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Systematic Review of Explicit Instruments Measuring Nature Connectedness: What Do We Know and What is Next?

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Abstract

This systematic review assesses the methodological quality of manuscripts focusing on scales that explicitly measure nature connectedness. A literature search in six electronic databases was conducted using a search strategy based on PICO guidelines. Only peer-reviewed primary research available in

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English language, published between 2000 and 2021, meeting the scope of this review were included. Data from 35 studies were narratively analyzed. Their methodological quality was assessed using the COSMIN Risk of Bias checklist. Only five studies were rated as high/adequate quality. Based on the findings we make the following recommendations: (a) the need for the development of a more universal nature connectedness construct, (b) the requirement to increase the methodological quality of the scales, (c) the need to identify which the scales measure trait or state, (d) the need to increase the validate scales cross-culturally, and (e) the need to develop scales that can be employed with non-adult samples.

Keywords

connectedness to nature, validity, reliability, PRISMA, PICO

Introduction

Both access to natural areas and engagement with nature can help to alleviate some of the societal challenges that we are facing (Barboza et al., 2021; Murphy et al., 2022; Nieuwenhuijsen et al., 2022). Global challenges in mental health (World Health Organization (WHO), 2021) are exacerbated by issues such as urbanization (WHO, 2021) which exposes city dwellers to numerous stressors. Nature has the capacity to ameliorate stressors as demonstrated with both specific nature-based interventions (Gritzka et al., 2020) and more generally, by accessing nature (White et al., 2021). A recent health impact assessment (Barboza et al., 2021) estimated that up to 43,000 lives could be saved annually in European cities if the WHO guidelines for nature access were met (i.e., 0.5 hectares within 5 min. walk of residence). The imperative to provide access to greenspace for urban citizens is highlighted by the Sustainable Development Goal 11, which is a United Nations initiative, focusing on the development of sustainable cities and communities, and the specific target 11.7 according to which “universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities” (United Nations, 2022c, para.11.7) should be provided (United Nations, 2022a, 2022b, 2022c). Greenspace access is considered important for urban health and mental health, but what are the key psychological factors underlying this association.

The impact of nature experience on cognitive functioning, emotional well-being, and other dimensions of mental health has been highlighted in a recent conceptual review. This paper states that stakeholders should use a tool to

anticipate the impact on mental health of the decisions they make at the environmental level. Furthermore, it strongly mentions that accessibility to nature must be increased in order to reduce health inequalities (Bratman et al., 2019). However one topic that was overlooked in that review was the concept of nature connectedness which, although it has no single definition today (Tam, 2013a), has shown a strong association with mental health and well-being (Murphy et al., 2022; W. P. Schultz, 2002; Sheffield & Lumber, 2020). Previously, nature connectedness was positively associated with positive well-being (Capaldi et al., 2014) with greater benefits for those with higher levels of nature connectedness. In addition, it has also been shown that fostering a deep sense of nature connectedness holds significant potential in encouraging individuals to engage in behaviors to protect the environment, which is important given that pressing environmental issues such as climate change are caused by human activities (Mackay & Schmitt, 2019; Oreskes, 2004). More recently, White et al. (2021), in a Pan-European study, reported that nature connectedness was also positively associated with positive well-being, negatively associated with mental distress and was, in addition to green space visits, associated with a lower likelihood of using medication to alleviate depression. Hence, it is vital to ensure further research to explore the importance of fostering the relationship between humans and nature as a pathway to well-being, mental health and pro-environmental behavior.

Up to now, various high-quality reviews have revealed that being connected to nature enables people to have a better mental health, be happier, have a greater eudaimonic well-being and in general flourish in their life (Arola et al., 2023; Capaldi et al., 2014; Pritchard et al., 2020; Yao et al., 2021). Furthermore, another systematic review found that nature connectedness is directly related to life satisfaction and quality of life (Houlden et al., 2018). More recently, a scoping review that aimed to identify and synthesize “existing measures of land, nature, and/or environmental connectedness, relatedness, and attitudes,” with a primary focus on indigenous communities, concluded that nature connectedness is not only vital for human well-being but also strongly connected to other factors, such as health, education, research, and politics. In the educational domain, for example, it highlights the relevance of including environmental education in schools, which play a decisive role in promoting nature connectedness education and fostering a connection with ancestral lands. At the policy level, for example, it highlights the significance of supporting the connection to the land, which has predominantly positive impacts on indigenous groups who have been remarkably disconnected from their lands (Keaulana et al., 2021).

It is important to point out from the aforementioned systematic reviews that all included studies used different scales based on different definitions of

nature connectedness (Cervinka et al., 2012; Howell et al., 2013; Kashima et al., 2014). This disagreement in the nature connectedness construct has led to an arbitrary, confusing and disorganized growth of measurement scales (Tam, 2013a). The difficulty for researchers and clinicians is that it becomes challenging to clearly understand the measurement of the construct as an array of different instruments are employed. Such instruments include, for instance, a scale measuring nature connectedness and pro-environmental behavior (i.e., New Environmental Paradigm Scale (Dunlap & Van Liere, 1978)), or nature connectedness and empathy toward nature (i.e., Dispositional Empathy with Nature Scale (Tam, 2013b)). This lack of clarity in measurement potentially leads to confusion among stakeholders, who wish to use valid and reliable tools to measure this specific construct (Restall & Conrad, 2015; Tam, 2013a). Therefore, this systematic review aims to provide an overview, and assess the methodological quality of research validating explicit instruments that measure the nature connectedness construct in children, adolescents and/or adults with or without special needs.

Methods

The methodological procedure of this systematic review is described in greater detail in the related protocol, which, unlike this review, provides a comprehensive account of the data management and screening process utilized (Schönbach et al., 2022). This article was drafted using the “Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement” (Page et al., 2021).

To conduct this systematic review, it was necessary to reach a consensus on defining the construct that encompassed both: key data from the synonymous constructs of nature connectedness that have previously been developed (see Table 1) and key information from the literature on the subject. This operational definition was developed from the extant literature and a more comprehensive definition should be developed in further research.

Based on the above, we developed the following preliminary definition for the purpose of conducting this review: People have a basic need of belonging (Baumeister & Leary, 1995), which can be satisfied by being subjectively (Pritchard et al., 2020) and positively (Barrable et al., 2021) connected to nature. Being connected to nature includes being close to (Wilson, 1984) or one with (Mayer & Frantz, 2004) the natural world.

Eligibility Criteria

The eligibility criteria for this systematic review is detailed in Table 2 below.

Table 1. Definitions of the Nature Connectedness Construct from the Extant Literature.

Author (Year)	Synonyms of nature connectedness	Definition
W. P. Schultz (2002)	Connectedness With Nature	This term refers to the extent to which an individual includes nature within his/her cognitive representation of self.
Clayton (2003)	Environmental Identity (EID)	This term refers to the connection that exists between a person and his or her non-human environment.
Mayer and Frantz (2004)	Connectedness to Nature (CN)	This term refers to one's affective, experiential sense of oneness with the natural world.
Dutcher et al. (2007)	Connectivity With Nature	"perception of sameness between the self, others, and the natural world" (p. 474)
Nisbet and Zelenski (2013)	Nature Relatedness (NR)	"individual levels of connectedness with the natural world" (p. 718)
Perkins (2010)	Love and Care for Nature (LCN)	"deep love and caring for nature which includes a clear recognition of nature's intrinsic value as well as a personal sense of responsibility to protect it from harm" (p. 456)
Davis et al. (2009)	Commitment to the Environment	"psychological attachment and long-term orientation to the natural world" (p. 174)
Kals et al. (2016)	Emotional Affinity Toward Nature (EATN)	This term refers to a preference for nature that will facilitate actions to protect it.
Suganthi (2019)	Ecospirituality	This term refers to the feeling of oneness that a person has with the environment, as well as the amazement generated by understanding it. It is also a reflection of the awareness of the danger that can be generated by creating an imbalance in it.

Table 2. Eligibility Criteria.

Inclusion criteria	Exclusion criteria
Manuscripts that describe the validation process of an explicit instrument/scale/questionnaire that measures the nature connectedness construct. Thus, not all dimensions in the scale (i.e., care, ecology) have to fulfill our definition.	Manuscripts that do not describe the validation process of an explicit instrument to measure the construct of nature connectedness (i.e., implicit association test).
Manuscripts that have passed through a peer-review process before publication.	Manuscripts that did not pass a peer-review process (i.e., gray literature) and/or were secondary literature (i.e., meta-analysis).
Manuscripts that are primary literature.	Manuscripts that describe the validation process of an explicit instrument that does not measure the construct of nature connectedness (i.e., pro-environmental behavior scale and dispositional empathy with nature scale) (Schönbach et al., 2022)
Manuscripts that were published between 2000 and 2021, since during that time, there was a significant increase in the development of instruments that measure nature connectedness (Martin & Czellar, 2016).	Manuscripts that were published before the year 2000.
Manuscripts that focus on scales addressing children, adolescents and/or adults with or without special needs or additional needs.	
Manuscripts that were published in English.	

Note. To be included in this review, manuscripts needed to directly refer to a validation process of an explicit nature connectedness scale.

Search Strategy and Databases

For this systematic review, an exhaustive search strategy based on the categories of “PICO” (i.e., population, interest, context) (Murdoch University, 2021) was generated by and XT-O, with the assistance of two librarians (Schönbach et al., 2022). DMIS and XT-O previously piloted the search strategy before being entered into the following databases used for the search: PsycINFO: EBSCO, PSYINDEX: EBSCO, PubMed: NCBI, PsycARTICLES:

EBSCO, Scopus: ELSEVIER, and Web of Science: Clarivate Analytics. These databases were selected because they are multidisciplinary and include topics in environmental psychology.

