Nature Engagement for Health:

Enhanced Methods to Improve Connection and Reduce Stress

A Dissertation

Presented in Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

with a

Major in Education

in the

College of Education

University of Idaho

by

Erik L. Luvaas

Major Professor: Sharon Stoll, Ph.D.

Committee Members: Jennifer Beller, Ph.D., Chun-Chu Chen, Ph.D., Justin Barnes, Ph.D.

Department Administrator: Philip W. Scruggs, Ph.D.

December 2019

Authorization to Submit Dissertation

This dissertation of Erik Luvaas, submitted for the degree of Doctor of Philosophy with a Major in Education and titled "Nature Engagement for Health: Enhanced Methods to Improve Connection and Reduce Stress," has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

Major Professor: _____ Date: _____
Sharon Kay Stoll, Ph.D.

Committee Members: _____ Date: _____
Jennifer Beller, Ph.D.

_____ Date: _____
Bamboo Chen, Ph.D.

_____ Date: _____
Justin Barnes, Ph.D.

Department Administrator: _____ Date: _____
Philip Scruggs, Ph.D.

Abstract

Guided by literature on wellbeing benefits of nature interactions, this dissertation presents a quasi-experimental study examining the effects of four barrier-lifting lessons to prepare participants for a nature engagement intervention versus control in natural versus urban environments. Previous research has not addressed the way people engage with natural environments for optimimizing health and wellness. Measures of perceived stress, connectedness to nature, and mindfulness in nature were collected at three time points to examine the effect of type of engagement with nature and` natural versus urban environments. Results from repeated measures analysis of variance indicate all groups increased connection to nature ($F(1, 86) = 74.22$, $p < .001$) and mindfulness in nature (F (1, 86) = 50.88, $p < .001$) over time, but no significant differences were observed between groups pairwise on either variable. However, raw survey scores indicated the intervention groups had a non-significant greater increase in mindfulness in nature in both environments compared to controls. All groups had a reduction in stress (F (1, 86) = 144.92, $p < .001$), and the intervention group in the natural setting observed the greatest non-significant reduction in stress ($p = .063$) compared to control in the same environment. Correlations supported previous research where psychological stress was inversely correlated with connection to nature ($r(88) = -.372$, $p = .01$) and mindfulness in nature ($r(88) = -.500$, $p < .01$). Mindfulness in nature and connection to nature were positively correlated ($r(88) = .524$, $p < .01$). A discussion is presented about what factors likely contributed to the finings, and suggestions for future research are outlined. Implications follow about how and why optimal forms of nature engagement in urban settings should be considered and implemented the for health and wellbeing practices of individuals and specific groups.

Acknowledgements

Dedication

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Modern urban society, with all its demands and ever-increasing access to vast amounts of information and media, can be overwhelming to the human brain and eventually takes a toll on the brain and the body (Soga et al., 2015). Attentional capacity and especially, increased and/or sustained stress response from all these stimuli can be detrimental to our wellbeing (Carlson, 2013). With 54% of the world's population now living in urban settings and 66% projected by 2050 (United Nations, 2014), it is increasingly important to address the epidemic of stress in modernized cultures.

Stress-related disorders can be caused by any number of aversive stimuli that elicit a stress, or fight-or-flight response, and can cause bodily harm if the stress response is prolonged through long-term exposure to the eliciting stimuli. Stress-related disorders include those with specific diagnostic criteria such as posttraumatic stress disorder and others that exhibit a more generalized manifestation throughout different body systems (Carlson, 2013). Harm from long-term exposure to stress can include brain damage that affects one's memory, learning capacity, and emotional reactivity due to sustained damage to the hippocampus from the release of certain glucocorticoids (i.e., stress hormones) during stress response (2013), all of which can cause neuron death or reduced lifespan of neurons produced by neurogenesis in the hippocampus. The hippocampus is a brain center involved with emotion, memory, and the autonomic nervous system. In addition to these deficits, impaired neurogenesis in the hippocampus relates to the onset of depression (2013).

Another harmful effect of a prolonged stress response is damage to human body structures and systems from the overproduction of glucocorticoids such as cortisol, and other hormones including epinephrine and norepinephrine that aid the fight-or-flight response.

Prolonged secretion of certain glucocorticoids can also produce a myriad of damage to the body including “increased blood pressure, damage to muscle tissue, steroid diabetes, infertility, inhibition of growth, inhibition of the inflammatory responses, and suppression of the immune system” (p. 619, 2013). Suppression of the immune system is one effect of long-term stress exposure that can be particularly deleterious due to the cascading consequences of the body’s reduced ability to fight off disease and infection. All these ailments result in reduced quality of life and global health and a higher risk of mortality (2013).

One option for both prevention and treatment to address the deleterious effects of chronic stress is engagement with natural environments. In the past two decades, a significant increase in popular media attention and research on this topic has occurred. With the release and widespread discussion of Richard Louv’s (2008) book, “The Last Child in the Woods: Saving our Children from Nature-Deficit Disorder,” numerous conferences, special topics issues of research journals, popular media, non-profit and government initiatives, and academic curricula caused a heightened awareness of the importance of nature to the health and wellbeing of children and adults.

Much of the research on the mental health benefits of nature interaction is built upon two prominent mechanistic theories, Kaplan’s (1995) Attention Restoration Theory (ART) and Ulrich’s (Ulrich et al., 1991) Psycho-evolutionary Theory (PET) or Stress Reduction Theory (SRT). ART describes the separation of involuntary attention and voluntary or directed attention, which are executive functioning processes of the frontal lobe of the brain (Carlson, 2013). ART addresses cognitive functioning benefits by identifying that directed attention could be restored by interactions with nature, or environments that contain inherently fascinating stimuli such as sunsets, which typically activate involuntary attention,

not directed attention (Berman et al., 2012). Urban environments, on the contrary, typically activate directed attention because one must negotiate various stimuli found such as car horns, traffic, pedestrians, and other obstacles and sensory bombardment. The important difference is that involuntary attention is captured by salient stimuli that does not require directed attention to negotiate. Directed attention requires a cognitive-control process, which has also been implicated in short-term memory performance (2012). Time spent in nature provides the salient stimuli to activate indirect attention and not overtax directed attention, thereby replenishing directed attention capacity.

Stress Reduction Theory, addressing psycho-emotional benefits and proposed by the fields of psychology and landscape architecture, posits that humans have spent much of their evolution in natural environments among plants, animals, and nature-formed landscapes (Berto, 2014). Because of this history, we are hardwired to seek out and feel comfort from surroundings that contain certain natural features, from which we elicit a positive affective response leading to a reduction in psychophysiological stress (Bratman, Hamilton, & Daily, 2012). A significant portion of the research on the benefits of nature interaction relies on this theory beginning with Ulrich's (1984) seminal study demonstrating that patients with a view of nature recovered faster after surgery than those without. Exact mechanisms and optimal forms of interactions with nature remain unclear (Beery, 2013; Berto, 2014; de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Gidlow et al., 2016; Pearson & Craig, 2014; Stigsdotter & Grahn, 2011; Triguero-Mas et al., 2015; Wheeler et al., 2015), but recent studies are getting closer to elucidating these questions.

Setting the Problem

Our species is becoming more and more disconnected from the natural world and considerably surrounded by built human-managed environments (United Nations, 2014). Considering the mountain of research generated over the last three decades on the multi-faceted health and wellbeing benefits of nature exposure and interaction (Lin, Fuller, Bush, Gaston, & Shanahan, 2014), identifying strategies to increase nature engagement in our daily lives seems prudent. Research suggests that to avoid the stress linked to "extinction of experience" with nature, we must find ways to reconnect people to the natural environment within urban settings and on a more frequent basis (Lin et al., 2014).

Problem Statement

The purpose of this quantitative, descriptive and quasi-experimental study will be in two sections and four parts:

A. Philosophical and aesthetic (Descriptive)
    1. To examine the aesthetic and descriptive effect of four barrier-lifting lessons to prepare participants for a nature engagement experience. Participants were assessed (pre-barrier-lifting experience) for their preparedness for a nature experience (measures of connection to nature and mindfulness in nature), and
    2. Participants were assessed post-barrier-lifting experience (measures of stress, connection to nature, and mindfulness in nature).

B. Quasi-experimental
    3. To guide two participant groups through an actual nature engagement experience to reduce stress (Group 1, Natural-Sensory Engagement, will experience a mostly natural environment. Group 2, Urban-Sensory

Engagement, will experience a mostly built urban environment with some elements of nature), and

4. To reassess stress, connection to nature, and mindfulness in nature after the experience.

The study will utilize a quantitative non-crossover quasi-experimental design to measure the effects of two types of engagement with a natural and an urban environment on connectedness to nature, mindfulness in nature, and psychological stress in college students.

Statistical Sub-Problems

1. What is the effect of an intervention program by environment type on **connection to nature**?
2. What is the effect of an intervention program by environment type on **mindfulness in nature**?
3. What is the effect of an intervention program by environment type on **psychological stress**?
4. What is the relationship between **connection to nature** and **psychological stress** after intervention program?
5. What is the relationship between **mindfulness in nature** and **psychological stress** after intervention program?
6. What is the relationship between **connection to nature** and **mindfulness in nature** after intervention program?

Statistical Null-Hypotheses

H_1: No differences exist between intervention and control by environment type on **connection to nature**.

H_2: No differences exist between intervention and control by environment type on **mindfulness in nature**.

H_3: No differences exist between intervention and control by environment type on **psychological stress**.

H_4: No relationship exists between **connection to nature** and **psychological stress** across intervention and control groups.

H_5: No relationship exists between **mindfulness in nature** and **psychological stress** across intervention and control groups.

H_6: No relationship exists between **connection to nature** and **mindfulness in nature** across intervention and control groups.

Operational Definitions

Variables. The independent variables in the study include type of engagement (sensory engagement intervention or control) and type of environment (natural and urban). The dependent variables include psychological stress, connectedness to nature, and mindfulness in nature.

Type of engagement with environment. Previous research on the benefits of nature engagement has not addressed the *way* people engage with elements of natural environments. For this study, type of engagement will include either (1) a passive walk through an environment where the individual is not directed to pay particular attention to any specific elements but rather takes in the scene as a whole (i.e., a typical walk for transportation) or (2) a sensory engagement walk where participants are directed to actively seek out sensory stimulation from the natural elements in the environment (e.g., touching plants and trees, listening for birdsong, smelling the aroma of trees or flowers, or looking at specific natural

elements with curiosity). This difference emphasizes the intent of the individual to actively engage with nature. In the first case (1), there will be no instruction provided by the researcher to engage with nature. In the second case (2), the primary researcher will direct participants to engage with nature.

Type of environment. In this study, the two selected environments are (1) natural, which consists of a great variety of natural elements including plants, trees, rocks, soil, animals, and possibly water (i.e. unmanaged forest ecosystem) and (2) urban, a primarily built environment with a few elements of nature such as planted trees, shrubs, or flowers (i.e., a city streetscape).

Connectedness to nature. This construct is a measurement of how emotionally connected one feels to the natural world at a given time. It is measured by the Connectedness to Nature Scale (CNS) (Mayer & Frantz, 2004).

Psychological stress. Subjective stress can be assessed using a variety of self-report survey instruments to measure how much stress an individual perceives they are experiencing at a given time. To assess an individual's state of feeling stressed, a measure of acute stress, the Psychological Stress Measure (PSM-9) will be administered (Lemyre, 2009).

Mindfulness. With the popularization of various forms of meditation and "mindfulness practices," the term mindfulness has become quite nebulous. Definitions relating to Eastern philosophies often describe focusing one's awareness on the present moment while practicing acceptance and non-judgement of one's feelings, thoughts, and sensations. For this study, however, the concept will be used to address the state of being cognitively present and actively aware of one's natural environment. It will be measured by the Mindfulness in

Nature Scale, the current study author's modification of the Five Facet Mindfulness Questionnaire (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006).

Limitations and Delimitations

Limitations of this study include the quasi-experimental design using a relatively small, non-randomized sample size. This limits generalizability to other populations of college students and other groups. Assigning students to groups based on convenience of class schedules and access to existing student groups is a threat to internal validity in the form of selection bias (Campbell & Stanley, 1999). In other words, the convenience sample does not control for unequal proportions of participants in each group with similar variables. However, pre-test scores for all groups will be compared to potentially reduce this threat to internal validity.

In addition, experimenter bias may be introduced since the researcher will be leading the experimental interventions on classes for which he is the instructor (1999). The so-called Hawthorne effect is a threat to validity because participants may be tempted to modify or improve their survey responses based on their awareness of being observed. However, this aspect of the study design was intentional in an attempt to control for non-compliance with participation in experimental conditions. Finally, the study design introduces a threat to testing via the three time points for repeated measures. Participants may develop assumptions about the intent of the experiment by seeing the same surveys multiple times, and, therefore, adjust their responses according to any motivation to sway the results. In an attempt to control for a threat to testing, participants were provided clear instructions that they should answer each survey question honestly and as it pertains to the present moment.

Significance of the Study

The present study has significant implications for the health and wellbeing of all humans living along the gradient of urbanization present in modern society. First, the participants in the study, the students, will benefit from learning a stress reduction strategy that can be utilized in the urban environment in which they live. They may also become more connected to nature and experience benefits associated with nature connection.

The study will inform nature engagement research about practical applications to lift barriers to being open to the experience of nature engagement. The study will also further the body of knowledge on optimal forms of nature engagement in both natural and built environments as related to stress reduction.

Humans' progressive disconnection from nature experiences through urbanization, and the resulting diminished comfort and literacy in experiencing nature, create barriers to eliciting the known benefits of nature interaction. The results of the study have the potential to inform further development of interventions and educational modalities to improve human health and wellbeing by means of stress reduction through nature engagement. Since nature can be found even in the most densely urbanized cities, optimal forms of engagement with nature are an accessible health resource for all people.

Implications of the study may be particularly important for underrepresented groups. For instance, groups such as those living in institutions (e.g., hospitals, prisons, long-term care facilities) and people in areas of lower socioeconomic status could be targeted. Nature engagement interventions and education may be more accessible complimentary health practices for those with limited access to medical care, social capital, or wellbeing enhancing resources such as parks and other public services. In addition, stress-reducing nature

engagement practices offer a universally accessible tool with which individuals can take an active role in their preventative healthcare. Further development of such practices may be tailored for specific groups' needs such as sectors of employment known to experience high levels of burnout due to job stress, people with different cultural connections to nature, or patients in different stages of rehabilitation or recovery in our healthcare system. In addition, the study provides evidence for practices that can be utilized by allied health professionals such as recreational, occupational, physical, and mental health therapists.

Chapter 2: Literature Review

Problem Statement

The purpose of this quantitative, descriptive and quasi-experimental study will be in two sections and four parts:

A. Philosophical and aesthetic (Descriptive)

1. To examine the aesthetic and descriptive effect of four barrier-lifting lessons to prepare participants for a nature engagement experience. Participants will be assessed (pre-barrier-lifting experience) for their preparedness for a nature experience (measures of connection to nature and mindfulness in nature), and
2. Participants will be assessed post-barrier-lifting experience (measures of stress, connection to nature, and mindfulness in nature).

B. Quasi-experimental

3. To guide two participant groups through an actual nature engagement experience to reduce stress (Group 1, Natural-Sensory Engagement, will experience a mostly natural environment. Group 2, Urban-Sensory Engagement, will experience a mostly built urban environment with some elements of nature), and
4. To reassess stress, connection to nature, and mindfulness in nature after the experience.

Researchers have pointed to a few major lines of inquiry to explore the human-nature connection and the benefits therein. Accordingly, and in line with the present study's problem statement, this literature review will cover nature engagement and stress reduction,

stress-reducing benefits of a personal connection to nature, and methods used to assess the stress-reduction benefits of nature engagement.

Nature Engagement and Stress Reduction

As a result of a review of the literature on stress reduction benefits of contact with the natural world, a total of 27 articles addressing stress changes from direct engagement with natural environments were identified. Table 2.1 (see Appendix F) provides a summary of key elements of each selected study. The type of engagement with nature addressed in the studies varied from exercise in green space to sitting in greenspace to recalling past experiences. Of the articles selected, six of the studies' designs involved subjects exercising in greenspace, 11 involved subjects living near greenspace, four had subjects recall past nature visits, and five had subjects walking and sitting in greenspace. Subjects in the selected studies varied widely from large representative population samples to small, selective studies (e.g., 12 Japanese male adults in Lee et al., 2011). Study designs and measurement instruments also varied widely from cross-sectional surveys to randomized cross-over field-based trials, from batteries of psychological self-report surveys to physiological data including blood pressure, salivary cortisol, and heart rate variability.

In order to simplify such great variability in study elements, two categories are presented to group the studies and assist in synthesizing their contribution to the literature on this topic: greenspace engagement studies and greenspace proximity studies. It is important to note that the lack of published studies reporting *non-significant* results of stress reduction after direct engagement with nature is reflective of what is available in the recent literature. Only a few studies have pointed to contradictory findings, and these articles report no stress reduction benefit from nature experiences in tropical climates (Saw, Lim, & Carrasco, 2015)

where elements of nature are more threatening (e.g., venomous/poisonous organisms, large predators, and disease vectors are more prevalent) (Karjalainen, Sarjala, & Raitio, 2010). The vast majority of research available on this topic has been conducted in northern hemisphere, temperate environments, which is what is reported in the following discussions and tables.

Greenspace engagement studies. Much of the research attempting to elucidate the stress reduction benefits of engaging in natural environments, or greenspace, has been conducted using experimental or quasi-experimental designs where subjects' stress levels are assessed using a variety of methods before and after engaging in two conditions, greenspace and non-green environments. Largely, the result of these studies has been that green environments produce greater short- and long-term stress reduction than non-green environments such as urban areas (Thompson, Coon, Stein, Barton, & Depledge, 2011). Many studies report, compared to non-green environments, walking in greenspace elicited a significant reduction in the stress hormone cortisol (Gidlow et al., 2016; Lee et al., 2009 & 2011; Tyrvainen et al., 2014), lower blood pressure (Hartig, Evans, Jamner, Davis, & Garling, 2003; Shanahan et al., 2016; Tsunetsugu et al., 2013), improved mood (Barton & Pretty, 2010; Gidlow et al., 2016; Park et al., 2011) and mental wellbeing (Hartig, Evans, Jamner, Davis, & Garling, 2003; Pasanen, Tyrvainen, & Korpela, 2014; Thomson, Coon, Stein, Barton, & Depledge, 2011), and a reduction in psychological distress (Astell-Burt, Feng, & Kolt, 2013; Tyrvainen et al., 2014). These results support Ulrich's (1984) Stress Reduction Theory and provide motivation for continued study and use of natural environments for effective stress reduction.

Although the selected greenspace engagement studies provide robust results supporting the use of nature engagement to reduce stress in a variety of populations, there is

considerable variability in the study designs. The type of greenspace used in each study (i.e., quantity, quality, and features of greenspace, proximity to urban areas, effect of noise and weather, etc.) varied widely or was uncontrolled. Consistency of experience is another limitation since many studies used vague instructions for participants about walking in a natural area (i.e., vs. walking without the use of headphones or screens, walking while intentionally engaging the senses, walking with a consistent speed, walking with/out talking to others, or walking with curiosity).

Perhaps some of the most consistent and long-term research conducted on the psychophysiological stress-reduction benefits of nature engagement has occurred in Japan with the study of shinrin-yoku. Forest bathing, known in Japan where it originated as shinrin-yoku, is translated literally as “forest” + “bathing/basking in” (Williams, 2012). The idea for the term, which the Japanese government coined in 1982, was inspired by ancient Shinto and Buddhist practices of letting nature fully enter one’s body through all five major senses (2012). It has been used to treat over-stressed corporate urbanites by systematically immersing them in a forest environment (2012). The Japanese government has been studying the physiological and psychological response of individuals who use its 48 official Forest Therapy trails since 1990, and other countries are beginning to do their own interventions and research including South Korea and Finland (2012). Largely, the benefits of this intervention have been marked reductions in a number of measured physiological stress responses indicators (e.g., stress hormones cortisol and alpha-amylase production, blood pressure, pulse rate, and heart rate variability) and improved scores on a variety of psychological self-report measures (e.g., Profile of Mood States, Positive and Negative Affect Schedule).

Examples of shinrin-yoku research include a study published in 2007, Japanese researchers from a number of universities collaborated to complete a study to measure the effectiveness of using forest therapy to treat acute stress (Morita et al., 2007). With a sample of 498 healthy volunteers, the researchers administered mental health surveys two times during the forest therapy intervention and twice again on a control day without forest therapy intervention (2007). According to the study authors, results from analysis of variance and multiple regression analyses of the data from the Multiple Mood Scale-Short Form and the State-Trait Anxiety Inventory A-State Scale showed improvements in stress levels of the participants. In particular, significant decreases in hostility and depression scores along with a significant increase in scores on liveliness were observed for the forest day compared to the control day as a cross-check. In addition, the analysis demonstrated that the more stressed an individual was going into the forest therapy day, the greater the effect of the experience was on reducing their stress level (2007). Therefore, the study results suggest that forest therapy could be an effective treatment for people suffering from very high acute stress.

In another Japanese study, Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki (2010) report the results of field experiments in 24 forests around Japan to assess the physiological effects of forest therapy. According to the authors, for each experiment 12 subjects were sent to either a forest or a city on the first day of the experiment and they switched places on the second day. A number of physiological indicators were measured including salivary cortisol, blood pressure, pulse rate, and heart rate variability. Results from statistical analysis to compare the forest group to the city group showed that the forest environment “promoted lower concentrations of cortisol, lower pulse rate, lower blood pressure, greater parasympathetic nerve activity, and lower sympathetic nerve activity” than the city

environment (p. 18). The authors concluded that forest therapy is ripe for future research on using forests as venues for preventative medicine, especially related to stress (2010).

As evidenced by the selected studies, but in particular, the compelling physiological data from the shinrin-yoku studies, greenspace engagement is a research topic full of potential to uncover additional benefits for stress reduction and population mental wellbeing. A look at larger population-based studies provides further evidence that humans' interface with the natural world is tied to our health.

Greenspace proximity studies. A more atypical but increasingly utilized method to assess greenspace health implications has been the use of epidemiological study designs. With the use of Geographic Information Systems (GIS) to assess greenspace land coverage, governmental population demographics data and population-wide health survey data, researchers across the globe have recently been able to analyze the effect of proximal greenspace on multiple health indicators at a population level. The selected epidemiological studies report that greater surrounding greenness buffered stress experiences (van den Berg, Maas, Verheij, & Groenewegen, 2010), is associated with greater self-perceived general health and mental health (Alcock, White, & Wheeler, 2014; de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Triguero-Mas et al., 2015; Wheeler et al., 2015), and is associated with lower levels of negative mental health symptoms (Beyer et al., 2014) and self-reported stress (Nielsen & Hansen, 2007); increased distance from greenspace was associated with an increase in prevalence of depressive symptoms (Reklaitiene et al., 2014) and increased odds of experiencing stress (Stigsdotter et al., 2010).

