

**Table 1.** Publications that related greenness, university campus, wellness or mental health.

Authors	Region/Year	Study Objective	Method	Sample	Results
Tian et al. [26]	Anhui and Shandong provinces, China, 2023	To investigate the correlations of greenness exposure with test anxiety among university students during COVID-19 lockdowns.	Cross-sectional study with perceived campus greenness (5-point Likert scale: quality, visibility, abundance, usage, accessibility) and Normalized Difference Vegetation Index (NDVI) for objective greenness	2609 university students	NDVI 1500-m correlated with lower test anxiety, physical activity may partially mediate this association. Increased campus greenness may alleviate test anxiety among Chinese university students.
Gulwadi et al. [4]	Turkey and the United States, 2019	To correlate objective and perceived greenness and restorative effects among students from two campuses in the USA and two campuses in USA.	Cross-sectional study for perceived greenness and quality of life survey (WHOQOL-BREF: psychological, physical, social, and environmental) and use of NDVI for objective greenness	1079 university students of business, design, and psychology	The space immediately next to buildings in which instruction takes place gain more significance when students spend longer hours in class, as that offers the closest access to greenspaces and enables a setting for social support.
Liu et al. [7]	University in Fuzhou, China, 2018	To develop a self-rated naturalness scale to measure perceived naturalness, and examine the association between self-rated naturalness and students' restoration and health	Questionnaire with indicators for assessing perceived naturalness (self-rated naturalness scale SRNS developed at Fujian University) based on Chinese socio-cultural background in 8 university campus areas.	2550 university students of agriculture and forestry	Self-rated health and higher levels of restoration showed a positive relation with the perception of high natural attributes and the perception of natural form, both for men and women, even controlling for physical activity and social cohesion.
Liprini & Coetzee [21]	University of Pretoria, South Africa, 2017	To determine where students spend their free time on campus, how they perceive their on-campus green spaces and the extent they found these spaces restorative.	Questionnaire for Perceived restorativeness Scale (PRS a 26-item scale that measures constructs of Attention Restoration Theory, ART). Statistical analyses to determine which of the green spaces contributed most significantly to overall PRS scores.	286 university students	All green areas made significant contributions, but the campus' botanical garden with a large amount of variety was the greatest contributor to Perceived Restoration Scale, followed by areas with presence of water.
Hipp et al. [8]	United States, 2016	To verify if green campus spaces provide restorative potential to university students and if students perceive it.	Students were surveyed with items on perceived greenness of campus, perceived restorativeness of campus, and the World Health Organization Quality-of-Life Scale (WHOQOL-BREF)	5683 students of three universities	Results indicate that those with higher perceived campus greenness report greater quality of life, a pathway significantly and partially mediated by perceived campus restorativeness.
Bernat et al. [15]	Lublin, Poland, 2022	To determine whether and to what extent the COVID-19 pandemic influenced the importance of recreation areas and the perception of landscape among students affected by lockdown.	Survey conducted in two stages, using online surveys. The first concerned with the perception of landscape and the second with the importance of recreational areas. (18 closed, single, and multiple-choice questions, a few with use of the 5-point Likert scale)	381 university students	Significance of recreation areas increased during the pandemic. The perception of landscape changed as well: the value of nature, scenic views, and therapeutic effect of the landscape began to be appreciated to a greater extent. Survey results indicate the need to ensure diversity of green areas and improve their accessibility, and to consider quiet areas, green mobility, and places of recreation.
Larson et al. [16]	United States, 2022	To assess how, and why, outdoor recreation and park use changed since COVID-19.	During the early stages of the pandemic, web survey measured students' self-reported levels of emotional distress (open-ended responses coded and analyzed using conventional content analysis) and assessed potential demographic and contextual correlations to distress, including county-level per capita park area and greenness, using generalized linear models. Objective greenness measured by NDVI.	1280 students of four large public universities across the country	Reducing use of outdoor spaces due to lockdowns, concerns about viral transmission, and negative emotions. Those who maintained pre-pandemic park desired to be in nature, for improving mental and physical health. Emotional distress among students was widespread. Higher levels of emotional distress were associated with reducing park use and residing in counties with a smaller area of parks per capita.