The search formula employed in the systematic review is outlined below: (child* OR infan* OR adolescen* OR preadolescenc* OR juven* OR teen* OR young* OR youth* OR kid* OR pediatric* OR pediatric* OR boy* OR girl* OR preschool* OR schoolchild* OR schoolboy* OR schoolgirl* OR student* OR pupil* OR woman OR women OR man OR men OR adult* OR grown-up* OR elderly OR human* OR people OR person* OR individual*) and (questionnaire* OR survey* OR questionar* OR instrument* OR tool* OR scale* OR dimension* OR item* OR element* OR component* OR construct OR concept OR measur* OR evaluat* OR assess* OR rate* OR rating OR report* OR descri*) and (“commitment to nature” OR “commitment with nature” OR “connect* to nature” OR “connect* with nature” OR “relat* to nature” OR “relat* with nature” OR “emotional affinity toward* nature” OR “emotional affinity with nature” OR “inclusion of nature in self” OR “inclusion of nature in the self” OR “nature commitment” OR “nature connect*” OR “nature relat*” OR “human-nature connect*” OR “human-nature relat*” OR “self-nature connect*” OR “self-nature relat*” OR “being one with nature” OR “interconnection with nature” OR “interconnection to nature”). The terms used in the search formula mentioned above were based on existing literature (Capaldi et al., 2014; Häyrynen & Pynnönen, 2020; Pritchard et al., 2020).

Study Selection

The identified papers were imported into EndNote (Version X9), where duplicates were removed manually. Any disagreement between both reviewers was resolved by discussion. The study selection process is shown in Figure 1. Authors of relevant papers were contacted a maximum of two times to request the full text if it could not be found.

Data Extraction

Data extraction was performed by two independent extractors XT-O and SM. Any disagreement between both extractors was resolved by discussion. In case of a continued disagreement, the opinion of a third independent data extractor was needed and DMIS was consulted. As a consensus was always reached as a result of this procedure, no inter-rater agreement between extractors could be computed. The data of the same measuring instruments were extracted separately from each paper, if they analyzed a different type of validity and/or reliability. In the case two publications analyzed the same

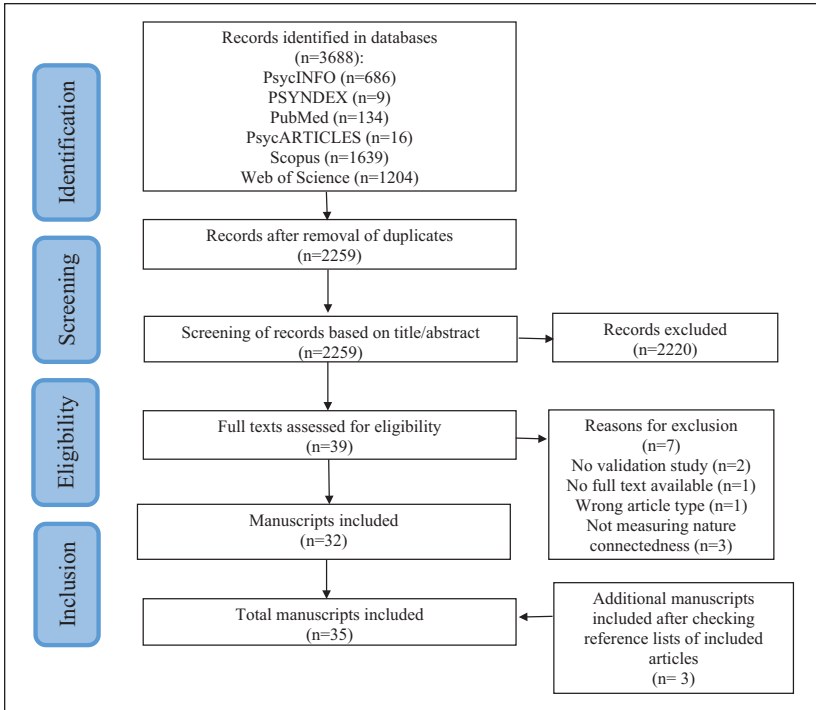


Figure 1. Flow diagram of the study selection process.

psychometric properties, data extraction from one was omitted. Data were extracted using a spreadsheet that [a] and [b] previously piloted as independent data extractors based on three randomly chosen articles. If data intended to be extracted was missing or uncertain, authors of included papers were contacted no more than two times. The following information was extracted based on the adapted Qualitative Assessment of Physical Activity Questionnaires (QAPAQ) checklist (Terwee et al., 2010):

- (a) General details (i.e., author(s), publication year)
- (b) Participants (i.e., recruitment rate, sample size, age)
- (c) Measuring instrument (i.e., name of measuring instrument, construct and dimensions intended to be measured)
- (d) Study design
- (e) Statistical analysis
- (f) Results (i.e., validity types, reliability)

Methodological Quality Assessment

The quality assessment of this systematic review was based on the comprehensive CONsensus-based Standards for selecting health Measurement INSTRuments (COSMIN) Risk of Bias checklist (Mokkink et al., 2018). The COSMIN checklist was previously piloted by all three independent reviewers based on three randomly chosen papers. Subsequently, three separate reviewers XT-O and AM/MP assessed the methodological quality from each study. In case of disagreement in the rating given to each item belonging to the evaluated components an independent reviewer RJ was also consulted. We assessed content validity, structural validity, internal consistency, cross-cultural validity/measurement invariance, reliability, measurement error, criterion validity, and hypotheses testing for construct validity components, as they are aligned with the aim of this review. The components PROM development and responsiveness were not assessed. The rating of the checklist is “very good,” “adequate,” “doubtful,” “inadequate,” or “not applicable.” The hypothesis testing for construct validity is comprised by convergent and discriminant validity. To assess convergent validity, we utilized all nature connectedness scales presented in studies, which include scales that were included in the content validity assessment (i.e., Nature Relatedness Scale, Nature Connectedness Scale, Environmental Identity Scale, Inclusion of Nature in Self). Additionally, based on the expert statistical discussion and on its recommendation, we decided not to use the checklist item asking about “any other major flaws in the design or statistical methods” as this item increases the degree of subjectivity of the tool, which depends entirely on the examiner’s criteria. Thus, including this item in the checklist could bias the final rating of the components and the final rating of the entire quality assessment. This is particularly pertinent as the criterion that will be used to rate the scale is the “lowest/worst score counts,” commonly used to evaluate the COSMIN checklist (Hidding et al., 2017, 2018). Separate quality assessments for each instrument validated were performed for both the component-based and overall rating. If the information intended to be assessed uncertain, authors of included papers were contacted on two further occasions to elicit the information.

Therefore, the consultants were not blinded to the general information of the investigations (i.e., author(s)). The rating scale was based on the COSMIN Methodology for Systematic Reviews of Patient Reported Outcome Measures (PROMS) (Prinsen et al., 2018). In addition, one of the tool’s representatives was consulted about evaluating the content and construct validity sections, which are composed of subsections 5 and 2, respectively. Each subsection was rated and indicated as “not reported” when authors had not considered the topic during their scale evaluation.

Data Synthesis

Data extracted from each of the studies included in this systematic review and the results of the methodological quality assessment of each instrument reported, was summarized narratively. Both the methodological quality ratings of individual components and the resulting overall quality rating based on COSMIN, were reported separately in figures and tables under consideration of the stage of life of the studied sample (i.e., children ≤ 12 years, adolescents ≥ 13 years, adults ≥ 18 years).

Results

A total of 3,688 records were found (Figure 1). After removing 1,429 duplicates, 2,259 records were screened based on title and abstract. Subsequently, 39 full texts were assessed for eligibility. Finally, 35 manuscripts were included in the systematic review, which included three manuscripts identified after screening the reference lists of included articles.

General Information of Included Manuscripts

Within the 35 manuscripts, a total of 70 studies, 75 different samples, 34 different scales and 48 scales were found (see Table 3). An increasing interest in scale validation was detected in 2011 to 2013 and 2017 to 2021. Fourteen manuscripts originated from Europe (i.e., the UK, Germany, Switzerland, Greece, Austria, France, and Sweden); Spain was the most frequent country of study ($n=5$). Nine manuscripts originated from North America, of which seven were from the USA and two from Canada. South America was the origin of three manuscripts in Brazil, Peru and Chile. Eight manuscripts originated from Asia, of which five were conducted in China. Three manuscripts originated from Australia. The most common study design used was cross-sectional ($n=35$); one study also included a longitudinal study (See Figure 2).

Throughout 35 manuscripts, the following dimensions were measured: affective, such as the emotion that generates or supports nature connectedness (77%); cognitive, such as beliefs, knowledge, attitudes, values, identity, and awareness that are related to nature connectedness (69%); behavior, such as the commitment that a person has with nature (49%); experiential, such as the direct exposure and experience (14%); and philosophical, such as spirituality (11%). Concerning dimensionality, 48% of the scales were reported as unidimensional, 6% as bidimensional, 25% as multidimensional, and 21% did not report their dimensionality.

Depending on the authors' perspective, nature connectedness can be classified as a consistent personality trait or a temporary state. The vast majority

Table 3. General Information About Characteristics of Included Manuscripts, Sorted by Age Group.

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait	Amount and type of items; amount and type of response
Children	Cheng & Monroe (2010); USA; Cross-Sectional; "Children's Connection to Nature Index"	Sample size and status: 1,432 students (26% fourth grade students) Gender: NR Age: NR	Multidimensional (affective, experiential, and cognitive): (a) enjoyment of nature, (b) empathy for creatures, (c) sense of oneness, (d) sense of responsibility Settings: urban/rural Theoretical background: Yes Measuring state/trait: NR	16 items (NR); 5-point Likert Scale
	Sobko et al. (2018); China; Cross-Sectional; "Connectedness to Nature Index - Parent Preschool Children (CNI-PPC)"	Study 1a Sample size and status: parents of 31 children Gender: NR Age: children aged 2 to 5 (2.16 ± 0.90) years Study 1b Sample size and status: 20 parents Gender: NR Age: children aged 2 to 5 years Study 2 Sample size and status: 299 families Gender: 51% boys, 90.5% mothers, 9.1% fathers, and 0.3% others Age: children aged 2 to 5 (2.7 ± 1.2) years	Multidimensional (adults: affective, cognitive, behavior; children: affective and cognitive): (a) enjoyment of nature, (b) empathy for nature, (c) responsibility toward nature, (d) awareness of nature Settings: urban/rural Theoretical background: Yes Measuring state/trait: NR	16 items (NR); 5-point Likert Scale

(continued)

Table 3. (continued)