Much of this sort of research design has been conducted in Europe, and many of the recent studies coming out of the Netherlands have looked at how streetscape greenery may

impact health with stress as one of the mediators (de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013). The authors of one study describe measuring the quantity and quality of streetscape greenery by observation in eighty neighborhoods within four Dutch cities (2013). Questionnaires were collected from 1,641 participants to measure self-reported health and the proposed mediators. Results from multilevel regression analysis, controlling for socio-demographic characteristics, showed that "both quantity and quality of streetscape greenery were related to perceived general health, acute health-related complaints, and mental health" (p. 26). Stress and social cohesion were shown to be the most significant mediators of health suggesting that the quantity and quality of green space may affect stress, which in turn affects various levels of health indicators (2013).

Some studies on the stress-reducing benefits of forested areas or other green space have used GIS to quantify how the amount of green space one has access to may affect stress levels and other mental health measures (Alcock et al., 2013; Huynh, Craig, Janssen, & Pickett, 2013). In a study out of England, Alcock et al. (2013) used five years of mental health data from the British Household Panel Survey to explore the effect of quantity of green space on participants who moved to new towns with varying quantities of green space. The authors' results show that, while controlling for changes in income, employment, and marital status, individuals who moved to greener areas had significantly better mental health scores than before they moved. In contrast, individuals who moved to less green areas showed no significant difference in mental health scores. The authors suggest that greener urban areas have the potential to elicit sustained mental health improvements (2013).

In a similar study out of Wisconsin, Beyer et al. (2014) use the population-based Survey of the Health of Wisconsin database to analyze the effect of neighborhood green

space on mental health measures. The authors found that “higher levels of neighborhood green space were associated with significantly lower levels of symptomology for depression, anxiety and stress, after controlling for a wide range of confounding factors” including age, gender, race/ethnicity, marital status, socio-economic status, education, annual household income, and occupational status (p. 3453-54). The authors suggest that “greening” US cities, both small and large in population, could provide a potential mental health improvement strategy on a population scale (2014).

A comparable study from Spain (Triguero-Mas et al., 2015) used the Catalonia Health Survey to measure a variety of self-perceived general health and mental health indicators of a population of adults. This data was compared with indicators of surrounding greenness and access to outdoor environments. Results of data analysis indicated that surrounding greenness was associated with better mental health and better self-perceived general health regardless of degree of urbanization. This study further supports the “greening” of cities, no matter how urban or rural, to improve population mental health.

Considering the significant variability in study locations and data collection methods (i.e., variability in land greenness classification methods, government population health indicator standards, and mental health questionnaires utilized), the selected epidemiological studies have inherent limitations in their application to general populations. A limitation commonly cited by authors in the selected articles was the effect of “micro-restorative” nature experiences or the proximity of unaccounted small greenspace areas such as pocket parks or community gardens may have on the greater population health associated with nearby nature. Another commonly cited limitation was the lack of consideration of type of engagement with proximal greenspace and how that may mediate or moderate the

populations effects observed. The selected epidemiological studies bolster the greenspace engagement studies to provide powerful evidence of the benefits of nearby nature at the population level. A discussion of aims for future research based on author recommendations and limitations to greenspace proximity studies and greenspace engagement studies follows.

Future research. The body of knowledge on the psychological and physiological stress-reduction benefits of engaging in natural environments is compelling. It is clear that proximity to greenspace has the potential to promote greater mental health and general health in large populations. It is also well documented that intentional engagement with natural environments (i.e., walking in and observing forests) has the potential to reduce multiple biomarkers of stress response. However, there is a dearth of research investigating the optimal form of engagement with natural environments to elicit maximum benefits. Many of the selected studies' authors have pointed to this gap in the research literature (de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Gidlow et al., 2016; Stigsdotter & Grahn, 2011; Triguero-Mas et al., 2015; Wheeler et al., 2015;). It is also unclear what effect, if any, small green spaces (i.e., pocket parks, backyards, small community gardens, or building-front green areas) may have on stress reduction (Reklaitiene et al., 2014; van den Berg, Maas, Verheij, Groenewegen, 2010). The question remains to what extent does the type of engagement with greenspaces affect the stress-reducing potential of those environments, and if type of engagement is a salient variable, can smaller nearby nature areas such as urban parks or neighborhood parkways perform as well as vaster, potentially less ubiquitous and accessible areas such as national forests and wilderness areas?

Connection to Nature and Related Benefits

As a result of a review of the literature on the role of connection to nature in eliciting stress-reduction benefits from nature experiences, a total of 13 articles were identified. Table 2.2 (see Appendix F) provides a summary of key elements of each selected study. Although no studies could be found that measured a stress change from experiencing natural environments and also assessed nature connectedness, many studies measured variables that are closely related to subjective experiences of stress and thus were included (e.g., various measures of wellbeing (Capaldi, Dopko, & Zelenski, 2014)). Subjects in the selected studies varied primarily between university students accessible to the authors and local community members, with two studies utilizing subjects recruited online and one qualitative study with only one subject. Study designs varied from primarily cross-sectional self-report survey designs to one meta-analysis, one qualitative, and one experimental study. Measurement instruments varied widely, but most measured the constructs nature connectedness or nature relatedness (with some including additional variations of nature connection scales) combined with a series of measures for happiness or subjective wellbeing. Many studies also assessed mindfulness using a few different instruments.

Key findings from the selected articles provided primarily correlational results due to the cross-sectional study designs. The most frequently cited result – in all selected articles – was a significant positive association between measures of connection to nature and subjective wellbeing. A variety of constructs, and respective measurement instruments, were utilized to assess subjective wellbeing (see Table 2.2 in Appendix F). Measures included surveys for depression, psychological and social wellbeing, meaningfulness in life, vitality, positive and negative affect, life satisfaction, and happiness.

No studies measured changes in stress response, and only one study considered nature connectedness as a mediator or moderator of the benefits of nature experiences (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009). Not surprisingly, this was also the only experimental study meeting the criteria for this review. The authors conducted three studies with a total of 232 university students to elucidate the effects of exposure to nature on positive affect and the ability to reflect on a life problem. After walking in a natural setting for 15 minutes (Studies 1, 2, and 3), an urban setting (Study 1), or watching videos of nature and urban scenes (Studies 2 and 3), exposure to nature provided the most beneficial effects. Subjects scored higher on measures of connectedness to nature, positive emotions, attentional capacity, and ability to reflect on a life problem. Actual nature outperformed virtual nature for mood improvements. The authors also found that improvements in subjects' affect due to the nature condition was partially mediated by their connectedness to nature scores. This result provides the only mediating effect of connectedness to nature available at the time of this review.

Other selected studies considered a variety of mediators for the relationship between connectedness to nature and subjective wellbeing measures. Howell, Passmore, and Buro (2013), in two studies of a total of 538 undergraduate students, found that measures of meaning in life fully mediated the positive correlation between the connectedness to nature and measures of wellbeing and happiness. Kamitsis and Francis (2013) conducted a cross-sectional study of 190 Australian adults on the relationship between previous nature exposures, connectedness to nature, spirituality, and wellbeing. Results indicated that nature exposure and connectedness to nature were positively correlated with psychological wellbeing and that both associations were mediated by spirituality. Nisbet, Zelenski, and

Murphy (2011) used the Nature Relatedness Scale, a similar construct to the Nature Connectedness Scale, to show that nature relatedness is positively correlated with subjective wellbeing in a three-study sample totaling 354 Canadian university students and 145 community business executives. The studies also demonstrated that an environmental education class helped maintain subjects' nature relatedness scores while the control group's scores were reduced over time. In addition, nature relatedness was shown to mediate the positive correlation between environmental education and vitality. Finally, in a survey of 1,108 online respondents and 151 college students, Zhang, Howell, and Iyer (2014) found that connectedness to nature is positively correlated with wellbeing only if subjects' scores on engagement with natural beauty were higher, not lower. As is evidenced by the selected studies, only a small number of articles cite connectedness to nature in a mediation or moderation relationship. Furthermore, while most studies have considered variables that may mediate or moderate nature connectedness in its relation to wellbeing, only one study considered how connectedness to nature acts as a mediator for the benefits of nature exposure.

Beyond wellbeing and nature connectedness, the only other construct considered in the selected studies was mindfulness, measured by a variety of survey instruments. Howell, Dopko, Passmore, and Buro's (2011) two-study article (452 and 275 undergraduates, respectively) showed that not only were measures of nature connectedness positively correlated with psychological and social wellbeing (Study 1 and 2), but nature connectedness also positively correlated with measures of mindfulness (Study 2). In three cross-sectional self-report survey studies totaling 656 community college students and 242 adult community members, Wolsko and Lindberg (2013) reported that mindfulness measures were positively

correlated with psychological wellbeing, connectedness to nature, and appreciative outdoor activity participation such as hiking, canoeing, and snowshoeing.

Future research. The selected articles addressing the role of connection to nature in eliciting stress-reduction and other wellbeing measures provide ample evidence that other constructs (e.g., mindfulness, meaning in life, spirituality, engagement with natural beauty) may impact the relationship between connectedness to nature and wellbeing. However, very limited inferences can be made about the effect connectedness to nature has on the nature engagement and wellbeing relationship, and even less about changes in stress response. While some evidence exists that connectedness to nature mediates improved affect after nature exposure (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009), and environmental education may improve vitality as mediated by nature relatedness (Nisbet, Zelenski, & Murphy, 2011), the research literature largely has not addressed the role of nature connectedness in eliciting benefits from human-nature relationships. This lack of evidence is due to ubiquitous cross-sectional survey studies and the absence of experimental studies including actual nature exposure as an independent variable, and wellbeing constructs and connectedness to nature as the dependent variable. Without future research utilizing a similar study design, the research question cannot be fully explored. Furthermore, a number of studies point to the possibility that mindfulness may play a role in eliciting benefits from nature engagement, and the construct may be related to nature connectedness (Howell, Dopko, Passmore, & Buro, 2011; Wolsko & Lindberg, 2013). Further study into this connection and the potential mechanism of mindfulness in the human-nature relationship is warranted.

Measuring Changes in Stress Response after Nature Experiences

As a result of a review of the literature on methods used to assess changes in stress response following nature exposure, a total of 12 articles were identified that met the selection criteria of utilizing both biomarkers and psychological self-report surveys (physiological and psychological measures, respectively). Table 2.3 (see Appendix F) provides a summary of key elements of each selected study. Although no studies could be found that aimed to analyze the efficacy of biomarkers compared to self-report surveys to measure stress change after nature exposure, four of the 12 studies directly measured the construct of stress in psychological self-report measures alongside measures of stress biomarkers, primarily salivary cortisol. Three of these studies reported on some relationship between biomarkers and self-report measures of stress. Findings from these studies are discussed later in this section.

Of the 12 selected studies, a total of nine studies measured salivary cortisol, one study measured hair cortisol concentration, one study measured salivary alpha-amylase, five studies measured heart rate variability, four studies measured blood pressure, and four studies measured heart rate. Other psychological self-report measures in the selected studies did not directly measure stress, but utilized a variety of measures of wellbeing, mood, affect, and anxiety which are related to but not direct measures of stress (see Table 2.3 in Appendix F). Subjects in the selected studies varied between U.S. college student samples and community members sampled from the U.S., Japan, Scotland, Finland, and the Netherlands. Study design for the selected articles varied, but experimental or quasi-experimental studies that included an actual nature engagement intervention as the independent variable were the most

frequently utilized (nine studies) followed by cross-sectional studies that considered subjects' nature proximity as an independent variable (three studies).

Key findings from the selected articles indicated nature exposure can improve measures of stress biomarkers in subjects including significant reductions in salivary cortisol (Lee et al., 2011; Lee et al., 2009; Roe et al., 2013; Thompson et al., 2012; Tyrvainen et al., 2014; Van Den Berg & Custers, 2011), hair cortisol concentration (Gidlow, Randall, Gillman, Smith, & Jones, 2016), blood pressure (Park et al., 2009), heart rate, and improved heart rate variability indicating a reduction in sympathetic nerve activity and an increase in parasympathetic nerve activity (Lee et al., 2011; Lee et al., 2009; Lee et al., 2014; Park et al., 2009; Song et al., 2013). Nearly all studies also reported improvements in measures of psychological wellbeing. Of the four studies including psychological measures of stress, two studies reported significant negative correlations between the Perceived Stress Scale and percentage of green space in subjects' neighborhoods (Roe et al., 2013; Thomson et al., 2012). One study reported significant reductions in the Perceived Stress Scale scores after subjects experienced a very natural setting (Beil & Hanes, 2013). The other study directly measuring psychological stress did not include correlational analysis of this construct with nature exposure.

The majority of studies selected met the selection criteria but did not conduct analysis to address the efficacy of using physiological vs. psychological measures of stress to elucidate the benefits of nature exposure. Three of the 12 selected studies at least partially addressed this objective in their analyses. Two studies reported no significant association between physiological stress biomarker (salivary cortisol and hair cortisol concentration, respectively) and the psychological instrument, the Perceived Stress Scale, which is a

measure of general stress over the previous month (Beil & Hanes, 2013; Gidlow, Randall, Gillman, Smith, & Jones, 2016). However, Beil and Hanes (2013) cite limitations to their study in the small sample size (n=15) and short duration to nature exposure, which may not have provided enough reaction time to capture salivary cortisol change. Salivary cortisol change in reaction to a stimulus has been reported to have a 20- to 40-minute lag (Ewert, Davidson, & Chang, 2016).

Gidlow, Randall, Gillman, Smith, & Jones (2016) reported that in relation to measures of neighborhood green space, subjects' hair cortisol concentration (HCC), an indicator of chronic stress, was significantly associated with the Appraisal of Life Events Scale-Loss subscale (ALES-Loss) but not the Perceived Stress Scale, a measure of general stress over the previous month. The authors interpret their findings to mean that in less natural environments, subjects who have higher HCC are more likely to have higher ALES-Loss scores, indicating chronic stress was associated with stressful loss events within the previous three months. This means that stress may manifest itself differently in one's biological state compared to one's perception of experienced stress. The data suggests individuals were unaware of their stress state when considering the previous month but did identify their experienced stress when considering the previous three months related to loss events. However, the authors cite a small sample size for the size of the land area studied, which limits the generalizability of their results.

In their study on neighborhood green space and physiological and psychological stress measures, Thompson et al. (2012) reported a steeper cortisol slope (change in cortisol from high to low within one day; steeper slope indicating less overall stress) was negatively correlated with stress levels as measured by the Perceived Stress Scale and positively

correlated with percentage of neighborhood greenspace. Linear regression analysis showed that percentage of greenspace was a significant predictor of both cortisol slope and Perceived Stress Scale scores. The study results indicate congruence between the physiological and psychological stress measures used since they are significantly correlated and share the same predictive independent variable. However, the study's authors cite limitations including small sample size (n=25), limiting generalizability, and coarse measures of greenspace, limiting the accuracy of the predictive function of the independent variable.

Future research. Cumulative results of the three studies addressing the efficacy of physiological vs. psychological measures of stress are mixed. While one study found no significant association between the two data collection methods, another study found an association between the stress biomarker and only one of two subjective stress scales used, and a third study reported that both the stress biomarker and subjective stress measure were correlated and could be predicted by the independent variable, percentage of neighborhood greenspace. These mixed analyses are indicative of the lack of clarity in the literature on which methods of measuring stress after nature exposure are the most accurate and reliable. Subjective psychological stress surveys do not always measure the same form of stress, for the same time period, or the same mechanism of stress response (e.g., present feeling vs. memory-triggered stress vs. past month's stress). Similarly, even physiological measures of the same biomarker can vary in interpretation (e.g., mean salivary cortisol vs. salivary cortisol slope vs. hair cortisol concentration). The findings in these studies also point to the nebulous nature of stress as a construct, where physiological representations of a stress response may not always be accurately interpreted or even consciously experienced by individuals. Clearly, further study into this question is warranted, and data collection

methods are needed that not only measure stress using both physiological and psychological measures but those that analyze the soundness of the two methods.

Conclusions and Directions for Future Research

The purpose of this literature review was to examine existing literature on the physiological and psychological stress-reduction benefits of nature engagement within three focus areas. Specifically, this review summarized the research on (1) optimal forms of engagement with natural environments to reduce stress, (2) the effect of one's connectedness to and perception of nature on benefits elicited from nature exposure, and (3) the use of physiological versus psychological measures of stress to most accurately assess changes after nature exposure. In the following, a summary of the literature review results and recommendations for future research are presented for each focus area.

Nature engagement and stress reduction. The articles selected to address this topic provide ample evidence that nature exposure is good for mental wellbeing and, specifically, has the ability to reduce the cascading effects of physiological and psychological stress in daily life. The preponderance of study designs on this topic have sought to identify the most beneficial elements of the natural environment for human benefit. Multiple variables are at play in the mechanistic relationship between nature exposure and stress response changes. Articles in this review have considered various durations and frequencies of nature exposure, quantity and quality of greenspace, type of activity (i.e., walking vs. sitting) within natural environments, acute vs. chronic stress, and male vs. female reactions to nature exposure.

Frequently cited limitations to the selected studies include small and/or homogeneous sample sizes, lack of control for individual behavior during nature interventions in experimental studies (i.e., focus of attention or mindfulness), and potential unaccounted

effects of "micro-restorative" nature experiences from daily engagement with nearby greenspaces. These limitations point to the need for studies that control for type of engagement (i.e., observable behavior such as sitting vs. walking vs. touching/exploring environment vs. mindfulness practices) in everyday, accessible nature encounters.

In addition, many authors cite the human health benefits of vast biodiverse environments such as forests, but a lack of access, awareness, knowledge, and motivation to visit these places limits many, especially underprivileged or uninformed populations. Frequently stated in the conclusions of such studies is need for research on optimal forms of engagement with nature (Beery, 2013; Berto, 2014; de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Gidlow et al., 2016; Pearson & Craig, 2014; Stigsdotter & Grahn, 2011; Triguero-Mas et al., 2015; Wheeler et al., 2015). Our increasingly urbanizing world is encroaching on the wilder natural spaces available to us and limiting our daily exposure and ease of access to purer greenspace. Perhaps a different view of nature is needed. Humans may do well to focus on improving wellbeing on the individual level, on a daily basis, and using the nature we have available to us in nearby environments.

It is proposed to put the onus on humans instead of the environment to achieve this goal. In other words, what can individuals do (i.e., in behavior and perception) to maximize their own physiological and psychological benefits in daily experiences with nearby nature, no matter the location? This new line of inquiry further warrants future studies on the optimal form of *human engagement* with nature, or put differently, how we interact with natural elements and how we allow those elements to engage with us.

The intentional use of our five senses is probably the most accessible form of engagement available to us. No studies in this review have controlled for this type of direct

engagement with natural environments, and most rely on visual stimulation or an assumed totality of sensory experiences while physically present in forest environments. However, much of the research on forest therapy, coming out of Japan, has pointed to the importance of the senses in eliciting benefits. Japanese researchers have even demonstrated physiological stress reduction from single sensory experiences in laboratory settings (e.g., "(1) olfactory stimulation using wood smell, (2) tactile stimulation using wood, and (3) auditory stimulation using forest sounds" (Miyazaki, Ikei, & Song, 2014)). Indeed, the connection between independent sensory elements in nature and humans' physiology makes sense considering we evolved in these environments (the basis for Stress Reduction Theory) (Ulrich et al., 1991). Tsunetsugu, Park, and Miyazaki (2010) describe this relationship best:

> Forest environments affect humans via the five senses, providing stimulation of various senses, such as vision (scenery), olfaction (smell of wood), audition (sound of running streams or the rustle of leaves), tactile sensation (feel of the surfaces of trees and leaves). Sensory information inputs via the five senses are processed in the corresponding sensory areas of the brain and are further transmitted through interaction among the various sensory inputs. These signals subsequently reach the areas of the brain that control emotions and physiological functions, where they effect physiological changes. (p. 29)

In further support of this notion, Richardson, Hallam, and Lumbar (2015) argue that "sensations are the sensory moment of human-nature interaction and relationship; the moments of interconnectedness that arise from how we, as biological beings, make sense of the world around us; the point where human and nature is experienced as one" (p. 13).

Future studies should consider utilizing nearby natural environments that are more equitably accessible to individuals, especially for those who are limited to their urban

confines due to a multitude of possible constraints. Richardson and Hallam (2013) support this notion in their qualitative analysis of journal entries from a year of nearby nature wanderings: “It is important to consider the accessible and typical landscape to see if, with time, positive experiences similar to those found in wilderness…can be found in the local landscape without the juxtaposition of home and wilderness” (p. 39). This line of research is both accessible and more pragmatic than much of the literature on nature engagement with vast, heavily forested and wild areas.

Connection to nature and related benefits. Researchers have considered the role of human’s views, beliefs, or perspectives about nature and how they fit into nature. Studies have reported how connectedness to nature may affect psychological and social wellbeing and provided evidence that connectedness to nature is positively correlated with subjective wellbeing and nature exposure. Nature connectedness has been shown to be closely related to individuals’ life satisfaction, overall happiness, and perspective-taking ability (Mayer & Frantz, 2004) while also measuring one’s affinity toward or feelings of connection with the surrounding natural world, a potentially cyclical relationship (Bratman et al., 2012). The articles selected for this section of the literature review primarily addressed the relationship between nature connectedness and subjective wellbeing variables. Only one study considered nature connectedness as a mediator or moderator of the benefits of nature exposure, and no studies measured changes in stress response.

Although changes in stress were not included in the experimental study, Mayer, Frantz, Bruehlman-Senecal, & Dolliver (2009) reported that connectedness to nature partially mediated improvements in subjects’ affect after a 15-minute walk in a natural setting. Other studies found positive correlations between nature exposure, improvements in psychological

and social wellbeing, connectedness to nature, and measures of mindfulness. In particular, mindfulness appears to be a construct that is associated with individuals' connectedness to nature and with measures of wellbeing. Future research is needed to further examine the role of mindfulness in eliciting stress-reduction from nature engagement.

Still, there is very little evidence of the role connectedness to nature plays in eliciting the known stress reduction benefits of spending time in natural environments. It is unclear if connectedness to nature is an antecedent to receiving greater psychological benefits from nature engagement or if it mediates or moderates the relationship. Again, with the onus on humans instead of the environment, future research should consider the role individual's perspectives of nature – and our ability to willingly change them – may have on the potential to maximize the psychophysiological benefits of engagement with it. Experimental study designs including a nature intervention as an independent variable and stress response, connectedness to nature, and mindfulness as dependent variables are needed.

