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A walk on the wild side: How interactions with non-companion animals might help reduce human stress

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Abstract

1. The literature addressing the potential for nature and natural environments to reduce stress and improve health outcomes has a relative paucity of work regarding interactions with animals, particularly those that are not domestic pets.
2. The present observational study sought to understand whether a brief encounter with non-domestic animals might reduce stress and improve well-being of participants, and whether participants' nature relatedness, and their appraisals of the interaction might influence these changes.
3. Participants (N = 86, mean age = 20.8 years, 81.8% women) took part in a brief wildlife encounter at a UK safari park, walking for approximately 11 min around an enclosure with free-roaming lemurs. Heart rate, cortisol and measures of mood were taken before and after the encounter to understand whether this activity could reduce biological levels of stress and improve psychological well-being.
4. There was no decrease in participants' heart rate after their encounter but there was a statistically significant decrease in salivary cortisol. Measures of mood significantly improved immediately after the encounter. Reductions in cortisol were associated with dimensions of an individual's nature relatedness, as well as aspects of the animal encounter (number of lemurs and lemur proximity).
5. The findings contribute to parallel literature on nature–health relationships, with the addition of factors seemingly driving the interaction (individuals' nature relatedness, and the number and proximity of the animals) providing important contributory information. The present study provides new information on how encounters with nature, particularly those involving animals, may be beneficial for health and well-being. Critically, this study was carried out in a setting where potential impact of visitors on animals is negligible, thereby demonstrating the potential for creating environments where both human and animal well-being are maximised.

KEYWORDS
biophilia, cortisol, health, human animal interaction, non-companion animals, well-being

1 | INTRODUCTION

Research into the health benefits of spending time in natural environments and interacting with nature has grown substantially in the last few decades. The term *biophilia* was coined by Wilson (1984) to describe humans' natural affinity with, and draw towards, natural landscapes and the biological organisms—both plant and animal—that inhabit them (referred to herein as 'nature'). The mechanisms by which nature is said to confer benefit hinge on two principal theories: stress reduction theory (Ulrich, 1983) and attention restoration theory (Kaplan, 1995). This is proposed to work by either providing cognitive space through 'soft fascination', allowing a quietening of the mind; or by reducing feelings of stress. Research to date has focused on how proximity of green and blue spaces to living or working environments provides psychological and physiological benefits. Proximity to nature has been associated with reduced morbidity and mortality (Gascon et al., 2015; James, Banay, Hart, & Laden, 2015), improved cognitive function (Cassarino & Setti, 2015) and a variety of cellular- and systems-level improvements supported by psychobiological processes such as reducing cortisol, or increasing immune cell function (Berto, 2014; Tzoulas et al., 2007). However, while the existing literature on engagement with nature does support its ability to improve human health and well-being, there are still substantial discrepancies between studies.

The majority of the literature to date focuses upon the operationalisation of nature as 'space' or 'place', rather than considering living entities. Indeed, the understanding of biodiversity within the broader field of nature-health linkages has only recently begun to be considered, despite the long-established health benefits of companion animals (O'Haire, 2010). There are several elements within the literature concerning interactions with animals and how they might confer health benefit to humans. In the therapeutic context, animal-assisted therapies are becoming increasingly common in educational and care environments and provide support benefits to human health and well-being (Beetz, Uvnäs-Moberg, Julius, & Kotrschal, 2012). Pet ownership is another well-studied area where health benefits may be derived from introducing or encouraging physical activity (Cutt, Giles-Corti, Knuiman, & Burke, 2007), reducing loneliness (Antonacopoulos & Pychyl, 2010), improving social capital by meeting others (Knight & Edwards, 2008), and reducing cortisol and increasing in oxytocin (Handlin et al., 2011). More broadly, pet ownership confers similar relationship benefits as those seen from living with human family members, providing opportunities to leave the house, meet others and protecting from loneliness when staying indoors (Beck & Meyers, 1996).

Non-companion animals could similarly support human health and well-being, but research is not as extensive in this area. Activities with wild animals are often a tourist draw particularly in ecotourism; and these have proven to elicit similar feelings of awe and privilege as those experiences with nature as place (Cox, Hudson, Shanahan, Fuller, & Gaston, 2017; Curtin, 2006; Orr, 1993). The key difference here is the type of benefit provided by the animal interaction. Whereas companion animals provide psychosocial benefits; interactions with wild animals may offer benefits more akin to the general benefits conferred by being in a natural space, such as through soft fascination (Ballew & Omoto, 2018; Curtin, 2009; Wells, 2009). In particular, it seems likely that awe and privilege provide a distraction from inner feelings of distress or turmoil, and that this more external perspective acts alongside the generally relaxing elements of having time and space to breathe and think (Ballew & Omoto, 2018; Curtin, 2009; Wells & Evans, 2003).

Another way that people can engage with non-companion animals, often more directly than is possible in the wild, is by visiting captive collections in zoos. Increasingly, such attractions include immersive exhibits, such as walk-through enclosures and animal encounter events such as 'touch tanks'. Although many factors affect visitor experience in zoos, the extent to which exhibits and enclosures facilitate 'special moments' and allow visitors to engage with animals are paramount (Lee, 2012; Morgan & Hodgkinson, 1999; Sickler & Fraser, 2009). The direct animal encounters that are possible in walk-through enclosures can be a powerful way of maximizing both education and memorable experiences (Fernandez, Tamborski, Pickens, & Timberlake, 2009; Moss & Esson, 2013; Woolway & Goodenough, 2017). Some research has been carried out to examine health parameters after visiting zoos or after engaging with zoo-based touch tank experiences. Significant reductions in blood pressure (both systolic and diastolic) were reported among zoo visitors (Sakagami & Ohta, 2010); however, as the content of the zoo experience was not studied, the drivers of this decrease could not be ascertained. More specifically, Sahrmann, Niedbalski, Bradshaw, Johnson, and Deem (2016) found that heart rate dropped significantly and mood improved, which both suggest a decrease in stress, after touch tank experiences.