Stage of life	Author (year), country; design; name of the scale	Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait	Scale	Amount and type of items; amount and type of response
Children, adolescent, and adults	Clayton et al. (2021); US, Russia, Switzerland, Taiwan, Peru; Cross-Sectional; "Revised Environmental Identity Scale (EID-R)"	<p>Sample 1 Sample size and status: 220 U.S. residents Gender: 36%F, 74%M Age: NR</p> <p>Sample 2 Sample size and status: 484 U.S. visitors to zoo and leisure Settings Gender: 58%F, 42%M Age: NR</p> <p>Sample 3 Sample size and status: 45 U.S. high school students Gender: 62%F, 38%M Age: NR</p> <p>Sample 4 Sample size and status: 310 Russian university students Gender: 80%F, 19%M Age: NR</p> <p>Sample 5 Sample size and status: 343 Swiss university students Gender: 36%F, 64%M Age: NR</p>	<p>Unidimensional (cognitive, affective, and behavior)</p> <p>Settings: urban/rural and natural</p> <p>Theoretical background: Yes</p> <p>Measuring state/trait: NR</p>	14 items (NR); 7-point Likert Scale	14 items (NR); 7-point Likert Scale

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait	Scale	Amount and type of items; amount and type of response
		<p>Sample 6</p> <p>Sample size and status: 91 Taiwanese undergraduate students</p> <p>Gender: 79%F, 21%M</p> <p>Age: NR</p> <p>Sample 7</p> <p>Sample size and status: 224 Peruvian farmers, tourists, urban residents rural residents</p> <p>Gender: 45%F, 55%M</p> <p>Age: NR</p>			
	<p>Kleespies et al. (2021); Germany; Cross-Sectional; "Extended Illustrated Inclusion of Nature in Self Scale (IINS)"</p>	<p>Study 2</p> <p>Sample size and status: 588 students</p> <p>Gender first data set: 64.3% women, 33.9% men, 1.8% no answer; second data set: 62.0% women, 35.3 men, 2.6 no answer</p> <p>Age: first data set: $M_{age} = 20.44$ years; second data set: $M_{age} = 20.51$ years</p> <p>Study 3</p> <p>Sample size and status: 106 students with special needs</p> <p>Gender: 45% women</p> <p>54% men 1% not specified</p> <p>Age: 9 to 14 years</p>	<p>Unidimensional (cognitive, affective, behavior)</p> <p>Setting: urban/rural</p> <p>Theoretical background: Yes</p> <p>Measuring state/trait: NR</p>		<p>Single item (NR); 7 graphical questioning tool</p>

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Scale	
		Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait
Children and adults	Mundaca et al. (2021); Chile; Cross-Sectional; "The Emotion and Cognitive Scale of the Human-Nature Relationship (ECS-HNR)"	Sample size and status: 474 Inhabitants from 38.40% Curicó, 21.31% Talca, 13.29% Santiago, and 7.17% Concepción Gender: 55.49% women to 43.88% men Age: NR	Bidimensional (cognitive and affective): (a) cognitive and (b) affective Setting: urban/rural Theoretical background: Yes Measuring state/trait: EAW measures state and EAF NR
	Richardson et al. (2019); UK; Cross-Sectional; "Nature Connection Index (NCI)"	Study 1/ Factor analysis 1 Sample size and status: 3,568 adolescents and adults participants Gender: 1826 women, 1,742 men Age: 49.98 ± 20.05 Study 2/ Factor analysis 2 Sample size and status: 553 participants Gender: 267 men, 286 women Age: NR Study 3/Factor analysis 3 Sample size and status: 351 children and adolescents participants Gender: 177 women, 174 men Age: NR	Unidimensional (affective, cognitive and behavior) Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR
Children and adults	Li & Lang. (2014); China; Cross-Sectional; "Human-Nature Relationship Scale (HNR- Scale)"	Sample size and status: 1,307 Children + Parents Gender: Children: 53.9% boys and 46.1 % girls, men children mean 0.539 Parents: 44% fathers and 587 56% mothers. Age: Children: NR Parents: NR	Bidimensional: (cognitive and behavior): NR Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Scale		Amount and type of items; amount and type of response
Adolescents and adults	Chew (2019); Singapore; Cross-Sectional; Scale 1 "Environmental Identity Scale (EID)" (long and short version) Scale 2 "Nature Relatedness Scale (NRS)" (long and short version)	Sample size and status: 209 Singaporean undergraduate students Gender: 67.9% women Age: 22.03 ± 4.56 years	Scale 1	Dimension(s) setting(s) theoretical background measuring state/trait	Scale 1 EID long version 24 items (NR); 5-point Likert Scale EID short version 11 items (NR); 5-point Likert Scale Scale 2 NRS long version 19 items (NR); 5-point Likert Scale NRS short version 6 items (NR); 5-point Likert Scale
			Short version Unidimensional (NR) Setting: NR Theoretical background: Yes Measuring state/trait: NR Long version Unidimensional (NR) Setting: NR Theoretical Background: Yes Measuring state/trait: NR Scale 2 Short version Unidimensional Setting: urban/rural Theoretical background: Yes Measuring state/trait: Trait Long version Multidimensional (affective, cognitive and experiential): (a) NR-self (b) NR-experience (c) NR-perspective Setting: urban/rural Theoretical background: Yes Measuring state/trait: Trait		

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait	Amount and type of items; amount and type of response
	Clayton et al. (2019); Russia; Cross-Sectional; "Russian version of the Environmental Identity Scale"	<p>Study 1 Sample size and status: 222 participants Gender: 180 women Age: 23.6 ± 6.7 years</p> <p>Study 2 Sample size and status: 94 participants; Gender: 78 women Age: 18.6 ± 1.2 years</p> <p>Study 3 Sample size and status: 200 participants Gender: 168 women, 84% women Age: 22.5 ± 6.2 years</p>	<p>Unidimensional (cognitive, behavior and affective) Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR</p>	<p>24 items (NR); 5-point Likert Scale)</p>
	Davis et al. (2009); U.S.A.; Study 1 Cross-sectional and correlational Study 2 Cross-sectional and causal; "Environment Scale (COM)"	<p>Study 1 Sample size and status: 71 undergraduate students Gender: 26 men, 45 women Age: NR</p> <p>Study 2 Sample size and status: 70 undergraduate students Gender: 35 men, 35 women Age: NR</p>	<p>Unidimensional (behavior) Setting Studies 1 + 2: urban/rural Theoretical background: Yes Measuring state/trait: NR</p>	<p>11 items (1 reverse question); 9-point Likert Scale</p>

(continued)

Table 3. (continued)

Stage of life	Author (year), country; design; name of the scale	Scale	
		Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait
	Martin and Czellar (2016); Switzerland; Study 2a + 2b + 3a + 3b	Study 2a Sample size and status: 107 students Gender: 65% men Age: NR	Unidimensional (cognitive and behavior) Setting: urban/rural
	Cross-Sectional Study 4	Study 2b Sample size and status: 585 participants Gender: 42% men Age: NR	Theoretical background: Yes Measuring state/trait: NR
	Longitudinal; "Extended Inclusion of Nature in Self Scale (EINS)"	Study 3a Sample size and status: 189 participants Gender: 45% men Age: NR	
		Study 3b Sample size and status: 178 participants Gender: 50% men Age: NR	
		Study 4 Time 1 Sample size and status: 38 students Gender: 48% men Age: NR	
		Study 4 Time 2 Sample size and status: 94 participants Gender: 47% men Age: NR	4 items (NR); 7 illustrations per item

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Scale	
			Dimension(s) setting(s) theoretical background measuring state/trait	Amount and type of items; amount and type of response
	Mayer and Frantz (2004); USA; Study 1 + 3 + 4 + 5 Cross-Sectional Study 2 Longitudinal; "Connectedness to Nature Scale (CNS)"	<p>Study 1 Sample size and status: 60 individuals Gender: 31 men, 29 women Age: 31 ± 13 years</p> <p>Study 2 Sample size and status: 102 students Gender: 42 men, 60 women Age: NR</p> <p>Study 3 Sample size and status: 270 students Gender: NR Age: NR</p> <p>Study 4 Sample size and status: 135 members outside the college community Gender: 31 men, 89 women, and 15 who did not disclose their gender Age: 36 ± 19 years</p> <p>Study 5 Sample size and status: 46 undergraduate psychology majors Gender: NR Age: NR</p>	<p>Unidimensional (affective) Setting: urban/rural Theoretical background: Yes Measuring state/trait: Trait</p>	<p>14 items (3 reverse wording); 5-point Likert Scale</p>

(continued)

Table 3. (continued)

Stage of life	Author (year), country; design; name of the scale	Participants (per sub-study)	Scale	Amount and type of items; amount and type of response
	Nisbet and Zelenski (2013); Canada; Study 1 + 2 + 3 Cross-Sectional Study 4 Longitudinal; "Nature Relatedness Scale-6 (NR-6)"	<p>Study 1 Sample size and status: 184 students; Gender: 67.4% women (n = 124; n = 60 men) Age: 19.48 ± 2.83 years</p> <p>Study 2 Sample size and status: 145 Canadian middle managers Gender: 87 men, 56 women, 2 did not indicate sex. Age: 42.37 ± 8.80 years</p> <p>Study 3 Sample size and status: 354 students Gender: 59.9% women (n = 212), men (n = 142) Age: 20.03 ± 4.36 years</p> <p>Study 4 Sample 1 Sample size and status: 207 community Gender: 78.6% community women (n = 84) Age: 37.86 ± 15.01 years</p> <p>Study 4 Sample 2 Sample size and status: 123 students Gender: 77.2% students women (n = 123) Age: 20.95 ± 5.60 years</p>	<p>Dimension(s) setting(s) theoretical background measuring state/trait</p> <p>Bidimensional (cognitive, affective and experiential): (a) self and (b) experience Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR</p>	6 items (NR); 5-point Likert Scale