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Authors	Region/Year	Study Objective	Method	Sample	Results
Ha & Kin [19]	United States, 2021	To verify if more biodiverse green spaces have more restorative effects than conventional lawns in campus environments.	Four-group pre-post-test randomized experiment, and a 360-degree view video via an online platform survey. Students were randomly assigned to four experimental settings: (1) low-biodiversity with no sound, (2) high-biodiversity with no sound, (3) low-biodiversity with sound, and (4) high-biodiversity with sound. Restorative and mood status were evaluated using the restorative state scale (RSS) and the Short Form of The Profile of Mood States (POMS-SF).	319 university students	Neither the level of biodiversity nor natural sound had a significant effect on restorative and mood states. However, there was a statistically significant interaction effect between auditory and visual stimuli in mood states. The presence of natural sound with a high biodiversity environment showed lower negative mood states than the absence of natural sound. Results indicated that perceived plant species richness is positively associated with negative mood states. These discrepancies may be explained by poor biodiversity identification.
Oswald et al. [27]	Australia, 2021	To explore associations between the four states of mental health and protective factors relevant to young Australians and their mental health in the context of COVID-19.	Online survey to assess mental illness and mental well-being and cross-classify into four mental health states using 14-item self-reported mental health continuum-short form (MHC-SF) and the self-report Kessler Psychological Distress scale. Multinomial logistic regressions used to examine associations, adjusting for socio-demographic confounders.	1004 (participants 18–24 years old)	Protective factors for flourishing mental health were secure employment, use of screen to connect, high levels of hope and incidental and purposive contact with nature. Lack of green/blue space within walking distance was associated with languishing mental health, and lower neighborhood greenness was associated with all three sub-optimal mental health states. Young adults require dedicated mental health services to deal with current burden, also supported through preventive strategies which target mental health risk factors, like precarious employment, and enhance protective factors, such as urban green infrastructure.
Nazif-Munoz et al. [28]	El Paso, TX, USA, 2020	To assess the association between depression and residential greenness, brownness, and grayness.	Prospect cohort study. Depression measured with Patient Health Questionnaire-9 scale (PHQ-9) and greenness with NDVI. Data from the National Land Cover Database, for measures of land patterns: grayness and brownness. Structural equation models assessed the relationships of these land patterns to depression.	393 Nursing students (18–60 years old)	After adjusting for individual characteristics, at buffers 250 m, greenness was not associated with a decrease in the incidence rate ratios of depression; however, grayness and brownness were, respectively, associated with increases by 64% and decreases by 35%. It found a protective association between brownness [natural desert landscape] and depression.
Loder et al. [23]	Graz, Austria, 2020	To investigate the perceived greenness of college students' home and study environments and its relation to mental health.	Online survey to assess perceived greenness at home and at university using questions on quality of and access to green space; mental health was measured with the WHO-5 well-being index. Uni- and multi-variate regression analyses used to analyze the data.	601 college students (24 years old)	The analyses revealed positive associations between perceived greenness at home and mental health, as well as perceived greenness at university and mental health. This adds more evidence to the existing literature that perceiving the environment as green is positively related to better mental health.
Loder et al. [29]	Graz, Austria, 2020	To verify the associations between objective or subjective neighborhood greenness and health.	Objective and perceived greenness assessed at home and at university. Health measures by questionnaire for mental health (WHO-5), IPAQ questionnaire for physical activity and sedentariness, and body mass index. Per location, quintile pairs of objective and perceived greenness were classified into underestimates, correct estimates, or overestimates.	377 university students	ANOVA models only showed poorer mental health for students underestimating greenness at university compared to those with correct estimates. Agreement between greenness scores at home but not at university was obtained, and mental health was related to the perception of greenness at university.