While the ability for animals to provide therapeutic benefits via specific mechanisms such as horse-riding, swimming with dolphins, experiencing a touch tank or via companion support has been assessed; comparatively little research has examined the potential benefits of interacting with animals on their terms rather than ours. Although many animal-based tourist attractions are becoming ever-more conscious of the well-being impact on the animals, some still have an element of forced interaction. In other cases, there is potential for the simple presence of visitors to initiate aggressive or stereotypical patterns of animal behaviour (i.e. 'the visitor effect') and thus be a stressor to captive animals even when there is no forced interaction (Fernandez et al., 2009; Hosey, 2000). This is especially likely in walk-through enclosures where animals are in closer proximity to visitors (Larsen, Sherwen, & Rault, 2014; Sherwen, Hemsworth, Butler, Fanson, & Magrath, 2015). The ideal would be to facilitate animal interactions that provide tangible and measurable benefits for human health and well-being, while not being detrimental in any to the animals involved.

1.1 | The present study

To address the lack of research on human animal interactions in a non-structured and non-therapeutic setting, this study evaluates whether humans derive physiological and psychological well-being benefit from non-companion animal interaction. The aims were to evaluate whether such an encounter could provide reductions in biological stress (heart rate and cortisol) and increases to well-being (mood) in human participants, alongside evaluating whether such physiological and psychological changes could be explained by variables associated with an individual's nature relatedness or subjective experience of the interaction. Participants were immersed in a naturalistic environment inhabited by free-roaming captive lemurs housed in a large, ethologically appropriate enclosure where the animals are not encouraged to interact with humans and are able to stay secluded or fully interact with humans as they choose. Although this experience was in a captive environment with captive animals rather than being truly 'natural', both the naturalistic setting and the fact that lemur sightings were neither predictable nor guaranteed acted to replicate a natural encounter, and elicit human responses that would be typical of a natural encounter, as far as possible. As such, the use of captive animals here not only allowed us to investigate psychological and physiological responses of visitors to the animals they encounter in zoological parks, but also, with caveats, make some broader inferences about human animal interactions.

FIGURE 1 Ring-tailed lemurs in the walkthrough enclosure

2 | MATERIALS AND METHODS

2.1 | Study setting

The present study was conducted at West Midland Safari Park, UK, in the Lemur Wood walk-through exhibit. The enclosure is a large area of mature woodland (approximately 5,600 m^2), bordered on one side by a lake, and is a mixed-species exhibit that houses ring-tailed lemurs *Lemur catta*, white-fronted lemurs *Eulemur albifrons* and red-bellied lemurs *Eulemur rubriventer* (*N*s = 13, 2, 3). Within the enclosure, lemurs can roam freely along pathways or climb the numerous beeches, oaks and lime trees (Figure 1). The long pathway through the wood has a gentle incline and is bordered by a low wooden fence to encourage visitors to keep to the path. Normally, there is a separate entrance and exit, but for the purposes of the study, participants were led on a circular walk back to the entrance to allow data collection to be conducted with minimal disruption to other visitors. A keeper was present inside the enclosure during each visit, as is standard policy to ensure appropriate visitor behaviour and animal welfare.

From a human perspective, the enclosure has been carefully designed to be as naturalistic as possible, with its large size, mature planting and very fine mesh boundary meaning that it is not immediately obvious when inside that it is, in fact, an enclosure. From a husbandry perspective, the enclosure has been designed to allow the lemurs to display a full suite of typical behaviours, including sun bathing under infrared heat lamps and arboreal activity within the trees. A range of different enrichment, including hidden food and cogitative stimulation, are used in regular rotation. Human impact on the animals had already been assessed and the lemurs in this specific enclosure are largely unaffected by visitor presence (Goodenough, McDonald, Moody, & Wheeler, 2019).

2.2 | Participants

An opportunity sample of 86 undergraduate students was sampled as part of a wider field trip on separate days in two consecutive weeks in October 2018. Of a possible 125 eligible attendees, 100 attended across the 2 days (*N* = 49 on day 1; *N* = 51 on day 2). Of these, 44 (89.8%) participated in the study on the first day, and 42 (82.4%) participated on the second day. Attendees were advised of the study, were provided with information about the study ahead of the trip date, and elected whether or not to participate in the study part of the trip en route to the venue. Attendees were advised their participation was neither integral to the trip nor to taking part in the lemur activity. There were no restrictions on participation for the study; however, cortisol sampling was only undertaken by those participants (*N* = 49) that were not currently diagnosed with a chronic medical condition or taking long-term medications (aside from oral contraceptives). Participants provided written consent before the study commenced. At the safari park, participants also engaged with a variety of other activities, including that reported here. Other field trip attendees were present during the activity even if they had not provided consent for data collection. The present research was approved by the University of Gloucestershire Research Ethics Committee (REF: REC.18.101.1c).

2.3 | Materials

2.3.1 | Psychological measures

Participants completed a study pack individually while travelling to the park and immediately after the activity. The pack included a demographic survey as well as psychological measures capturing perceived stress, general well-being and nature relatedness. These scales were included to control for potential confounding factors (stress, well-being) or to explore drivers for subsequent of psychological and physiological change in inferential analysis (nature relatedness). Self-reported stress and well-being were determined using the Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983) and Warwick Edinburgh Mental Wellbeing Scale (WEMWBS; Tennant et al., 2007), respectively. Reliability scores in the current study were PSS α = 0.60 and WEMWBS α = 0.91. The nature relatedness scale (NRS; Nisbet, Zelenski, & Murphy, 2009) comprised three subscales: 'self', the understanding of how the self is situated among nature; 'perspective', the metric of a nature-related worldview and 'experience', the desire and degree of comfort relating to being in nature. The overall scale showed excellent internal consistency here (α = 0.82).

In addition to PSS, WEMWBS and NRS scores taken at the start of the day, participants also completed the 40-item abbreviated profile of mood states (aPOMS; Grove & Prapavessis, 1992) immediately before and immediately after the Lemur Wood walk. This showed good consistency in both pre- (α = 0.84) and post-measurements (α = 0.85). The aPOMS comprises seven subscales (tense, angry, fatigued, depressed, esteem-related affect, vigour and confusion), which are combined to make a total score referred to as total mood disturbance (TMD). This abbreviated version was devised to address participant interpretation and factor loading issues with the original scale (Grove & Prapavessis, 1992).

