. Egger's regression coefficient was nonsignificant, intercept = 0.57, $t(18) = 0.76$, $p = 0.46$, similarly indicating a lack of bias in the data.

Moderator analyses

Given significant heterogeneity among the effect sizes for the effect of exposure to nature on positive affect, we conducted several univariate moderator analyses addressing whether specific study characteristics moderate this effect. Univariate categorical analyses were used to assess whether location of study, type of emotion measure, type of exposure, and environment type moderated the effect of exposure to nature on positive affect. Random-effects metaregression with method of moments estimation was used to analyze the relationship between effect size and publication year, average age of sample, and percentage female participants per sample. Given a lack of heterogeneity among effect sizes for the effect of exposure to nature on negative affect, the following moderator analyses focus exclusively on the effect of nature on positive affect.

Categorical moderator analyses

The results of the univariate categorical analyses are presented in Table 4. For location of study, we only included those locations that were represented by three or more effect sizes. Thus, only studies conducted in Canada ($k = 4$), Japan ($k = 4$), Sweden ($k = 4$), and the

Table 3. Overall effect size estimates for the effect of brief exposure to natural environments on positive and negative affect.

Outcome	N	k	r	95% CI for r (lower, upper)	T^2	I^2
Positive affect	2284	31	0.31	0.24, 0.37	0.02	56.95
Negative affect	1630	20	−0.12	−0.17, −0.07	0.00	13.08
Overall	2356	32				

Note: N = number of participants included in analysis; k = number of studies; r = effect size estimate; CI = confidence interval; T^2 = estimate of between-study variability; I^2 = estimate of total variability due to between-study variability.

Table 4. Results of the categorical univariate moderator analyses of the effect of nature on positive affect.

Variable and class	Between-class effect (Q)	k	r	95% CI for r (lower, upper)	T^2
Location	6.71†				
United States		14	0.32	(0.21, 0.42)	0.03
Canada		4	0.24	(0.13, 0.34)	0.00
Japan		4	0.51	(0.22, 0.71)	0.00
Sweden		4	0.15	(0.01, 0.29)	0.00
Emotion measure	10.66*				
PANAS		7	0.41	(0.20, 0.59)	0.08
ZIPERS		11	0.20	(0.14, 0.26)	0.00
SVS		3	0.30	(0.20, 0.39)	0.00
OTHER		10	0.37	(0.27, 0.46)	0.01
Intervention type	2.70†				
Laboratory simulation		16	0.26	(0.19, 0.33)	0.01
Physically present		15	0.37	(0.25, 0.48)	0.04
Environment type	0.50				
Manicured nature		13	0.33	(0.23, 0.42)	0.03
Wild nature		18	0.28	(0.20, 0.36)	0.01

Note: k = number of studies; r = effect size estimate; CI = confidence interval; T^2 = estimate of between-study variability; PANAS = Positive and Negative Affective Schedule; ZIPERS = Zuckerman Inventory of Personal Reactions; SVS = Subjective Vitality Scale; OTHER = other measure of emotion. *$p < 0.05$; †$p < 0.10$.

United States ($k = 14$) were assessed in this analysis. Results indicated a significant difference in average effect size between locations, $Q(3) = 6.71$, $p = 0.05$. The largest average effect size was observed for studies conducted in Japan ($r = 0.51$), followed by those conducted in the United States ($r = 0.32$), Canada ($r = 0.24$), and Sweden ($r = 0.15$).

We then examined whether effect sizes differed based on the instrument used to measure positive affect. Instruments used to measure positive affect in the current sample included the PANAS ($k = 7$), the ZIPERS ($k = 11$), the SVS ($k = 3$), and those in the OTHER category ($k = 10$). Results indicated a significant difference in average effect size between the instruments, $Q(3) = 10.66$, $p = 0.01$. The largest average effect size was observed for the PANAS ($r = 0.41$), followed by the OTHER category ($r = 0.37$), the SVS ($r = 0.30$), and the ZIPERS ($r = 0.20$).

