

**Title:** Healthy by Nature: Policy Practices Aimed at Maximizing the Human Behavioral Health Benefits of Nature Contact

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## **Abstract**

Research suggests that spending time in nature is associated with numerous human behavioral health benefits, including improved executive functioning abilities, enhanced recovery from stressful situations, better mental health, and better educational outcomes. Greener neighborhoods also tend to have positive population-level health outcomes. Although promising, much of this research has focused primarily on selective populations and fails to account for cultural differences in how “nature” is conceptualized. Therefore, challenges may arise as policy makers aim to implement nature-based policies in their communities, given the immense cultural diversity of the U.S. alone. Given this ever-present challenge in behavioral sciences, policy recommendations aim both to maximize benefits of nature contact and to employ a flexible equity lens that allow for differences according to community need.

## **Social Media Post**

Spending time in nature has been shown to improve behavioral health. However, both the research and practice of nature immersion needs to be more diverse and just to ensure that interventions and policies are culturally relevant, adequate, and accessible to all communities.

## **Highlights**

- Research shows that spending time in nature is associated with numerous individual behavioral benefits: improved mental health, enhanced stress recovery, and better executive functioning abilities.
- Community-level benefits to spending time outside include better social relationships, increased physical activity, and better educational outcomes.

- While these results are promising, much of the research has focused on White, Western populations and their conceptualizations of what nature is—a well-documented problem in all behavioral sciences—and a future challenge.

- Given the tension between the accumulating knowledge about nature's benefits, and the glaring lack of inclusion, our policy recommendations aim to maximize benefits for all by accounting for cultural differences.

## **The Science of Nature and Human Health**

An emerging body of human behavioral science has documented the importance of spending time connected to nature. “Nature” can mean many things to different people (as discussed later), but for the purpose of clarity, the present manuscript operationalizes nature as interacting with living environments—whether natural (e.g., forests, oceans), cultivated (e.g., gardens), or virtual imitations of the former (e.g., photos, videos, virtual reality). Nature contact appears to provide several behavioral benefits—including improvements in cognitive abilities, recovery from stress, mental health symptomology, and educational outcomes. Yet—access to nature is not distributed equally across the U.S., and the science has primarily been conducted on White, Western populations. Recommended policies aim both to maximize the benefits of this low-cost, effective well-being practice, while also accounting for a diversity of cultural perspectives in conceptualizations of what “nature” and “health” mean.

### **Cognitive Benefits**

A wealth of experimental behavioral and neuroscientific data support the idea that nature interaction can enhance attention, improve ability to regulate emotions, and promote recovery from stress (Scott et al., 2021). On a behavioral level, randomized control trials demonstrate that, compared to control conditions, interacting with nature reliably improves all three core components of “executive functioning” (Stevenson et al., 2018), which underlies the ability to focus attention, inhibit unwanted behaviors and actions, and stay on task (Diamond, 2013). This is supported by converging neuroscience evidence that shows improved engagement of the brain’s visual systems (Hopman et al., 2020) and evidence of more attentional resources in nature (LoTemplio et al., 2020). Executive functioning abilities also support regulation of emotion and stress, and so these brain regions may change in nature as well. Indeed, walks in

nature can influence activity in regions of the brain associated with regulating stress and emotion (Bratman et al., 2015; Sudimac et al., 2022).

### **Physiological Benefits**

Originating in East Asia with the cultural practice of forest bathing (also known as *Shirin-yoku*), researchers across the globe have explored how spending time in natural environments can reduce stress. A large body of experimental evidence suggests that spending time in nature and proximity to green spaces can improve indices of physiological stress across a variety of measures, including cardiovascular (e.g., reductions in blood pressure and heart rate), endocrine (e.g., reductions in cortisol), and immune responses (e.g., increases in killer-T cell activity; for review see Twohig-Bennett & Jones, 2018). Similarly, spending time in nature can increase the body's calming, parasympathetic "rest and digest" response, as indexed by increases in vagally mediated heart-rate variability in nature compared to non-natural environments (Cheng et al., 2021). Many of these studies demonstrate that nature not only reduces overall stress levels but helps individuals recover more efficiently from stressful events—promoting better mental and physical health outcomes.

### **Mental Health Benefits**

In addition to cognitive and physiological health, spending time in nature has a positive effect on human mental health. People experience improved mood, lower anxiety, less depression, and lower stress after spending time in nature compared to urban environments (Barnes et al., 2019; Trøstrup et al., 2019). Similarly, outdoor exercise tends to produce more positive mood, decreased anger, and improved self-esteem compared to indoor exercise (Thompson Coon et al., 2011). The amount of time one spends in nature is more meaningful in

terms of reducing mental health distress than the kind of nature where one spends time (Shanahan et al., 2016).