2.3.2 | Physiological measures

Heart rate was measured in beats per minute immediately before and after each walk using pulse oximeters (Model CMS50M, Contec Medical Systems Company Ltd). For heart rate measures at baseline, participants were standing, but had been ceased walking for a minimum of 3 min. Participants that consented to, and were eligible to, provide saliva samples were given two saliva collection tubes (Sarstedt Ltd). The correct sampling procedure was outlined and participants were instructed to take one sample immediately before the walk, and the second 15 min after the walk was completed (time between the saliva samples = approximately 30 min). Prior to data collection, participants were briefed to not eat, drink or use nicotine products for 30 min before their activity until after the second saliva sample was provided. Samples were stored on ice before being frozen at −20°C until processing. After thawing, samples were centrifuged at 3000 *g* for 10 min before being assayed using commercially available cortisol ELISA kits (DRG Diagnostics). Each sample was assayed in duplicate, with the mean value between wells being recorded as well as the sample value. Assays were read using a Biotek ELX800 plate reader and Gen5 software (both Bio-Tek). Intra-assay % coefficient of variation (%CV) was 9.56%, and mean inter-assay %CV was 4.84%.

2.3.3 | Nature interaction measures

In order that an understanding of the individual's interaction with this natural encounter could be obtained, two questions were asked at the end of each walk in the participant study pack. Participants were asked to state how many lemurs they saw (none; few [1–4]; several [5–9]; many [10+]) and to comment on level of interaction with the lemurs. Specifically, participants were asked, 'Considering the possible interaction with the lemurs during your walk (e.g. were they close, did they walk among you, did you make eye contact?), how would you rate your encounter with the lemurs during your walk?' This question was phrased to provide a measure of both proximity and interactivity. Interaction was collapsed pre-analysis to provide a numerical interaction score of none, medium and high. Participants were clearly instructed before each walk that they should not touch the animals (as per general visitor instructions), and so the variable is named 'lemur proximity' rather than 'lemur interaction' to avoid misinterpretation.

2.4 | Procedure

Participants were briefed before attending the park that they would have the opportunity to take part in a study. In the case of all activities on the day, study candidates were advised they did not have to participate to carry out the activity, nor did they have to carry out the activity at all. Participants were advised that the study was seeking to understand whether having interactions with non-domesticated animals can provide relaxation or stress reduction. Each group met at the entrance to Lemur Wood, where participants completed their pre-aPOMS questionnaire, took their heart rate (while standing and at least 3 min after walking), and gave the first saliva sample. Participants were instructed to follow the researcher (RS) so a gentle and uniform pace was set, and were asked to refrain from talking. This procedure was unique to the study, as guests are not routinely closely monitored in the park, and was undertaken to standardise the experience across and within each group as much as possible. Participants were advised that the group would stop when lemurs were encountered so participants could view them, and to allow potential animal-instigated non-contact interaction. Each walk lasted 11.05 ± 1.69 min (range: 10–15 min). Immediately after completing the walk, participants recorded their post-heart rate, followed by the completion of the post-aPOMS questionnaire and, after 15 min, gave their second saliva sample. Participants were always cycled through the same activities, meaning their post-saliva samples were collected in a uniform manner. On both days, the ambient temperature and weather were similar: dry, some sunshine, 15–19°C (mean temperatures: Day 1:16.7°C; Day 2:17.3°C). Participants were split approximately equally between the days and were split into sub groups of ≈10 (range 6–11, mean group size 8.6 ± 1.69), including non-participating peers.

2.5 | Data analysis

Paired samples *t* tests were used to assess differences pre- and post-Lemur Walk in: heart rate (one test), cortisol (one test) and mood (aPOMS; eight tests, one for TMD and one for each of the seven subscales). For all metrics (heart rate, cortisol and the different aPOMS subscales), pre-data were subtracted from post-data to provide a change score. Cortisol and heart rate data were normally distributed; however, one extreme (i.e. greater than two standard deviations) cortisol outlier and three extreme heart rate outliers were removed. Although 49 participants provided saliva samples before entering the Lemur Wood, only 47 post-samples were available (one where there was insufficient yield for assay, another where the post-sample had not been collected), such that after exclusion of the outlier, cortisol sample size was $N = 92$ samples in 46 pairs. A priori power analysis demonstrated that this sample size was sufficient to detect a medium effect size (Cohen's $d = 0.5$) with a power of 0.997, while an effect size of 0.3 could be detected with a power of 0.813 using a paired-samples test (Cohen, 1988).

To examine any effect of baseline variables on cortisol change, and thus ensure there were no confounding factors in later multivariate models, a series of four one-way ANOVAs and four bivariate regressions was run with cortisol change as the dependent variable in all cases. This covered experimental differences (day of visit, morning or afternoon slot, specific time slot of walk: ANOVAs) and details of participants (gender: ANOVA; age: correlation) as well as baseline levels of perceived stress, well-being and hours of sleep the night before the Lemur experience (correlations).

To analyse the potential contribution of nature relatedness scores (NRS) and Lemur experience to cortisol change, a series of GLMs were run with a normal distribution and identity link function. The models used difference in cortisol (post–pre) as the dependent variable in all cases. To allow for initial cortisol levels possibly influencing the magnitude of change, either naturally or in response to the external stimulus of Lemur exposure, pre-cortisol was included in all analyses. The three subscales that comprised NRS (self, perspective and experience) were entered as individual continuous predictors, while participant appraisal of Lemur numbers and proximity were entered as fixed factors. An information theoretic approach was used to create a series of (essentially) univariate models (each containing one of the five independent variables plus pre-cortisol) and then for combinations of these variables. In total, 11 different models were generated: five univariate models, five partial multivariate models and the full model. To ensure that analyses had appropriate power, the case:variable ratio was 8:1 or better in all models: notably higher than the 3:1 ratio recommended by Tabachnick and Fidell (2013). The observed statistical power for significant analyses, calculated *a postori*, ranged between 0.947 and 0.983. This same analytical framework was used to assess change in TMD after the Lemur walk related to the score for the same individuals before the Lemur walk, with pre-TMD replacing pre-cortisol level but all other parameters being kept identical.

To compare between competing models, Akaike's information criterion (AIC) was calculated. This allowed identification of the model that best-balanced explanatory power (model fit) with parsimony (minimising the number of variables in the model). The model with the smallest AIC (ΔAIC = 0) was considered optimal, models within ΔAIC ≤ 2 were regarded as essentially having equal support, models with ΔAIC 3–4 = strong support, models with ΔAIC 5–9 = considerably less support and models with ΔAIC ≥10 = essentially no support (Anderson & Burnham, 2002).