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Srugo et al. [13]	Ontario, Canada, 2019	To investigate associations between school-based measures of greenness and students' mental health in Canada.	Link participant responses from the 2016–2017 Ontario Student Drug Use and Health Survey to school-based features of the built environment. Measures of greenness with NDVI. Measures of mental health included: serious psychological distress [Kessler 6-item Psychological Distress Scale], self-rated mental health, suicide ideation, and suicide attempt.	6313 students (11–20 years)	Prevalence of serious psychological distress and low self-rated mental health was 16.7% and 20.3%, respectively. Suicide ideation reported by 13.5%, and 3.7% reported a suicide attempt. Quantity of greenness was similar between schools. In logistic regressions there was no association between objective school-based greenness and mental health, as assessed by multiple measures.
Dzhambov et al. [30]	Plovdiv, Bulgaria, 2019	To examine relations among restorative experience, mindfulness, rumination, and psychological resilience, linking residential greenspace to anxiety and depression symptoms.	Greenspace measured by NDVI and tree cover density. Symptoms of anxiety and depression measured with the Generalized Anxiety Disorder scale (GAD-7) and Patient Health Questionnaire (PHQ-9). Mediators assessed by self-report: perceived greenspace, restorative quality of the neighborhood, dispositional mindfulness, rumination, and psychological resilience. Structural equation modeling techniques used to test the theoretically indicated relations among variables.	529 undergraduate university students in health professions: medicine, pharmacy, and dentistry	Across different buffer sizes, higher greenspace was consistently associated with reduced scores on the anxiety and depression scales. This effect was partially mediated via several pathways. Specifically, higher NDVI 500-m was associated with higher perceived greenspace, and in turn, with higher restorative quality, and then with higher mindfulness, lower rumination, and greater resilience to stress, and consequently, with better mental health.
Dzhambov et al. [5]	Plovdiv, Bulgaria, 2018	To examine how different pathways between green/blue space and mental health can work together.	Residential greenspace measured by NDVI, tree cover density, percentage of green areas, and distance to green space. Blue space is measured by presence in the neighborhood. Mental health measured with General Health Questionnaire (GHQ-12). Mediators considered: perceived neighborhood green/blue space, restorative quality of the neighborhood, social cohesion, physical activity, noise and air pollution, and environmental annoyance. Structural equation modeling used to analyze data.	720 (18–35 years old) medical students	Higher NDVI within a 300 m buffer around the residence was associated with better mental health through higher perceived greenspace, leading to increased restorative quality, and subsequently to increased physical activity; through lower noise exposure, which in turn was associated with lower annoyance. Presence of blue space within a 300 m buffer did not have a straightforward association with mental health owing to competitive indirect paths.
Ibes et al. [9]	Williamsburg, USA, 2018	To investigate the psychological impact of two short green space interventions that integrate two proven approaches to stress reduction, mind-body skills, and nature exposure.	Two models of short, low-cost interventions were evaluated for their potential to mitigate chronic stress while providing interactions with nature, RESET (Release Everyday Stress and Enjoy Trails): first a 1 min “Digital detox nature stop”, second a 5 min. “Mindfulness in Nature trail”. coding schema and method for evaluation.	558 voluntary participants (undergraduate and graduate students, faculty, staff, and visitors)	Statistical and qualitative analysis of the participants reveals that these simple, low-cost interventions were instantly popular and well-received and had a positive psychological effect on 96% of participants who reported psychological impact, most commonly, relief from stress (82%).
Dzhambov et al. [31]	Plovdiv, Bulgaria, 2018	To investigate whether residential greenspace modified the effect of road traffic noise on general mental health in students.	Road traffic noise (Lden) level was calculated from the strategic noise map of the city. Objective greenspace tested: NDVI, tree cover density, and distance to the nearest green space. Mental health measured with the General Health Questionnaire (GHQ-12). Moderation analysis and the Johnson-Neyman (J-N) procedure were used to identify values along the continuous moderators.	399 (15–25 years students from two high schools and three universities)	Results indicated that living in a neighborhood deprived of trees enhanced the negative effect of noise, whereas in neighborhoods with higher tree cover density noise had no effect. Living in a less green neighborhood may enhance the negative effect of road traffic noise on mental health. This observed effect modification may not only be due to disrupted propagation of sound waves, but also to higher recreational quality in a greener environment.