Measuring changes in stress response after nature experiences. Measuring the true stress reduction benefits of nature exposure is a challenging endeavor considering the lack of evidence corroborating the link between measures of psychological and physiological stress. Research on the wellbeing benefits of nature exposure have used a plethora of instruments to measure both physiological and psychological changes in stress response. However, no studies were found that aimed to evaluate whether physiological or psychological measures are more accurate and reliable. The selected articles for this section of the literature review yielded three studies that analyzed the association between psychological and physiological measures. Unfortunately, the results of these studies are mixed with one citing no significant correlation between measurement types. One study reported a correlation between a stress

biomarker and one stress survey but not the other. Finally, a third study showed a correlation between a stress biomarker and a stress survey in addition to sharing the same predictive independent variable.

The literature reviewed clearly points to the need for studies clarifying the accuracy and reliability between specific physiological and psychological measures of stress after nature exposure. Humans are notorious for having limited understanding of their own emotions and cognitive processes (Pearson & Craig, 2014; Ward Thomson et al., 2012). Future research that utilizes both psychological and physiological measures of stress and simultaneously analyzing their corroboration is important for understanding the impact nature has on our bodies and minds. Such studies will inform how we may be able to optimize our engagement with nature's elements on a daily basis and in even the simplest of exposures.

Chapter 3: Methods

Problem Statement

The purpose of this quantitative, descriptive and quasi-experimental study was in two sections and four parts:

A. Philosophical and aesthetic (Descriptive)

1. To examine the aesthetic and descriptive effect of four barrier-lifting lessons to prepare participants for a nature engagement experience. Participants were assessed (pre-barrier-lifting experience) for their preparedness for a nature experience (measures of connection to nature and mindfulness in nature), and
2. Participants were assessed post-barrier-lifting experience (measures of stress, connection to nature, and mindfulness in nature).

B. Quasi-experimental

3. To guide two participant groups through an actual nature engagement experience to reduce stress (Group 1, Natural-Sensory Engagement, experienced a mostly natural environment. Group 2, Urban-Sensory Engagement, experienced a mostly built urban environment with some elements of nature), and
4. To reassess stress, connection to nature, and mindfulness in nature after the experience.

Subjects

College students have been previously identified as good candidates for research on stress and stress-reduction interventions due to the inherently stressful lifestyles they lead while transitioning from high school to a more rigorous academic environment with less

structure and supervision, more personal care responsibility, and heightened pressure to form new social relationships and personal identity (Hales, 2009; Hicks & Heastlie, 2008). Initial sample size calculations based on heart rate variability effect sizes from previous studies on natural vs. urban walking indicate a minimum sample of 22 participants for each of the four treatment groups in order to achieve a power of 0.8 and an alpha of 0.05.

Participants for this study were recruited from the California State University, Sacramento campus student population via four different department classes. Two of the classes assigned as intervention groups were taught by the researcher conducting the study and running the intervention activities. The intervention group classes were comprised of students majoring in the department. The two control classes were taught by different faculty from within the department. However, the control group classes were comprised of students from various majors. Implication of the participant selection are discussed further in Chapter 4.

Participants were screened for any excluding health conditions including recent history of cardiac, neuro/psychiatric, endocrine, or acute/chronic pain disorder or the use of medications or recreational drugs that may affect physiological measures (Beil & Hanes, 2013). Age was considered as a variable for which to control in participant recruitment, but since only global measures of HRV are significantly affected by age, and not the short-term components of interest in this study, participants of all ages were accepted (Reardon & Malik, 1996).

To participate in the study, interested participants must have agreed to the following before the data collection day: arrive well rested and refrain from using tobacco, alcohol and recreational drugs for at least 24 hours, and caffeine or strenuous activity for 12 hours (Beil

& Hanes, 2013). Participants who completed the entirety of the study were entered into a drawing for a popular fitness tracker watch.

Although there were no, or minimal, risks associated with the project, some people may have found some of the survey questions emotionally taxing. There may have been minimal discomfort from putting on and wearing a chest-strap heart rate monitor, but participants were assisted to maximize comfort and privacy while putting on and wearing a heart rate monitor. Participants may have benefited from this project by learning about or participating in an experience that may improve their wellbeing. Participants in the control groups were offered the opportunity to participate in the experimental intervention at a later time if they wish.

Protection of Subjects

The principal investigator conducting the study passed the Collaborative Institutional Training Initiative's IRB Investigators and Student Researchers Basic Course (ID# 26811986, exp. April 12, 2021). The study was reviewed and approved by the University of Idaho Institutional Review Board (protocol exp. April 19, 2019) and entered into a cooperative research agreement with California State University, Sacramento (signed October 31, 2018) for data collection at CSU, Sacramento.

There was minimal risk to participants in the barrier-lifting series and the guided sensory engagement (SE) walking interventions because participants were considering information, viewing natural landscapes, and going on a walk on a college campus. The walks took place in either an urban area with traffic or in a wooded area. There is always risk of twisted ankles, and minor injuries. However, the walking routes selected did not pose any potential for harm outside of a typical day walking on campus. If participants were in any

way uncomfortable, they were welcome to withdraw. The researcher in charge of intervention was a Wilderness First Responder and prepared to administer first aid and call for EMS in the unlikely event of any incident.

The instruments to evaluate the intervention posed minimal risk; the questions dealt with perception of environment, stress, and personal views about environment. All participants, whether completing or not, remained in the drawing for a free fitness tracker.

Study Design and Procedures

Philosophical and Aesthetic. In an earlier pilot study with a convenience sample of n=55 total participants and an average of 14 participants per treatment group, through post-exposure discussions with the participants certain realities come to light (see Appendix C for pilot study details). (1) Behaviors were observed in the pilot study participants that suggested discomfort with the experimental intervention of actively engaging one's senses with nature in a public space. (2) Participants were also observed being easily distracted by any technological devices in their proximity.

Considering the above, perhaps an aesthetic, philosophic intervention was needed to prepare participants for full immersion into the experimental intervention. A series of mini-interventions were devised where participants complete four lessons prior to the scheduled experimental intervention (see Appendix A for the lessons). Basically, the "barrier lifting" lessons attempted to prepare participants in the experimental intervention groups (N-SE and U-SE) for a mindful sensory engagement with nature practice to reduce stress (see Appendix B for a rationale for the lessons). Below is a representation of the quasi-experimental research design using notation:

Research Design Notation.

Note: a = primers, b = guided intervention

N-SE	O_1	X_a	O_2	X_b	O_3
U-SE	O_1	X_a	O_2	X_b	O_3
N-C			O_2		O_3
U-C			O_2		O_3

To begin participation in the study, the principal investigator provided participants in the experimental intervention group a brief oral description of the study procedures followed by participants signing consent forms and completing baseline measures of current subjective stress, a measure of how connected they feel to nature, and a measure of how mindful they are of their surroundings in natural environments (Time1). Participants then completed each of the "barrier-lifting" lessons over the course of two days. Three of the four lessons were facilitated during a class session, while the final barrier-lifter was for the participants to engage in on their own time. Participants in the control groups (N-C and U-C) did not participate in the "barrier-lifting" lessons, so they completed baseline measures at Time2 (the first contact with the researcher). For analysis purposes, intervention groups' Time2 data was copied to Time1 in the data set, assuming their baseline had not changed during the previous one week.

Quasi-experimental. One week following the "barrier-lifting" mini-intervention series, the final guided mindful sensory engagement intervention was conducted with participants in each of the two experimental groups. Control groups for the nature and urban environmental settings participated in the same walk as the experimental groups, but without the sensory engagement with nature intervention. Participants reported to study lab when data collection was scheduled to complete psychological measures and participate in one of four conditions.

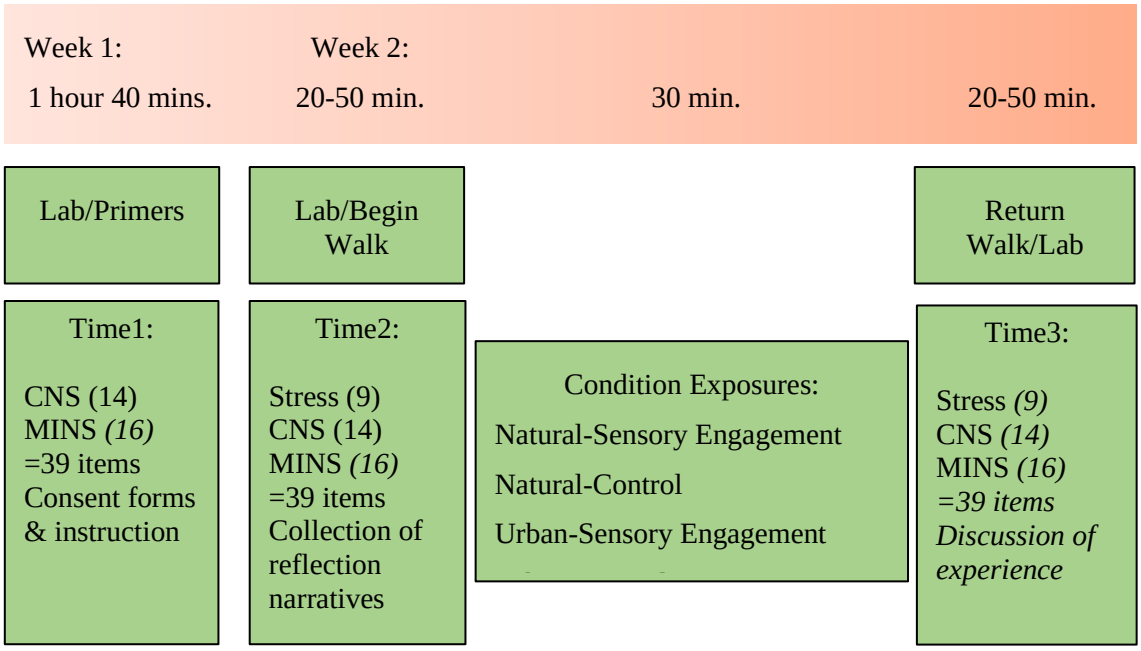
During each scheduled data collection, only one experimental condition was conducted at a time, and the maximum number of participants was limited to 35 due to lab space limits. Participant groups were randomly assigned to one of four conditions described below (Natural-Sensory Engagement, Natural-Control, Urban-Sensory Engagement, Urban-Control) before they report to the study lab.

The experiment utilized a four-arm non-cross-over design (non-cross-over to avoid the "carry-over" or "learning" effect of subjects participating in experimental and control conditions), and each data collection day was conducted using the following sequence and starting at the same time of day (see Figure 3.1): upon arrival, participants were asked to turn off any electronic devices and refrain from talking with any other study participants during their participation in the study. Then they again complete measures of current subjective stress, connectedness to nature, and mindfulness in nature (Time2). Participants were then led on foot to their assigned study site where they were instructed on how to engage in their assigned condition (urban or natural experimental groups, or urban or natural control groups) (see Appendix A for intervention protocols).

Walking distance to each study site was approximately equal, and participants were led by part of the research team to ensure compliance with a set walking pace and route. After 30 minutes of participation in one of the four conditions – which has been shown to be enough time for changes in psychological variables (Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010) – participants were led back to the lab. Once back in the lab, post-exposure current subjective stress, connectedness to nature, and mindfulness in nature was collected (Time3). Participants were thanked for their participation and informed of opportunities to learn more about the results of the research at a time in the future (Time3).

Figure 3.1:

Flow diagram for each group in quasi-experimental procedures.



Note: PSM-9: Psychological Stress Measure, CNS: Connectedness to Nature Scale, MINS: Mindfulness in Nature Scale, TFOAS: The Focus of Attention Scale.

All settings were located within walking distance of the university campus study lab. Each setting was chosen based on proximity to the study lab, a desire for non-challenging terrain, and the study author's desire for environments that match each experimental condition. The settings were categorized as "Natural-Sensory Engagement" (N-SE), "Natural-Control" (N-C), "Urban-Sensory Engagement" (U-SE), and "Urban-Control" (U-C) (see Figure 2). Conditions in the "Natural" setting utilized a university campus arboretum for its relatively unmanaged forest ecosystem, separation from the city environment, and practical availability as a source of nearby nature (as in Berman et al., 2012). Conditions in the "Urban" setting utilized a busy streetscape on the edge of a university campus which contains some natural elements but a predominantly built environment with high traffic volume. The "Sensory Engagement" conditions included practices (see Appendix A for intervention protocols) for participants to actively engage their five senses within the selected

environment so as to become more presently connected and aware of their surroundings and the specific features of the environment. In the “Control” condition, participants were given no instructions for how to engage with the environment beyond walking through the environment for the time allotted.

The category names were not shared with participants so there was no anticipation of the setting attributes. If undesirable weather (e.g., rain, snow – conditions that may negatively impact experience) were to be forecasted for one of the data collection days, the participants would have been rescheduled. Transportation to and from each setting was done using the same walking route with the same relaxed pace (about 2.5 miles/hour) and took no longer than six minutes one-way. Both settings were within about a quarter mile of the study lab to minimize the amount of walking required to participate in each experimental condition. Each condition had a set walking route of approximately the same distance (about 1.25 miles). Participants were instructed to walk at a leisurely pace while paying attention to their environments.

Figure 3.2:

Photos depicting both environmental settings used in the study.

“Natural” setting in CSU, Sacramento’s Charles M. Goethe Arboretum.

“Urban” setting on Sacramento, CA street.

Measurement Instruments

The following outcome measures were utilized to track changes in psychological stress, connectedness to nature, and mindfulness in nature over the course of the study conditions.

Psychological Stress Measure (PSM-9). This 9-item scale measures participants' perceived psychological stress with a rating scale from 1 to 8 indicating the degree to which each statement applies to the participant ranging from "not at all" to "extremely." Statements include items such as "I feel calm," "I have difficulty controlling my reactions, emotions, moods, or gestures," and "I feel stressed." Items 1 and 6 are reverse scored. is a validated and reliable scale with test-retest stability of .68 to .80 and internal consistency of .89 (Lemyre, 2003).

Connectedness to Nature Scale (CNS). The CNS is a validated (CNS correlates with ecological behavior, r = .44; environmentalism, r = .56; and environmental perspective taking, r = .50) and reliable (alpha = .79 to .84 across four studies) 14-item scale created by Mayer and Frantz (2004). The CNS asks respondents to rate how much they agree with questions regarding their affective connection to the natural world such as "Like a tree can be part of the forest, I feel embedded within the broader natural world," and is rated on a 5-point scale with endpoints 1 = *strongly disagree* and 5 = *strongly agree*. Items 4 and 12 are reverse scored. Higher total scores indicate higher nature connectedness. The current study will utilize the state version of the CNS, not the trait version originally created, so as to measure the present state of individuals' nature connectedness before and after each treatment condition. Mayer, Frantz, Bruehlman-Senecal, & Dolliver (2009) report that the state CNS correlates well with the trait CNS (r's > .6) in a sample of 76 first-year college students and is a reliable measure (α = .91).

Mindfulness in Nature Scale (MINS). The MINS is a scale adapted from the Five Facet Mindfulness Questionnaire by the current study author with some items added and some items modified. The FFMQ is a mindfulness scale that measures how aware and attendant an individual is to their current experience based on responses to each of the 39 items which are rated on a 5-point scale with endpoints 1 = *never or very rarely true* and 5 = *very often or always true* (Christopher, Neuser, Michael, & Baitmangalkar, 2012). Higher total scores indicate greater mindfulness. To fit the operational definition of mindfulness for the current study, only the "Observe" and "Act with awareness" facets of the FFMQ were retained, while the "Describe," "Nonjudge," and "Nonreact" items were eliminated. Modifications to remaining items included adding words relating to natural environments and eliminating unrelated words (e.g., "When I am outside in the wind or rain, I stay alert to the sensations of water or wind on my body" instead of " When I take a shower or bath, I stay alert to the sensations of water on my body"; and "I notice how the temperature and moisture of the air affects my bodily sensation" instead of "I notice how foods and drinks affect my thoughts, bodily sensations, and emotions") to maintain thematic consistency in the scale. One item was also replaced to maintain consistency ("When I'm outside, I notice movements around me, such as trees swaying in the wind" instead of "I pay attention to how my emotions affect my thoughts and behavior"). For the modified scale, even items (2, 4, 6, 8, 10, 12, 14, 16) are reverse scored. Internal consistency reliability of the MINS will be calculated across all treatment group scores to produce a Cronbach alpha coefficient for the modified scale. Previous studies verifying reliability on all facets of the FFMQ have produced adequate-to-good internal consistency scores for the "Observe" (α = .70 and α = .84) and "Act with Awareness" (α = .81 and α = .90) facets (de Bruin, Topper, Muskens,

Bögels, & Kamphuis, 2012; Christopher et al., 2012, respectively). Validity will be assessed via establishing face validity for scale items and via factor analysis to evaluate construct validity on retained "Observe" and "Act with awareness" facets from the FFMQ. Christopher et al., 2012). reported support for convergent and divergent validity where FFMQ total score was positively correlated with the Satisfaction with Life Scale ($r = 0.52$) and Trait Meta-Mood Scale used to evaluate emotional intelligence ($r = 0.64$), and negatively correlated with the Center for Epidemiological Studies Depression Scale ($r = -0.58$).

Significant associations have been observed between measures of mindfulness and well-being (Wolsko & Lindberg, 2013) and mindfulness and connectedness to nature (Howell, Dopko, Passmore, & Buro, 2011; 2013). Therefore, it can be argued that mindfulness may play a role in the emotional connection one has to nature and the subsequent benefits one may receive from engaging with natural environments. The MINS will be used to analyze relationships between mindfulness and stress reduction during nature experiences.

Statistical Analysis

For comparing differences in outcome measures for repeated measures (Time1, Time2, Time3) among the four treatment groups, a split-plot ANOVA was conducted for each measure (PSM-9, CNS, MINS). Post-hoc analysis via the Games-Howell procedure (for unequal group sizes and any violations of homogeneity of variance) was conducted to verify any significant differences between groups on each outcome measure.

Potential relationships between psychological stress, connection to nature, and mindfulness in nature measures were evaluated via multiple Pearson correlations at Time3.

The target sample size for the primary analyses, split-plot ANOVAs, was an estimated 22 participants per group (n=88) required to detect a medium effect, a power of 0.9, and an alpha level of 0.05. Analysis was carried out using IBM SPSS Version 24.

Chapter 4: Results

The purpose of this quasi-experimental study was to examine the effect of four barrier-lifting lessons to prepare participants for a nature engagement intervention. The study proposed to measure the effects of type of engagement with a natural and an urban environment on connectedness to nature, mindfulness in nature, and psychological stress of students at a Western US university. Survey instruments were administered before the barrier-lifting primers (Time1), one week later before nature engagement intervention (Time2), and after intervention (Time3).

Participants

The participants in this study were 90 college students from various majors at a Western US university. The participants were divided into four groups. The Nature-Sensory Engagement group (n=32) experienced the barrier-lifting primers and the nature engagement intervention in the natural environment. The Nature-Control group (n=21) experienced only a walk in the natural environment with no intervention. The Urban-Sensory Engagement group (n=25) experienced the barrier-lifting primers and the nature engagement intervention in the urban environment. The Urban-Control group (n=12) experienced only a walk in the urban environment with no intervention. The participants completed pre- and post-test measures of connectedness to nature, mindfulness in nature, and psychological stress. Approximately 99 students began the study, but 9 (9%) were dropped due to incomplete survey data on either the pre- or post-test surveys. Outcome variable means by treatment condition and time are displayed in Table 4.1.

Table 4.1:

Outcome Variable Means by Group

Measure	CONDITION	Mean	Std. Deviation	N
Connectedness to Nature Scale (Time1)	Nature Control	52.71	12.939	21
	Nature Intervention	56.66	12.635	32
	Urban Control	42.58	17.850	12
	Urban Intervention	60.40	13.901	25
	Total	54.90	14.694	90
Connectedness to Nature Scale (Time2)	Nature Control	52.71	12.939	21
	Nature Intervention	52.72	14.147	32
	Urban Control	42.58	17.850	12
	Urban Intervention	55.76	15.382	25
	Total	52.21	15.057	90
Connectedness to Nature Scale (Time3)	Nature Control	61.48	10.939	21
	Nature Intervention	65.53	12.029	32
	Urban Control	56.42	17.855	12
	Urban Intervention	70.76	11.638	25
	Total	64.82	13.247	90
Mindfulness In Nature Scale (Time1)	Nature Control	52.90	10.305	21
	Nature Intervention	49.75	7.972	32
	Urban Control	54.33	4.053	12
	Urban Intervention	51.76	6.796	25
	Total	51.66	7.945	90
Mindfulness In Nature Scale (Time2)	Nature Control	52.90	10.305	21
	Nature Intervention	50.91	8.888	32
	Urban Control	54.33	4.053	12
	Urban Intervention	51.00	9.781	25
	Total	51.86	8.990	90
Mindfulness In Nature Scale (Time3)	Nature Control	58.14	10.947	21
	Nature Intervention	60.16	7.976	32
	Urban Control	56.75	5.895	12
	Urban Intervention	63.36	7.404	25
	Total	60.12	8.577	90
Psychological Stress Measure (Time2)	Nature Control	30.86	9.941	21
	Nature Intervention	41.03	12.207	32
	Urban Control	29.83	8.851	12
	Urban Intervention	39.56	10.344	25
	Total	36.76	11.666	90
Psychological Stress Measure (Time3)	Nature Control	22.48	7.487	21
	Nature Intervention	24.47	8.004	32
	Urban Control	26.42	8.670	12
	Urban Intervention	23.96	7.945	25
	Total	24.12	7.914	90

Scale Validation and Reliability

Prior to hypothesis testing, psychometric parameters were assessed using Chronbach's alpha. Reliability was acceptable for the Connectedness to Nature Scale at Time1 (α = 0.91), Time 2 (α = 0.919), and Time 3 (α = 0.908). Reliability was acceptable for the Mindfulness in Nature Scale at Time1 (α = 0.817), Time 2 (α = 0.873), and Time 3 (α = 0.883). The measure of stress, the Psychological Stress Measure, also had an acceptable reliability at both Time1 (α = 0.879) Time 2 (α = 0.828).

Since the Mindfulness in Nature Scale was adapted from the Five Facet Mindfulness Questionnaire (FFMQ), alpha factor analysis was conducted to assess the construct validity of the newly formed scale based on the two factors retained from the original scale, "Observe" and "Act with awareness." Items from the other factors of the FFMQ were not included in this study, as was discussed in chapter three. Results of alpha factor analysis of the Mindfulness in Nature Scale at Time1 show an eigen value of 4.37 for the first factor, indicating factor one explained 27.32% of the variance of observed variables in the scale. The eigen value for the second factor was 3.55, indicating factor two explained 22.21% of the variance of observed variables in the scale. No other factor's eigen values explained more than 10% of the variance of observed variables, and so were discarded. Initial results from alpha factor analysis indicate the items in the Mindfulness in Nature Scale at Time1 can be separated into two main factors, "Observe" and "Act with awareness," as intended.