3 | RESULTS

The sample ($N = 86$) comprised mainly female (82.5%), white (86.3%) and single (91.3%) participants with a mean age of 20.8 years (±5.56). The majority had grown up in suburban or semi-rural environments (55.1%) with pets (84.8%), and continued to live in these types of areas (84.8%) and had pets (62.0%) currently. Most participants reported seeing several (i.e. 5–10; 44.4%) or many (i.e. 10+; 27.8%) lemurs, but reported low (33.8%) or medium (40.8%) levels of interaction (operationalisation outlined in methods). The cortisol subsample ($N = 46$) comprised similar patterns in participant demographics, ratings of Lemur experience and psychological characteristics. A description of participant demographics, ratings of their animal encounter and psychological variables is presented in Table 1.

3.1 | Changes in mood, heart rate and salivary cortisol

The key outcomes of mood (aPOMS), heart rate and salivary cortisol were assessed to understand whether participants experienced benefit from their Lemur walk (Table 2). Paired *t* test data are presented as means for each variable with standard deviation. For the physiological data, change scores (post–pre) indicated that participants did not experience a significant change in heart rate (beats/minute; 88.8 ± 15.59 vs. 87.5 ± 14.36; $t = 0.73$, $df = 77$, $p = .467$), but did experience a significant decrease in salivary cortisol (ng/ml; 5.4 ± 1.74 vs. 4.7 ± 1.96; $t = 3.40$, $df = 45$, $p = .001$). To ensure that heart rate findings were not confounded medical conditions or prescription medications, the analysis was re-run including only those participants

TABLE 1 Demographic and psychological characteristics and ratings of animal encounter for the whole sample, and those that provided salivary cortisol samples

Variable	*N* (%)	Cortisol subsample, *N* (%)
Age, years: mean (*SD*)	20.8 (5.56)	20.5 (4.95)
Gender (female)	66 (82.5)	36 (81.8)
Ethnicity (white)	69 (86.3)	39 (88.6)
Level of education (secondary)	74 (92.5)	41 (93.2)
Marital status		
Single	73 (91.3)	41 (93.2)
Married/Civil partnership	2 (2.5)	1 (2.3)
Separated/divorced	4 (5.0)	1 (2.3)
Widowed	1 (1.3)	1 (2.3)
Area grew up		
Urban	24 (30.8)	11 (25.6)
Suburban/semi-rural	43 (55.1)	21 (48.8)
Rural	21 (27.3)	11 (25.6)
Area lives now		
Urban	24 (30.8)	8 (18.6)
Suburban/semi-rural	43 (55.1)	30 (69.8)
Rural	11 (14.1)	5 (11.6)
Pets growing up		
Yes	67 (84.8)	38 (86.4)
No	12 (15.2)	6 (13.6)
Pets now		
Yes	49 (62.0)	30 (68.2)
No	30 (38.2)	14 (31.8)
Mean hours of sleep (*SD*)	6.3 (1.69)	6.6 (1.65)
Mean perceived stress (*SD*)	24.4 (4.60)	24.5 (4.96)
Mean well-being (*SD*)	45.2 (8.41)	44.9 (8.70)
Mean nature relatedness (*SD*)	3.5 (0.49)	3.6 (0.43)
Mean NR-self (*SD*)	3.4 (0.67)	3.4 (0.61)
Mean NR-perspective (*SD*)	3.8 (0.45)	3.9 (0.41)
Mean NR-experience (*SD*)	3.3 (0.81)	3.5 (0.79)
Lemur interaction		
Low	24 (33.8)	19 (46.3)
Medium	29 (40.8)	14 (34.1)
High	18 (25.4)	8 (19.5)
Number of lemurs seen		
None	2 (2.8)	1 (2.4)
Few (1–4)	18 (25.0)	10 (24.4)
Several (5–9)	32 (44.4)	19 (46.3)
Many (10+)	20 (27.8)	22 (26.8)

whose cortisol data were used (i.e. those that were eligible to take part, who provided both samples, and were not excluded due to extreme outlying data); this was also non-significant (88.9 ± 14.22 vs. 88.7 ± 16.34; $t = 0.09$, $df = 45$, $p = .925$).

TABLE 2 Pre, post and change measures of the psychological, physiological and endocrine outcomes for the whole sample, and those that provided salivary cortisol samples

Variable	Whole sample, Mean (*SD*)	Cortisol subsample Mean (*SD*)
Mood (POMS) pre		
Tense	3.5 (3.62)	2.9 (2.86)
Angry	0.9 (2.01)	0.5 (0.94)
Fatigued	5.3 (3.94)	4.2 (3.40)
Depressed	1.9 (3.7)	1.1 (2.60)
Esteem-related affect	5.8 (3.48)	5.5 (2.82)
Vigour	5.1 (3.60)	5.2 (3.60)
Confusion	3.2 (2.88)	2.9 (2.77)
Total mood disturbance	4.0 (14.65)	1.0 (11.55)
Mood (POMS) post		
Tense	2.1 (3.45)	1.8 (2.77)
Angry	0.7 (2.23)	0.5 (2.14)
Fatigued	3.9 (2.23)	2.9 (2.79)
Depressed	1.2 (3.62)	0.7 (2.17)
Esteem-related affect	5.3 (2.70)	5.5 (2.63)
Vigour	5.0 (3.65)	5.3 (3.62)
Confusion	1.7 (1.87)	1.3 (1.7)
Total mood disturbance	−0.7 (13.5)	−3.1 (12.62)
Mood (POMS) change		
Tense	−1.4 (3.37)	−1.3 (2.78)
Angry	−0.2 (2.03)	0.1 (2.13)
Fatigued	−1.4 (2.76)	−1.4 (2.69)
Depressed	−0.7 (2.03)	−0.4 (1.45)
Esteem-related affect	−0.5 (2.76)	−0.1 (1.93)
Vigour	−0.1 (2.55)	−0.1 (2.44)
Confusion	−1.6 (2.08)	−1.6 (1.79)
Total mood disturbance	−5.2 (8.75)	−4.5 (8.05)
Heart rate[a] (beats/minute)		
Pre	88.7 (15.51)	88.9 (14.22)
Post	87.5 (14.36)	88.7 (16.34)
Change	−1.3 (15.19)	−0.2 (15.7)
Cortisol (ng/ml)		
Pre		5.4 (1.72)
Post		4.7 (1.96)
Change		−0.8 (1.50)

Abbreviation: POMS: profile of mood states.
[a]Sub sample of $N = 78$ accounting for removed outliers.