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Dzhambov [32]	Plovdiv, Bulgaria, 2018	Pilot study aimed to examine mechanisms/variables mediating associations between residential green/blue space and symptoms of anxiety/depression.	Cross-sectional and longitudinal. Students followed from the beginning to the end of the school year. Residential green space was defined by NDVI. Blue space assessed in the same buffers. Levels of anxiety/depression assessed using General Health Questionnaire (GHQ-12). mediator variables: residential noise and air pollution, environmental annoyance, perceived restorative quality of neighborhood, social cohesion, physical activity, and sleep disturbance.	109 students (18–35 years old of the Medical University)	Higher NDVI correlated with better mental health only indirectly through higher physical activity and restorative quality. Longitudinal data showed improved mental health but no significant effect of mediator variables. Similarly, blue space correlated with better mental health in all models, but physical activity and restorative quality were significant mediator variables only in the cross-sectional analysis.
Dzhambov et al. [33]	Plovdiv, Bulgaria, 2018	To compare single and parallel mediation models, which estimate the independent contributions of different paths, in the pathway from greenspace to mental health.	Objective greenspace defined by NDVI, Soil Adjusted Vegetation Index, tree cover density and distance to nearest greenspace. Self-reported measures of availability, access, quality, and usage of greenspace were used. Mental health measured with General Health Questionnaire (GHQ-12). Potential mediators considered in single and parallel mediation models: restorative quality of the neighborhood, neighborhood social cohesion, commuting and leisure time, physical activity, road traffic noise annoyance, and perceived air pollution. Four models tested with serial mediation components: [1] restorative quality → social cohesion; [2] restorative quality → physical activity; [3] perceived traffic pollution → restorative quality; [4] and noise annoyance → physical activity.	399 (15–25 years of age)	There was no direct association between objectively measured greenspace and mental health. For the 500-m buffer, the tests of the single mediator models suggested that restorative quality mediated the relationship between NDVI and mental health. Tests of the serial mediation models showed that higher restorative quality was associated with more physical activity and more social cohesion, and in turn with better mental health. As for self-reported greenspace measures, single mediation through restorative quality was significant only for time in greenspace; however, serial mediation through restorative quality and social cohesion/physical activity was indicated for all self-reported measures except for greenspace quality.
Asim et al. [12]	Himachal Pradesh, Himalayas, India, 2023	To explore the role of the built environment of an academic campus in influencing students' perception of mental restoration and well-being.	Survey to identify activity hotspots on campus, and a neuropsychological study involving mobile EEG and Perceived Restorativeness Scale (PRS) at these hotspots to investigate the role of built environment aspects on restorative approach/neglect behavior and perception of built environment. The study relies on prominent theoretical constructs in the area, namely Attention Restoration Theory (ART), Stress Reduction Theory (SRT).	429 college students (sub-sample 22 students)	Environmental aspects, such as vegetation, novelty/uncertainty, acoustic ambience, and expansive vistas, are positively associated with favorable approach behaviors and normalized average alpha brain waves, while other elements, such as presence of high density of buildings may be related to avoidance behaviors. Greenery and Sky had the most positive relationship with the normalized alpha, presence of buildings revealed negative relationships. Natural components such as grass, sky, and filtered and diffused light boost people's perceptions of an environment's restorative characteristics.

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Bardhan et al. [11]	Public university, SE United States, 2023	To conduct one of the first longer-term investigations of daily nature exposure and mood with a mobile app as part of the NatureDose™ Student Study (NDSS).	The NatureDose™ app uses GPS and a phone's sensors to evaluate levels of nature surrounding the person with the NatureScore™ measure, based on more than 30 remotely sensed datasets, geo-located health records, and machine learning models. College students' nature exposure monitored for eight weeks, their mood states calculated weekly using the Positive and Negative Affect Schedule (PANAS). Observational associations between average nature exposure and mood levels across the study period used mixed-effect linear regression models adjusting for gender and allergies.	97 university students (18–22 years old)	Positive association between nature exposure and positive mood. Findings supported by sensitivity analyses with ANOVA models on average NatureDose™ levels. Average nature exposure was 71 min per day. Study supports the utility of using NatureDose™ as an app-based tracking tool for objective nature exposure measurement and reinforces previous findings on the associations between nature exposure and positive mood states. Greening university campuses could support college students' mental health.