As shown in Table 4.2, varimax rotation yielded items with primary factor loadings all above .5 and with all items corresponding to the original two factors from which they were modified. No items cross-loaded above .16 with the opposite factor. The results indicate all

scale items have a reasonably strong relationship with one of the two factors of the Mindfulness in Nature Scale at Time 1.

Table 4.2:

Factor Loadings for Alpha Factor Analysis of Mindfulness in Nature Scale (Time1) using Modified Two Factors of the Five Facet Mindfulness Questionnaire

Items	Act with Awareness	Observe
Items 16	**.751**	-.046
Items q4	**.694**	.129
Items q2	**.685**	.035
Items q8	**.648**	.087
Items q12	**.646**	.160
Items q10	**.613**	.093
Items q6	**.579**	-.080
Items q14	**.563**	-.006
Items q15	-.045	**.808**
Items q7	-.010	**.755**
Items q9	-.026	**.702**
Items q1	.078	**.612**
Items q11	-.053	**.572**
Items q3	.101	**.571**
Items q5	.107	**.541**
Items q13	.155	**.533**

Note: Factor loadings > .40 are in boldface.

Results of alpha factor analysis of the Mindfulness in Nature Scale at Time2 show an eigen value of 5.62 the first factor, indicating factor one explained 35.1% of the variance of observed variables in the scale. The eigen value for the second factor was 3.17, indicating factor two explained 19.84% of the variance of observed variables in the scale. No other factor's eigen values explained more than 10% of the variance of observed variables, and so were discarded. Initial results from alpha factor analysis indicate the items in the Mindfulness in Nature Scale at Time2 can be separated into two main factors, "Observe" and "Act with awareness," as intended.

As shown in Table 4.3, varimax rotation yielded items with primary factor loadings all above .5 and with all items corresponding to the original two factors from which they were modified. No items cross-loaded above .35 with the opposite factor. The results indicate all scale items have a reasonably strong relationship with one of the two factors of the Mindfulness in Nature Scale at Time2.

Table 4.3:

Factor Loadings for Alpha Factor Analysis of Mindfulness in Nature Scale (Time2) using Modified Two Factors of the Five Facet Mindfulness Questionnaire

Items	Act with Awareness	Observe
Item 7	.010	**.791**
Item 15	.108	**.776**
Item 13	.153	**.750**
Item 9	.158	**.739**
Item 3	.081	**.726**
Item 1	.146	**.696**
Item 11	-.002	**.636**
Item 5	.197	**.597**
Item 16	**.805**	-.052
Item 6	**.670**	.086
Item 2	**.662**	.100
Item 8	**.625**	-.017
Item 4	**.623**	.251
Item 14	**.613**	.078
Item 10	**.593**	.150
Item 12	**.542**	.335

Note: Factor loadings > .40 are in boldface.

Results of alpha factor analysis of the Mindfulness in Nature Scale at Time3 show an eigen value of 5.90 for the first factor, indicating factor one explained 36.86% of the variance of observed variables in the scale. The eigen value for the second factor was 3.19, indicating factor two explained 19.95% of the variance of observed variables in the scale. No other factor's eigen values explained more than 10% of the variance of observed variables, and so

were discarded. Initial results from alpha factor analysis indicate the items in the Mindfulness in Nature Scale at Time3 can be separated into two main factors, “Observe” and “Act with awareness,” as intended.

As shown in Table 4.4, varimax rotation yielded items with primary factor loadings all above .5, with the exception of item 5, and with all items corresponding to the original two factors from which they were modified. No items cross-loaded above .3 with the opposite factor. The results indicate all scale items have a reasonably strong relationship with one of the two factors of the Mindfulness in Nature Scale at Time3.

Table 4.4:

Factor Loadings for Alpha Factor Analysis of Mindfulness in Nature Scale (Time3) using Modified Two Factors of the Five Facet Mindfulness Questionnaire

Items	Act with Awareness	Observe
Item 16	**.893**	.064
Item 6	**.828**	.086
Item 2	**.760**	.125
Item 10	**.746**	.267
Item 4	**.650**	.088
Item 12	**.643**	.212
Item 8	**.607**	.068
Item 14	**.603**	.135
Item 15	.128	**.807**
Item 9	.082	**.750**
Item 11	.014	**.746**
Item 7	.107	**.740**
Item 13	.121	**.687**
Item 3	.099	**.678**
Item 1	.231	**.540**
Item 5	.172	.390

Note: Factor loadings > .40 are in boldface.

Statistical Sub-problems and Statistical Null-Hypotheses 1 – 3

The first step in hypothesis testing to address the study's purpose was to compare the intervention program (Sensory Engagement vs. Control) by environment type (Nature vs. Urban) on all outcome variables (connection to nature, mindfulness in nature, and psychological stress) over the three testing times. A split-plot (mixed) repeated measures analysis of variance was conducted for each variable to address the statistical sub-problems and hypotheses 1 – 3.

Statistical sub-problem 1.

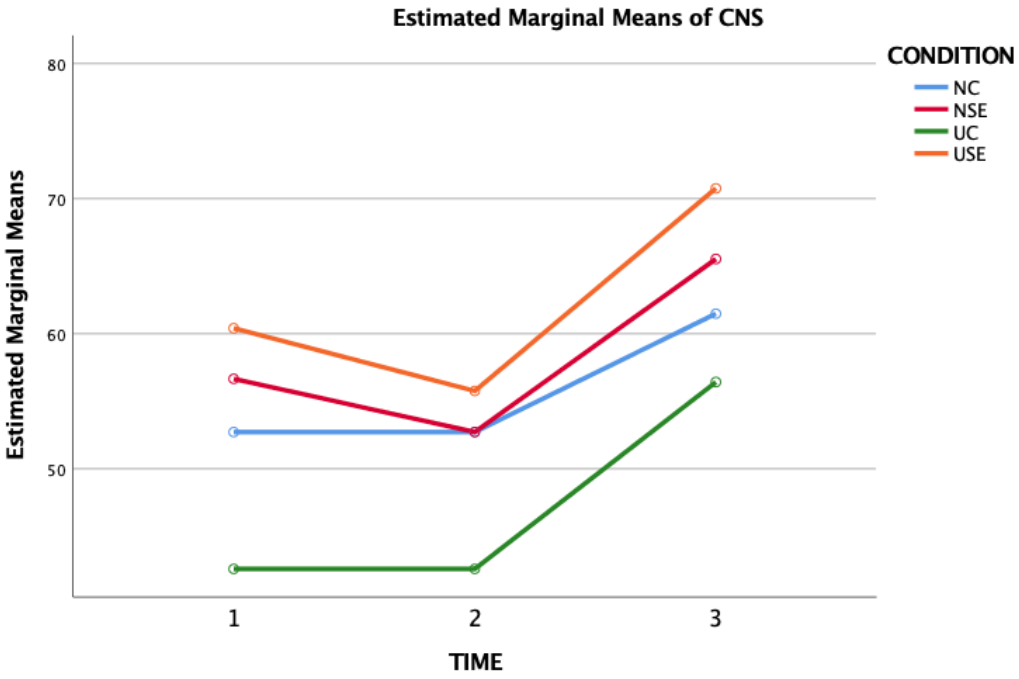
What is the effect of an intervention program by environment type on connection to nature?

H_1: No differences exist between intervention and control by environment type on connection to nature.

Results from the split-plot repeated measures ANOVA showed a significant difference among groups (N-SE, U-SE, N-C, U-C) across all time points on connection to nature ($F(1, 86) = 74.22$, $p < .001$). Therefore, there was a significant main effect of time on connection to nature. Pairwise comparisons of mean differences between repeated measures of all groups combined yielded significant increases in connection to nature from Time1 to Time3 ($p < .000$) and Time2 to Time3 ($p < .000$), but not from Time1 to Time2 ($p = .054$) (see Table 4.5). However, the interaction effect of time x condition was non-significant, $F(3, 86) = 1.27$, $p = .276$. Therefore, the null hypothesis failed to be rejected. The intervention program did not elicit significant differences between treatment groups over the repeated measures on connection to nature. Estimated marginal means for connection to nature are displayed graphically in Figure 3.3.

Figure 3.3:

Estimated marginal means of connection to nature



Statistical sub-problem 2.

What is the effect of an intervention program by environment type on mindfulness in nature?

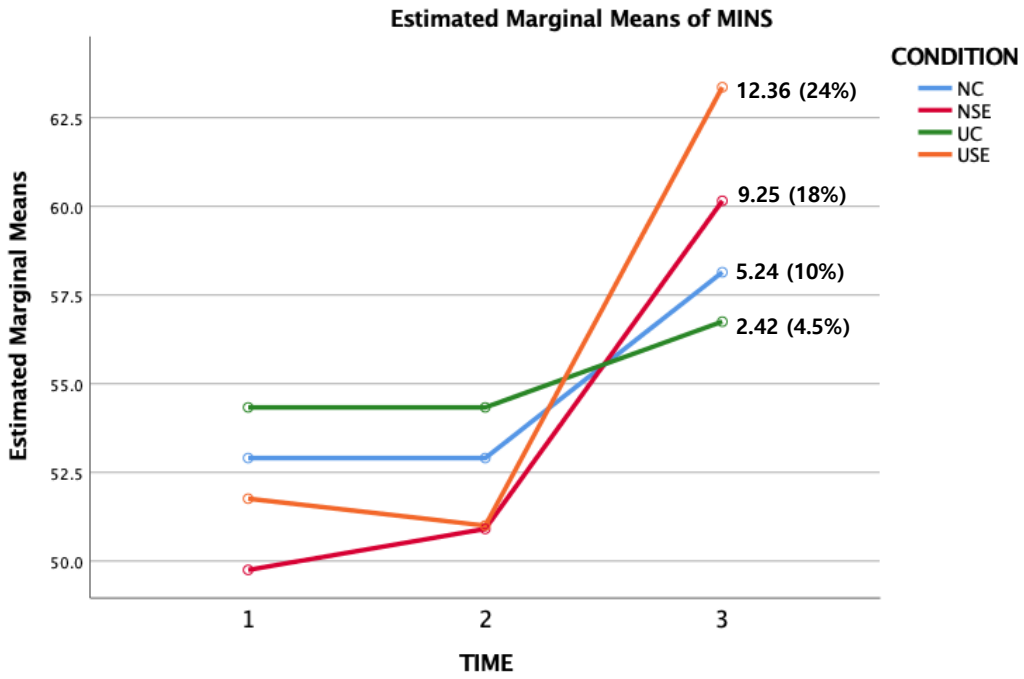
H_2: No differences exist between intervention and control by environment type on mindfulness in nature.

Results from the repeated measures ANOVA showed a significant difference among groups (N-SE, U-SE, N-C, U-C) across all time points on mindfulness in nature, F (1, 86) = 50.88, $p < .001$. Therefore, there was a significant main effect of time on mindfulness in nature. Pairwise comparisons of mean differences between repeated measures of all groups combined yielded significant increases in mindfulness in nature from Time1 to Time3 ($p <$ .000) and Time2 to Time3 ($p < .000$), but not from Time1 to Time2 ($p = 1.0$) (see Table 4.5).

The interaction effect of time x condition was also significant, F (3, 86) = 4.21, p = .001. Therefore, the null hypothesis was rejected. There were significant differences between intervention and control groups by environment type on mindfulness in nature, indicating post hoc analysis was warranted. The Games-Howell procedure was used to manage unequal group sizes and violation of Levene's test at Time1 (F = 3.18, p = .028) and Time3 (F = 3.62, p = .016), indicating unequal variances. However, results of post hoc analysis yielded non-significant differences between pairwise groups. The intervention program did not elicit significant differences between pairwise treatment groups over the repeated measures on mindfulness in nature. Estimated marginal means for mindfulness in nature are displayed graphically in Figure 3.4.

Figure 3.4:

Estimated marginal means of mindfulness in nature



Statistical sub-problem 3.

What is the effect of an intervention program by environment type on psychological stress?

H_3: No differences exist between intervention and control by environment type on psychological stress.

Results from the repeated measures ANOVA showed a significant difference among groups (N-SE, U-SE, N-C, U-C) across all time points on psychological stress, F (1, 86) = 144.92, $p < .001$. Therefore, there was as significant main effect of time on psychological stress. Pairwise comparisons of mean differences between repeated measures of all groups combined yielded significant decreases in stress from Time2 to Time3 ($p < .000$) (see Table 4.5).

The interaction effect of time x condition was also significant, F (3, 86) = 10.68, $p < .001$. Therefore, the null hypothesis was rejected. There were significant differences between intervention and control groups by environment type on psychological stress, indicating post hoc analysis was warranted. The Games-Howell procedure yielded non-significant differences between groups pairwise. However, it is worth noting that, although non-significant, the largest decreases in stress over time among multiple group comparisons was between the Nature-Sensory Engagement group and the Nature-Control group with an adjusted mean difference of 6.08 points greater stress reduction for the Nature-Sensory Engagement group ($p = .063$). The intervention program did not elicit significant differences between pairwise treatment groups over the repeated measures on psychological stress. Estimated marginal means for psychological stress are displayed graphically in Figure 3.5.

Figure 3.5:

Estimated marginal means of psychological stress

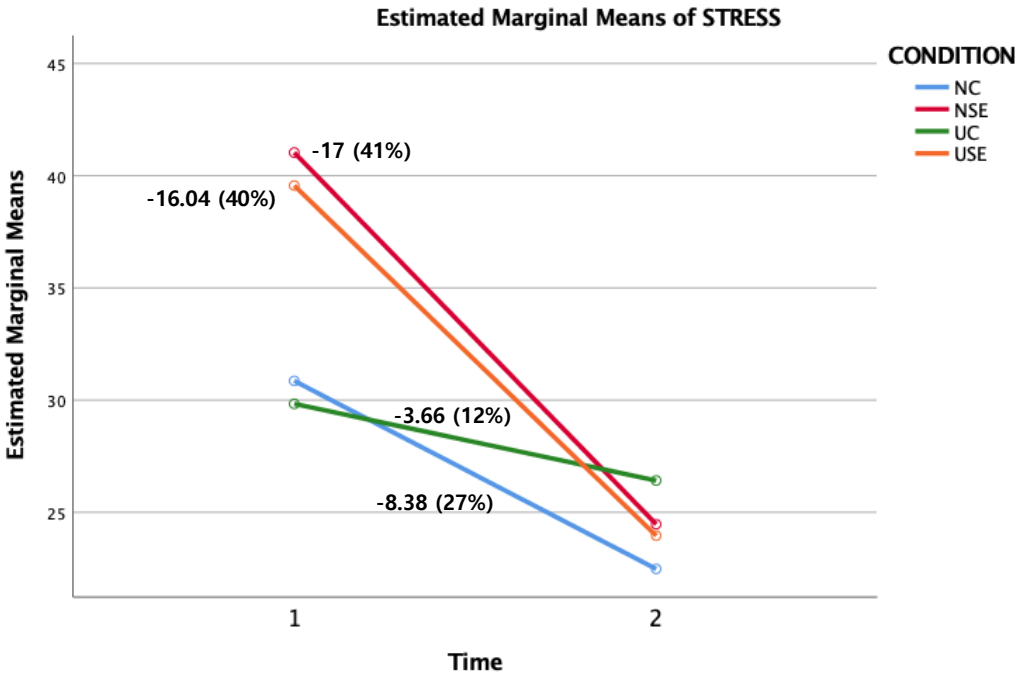


Table 4.5:

Pairwise Comparisons of All-groups by Repeated Measures Times

Measure	Time	Time	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Lower Bound	95% Confidence Interval for Upper Bound
CNS	1	2	2.144	.889	.054	-.026	4.315
		3	-10.458*	1.159	.000	-13.287	-7.629
	2	1	-2.144	.889	.054	-4.315	.026
		3	-12.602*	1.242	.000	-15.635	-9.569
	3	1	10.458*	1.159	.000	7.629	13.287
		2	12.602*	1.242	.000	9.569	15.635
MINS	1	2	-.099	.581	1.000	-1.519	1.321
		3	-7.415*	.907	.000	-9.629	-5.201
	2	1	.099	.581	1.000	-1.321	1.519
		3	-7.316*	.986	.000	-9.724	-4.908
	3	1	7.415*	.907	.000	5.201	9.629
		2	7.316*	.986	.000	4.908	9.724
PSM	1	2	10.990*	.913	.000	9.175	12.805
	2	1	-10.990*	.913	.000	-12.805	-9.175

Note: CNS = Connectedness to Nature Scale, MINS = Mindfulness in Nature Scale, PSM = Psychological Stress Measure

Statistical Sub-problems and Statistical Null-Hypotheses 4 – 6

To address the statistical sub-problems and hypotheses 4 – 6, multiple Pearson correlations were computed to assess relationships between change scores for all three outcome variables at Time3.

Statistical sub-problem 4.

What is the relationship between connection to nature and psychological stress after intervention program?

H_4: No relationship exists between connection to nature and psychological stress across intervention and control groups.

Pearson correlation showed that psychological stress was inversely correlated with connection to nature, $r(88) = -.372$, $p = .01$ (see Table 4.6). Therefore, the null hypothesis is rejected. The participants' survey responses indicated that, generally, higher connection to nature was associated with lower psychological stress.

Statistical sub-problem 5.

What is the relationship between mindfulness in nature and psychological stress after intervention program?

H_5: No relationship exists between mindfulness in nature and psychological stress across intervention and control groups.

Pearson correlation showed that psychological stress was inversely correlated with mindfulness in nature, $r(88) = -.500$, $p < .01$ (see Table 4.6). Therefore, the null hypothesis is rejected. The participants' survey responses indicated that, generally, higher mindfulness in nature was associated with lower psychological stress.

Statistical sub-problem 6.

What is the relationship between connection to nature and mindfulness in nature after intervention program?

H_6: No relationship exists between connection to nature and mindfulness in nature across intervention and control groups.

Connection to nature and mindfulness in nature were positively correlated, $r(88) = .524$, $p < .01$ (see Table 4.6). Therefore, the null hypothesis is rejected. The participants' survey responses indicated that, generally, higher levels of connection to nature are associated with higher levels of mindfulness in nature.

Table 4.6:

Correlations among change score variables

		CNS TIME3	MINS TIME3	PSM TIME3
CNS TIME3	Pearson Correlation	1	.524**	-.372**
	Sig. (2-tailed)		.000	.000
	N	90	90	90
MINS TIME3	Pearson Correlation	.524**	1	-.500**
	Sig. (2-tailed)	.000		.000
	N	90	90	90
PSM TIME3	Pearson Correlation	-.372**	-.500**	1
	Sig. (2-tailed)	.000	.000	
	N	90	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

Chapter 5: Discussion

The purpose of this quasi-experimental study was to examine the effect of four barrier-lifting lessons to prepare participants for a nature engagement intervention. The study proposed to measure the effects of types of engagement with a natural and an urban environment on connectedness to nature, mindfulness in nature, and psychological stress of students at a Western US university. Survey instruments were administered before the barrier-lifting primers (Time1), one week later before nature engagement intervention (Time2), and after intervention (Time3).

Statistical Sub-problem 1

What is the effect of an intervention program by environment type on **connection to nature**?

As reported in Chapter 4, the researcher found that a mindful sensory engagement with nature intervention, supported by four prior barrier-lifting lessons, elicited significant increases in connection to nature over time for all groups combined, but no significant differences between groups. Therefore, the study suggests connection to nature may not be readily affected by a short-term intervention in either natural or urban environments.

Connection to nature across all groups combined increased between Time1 to Time3 and Time2 to Time3, but not from Time1 to Time2. This may indicate the barrier-lifting primers did not have an effect on participants' connection to nature. Since the control groups did not experience the primers, their Time2 scores were copied to Time1. The addition of static nature connection scores may explain the non-significant finding, thereby reducing the variability of the outcome measure across all groups over time.

However, even more unexpected was the decrease, although non-significant, in connection to nature scores between Time1 and Time 2 for the intervention groups in both environments. It is unclear why the intervention groups would experience a reduction in connection to nature following the barrier-lifting primers (meant to normalize nature engagement and increase connection), but still have a significant increase in nature connection after the final intervention. It could be possible they experienced an increase in awareness of how disconnected they are from nature, and so their perception of connectivity to nature became more realistic, and therefore, decreased upon the Time2 survey, a week later. The phenomena might also be explained by experimenter bias, where participants might have attempted to appeal to the researcher's intentions by consciously or subconsciously rating their scores higher after the final intervention, or the threat to testing (threat to validity) since the surveys were administered in short succession. In addition, as mentioned in the description of participants in Chapter 3, the control groups' participants were from various majors in a class not taught by the researcher, whereas the intervention groups' participants were all from the same major in the class the researcher was instructing. This organization may have further increased the chance of experimenter bias affecting all survey responses.

Statistical Sub-problem 2

What is the effect of an intervention program by environment type on **mindfulness in nature**?

As reported in Chapter 4, the researcher found that a mindful sensory engagement with nature intervention, supported by four prior barrier-lifting lessons, elicited significant increases in mindfulness in nature over time for all groups combined, but no significant

differences between pairwise groups. However, a visual inspection of the data in Figure 3.4 indicates the intervention groups had a greater increase in mindfulness in nature in both environments compared to controls. Although not statistically significant and, therefore, not generalizable to other populations, the data suggests the potentiality that type of engagement with nature is a salient factor in eliciting benefits such as mindfulness in nature, not just environment type. Further investigation of the intervention's efficacy to increase mindfulness in nature is warranted.

Mindfulness in nature across all groups combined significantly increased between Time1 to Time3 and Time2 to Time3, but not from Time1 to Time2. In addition, similar to the connection to nature variable, mindfulness in nature scores paradoxically decreased between Time1 and Time2 for the intervention groups in both environments. Again, while this may indicate the barrier-lifting primers did not improve participants' mindfulness in nature (and perhaps reduced it), the situation is the same as for nature connection. Since the control groups did not experience the primers, their Time2 scores were copied to Time1 for stability of analysis. The addition of static mindfulness in nature scores may explain the non-significant finding between Time1 to Time2. Furthermore, in parallel with the connection to nature variable, participants may have rated their perception of mindfulness in nature lower at Time2 after having been exposed to information and experience in the barrier-lifting primers.

Statistical Sub-problem 3

What is the effect of an intervention program by environment type on **psychological stress**?