For mood, assessed using aPOMS, participants had significant decreases in TMD (4.3 ± 14.05 vs. −0.8 ± 13.42; $t = 5.08$, $df = 72$, $p < .001$) as well as the subscales for 'tense' (3.5 ± 3.66 vs. 2.1 ± 3.45; $t = 3.72$, $df = 79$, $p < .001$), 'fatigued' (5.3 ± 3.94 vs. 3.9 ± 3.64; $t = 4.58$, $df = 81$, $p < .001$), 'depressed' (1.9 ± 3.72 vs. 1.2 ± 2.74; $t = 3.07$, $df = 80$, $p = .003$) and 'confusion' (3.3 ± 2.89 vs. 1.7 ± 1.87; $t = 6.96$, *df* = 81, $p < .001$). There were no changes for the ‘angry’, ‘esteem-related affect’ and ‘vigour’ subscales. Again, analyses were re-run for the cortisol subsample to assess if medical diagnoses or medications affected mood change. All comparisons yielded the same significance pattern aside from ‘depressed’, which in this subsample was not significantly improved after the lemur walk (1.1 ± 2.60 vs. 0.7 ± 2.21; $t = 1.65$, $df = 44$, $p = .107$).

3.2 | Factors associated with changes in TMD

Testing the effect of baseline variables on change in TMD showed no significant differences with regard to participant gender, day of visit, time slot in each day or exact timing of Lemur walk, and were not significantly related to participant age, hours of sleep, baseline levels of perceived stress or well-being. The optimal explanatory GLM contained all variables (NRS ‘self’, ‘experience’ and ‘perception’, lemur number, lemur proximity) but this was non-significant and the effect size was extremely small ($F = 0.854$, $p = .864$, $R^2 = .07$). All sub-models were greatly inferior based on AIC (tests not shown).

3.3 | Factors associated with cortisol reduction

To establish whether experimental differences or basic differences in participants affected cortisol change, a series of one-way ANOVAs were run. Cortisol change was not significantly different depending on participant gender ($F_{(1,42)} = 0.01$, $p = .924$), day of visit ($F_{(1,45)} = 0.22$, $p = .645$), time slot in each day ($F_{(5,41)} = 0.16$, $p = .975$) or exact timing ($F_{(1,41)} = 0.01$, $p = .930$) of the Lemur walk. Additionally, cortisol change was not significantly correlated with participant age ($r = .01$, $p = .968$, $N = 42$), hours of sleep ($r = -.14$, $p = .387$, $N = 42$), nor baseline levels of perceived stress ($r = 0.16$, $p = .317$, $N = 40$) nor well-being ($r = 0.05$, $p = .759$, $N = 41$). This indicates that observed cortisol change is not likely to be relevant to individual biological or diurnal confounds.

GLMs showed that nature relatedness variables (‘self’, ‘perspective’ and ‘experience’) and lemur experience (number of lemurs seen and lemur proximity) together accounted for almost 40% of variation in cortisol change when controlling for baseline cortisol (Table 3). The model containing all predictor variables was optimal based on AIC but a slightly simpler model, which included lemur number but not proximity, was within 2 ΔAIC units with only slightly inferior r^2 (.349 vs. .396), and thus essentially had equal support. The competing model that combined NRS variables with lemur proximity rather than lemur number was somewhat inferior (ΔAIC = 2.002; $r^2 = .322$). The fact that, of the two lemur experience variables, it is number of lemurs that is the more important is also suggested greater support in the univariate models. The univariate models also show that ‘experience’ and ‘perception’ are more important than ‘self’ (although ‘self’ still added value because when it was experimentally dropped from the full model, ΔAIC increased from 0 to >4 and the model became non-significant). When considering models with just NRS variables versus just lemur experience variables, the former was more important than the latter (model = lower ΔAIC, higher r^2).

TABLE 3 GLMs (univariate and multivariate) of cortisol change including AIC

Type of model	Variables in model (in addition to pre-cortisol)	Total variables in model (inc. pre-cortisol)	*F*	*p*	R^2	Delta AIC (all models)	Delta AIC (univariate only)	Notes
Univariate	Lemur number	2	2.136	.114	.159	5.827	0.000	Most supported univariate model
	Lemur proximity	2	1.781	.498	.067	10.607	4.780	
	NRS self	2	1.128	.335	.061	10.900	5.073	Least supported univariate model
	NRS perception	2	1.854	.172	.096	9.140	3.313	
	NRS experience	2	1.590	.218	.083	9.774	3.947	
Multivariate	Lemur variables (number, proximity)	3	1.469	.227	.187	6.267		
	NRS variables (self, perception, experience)	4	3.667	**.014**	.308	3.856		Some support
	NRS variables + Lemur number	5	2.775	**.028**	.349	0.056		Very strong (almost equal) support
	NRS variables + Lemur proximity	5	2.451	**.047**	.322	2.002		Strong support
	All variables except NRS self[a]	5	1.640	.162	.277	4.866		Some support
	All variables	6	5.015	**.005**	.396	0.000		Optimal model

Abbreviations: AIC, Akaike's information criterion; NRS, nature relatedness scale.

[a]NRS variable with lowest univariate support.

[b]Bold value indicates $p < .05$.

This suggests that while lemur experience (especially the number of lemurs seen) is important, nature relatedness explains most variance.

In the AIC-optimal model, 'self' was significantly positively (0.040) related with cortisol change, such that increasing identification with nature was associated with less cortisol change. Conversely, 'perspective' and 'experience' were significantly negatively related (p = .035 and .020, respectively), where increases in a nature-related worldview and physical familiarity with nature were related to greater cortisol decrease. Lemur number and lemur proximity were both negatively correlated with cortisol change, such that seeing more lemurs closer to the participant was related to greater cortisol decrease but these were both non-significant as individual terms (p = .297 and .542, respectively). This suggests that lemur experience variables mediate the effect of NRS variables upon cortisol change rather than being important in isolation.