### **Improvements in Neighborhood Public Health Outcomes**

Beyond the benefits that individuals experience, nature can improve the health of entire communities by enhancing health-promoting aspects of neighborhoods. Physically, neighborhood nature can provide recreation, exercise, and active transportation opportunities, which is associated with improvements in cardiovascular health, obesity prevention, and diabetes management (Kondo et al., 2018; Rojas-Rueda et al., 2019). It can also increase human exposure to biodiversity and diversify the microbiome to support the human immune system (Egorov et al., 2016). Moreover, nature provides multiple ecosystem services essential for a healthy urban environment, such as reductions in air and noise pollution, mitigating heat stress and risks related to floods, all of which are associated with chronic diseases, injuries, and mortality (Egorov et al., 2016; Kondo et al., 2018). Socially, nature contact can foster social cohesion, civic engagement, and a sense of community, which can buffer against stress, loneliness, and violence (Markevych et al., 2017).

### **Educational and Pro-environmental Benefits**

Nature exposure is also associated with academic benefits for youth, such as improved academic performance (Wu et al., 2014; Berezowitz, 2015) and greater creativity (Neville, 2023). Exposure to nature also has been associated with pro-environmental behaviors (Rosa & Collado, 2019). For example, a study in England found that outdoor recreation was a significant predictor of pro-environmental behavior such as recycling, buying local produce, walking/cycling and volunteering for environmental organizations (Alcock et al., 2020).

### **Research Disparities Inhibit More Thorough Nature and Human-Health Understanding**

For years, research on human behavior was based on “convenience sampling” of populations that were convenient for researchers to access—predominately among undergraduate students in North America, Europe, and Australia. These Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies (Henrich et al., 2010) are non-representative of either the U.S. or the globe, making generalization across cultures in *any* behavioral science challenging. Unfortunately, although there are many promising health benefits to spending time in nature, the scientific evidence on this topic also suffers from a lack of ethnic/racial and cultural diversity.

Research on ethnic/racial sociodynamics is extensive (e.g., Baldassarri & Abascal, 2020). Yet, as a recent meta-analysis demonstrates, this body of scholarship is predominantly missing in research of nature’s effects on human mental health (Gallegos-Riofrío et al., 2022). This lack of inclusion limits practical applications of nature interventions in the U.S.—particularly to racially and ethnically minoritized groups. Troublingly, most studies on nature and mental health do not even report their participants' ethnicity/race (Gallegos-Riofrío et al., 2022), making generalizability of existing findings challenging. At the same time, and perhaps as a result, research also does not consider cultural differences in how “nature” is conceptualized. For example, Roberts (2022, p. 2) writes: [It] “is easy to forget that nature is intrinsically a part of our being” upon reflecting on the nuanced relationships that Black communities in the U.S. have to land, primarily due to the longstanding history of racial violence, segregation, and exclusion in natural spaces.

Future evidence must account for this such human variability, which requires critical engagement with issues around ethnicity/race, wealth, power, and historical reparation. Research priorities should include addressing the over-representation of WEIRD societies in population

sampling and their methods (Gallegos-Riofrío et al., 2022); understanding the sociocultural factors shaping nature preferences and experiences (Frumkin et al., 2017; Tomasso et al., 2021); and the nexus between residential segregation and culturally safe access to non-human nature (Bratman & Olvera-Alvarez, 2022). Research should also incorporate other ways of knowing about nature and health—for example, various indigenous groups’ knowledge about relationships between humans, nature, and health (Gallego-Riofrío, Zent & Gould, 2022).

### **Nature and Aging**

The lack of inclusion in the nature and health research has not only been limited to ethnicity, race, wealth, and power, but also to age. Although much of the research on nature and health has focused on younger adults, many older adults experience some facet of pathological aging that could likely be improved with exposure to nature (Klomp maker et al., 2022). One of the greatest benefits of nature therapy is the continuum of experiences that are available to expose someone to nature based on their needs, limitations, and mobility issues. Simply being present in nature can be therapeutic to those with severe physical and cognitive limitations. Incorporating therapeutic elements of design in nursing homes has been described as a “silent partner in caregiving” and when these elements include nature, significant effects on health and well-being are observed (Magnussen et al., 2021; Noelle, 1995). For those able to engage to a greater degree with nature, horticultural therapy has been shown to have positive effects on healthy and pathologically aging older adults and caregivers (Ascencio et al., 2019). Benefits include improved quality of life, reduced anxiety and depression, and improved physical and cognitive effects (Nicholas et al., 2019). These benefits have been observed not only for outdoor activities, but also when poor weather, limited outdoor space or limited mobility of participants required the outdoors to be brought indoors (Sefcik et al., 2022).