We also assessed whether effect sizes differed based on the type of exposure to nature, specifically exposure to real nature (e.g. being physically present in a natural environment; $k = 15$) vs. exposure to a laboratory-based simulations of nature (e.g. viewing photographs of natural environments; $k = 16$). Results indicated a significant difference in average effect size for type of exposure, $Q(1) = 2.70$, $p = 0.09$. Examination of average effect sizes for each group indicated a larger average effect size for exposure to real nature ($r = 0.37$) vs. laboratory simulations of nature ($r = 0.26$).

We then addressed whether effect sizes differed based on the type of natural environment participants were exposed to. Specifically, we compared exposure to managed natural settings (e.g. urban green space; $k = 13$) vs. exposure to nonmanaged and wilder natural environments (e.g. wilderness areas; $k = 18$). Results indicated that type of natural environment did not moderate the effect of exposure to nature on positive affect, $Q(1) = 0.50$, $p = 0.48$, and the effect of exposure to nature on positive affect was similar for both managed and wild natural environments.

Continuous moderator analyses

Table 5 displays the results of each random-effects metaregression addressing whether year of publication ($k = 31$, range = 1979–2012), mean age of sample ($k = 21$, range = 20.00–28.50 years), and percentage female ($k = 28$, range = 0–83) moderate the effects of

Table 5. Results of continuous moderator analyses of the effect of nature on positive affect.

Moderator	k	Estimate (SE)	95% CI (upper, lower)	Z	Q
Year of publication	31	0.01 (0.00)	(−0.00, 0.02)	1.64	2.68
Mean age	21	0.05 (0.02)	(0.02, 0.09)	3.00**	8.97***
Percent female	28	0.00 (0.00)	(−0.00, 0.01)	0.67	0.44

Note: k = number of studies; CI = confidence interval; Z = test statistic for significance of slope; Q = dispersion explained by moderator.
***p < .001; **$p < 0.01$.

exposure to nature on positive affect. Year of publication did not moderate the effect of exposure to nature on positive affect, as indicated by the nonsignificant association between year of publication and the effect size, $b = 0.01$, $p = 0.11$. A significant positive association was observed between mean age and the effect size, $b = 0.05$, $p = 0.01$, indicating that larger effects were observed in studies using older samples. Finally, percentage female per sample did not moderate the effect of exposure to nature on positive affect, as indicated by the nonsignificant association between percent female and the effect size, $b = 0.00$, $p = 0.73$.

Discussion

Affective responses to nature

Scholars and laypeople alike have claimed that being in nature improves well-being, and yet people are becoming increasingly disconnected from nature. It has been estimated that the typical individual living in the United States spends nearly 90% of his or her life within buildings (Evans & McCoy, 1998), and a growing body of empirical research indicates that this disconnection from nature may have negative repercussions for psychological functioning. One factor that likely contributes to a lack of contact with the natural world is that although many individuals believe that nature is beneficial for psychological functioning, they underestimate the degree to which even brief contact with the natural environment will benefit their well-being (Nisbet & Zelenski, 2011). A primary objective of the current meta-analytic review was thus to provide precise quantification of the effect of nature on one facet of psychological functioning, namely emotional well-being. To this end, the current findings indicate that across the studies included in this meta-analysis, brief contact with natural environments was associated with higher levels of positive affect relative to comparison conditions, and this effect was moderate in magnitude. In addition, the current findings indicate that brief contact with nature was associated with lower levels of negative affect relative to comparison conditions, and this effect, while consistent across studies, was smaller in magnitude. Taken together, these findings suggest substantial benefits of contact with nature for emotional well-being.