4 | DISCUSSION

The present study had two main aims: to examine the ability of an encounter with free-ranging non-companion animals to reduce biological stress and increase well-being; and to understand whether variables associated with nature relatedness and aspects of the animal encounter might explain a reduction in biological stress in human participants. Here, cortisol and mood levels, but not heart rate, were significantly improved after a brief encounter with lemurs in a walk-through enclosure. In multivariate analysis, the changes in cortisol are explained by dimensions of nature relatedness and the type of encounter (number of lemurs and lemur proximity) when controlling for baseline cortisol level. Although mood improved, similar multivariate comparisons were not significant for mood (as indexed by aPOMS TMD). To our knowledge, this is the first time a study has examined these variables in a non-companion animal encounter that is not specifically within a therapeutic setting or environment.

The present study supports existing literature regarding experiences with nature improving a variety of metrics of health and well-being (Berto, 2014). We also extend this existing literature to account for conceptualisations of biophilia through the nature relatedness measure, where we see greater levels of both 'perspective' and 'experience' being associated with greater decreases in cortisol, and greater levels of 'self' being inversely associated with cortisol change. These discrepant findings within related concepts is difficult to explain; however, it may be that the measure might be context-specific (Liefländer, Fröhlich, Bogner, & Schultz, 2013), and that its use could possibly have yielded different results had it been taken, for the same participants, but at another time or place. The subscale of 'self' is described to be an understanding of personal thoughts and feelings about being connected to nature, whereas 'perspective' and 'experience' refer more to proactivity and agency towards their individual impact of nature, and their actual behavioural tendencies towards engaging with nature, respectively (Nisbet et al., 2009). It is possible, therefore, that an individual's feeling of being connected to nature through the dimension of 'self', with such statements as 'I feel very connected to all living things and the earth' and 'my connection to nature and the environment is a part of my spirituality' are more subjective and may perhaps be relative to context. In contrast, the attitudinal concepts covered through 'perspective' (e.g. 'conservation is unnecessary because nature is strong', 'animals, birds and plants have fewer rights than humans'), and the behavioural activities tapped into by 'experience' (e.g. 'I enjoy being outdoors, even in unpleasant weather', 'The thought of being deep in the woods, away from civilisation, is frightening' (reversed)) constitute potentially more long-term or stable conceptualisations of nature affiliation. Another possibility may be that those who score more highly on the 'self' dimension of the NRS may find that engaging in activities with captive animals (no matter their housing) may be contrary to their beliefs. Looking further into the literature of the scale, however, it would appear that concepts such as humanitarianism and a love of animals, while correlated with the 'self' dimension, or more strongly related to the 'perspective' dimension (Nisbet et al., 2009).

A further interesting insight into the potential for nature interaction to reduce cortisol is via the subjective contextual elements of the specific interaction—captured here as number of lemurs seen and lemur proximity, both of which were positively related to outcomes. Previous studies have shown improvements in parameters of health after explicit, active interaction with non-companion animals (Sahrmann et al., 2016), but none have yet explored a passive animal-led interaction. An important part of biophilic response is said to be related to feelings of awe or privilege in nature interactions (Orr, 1993), the latter concept being something particularly evocative when animal encounters are unpredictable and not guaranteed. It is possible that this aspect of feeling privileged at sighting an animal in a natural environment (or, as in this study, a semi-natural environment where sighting is not guaranteed) may provide additional possibilities for distraction from inner feelings of distress (Curtin, 2009; Wells & Evans, 2003). Some qualitative research in the field has begun to unpick this particular question, finding elements of fascination seeming to be highly important, along with biodiversity (Schebella, Weber, Lindsey, & Daniels, 2017). This is particularly interesting given the recent focus of social prescribing in primary care, where 'nature' or natural experiences can be prescribed to help improve well-being in patients with challenging health problems. Such nature-based social prescribing includes nature walks (Robinson & Breed, 2019), where (provided the participant is resident in or can travel to a sufficiently green space) there may be opportunities for witnessing animals or rare plants. However, as little as 30% of the UK population spend substantial time (>75%) in nature (Cox et al., 2017), so if such areas are not accessible, or otherwise not accessed, the present findings indicate that individuals may be able to visit zoological parks to obtain similar benefit.

While this study provides new evidence in the literature surrounding human animal interactions, and—more broadly—interactions between nature and health, some limitations require acknowledgement. Given the naturalistic setting in which the encounters took place, it is possible that the pleasant green environment could have contributed to improvement in well-being reported here. Similar studies assessing cortisol change from walking have shown greater decreases in cortisol both in natural and urban environments (Gidlow et al., 2016); however, those analyses were for walks of up to 30 min and as such are difficult to use as comparison. Despite this, it is notable that lemur number and proximity were predictors of cortisol change, so animal interaction was certainly important. To further investigate this possibility, a case–control study comparing such a walk with a similar walk with no animals present would be beneficial. Furthermore, given the difficulties of reconciling the specific dimensions of nature relatedness, it may be that there are other psychological aspects that mediate or moderate the relationship between nature affiliation and the potential for stress reduction after an encounter with nature. There is also the possibility that as the animals were captive, they cannot be considered to be truly interacting on their own terms. It is recommended that future studies be carried out to expand the present research, and could plausibly done in wild natural environments such as when individuals are bird watching, or engaging in a nature walk. Further on this point, participants may very likely have very mixed feelings in regard to witnessing animals in captivity. It is therefore recommended that future studies extend the current work by exploring participants' attitudes and opinions towards the perception of this captivity, and whether or not this impacted their enjoyment. This will allow further disentangling of the multifaceted factors that influence both psychological and physiological responses to such animal encounters. Finally, the present study has a relatively modest sample size as is common with psychophysiological research, and therefore findings should be viewed with caution before further support can be garnered from related work.