Virtual reality (VR) nature therapy is also showing great promise for older adults in residential settings. Nature-based VR applications provide a rare opportunity for some older adults to visit nature in the safety of their rooms. VR applications can also be combined with natural props to include tactile experiences. While nature-based VR research for older adults is in its infancy, research to date indicates improvement in mood, feelings of joy and relaxation, and diminished anxiety after viewing synthetic nature (Sadowski & Khoury, 2022). The importance of nature exposure research on older adults grows as populations age, life expectancies increase, and physical and cognitive health attenuate at global levels.

### **Access to Nature**

Research investigating inequities associated with access to green space in the U.S. has found disparities across socio-economic status, race, and ethnicity (Klompaker et al., 2023; Williams et al., 2020). In the present paper, ‘access’ is operationalized in two ways: physical proximity and the barriers that may prevent individuals and communities from meaningfully engaging with the space. For example, public transportation access to large parks is higher in Whiter neighborhoods (Park et al., 2021). Further, an investigation of the perceived safety of green spaces in five major U.S. cities found that communities of color and low-income communities disproportionately lack of access to “safe” parks (Williams et al., 2020). While physical proximity and perceived safety is a component of “access,” other barriers may prevent individuals (or communities) from accessing space. Characteristics such as financial accessibility (Hong & Anderson, 2006), diverse representation (Armstrong & Greene, 2022), and culturally relevant/inclusive outreach (Lundin & Bombaci, 2022) are also components of access for a variety of minoritized social identities, such as communities of color, women, and LGBTQ+ communities.

## **Benefits of Nature Contact to Traditionally Excluded Populations**

While there is less research on traditionally excluded populations (i.e., non-WEIRD), and disparities in access to nature for many of these groups, some research suggests that underserved populations may also benefit disproportionately from this contact (Mitchell & Popham, 2008). One notable case example includes the extremely nature-deprived settings of correctional facilities—in which live 2.3 million incarcerated adults and 50,000 incarcerated youth in the U.S. alone (Nadkarni & Morris, 2018). Early research that documented positive responses to nature exposure in nature-deficit environments (e.g., hospitals, Ulrich, 1984) inspired scientists to provide exposure to incarcerated people directly, by engaging “incarcerated citizen scientists” to rear animal and plant species for ecological restoration activities (Kaye et al., 2015) and virtually with nature videos in solitary confinement cellblocks (Nadkarni et al., 2017; Nadkarni et al., 2021).

Nature contact contributed to a calmer, safer prison settings (Relf & Dorn, 1995), provided a sense of environmental contributions and pro-social behavior (Norton & Holguin, 2011), fostered pursuits of curiosity and learning (Ulrich & Nadkarni, 2009), and enhanced vocational skills that can reduce recidivism and increase the probability of post-release employment (Davis et al., 2013). Inmates participating in virtual nature experiences reported feeling significantly calmer, less irritable, and more empathetic, and they committed 26% fewer violent infractions compared to those who did not watch the videos. Prison staff corroborated these findings (Nadkarni et al., 2017). These promising results from work with incarcerated people underscore the potential of nature immersion as a strategy to improve the well-being of other traditionally excluded population when equity and justice are cornerstones of the research process.

## Summary and Future Directions

Spending time in nature can improve both individual and community health and wellbeing. At the individual level, nature contact can boost cognitive functioning, improve mental health, promote stress recovery, enhance learning outcomes, and foster pro-environmental behaviors. At the community level, green neighborhoods can improve health outcomes by promoting healthy exercise behaviors, fostering healthy social relationships, and by providing environmental services such as reductions in noise pollution, environmental cooling, and improved air quality.

While these results are encouraging, there is currently a significant lack of empirical research on how nature contact affects BIPOC (Black, Indigenous, and people of color) communities. Therefore, a major direction of future research is to prioritize racially, ethnically, and culturally diverse samples. The use of culturally safe and sensitive methods to study nature and human health is crucial. Efforts are underway to ensure that the tools researchers use to study nature and wellbeing in culturally diverse groups are valid, effective, and sensitive (Gallegos-Riofrío et al., 2022).