As reported in Chapter 4, the researcher found that a mindful sensory engagement with nature intervention, supported by four prior barrier-lifting lessons, elicited significant decreases in psychological stress over time for all groups combined, but no significant differences between pairwise groups. However, a visual inspection of the data in Figure 3.5 indicates the intervention groups had a greater reduction in stress in both environments compared to controls. Although not statistically significant and, therefore, not generalizable to other populations, the data suggests the potentiality that type of engagement with nature is a salient factor in eliciting benefits such as stress reduction, not just environment type. Further investigation of the intervention's efficacy to reduce stress is warranted.

Statistical Sub-problem 4

What is the relationship between **connection to nature** and **psychological stress** after intervention program?

As reported in Chapter 4, the researcher found a significant inverse correlation between psychological stress and nature connection. Regardless of group assignment, participants were more likely to experience less stress if they had a greater nature connection, and vice versa. While causality cannot be established, the result is not surprising since connection to nature has been shown to be associated with measures of wellness including affect (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009), happiness (Howell, Passmore, and Buro, 2013), and subjective wellbeing (Nisbet, Zelenski, & Murphy, 2011), to name a few.

However, the demonstrated link between connection to nature and psychological stress is not well established in the literature on nature-health/wellness benefits. To the researcher's knowledge, the data is the first to demonstrate the relationship, especially in an intervention study.

Statistical Sub-problem 5

What is the relationship between **mindfulness in nature** and **psychological stress** after intervention program?

As reported in Chapter 4, the researcher found a significant inverse correlation between psychological stress and mindfulness in nature. Regardless of group assignment, participants were more likely to experience less stress if they had greater mindfulness in nature, and vice versa. While causality cannot be established, the result is not surprising since mindfulness in general has been shown to be associated with a multitude of health and wellness benefits (Howell, Dopko, Passmore, & Buros, 2011; Wolsko & Lindberg, 2013). However, the use of a new modified survey, the Mindfulness in Nature Scale, has potential to explore the new construct of being mindful of natural elements in the present moment and how that experience relates to stress and other health and wellness outcomes.

Statistical Sub-problem 6

What is the relationship between **connection to nature** and **mindfulness in nature** after intervention program?

As reported in Chapter 4, the researcher found a significant positive correlation between connection to nature and mindfulness in nature. Regardless of group assignment, higher nature connection scores were associated with higher mindfulness in nature scores, and vice versa. Again, this is no surprise considering research demonstrating nature

connectedness is positively correlated with measures of mindfulness (Howell, Dopko, Passmore, & Buros, 2011; Wolsko & Lindberg, 2013). The current study confirms these previous findings and also contributes a new measure of mindfulness focused on attention to elements of nature.

Chapter 6: Conclusions and Implications

The present study demonstrated that a series of barrier-lifting nature engagement primers combined with a mindful sensory engagement with nature intervention increased connection to nature and mindfulness in nature and reduced stress in the intervention groups. Control groups experienced a similar effect with no intervention, although to a lesser degree overall. The findings are inconclusive whether type of engagement with nature may have an impact on the quantity and/or quality of health and wellness benefits elicited from experiencing nature in different environments. The study is also inconclusive whether type of engagement may be a salient factor involved with developing affective connection with nature and its associated wellbeing benefits (Cervinka, Roderer, & Hefler, 2011; Howell, Dopko, Passmore, Buro, 2011; Howell, Passmore, & Buro, 2013), and the same for developing mindfulness (Howell, Dopko, Passmore, Buro, 2011; Wolsko & Lindberg, 2013). Many studies have pointed to the need for research addressing optimal forms of engagement with nature to maximize beneficial outcomes (Beery, 2013; Berto, 2014; de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Gidlow et al., 2016; Pearson & Craig, 2014; Stigsdotter & Grahn, 2011; Triguero-Mas et al., 2015; Wheeler et al., 2015). To the researcher's knowledge, this study presents the first data to directly examine the effect of type of engagement with nature in natural and urban environments.

Although the results of this study are not readily generalizable to college students or other populations due to small, unequal group sizes and a non-randomized design, they support the need for future studies seeking to elucidate the impact of type of engagement with nature on the human condition. Nearly all previous research on the health and wellness benefits of spending time in nature have examined the effect of proximity to nature (Alcock,

White, & Wheeler, 2014; de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Triguero-Mas et al., 2015; van den Berg, Maas, Verheij, & Groenewegen, 2010; Wheeler et al., 2015), duration and frequency in nature (Nielsen & Hansen, 2007; Shanahan et al., 2016), and largely, natural versus urban or built landscapes (Thompson, Coon, Stein, Barton, & Depledge, 2011; Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010). Future research should consider methodology designed to investigate mechanisms of type of nature engagement and its impact on various health and wellbeing indicators. Studies should include standardized intervention protocols for easy replication and application in therapeutic settings. Intervention protocols may need to be increased in duration and facilitation intensity to elicit desired effects, and more controls should be implemented to reduce interference of personal technology during interventions and to address attrition issues. Furthermore, population-specific studies may allow for increased precision in detecting the effects of nature-engagement interventions.

While the findings of past studies have been profoundly in favor of people maximizing their nature exposure for psychological and physiological benefits, the body of knowledge provides few recommendations for individuals who do not have ready access to forests, urban green spaces, or even neighborhood gardens. People who live in “park deserts,” psychiatric institutions, prisons, assisted living facilities, or group homes often do not have regular access to the outdoor environment, especially those rich in natural elements such as diverse flora and fauna. Even individuals with means to travel to distant forests or parks often spend much of their waking hours inside buildings or within the concrete bounds of urban developments (Klepeis, 2001). Individuals’ nature encounters may also be limited by lack of awareness, knowledge, and motivation to make nature engagement a health and wellness

priority. Furthermore, we know spending more time disconnected from nature environments is associated with poorer health outcomes (Alcock, White, & Wheeler, 2014; de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Stigsdotter et al., 2010).

However, if individuals can learn to engage with the nearby nature readily available to them on a daily basis, perhaps these "micro doses" of intentional nature engagement could combine to provide a significant health and wellness improvement (White et al., 2019). Such a practice, if well evidenced through future research, could offer marginalized populations free, self-determined, side-effect free interventions that could be utilized in almost any environment even with the slightest natural attributes.

Beyond scholarly writing, momentum is increasing for a variety of human-nature relationship building practices to improve health. Some of these initiatives include nature-focused parks and recreation programming, nonprofit outdoor programs targeting underserved minority populations, and parks/nature prescriptions programs that encourage patients to engage with local parks and recreation programs to augment traditional pharmacological or surgical interventions. While these programs and practices are likely beneficial, there is still a need to reduce daily stress and increase nature connection in our overworked, increasingly urbanized society (Soga et al., 2015; Soga, Gaston, Koyanagi, Kurisu, & Hanaki, 2016). A new line of research focused on the efficacy of different forms of mindful or sensory engagement with *nearby* nature is both accessible and more pragmatic than much of the literature on nature engagement with vast, heavily forested and wild areas.

Richardson and Hallam (2013) support the notion of seeking intentional nearby nature engagement in their qualitative analysis of journal entries from a year of nearby nature wanderings: "It is important to consider the accessible and typical landscape to see if, with

time, positive experiences similar to those found in wilderness…can be found in the local landscape without the juxtaposition of home and wilderness" (p. 39). After all, as the famous naturalist explorer John Muir observed, "there is a love of wild nature in everybody." Perhaps we only need to seek to find it.

References

Alcock, I., White, M. P., Wheeler, B. W., Fleming, L. E., & Depledge, M. H. (2014). Longitudinal effects on mental health of moving to greener and less green urban areas. *Environmental Science & Technology*, *48,* 1247–1255.

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology*, *8*(1), 19–32. http://doi.org/10.1080/1364557032000119616

Astell-Burt, T., Feng, X., & Kolt, G. S. (2013). Mental health benefits of neighborhood green space are stronger among physically active adults in middle-to-older age: Evidence from 260,061 Australians. *Preventive Medicine*, *57*(5), 601–606. http://doi.org/10.1016/j.ypmed.2013.08.017

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment, 13*, 27–45.

Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health: A multi-study analysis. *Environmental Science and Technology*, *44*(10), 3947–3955. http://doi.org/10.1021/es903183r

Beery, T. H. (2013). Nordic in nature: Friluftsliv and environmental connectedness. *Environmental Education Research*, *19*(1), 1–24. http://doi.org/10.1080/13504622.2012.688799

Beil, K., & Hanes, D. (2013). The influence of urban natural and built environments on physiological and psychological measures of stress: A pilot study. *International Journal of Environmental Research and Public Health, 10*(4), 1250–1267. http://doi.org/10.3390/ijerph10041250

Beil, K., & Hanes, D. (2013). The influence of urban natural and built environments on physiological and psychological measures of stress: A pilot study. *International Journal of Environmental Research and Public Health*, *10*(4), 1250–1267. http://doi.org/10.3390/ijerph10041250

Beil, K., Hanes, D., & Zwickey, H. (2014). Environmental influence on holistic health measures. *Explore: The Journal of Science and Healing*, *10*(2), 115–117. http://doi.org/10.1016/j.explore.2013.12.006

Beil, K., Hanes, D., & Zwickey, H. (2014). Environmental influence on holistic health measures. *Explore: The Journal of Science and Healing*, *10*(2), 115–117. http://doi.org/10.1016/j.explore.2013.12.006

Berman, M. G., Kross, E., Krpan, K. M., Askren, M. K., Burson, A., Deldin, P. J., … Jonides, J. (2012). Interacting with nature improves cognition and affect for individuals with depression. *Journal of Affective Disorders*, *140*(3), 300–305. http://doi.org/10.1016/j.jad.2012.03.012

Berto, R. (2014). The role of nature in coping with psycho-physiological stress: a literature review on restorativeness. *Behavioral Sciences (Basel, Switzerland)*, *4*(4), 394–409. http://doi.org/10.3390/bs4040394

Beyer, K. M. M., Kaltenbach, A., Szabo, A., Bogar, S., Nieto, F. J., & Malecki, K. M. (2014). Exposure to neighborhood green space and mental health: Evidence from the survey of the health of Wisconsin. *International Journal of Environmental Research and Public Health*, *11*(3), 3453–72. http://doi.org/10.3390/ijerph110303453

Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health. *Annals of the New York Academy of Sciences*, *1249*(1), 118–136. http://doi.org/10.1111/j.1749-6632.2011.06400.x

Campbell, D.T. & Stanley, J.C. (1999). *Experimental and quasi-experimental designs for research*. Boston: Houghton Mifflin Company.

Capaldi, C. a, Dopko, R. L., & Zelenski, J. M. (2014). The relationship between nature connectedness and happiness: a meta-analysis. *Frontiers in Psychology*, *5*(September), 976. http://doi.org/10.3389/fpsyg.2014.00976

Carlson, N. R. (2013). *Physiology of behavior* (Eleventh edition.). Boston: Pearson.

Carrus, G., Scopelliti, M., Lafortezza, R., Colangelo, G., Ferrini, F., Salbitano, F., … Sanesi, G. (2015). Go greener, feel better? The positive effects of biodiversity on the well-being of individuals visiting urban and peri-urban green areas. *Landscape and Urban Planning*, *134*, 221–228. http://doi.org/10.1016/j.landurbplan.2014.10.022

Cervinka, R., Roderer, K., & Hefler, E. (2012). Are nature lovers happy? On various indicators of well-being and connectedness with nature. *Journal of Health Psychology*, *17*(3), 379–388. http://doi.org/Doi 10.1177/1359105311416873

Christopher, M. S., Neuser, N. J., Michael, P. G., & Baitmangalkar, A. (2012). Exploring the psychometric properties of the five-facet mindfulness questionnaire. *Mindfulness*, *3*(2), 124–131. http://doi.org/10.1007/s12671-011-0086-x.

Cohen, S., Kamarck, T., Mermelstein, R. (1983). A global measure of perceived stress. *J. Health Soc. Behav*., *24*, 385–396

de Bruin, E. I., Topper, M., Muskens, J. G. A. M., Bögels, S. M., & Kamphuis, J. H. (2012). Psychometric properties of the five facets mindfulness questionnaire (FFMQ) in a

meditating and a non-meditating sample. *Assessment*, *19*(2), 187–197. http://doi.org/10.1177/1073191112446654

de Vries, S., van Dillen, S. M. E., Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine (1982)*, *94*, 26–33. http://doi.org/10.1016/j.socscimed.2013.06.030

de Vries, S., Verheij, R. A., Groenewegen, P. P., & Spreeuwenberg, P. (2003). Natural environments - Healthy environments? An exploratory analysis of the relationship between greenspace and health. *Environment and Planning A*, *35*(10), 1717–1731. http://doi.org/10.1068/a35111

Ewert, A. (2016). The body doesn't lie. *Journal of Leisure Research*, *48*(4), 327–337.

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. http://doi.org/10.1016/j.jenvp.2015.11.003

Gidlow, C. J., Randall, J., Gillman, J., Smith, G. R., & Jones, M. V. (2016). Natural environments and chronic stress measured by hair cortisol. *Landscape and Urban Planning*, *148*, 61–67. http://doi.org/10.1016/j.landurbplan.2015.12.009

Grahn, P., & Stigsdotter, U. K. (2010). The relation between perceived sensory dimensions of urban green space and stress restoration. *Landscape and Urban Planning*, *94*(3–4), 264–275. http://doi.org/10.1016/j.landurbplan.2009.10.012

Greater Good Science Center (2018). Savoring walk. Retrieved from https://ggia.berkeley.edu/practice/savoring_walk#

Hales D. (2009). *An invitation to health*, 13th ed. Belmont, CA: Wadsworth/Cengage Learning.

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

Hartig, T., Korpela, K., Evans, G. W., & Gärling, T. (1997). A measure of restorative quality in environments. *Scandinavian Housing and Planning Research*. http://doi.org/10.1080/02815739708730435

Hassan, R. (2012). The age of distraction. New York: Routledge.

Hicks, T., Heastlie, S. (2008). High school to college transition: A profile of the stressors, physical and psychological health issues that affect the first-year on-campus college student, *Journal of Cultural Diversity*, *15*, 143-146.

Hinds, J., & Sparks, P. (2008). Engaging with the natural environment: The role of affective connection and identity. *Journal of Environmental Psychology*, *28*(2), 109–120. https://doi.org/10.1016/j.jenvp.2007.11.001

Hodge, C., Bocarro, J. N., Henderson, K. A., Zabriskie, R., Parcel, T. L., & Kanters, M. A. (2015). Family leisure: An integrative review of research from select journals. *Journal of Leisure Research*, *47*(5), 577–600.

Howell, A. J., Dopko, R. L., Passmore, H.A., & Buro, K. (2011). Nature connectedness: Associations with well-being and mindfulness. *Personality and Individual Differences*, *51*(2), 166–171. http://doi.org/10.1016/j.paid.2011.03.037

Howell, A. J., Passmore, H. A., & Buro, K. (2013). Meaning in nature: Meaning in life as a mediator of the relationship between nature connectedness and well-being. *Journal of Happiness Studies*, *14*(6), 1681–1696. http://doi.org/10.1007/s10902-012-9403-x

Huynh, Q., Craig, W., Janssen, I., & Pickett, W. (2013). Exposure to public natural space as a protective factor for emotional well-being among young people in Canada. *BMC Public Health*, *13*(407).

Kamitsis, I., & Francis, A. J. P. (2013). Spirituality mediates the relationship between engagement with nature and psychological wellbeing. *Journal of Environmental Psychology*, *36*, 136–143. http://doi.org/10.1016/j.jenvp.2013.07.013

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. Journal of Environmental Psychology, 15(3), 169–182. http://doi.org/10.1016/0272-4944(95)90001-2

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*(3), 169–182. http://doi.org/10.1016/0272-4944(95)90001-2

Karjalainen, E., Sarjala, T., & Raitio, H. (2010). Promoting human health through forests: Overview and major challenges. *Environmental Health and Preventive Medicine*, *15*(1), 1–8. http://doi.org/10.1007/s12199-008-0069-2

Klepeis, N.E., Nelson, W.C., Ott, W.R., Robinson, J.P., Tsang, A.M., Switzer, P. … Engelmann, W.H. (2001). The National Human Activity Pattern Survey (NHAPS): A resource for assessing exposure to environmental pollutants. *Journal of Exposure Analysis and Environmental Epidemiology*, *11*(3), 231–252. https://doi.org/10.1038/sj.jea.7500165

Kobayashi, H., Ishibashi, K., & Noguchi, H. (1999). Heart rate variability: An index for monitoring and analyzing human autonomic activities. *Applied Human Science, 18*(2), 53–59

Kobayashi, H., Park, B.J., & Miyazaki, Y. (2012). Normative references of heart rate variability and salivary alpha-amylase in a healthy young male population. *Journal of Physiological Anthropology, 31*(1), 9. http://doi.org/10.1186/1880-6805-31-9

Lachowycz, K., & Jones, A. P. (2013). Towards a better understanding of the relationship between greenspace and health: Development of a theoretical framework. *Landscape and Urban Planning, 118*, 62–69. http://doi.org/10.1016/j.landurbplan.2012.10.012

Langer, E.J. (2000). Mindful learning. *Current Directions in Psychological Science, 9*(6), p. 220-23.

Lee, J., Park, B. J., Tsunetsugu, Y., Ohira, T., Kagawa, T., & Miyazaki, Y. (2011). Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. *Public Health, 125*(2), 93–100. http://doi.org/10.1016/j.puhe.2010.09.005

Lee, J., Park, B.J., Tsunetsugu, Y., Kagawa, T., & Miyazaki, Y. (2009). Restorative effects of viewing real forest landscapes, based on a comparison with urban landscapes. *Scandinavian Journal of Forest Research, 24*(3), 227–234. http://doi.org/10.1080/02827580902903341

Lee, J., Tsunetsugu, Y., Takayama, N., Park, B. J., Li, Q., Song, C., … Miyazaki, Y. (2014). Influence of forest therapy on cardiovascular relaxation in young adults. *Evidence-Based Complementary and Alternative Medicine, 2014*. http://doi.org/10.1155/2014/834360

Leger, L. S. (2003). Health and nature: New challenges for health promotion. *Health Promotion International*, *18*(3), 173–175. http://doi.org/10.1093/heapro/dag012

Lemyre, L. (2009). Psychological stress measure (PSM-9): Integration of an evidence-based approach to assessment, monitoring, and evaluation of stress in physical therapy practice. *Physiotherapy Theory and Practice*, *25*(5–6), 453–462. http://doi.org/10.1080/09593980902886321

Lin, B. B., Fuller, R. A., Bush, R., Gaston, K. J., & Shanahan, D. F. (2014). Opportunity or orientation? Who uses urban parks and why. *PLoS ONE*, *9*(1), 1–7. http://doi.org/10.1371/journal.pone.0087422

Louv, R. (2008) Last child in the woods: Saving our children from nature-deficit disorder. Algonquin Books, New York, NY.

Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, *24*(4), 503–515. http://doi.org/10.1016/j.jenvp.2004.10.001

Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, *24*(4), 503–515. http://doi.org/10.1016/j.jenvp.2004.10.001

Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why Is nature beneficial? The role of connectedness to nature. *Environment and Behavior*, *41*(5), 607–643. http://doi.org/10.1177/0013916508319745

McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine*, *338*, 171–179.

McIntyre, N., & Roggenbuck, J. W. (1998). Nature/person transactions during an outdoor adventure experience: A multi-phasic analysis. *Journal of Leisure Research, 30,* 401 – 422

Mclntyre, N., Zealand, N., McIntyre, N., & Roggenbuck, J. W. (1998). Nature/person transactions during an outdoor adventure experience: a multi-phasic analysis. *Journal of Leisure Research*, *30*(4), 401–422. Retrieved from http://articles.sirc.ca/search.cfm?id=S-23170%5Cnhttp://findarticles.com/p/articles/mi_qa3702/is_4_30/ai_n28720726/

Miyazaki, Y., Ikei, H., Song, C. (2014). Forest medicine research in Japan. *Nihon eiseigaku zasshi (Japanese Journal of Hygiene), 69*(2), 122-35.

Morita, E., Fukuda, S., Nagano, J., Hamajima, N., Yamamoto, H., Iwai, Y., … Shirakawa, T. (2007). Psychological effects of forest environments on healthy adults: Shinrin-yoku (forest-air bathing, walking) as a possible method of stress reduction. *Public Health*, *121*(1), 54–63. http://doi.org/10.1016/j.puhe.2006.05.024

Mulrine, B. L., Sheehan, M. F., Burrell, L., & Matthews, M. D. (2011). Measuring stress and ability to recover from stress with salivary alpha-amylase levels. *Research Report: United States Military Academy*, 1–17

Nature Rx. (2015, August 4). Nature Rx Part 1 [Video file]. Retrieved from https://www.youtube.com/watch?v=Bf5TgVRGND4

Nielsen, T. S., & Hansen, K. B. (2007). Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators. *Health and Place*, *13*(4), 839–850. http://doi.org/10.1016/j.healthplace.2007.02.001

Nisbet, E. K., & Zelenski, J. M. (2013). The NR-6: A new brief measure of nature relatedness. *Frontiers in Psychology*, *4*(NOV), 1–11. http://doi.org/10.3389/fpsyg.2013.00813

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

Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2011). Happiness is in our nature: Exploring nature relatedness as a contributor to subjective well-being. *Journal of Happiness Studies*, *12*(2), 303–322. http://doi.org/10.1007/s10902-010-9197-7

Park, B. J., Furuya, K., Kasetani, T., Takayama, N., Kagawa, T., & Miyazaki, Y. (2011). Relationship between psychological responses and physical environments in forest settings. *Landscape and Urban Planning*, *102*(1), 24–32. http://doi.org/10.1016/j.landurbplan.2011.03.005

Park, B. J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., & Miyazaki, Y. (2010). The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): Evidence from field experiments in 24 forests across Japan. *Environmental Health and Preventive Medicine*, *15*(1), 18–26. http://doi.org/10.1007/s12199-009-0086-9

Park, B. J., Tsunetsugu, Y., Kasetani, T., Morikawa, T., Kagawa, T., & Miyazaki, Y. (2009). Physiological effects of forest recreation in a young conifer forest in Hinokage Town, Japan. *Silva Fennica*, *43*(2), 291–301. http://doi.org/10.14214/sf.213

Pasanen, T. P., Tyrväinen, L., & Korpela, K. M. (2014). The relationship between perceived health and physical activity indoors, outdoors in built environments, and outdoors in

nature. *Applied Psychology: Health and Well-Being*, *6*(3), 324–346. http://doi.org/10.1111/aphw.12031

Pearson, D. G., & Craig, T. (2014). The great outdoors? Exploring the mental health benefits of natural environments. *Frontiers in Psychology*, *5*, 1–4. http://doi.org/10.3389/fpsyg.2014.01178

Reardon M., & Malik, M. (1996). Changes in heart rate variability with age. *Pacing and Clinical Electrophysiology*, *19*(11), 1863–1866. http://doi.org/10.1111/j.1540-8159.1996.tb03241.x

Reklaitiene, R., Grazuleviciene, R., Dedele, A., Virviciute, D., Vensloviene, J., Tamosiunas, A., … Nieuwenhuijsen, M. J. (2014). The relationship of green space, depressive symptoms and perceived general health in urban population. *Scandinavian Journal of Public Health*, *42*(7), 669–76. http://doi.org/10.1177/1403494814544494

Richardson, M., & Hallam, J. (2013). Exploring the psychological rewards of a familiar semi-rural landscape: connecting to local nature through a mindful approach. *The Humanistic Psychologist*, *41*(1), 35–43. http://doi.org/10.1080/08873267.2012.732156

Richardson, M., Hallam, J., & Lumber, R. (2015). One thousand good things in nature: Aspects of nearby nature associated with improved connection to nature. *Environmental Values*, *24*(5), 603–619. http://doi.org/10.3197/096327115X14384223590131

Roe, J. J., Ward Thompson, C., Aspinall, P. A., Brewer, M. J., Duff, E. I., Miller, D., … Clow, A. (2013). Green space and stress: Evidence from cortisol measures in deprived urban communities. *International Journal of Environmental Research and Public Health*, *10*(9), 4086–4103.