5 | CONCLUSIONS

For the first time, we have shown that an encounter with free-ranging animals in an ethologically appropriate walk-through enclosure can improve mood and reduce physiological stress. It is important to note the following: (a) that these benefits were derived after a short encounter (and could possibly be stronger with longer experience) and (b) that the Lemur troop involved have already been shown to be largely unaffected by visitor presence (Goodenough et al., 2019) and so the human benefits reported here come without cost to the animals involved. The finding that both nature relatedness (as an index of biophilia or affinity towards nature), and interaction-specific variables (appraisals of Lemur number and proximity) provide much needed context to the literature on the potential for interactions with nature to provide health benefit. As a first step into understanding more about how animal encounters within nature (rather than nature as a space or place) may be beneficial to health, the present findings indicate that benefit from such encounters can be a product of both the specific qualities of the environment and predisposing factors of the individual. Of importance for future studies will be to assess elements of personality within this context, as it is known to impact experience of stress and changes in cortisol (Oswald et al., 2006; Soye & O'Súilleabháin, 2019), is associated with nature relatedness (Nisbet et al., 2009), and may also play a part in the specific dynamics of person–environment interaction. The potential for such encounters with wildlife to improve health and well-being underlines the importance of supporting conservation efforts so that these experiences might be had in day-to-day living, not just through visits to wildlife parks. Such encounters provide both excitement (at the opportunity to glimpse or have a close encounter with an animal) and an element of peaceful relaxation (through being immersed in a naturalistic environment)—and may often be some of the only experiences some people have of engaging with wildlife (Cox et al., 2017; Sakagami & Ohta, 2010). From a zoological perspective, this study also shows that walk-through enclosures (already noted as being popular with visitors, and reducing conflicts between public requirements and maintaining good welfare: Moss, Francis, & Esson, 2008; Sickler & Fraser, 2009; Woolway & Goodenough, 2017) can also facilitate improvement in health and well-being of visitors. Critically, the present work provides evidence for human health benefit which does not come at the cost of animal welfare; and may indeed further conservation efforts to extend benefit more broadly.

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CONFLICT OF INTEREST

The authors report no conflicts of interest.

AUTHORS' CONTRIBUTIONS

R.C.S. and A.E.G. conceived the ideas and designed methodology; R.C.S. collected the data; R.C.S. and A.E.G. analysed the data; R.C.S. led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

The anonymous dataset for this project is held on University of Gloucestershire repository. To preserve the anonymity of the participants, some of whom may be identifiable from their demographic data, an embargo of 3 years has been set before the data will become openly available. The data will be available from http://eprints.glos.ac.uk/id/eprint/7962 after 31st January 2023.

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REFERENCES

Anderson, D. R., & Burnham, K. P. (2002). Avoiding pitfalls when using information-theoretic methods. *The Journal of Wildlife Management*, *66*(3), 912–918. https://doi.org/10.2307/3803155

Antonacopoulos, N. M. D., & Pychyl, T. A. (2010). An examination of the potential role of pet ownership, human social support and pet attachment in the psychological health of individuals living alone. *Anthrozoös*, *23*(1), 37–54. https://doi.org/10.2752/175303710X12627079939143

Ballew, M. T., & Omoto, A. M. (2018). Absorption: How nature experiences promote awe and other positive emotions. *Ecopsychology*, *10*(1), 26–35. https://doi.org/10.1089/eco.2017.0044

Beck, A. M., & Meyers, N. M. (1996). Health enhancement and companion animal ownership. *Annual Review of Public Health*, *17*(1), 247–257. https://doi.org/10.1146/annurev.pu.17.050196.001335

Beetz, A., Uvnäs-Moberg, K., Julius, H., & Kotrschal, K. (2012). Psychosocial and psychophysiological effects of human-animal interactions: The possible role of oxytocin. *Frontiers in Psychology*, *3*(234). https://doi.org/10.3389/fpsyg.2012.00234

Berto, R. (2014). The role of nature in coping with psycho-physiological stress: A literature review on restorativeness. *Behavioral Sciences*, *4*(4), 394. https://doi.org/10.3390/bs4040394

Cassarino, M., & Setti, A. (2015). Environment as 'Brain Training': A review of geographical and physical environmental influences on cognitive ageing. *Ageing Research Reviews*, *23*, 167–182. https://doi.org/10.1016/j.arr.2015.06.003

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, *24*(4), 385–396. https://doi.org/10.2307/2136404

Cox, D. T. C., Hudson, H. L., Shanahan, D. F., Fuller, R. A., & Gaston, K. J. (2017). The rarity of direct experiences of nature in an urban population. *Landscape and Urban Planning*, *160*, 79–84. https://doi.org/10.1016/j.landurbplan.2016.12.006

Curtin, S. (2006). Swimming with dolphins: A phenomenological exploration of tourist recollections. *International Journal of Tourism Research*, *8*(4), 301–315. https://doi.org/10.1002/jtr.577

Curtin, S. (2009). Wildlife tourism: The intangible, psychological benefits of human–wildlife encounters. *Current Issues in Tourism*, *12*(5–6), 451–474. https://doi.org/10.1080/13683500903042857

Cutt, H., Giles-Corti, B., Knuiman, M., & Burke, V. (2007). Dog ownership, health and physical activity: A critical review of the literature. *Health & Place*, *13*(1), 261–272. https://doi.org/10.1016/j.healthplace.2006.01.003

Fernandez, E. J., Tamborski, M. A., Pickens, S. R., & Timberlake, W. (2009). Animal–visitor interactions in the modern zoo: Conflicts and interventions. *Applied Animal Behaviour Science*, *120*(1), 1–8. https://doi.org/10.1016/j.applanim.2009.06.002

Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Forns, J., Plasència, A., & Nieuwenhuijsen, M. J. (2015). Mental health benefits of long-term exposure to residential green and blue spaces: A systematic review. *International Journal of Environmental Research and Public Health*, *12*(4), 4354–4379. https://doi.org/10.3390/ijerph120404354

Gidlow, C. J., Jones, M. V., Hurst, G., Masterson, D., Clark-Carter, D., Tarvainen, M. P., … 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

Goodenough, A. E., McDonald, K., Moody, K., & Wheeler, C. (2019). Are "visitor effects" overestimated? Behaviour in captive lemurs is mainly driven by co-variation with time and weather. *Journal of Zoo and Aquarium Research*, *7*(2), 59–66.

Grove, J. R., & Prapavessis, H. (1992). Preliminary evidence for the reliability and validity of an abbreviated profile of mood states. *International Journal of Sport Psychology*, *23*(2), 93–109.