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait	Amount and type of items; amount and type of response
	Nisbet et al. (2008); Canada; Study 1 + 2 Cross-Sectional; "Nature Relatedness Scale (NRS)"	Study 1 Phase 1 Sample size and status: 83 Canadian undergraduate psychology students Gender: NR Age: NR Study 1 Phase 2 Sample size and status: 184 random selection of the Canadian undergraduate psychology students Gender: 67.4% women n = 124 women; n = 60 men Age: 19.48 ± 2.83 years Study 2 Sample size and status: 145 executives from the government and private sector Gender: 61 % men n = 87, n = 56 women, 2 participants did not indicate gender Age: 42.37 ± 8.80 years	Multidimensional (affective, cognitive and experiential): (a) NR-self, (b) NR-perspective, (c) NR-experience Setting: urban/rural Theoretical background: Yes Measuring state/trait: trait	21 items (1 reverse wording); 5-point Likert Scale
	Pasca et al. (2020); Spain; Cross-Sectional; "Love for Nature Scale (LNS)"	Study 1 Sample size and status: 51 undergraduates Gender: 90.20% women Age: 20.37 ± 1.04 years Study 2 Sample size and status: 1,071 participants Gender: 56.70% women; Age: 26.42 ± 14.58 years Study 3 Sample size and status: 151 general population Gender: 53.6% women Age: 40.96 ± 12.50 years	unidimensional (affective): (a) connectedness (b) well-being Setting: urban/rural Theoretical Background: Yes Measuring state/trait: NR	10 items (NR); 7-point Likert Scale

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Scale	Amount and type of items; amount and type of response
	Tam (2013a, 2013b); China; Cross-Sectional; Scale 1 "Commitment to Nature (COM)"	Study 1 Sample size and status: 322 students Gender: 173 men, 146 women, and 3 NR Age: 20.36 ± 1.34 years	Scale 1: NR (affective and behavior) Setting: urban/rural Theoretical background: NR Measuring state/trait: NR	Scale 1 11 items (NR); 7-point Likert Scale
	Scale 2 "Connectedness to Nature (CTN)"	Study 2 Sample size and status: 185 residents in the U.S.	Scale 2: NR (affective and cognitive) Setting: urban/rural Theoretical background: NR Measuring state/trait: NR	Scale 2 14 items (NR); 7-point Likert Scale
	Scale 3 "Connectivity with Nature (CWN)"	Gender: 67 men and 118 women Age: 33.43 ± 13.20 years	Scale 3: NR (NR) Setting: urban/rural Theoretical background: NR Measuring state/trait: NR	Scale 3 4 items (NR) +diagram; 7-point Likert Scale
	Scale 4 "Emotional Affinity Toward Nature (EATN)"		Theoretical background: NR Measuring state/trait: NR Scale 4: NR (affective)	Scale 4 16 items (NR); 7-point Likert Scale
	Scale 5 "Environmental Identity (EID)"		Setting: urban/rural Theoretical background: NR Measuring state/trait: NR	Scale 5 24 items (NR); 7-point Likert Scale
	Scale 6 "Inclusion of Nature in Self (INS)"		Scale 5: NR (affective and cognitive) Setting: urban/rural Theoretical background: NR Measuring state/trait: NR	Scale 6 4 items (NR); Diagram Scale 7
	Scale 7 "Nature Relatedness (NR)"		Theoretical background: NR Measuring state/trait: NR	Scale 7 21 items (NR); 7-point Likert Scale
	Scale 8 "Allo-Inclusive Identity (AID)"		Scale 6: NR (cognitive) Setting: urban/rural Theoretical background: NR Measuring state/trait: NR	Scale 8 8 items (NR); 7-point Likert Scale
	Scale 9 "Love and Care for Nature (LCN)"		Scale 7: NR (affective, cognitive and experiential) Setting: urban/rural	Scale 9 15 items (NR); 7-point Likert Scale

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Scale	Amount and type of items; amount and type of response
ADULTS	Beery (2013); Sweden; Cross-Sectional; "Measure of Environmental Connectedness (EC)"	Sample size and status: 120 Swedish law students Gender: 55% women and 45% men Age: NR	Theoretical background: NR Measuring state/trait: NR Scale 8: NR (cognitive) Setting: urban/rural Theoretical background: NR Measuring state/trait: NR Scale 9: NR (affective) Setting: urban/rural Theoretical background: NR Measuring state/trait: NR Unidimensional (philosophical, behavior and NR) Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR	3 items (NR); NR
	Braitto et al. (2017); Austria and the U.S.A; Cross-Sectional; "Human-Nature Relationship Scale"	Sample size and status: 402 participants (45% BOKU, 55% USU) Gender: 38% men, 62% women Age: NR	Multidimensional (behavior and NR): (a) Positionality dimensions, (b) Character of bond dimensions, (c) Understanding of nature dimensions Setting: Urban/rural Theoretical Background: Yes Measuring state/trait: NR	NR (NR); 5-point Likert Scale (Modules 2-5).

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Scale	Amount and type of items; amount and type of response
	Brügger et al. (2011); Switzerland; Cross-Sectional; "Disposition to Connect with Nature Scale (DCN)"	Sample size and status: 1,309 participants Gender: women =45.16% Age: 34.05 ± 15.30 years	Unidimensional (behavior and NR) Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR	40 items (3 items in reverse wording); (a) 17 items measured in a 3 point Likert Scale, (b) 9 items in dichotomous y/h, (c) 14 items in dichotomous y/h 14 items (3 reverse wording); NR
	Cheung et al. (2020); China; Cross-Sectional; "Chinese version of the CNS"	Pilot Sample size and status: 30 TCM practitioners in Hong Kong Gender: NR Age: NR Testing Sample size and status: 84 TCM practitioners across China's Guangdong province Gender: 64 men, 24 women Age: NR	Unidimensional (affective) Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR	14 items (3 reverse wording); NR
	Dutcher et al. (2007); U.S.A.; Cross-Sectional; "Connectivity with Nature"	Sample size and status: 741 landowners Gender: men > women Age: 57 ± 14.12 years	Multidimensional (affective, cognitive, philosophical and behavior): (a) connectivity with nature, (b) environmental concern, (c) environmental behavior Theoretical Background: Yes Setting: urban/rural Measuring state/trait: NR	16 (3 reverse wording); 9 items with 5- point Likert Scale, 1 item with Venn diagram, 6 dichotomous answer (Y/N)

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Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Scale	Amount and type of items; amount and type of response
	Gkargkavouzi et al. (2021); Greece; Cross-Sectional; Scale 1	Study 1 Sample size and status: 400 general population contacted by phone calls in Greece Gender: 52.23% Women, 47.7% Men Age: 39.85 ± 15.11 years	Scale 1 Unidimensional (NR) Setting: urban/rural	Scale 1 14 items (NR); 5-point Likert Scale
	Connectedness to Nature Scale (CNS)	Age: 39.85 ± 15.11 years Study 2	Theoretical Background: Yes Measuring state/trait: NR	Scale 2 12 items (NR); 5-point Likert Scale
	Environmental Behavior (EB) Scale 3	Sample size and status: 400 general population contacted by phone calls in Greece Gender: 52% women, 48% men Age: 38.36 ± 14.29 years	Multidimensional (NR); NR Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR	Scale 3 10 items (NR); 5-point Likert Scale
	Concern (Construct measured through the "Environmental Motives Scale(EMS)")		Scale 3 Multidimensional (NR); NR Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR	
	Hatty et al. (2020); Australia; Cross-Sectional; "Connection with Nature-12 (CN-12)"	Study 1 Sample size and status: 3,090 residents in the state of Victoria Gender: NR Age: NR Study 2 Sample size and status: 1,069 participants— Gender: 48.7% women Age: 52.81 ± 14.8 years	Multidimensional (affective, cognitive and behavior); (a) identity, (b) experience, (c) philosophy Setting: urban/rural Theoretical Background: Yes Measuring state/trait: NR	12 items (NR); 7-point Likert Scale

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Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Scale	Amount and type of items; amount and type of response
	Matas-Terrón and Elósegui-Bandera (2012); Spain; Cross-Sectional; "Spanish adaptation of the Connectedness to Nature Scale (CNS)"	Sample size and status: 430 university students Gender: 76.04% women, 23.95% men Age: 21.7 ± 5.19 years	Unidimensional (cognitive) Setting: urban/rural Theoretical Background: Yes Measuring state/trait: NR	14 items (3 reverse wording); 5-point Likert Scale
	Meis-Harris et al. (2020); Australia; Cross-Sectional; "AIMES Connection with Nature Scale"	Sample size and status: 3,090 Victorians Gender: 50.2% women Age: 47 ± 16.3 years	Multidimensional (affective, cognitive, behavior and philosophical): (a) identity (b) materialism, (c) experiential and (d) philosophical Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR	19 items (NR); 5-point Likert Scale
	Navarro et al. (2017); France; Cross-Sectional; "CNS French version"	Study 1 Sample size and status: 204 participants from France Gender: 72% women Age: 29 ± 10.37 years Study 2 Sample size and status: 153 general population Gender: 58.8% women Age: 30.5 ± 10.75 years Study 3 Sample size and status: 322 participants total Subsample 1 Sample size and status: 267 French students Gender: 19.60 ± 3.75	Unidimensional (NR) Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR	11 items (NR); 5-point Likert Scale

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Table 3. (continued)

		Scale		
Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait	Amount and type of items; amount and type of response
		Age: NR		
		Subsample 2		
		Sample size and status: 55 French students		
		Gender: 61.8% women		
		Age: 22.24 ± 5.04 years		
	Olivos et al. (2011);	Sample size and status: 282 university students	Multidimensional (affective, behavior, cognition): (a) environmental identity, (b) enjoying nature, (c) appreciation of nature environmentalism	24 items (NR); NR
	Spain; Cross-Sectional; "Environmental Identity Scale (EID)"	Gender: 18% men; 81% women	Setting: urban/rural	
		Age: 21.4 ± 3.58	Theoretical background: Yes	
			Measuring state/trait: NR	
	Olivos et al. (2011);	Study 1 Sample size and status: 247 participants (conformed by 135 university students and 112 general population)	Unidimensional (NR)	13 items (1 reverse wording item);
	Spain; Cross-Sectional; "Spanish version of the Connectedness to Nature Scale"	Gender: 32% men, 68% women	Setting: urban/rural	5-point Likert Scale
		Age: students 20 ± 1.26 years, general population 44 ± 9.09 years	Theoretical background: Yes	
		Study 2	Measuring state/trait: NR	
		204 college students		
		Gender: 18% men and 82% women		
		Age: 20 ± 2.55 years		