A great deal of research within positive psychology has examined the cognitive and behavioral factors that increase happiness, often operationally defined as subjective well-being (SWB; see Lyubomirsky, Sheldon, & Schkade, 2005). This research indicates that engagement in a wide variety of activities, such as writing gratitude letters, practicing optimistic thinking, socializing, and mentally replaying pleasurable experiences, produces stable increases in SWB (Mazzucchelli, Kane, & Rees, 2010; Sin & Lyubomirsky, 2009). Given that positive and negative affect are two key components of SWB (Diener, 2012, 2013), the results summarized here complement the above literature and suggest that contact with the natural environment may be an additional route through which individuals can increase SWB. Notably, each of the studies included in the current meta-analysis used only brief exposures to natural environments, indicating that contact with nature provides benefit even in small doses. Incorporating brief ventures in nature into one's daily routine may thus be one relatively easy and enjoyable way to achieve sustainable increases in SWB. Although existing research on this possibility is limited, the mounting evidence summarized here does provide strong support for continued research on the positive effects of exposure to nature on well-being.

The function of affective responses to nature

The difference in the average effect size estimates for the effect of nature on positive affect and the effect of nature on negative affect is particularly noteworthy, as this finding suggests that the beneficial effects of nature on emotional well-being are driven primarily by increases in positive affect and, only to a lesser extent, decreases in negative affect. This is somewhat inconsistent with the perspectives of SRT (Ulrich et al., 1991) and ART (Kaplan, 1995), theories which have focused on the reduction of negative affect as the primary source of improvements in emotional well-being during exposure to natural environments. However, research and theory on the evolutionary significance and function of positive emotions may provide some insight into this pattern of findings. From this theoretical perspective, the primary function of positive emotions is to facilitate and maintain approach-oriented behavior and engagement in activities that were evolutionarily adaptive (Carver & Scheier 1990; Clore, 1994; Davidson, 1993; Frijda, 1994). The experience of positive emotions in many natural environments was likely adaptive throughout the majority of our evolutionary history because these emotions would motivate approach behaviors aimed at the acquisition of resources that contributed to survival (e.g. food, water, shelter, raw materials). As a result, the primary emotional response to natural environments that signal the presence of or access to evolutionarily significant resources would be increased positive affect, rather than decreased negative affect.

One implication of the above interpretation is that not all natural environments will elicit increased positive affect. Rather, increased positive affect should only be observed in response to natural environments which signal the presence of resources. In more barren natural environments, increased positive affect would be maladaptive because it might prompt the approach and exploration of environments which contain relatively few resources. In addition, many natural environments contain elements which were a threat to survival throughout the majority of our evolutionary history (e.g. large predators, natural hazards). Exposure to natural environments that signal the presence of these threats should thus elicit increased negative affect and, in turn, avoidance-oriented behavior. Therefore, it seems implausible that exposure to all forms of nature will invariably elicit a more positive hedonic state. Instead, emotional responses to natural environments, like all emotional responses, are likely functional in nature, with the specific emotions elicited in response to exposure to a natural environment depending on the degree to which that environment signals the presence of evolutionarily significant resources or hazards.

Why then does the majority of the previous research reviewed here indicate that exposure to nature leads to a more positive hedonic state? It is possible that this is due to a methodological issue concerning the specific natural environments that participants are being exposed to, with natural environments that contain a relatively high concentration of evolutionary significant resources being used more frequently in this research than barren or hazardous natural environments. Future research may be able to address this possibility by examining affective responses to natural environments which systematically vary in terms of the presence of evolutionarily significant resources and hazards.

This functional account of affective responses to natural environments is consistent with more general theoretical perspectives on the function of emotions (Panksepp & Biven, 2012; Tooby & Cosmides, 2008) and provides both a parsimonious explanation of previous research and a powerful explanatory framework from which to derive predictions for future research. As stated above, this approach seems better able to explain the findings from the current meta-analysis than ART and SRT. In addition, this perspective is in line with findings from other areas of research that document negative affective responses to evolutionarily significant natural hazards and threats (e.g. snakes, spiders; see de Silva, Rachman, & Seligman, 1977; Öhman & Mineka, 2001), findings that are difficult to reconcile with the biophilia hypothesis which focuses exclusively on positive affective responses to natural entities. Thus, this alternative theoretical approach may have some advantages over SRT, ART, and the biophilia hypothesis. Moreover, this approach encourages a more nuanced view of the ways in which nature impacts affective well-being by focusing on how the specific elements within natural environments, rather than natural environments in general, elicit specific emotional responses. However, future research testing hypotheses derived from this theoretical perspective is needed to more fully address the validity of this approach.