Future work is underway to determine the most effective applications of nature and human health. Currently, the research has occurred on a variety of environment types, and with different exposure lengths. Due to logistical ease, much of the current nature intervention research has focused on short (1-2 hours or less) visits to nearby natural areas. Far fewer studies have examined longer doses, or systematically compared longer (multi-day) visits to short visits. Furthermore, few studies have examined the duration of benefits following different lengths of nature exposure. This “dose-response” science is an important direction for future research, as it is possible that there is a point at which benefits diminish. For example, some research on

parasympathetic nervous activity suggests that longer (> 2 hour) exposures can *decrease* parasympathetic activity (Scott et al., 2021; for review see Cheng et al., 2021), at least in the short-term. Therefore, in the absence of additional findings, practitioners should prioritize providing opportunities for regular, routine use of nearby nature over extremely long dosages of nature to improve health outcomes.

The significant variability in how researchers define nature (Bratman & Olvera-Alvarez, 2022) and the lack of research directly comparing different exposure lengths somewhat limit the “policy readiness” (Ijzerman et al., 2020) of nature and human health in certain contexts. Researchers are currently investigating which nature interventions work best, and for whom they work best. Given current limitations in knowledge about nature and wellbeing in *every* context, nature-based interventions should not substitute for regular medical treatment or mental health treatment. However, enough evidence suggests that time in nature may serve as a supplemental health-promoting intervention. Below are recommendations that can be safely implemented, given both the knowledge and the gaps in knowledge.

### **Policy Recommendations for Promoting Human-Nature Contact**

Given the substantial health and wellbeing benefits that communities may receive from nature contact, our policy recommendations aim at multiple societal levels (i.e., local, state, and federal). Given the aforementioned limitations on population sampling in the research, justice and equity lenses must be applied at every step and should be central to each decision. In addition, diverse representation from communities where policies are being considered must be present in leadership and decision-making. Nature immersion has the potential to improve health equity, but only if policy changes incorporate diverse voices and truly engage with communities to understand their needs. Straying from this equity-based philosophy risks policy failure.

## **General Recommendations**

### ***Invest in the Agency of Communities to Break Down Barriers to Accessing Wellbeing in Nature***

Given the broad range of human and cultural experiences in the U.S. alone, activities or practices that work in one neighborhood or community may not work in another. While understanding the unique needs of a particular group, those implementing policy should remember the power of community agency and resilience—often community members know exactly what they need. Therefore, investing in flexible, community-based approaches can leverage community agency to understand local needs. For example, one community may be interested in outdoor recreation, but lack equipment or skillsets—and therefore decide to invest in initiatives to provide equipment and training. Another community may decide community gardens are more important. Policymakers should therefore provide ample opportunities for local community members to engage in decision making (e.g., town halls) and, when appropriate, directly fund pre-existing community initiatives and groups that aim to improve nature access and contact.

### ***Create Public Programming***

Culturally relevant public programming outdoors is one of the most effective ways to promote human/nature contact. Examples include guided nature walks, outdoor fitness classes (yoga, tai chi), community gardening, service projects, youth events, and outdoor concerts. To broaden participation, events need be accessible to all individuals regardless of income or ability and welcoming and inclusive to the targeted communities. These goals require long-term planning and collaboration to establish trusting relationships. Leveraging work already underway

by trusted organizations in this space raises the potential for equitable action that connects local needs to resources.

## **Recommendations for Land Management**

### ***Natural Areas and Greenspaces Built With and For Every Community***

It is possible to envision a world in which *everyone* has safe access to nearby nature and feels welcome and affirmed in these spaces. As previously discussed, disadvantaged communities and communities of color have less access to nature, both due to physical proximity and invisible barriers such as perceived lack of safety. Therefore, prioritization of new parks should be given to neighborhoods highest in need. Crucially, the design of these new parks should be centered on the needs of local communities, which will require long-term engagement with local partners across sectors. For example, some communities may prefer challenging trails for exercise, while others may prefer access to picnic locations. These needs should be assessed *before* breaking ground. Additionally, potential negative impacts such as gentrification and subsequently displacement should be carefully considered (Gould & Lewis, 2016). Useful toolkits on park creation exist for community leaders, such as the [Pocket Park Toolkit](#) by the Trust for Public Land.

### ***Connect Climate, Biodiversity, and Equity Pursuits***

New parks are important opportunities to address not only human health needs, but also biodiversity, and climate resilience. As such, parks should support native plants and local biodiversity, and consider adaptation to climate hazards. New parks should be strategically established in areas with high levels of air pollution and urban heat island effects, to counteract the negative human health effects of a changing climate. Finally, it is also crucial that cultural

sensitivity be incorporated into these projects, again leveraging current work and trusted local partners.