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Scale		
		Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait	
	Pasca et al. (2018); Spain & U.S.A.; Cross-Sectional; "Connectedness to Nature Scale CNS"	<p>Sample size and status: 745 total sample size. Sample divided in:</p> <p>Subsample 1</p> <p>Sample size and status: 361 Americans- sample taken from the Study made by Mayer and Frantz (2004)</p> <p>Gender: NR</p> <p>Age: 31.29 ± 17.06 years</p> <p>Subsample 2</p> <p>Total sample size and status: 384 participants from the Spanish group</p> <p>Gender: NR</p> <p>Age: 23.15 ± 7.45 years</p> <p>Study 1</p> <p>Total sample size and status: 1,008 participants</p> <p>Gender: 74.9% women</p> <p>Age: 21.7 ± 4.2 years</p> <p>Study 2</p> <p>Total sample size and status: 321 individuals from the general population of Madrid</p> <p>Gender: 53.6% women</p> <p>Age: 45.42 ± 9.62 years</p>	<p>Unidimensional (NR)</p> <p>Setting: urban/rural</p> <p>Theoretical background: Yes</p> <p>Measuring state/trait: NR</p>	<p>13 items (NR); 5-point Likert Scale.</p>
	Pasca et al. (2017); Spain; Cross-Sectional; "Connectedness to Nature Scale-7 (CNS-7)"		<p>Unidimensional (cognitive)</p> <p>Setting: urban/rural</p> <p>Theoretical background: Yes</p> <p>Measuring state/trait: NR</p>	<p>7 items (NR); 5-point Likert Scale</p>

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Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Scale		
		Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait	
	Perkins (2010); Australia; Study 3 + 4 Cross-Sectional: "Love and Care for Nature Scale (LCN)"	<p>Study 1 Total sample size and status: 10 interdisciplinary experts Gender: NR Age: NR</p> <p>Study 2 Total sample size and status: 53 staff members from the university, students and other university members Gender: 44% men and 56% women Age: NR</p> <p>Study 3 Total sample size and status: 307 university students Gender: 62% women and 38% men Age: NR</p> <p>Study 4 Total sample size and status: 261 tourists Gender: 42% men and 58% women Age: NR</p>	<p>Unidimensional (affective) Setting Studies 1 + 2 + 3: urban/rural Setting Study 4: natural Theoretical Background: Yes Measuring state/trait: NR</p>	15 items (NR); 7-point Likert Scale

(continued)

Table 3. (continued)

Stage of life	Author (year); country; design; name of the scale	Participants (per sub-study)	Dimension(s) setting(s) theoretical background measuring state/trait	Amount and type of items; amount and type of response
Study 1	Perrin and Benassi (2009); USA; Cross-Sectional; "Connectedness to Nature Scale (CNS)"	Total sample size and status: 361 participants from Mayer and Frantz (2004) Gender: NR Age: NR	Unidimensional (cognitive) Setting: urban/rural Theoretical background: Yes Measuring state/trait: Trait	14 items (NR); 5-point-Likert Scale
Study 2		Total sample size and status: 231 students Gender: 69 men and 162 women Age: NR		
Study 3		Total sample size and status: 56 students Gender: 20 men and 36 women Age: NR		
Study 4		Total sample size and status: 29 students Gender: 12 men and 17 women Age: NR		
Study 5		Total sample size and status: participants were subjects from study 4 of the original Scale Gender: NR Age: NR		
Rosa et al. (2020); Brazil; Cross-Sectional; "CNS-7 (Brazilian version)"		Total sample size and status: 224 university students Gender: 140 women Age: 23.6 ± 5.96 years	Unidimensional (affective, cognition and behavior) Setting: urban/rural Theoretical Background: Yes Measuring state/trait: NR	7 items (NR); 5-point Likert Scale

(continued)

Table 3. (continued)

Stage of life	Author (year), country; design; name of the scale	Participants (per sub-study)	Scale	
			Dimension(s) setting(s) theoretical background measuring state/trait	Amount and type of items; amount and type of response
	P. W. Schultz et al. (2004); U.S.A.; Cross-Sectional; "Inclusion of Nature in Self (INS) Scale"	Total sample size and status: 100 undergraduate students Gender: 40 men and 60 women Age: 23.62 ± 5.68 years	NR (NR) Setting: NR Theoretical background: NR Measuring state/trait: NR	1 item (NR); 7 graphical responses
	Suganthi (2019); India; Cross-Sectional; "Ecospirituality Scale (ES)"	Delphi method: Total sample size and status: 10 experts Gender: NR Age: NR Study 1 Total sample size and status: 527 employees Gender: 295 men (56%) and 232 women (44%) Age: NR Study 2 Total sample size and status: 321 general population Gender: 189 men (58.9%), 132 women (41.1%) Age: NR	Multidimensional (philosophical and affective): (a) dwelling, (b) caring, (c) revering, (d) experiencing, and (e) relating Setting: urban/rural Theoretical background: Yes Measuring state/trait: NR	20 items (NR); 7-point Likert Scale

Note. NR = not reported.

of included manuscripts (86%) did not report if they treated nature connectedness as a state or trait. Eight percent of the manuscripts that only validated one scale treated nature connectedness as a trait (Mayer & Frantz, 2004; Nisbet et al., 2008; Perrin & Benassi, 2009). One manuscript, including two different scales, treated nature connectedness as a state in one scale. Still, it remained unclear how it was classified in the second scale (Mundaca et al., 2021). Another study was treated nature connectedness as a trait in one scale, but it was unclear how the authors classified the concept in the second scale (Chew, 2019).

Regarding the provision of instructions, only eight manuscripts reported clearly how to fill out their scale. Concerning the type and amount of items, one scale presented a diagram where participants had to select the option that better described their connection with nature (Tam, 2013a) and in all other scales, several items, ranging from 1 to 40, were provided. The average number of items per scale was 13.4 ($SD=7.4$). The response type mostly used was a Likert Scale ($n=41$), ranging from 9 to 9 point, and only two scales used dichotomous response categories (i.e., Yes/No) (Brügger et al., 2011; Dutcher et al., 2007) or diagrams ($n=5$) (Dutcher et al., 2007; Kleespies et al., 2021; Martin & Czellar, 2016; P. W. Schultz et al., 2004; Tam, 2013a).

One manuscript assessed a proxy report to assess nature connectedness in children between 2 and 5 years old (Sobko et al., 2018). Thirty-four manuscripts assessed self-report scales and the participants' age range was between 13.6 (± 1.2) and 52 (± 14.18) years. Most scales were developed for adults 54%, followed by adolescents and adults 26%, children, adolescents and adults 11%, children 6%, and children and adults 3%. The study samples were mainly students ($n=22$). Only one study validated the scale among children and adolescents with special/additional needs (Kleespies et al., 2021). In one manuscript, the targeted and studied populations did not match (Cheung et al., 2020). Of those studies providing a detailed breakdown of manuscript participants, between 112 and 30,753 volunteers were invited to participate in the included manuscripts, and between 60 and 3,090 completed the study. Of all the samples studied, 48% treated gender as a binary variable. However, several studies did not report the gender of participants ($n=17$). Only one study considered a third gender as the category "other" (Sobko et al., 2018). Most studies validated the scales in urban and/or rural contexts ($n=44$), a term used when there was a lack of clarity/specificity within the studies as to the type of environment in which the validation studies were carried out. Only two studies explicitly conducted their research in natural contexts (Clayton et al., 2021; Perkins, 2010), a term used when the participants of the manuscripts were in direct contact with nature (e.g., walking in the forest, gardening, practising exercise outdoors). The rationale of the dimensions and

constructs of 38 scales was based on theoretical frameworks, and 10 did not report their theoretical underpinnings.

In descending order, the following types of validity were mentioned in included manuscripts (see Table 4): construct ($n=22$), predictive ($n=5$), criterion and content ($n=3$, respectively), concurrent, face and external ($n=2$, respectively), cross-cultural, incremental, ecological, criteria, intercultural, structural, and known-group ($n=1$, respectively). However, the type of validity was not specifically reported in nine studies. About 14% of the manuscripts reported test-retest reliability, while 86% reported internal consistency reliability.

Quality Assessment (QA)

The QA revealed that five manuscripts had a high/adequate quality (see Table 5) (Matas-Terrón & Elósegui-Bandera, 2012; Olivos et al., 2011; Pasca et al., 2020; Perrin & Benassi, 2009; Rosa et al., 2020), nine had a moderate/sufficient quality (Beery, 2013; Brügger et al., 2011; Clayton et al., 2019; Dutcher et al., 2007; Gkargkavouzi et al., 2021; Martin & Czellar, 2016; Mundaca et al., 2021; Navarro et al., 2017; Nisbet & Zelenski, 2013), 10 had doubtful/low quality (Cheng & Monroe, 2010; Cheung et al., 2020; Chew, 2019; Meis-Harris et al., 2020; Nisbet et al., 2008; Pasca et al., 2018; Perkins, 2010; Richardson et al., 2019; P. W. Schultz et al., 2004; Suganthi, 2019), and 11 had inadequate/very low quality (Braito et al., 2017; Clayton et al., 2021; Davis et al., 2009; Hatty et al., 2020; Kleespies et al., 2021; Li & Lang, 2014; Mayer & Frantz, 2004; Olivos et al., 2011; Pasca et al., 2017; Sobko et al., 2018; Tam, 2013a).

None of the manuscripts performed all sections indicated in COSMIN. Internal consistency was the best-evaluated psychometric property, with 29 manuscripts rated in the high/adequate category. Content validity was the property that was most often rated as doubtful/low. Structural validity was the property most frequently rated as moderate/sufficient. The psychometric property that was most often calculated was structural validity ($n=35$), while measurement error was never calculated ($n=35$). Regarding the validities that determine the extent to which the instrument is designed to measure the construct to be evaluated accurately, it emerged that only 13 manuscripts from the hypothesis testing for construct validity were classified within the high/adequate range, while 12 studies did not calculate the construct validity. On the one hand, 57% of the manuscripts calculated their correlation with one or more scales that also measured nature connectedness (e.g., the Nature Connectedness Scale or the Environmental Identity Scale). The remaining 43% did not calculate their correlation with a scale measuring only nature

Table 4. Explicitly Reported Validity and Reliability of Scales Sorted by Stage of Life.