Handlin, L., Hydbring-Sandberg, E., Nilsson, A., Ejdebäck, M., Jansson, A., & Uvnäs-Moberg, K. (2011). Short-term interaction between dogs and their owners: Effects on oxytocin, cortisol, insulin and heart rate – An exploratory study. *Anthrozoös*, *24*(3), 301–315. https://doi.org/10.2752/175303711X13045914865385

Hosey, G. R. (2000). Zoo animals and their human audiences: What is the visitor effect? *Animal Welfare*, *9*(4), 343–357.

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

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

Knight, S., & Edwards, V. (2008). In the company of wolves: The physical, social, and psychological benefits of dog ownership. *Journal of Aging and Health*, *20*(4), 437–455. https://doi.org/10.1177/0898264308315875

Larsen, M. J., Sherwen, S. L., & Rault, J.-L. (2014). Number of nearby visitors and noise level affect vigilance in captive Koalas. *Applied Animal Behaviour Science*, *154*, 76–82. https://doi.org/10.1016/j.applanim.2014.02.005

Lee, H.-S. (2012). Perception and satisfaction among zoological park visitors. *Journal of the Korean Institute of Landscape Architecture*, *40*(3), 51–59. https://doi.org/10.9715/KILA.2012.40.3.051

Liefländer, A. K., Fröhlich, G., Bogner, F. X., & Schultz, P. W. (2013). Promoting connectedness with nature through environmental education. *Environmental Education Research*, *19*(3), 370–384. https://doi.org/10.1080/13504622.2012.697545

Morgan, J. M., & Hodgkinson, M. (1999). The motivation and social orientation of visitors attending a contemporary zoological park. *Environment and Behavior*, *31*(2), 227–239. https://doi.org/10.1177/00139169921972074

Moss, A., & Esson, M. (2013). The educational claims of zoos: Where do we go from here? *Zoo Biology*, *32*(1), 13–18. https://doi.org/10.1002/zoo.21025

Moss, A., Francis, D., & Esson, M. (2008). The relationship between viewing area size and visitor behavior in an immersive Asian elephant exhibit. *Visitor Studies*, *11*(1), 26–40. https://doi.org/10.1080/10645570801938418

Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2009). The nature relatedness scale: Linking individuals' connection with nature to environmental concern and behavior. *Environment and Behavior*, *41*(5), 715–740. https://doi.org/10.1177/0013916508318748

O'Haire, M. (2010). Companion animals and human health: Benefits, challenges, and the road ahead. *Journal of Veterinary Behavior*, *5*(5), 226–234. https://doi.org/10.1016/j.jveb.2010.02.002

Orr, D. W. (1993). Love it or lose it: The coming biophilia revolution. In S. R. Kellert & E. O. Wilson (Eds.), *The biophilia hypothesis* (pp. 414–440). Washington, DC: Island Press.

Oswald, L. M., Zandi, P., Nestadt, G., Potash, J. B., Kalaydjian, A. E., & Wand, G. S. (2006). Relationship between cortisol responses to stress and personality. *Neuropsychopharmacology*, *31*(7), 1583–1591. https://doi.org/10.1038/sj.npp.1301012

Robinson, J. M., & Breed, M. F. (2019). Green prescriptions and their co-benefits: Integrative strategies for public and environmental health. *Challenges*, *10*(1), 9. https://doi.org/10.3390/challe10010009

Sahrmann, J. M., Niedbalski, A., Bradshaw, L., Johnson, R., & Deem, S. L. (2016). Changes in human health parameters associated with a touch tank experience at a zoological institution. *Zoo Biology*, *35*(1), 4–13. https://doi.org/10.1002/zoo.21257

Sakagami, T., & Ohta, M. (2010). The effect of visiting zoos on human health and quality of life. *Animal Science Journal*, *81*(1), 129–134. https://doi.org/10.1111/j.1740-0929.2009.00714.x

Schebella, M. F., Weber, D., Lindsey, K., & Daniels, C. B. (2017). For the love of nature: Exploring the importance of species diversity and micro-variables associated with favorite outdoor places. *Frontiers in Psychology*, *8*(2094). https://doi.org/10.3389/fpsyg.2017.02094

Sherwen, S. L., Hemsworth, P. H., Butler, K. L., Fanson, K. V., & Magrath, M. J. L. (2015). Impacts of visitor number on Kangaroos housed in free-range exhibits. *Zoo Biology*, *34*(4), 287–295. https://doi.org/10.1002/zoo.21226

Sickler, J., & Fraser, J. (2009). Enjoyment in zoos. *Leisure Studies*, *28*(3), 313–331. https://doi.org/10.1080/02614360903046649

Soye, A., & O'Súilleabháin, P. S. (2019). Facets of openness to experience are associated with cardiovascular reactivity and adaptation across both active and passive stress exposures. *International Journal of Psychophysiology*, *140*, 26–32. https://doi.org/10.1016/j.ijpsycho.2019.03.016

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Essex, UK: Pearson Education Limited.

Tennant, R., Hiller, L., Fishwick, R., Platt, S., Joseph, S., Weich, S., … Stewart-Brown, S. (2007). The Warwick-Edinburgh Mental Well-being Scale (WEMWBS): Development and UK validation. *Health and Quality of Life Outcomes*, *5*(1), 63. https://doi.org/10.1186/1477-7525-5-63

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landscape and Urban Planning*, *81*(3), 167–178. https://doi.org/10.1016/j.landurbplan.2007.02.001

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman & J. F. Wohlwill (Eds.), *Behavior and the natural environment* (pp. 85–125). Boston, MA: Springer.

Wells, D. L. (2009). The effects of animals on human health and well-being. *Journal of Social Issues*, *65*(3), 523–543. https://doi.org/10.1111/j.1540-4560.2009.01612.x

Wells, N. M., & Evans, G. W. (2003). Nearby nature: A buffer of life stress among rural children. *Environment and Behavior*, *35*(3), 311–330. https://doi.org/10.1177/0013916503035003001

Wilson, E. O. (1984). *Biophilia*. Cambridge, MA: Harvard University Press.

Woolway, E. E., & Goodenough, A. E. (2017). Effects of visitor numbers on captive European red squirrels (*Sciurus vulgaris*) and impacts on visitor experience. *Zoo Biology*, *36*(2), 112–119. https://doi.org/10.1002/zoo.21357

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