### ***Conserve Pre-existing Public Lands***

It is essential that regulations are put in place to protect and conserve public lands to ensure that individuals can continue to access the human health benefits these lands provide. This can include policies to reduce habitat destruction and fragmentation, prevent the spread of invasive species, limit resource extraction, and improve environmental monitoring of these spaces. In addition, policies should be implemented to promote sustainable use of public lands, such as low-impact recreation and eco-tourism, and transit to promote usability. It is important that this work is accomplished with and by local communities, and that it acknowledges the history and colonization of the land.

### **Recommendations for Education**

To promote human-nature contact among young people, it is essential to integrate nature into both formal and informal education. Several model examples exist—for example, the National League of Cities and the Children & Nature Network is currently partnering with school systems and local municipalities nationwide to connect school children to nature. This group has already issued [comprehensive toolkits](#) for institutions to promote childhood nature contact including 1) green schoolyards, 2) creating natural early childhood playscapes, 3) creating opportunities for nature-based after school & summer programs, and 4) culturally inclusive youth programming in local greenspaces. To ensure that nature is accessible to all students, schools should work with local communities and partners to understand inequities and barriers, and then work to provide the supports that are needed.

### **Recommendations for Healthcare**

### ***Train Healthcare Workers to Use Nature as a Supplement for Wellbeing***

Many individuals look to their health care providers for wellness strategies. However, barriers exist for health care providers to issue recommendations about park prescriptions (Besenyi et al., 2020), such as lack information about nature's benefits, or local natural areas and pre-existing community initiatives. Therefore, communities should invest in resources to train healthcare trainees in this topic, provide continuing education for existing healthcare practitioners, and connect health care centers to relevant community nature programming. Park prescription programs such as the Appalachian Mountain Club's Outdoors Rx or the nationally active Parks Rx initiative exemplify the merger of public health goals, outdoor nature contact, medical practice, and public land availability to achieve results.

### ***Integrate Nature Contact into Long-term Care Facilities***

“Secure outside activity space” has been listed by professionals serving those with Alzheimer’s disease and related dementias as a top priority for elements in the physical design of residential care communities for over two decades. This, paired with research suggesting widespread benefits from exposure to nature in older adults, suggests that increased use of nature-based therapies for healthy older adults and those with pathological aging is warranted (Keane et al., 2003, p.15). Therefore, safe and accessible nature, such as VR technologies and healing gardens, should be implemented whenever possible in senior and other long-term care facilities.

### ***Expand Capacity of Other Practitioner Organizations***

While traditional healthcare and mental health care is a resource for some, many do not have access to healthcare, or do not trust their health care providers. Therefore, investments should be made in expanding the capacity of other community practitioners that are focused on



some aspect of human wellbeing in nature, such as local outdoor recreation or environmental youth development groups. Training organizations and their staff to leverage science to increase their impact is key for harnessing the potential of nature to help address health inequities. Funding should be directed towards increasing the capacity of these other on-the-ground practitioners.

### **Recommendations for Federally Funded Research:**

#### ***Close the Research Gaps***

Federal funding mechanisms are needed to fill the various research gaps that establish nature contact as a public health priority. To date, research has overlooked certain demographics, variances in urban nature availability, and dose-response associations between nature connection and health. New and continued research needs to help understand many nuances and unanswered questions of how outcomes vary among different groups nature-based environments. Longitudinal research is needed to quantify and qualify results and change through time, preferably done in close collaboration with practitioners so that science draws on realistic conditions of how individuals connect with nature in routine ways. Finally, as discussed, culturally sensitive methods are critical, and community-based research efforts should be prioritized.

#### ***Access To Evidence-Based and Culturally Relevant Information for All***

Recent efforts to make federally funded research publications open-access are laudable. However, they do not address other access issues, such as highly technical and jargon-laden language. Therefore, social science and health communications strategies are needed to craft messaging campaigns that provide information about the use of nature as an agent of health and well-being. Campaigns should work with trusted community organizations to target underserved

groups and non-English speaking groups. Ideally, everyone should have easy-to understand access to knowledge about how nature benefits health, where and how to access nature, about environmental injustice issues, and where and how to voice their needs.