Saw, L. E., Lim, F. K. S., & Carrasco, L. R. (2015). The relationship between natural park usage and happiness does not hold in a tropical city-state. *PLOS ONE*, *10*(7), 1–16. http://doi.org/10.1371/journal.pone.0133781

Semi:Free Creative (2015, May 1). Nature therapy: Relaxing full motion forestry with natural sounds [Video file]. Retrieved from https://www.youtube.com/watch?v=Kb8CW3axqRE

Shanahan, D. F., Bush, R., Gaston, K. J., Lin, B. B., Dean, J., Barber, E., & Fuller, R. A. (2016). Health benefits from nature experiences depend on dose. *Scientific Reports*, *6*(February). http://doi.org/10.1038/srep28551

Sofferin, M. (2015). The big disconnect [Online image]. Retrieved from http://naturelover.ca/giving-us-reasons-to-get-outside/

Soga, M., Gaston, K. J., Koyanagi, T. F., Kurisu, K., & Hanaki, K. (2016). Urban residents' perceptions of neighbourhood nature: Does the extinction of experience matter? BIOC, 203, 143–150. http://doi.org/10.1016/j.biocon.2016.09.020

Soga, M., Yamaura, Y., Aikoh, T., Shoji, Y., Kubo, T., & Gaston, K. J. (2015). Reducing the extinction of experience: Association between urban form and recreational use of public greenspace. *Landscape and Urban Planning*, *143*, 69–75. http://doi.org/10.1016/j.landurbplan.2015.06.003

Song, C., Joung, D., Ikei, H., Igarashi, M., Aga, M., Park, B.J., … Miyazaki, Y. (2013). Physiological and psychological effects of walking on young males in urban parks in winter. *Journal of Physiological Anthropology*, *32*, 18. http://doi.org/10.1186/1880-6805-32-18

Stigsdotter, U. K., & Grahn, P. (2011). Stressed individuals' preferences for activities and environmental characteristics in green spaces. *Urban Forestry and Urban Greening*, *10*(4), 295–304. http://doi.org/10.1016/j.ufug.2011.07.001

Stigsdotter, U. K., Ekholm, O., Schipperijn, J., Toftager, M., Kamper-Jorgensen, F., Randrup, T. B., … Randrup, T. B. (2010). Health promoting outdoor environments: Associations between green space, and health, health-related quality of life and stress based on a Danish national representative survey. *Scandinavian Journal of Public Health*, *38*(4), 411–417. http://doi.org/10.1177/1403494810367468

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M. H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental Science and Technology*, *45*(5), 1761–1772. http://doi.org/10.1021/es102947t

Triguero-Mas, M., Dadvand, P., Cirach, M., Martínez, D., Medina, A., Mompart, A., … Nieuwenhuijsen, M. J. (2015). Natural outdoor environments and mental and physical health: Relationships and mechanisms. *Environment International*, *77*, 35–41. http://doi.org/10.1016/j.envint.2015.01.012

Tsunetsugu, Y., Lee, J., Park, B. J., Tyrvainen, L., Kagawa, T., & Miyazaki, Y. (2013). Physiological and psychological effects of viewing urban forest landscapes assessed by multiple measurements. *Landscape and Urban Planning*, *113*, 90–93. http://doi.org/10.1016/j.landurbplan.2013.01.014

Turner, R. (2009). The discursive construction of anthropocentrism. *Environmental Ethics* *31*(2), 183-201. 10.5840/enviroethics200931219.

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

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Source: Science, New Series*, *224*(4647), 420–421. http://doi.org/10.1126/science.6143402

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, *11*(3), 201–230. http://doi.org/10.1016/S0272-4944(05)80184-7

United Nations. (2014). Department of Economic and Social Affairs, Population Division. World urbanization prospects: The 2014 revision, highlights (ST/ESA/SER.A/352). Available: https://esa.un.org/unpd/wup/publications/files/WUP2014-Highlights.pdf

van den Berg, A. E., & Custers, M. H. G. (2011). Gardening promotes neuroendocrine and affective restoration from stress. *Journal of Health Psychology*, *16*(1), 3–11. http://doi.org/10.1177/1359105310365577

van den Berg, A. E., Maas, J., Verheij, R. A., & Groenewegen, P. P. (2010). Green space as a buffer between stressful life events and health. *Social Science and Medicine*, *70*(8), 1203–1210. http://doi.org/10.1016/j.socscimed.2010.01.002

van Herzele, A., & de Vries, S. (2012). Linking green space to health: A comparative study of two urban neighbourhoods in Ghent, Belgium. *Population and Environment*, *34*(2), 171–193. http://doi.org/10.1007/s11111-011-0153-1

Ward Thompson, C., Roe, J., Aspinall, P., Mitchell, R., Clow, A., & Miller, D. (2012). More green space is linked to less stress in deprived communities: Evidence from salivary cortisol patterns. *Landscape and Urban Planning, 105*(3), 221–229. http://doi.org/10.1016/j.landurbplan.2011.12.015

Wheeler, B. W., Lovell, R., Higgins, S. L., White, M. P., Alcock, I., Osborne, N. J., … Depledge, M. H. (2015). Beyond greenspace: An ecological study of population general health and indicators of natural environment type and quality. *International Journal of Health Geographics*, *14*, 17. http://doi.org/10.1186/s12942-015-0009-5

White, M. P., Alcock, I., Grellier, J., Wheeler, B. W., Hartig, T., Warber, S. L., … Fleming, L. E. (2019). Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Scientific Reports*, *9*(1), 7730. https://doi.org/10.1038/s41598-019-44097-3

Williams, F. (2012). Take two hours of pine forest and call me in the morning. *Outside, Dec. 2012*. Retrieved from: http://www.outsideonline.com/1870381/take-two-hours-pine-forest-and-call-me-morning

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

Wolsko, C., & Lindberg, K. (2013). Experiencing connection with nature: The matrix of psychological well-being, mindfulness, and outdoor recreation. *Ecopsychology*, *5*(2), 80–91. http://doi.org/10.1089/eco.2013.0008

Wolsko, C., & Lindberg, K. (2013). Experiencing connection with nature: The matrix of psychological well-being, mindfulness, and outdoor recreation. *Ecopsychology*, *5*(2), 80–91. http://doi.org/10.1089/eco.2013.0008

Yamaguchi, M., Deguchi, M., Wakasugi, J., Ono, S., Takai, N., Higashi, T., & Mizuno, Y. (2006). Hand-held monitor of sympathetic nervous system using salivary amylase activity and its validation by driver fatigue assessment. *Biosensors and Bioelectronics*, *21*, 1007–1014. http://doi.org/10.1016/j.bios.2005.03.014

Zelenski, J. M., & Nisbet, E. K. (2014). Happiness and feeling connected: The distinct role of nature relatedness. *Environment and Behavior*, *46*(1), 3–23. http://doi.org/10.1177/0013916512451901

Zhang, J. W., Howell, R. T., & Iyer, R. (2014). Engagement with natural beauty moderates the positive relation between connectedness with nature and psychological well-being. *Journal of Environmental Psychology*, *38*, 55–63. http://doi.org/10.1016/j.jenvp.2013.12.013

Appendix A: Intervention Protocols

The following are protocols and scripts for each study condition to ensure consistent participant experiences throughout data collection.

Sensory Engagement Condition (Experimental Intervention)

Mindful Sensory Engagement with Nature Series: "Barrier Lifting" Primers

1. *(~15 mins.)* Over the past few decades the significance of nature's impact on a variety of health measures has been increasingly researched and popularized in the media. This video provides a funny, satirical approach to the issue. Watch this video in full screen: Nature Rx
    a. Consider this: Humor aside, why do you think this video was made? How disconnected from nature is the average American, and what do you think are the consequences of that?
    b. Practice this today: Examine your life and daily interactions with nature. Do you spend time outside, and if not, why? If yes, write down approximately how many hours you spent outside for each of the past three days. Write down what you were doing outside for each of those blocks of outdoor time. Were you engaging with nature during this time?
2. *(~20 mins.)* Much of the research on nature and health has focused on the negative consequences of a lack of nature as well as the significant health benefits of spending more time in nature. Explore the following infographic which illustrates some of these issues using a graphical representation of the data. Download or "full-screen" the graphic and zoom in closer to explore each section: The Big Disconnect

a. Consider this: Look at the section titled “Urban Lifescape” and the two sections below it to get an idea of how disconnected we are from nature on a daily basis. Considering the “Conditions on the Rise,” which of these negative consequences of a lack of nature time can you relate to in your life? Why do you think nature may be key to avoiding these negative outcomes?

Now look at the bottom sections of the infographic to learn about the benefits of spending time in nature. What specific benefits have you experienced after time spent in natural environments? Even if you cannot pinpoint any, why do you think nature might provide such benefits?

b. Practice this today: Examine the following photos. Then, spend a few minutes considering each of the following questions:

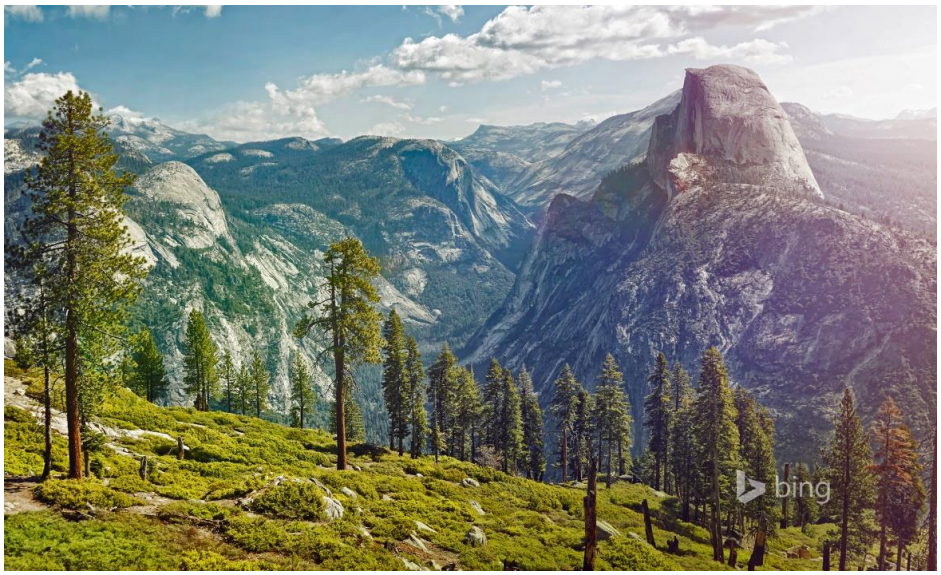
    i. Imagine yourself standing in the middle of each of these environments. Which environment most appeals to you or draws your interest? Why?

    ii. Consider what elements of your selected environment are most appealing to you. What specific features of nature stand out or captivate your interest and curiosity?

    iii. Do you have a past connection to a place like the one in the photo you chose?

    iv. If you were standing in the middle of the environment in your chosen photo, what emotions would the surroundings evoke? How would you feel physically?


bing


bing

3. *(45 mins.)* Now that you know a little more about the nature-health connection and why you may want to spend more time in nature for health reasons, watch this video in full screen with the volume at a comfortable level so you can clearly hear all the sounds, or use headphones for a more immersive experience. Spend the first two minutes listening to the video with your eyes closed. Then open your eyes and notice what you see. Watch for at least five minutes. See how it makes you feel: Forest Sounds

    a. Consider this: What natural elements of what you observed did you enjoy the most? Do you seek out any of these elements in nature throughout your week? How did what you saw and heard in this video make you feel?

    b. Practice this today: Find a quiet place to sit with trees and greenery surrounding you. Spend 15-30 minutes considering what you enjoy about this environment and the nature that surrounds you.

4. *(20 mins.)* Now that you have had an opportunity to experience both still and full-motion virtual nature from a seated position and assess how it impacts you, try this practice of savoring what you like in nature during a relaxing walk through an area with many trees.

    Try this: Savoring Walk

    a. Then, recall back to your Savoring Walk, and think about all that you saw, heard, smelled, or touched during the walk.

    b. Consider this: What elements most drew in your attention on your walk? Whatever it was, why were you drawn to it? How did those elements of nature make you feel?

5. Final Reflections

    a. How did these practices impact your feelings of connection to nature? Please explain.

    b. How did these practices impact how mindful you are of nature around you? Please explain.

    c. After these practices, how likely are you to spend more frequent time in nature (circle your response)?

1	2	3	4	5	6	7
Not Very Likely			Neutral			Highly Likely

    d. After these practices, how likely are you to spend time simply paying attention to the nature in your surroundings (circle your response)?

1	2	3	4	5	6	7
Not Very Likely			Neutral			Highly Likely

    e. After these practices, how likely are you to avoid looking at your phone the next time you are in nature (circle your response)?

1	2	3	4	5	6	7
Not Very Likely			Neutral			Highly Likely

6. *(30 mins.)* Final Guided Mindful Sensory Engagement Intervention.

Final Sensory Engagement in Nature Intervention: Researcher Script

Thank you for participating in this study. Today, you will participate in a "sensory engagement with nature" exercise during a 30-mintue walk *[insert environment for each group]*. The walk will begin after I explain the sensory engagement exercise. Unless there are any questions, let's begin.

Using our senses, we are going to try to observe and interact with the nature around us so that we can more fully engaged with it and see what we can experience.

Start by closing your eyes and taking three deep breaths, counting to six as you inhale, and six as you exhale. Observe your mind slowing with your breath. You are invited to be fully in the present moment. All that matters in this walk is that you observe nature as you explore your sensory experience in the environment. What you observe is your own, and you are invited to enjoy the experience with a sense of curiosity for what you might find in the nature that surrounds you.

Now, with eyes staying closed, pay attention to the sensations you can experience in the present moment. What can your skin tell you about the environment? Is it cool or warm in this place? Do you feel the wind going one direction or another? Can you observe the warmth of the sun or shade of a tree? What other sensations can you experience through touch, with your hands, feet, and other parts of your body? Take a moment to experience anything natural you can touch in this environment.

Now focus on what your ears can tell you about this place. What sounds do you hear, near and far? Do you hear animals, branches and leaves, water, wind? Is there silence, however brief? Take a moment to experience any nature you hear in this environment.

Now turn to your sense of smell. Are there any scents in the air? What can you make of them? Does the air feel thick with humidity or dry and crisp? Take a moment to experience any nature you smell in this environment.

Finally, open your eyes. Imagine you are seeing this place for the first time. What do you notice? Can you pick out details that interest you very nearby and up close, and also far away? What do you see above and below your initial gaze? What movements of nature do you notice out of the corners of your eyes? Take a moment to experience any nature you see in this environment.

Including all of your senses as guides, be mindful of what peaks your interest in the environment during your walk. Let your observations wander to things near and far, in the broad landscape, and in the few inches of space nearby. Play with your different senses and discover what you can observe that you haven't noticed before in the nature around you. What do you find intriguing and pleasant? There is no right or wrong way to do this. Just let your senses be your guide to experience the natural elements around you, and most importantly, notice anything novel about the nature you observe (Langer, 2000).

During the walk, please follow the pace and route set by the group. Unless there are any questions, let's begin.

Control Group Condition:

No mini-intervention series “barrier-lifting” primers.

Control Group Researcher Script

Thank you for participating in this study. Today, you will participate in a 30-mintue walk *[insert environment for each group]*. During the walk, please follow the pace and route set by the group. Unless there are any questions, let’s begin.

Appendix B: Rationale for "Barrier Lifting" Primers Intervention Series

The following is a description and justification for the series of mini-interventions to be provided via Canvas (online education platform) prior to the final guided sensory engagement with nature intervention.

With today's distracted and constantly device-connected culture (Hassan, 2012), the major challenge of such an intervention is to inspire and teach participants to disconnect from technology alleviating the constant distraction of bombarding information. If this can be accomplished, the participants will have cognitive space and frame of mind to connect with a nature engagement practice (Kaplan, 1995). For maximum effect, participants must comprehensively experience what nature offers through their senses. The attention to the sensory inputs is the important part instead of passively disregarding them and not fully processing or valuing what they have to offer.

Second, individuals should believe they will receive some benefit from the nature engagement experience. They need to believe that sensory engagement with nature is a normal, worthwhile activity. Western society's anthropocentric view that human beings are separate from nature (Turner, 2009) and the rapid urbanization of modern society has resulted in an extinction of daily experiences with nature (Soga, Gaston, Koyanagi, Kurisu, & Hanaki, 2016). The combination of these two factors has perpetuated a narrative that spending time in nature must be purposeful (i.e., visits to parks and wilderness areas for recreation or site-seeing, gardening for leisure or crop yield, bird watching to collect species sightings). The narrative most of us have adopted emphasizes **doing** instead of simply **being** and **observing**. The being and observing is what become important in a mindful sensory

engagement practice. Participants must relinquish much of the doubt about the normality of regular nature connection outside of their learned purposeful engagement.

In the present research, participants should feel comfortable seeking connection to nature in an urban setting with other people present – who may watch them with an eschewed eye. The participants will learn to be comfortable in nature engagement practices that are outside of the status quo behaviors of our culture. Examples might be: closely examining the foliage and invertebrate life found in a planter or looking upward at songbirds flying about the trees while sitting on a town square bench. Other examples may be watching swaying branches of trees or rubbing leaves between the fingers and smelling the fragrance. Participants will learn not to be self-conscious when today's norm for idle public behavior is to studiously study a screen. By normalizing nature engagement, participants are encouraged to find purpose in sensory engagement with nature.

To that end, a series of "barrier-lifting" primers (see Appendix A) prior to a final sensory engagement with nature practice should prepare one's state of mind. These primers should help lift the barriers to nature engagement that are imposed by society's expectations of our behavior and our own self-imposed addiction to a screen. The primers will only be facilitated for the experimental groups (N-SE and U-SE), not the controls.

"Barrier-lifting primers."

A series of mini-interventions, henceforth called primers, will be implemented over a number of days with participants. Each primer invites the participants to try a form of nature engagement followed by brief written reflections. Primer 1 introduces participants to the concept of spending time in nature as useful for one's health and wellness. The video (Nature

Rx, 2015) incorporates a satirical pharmaceutical-style commercial about the benefits of nature contact with pointed humor throughout. Participants are asked to:

1.a Watch the video and then personally consider their answers to a series of questions about their view of nature connection in American society.

1.b Evaluate their own daily behavior in terms of how often and to what degree they engage with nature. The intention is to stimulate interest in the health impacts of nature and encourage thinking about a connection with nature in a way that is humorous and non-threatening.

The first primer provides a fun and light introduction which leads into a more serious consideration of nature's impacts on our health and wellbeing and the negative consequences of not engaging with nature. The purpose of Primer 2 for the participant is to:

2.a Examine an infographic (Sofferin, 2015). The infographic presents empirical data on society's progressive disconnection with nature and the correlation with an increase in many preventable diseases and threats to health and wellbeing.

2.b Reflect on this information and why nature may be an antidote to the negative trajectory presented.

2.c Consider the benefits of spending time in nature and reflect on:

2.d Personal experiences in natural environments.

2.e Identify any benefits received from those experiences.

2.f Reflect on why they think nature appears to be a key to augmenting health and wellbeing.

The intention of the infographic exercise is to address the barrier of doubt; the doubt that something as simple as paying attention and giving consideration to natural beauty has

inherent value and can provide tangible benefits for our body and mind. By providing graphical representations of research data, participants should be able to understand and agree that nature engagement is worthwhile for health and wellbeing. The second part of Primer 2 asks participants to:

2.g Examine three photos of nature:

a. A dense green forest environment.

b. A thick groundcover of herbaceous multi-colored flowering plants.

c. A sweeping vista of mountains, trees, and green groundcover.

2.h Consider which environment is preferable and what particular features attract their interest and curiosity.

2.i Reflect on any emotions and/or physical feelings they might experience in their preferred environment, and if they have a personal or past connection to such a natural environment, and why.

The exercise invites participants to imagine spending time in nature and how it might impact them. The idea is that intentional nature engagement and consideration of its mental and physical effects can be a normal practice. By offering this sort of simulated nature engagement exercise, participants should become comfortable and familiar with nature engagement. The time required for the exercise is also intentionally quite short so as to slowly disconnect participants from the need for constant mental stimulation and offer a step-by-step process to familiarize them with some brief reflection practices.

Primer 3 invites participants to watch a time-lapse video (Semi:Free Creative, 2015) of pristine forest and prairie environments with lush greenery and sounds of birdsong, running water, rain, and gentle wind. Participants are encouraged to spend time first listening with

their eyes closed and then incorporate vision into this simulated experience of being in a natural environment. Participants are then asked to:

3.1 Consider what natural elements from the video they enjoyed the most.

3.2 Consider what emotions or physical feelings those natural features elicited.

3.3 Answer if they seek out any of those elements in their weekly activities.

In the final step of Primer 3, participants are invited to find a quiet place to spend 15-30 minutes experiencing nature and reflect on what they enjoy about the natural elements. The goal of Primer 3 is to help participants normalize intentional sensory engagement with nature on a regular basis. Watching a video simulation of natural environments provides a more engaging sensory experience than the photographs in Primer 2 while also taking advantage of the captivating quality of streaming video. Primer 3 also asks the participant to again reflect on what nature provides for them in the present moment. The exercise should bolster participants' skills for reconnecting with elements of nature and identifying how they respond to natural environments including what benefits may realize.

Primer 4 invites participants to take an actual walk through a natural environment (Greater Good Science Center, 2018). Just like the previous primers, participants are directed to notice those natural elements they most enjoy and how the environment impacts their body and mind. The final primer is to help participants draw closer to mindful sensory engagement with natural environments and to further normalize disconnect from technology. It is a practice worth pursuing on a regular basis since such experiences may bolster health and wellbeing in a number of ways.