Moderators of the effect of nature on positive affect

A second objective of the current study was to identify variables that moderate the effect of nature on emotional well-being. Because significant heterogeneity in effect sizes was observed only for positive affect, we examined only those factors that may moderate the effect of nature on positive affect. Results of these analyses indicated that year of publication, percent female of sample, and type of environment did not moderate the effect of nature on positive affect. In contrast, mean age of sample, study location, type of emotion assessment, and type of exposure did moderate this effect.

Mean age of sample moderated the effect of nature on positive affect, with larger effect sizes observed in those studies using older samples. This finding is notable considering the restricted range of ages included in the meta-analysis (20–28.5 years), with the majority of participants being in late adolescence and emerging adulthood. As stated by Arnett (2006, 2007), exploration and finding one's place in the world take on greater importance as one transitions from adolescence to adulthood, and it is possible that contact with the natural environment provides one mechanism through which individuals in these developmental periods can satisfy the need for exploration and gain some perspective on their place within the broader environment. Future research should more directly address this possibility. Location of study also moderated the effect of nature on positive affect, with the largest effect sizes observed in studies conducted in Japan, followed by those conducted in the United States, Canada, and Sweden. It is possible that this particular finding was due, at least in part, to systematic differences in methodology and design-related characteristics between locations, rather than to location of study per se. For example, the studies conducted in Japan were very similar in terms of sample composition, measures, and design, and no studies conducted outside of Japan used the same types of procedures. In result, the relatively large effect sizes observed in Japanese samples, when compared to samples from other countries, may be an artifact of the methods used rather than the location of the study.

Type of emotion assessment moderated the effect of nature on positive affect, with the largest effect sizes observed in those studies using the PANAS, followed by those measures included in the OTHER category, the SVS, and the ZIPERS. This finding is likely due to the fact that these instruments vary with respect to the emotions assessed and consistent with theories regarding the situational specificity of discrete emotional responses (see Lench, Flores, & Bench, 2011), the elements present in natural environments likely elicit a specific suite of emotions that may be differentially tapped by each of the instruments. A notable limitation of previous research is that although studies have examined relatively specific negative emotional responses to nature (e.g. anger, anxiety, fear; Hartig, Nyberg, Nilsson, & Gärling, 1999; Hartig et al., 2003), less existing research has examined the specific positive emotions (e.g. happiness, enjoyment, interest, love, etc.) that are elicited by exposure to natural environments (cf. Hartig, Mang & Evans, 1991; Johansson, Hartig, & Staats, 2011; Lee et al., 2009). The relative lack of studies addressing the effects of exposure to nature on specific positive emotions precludes the quantitative comparisons of these effects using meta-analytic techniques. Therefore, future research examining discrete emotional responses to natural environments should be conducted to provide a more nuanced picture of the effect of nature on emotional well-being.

Of particular interest in the current study was addressing whether type of exposure, specifically exposure to real nature vs. laboratory simulations of nature, moderated the effect of nature on well-being. Findings indicated significant moderation, with exposure to real environments having a greater effect on positive affect than exposure to laboratory simulations of nature. Thus, consistent with the limited existing literature directly comparing the effects of real vs. simulated nature on well-being (e.g. Kjellgren & Buhrkall, 2010; Mayer et al., 2009), the current study indicated that people reap additional benefit from being out in real nature when compared to being exposed to simulations of nature. However, exposure to virtual nature still produced a substantial increase in positive affect, indicating that viewing nature indirectly through various types of media may be an effective means to improving well-being. This finding would seem to be particularly relevant to people who do not have easy access to natural areas, such as those who live in major urban centers or those who have functional limitations that prevent them from venturing out in nature. For these individuals, exposure to simulated nature may be one way to capitalize on the benefits of nature without actually being in nature.