## References

- Alcock, I., White, M. P., Pahl, S., Duarte-Davidson, R., & Fleming, L. E. (2020). Associations between pro-environmental behaviour and neighbourhood nature, nature visit frequency and nature appreciation: Evidence from a nationally representative survey in England. *Environment International*, *136*, 1-10.
- Ascencio, J., Wojtaszek, M., & Davalos, D. (2019). Horticultural therapy support group for older adult caregivers: Examining intervention effectiveness using psychometrically validated measures. *Journal of Therapeutic Horticulture*, *29*(2), 14-26.
- Armstrong, A., & Greene, B. T. (2022). Sense of inclusion and race in a public, outdoor recreation setting: Do place meanings matter? *Society & Natural Resources*, *35*(4), 391-409.
- Baldassarri, D., & Abascal, M. (2020). Diversity and prosocial behavior. *Science*, *369*(6508), 1183-1187.
- Barnes, M. R., Donahue, M. L., Keeler, B. L., Shorb, C. M., Mohtadi, T. Z., & Shelby, L. J. (2019). Characterizing nature and participant experience in studies of nature exposure for positive mental health: An integrative review. *Frontiers in Psychology*, *9*, 1-8.
- Berezowitz, C. K., Bontrager Yoder, A. B., & Schoeller, D. A. (2015). School gardens enhance academic performance and dietary outcomes in children. *Journal of School Health*, *85*(8), 508-518.
- Besenyi, G. M., Hayashi, E. B., & Christiana, R. W. (2020). Prescribing physical activity in parks

- and nature: Health care provider insights on park prescription programs. *Journal of Physical Activity and Health*, 17(10), 958-967.
- Bratman, G. N., Hamilton, J. P., Hahn, K. S., Daily, G. C., & Gross, J. J. (2015). Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proceedings of the national academy of sciences*, 112(28), 8567-8572.
- Bratman, G. N., & Olvera-Alvarez, H. A. (2022). Nature and health: Perspectives and pathways. *Ecopsychology*, 14(3), 133-136.
- Cheng, X., Liu, J., Liu, H., & Lu, S. (2021). A systematic review of evidence of additional health benefits from forest exposure. *Landscape and Urban Planning*, 212, 1-13.
- Davis, L. M., Bozick, R., Steele, J. L., Saunders, J., & Miles, J. N. (2013). *Evaluating the effectiveness of correctional education: A meta-analysis of programs that provide education to incarcerated adults*. RAND Corporation.
- DeVille, N. V., Tomasso, L. P., Stoddard, O. P., Wilt, G. E., Horton, T. H., Wolf, K. L., Brymer, E., Kahn, P. H., & James, P. (2021). Time spent in nature is associated with increased pro-environmental attitudes and behaviors. *International Journal of Environmental Research and Public Health*, 18(14), 1-18.
- Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64, 135-168.
- Dudley, M. D. (2020). Māori Assessment of Neuropsychological Abilities (MANA): A cognitive, functional and wellbeing screening tool for dementia in older Māori: Development and validation of cognitive and quality of life assessments for older indigenous peoples internationally. *Alzheimer's & Dementia*, 16, e040110.
- Egorov, A.I., Mudu, P., Braubach, M., Martuzzi, M., 2016. *Urban green spaces and health: A review of the evidence*. Copenhagen: WHO Regional Office for Europe.

- Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Kahn, P. H., Lawler, J. J., ... & Wood, S. A. (2017). Nature contact and human health: A research agenda. *Environmental Health Perspectives, 125*(7), 1-18.
- Gallegos-Riofrío, C. A., Arab, H., Carrasco-Torrentegui, A., & Gould, R. K. (2022). Chronic deficiency of diversity and pluralism in research on nature's mental health effects: A planetary health problem. *Current Research in Environmental Sustainability, 100148*, 1-11.
- Gallegos-Riofrío, C. A., Zent, E., & Gould, R. K. (2022). The importance of Latin American scholarship-and-practice for the relational turn in sustainability science: a reply to West et al.(2020). *Ecosystems and People, 18*(1), 478-483.
- Gould, K. A. & Lewis T. L. (2016). *Green gentrification: Urban sustainability and the struggle for environmental justice*. Routledge.
- Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences, 33*(2-3), 61-83.
- Hong, A., & Anderson, D. H. (2006). Barriers to participation for latino people at dodge nature center. *The Journal of Environmental Education, 37*(4), 33-44.
- Hopman, R. J., LoTempio, S. B., Scott, E. E., McKinney, T. L., & Strayer, D. L. (2020). Resting-state posterior alpha power changes with prolonged exposure in a natural environment. *Cognitive Research: Principles and Implications, 5*, 1-13.
- IJzerman, H., Lewis Jr, N. A., Przybylski, A. K., Weinstein, N., DeBruine, L., Ritchie, S. J., ... & Anvari, F. (2020). Use caution when applying behavioural science to policy. *Nature Human Behaviour, 4*(11), 1092-1094.
- Jacklin, K., Pitawanakwat, K., Blind, M., O'Connell, M. E., Walker, J., Lemieux, A. M., & Warry,