Lemyre et al. [34]	Oxford and Southampton, United Kingdom, 2023	To investigate use of neighborhood greenspace access and well-being.	During the tail end of the third 'lockdown', an online questionnaire was used to better understand mental well-being in relation to use of outdoor green space (assessed using a 5-item Likert scale). Analyses include descriptive results of indicators and hierarchical multiple linear regression models.	424 university students	Quality of greenspace had a greater importance on mental well-being than use and quantity of greenspace, even when controlling for sociodemographic factors. Also, neighborhood greenspace quality contributed to well-being above and beyond sociodemographic, physical activity and social support. This result held true even among students with prior mental health difficulties.
Ning et al. [35]	Changchun, Jilin Province, China, 2023	To explore the transient recovery effects of four types of campus environments, square space, dense forest, sparse forest, and waterfront.	Field experiment students, measuring systolic blood pressure, diastolic blood pressure, and heart rate as physical parameters to assess stress recovery. Respondents also reported scores (Restorative components scale -RCS-based on environmental restorative scale-PRS) about their personal feelings in questionnaires to evaluate their psychological states.	60 university students of Landscape Architecture	Physiological and psychological indicators responded to the brief natural exposure [5 min], and physiological and psychological health was restored. Only the recovery amounts of psychological indicators were significantly different in waterfront space, dense forest space, and sparse forest space. Brief exposure in the waterfront space was the most beneficial to students' psychological health recovery.
Boyd [36]	University of Sheffield, United Kingdom, 2022	To examine the participants' interactions with nature and experience of the university campus and design interventions.	Mixed methods approach, with statistical analysis and focus group discussion. Use of a green prescription style activity and a specially designed mobile phone app (Shmapped) to evaluate how participants experienced the 30 days interventions.	55 students completed the experiment	Findings qualify research into young adult's experience of urban green spaces and their tangible connection to plants such as trees. Policy and practice implications include the requirement for a coherent approach to understanding the place-attachment aspects to nature in the university environment. There is a need for collaborative well-being interventions and urban green space development within the UK context.



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Stepansky et al. [37]	Private university, NE United States, 2022	To verify if engagement in the use of green spaces improved health and well-being.	Pilot study with lived experience of two students and investigation of perceptions of a university campus therapeutic sensory garden on the quality of life (WHOQOL) based on the utilization of the green space. Quantitative and qualitative measures assessed student use of therapeutic sensory garden and perceived quality of life related to social, mental, and physical well-being.	Two university students	Findings from quantitative and qualitative analysis of the lived experiences of two students are consistent with that of current evidence literature indicating a positive association between time spent in a green space/natural environment and perceptions of quality of life. Pilot study findings present structure and hypotheses related to time utilization, anticipated outcomes, and active ingredients for therapeutic sensory garden intervention with larger sampled groups of university students.
Asim et al. [12]	Haridwar District, Himalayan, India, 2021	To understand the role of containment zone built environments in the prevalence of anxiety and depression.	Questionnaires to participants in three hostels in the containment zone. Linear regression between Built Environment Variable Score with Center for Epidemiologic Studies-Depression (CES-D) and Generalized Anxiety Disorder Scale (GAD-7).	432 University students	Results revealed that students living in rooms with access to quality window views overlooking greenery and sky in addition to the presence of indoor plants and portrait/artworks, are at lower risk of depression and severity of anxiety.