Through the series of four progressively and more engaging nature connection practices, participants should become comfortable and familiar with the practice of:

1. Noticing new appealing things in nature.
2. Reflecting on how the environment makes them feel.
3. Identifying how the environment affects them physically, mentally, and emotionally.

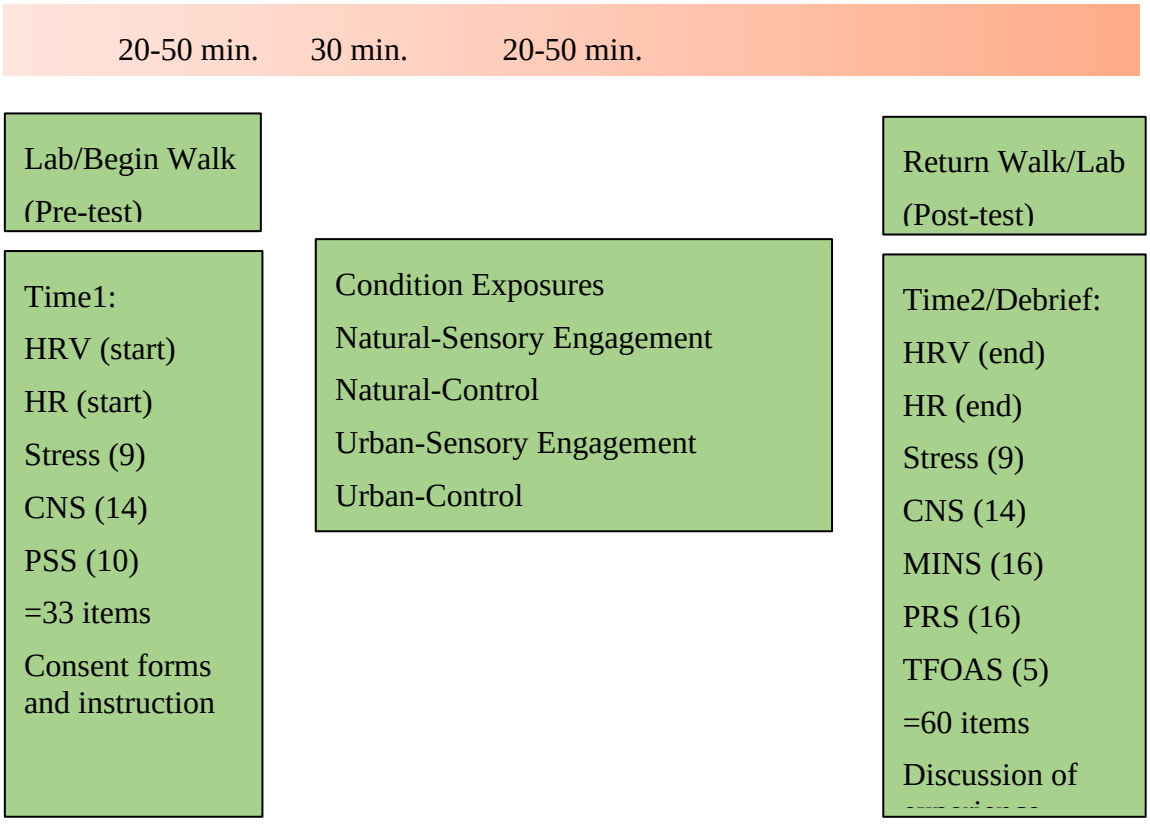
The primers should prepare participants for the main intervention of a guided mindful sensory engagement practice in a group setting. The primers should help lift the barrier of constant connection (i.e., to technology, information, and busyness) which inhibits our reconnection with the slower, less-demanding rhythms of nature. The primers should also lift the barrier of doubt (i.e., from society) and help participants return to the normalcy and purposefulness of sensory engagement with nature practices.

Appendix C: Pilot Study Design and Conclusions

Prior to final study design and data collection, a pilot study was conducted to evaluate any data collection problems and undue participant burden that needed to be addressed. A convenience sample of n=55 total college student participants with an average of 14 participants per treatment group were recruited. Methodology for the pilot study followed the final study design with the exception of the barrier-lifting primers. Figure 3.3 below illustrates the data collection procedures. Figure 3.4 below depicts the two environmental conditions.

Figure 3.6.

Flow diagram for each group in pilot study procedures.



Note: HRV: heart rate variability, HR: hear rate, Stress: Psychological Stress Measure (PSM-9), CNS: Connectedness to Nature Scale, MINS: Mindfulness in Nature Scale, PSS: Perceived Stress Scale, PRS: Perceived Restorativeness Scale, TFOAS: The Focus of Attention Scale.

Figure 3.7:

Photos depicting both environmental settings used in the pilot study.

"Natural" setting in University of Idaho's Charles H. Shattuck Arboretum.

"Urban" setting on Moscow, ID street.

Participants were selected from two different classes taught by one of the researchers. Threats to internal validity were present due to selection bias and experimenter bias (Campbell & Stanley, 1999). However, this aspect of the study design was intentional in an attempt to control for non-compliance with participation in experimental conditions.

Through participant observations during the study and post-exposure discussions with the participants certain realities come to light. (1) Behaviors were observed in the pilot study participants that suggested discomfort with the experimental intervention of actively engaging one's senses with nature in a public space. (2) Participants were also observed being easily distracted by any technological devices in their proximity.

During pilot study data collection, participants were generally compliant with the research protocols including strapping on chest heart rate monitors, participating in the planned walk and/or intervention, and completing both pre- and post-test survey packets. Participant compliance was likely at least partially due to the relationship the students had with their instructor for the course, one of the researchers in this study. However, non-compliant behavior was observed in the intervention groups during the sensory engagement with nature interventions. Many students were not engaging any particular sense in the natural environment, but instead, were fidgeting with the phone in their pocket, some taking the phone out to use it, while others appeared to be uncomfortable with the experience in a public setting. There appeared to be a lack of focus in many of the participants during the unfacilitated portion of the intervention. Observations from the pilot study informed the final study via the motivation to create barrier-lifting primer lessons to help participants become more comfortable with the intervention protocol and gradually less distracted by technology.

The researchers also discovered the data collection methods needed to be simplified for the final study. The number of survey items presented too great of a participant burden. Therefore, three of the six surveys were dropped from the final study, instead focusing on the three most salient variables. Heart rate and heart rate variability data collection presented serious challenges including (1) problems with wireless connectivity of equipment, (2) technological distraction from the use of iPads to connect to heart rate monitors, and (3) inconsistent connectivity via skin conductance variability. These issues were address in planning the final study by (1) ensuring the devices had a clear line-of-sight Bluetooth connection not through the participant's body, (2) utilizing less obtrusive and distracting data collection hardware in the form of small smartphones, and (3) moistening the chest heart rate monitor straps before adhering to the skin. Unfortunately, heart rate and hear rate variability data collection procedures were also dropped from the final study due to administrative challenges in ordering the units in time for implementation.

Appendix D: IRB Agreements

University *of* Idaho
Office of Research Assurances
Institutional Review Board
875 Perimeter Drive, MS 3010
Moscow ID 83844-3010
Phone: 208-885-6162
Fax: 208-885-5752
irb@uidaho.edu

To: Sharon K. Stoll

Cc: Erik Lee Luvaas

From: Jennifer Walker
IRB Coordinator, University of Idaho Institutional Review Board

Date: April 20, 2018

Title: Nature Engagement and Psychological and Physiological Indicators of Stress
Project: 18-073

Review Type: Expedited
Approved: 04/20/2018
Renewal: 04/19/2019

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the protocol for the research project Nature Engagement and Psychological and Physiological Indicators of Stress is approved as offering no significant risk to human subjects. This approval is valid until 04/19/2019.

This study may be conducted according to the protocol described in the application. Research that has been approved by the IRB may be subject to further appropriate review and approval or disapproval by officials of the Institution. Every effort should be made to ensure that the project is conducted in a manner consistent with the three fundamental principles identified in the Belmont Report: respect for persons; beneficence; and justice. As Principal Investigator, you are responsible for ensuring compliance with all applicable FERPA regulations, University of Idaho policies, state and federal regulations.

Federal regulations require researchers to follow specific procedures in a timely manner. For the protection of all concerned, the IRB calls your attention to the following obligations that you have as Principal Investigator of this study.

1. For any changes to the study (except to protect the safety of participants), an Amendment Application must be submitted to the IRB. The Amendment Application must be reviewed and approved before any changes can take place.

2. Any unanticipated/adverse events or problems occurring as a result of

participation in this study must be reported immediately to the IRB.

3. Principal investigators are responsible for ensuring that informed consent is properly documented in accordance with 45 CFR 46.116.

4. A Continuing Renewal Application must be submitted and approved by the IRB prior to the expiration date else automatic termination of this study will occur. If the study expires, all research activities associated with the study must cease and a new application must be approved before any work can continue.

5. Please complete the Continuing Renewal/Closure form in VERAS when the project is completed.

6. Forms can be found at https://veras.uidaho.edu.

SACRAMENTO STATE
Redefine the Possible

Institutional Review Board (IRB)
FWA00003873

Cooperative Research Agreement for Human Subjects Research

Instructions

1. This form is to be used when Sacramento State is *engaged* in research with another institution through collaborative research.
2. Submit this form and required attachments to the Office of Research Affairs electronically to leah.vargas@csus.edu. If you have any questions, please call Leah Vargas, (916) 278-5674 or email.

External Institution Information	
External Investigator's Name: Dr. Sharon Stoll	Email Address: sstoll@uidaho.edu
Phone Number: (including area code): 208-885-2103	Other: (if needed):

Name of External Investigator's Institution or Agency: University of Idaho
FWA# (IRB staff can complete): FWA00005639
Administration Contact Information for External IRB (if applicable): Jennifer Walker, IRB Coordinator, 208-885-6340, irb@uidaho.edu

Project / Research Title: Nature Engagement and Psychological and Physiological Indicators of Stress

Describe the relationship between your institution and CSUS in this research (required): University of Idaho is supporting the dissertation research of Erik Luvaas, Assistant Professor of Recreational Therapy at CSUS. This cooperative agreement will permit Erik to collect data from CSUS students for his dissertation research and degree completion, as part of the criteria for his retention as CSUS faculty within the first two years of his appointment (2018-19 to 2019-20).

Sacramento State Information	
Sacramento Sate will be the: [ ] Reviewing IRB for both institutions engaged in research. [v] Relying on the lead IRB's approval.	
Sac State Investigator's Name: Erik Luvaas	Email Address: erik.luvaas@csus.edu
Phone Number: (including area code): 208-596-1619	Other: (if needed):

Required Attachments
Required Attachments if Sacramento State is **relying**: 1. ☐ Approved protocol from external investigator's home IRB 2. ☐ Approval letter/ Exemption letter from the external investigator's home IRB 3. ☐ Certification of training in human subject research protections for all personnel involved
Required Attachments if Sacramento State is **reviewing**: 1. ☐ Protocol Review Form

2. ☐ Data collection instruments and recruitment materials, consent forms, etc.
3. ☐ Certification of training in human subject research protections for all personnel involved

The review performed by the designated IRB will meet the human subjects protection requirements of the relying IRB's OHRP-approved FWA. The Reviewing Institution will follow written procedures for reporting its findings and actions to appropriate officials at the Relying Institution. Relevant minutes of IRB meetings will be made available to the Relying Institution upon request. The Reviewing Institution remains responsible for ensuring compliance with the IRB's determinations and with the Terms of its OHRP-approved FWA. This document must be kept on file by both parties and provided to OHRP upon request.

External Institution Authorization

Signature of External Institutional Official or IRB Chair: _____ Date: 10/25/18

Print Full Name: Janet E. Nelson, Ph.D.
Institutional Title: Vice President for Research and Economic Development

Sacramento State Authorization

Signature of Sacramento State's Institutional Official or IRB Chair: _____ Date: 10-31-18

Print Full Name: Yvonne Harris Institutional Title: AVP, Research, Innovation, and Economic Dev.

Psychological Stress Scale (PSM-9)

Name:_____

Check the number that best indicates the degree to which each statement applies to you now.

DESCRIPTION OF MOOD	NOT AT ALL	NOT REALLY	VERY LITTLE	A BIT	SOMEWHAT	QUITE A BIT	VERY MUCH	EXTREMELY
	1	2	3	4	5	6	7	8
I feel calm.								
I feel rushed; I do not seem to have enough time.								
I have physical aches and pains: sore back, headache, stiff neck, stomachache.								
I feel preoccupied, tormented, or worried.								
I feel confused; my thoughts are muddled; I lack concentration; I cannot focus.								
I feel full of energy and keen.								
I feel a great weight on my shoulders.								
I have difficulty controlling my reactions, emotions, moods, or gestures.								
I feel stressed.								

Connectedness to Nature Scale (CNS)

Connectedness to Nature Scale (State)

Please answer each of these questions in terms of the way you feel at the present moment. There are no right or wrong answers. Using the following scale, in the space provided next to each question simply state as honestly and candidly as you can what you are presently experiencing.

1	2	3	4	5	6	7
Strongly Disagree			*Neutral*			*Strongly Agree*

____ 1. Right now I'm feeling a sense of oneness with the natural world around me.
____ 2. At the moment, I'm feeling that the natural world is a community to which I belong.
____ 3. I presently recognize and appreciate the intelligence of other living organisms.
____ 4. At the present moment, I don't feel connected to nature.
____ 5. At the moment, I can imagine myself as part of the larger cyclical process of living.
____ 6. At this moment, I'm feeling a kinship with animals and plants.
____ 7. Right now, I feel as though I belong to the earth just as much as it belongs to me.
____ 8. Right now, I am feeling deeply aware of how my actions affect the natural world.
____ 9. Presently, I feel like I am part of the web of life.
____10. Right now, I feel that all inhabitants of earth, human and nonhuman, share a common life force.
____11. At the moment, I am feeling embedded within the broader natural world, like a tree in a forest.
____12. When I think of humans' place on earth right now, I consider them to be the most valuable species in nature.
____13. At this moment, I am feeling like I am only a part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.

Mindfulness in Nature Scale (MINS)

Please rate each of the following statements using the scale provided. Write the number in the blank that best describes your own opinion of what is true for you at this present moment.

1	2	3	4	5
never or very rarely true	rarely true	sometimes true	often true	very often or always true

_____ 1. When I'm walking, I deliberately notice the sensations of my body moving.

_____ 2. When I do things, my mind wanders off and I'm easily distracted.

_____ 3. When I am outside in the wind or rain, I stay alert to the sensations of water or wind on my body.

_____ 4. I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted.

_____ 5. I notice how the temperature and moisture of the air affects my bodily sensations.

_____ 6. I am easily distracted.

_____ 7. I pay attention to sensations, such as the wind in my hair or sun on my face.

_____ 8. I find it difficult to stay focused on what's happening in the present.

_____ 9. I pay attention to sounds, such as wind in the grass or bushes or birds chirping.

_____ 10. It seems I am "running on automatic" without much awareness of what I'm doing.

_____ 11. I notice the smells and aromas of things.

_____ 12. I rush through activities without being really attentive to them.

_____ 13. I notice visual elements in nature, such as colors, shapes, textures, or patterns of light and shadow.

_____ 14. I do jobs or tasks automatically without being aware of what I'm doing.

_____ 15. When I'm outside, I notice movements around me, such as trees swaying in the wind.

_____ 16. I find myself doing things without paying attention.

Demographic Information

Demographic Information

(All data remains confidential and your name will be removed from the data)

Name: _____

What is your age? _____years.

Which gender do you most closely identify with?

- ○ Male
- ○ Female

Are you Spanish, Hispanic, or Latino? (Mark one)

- ○ Yes, I consider myself to be Spanish, Hispanic, or Latino
- ○ No, not Spanish, Hispanic, or Latino

What is your race? (Mark one or more races)

- ○ American Indian or Alaskan Native
- ○ Asian, Asian Indian, or Pacific Islander
- ○ Black or African American
- ○ White
- ○ Other: _____

Appendix F: Literature Review Findings Summary Tables

Table 2.1:

Summary of studies on engagement with nature and stress response organized by type of engagement.

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
Exercise in greenspace	Astell-Burt, Feng, & Kolt (2013)	Comparison study; population survey data and GIS data	260,061 Australians over 45 years old	Physical activity measured by Active Australia survey; government dominant land use data	Compared to non-green areas, those in green areas had lower psychological distress and were less sedentary; Lowest distress for those in green areas was contingent upon physical activity participation	Limited sample age range; no control for type of greenspace in which participants were physically active	Studies to evaluate which types of greenspaces are most attractive for engaging within
Exercise in greenspace	Barton & Pretty (2010)	Meta-analysis comparison study	10 UK studies involving 1252 participants	Rosenberg Self-Esteem Scale; Profile of Mood States	Compared to non-green, acute (5 mins.) green exercise improved self-esteem, mood; water elicited greater effects; mentally ill had greatest self-	Results are from short-term exposures to single interventions; localized study population	Longitudinal studies to measure longevity of positive effects

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
					esteem improvements		
Exercise in greenspace	Gidlow et al. (2016)	Randomized, cross-over, field-based trial comparing psychological and physiological responses to walking in natural and urban environments	38 adults	BRUMS Profile of Mood States, Backward Digit Span, Restoration Outcome Scale, salivary cortisol, ambulatory heart rate, Rate of Perceived Exertion	Mood and cortisol improved for both post-walk measures across environment types; greater restoration experiences and cognitive function improvements were reported for green and blue environments	Consistency of experience was lacking (i.e., walking speed, weather, researcher presence)	Studies to assess longevity of benefits from walking in natural environments and those that control for type of experience
Exercise in greenspace	Hartig, Evans, Jamner, Davis, & Garling (2003)	Experimental design with natural/urban walks crossed with pretreatment condition (task, no-task)	112 college students	Blood pressure, Zuckerman's Inventory of Personal Reactions, Overall Happiness Scale, Necker,	Compared to walking in urban surroundings, walking in nature reserve elicited greater reduction in blood pressure, increased positive affect and decreased anger (reverse for urban	Results are representative of college students, not broader healthy adult populations	Further studies on anger reduction as a benefit of exposure to natural environments

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
				Cube Pattern Control task	walk), and improved attentional test performance between pretest and midpoint		
Exercise in greenspace	Pasanen, Tyrvainen, & Korpela (2014)	National survey data analysis	2070 respondents	Emotional well-being, perceived general health, and sleep questions from national survey; self-report PA in different indoor/outdoor settings	Emotional well-being positively connected to PA in nature; general health positively associated with PA in both natural and built outdoor settings; sleep quality positively associated with frequent outdoor PA, but a weak connection	Cross-sectional data limits causality; social desirability and memory bias of self-report measures; lack of standardized measurements used	Studies to examine the relationships between sleep quality and nature exposure
Exercise in greenspace	Thompson Coon, Stein, Barton, & Depledge (2011)	Systematic literature review	11 experimental studies included	Systematic review	Most trials showed some form of improvement in mental wellbeing for exercise outdoors, especially in		Large, longitudinal trials on the benefits of outdoor exercise for mental and physical wellbeing

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
					comparison to exercise indoors		
Living near green or blue spaces	Triguero-Mas et al. (2015)	Regional cross-sectional interviews	8793 residents in Catalonia, Spain	Catalonia Health Survey, GIS indicators of and access to surrounding greenness	Better self-perceived general health and mental health was associated with surrounding greenness.	No consideration of frequency of use or type of engagement in green or blue spaces	Studies examining how frequency of use and type of activity/engagement affect health
Living near green space	Reklaitiene et al. (2014)	Cross-sectional epidemiological survey	6,944 45-72-year-old Kaunas, Lithuanian residents	GIS proximity resident to greenspace, CES-D10 scale (depression), demographic, smoking, alcohol consumption, BMI, and perceived general health	Increased distance from nearest park associated with increase in prevalence of depressive symptoms and poor and very poor perceived general health in women only	Privately owned natural space nor small-scale natural elements and areas were taken into account	Studies examining the benefits of small-scale natural areas and continued use of GIS to measure green space effects on wellbeing

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
Living near green space	Stigsdotter et al. (2010)	Cross-sectional epidemiological survey	11,238 adult Danes	Danish Health Interview Survey, Short-Form Health Survey, Perceived Stress Scale	Respondents living more than 1 km away from greenspace had higher odds of experiencing stress and poorer health and health-related quality of life than those living less than 300 m away. Those more stressed reported seeking green space specifically for stress reduction	Nearest nature type not defined	Studies exploring how different nature types affect stress reduction and health and health quality
Living near green space	van den Berg, Maas, Verheij, & Groeneweg en (2010)	Representative population survey	4529 Dutch respondents	Dutch National Survey of General Practice	Relationships of stressful life events with perceived general health and number of health complaints, as well as perceived mental health, were moderated by amount of green space in 3-km radius. More	"micro-restorative" experiences with nearby or small nature elements not taken into account; survey only representati	Longitudinal research examining the buffering effects of proximity to greenspace; studies examining the effect of "micro-restorative" nature experiences on mental health

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
					proximal greenspace buffered stress experiences	ve of Dutch residents	
Living near green space	van Herzele & de Vries (2012)	Neighborhood-focused random population survey	190 Dutch respondents from two different neighborhoods	Belgian Health Interview Survey; Short Questionnaire to Assess Health Enhancing PA; Survey of Life Situation; perceived stress and neighborhood satisfaction	Self-reported happiness was reported higher in the greener neighborhood; neighborhood satisfaction mediated relationship between neighborhood greenness and happiness; view from living room mediated relationship between neighborhood greenness and neighborhood satisfaction	Limited sampling frame; cross-sectional sample limits causality of observed relationships	Studies to examine the effect of visual availability and proximity of greenspace from the home
Living near greenspace	Alcock, White, &	Longitudinal analysis of population	1064 British citizens	British Household Panel Survey	Individuals who moved to greener areas had better	Motivations to move to more/less	Studies to explore mechanisms for greenspace

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
	Wheeler (2014)	mental health after moving to greener areas		with mental health data	mental health in all three years post move. Opposite effect for those who moved to less green areas	green areas was not modeled	benefits in longitudinal studies
Living near greenspace	Beyer et al. (2014)	Population database mining and GIS neighborhood tree canopy measurements	N/A	Survey of Health of Wisconsin database, tree canopy coverage, level of "greenness"	Greater neighborhood greenspace associated with lower levels of negative mental health symptoms	Neighborhood selection bias	Broader population studies needed; study of how demographic variables influence greenspace benefits
Living near greenspace	de Vries, van Dillen, Groeneweg en, & Spreeuwen berg (2013)	Cross-sectional analysis of self-report health indicator surveys and quantity and quality of street greenspace with mediators: stress, social	1641 adults from four Dutch cities	Author-designed greenspace quantity and quality measures, Perceived Stress Scale, Mental Health Inventory, author-developed social	Perceived stress was a significant mediator of the effect of greenery quantity and quality on health, and more so than green physical activity	Some unreliability of self-report measures; low response rate in some neighborhoods	Further studies to explore the role of stress reduction in identifying types of greenspaces to elicit maximal health benefits