- W. (2020). Developing the Canadian Indigenous cognitive assessment for use with Indigenous older Anishinaabe adults in Ontario, Canada. *Innovation in Aging*, 4(4), 1-13.
- Kaye, T. N., Bush, K., Naugle, C., & LeRoy, C. J. (2015). Conservation projects in prison: The case for engaging incarcerated populations in conservation and science. *Natural Areas Journal*, 35(1), 90-97.
- Keane W., Cislo A., & Fulton B. (2003). Defining the dementia market. *Assisted Living Today*, 10(3), 14–17.
- Klompaker, J. O., Laden, F., Browning, M., Dominici, F., Jimenez, M. P., Ogletree, S. S., Rigolon, A., Zanobetti, A., Hart, J. E., James, P. (2022). Associations of greenness, parks, and blue space with neurodegenerative disease hospitalizations among older U.S. adults. *JAMA Network Open*, 5(12), 1-13.
- Klompaker, J. O., Hart, J. E., Bailey, C. R., Browning, M. H. E. M., Casey, J. A., Hanley, J. R., Minson, C. T., Ogletree, S. S., Rigolon, A., Laden, F., & James, P. (2023). Racial, ethnic, and socioeconomic disparities in multiple measures of blue and green spaces in the United States. *Environmental Health Perspectives*, 131(1), 1-9.
- Kondo, M. C., Fluehr, J. M., McKeon, T., & Branas, C. C. (2018). Urban green space and its impact on human health. *International Journal of Environmental Research and Public Health*, 15(3), 1-28.
- Li, Q., Morimoto, K., Kobayashi, M., Inagaki, H., Katsumata, M., Hirata, Y., ... & Miyazaki, Y. (2008). A forest bathing trip increases human natural killer activity and expression of anti-cancer proteins in female subjects. *Journal of Biological Regulators & Homeostatic*

- Agents*, 22(1), 45-55.
- LoTemplo, S. B., Scott, E. E., McDonnell, A. S., Hopman, R. J., Castro, S. C., McNay, G. D., ... & Strayer, D. L. (2020). Nature as a potential modulator of the error-related negativity: A registered report. *International Journal of Psychophysiology*, 156, 49-59.
- Lundin, M., & Bombaci, S. (2022). Making outdoor field experiences more inclusive for the LGBTQ+ community. *Ecological Applications*, n/a(n/a), 1-8.
- Magnussen, I. L., Alteren, J., & Bondas, T. (2021). "Human flourishing with dignity": A meta-ethnography of the meaning of gardens for elderly in nursing homes and residential care settings. *Global Qualitative Nursing Research*, 8, 1-17.
- Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., de Vries, S., Triguero-Mas, M., Brauer, M., Nieuwenhuijsen, M.J., Lupp, G., Richardson, E.A., Astell-Burt, T., Dimitrova, D., Feng, X., Sadeh, M., Standl, M., Heinrich, J., & Fuertes, E. (2017). Exploring pathways linking greenspace to health: Theoretical and methodological guidance. *Environmental Research*, 158, 301–317.
- Mitchell, R., & Popham, F. (2008). Effect of exposure to natural environment on health inequalities: an observational population study. *The Lancet*, 372(9650), 1655-1660.
- Nadkarni, N. M., Hasbach, P. H., Thys, T., Crockett, E. G., & Schnacker, L. (2017). Impacts of nature imagery on people in severely nature-deprived environments. *Frontiers in Ecology and the Environment*, 15(7), 395-403.
- Nadkarni, N., & Morris, J. (2018). Informal science education for a novel public audience: Baseline attitudes and impacts of science lectures on content knowledge and values of science among incarcerated populations. *Science Communications*, 40, 718–748.
- Nadkarni, N. M., Thys, T., Ruff, J., Anholt, A., Trevino, J., & Yeo, S. (2021). Providing virtual

nature experiences to incarcerated men reduces stress and increases interest in the environment. *Ecopsychology*, 13, 71-83.

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., ... & Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, 53(4), 695-699.

