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# **Psychological and physical connections with nature improve both human well-being and nature conservation: A systematic review of meta-analyses**

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Psychological and physical connections with nature improve both human well-being and  
nature conservation: A systematic review of meta-analyses

**Type: Perspectives**

**Running title:** Human-nature connection and sustainability

29 **Abstract**

30 Despite growing evidence that “connectedness” of humans with nature creates multiple  
31 benefits for both humans and nature, these benefits are not fully considered by health and  
32 conservation policymakers. Studies are scattered across scientific disciplines including health,  
33 education, psychology and biology, making it difficult to get a complete overview. Here, we  
34 conduct a systematic review, focused on recent meta-analyses that investigate impacts of  
35 psychological and/or physical connection with nature on human health and well-being and on  
36 attitudes and actions that promote nature conservation. By “psychological connection” we  
37 mean the extent to which people see themselves as part of nature and by “physical  
38 connection” we mean contact with natural areas. We identified 16 relevant meta-analyses  
39 covering 832 independent studies. We found consistent conclusions across geographically  
40 diverse experimental studies that physical connection with nature improved human cognition,  
41 social skills, physical and mental health, and psychological connection to nature. Experiments  
42 also showed that psychological connection with nature had significant positive impact on pro-  
43 environmental behaviors and values. Correlational studies supported experimental results and,  
44 in addition, found psychological connection with nature positively correlated with mental and  
45 physical health. Studies are biased toward adults rather than children and away from southern  
46 regions (Africa, Oceania and South America). Overall, our review suggests a critical role for  
47 psychological and physical human-nature connections in developing a sustainable future.  
48 Although experimental studies are rare, conducting cross-cultural experimental research is  
49 needed if governmental and non-governmental stakeholders, researchers and citizens are to  
50 develop appropriate actions towards achieving United Nations Sustainable Development  
51 Goals.

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53 **Keywords:** human-nature interactions; health; people and nature; sustainability; pro-  
54 environmental behavior; nature-based conservation

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## 1. Introduction

Human activities are threatening natural systems and human health (He and Silliman, 2019; Rutz et al., 2020; Tollefson, 2020). To counter these negative impacts, four different conservation strategies have been proposed over the past 50 years (Mace, 2014): “*Nature for itself*” in which conservation actions protect nature from people, “*nature despite people*” in which conservation actions restore degraded environments, “*nature for people*” which focuses on the importance of nature for human well-being, health and economy and “*people and nature*” which focuses on bidirectional positive relationships between humans and other living beings (Howe et al., 2014). This last view, that human well-being and ecosystem health are coupled, has increasing evidence from the scientific literature. Several recent reports have concluded that success in reaching the United Nations Sustainable Development Goals and in achieving climate-resilient development necessitates incorporating maintenance of ecosystem health into planning for societal development (IPBES 2019; IPCC 2019; Pörtner et al. 2021, IPCC 2022).

Here, we focus on the “people and nature” concept, which explores the psychological, societal and cultural factors that should promote a sustainable, synergistic and resilient relationship between humans and other living beings (Howe et al., 2014; Mace, 2014; Whitburn et al., 2020). Peoples' differing worldviews - defined by Matthews (2009) as the “overall perspective on life that sums up what we know about the world” - are expected to be important influences on how citizens and stakeholders perceive, react to, and support public policies (Matthews, 2009; Mayer, 2018). In order to discuss existing worldviews about human-nature relationships, we identify below two categories that are easy to describe and that represent extremes of a continuum in peoples' perception of the relative importance of humans and non-human nature.

The ecocentric (or biospheric) worldview is “nature-centered” and assumes that humans are a part of the natural world. This may include the idea that humans have the same intrinsic value as other living beings and should live “in harmony” with them (Oelschlaeger, 1992; Salmón, 2000; Louv, 2008). By contrast, the anthropocentric worldview is “human-centered,” assuming that humans are the most important element in the system and that all other things exist to serve or be exploited by humans. In this latter worldview, nature is seen as a resource that can and should be controlled and managed by humans (Gagnon Thompson and Barton, 1994; Stokols, 1990).

In anthropocentric worldviews, which have become particularly well-developed in some sectors of industrialized societies (Stokols, 1990), humans see themselves as disconnected from the rest of nature (Barrable and Booth, 2022), both desiring and expecting to dominate and exploit other living beings through the development of new technologies. This psychological disconnection between humans and nature is emphasized by physical disconnection between people and the natural world through increasing urbanization and reduced opportunities to experience real nature, ultimately leading to the so-called “extinction of experience” with nature (Miller, 2005; Cazalis et al., in press). Both psychological and physical disconnection from the natural world may lead people to develop destructive habits, norms and practices towards nature, with adverse consequences for humans themselves (Stokols, 1990; Louv, 2008; Butchart et al., 2010; Estes et al., 2011; Brenner et al., 2015).

At the other end of the nature-connectedness spectrum, some traditional pre-industrialized societies do not make clear distinctions between humans and nature, considering non-humans

105 (animals and plants) as full and equal members of their own social community with whom  
106 they must maintain sustainable and reciprocal interactions (Alcorn, 1993; Salmón, 2000;  
107 Descola, 2013; Ojalehto Mays et al., 2020). Such a worldview has been shown to encourage  
108 sustainable norms and practices toward nature (Alcorn, 1993; Atran et al., 2002; Salmón,  
109 2000; Castleden et al., 2009). For example, one traditional society with an ecocentric  
110 worldview engaged in more practices favoring forest biodiversity than a neighboring  
111 traditional population, living in the same environment, that did not share such beliefs (Atran  
112 et al., 2002). In a second example, the traditional Native American "huu-ay-aht" society near  
113 Vancouver has implemented a management strategy for their forest whose name translates as  
114 "everything interacts, everything is one." "Everything" in this case includes animals, plants  
115 and humans, and the result has been sustainable forest management (Castleden et al., 2009).