Kim et al. [14]	Chungbuk National University, campus forest, South Korea, 2021	To examine the psychological effects of forest activities in a campus forest.	Pre and post-test to evaluate psychological effect of forest activities in a campus. The Profile of Mood State (POMS) questionnaire, the Concise Measure of Subjective Well-Being (COMOSWB), and the Stress Response Inventory (SRI-MF) were administered to assess psychological effects.	38 university students [mean age 22, with no diagnosis of severe stress or depression and no drug or alcohol abuse]	This study revealed that participants in the forest activities intervention group had significantly positive increases in their mood, stress response, and subjective well-being, compared with those of control group participants who did not partake in any forest activities.
Souter-Brow et al. [24]	Auckland, New Zealand, 2021	To explore the potential of salutogenic design as a stress-reducing health promotion tool for ‘apparently well’ people in a workplace setting.	Randomized controlled trial compared ‘apparently well’ participants into intervention groups, sensory garden (SG), urban plaza (UP), and a control group (CG). SG and UP participants had ‘appointments outdoors’ once weekly for 4 weeks. All tested for salivary cortisol, perceived well-being, productivity, perceived stress, nature relatedness pre- and post-intervention; data analyzed using generalized linear models.	164 (18–65 years old staff and students)	Significant intervention effects were observed for salivary cortisol, well-being and productivity. Although not significant, a surprising trend towards negative effects of the urban plaza on well-being, productivity, and perceived stress were observed when compared to the sensory garden group. This study suggests a sensory garden effectively reduces stress, enhances well-being and improves productivity of ‘apparently well’ people in the workplace.
Malekinezhad et al. [22]	Malaysia, 2020	To investigate how the perception of characteristics of natural space, directly and indirectly, affects restoration experience within the area of green outdoor landscape.	Test of associations through application of partial least squares with structural equation modeling (PLS-SEM), inputting data from a sample of university students. Perceived Sensory Dimension (PSD) and Restorative Outcome Scale (POS-6 items) were used in measuring restoration experience.	550 students (five universities)	The effect of perceived sensory dimensions (PSD) on perceived restorativeness leading to better explanation of restoration experience. Perceived landscape characteristics of PSD enhance restoration experience and is a mediator of the relationship between perceived campus greenness and students ‘quality of life.’

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Reese et al. [38]	Pacific Northwest, United States, 2020	To explore the role that campus greenspaces might play in preventing stress and promoting student health on college campuses	Qualitative study using photovoice (community-based participatory research) in crafting a vision for how natural spaces might be maintained and developed to promote health. Five themes emerged: mental and physical health, community spaces, sustainable infrastructure design, preserving natural habitat and history, homelessness.	72 undergraduate students	Aspects of the student vision may be incorporated into future campus environmental planning efforts. Additional research is needed in determining whether community-based greenspace planning on college campuses can positively impact the extent to which students access natural spaces for the purposes of alleviating stress and promoting health.
Krasny & Delia [39]	The Cornell campus at Cornell Natural area, USA, 2014	To understand how university students experience engagement in campus natural area stewardship and related policy discussions.	Adaptative co-management (ACM) “learning from doing” concept guided encompassing social learning, social capital, and shared action. Student semi-structured interview and focus group discussion in “an experiment effect”.	Ten undergraduate students	Authors found that three conditions explain student engagement in the adaptive co-management process: the presence of a pre-existing student organization that had built bonding social capital and was committed to campus natural area stewardship, openness to multiple stakeholder viewpoints and commitment to action on the part of the university administration, and the presence of a crisis that spurred emotions and action. Student organizations can contribute to an adaptive co management process, consistent with university and campus sustainability.
Lau & Yang [40]	China. Hong Kong University, 2009	To study the potential role of the introduction of healing gardens to a compact campus in creating a health-supportive and sustainable campus environment.	Case study of introducing healing gardens and observation of design and use patterns. Questionnaire survey on green space perception and usage, natural view, and preferred resting points.	33 undergraduate and postgraduate students	Therapeutic benefits of a healing garden are recognized by staff and students. Because of the small campus size, green spaces are reduced and do not encourage large groups of people but provide nature like view from surrounding paths and windows, providing physiological benefits such as stress attenuation and attention restoration. Natural settings such as courtyard, atrium and green roof gardens, and green walls are suitable for a small campus.
Total				27,955	

Source: Organized by the authors.