Neville, I. A., Petrass, L. A., & Ben, F. (2023). The impact of an outdoor learning experience on the development of English creative writing skills: An action research case study of year 7 and 8 secondary school students in Australia. *Journal of Adventure Education and Outdoor Learning*, 23(2), 132-145.

Nicholas, S. O., Giang, A. T., & Yap, P. L. (2019). The effectiveness of horticultural therapy on older adults: A systematic review. *Journal of the American Medical Directors Association*, 20(10), 1-11

Noell, E. (1995). Design in nursing homes: Environment as a silent partner in caregiving. *Generations: Journal of the American Society on Aging*, 19(4), 14-19.

Norton, C. L. & Holguin, B. (2011). Promoting ecological health: An exploratory study of an environmentally based program for formerly incarcerated young adults. *Ecopsychology*, 3(3), 205-212.

Park, K., Rigolon, A., Choi, D., Lyons, T., & Brewer, S. (2021). Transit to parks: An environmental justice study of transit access to large parks in the U.S. West. *Urban Forestry & Urban Greening*, 60, 1-12.

Relf, D., & Dorn, S. (1995). Horticulture: Meeting the needs of special populations. *HortTechnology*, 5(2), 94-103.

- Roberts, J. (2022). Black bodies: It's time to reclaim our green space freedom. *Journal of Healthy Eating and Active Living*, 2(1), 1-4.
- Rojas-Rueda, D., Nieuwenhuijsen, M.J., Gascon, M., Perez-Leon, D., & Mudu, P. (2019). Green spaces and mortality: A systematic review and meta-analysis of cohort studies. *The Lancet Planetary Health*, 3(11), 69-77.
- Rosa, C. D., & Collado, S. (2019). Experiences in nature and environmental attitudes and behaviors: Setting the ground for future research. *Frontiers in Psychology*, 10, 1-9.
- Sadowski, I. & Khoury, B. (2022). Nature-based mindfulness-compassion programs using virtual reality for older adults: A narrative literature review. *Frontiers in Virtual Reality*, 3, 1-30.
- Scott, E. E., LoTempio, S. B., McDonnell, A. S., McNay, G. D., Greenberg, K., McKinney, T., ... & Strayer, D. L. (2021). The autonomic nervous system in its natural environment: Immersion in nature is associated with changes in heart rate and heart rate variability. *Psychophysiology*, 58(4), 1-14.
- Sefcik, J. S., Petrovsky, D. V., Huang, L., Behrens, L. L., Naylor, M. D., Hodgson, N. A., & Hirschman, K. B. (2022). Predictors of change over time in satisfaction with outdoor activities ratings among long-term care services and supports recipients. *Geriatric Nursing*, 45, 153-159.
- 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(1), 1-10.
- Stevenson, M. P., Schilhab, T., & Bentsen, P. (2018). Attention Restoration Theory II: A systematic review to clarify attention processes affected by exposure to natural environments. *Journal of Toxicology and Environmental Health, Part B*, 21(4), 227-268.



- Sudimac, S., Sale, V., & Kühn, S. (2022). How nature nurtures: Amygdala activity decreases as the result of a one-hour walk in nature. *Molecular Psychiatry*, 27, 4446–4452.
- 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 & technology*, 45(5), 1761-1772.
- Tomasso, L. P., Cedeño Laurent, J. G., Chen, J. T., Catalano, P. J., & Spengler, J. D. (2021). Cultural sets shape adult conceptualizations and relationships to nature. *Sustainability*, 13(20), 1-21.
- Trøstrup, C. H., Christiansen, A. B., Stølen, K. S., Nielsen, P. K., & Stelter, R. (2019). The effect of nature exposure on the mental health of patients: A systematic review. *Quality of Life Research*, 28, 1695-1703.
- Twohig-Bennett, C., & Jones, A. (2018). The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. *Environmental Research*, 166, 628-637.
- Ulrich, C., & Nadkarni, N. M. (2009). Sustainability research and practices in enforced residential institutions: Collaborations of ecologists and prisoners. *Environment, Development and Sustainability*, 11, 815-832.
- Williams, T. G., Logan, T. M., Zuo, C. T., Liberman, K. D., & Guikema, S. D. (2020). Parks and safety: A comparative study of green space access and inequity in five US cities. *Landscape and Urban Planning*, 201, 1-18.
- Wu, C. D., McNeely, E., Cedeño-Laurent, J. G., Pan, W. C., Adamkiewicz, G., Dominici, F., ... & Spengler, J. D. (2014). Linking student performance in Massachusetts elementary schools

with the “greenness” of school surroundings using remote sensing. *PloS One*, 9(10), 1-9.