The current study also addressed whether type of natural environment, specifically managed natural environments vs. wild natural environments, moderated the effect of exposure to nature on emotional well-being. No evidence of moderation was observed, suggesting that contact with managed nature and wild nature produces similar effect for emotional well-being. Perhaps this is due to the fact that many managed natural environments, such as urban green spaces and arboretums, are designed to mimic those characteristics of wild nature that people find appealing, aesthetically pleasing, and restorative (see Appleton, 1975; Hagerhall, 2001; Kaplan, Kaplan, & Brown, 1989; Konijnendijk, 2008). In result, managed nature may serve as effective substitute for wild nature, by design.

Limitations and conclusion

The current meta-analysis provides strong evidence that nature improves emotional well-being by increasing positive affect and, to a lesser extent, decreasing negative affect. However, the findings of the current study should be considered with respect to the following limitations. First, because we chose to include only those studies that examined the effect of nature on emotional well-being using randomized control group designs, the number of studies included in the current review was relatively small. Additional research will need to address whether the findings of the current study generalize to those studies using alternative research designs. Second, several included studies used small samples, which tend to provide a less stable estimate of effect size. Future research examining the effects of nature on well-being should use larger samples in order to provide more accurate estimates of the size of this effect. It is hoped that such studies will become increasingly available for inclusion in future meta-analyses. Third, the majority of the studies included in this meta-analysis assessed emotion at a single point in time directly after exposure to nature. Future research should directly address the duration of the positive effects of exposure to natural environments on emotional well-being over more extended periods of time. Fourth, all of studies included in the meta-analysis were conducted in developed industrialized nations, and the degree to which the current findings would generalize in more traditional cultures and among those living in developing nations is yet to be determined. An additional limitation of the current review is that it focused exclusively on the effect of nature on emotional components of well-being. Importantly, well-being is a complex construct, including both hedonic and eudaimonic components (McMahan & Estes, 2011; Ryan & Deci, 2001), and additional research should address whether contact with nature positively impacts other facets of well-being.

Despite the above limitations, the current meta-analytic review is a significant step in the development of a comprehensive and detailed understanding of the effects of contact with natural environments on well-being. Although this review highlights several areas where additional empirical work is needed, it is our hope that addressing these limitations will yield additional fruitful research on this important topic. Such research should help clarify the manner in which nature contributes to optimal human feeling and functioning and may possibly answer more fundamental questions regarding the nature of the relationship between humans and our natural environment.

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Notes

1. Although the bulk of empirical research using an ART framework has focused on the restorative effects of natural environments, it should be noted that natural environments are not the only environments that can be restorative. Rather, any environment which places few demands on attentional resources while also including softly fascinating stimuli would be restorative. For example, viewing pieces of art in a gallery could be restorative if the experience meets the above criteria.
2. Of the studies included in the meta-analysis, only five studies used non-urban/built comparison conditions (e.g. no simulation control, exposure to neutral stimuli, etc.). Of these five studies, four included a non-urban/built comparison condition in conjunction with an urban/built comparison condition. In each of these cases, the effect of nature relative to the urban and non-urban comparison conditions was quite similar, and the effect sizes were combined to yield a single effect size estimate reflecting the difference between the nature condition and, generally speaking, non-nature conditions. The remaining study (Valtchanov, Barton, & Ellard, 2010) did not use an urban/built comparison condition and instead utilized a comparison condition involving exposure to abstract art.
3. Although many studies examining green exercise (i.e., exercising in natural vs. built environments) fit the criteria for inclusion (e.g. Barton & Pretty, 2010; Pretty, Peacock, Hine, Sellens, South, & Griffin, 2007), we decided not to include these studies to reduce unnecessary variability across experimental paradigms and to ensure that studies employed in the present meta-analysis are directly comparable. For a comprehensive meta-analytic review of studies specifically examining research on green exercise, see Bowler, Buyung-Ali, Knight, and Pullin (2010).

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