Stage of life	Author; Year	Name of the scale	Psychometric properties	
			Explicitly reported validity	Reliability
Children	Cheng & Monroe (2010)	Children's Connection to Nature Index	NR	$\alpha = .87$
	Sobko et al. (2018)	Connectedness to Nature Index - Parent Preschool Children (CNI-PPC)	Face, construct, external, criteria	Enjoyment of nature: $\alpha = .86$; Empathy for nature $\alpha = .87$; Responsibility toward nature: $\alpha = .75$; Awareness of nature: $\alpha = .80$
Children, adolescents and adults	Clayton et al. (2021)	Revised Environmental Identity Scale (EID-R)	Criterion, cross-cultural, intercultural, face validity	Sample 1: $\alpha = .94$; Sample 2: $\alpha = .94$; Sample 3: $\alpha = .82$; Sample 4: $\alpha = .86$; Sample 5: $\alpha = .87$; Sample 6: $\alpha = .94$; Sample 7: $\alpha = .87$; Overall: $\alpha = .89$
	Kleespies et al. (2021)	Extended Illustrated Inclusion of Nature in Self Scale (IINS)	Study 2 + 3: construct	Correlation of EINS With CNS: $R = .570$; Correlation of EINS With NR-6: $R = .605$
Children and adults	Mundaca et al. (2021)	The Emotional and Cognitive Scale of the Human-Nature Relationship (ECS-HNR)	Construct	EAW: Perception $\alpha = .73$; Appreciation $\alpha = .71$; Understanding $\alpha = .71$; EAF: Connectedness $\alpha = .75$; Enjoyment $\alpha = .64$; Empathy $\alpha = .64$
	Richardson et al. (2019)	Nature Connection Index (NCI)	Concurrent	Adolescents and adults: FA1 $\alpha = .92$, FA2 $\alpha = .92$; Children and Adolescents: FA3 $\alpha = .85$
Children and adults	Li & Lang, (2014)	Human-Nature Relationship Scale (HNR- Scale)	NR	3 Items factor: $\alpha = .669$; 2 Items factor: $\alpha = .629$
	Chew (2019)	(A) Environmental Identity Scale (EID) (Long and Short Version), (B) Nature Relatedness Scale (NRS) (Long and Short Version)	NR	EID full version: $\alpha = .96$; EID Short version: $\alpha = .92$; NRS Full version: NR Self $\alpha = .87$; NR Experience $\alpha = .77$; NR perspective $\alpha = .62$; NRS short version: $\alpha = .82$

(continued)

Table 4. (continued)

Stage of life	Author; Year	Name of the scale	Psychometric properties	
			Explicitly reported validity	Reliability
	Clayton et al. (2019)	Russian Version of the Environmental Identity (EID) Scale	Content, construct	$\alpha = .88$
	Davis et al. (2009)	Environment Scale (COM)	Study 1: construct Study 2: ecological, predictive	$\alpha = .91$
	Martin and Czellar (2016)	Extended Inclusion of Nature in Self Scale (EINS)	Study 2a: Construct, criterion Study 2b: external Study 3a: criterion, construct Study 3b: criterion, construct Study 4: construct	Study 2a: $\alpha = .82$; Study 2b: $\alpha = .87$; Study 3a: $\alpha = .87$; Study 3b: $\alpha = .90$; Study 4: Test-Retest Reliability T1: $\alpha = .88$, T2: $\alpha = .91$, $R = .843$
	Mayer and Frantz (2004)	Connectedness to Nature Scale (CNS)	Study 1: Construct Study 2: construct	Study 1: $\alpha = .72$ and $\alpha = .84$ (after erasing items); Study 2: $\alpha = .82$; Study 3: $\alpha = .82$; Study 4: $\alpha = .79$; Study 5: $\alpha = .79$
	Nisbet and Zelenski (2013)	Nature Relatedness Scale (NR-6)	Study 4: predictive, concurrent	Study 1: $\alpha = .83$; Study 2: $\alpha = .84$; Study 3: $\alpha = .86$; Study 4: Community/Students $\alpha = .90/.89$ at baseline, $\alpha = .89/.90$ at 1 month
	Nisbet et al. (2008)	Nature Relatedness Scale (NR)	Construct	Phase 1: Overall $\alpha = .87$; NR-Self $\alpha = .84$; NR-Perspective $\alpha = .66$; NR-Experience $\alpha = .80$. Phase 2: (Test-Retest): NR $\alpha = .85$; NR-Self $\alpha = .81$; NR-Perspective $\alpha = .65$; NR-Experience $\alpha = .85$
	Pasca et al. (2020)	Love for Nature Scale (LNS)	Study 3: construct	Study 2: Unidimensional Model $\alpha = .90$; Two-Dimensional Model $\alpha = .87/.69$; Study 3: $\alpha = .95$

(continued)

Table 4. (continued)

Stage of life	Author; Year	Name of the scale	Psychometric properties	
			Explicitly reported validity	Reliability
Adults	Tam (2013a, 2013b)	(A) Commitment to Nature (COM), (B) Connectedness to Nature (CTN), (C) Connectivity with Nature (CWN), (D) Emotional Affinity Toward Nature (EATN), (E) Environmental Identity (EID), (F) Inclusion of Nature in Self (INS), (G) Nature Relatedness (NR), (H) Allo-Inclusive Identity (AID), (I) Love and Care for Nature (LCN)	Convergent, incremental, construct	Study 1: COM: $\alpha = .83$; CTN: $\alpha = .79$; CWN: $\alpha = .61$; EATN: $.84$; EID: $\alpha = .89$; INS: $-.$; NR: $\alpha = .83$; AID: $-.$; LCN: $-.$; Study 2: COM: $\alpha = .93$; CTN: $\alpha = .89$; CWN: $\alpha = .86$; EATN: $\alpha = .93$; EID: $\alpha = .96$; INS: $-.$ NR: $\alpha = .83$; NR: $\alpha = .90$; AID: $\alpha = .92$; LCN: $\alpha = .97$
	Beery (2013)	Measure of Environmental Connectedness (EC)	Construct	$\alpha = .83$
	Braito et al. (2017)	Human-Nature Relationship Scale	NR	α for most single statements: > 0.6 ; Reliability for Groups User $\alpha = .43$ Master $\alpha = .53$; Nature Distant Guardian $\alpha = .55$
	Brügger et al. (2011)	Disposition to Connect with Nature Scale (DCN)	Predictive, construct	Rasch-Model-Based Reliability-Estimates or Internal Consistency Reliability $\alpha = .89$
	Cheung et al. (2020) Dutcher et al. (2007)	Chinese Version of the CNS Connectivity with Nature	Construct NR	$\alpha = .74$ First Factor: $\alpha = .72$; Second Factor: $\alpha = .77$; Third Factor: $\alpha = .67$

(continued)

Table 4. (continued)

Stage of life	Author; Year	Name of the scale	Psychometric properties		
			Explicitly reported validity	Reliability	
	Gkargkavouzi et al. (2021)	(A) Connectedness to Nature Scale (CNS), (B) Environmental Behavior (EB), (C) Environmental Concern (Construct measured through the Environmental Motives Scale (EMS))	Construct	CNS Connectedness to Nature $\alpha = .88$; EMS Biospheric Motives Concern $\alpha = .94$; Egoistic Motives Concerns $\alpha = .92$; Altruistic Motives Concerns $\alpha = .87$; EB Environmental Action $\alpha = .90$; Personal Practices $\alpha = .90$ CN-Total $\alpha = .94$; CN-Identity $\alpha = .88$; CN-Experience $\alpha = .90$; CN-Philosophy $\alpha = .77$ $\alpha = .772$	
	Hatty et al. (2020)	Connection with Nature-12 (CN-12)	Construct, predictive		
	Matas-Terrón and Elósegui-Bandera (2012)	Spanish Adaptation of the Connectedness to Nature Scale	NR		
	Meis-Harris et al. (2020)	AIMES Connection with Nature Scale	Construct		Attachment $\alpha = .87$; Identity $\alpha = .88$; Materialism $\alpha = .65$; Experiential $\alpha = .84$
	Navarro et al. (2017)	CNS French Version	Study 2: convergent Study 3: convergent, construct, predictive	Study 1: $\alpha = .80$; Alpha Per Item: (A) $\alpha = .78$, (B) $\alpha = .77$, (C) $\alpha = .78$, (D) $\alpha = .82$, (E) $\alpha = .77$, (F) $\alpha = .76$, (G) $\alpha = .76$, (H) $\alpha = .79$, (I) $\alpha = .77$, (J) $\alpha = .78$, (K) $\alpha = .76$, (L) $\alpha = .83$, (M) $\alpha = .78$, (N) $\alpha = .82$; Study 2: $\alpha = .85$; Study 3: R = .774	
	Olivos et al. (2011)	Environmental Identity Scale (EID)	Construct, predictive	Overall $\alpha = .90$	

(continued)

Table 4. (continued)

Stage of life	Author; Year	Name of the scale	Psychometric properties	
			Explicitly reported validity	Reliability
	Olivos et al. (2011)	Spanish Version of the Connectedness to Nature Scale	Construct	$\alpha = .788$
	Pasca et al. (2018)	Connectedness to Nature Scale (CNS)	NR	$\alpha = .811$
	Pasca et al. (2017)	Connectedness to Nature Scale-7 (CNS-7)	Construct	$\alpha = .866$
	Perkins (2010)	Love and Care for Nature (LCN) Scale	Study 3: construct Study 4: content, construct, criterion	$\alpha = .97$
	Perrin and Benassi (2009)	Connectedness to Nature Scale (CNS)	NR	$\alpha = .75$
	Rosa et al. (2020)	CNS-7 (Brazilian Version)	Structural, known-group, predictive, construct	$\alpha = .81$
	P. W. Schultz et al. (2004)	Inclusion of Nature in Self (INS) Scale	NR	Study 2: INS: Immediate Retest: $\alpha = .98$, 1-week Retest: $\alpha = 0.90$, 4-week Retest: $\alpha = .84$
	Suganthi (2019)	Ecospirituality Scale (ES)	Construct, content	Overall $\alpha = .953$

Notes. NR = not reported.

Table 5. Sectional and Global Quality Rating of Each Included Manuscript.