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
		cohesion, green physical activity		cohesion scale, Short Questionnaire to Assess Health-enhancing physical activity			
Living near greenspace	de Vries, Verheij, Groeneweg en, & Spreeuwen berg (2003)	Analysis of self-report health data and greenspace using land-use data	10,000 Dutch citizens	Dutch National Survey of Morbidity and Interventions in General Practice; National Land Cover Classificatio ns database	Proximity to green environments was positively related to all health indicators; this relationship was stronger for lower educated people	Possible bias from to neighborhoo d selection due to health status	Studies on possible mechanisms for greenspace health benefits such as outdoor recreational behavior, air quality or time budgets
Living near greenspace	Nielsen & Hansen (2007)	Observational survey study	1200 Danes age 18-80	Distance to green areas, frequency of use, experienced stress	Access to gardens or green areas in close proximity were associated with less stress and lower likelihood of obesity; frequency of visit cannot	Experienced stress not a standardized measure	Exploration of mechanisms to explain effect of distance to green areas on experienced stress

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
				questionnaire, BMI	account for the effects of green areas		
Living near greenspace	Wheeler et al. (2015)	UK Census survey data and ecological database data	N/A	Database data on: Population general health, environmental indicators, land cover and quality, biodiversity	Density of greenspace, biodiversity, and land cover / protected areas density positively correlated with good health prevalence	Residual confounding variables; analysis does not account for small greenspace areas such as ‘pocket parks’	Type, quality, and context of greenspace should be considered in future studies on greenspace and human health relationships
Recall of past nature visits	Grahn & Stigsdotter (2010)	Randomized postal questionnaire	953 people from nine Swedish cities	Author-designed survey of preferences for qualities in urban green spaces, health status questions	Eight perceived sensory dimensions of urban greenspace identified; Refuge and Nature and Rich in Species were indicated as preferred by the most stressed individuals	Study was limited to urban greenspaces, not including any rural environments or parks	Future studies on the proposed perceived sensory dimensions of urban green spaces

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
Recall of past nature visits	Shanahan et al. (2016)	Cross-sectional epidemiological survey	1538 representative Australian adults	Self-report of duration, frequency, and intensity of outdoor green space visitation within previous week; batter of health indicators	Nature visits of longer duration were associated with lower rates of depression and high blood pressure, higher frequency with greater social cohesion.	Self-report survey limitations such as reliability of memory of past nature visits	Studies exploring other variables affecting the mechanistic pathways linking nature exposure to health such as socio-demographic and community factors.
Recall of past nature visits	Stigsdotter & Grahn (2011)	Representative population survey	953 Swedish residents	Modified Stress and Crisis Inventory SC-93), preferences for perceived sensory dimensions and for outdoor activities, self-estimation of health, EuroQoL	Most preferred 'activity-sensory dimension types' for the most stressed respondents were 'animal activities' in the Perceived Sensory Dimensions 'rich in species' and 'refuge' followed by 'rest activities' in the PSD 'nature'	Study is only generalizable to Swedish cities, study did not account for actual outdoor activities of respondents	Studies measuring most effective activities/engagement in green space to maximize stress-reduction benefits

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
Walking and sitting in forest	Lee et al. (2011) and Lee et al. (2009)	Experimental	12 Japanese male adults	Heart rate variability, salivary cortisol, pulse, blood pressure, Profile of Mood States	15 minutes of forest viewing significantly increased parasympathetic nervous activity and suppressed sympathetic activity, decreased cortisol level and pulse rate, and increased positive feels and decreased negative feelings compared to urban environment	Small sample size, no control for effect of escape from daily routine	Studies with larger sample sizes and mixed gender
Walking and sitting in forest	Morita et al. (2007)	Experimental	498 healthy adults	Multiple Mood Scale-Short Form, State Trait Anxiety Inventory A-State Scale	Compared to a non-forest control day, the forest day produced decreases in participants' hostility and depression and increases in liveliness. Greater effect was shown	No control for activities/engagement with environment during forest days	Studies on mechanisms of benefits from forest walking

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
					for those with higher stress levels		
Walking and sitting in forest	Park et al. (2011)	Experimental	168 male university students	Semantic differential method, Profile of Mood States, measures of air temperature, relative humidity, radiant heat, wind velocity, and thermal comfort	Higher positive emotions and decreases in negative mood states reported from forest versus urban environments; positive emotions were positively correlated with thermal comfort	Effects of changes in seasons not considered	Effects of sensory-specific stimuli in the forest environment; exploration of seasonal changes in benefits from forest bathing
Walking and sitting in forest	Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki (2010)	Experimental crossover design	12 Japanese adults in each forest study	Salivary cortisol, blood pressure, pulse rate, heart rate variability	Compared to city walk/viewing, the forest days promoted lower concentrations of cortisol, lower pulse rate, lower blood pressure, greater parasympathetic nerve activity, and	Crossover design risks a “carry-over” effect between treatments; small sample sizes, no control for effect of	Further studies on different natural environments besides forests

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
					lower sympathetic nerve activity.	escape from daily routine	
Walking and sitting in natural environments	Tsunetsugu et al. (2013)	Experimental crossover design	48 young male urban Japanese	Profile of Moods States, heart rate variability blood pressure, and a scale to measure state of being refreshed	In forested area vs. urban area, subjects exhibited lower diastolic blood pressure, sympathetic nervous activity, and heart rate; higher parasympathetic nervous activity; less negative and more vigorous moods	Crossover design risks a "carry-over" effect between treatments; male sample not generalizable to general population	Studies to understand the physiological effects of viewing forest landscapes on more diverse groups of people
Walking and sitting in natural environments	Tyrvainen et al. (2014)	Experimental	77 adult Helsinki Metro residents	Focus of Attention Scale, Restoration Outcome Scale, Perceived Restorativeness Scale, PANAS, Subjective Vitality	Large urban park and managed urban woodland elicited increased perceived stress relief in participants compared to the urban environment; cortisol levels decreased	Primarily female participant sample	Studies analyzing relationships between psychological and physiological measures of stress after nature exposure

Type of Engagement	Author	Design	Subjects	Measurement	Key Findings	Limitations	Recommendations
				Scale, Creativity Scale, salivary cortisol	similarly in all three settings		

Table 2.2:

Summary of studies on nature connectedness and effect on stress response after engagement with nature.

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
Capaldi, Dopko, & Zelenski (2014)	Meta-analysis	30 studies of the relationship between nature connectedness and happiness	Variety of nature connectedness and happiness measures	Subjects more connected to nature tended to experience more vitality, positive affect, and life satisfaction.	Lack of consideration of other related variables of wellbeing	Studies exploring the directional relationship between nature connectedness and happiness or other wellbeing measures
Cervinka, Roderer, & Hefler (2011)	Five cross-sectional self-report survey studies	Each of five studies included ~100 Austrian citizens	Connectedness to Nature Scale and Connectedness to Nature-Single Item; Five measures of wellbeing	Psychological wellbeing, meaningfulness, and vitality were all correlated with connectedness to nature	Limited use of connectedness to nature scales; no measure of current or recent effect of exposure to nature	Studies elucidating further relationships between wellbeing and nature connectedness
Howell, Dopko, Passmore, Buro (2011)	Study 1 and 2: Cross-sectional self-report survey design	Study 1: 452 undergraduates Study 2: 275 undergraduates	Study 1: Connectedness to Nature Scale, 40-item measure of wellbeing, Mindful Attention Awareness Scale,	Study 1: Nature connectedness positively correlated with psychological and social wellbeing, while mindfulness did not correlate	Not an experimental study, so no effect of subjects' nature experiences on	Studies examining moderators and mediators of the relationship between connectedness to

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
			Balanced Inventory of Desirable Responding Study 2: Study 1 measures plus Nature Relatedness Scale, Allo-Inclusive Identity Scale, and Philadelphia Mindfulness Scale	Study 2: Three connectedness to nature scales positively correlated with psychological and social wellbeing; nature connectedness correlated with mindfulness; Confirmatory Factor Analysis of scales showed that greater connectedness to nature was associated with greater wellbeing and mindfulness	the measures can be known	nature and mental health.
Howell, Passmore, & Buro (2013)	Two cross-sectional self-report survey studies	Study 1: 311 undergraduates Study 2: 227 undergraduates	Connectedness to Nature Scale, Nature Relatedness Scale, Allo-Inclusive Identity Scale, The Meaning in Life Questionnaire, Meaningful Life Measure, General Life Purpose Scale,	Meaning in life fully mediated association between nature connectedness and wellbeing (Study 1 and 2). Meaning in life fully mediated association between religiousness and wellbeing	Measures were restricted to self-reports of undergraduate students	Studies exploring pathways to increased wellbeing through increased meaning in life and/or nature connectedness

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
			Steen Happiness Index, and a global measure of wellbeing			
Kamitsis & Francis (2013)	Cross-sectional self-report survey study	190 Australian adults	Nature Exposure Scale, Connectedness to Nature Scale, Mysticism Scale, psychological subscale of the WHO-Quality of Life-BREF	Nature exposure and connectedness to nature were positively correlated with psychological wellbeing and greater spirituality; Both associations were mediated by spirituality.	Lack of measure of real nature experience (self-report only)	Experimental or quasi-experimental approaches to explore additional mediating pathways.
Mayer & Frantz (2004)	Cross-sectional self-report survey study	Five studies totaling 613 college students	Connectedness to Nature Scale, New Environmental Paradigm scale, a nature-contact behavioral assessment	CNS showed good psychometric properties, correlated with related variables and uncorrelated with potential confounds (verbal ability, social desirability)	Assessment of only colleges students	Further studies on any causal pathway between nature connectedness and measures of subjective wellbeing.

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
Mayer, Frantz, Bruehlman-Senecal, & Dolliver (2009)	Three experimental studies using a variety of physical and virtual nature experiences	Study 1: 76 undergraduates Study 2: 92 undergraduates Study 3: 64 undergraduates	Attentional capacity measure, Positive and Negative Affect Schedule, Connectedness to Nature Scale, Situational Self-Awareness Scale	Subjects in nature condition reported significantly more positive emotions and higher CNS scores than those in the urban condition; CNS scores were shown to partially mediate positive changes in affect after nature condition; real nature elicited greater mood benefits than virtual nature	Use of only one connection to nature scale	Studies exploring other mechanisms of nature's beneficial effects
Nisbet & Zelenski (2013)	Four cross-sectional self-report survey design studies	Study 1: 184 Canadian undergraduates Study2: 145 Canadian middle managers Study 3: 354 Canadian undergraduates Study 4: 207 students and	Study 1: Nature Relatedness Scale, PANAS, Psychological Well-Being Inventory, Satisfaction with Life Scale, Ecology Scale-SF, New Ecological Paradigm Scale, New Ecological	A test of the brief Nature Relatedness Scale's (NR-6) predictive ability across multiple samples yielded good temporal stability, internal consistency, and predicted environmental concern, happiness, and nature contact. The scale only	Generalizability is limited due to homogeneous study samples.	Future research in applicability of scale across cultures.

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
		community members	Consciousness Scale Study 2: Scales from Study 1 plus assessment of time spent outdoors Study 3: Scales from Study 1 plus Inclusion of Nature in Self Scale, Environmental Concern scale, Sustainability Survey Study 4: NR and NR-6, combination of scales used in previous studies	includes the "self" (identification with nature) and "experience" (contact with nature) and not "perspective" (pro-nature conservation attitudes) dimensions, thus is appropriate for assessing connectedness elements rather than environmental attitudes.		
Nisbet, Zelenski & Murphy (2011)	Study 1 and 2: Cross-sectional self-report survey studies Study 3: Cross-sectional self-report survey	Study 1: 184 Canadian undergraduates Study 2: 145 Canadian business executives	Nature Relatedness Scale, Psychological Well-Being Inventory, Positive and Negative Affect Schedule, Satisfaction with Life Scale, New	Study 1 and 2: Nature relatedness was positively correlated with wellbeing measures. Study 3: NR remained consistent before and after environmental	Quasi-experimental study design cannot address causal links between NR and wellbeing.	Studies further investigating the "'active ingredients' that may promote or sustain NR" (p. 318)

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
	study with control group	Study 3: 170 Canadian undergraduates	Ecological Paradigm Scale, New Ecological Consciousness Scale, Ecology Scale-SF, Vitality Scale	education class group, but decreased for non-environmental ed. class. NR mediated the positive correlation between environmental education and change in vitality (inverse for control group).		
Richardson & Hallam (2013)	Qualitative analysis of engaging with nature diary	One 42-year old male	Diary of over 200 trips engaging with nature	Subject experienced transition from observer to being connected with nature and his experience of the environment was thus changed	Only one subject	Studies exploring how reflective journaling and mindful awareness of the environment can enhance nature connectedness
Wolsko & Lindberg (2013)	Three cross-sectional self-report survey studies	Study 1: 265 college students Study 2: 223 college students Study 3: 168 college	Study 1 and 2: Connectedness to Nature Scale, Mindfulness Attention Awareness Scale, Flourishing scale, Scale of Positive and Negative	Appreciative outdoor activities and subjects' CNS scores were significantly correlated with higher levels of all psychological wellbeing and mindfulness	Non-experimental, cross-sectional study not able to explain causal link between mindfulness	Studies further exploring the bi-directional relationship between nature exposure and mindfulness

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
		students and 242 adults in the community	Experience, Subjective Vitality scale, and an outdoor activities assessment (Study 2 only); Study 3: CNS and an outdoor activities assessment	measures. Psychological wellbeing and mindfulness measures were also positively correlated. CNS was positively correlated with appreciative outdoor activities and negatively correlated with consumptive and motorized outdoor activities.	and connection to nature	
Zelenski & Nisbet (2014)	Two cross-sectional self-report survey studies	Study 1: 331 Canadian undergraduates and 415 community participants from more than five countries Study 2: 204 US online participants	Study 1: NR-6, Inclusion of Nature in Self (1-item), Subjective Happiness Scale, PANAS, Vitality Scale, Centre for Epidemiological Studies Depression Scale Study 2: Study 1 scales (but full NR scale) and a composite of	General connectedness predicted happiness, but nature relatedness distinctly predicted many happiness indicators, supporting NR as a potential pathway to human happiness	Causation of variable relationships not assessed due to non-experimental design	Further studies to confirm the suggestion that NR may lead to increased human happiness

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
			various scales assessing subjective connections			
Zhang, Howell, and Iyer (2014)	Opt-in survey sample from YourMorals website & college student convenience sample	1108 US residents who opted-in & 151 volunteer college students	Connectedness to Nature Scale, Engagement with Natural Beauty Scale, Satisfaction with Life Scale	Connectedness to nature (CNS) and life satisfaction are positively correlated only if scores on engagement with natural beauty are high	Use of only one connection to nature scale	Expand study to different age groups, cultures, etc. Explore how access to nature affects the study's variables

Table 2.3:

Summary of studies on biomarkers and self-report survey instruments to measure nature engagement stress response.

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
Beil & Hanes (2013)	Cross-over experimental	15 community members	Salivary cortisol, salivary alpha-amylase, Subjective Stress Scale, Environmental Identity Scale, Perceived Stress Scale, Perceived Restorativeness Scale	No significant differences in salivary cortisol among settings; salivary alpha-amylase levels significantly increased in very built setting indicating a non-psychological stress response; subjective stress was significantly lower after very natural setting; however, no significant differences were found between setting; no significant correlation between physiological stress measures and psychometric stress measure	Limited exposure to environments in each condition may not have provided enough reaction time to capture cortisol change; small sample limits generalizability and power	Further studies investigating the optimal "dose" of nature exposure, the duration of stress changes, and the effect of repeated vs. single exposures
Beil, Hanes, & Zwickey (2014)	Quasi-experimental: subjects	Seven students	Salivary cortisol, Profile of Mood States (POMS),	No significant cortisol differences between settings; Nature	Small sample size; only 2 of 7 subjects	Studies further investigating how environmental

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
	experienced each of 3 settings		verbal qualitative assessment of each setting	setting significantly reduced Confusion/Bewilderment subscale of POMS compared to Urban and Indoor settings; no correlational analysis between biomarker and psychometric measures	experienced all three settings; homogeneous population	settings may impact measures of holistic health and influence health therapies
Ewert, Davidson, & Chang (2016)	Time-series study (pre-, during, post-rappelling)	15 college students enrolled in an outdoor leadership program	Salivary cortisol	Salivary cortisol stress response was higher before rappelling, lower just before the initiative, and higher again after rappelling. The 20-40-minute lag in salivary cortisol stress response may explain why results were inverse of the authors' predictions	Small sample size; only one biomarker of stress measured; first measurement point could have triggered a stress response (packing for trip)	Studies considering other biomarkers of stress responses including epinephrine, norepinephrine, alpha-amylase, blood pressure, or heart rate variability
Gidlow, Randall, Gillman,	Cross-sectional study with	132 employed adults from the	Hair cortisol concentration (HCC); Appraisal	HCC-measured chronic stress was higher in areas with	Sample size was small for land area	Further studies utilizing HCC as a chronic stress

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
Smith, & Jones (2016)	biomarker (HCC) and participant profile and stress and neighborhood assessment measures	West Midlands, UK	of Life Events Scale (ALES); Perceived Stress Scale (PSS); demographics; overall deprivation measures; neighborhood characteristics; measures of health, lifestyle, natural environment, income deprivation, and urbanicity	less natural environment; HCC was not associated with Perceived Stress Scale (PSS) which measures general stress over the previous month, but was correlated with ALES-Loss subscale score indicating chronic stress was associated with stressful loss events within the previous three months	studied; homogeneity of socioeconomic status of subjects; not generalizable data due to cross-sectional design	measure; studies exploring the differences in accuracy of using biomarkers vs. psychometric self-report measures
Lee et al. (2011) and Lee et al. (2009)	Experimental	12 Japanese male adults	Heart rate variability, salivary cortisol, pulse, blood pressure, Profile of Mood States	15 minutes of forest viewing significantly increased parasympathetic nervous activity and suppressed sympathetic activity, decreased cortisol level and pulse rate, and increased positive feels and decreased negative feelings	Small sample size, no control for effect of escape from daily routine; no analysis of psychological vs. physiological measures	Studies with larger sample sizes and mixed gender

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
				compared to urban environment		
Lee et al. (2014)	Experimental	48 Japanese male adults	Heart rate variability, blood pressure, Profile of Mood States, Speilberger State-Trait Anxiety Inventory, and an assessment of a "refreshed" feeling and feelings of comfort, naturalness, and soothing in the environment	Two days of 15-minute walks in a forest elicited increased parasympathetic nervous activity, decreased sympathetic nervous activity, decreased heart rate, and a reduction in negative mood states and anxiety levels compared to control	Small sample size, no control for effect of escape from daily routine; no analysis of psychological vs. physiological measures	Studies with larger sample sizes and mixed gender
Park et al. (2009)	Experimental crossover design	12 male Japanese university students	Heart rate variability, blood pressures, pulse rate; subjective measures of participants' comfort, calmness, and feeling refreshed	Compared to city walk/viewing, the forest promoted lower pulse rate, lower blood pressure, lower sympathetic nerve activity, and increased feelings of comfort, calm, and feeling refreshed	Crossover design risks a "carry-over" effect between treatments; small sample sizes, no control for effect of escape from daily routine; no	Further studies on different natural environments besides forests

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
					analysis of psychological vs. physiological measures	
Roe et al. (2013)	Cross-sectional	106 unemployed middle-aged women and men living in socially disadvantaged districts in Scotland	Salivary cortisol, Perceived Stress Scale (PSS), Warwick and Edinburgh Mental Well-Being Scale; objective measure of greenspace for each subjects' postcode	Living in higher green space areas was negatively associated with stress levels; women were more likely than men to have healthier mean cortisol levels due to higher levels of neighborhood green space	Cross-sectional design cannot demonstrate causality; coarse measures of percentage of greenspace; no analysis of psychological vs. physiological measures	Assessment of the effect of type of greenspace available on perceived and physiological stress
Song et al. (2013)	Experimental crossover design	13 Japanese male adults	Subjective measures of comfort, naturalness, and feeling relaxed; profile of Mood States; State-Trait Anxiety Inventory;	Heart rate was significantly lower, heart rate variability was improved, mood improved, and negative feelings and anxiety decreased for the forest condition	Crossover design risks a "carry-over" effect between treatments; small sample sizes, no control for effect of escape	Studies with more heterogeneous sample; studies conducted in other seasons

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
			heart rate; and heart rate variability	compared to the control	from daily routine; no analysis of psychological vs. physiological measures	
Tyrvainen et al. (2014)	Experimental	77 adult Helsinki Metro residents	Focus of Attention Scale, Restoration Outcome Scale, Perceived Restorativeness Scale, PANAS, Subjective Vitality Scale, Creativity Scale, salivary cortisol	Large urban park and managed urban woodland elicited increased perceived stress relief in participants compared to the urban environment; cortisol levels decreased similarly in all three settings	Primarily female participant sample, lack of cortisol variance across settings may be related to lack of variability between settings, or minimal reception to cortisol change in females	Studies analyzing relationships between psychological and physiological measures of stress after nature exposure
Van Den Berg & Custers (2011)	Quasi-experimental	30 adult garden plot holders from the Netherlands	Salivary cortisol, Positive and Negative Affect Schedule (PANAS)	Subjects who spent 30 minutes gardening after a stress induction task experienced greater	Only one control group limited interpretation of gardening	Further investigation into the psychophysiological mechanisms

Author	Design	Subjects	Measurements	Key Findings	Limitations	Recommendations
				reductions in cortisol and improvement in mood, while the control group (indoor reading) did not experience improved mood	benefits (physical activity or greenspace); no analysis of psychological vs. physiological measures	contributing to the benefit of gardening
Ward Thompson et al. (2012)	Cross-sectional	25 middle-aged men and women living in socially disadvantaged districts in Scotland	Salivary cortisol; Perceived Stress Scale; Warwick and Edinburgh Mental Wellbeing Scale; various measures of socio-economic deprivation; objective measure of greenspace for each subjects' postcode	A steeper cortisol slope was positively correlated with physical activity, wellbeing, and percentage of green space and negatively correlated with stress levels; linear regression analysis yielded percentage of green space a significant predictor of cortisol slope and self-reported stress	Small sample size limits generalizability of results to larger populations; coarse measures of percentage of greenspace	Further investigation into the optimal form of nature exposure (duration and activity) in everyday life