Stage of life	Author (Year)	Content validity										Hypotheses testing for construct validity					
		Relevance participants	Comprehensiveness	Participants	Comprehensibility	Participants	Relevance professionals	Comprehensiveness	Structural validity	Internal consistency	Cross-cultural validity/ measurement invariance	Reliability	Measurement error	Criterion validity	Convergent validity	Discriminative validity	Global rating
Children	Cheng & Monroe (2010)	NR	-	NR	NR	NR	+	+	NR	NR	NR	NR	NR	NR	NR	NR	-
Children, adolescents, and adults	Sobko et al. (2018)	-	-	NR	NR	+	+	+	NR	NR	NR	NR	NR	-	+	NR	-
	Clayton et al. (2021)	-	-	-	-	-	+	+	-	NR	NR	NR	NR	NR	NR	NR	-
	Kleespies et al. (2021)	-	NR	NR	NR	NR	o	-	NR	NR	NR	NR	NR	+	o	NR	-
Children and adults	Mundaca et al. (2021)	NR	NR	NR	NR	NR	o	+	NR	NR	NR	NR	NR	NR	NR	NR	o
	Richardson et al. (2019)	NR	NR	NR	NR	NR	o	+	NR	NR	NR	NR	NR	+	+	-	-
Children and adults	Li & Lang, (2014)	NR	NR	NR	NR	NR	-	+	+	NR	NR	NR	NR	NR	NR	NR	+
Adolescents and adults	Chew (2019)	NR	NR	NR	NR	NR	o	+	NR	NR	NR	NR	NR	NR	NR	NR	-
	Clayton et al. (2019)	NR	NR	NR	NR	NR	o	+	NR	NR	NR	NR	NR	NR	NR	NR	o

(continued)

Table 5. (continued)

Stage of life	Author (Year)	Content validity					Hypotheses testing for construct validity								
		Relevance participants	Comprehensiveness participants	Comprehensibility participants	Relevance professionals	Comprehensiveness professionals	Structural validity	Internal consistency	Cross-cultural validity/ measurement invariance	Reliability	Measurement error	Criterion validity	Convergent validity	Discriminative validity	Global rating
Adults	Davis et al. (2009)	NR	NR	NR	NR	NR	-	NR	NR	NR	NR	+	o	NR	-
	Martin and Czellar (2016)	NR	NR	NR	NR	NR	o	NR	NR	NR	NR	+	+	o	o
	Mayer and Frantz (2004)	NR	NR	NR	NR	NR	-	NR	-	NR	NR	+	NR	NR	-
	Nisbet and Zelenski (2013)	NR	NR	NR	NR	NR	o	NR	NR	o	NR	+	+	NR	o
	Nisbet et al. (2008)	NR	NR	NR	NR	NR	o	NR	-	NR	NR	NR	NR	NR	-
	Pasca et al. (2020)	NR	NR	NR	NR	NR	+	NR	NR	NR	NR	+	+	NR	+
	Tam (2013a, 2013b)	NR	NR	NR	NR	NR	o	NR	NR	NR	NR	+	o	NR	-
	Beery (2013)	NR	NR	NR	NR	NR	+	NR	NR	NR	NR	+	+	o	o
	Braito et al. (2017)	-	NR	NR	NR	NR	-	NR	NR	NR	NR	NR	NR	NR	-
	Brügger et al. (2011)	NR	NR	NR	NR	NR	o	NR	NR	NR	NR	+	+	+	o

(continued)

Table 5. (continued)

Stage of life	Author (Year)	Content validity						Hypotheses testing for construct validity							
		Relevance participants	Comprehensiveness participants	Comprehensibility participants	Relevance professionals	Comprehensiveness professionals	Structural validity	Internal consistency	Cross-cultural validity/ measurement invariance	Reliability	Measurement error	Criterion validity	Convergent validity	Discriminative validity	Global rating
	Cheung et al. (2020)	NR	-	-	-	-	+	NR	NR	NR	NR	NR	NR	NR	-
	Dutcher et al. (2007)	NR	NR	NR	NR	NR	+	NR	NR	NR	NR	NR	NR	NR	o
	Gkangakavouzi et al. (2021)	NR	NR	NR	NR	NR	+	NR	NR	NR	NR	NR	o	NR	o
	Hatty et al. (2020)	NR	NR	NR	NR	NR	+	NR	-	NR	NR	NR	+	NR	-
	Matas-Terrón and Elósegui-Bandera (2012)	NR	NR	NR	NR	NR	+	NR	NR	NR	NR	NR	+	NR	+
	Meis-Harris et al. (2020)	-	-	-	-	-	+	NR	NR	NR	NR	NR	NR	NR	-
	Navarro et al. (2017)	NR	NR	NR	NR	NR	+	NR	o	NR	NR	NR	+	+	o
	Olivos et al. (2011)	NR	NR	NR	NR	NR	+	NR	NR	NR	NR	NR	+	NR	+
	Olivos et al. (2011)	NR	NR	NR	NR	NR	+	NR	NR	NR	NR	NR	+	NR	-

(continued)

Table 5. (continued)

Stage of life	Author (Year)	Content validity										Hypotheses testing for construct validity					
		Relevance participants	Comprehensiveness	Participants	Comprehensibility	Participants	Relevance professionals	Comprehensiveness Professionals	Structural validity	Internal consistency	Cross-cultural validity/measurement invariance	Reliability	Measurement error	Criterion validity	Convergent validity	Discriminative validity	Global rating
	Pasca et al. (2018)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	-
	Pasca et al. (2017)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	-
	Perkins (2010)	-	-	-	-	-	-	o	+	NR	NR	NR	NR	NR	NR	NR	-
	Perrin and Benassi (2009)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	+
	Rosa et al. (2020)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	+
	P. W. Schultz et al. (2004)	-	NR	-	NR	NR	NR	o	NR	NR	-	NR	NR	NR	NR	NR	-
	Suganthi (2019)	-	-	-	-	-	-	o	+	NR	NR	NR	NR	NR	NR	NR	-

Note. Scores defined as follows: + = high/adequate; o = moderate/sufficient; - = doubtful/low; -- = inadequate/very low; NR = not reported.

connectedness. On the other hand, 23% of the manuscripts calculated their correlation with scales that did not measure connectedness with nature (e.g., New Ecological Paradigm, Positive and Negative Affect Scale, Pro-Environmental Behavior). The remaining 77% did not calculate their correlation with a non-nature connectedness scale. In addition, 25 manuscripts did not calculate content validity. The rating of the remaining studies ($n=10$) ranged between low and very low (see Figure 3). The rationale of the dimensions and constructs of 36 scales was based on a theoretical foundation. In comparison, 12 studies did not report the rationale for the included constructions and dimensions.

Discussion

This systematic review aims to: (1) provide an overview and (2) evaluate the methodological quality of the existing research that validates explicit instruments measuring the construct of nature connectedness in children, adolescents and/or adults with or without special needs. Several findings were obtained from the completion of the current systematic review. For instance, the low representation of developing countries in the validation of nature connectedness measurement scales, the lack of measurement scales that take vulnerable populations into account, the unclear measurement of state or trait nature connectedness, and the scarcity of high-quality research in the validation of nature connectedness construct measurement scales. Each of these findings will be explored below.

General Information of Included Manuscripts

The absence of a concise definition of the construct of nature connectedness was notable. This is consistent with previous research, which has also stated a multiplicity of nature connectedness terms (Tam, 2013a). Furthermore, it is important to mention that the lack of consensus in the operational definitions of the construct is problematic both conceptually and methodologically. For the purpose of this systematic review, the following definition was employed: People have a basic need of belonging (Baumeister & Leary, 1995), which can be satisfied by being subjectively (Pritchard et al., 2020) and positively (Barrable et al., 2021) connected to nature. Being connected to nature includes being close to (Wilson, 1984) or one with (Mayer & Frantz, 2004) the natural world.

This definition was designed to be broad in order to encompass a wide range of concepts. This approach not only reflects the existing literature but also allows for inclusivity in the literature search. However, it is important to

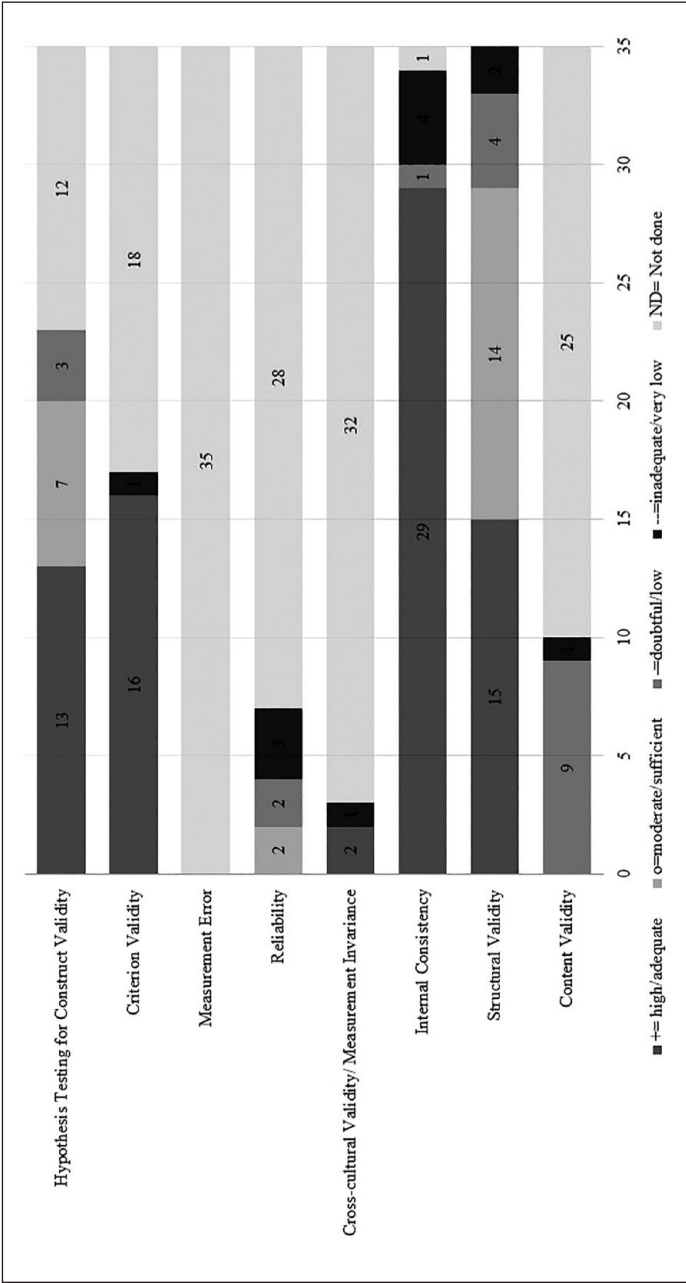


Figure 3. Quality rating per sections across included manuscripts.

argue some terms, psychologically, being one with nature (Mayer & Frantz, 2004) or being close to nature (Wilson, 1984) refers to the phenomena observed within various theoretical approaches that explain the benefits of this relationship for both humans and nature. Examples of such theoretical approaches include the biophilia hypothesis, attention restoration theory, and stress reduction theory (Kaplan, 1995; Ulrich et al., 1991; Wilson, 1984). In addition, the literature has shown a debate in which, on one hand, it argues that nature connectedness is capable of fulfilling belongingness needs (Baumeister & Leary, 1995; L. M. W. Li et al., 2021), while other authors suggest that it is an outcome of having a cognitive connection (Perrin & Benassi, 2009) or an affective connection (Perkins, 2010) with nature, rather than being a defining aspect itself.

Likewise, the authors identified many differing scales that correlate with one another to varying degrees consistent with previous findings (Restall & Conrad, 2015). For instance, W. P. Schultz (2002) characterizes nature connectedness as a cognitive experience, while Clayton (2003) defines it as the bond with nature and, Mayer and Frantz (2004) describe it as a more affective and experiential construct. These attempts of definitions reflect the strong disagreement in the literature. Therefore, despite the debates and divergences present in the literature, and in order to meet the requirements of this systematic review, the aforementioned preliminary definition was formulated.

According to the Human Development Report 2020 (United Nations, 2020), only one scale was developed in a medium human development country (Suganthi, 2019) and none of the studies included were conducted in a low human development country. This low representation of developing countries might be a bias in the measurement of the nature connectedness construct (Häyrynen & Pynnönen, 2020) because the time spent in nature and specific cultural factors have been shown to impact the nature connectedness of people and these elements differ considerably between Low, Medium, High, and Very High Human Development Countries (Dornhoff et al., 2019). Likewise, not all studies of scales performed a cross-cultural validation, which is a process needed to use them in other countries. This limits the measurement of nature connectedness in different nations, the integration of this topic in developing countries and, thus, the globalization of the nature connectedness construct (Scopelliti et al., 2016; Tam & Milfont, 2020).

In addition, it is important to note that the location where the scales were developed relates closely to the level of nature connectedness observed in men and women. This can be seen in previous research showing that nature connectedness in men and women may vary depending on the country (Clayton et al., 2021; Dornhoff et al., 2019). Therefore, the consideration of gender when generating nature connectedness measurement instruments is of

particular pertinence as women are more likely to suffer mental health diseases (i.e., depression) (WHO, 2022). Some research findings suggest that women may have a greater propensity to connect with nature than men (Haluza et al., 2014), which is an important factor to consider when developing mental health prevention programs for women, given the links between nature connectedness and positive mental health outcomes previously discussed. Furthermore, most of the scales were approached from a binary context (i.e., male/female), another aspect that limits equality (Human Rights Watch, 2022) and, therefore, places restraints upon the capacity for generalization of the scales.

Regarding the population, it was found that just two manuscripts out of 35 used children as the sole study population (Cheng & Monroe, 2010; Sobko et al., 2018), while five combined them with other populations (i.e., adolescents and/or adults) (Clayton et al., 2021; Kleespies et al., 2021; Li & Lang, 2014; Mundaca et al., 2021; Richardson et al., 2019). This not only shows that the measurement of the nature connectedness construct is based upon the opinions and responses of an adult population but also makes evident the lack of developmental research on nature connectedness that has been conducted to date. This is in line with Whitburn et al. (2020), stating that most of the research assessing the nature connectedness and Pro-Environmental Behavior constructs is based on the adult population. Furthermore, among the 35 studies, only one paper addressed a population of children with special needs (Kleespies et al., 2021). This paucity of research not only on children but also on adults with special or additional needs perpetuates the health inequity that this population experience and maintains the exclusion in which they are immersed (United Nations Children's Fund, 2023; WHO, 2023).

In addition, it is important to highlight the significant lack of intergenerational research on nature connectedness. None of the scales found measure nature connectedness specifically in older adults. This has led the research with this population to use unspecific measurement scales to assess levels of nature connectedness in older adults. For instance, Freeman et al. (2019) and Nisbet et al. (2020), conducted a mix-method study and a cross-sectional study respectively where they investigated how nature connectedness impacts age, how it changes over time, and how it impacts well-being. However, neither of them used a scale within their methodology that was specifically intended for an older population. This approach has a knock-on effect in limiting the validity of the study results.

Moreover, the findings demonstrate the lack of consensus in the assessment of the trait or state of the nature connectedness construct (e.g., Mayer & Frantz, 2004; Mundaca et al., 2021). The finding that 83% of the manuscripts

do not specify if nature connectedness is considered to be a trait construct, which means that it is neither modifiable nor malleable, or a state construct, which means that it is temporary and malleable, provides important insights (Schmitt & Blum, 2020). For instance, several studies have reported changes in nature connectedness using tools that did not report measuring trait (Choe et al., 2020; Coughlan et al., 2022; McEwan et al., 2021). This is an important gap that should be addressed in further research.

Sixty-nine percent of the studies validated their scales in urban and/or rural environments. This is critical because 55% of the world's population lives in urban environments (United Nations, 2018). It is important to promote and measure nature connectedness in environments that are related to the current conditions in which the majority of the population lives. This is in line with several research studies that demonstrate the relevance of conducting research, interventions, programs, and public policies to foster contact with nature in urban conditions (Barboza et al., 2021; Nieuwenhuijsen et al., 2022).

Quality Assessment (QA)

The major difficulty in assessing criterion validity was the lack of a consensus in measuring nature connectedness. For this reason, the two most commonly used scales "Inclusion of Nature in Self" and the "Connectedness to Nature Scale" (Mayer & Frantz, 2004; P. W. Schultz et al., 2004) were employed as the comparator instruments to calculate a correlation between the studied instruments.

Relatedly, due to the lack of a previously established instrument to measure convergent and discriminant validity, it was necessary to select scales to measure these two values. For convergent validity, all the scales included in the review were selected. For discriminant validity, all scales that were not included in the review, as they did not assess nature connectedness, were selected (i.e., the New Environmental Paradigm Scale, which intends to assess the level of agreement with a world view that promotes ecological values and attitudes, and the Positive and Negative Affect Scale, which assesses mood and emotion). This is in line with existing research, which states that the convergent validity of the nature connectedness construct has not been strongly studied (Tam, 2013a).

The relationship between humans and nature is intrinsically impacted by culture (Dornhoff et al., 2019). To mitigate the challenges that the world and society are facing, it is necessary to understand the environment in general but also at a more region-specific level. This highlights the need for additional research regarding the manner in which the human-nature relationship changes

from region to region. Therefore, it is important to generate instruments with sufficient psychometric properties to measure the nature connectedness construct across different regions and cultures. When the quality assessment was carried out, it was found that only 25% of the manuscripts that needed to calculate cross-cultural validity did so (Clayton et al., 2021; Li & Lang, 2014; Pasca et al., 2018). The need for cross-cultural research has recently been raised in the sub-discipline of environmental psychology (Tam & Milfont, 2020) and more broadly in psychology. This requirement also emerged in the findings of the current review (Henrich et al., 2010).

Regarding reliability, it was determined that 80% of studies did not calculate any type of reliability, making it impossible to draw firm conclusions on this psychometric property.

Strengths and Limitations

The present systematic review has several strengths but is ultimately limited by the quality of the extant literature as none of the evaluated studies reported all criteria investigated in the quality assessment. For reasons of objectivity, two independent researchers identified relevant scales from the literature, four independent researchers extracted data, and five independent researchers assessed the quality of included scales. In addition, the data extraction spreadsheet was piloted prior to use. A very comprehensive analysis of the studies was also carried out using the COSMIN procedure. Furthermore, both the QA, as well as the interpretation of results were performed separately to enhance the procedure and evaluation transparent.

Our research could be influenced by the absence of a universal definition of nature connectedness, requiring us to formulate our own concept based on existing literature. Consequently, we excluded scales that encompassed dimensions associated with empathy or pro-environmental behavior. Limiting our analysis to articles published in English may have impacted our search via selection bias.

Conclusion

Overall, our findings indicate challenges in the methodological quality of most manuscripts conducted to date. We conclude that the methodological rigor of current scales purporting to assess the concept is insufficient, limiting their wider application. Of 35 manuscripts, only five were reported as having a high/adequate quality rating. Based on this finding, there is a need for more high-quality manuscripts explicitly measuring nature connectedness. Future studies to develop and validate explicit nature connectedness scales should:

(a) Conduct research in a broader scope of continents/countries. (b) Longitudinal study designs are needed to examine test-retest-reliability to identify nature connectedness as a trait or state. (c) Researchers should strive to achieve consensus on the construct of nature connectedness (d) Ensure that the dimensions are adequately reflected in sub-scales. (e) Clear instructions on how to use scales are required to standardize their application. (f) Scales for children and adolescents are currently lacking, and efforts should be made to address this gap in the literature. (g) More heterogeneous samples should be investigated to ensure generalizability of scales (i.e., recruit not only students) and a more inclusive culture in participant recruitment should also be established for this reason (i.e., consideration of people with special or additional needs, with different socioeconomic background, and with diverse gender identity). (h) When reporting studies, it is recommended that a concise checklist be used to ensure that all relevant information is provided (e.g., gender ratio, location as either urban or rural, and theoretical foundation). (i) Scales should be validated systematically in order to consider different types of validity (e.g., cross-cultural or content validity) and reliability (e.g., measurement error). (j) Scales should clearly indicate whether they assess the state or trait dimension of the concept.

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Contribution of Effort

XT-O developed and piloted the strategy of the literature search, extracted data and assessed the quality of all included studies, analyzed data, and drafted the manuscript. AM, MP, and RJ were independent quality assessors. DMIS supervised XT-O. YD was involved in planning the review and had an advisory function in the quality assessment. TM and JB obtained the project's funding. DM proofread the manuscript. AM, MP, RJ, DMIS, YD, TM, DM, SS, DS, MJ, and JB critically reviewed the manuscript. All authors agreed with the final version to be published.

Declaration of Conflicting Interests

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