116  
117 How do worldviews develop? Children, even in industrialized societies, tend to display  
118 spontaneous attraction to nature, described either as biophilia (Kellert and Wilson, 1993) or as  
119 "childish animism" (Piaget, 1929). Biophilia may indeed be "childish" in the sense of being  
120 lost as we age. Younger children showed higher "connection" with non-humans than  
121 adolescents (Hughes et al., 2019), and North American children under 9 years-old did not  
122 prioritize humans over non-human animals in a moral game, while adults did (Wilks et al.,  
123 2021).

124  
125 Our views on the degree and nature of resemblances between ourselves and other species are  
126 related to our behavior towards those species. Children who tended to assign intentionality  
127 and emotions to non-humans showed higher concern for the well-being of those non-humans  
128 than did other children (Gebhard et al., 2003). Similarly, adults from industrialized societies  
129 with a higher tendency to anthropomorphize non-humans engaged in more pro-environmental  
130 behavior than did humans in the same societies who were less prone to anthropomorphism  
131 (Waytz et al., 2010).

132  
133 Individuals in most industrialized nations seem to be influenced by worldviews that  
134 underestimate the actual impacts of nature on their welfare and behavior. Nisbet and Zelenski  
135 (2011) report that while individuals' happiness and environmental concern increased after  
136 taking an outdoor walk compared to an indoor walk, urban residents participating in a  
137 forecasting task systematically underestimated the positive impact on their daily lives of  
138 being exposed to a natural environment. This type of misunderstanding is problematic since it  
139 means that a worldview can prevent someone from correctly perceiving the benefits of being  
140 in nature, thereby facilitating behaviors with negative impacts on both health and  
141 environmental decision-making. In consequence, a worldview which places high value on  
142 technology might downplay the perceived efficiency of nature-based solutions for reaching  
143 sustainability targets.

144  
145 An important aspect of peoples' worldview is their psychological connection with nature, the  
146 extent to which humans see themselves as part of nature. This trait is most frequently  
147 described in the literature as "Human-Nature Connectedness" abbreviated as HNC and  
148 includes different concepts and metrics (e.g. nature relatedness, connectedness to nature,  
149 inclusion of nature in self, new environmental paradigm; see Tam, 2013 for a review).  
150 Hundreds of correlational studies show that HNC is linked to human welfare and nature  
151 conservation in industrialized countries and dozens of experimental studies show that being  
152 physically connected with nature (e.g., taking a walk in the forest) increases HNC (meta-  
153 analysis in Barragan-Jason et al., 2021). Yet, studies on this topic are scattered across various  
154 scientific disciplines such as health, education, psychology and biology, making it difficult to

155 create a complete and clear overview of findings. This difficulty may explain why the benefits  
156 for human health and nature conservation of physical and psychological connections with  
157 nature are still largely underappreciated by citizens in their daily lives (Nisbet and Zelenski,  
158 2011) and rarely considered or promoted by public policies. Here, we fill this research gap by  
159 including a wide range of disciplines, from biological to social science studies, in a systematic  
160 review of meta-analyses on the effects of psychological and physical connection with nature  
161 on human welfare and nature conservation. Our review, which covers 832 independent  
162 studies and 1876 effect sizes, is aimed at informing policy-makers in conservation and  
163 education.

164

## 165 2. Material and methods

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### 167 *Review question*

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169 We applied a broad definition of connections with nature to include both psychological  
170 connection - the extent to which people see themselves as part of nature - and physical  
171 connection that arises from contact with natural areas. We used Web of Science (WoS) from  
172 1900 to February 2022 to identify meta-analyses dealing with impacts of connections with  
173 nature on human welfare and/or nature conservation. We then followed the PRISMA  
174 guidelines to conduct the systematic review of these meta-analyses (O’Dea et al., 2021) using  
175 the RepOrting standards for Systematic Evidence Syntheses (ROSES) tool  
176 (<https://www.roses-reporting.com/>; Figure 1).

177

### 178 *Literature search and inclusion criteria*

179

180 We selected for inclusion only quantitative meta-analyses of independent studies following a  
181 robust and transparent methodology (PRISMA) and written in English. For instance, we did  
182 not include reviews, opinions, scoping reviews or meta-analysis of original unpublished data.  
183 We included both experimental and correlational studies, provided that they measured at least  
184 one physical or psychological connection with nature and at least one outcome falling within  
185 the scope of the present study. “Experimental studies” refer to papers studying the impact of  
186 an experimentally controlled or manipulated factor on an outcome variable while  
187 “correlational studies” assess observed relationships between two variables (Table 1). The  
188 distinction between the two is important, since only experimental studies can identify  
189 causality. For example, if people in good health were more likely to seek experience with  
190 nature (as a reviewer suggests), a positive association should be generated between good  
191 health and connection with nature that would be caused, not by an effect of connection with  
192 nature on health, but by the opposite, an effect of health on nature connection. This positive  
193 association would appear in studies that we describe as “correlative.” On the other hand, if  
194 human subjects were divided into groups chosen to be equivalent in their status of health and  
195 the groups were then given different experiences of nature, any differences that developed  
196 between the groups could be interpreted as effects of the difference in their treatment. This we  
197 would class as an experimental study. In general, such studies use manipulations to estimate  
198 the influence of one variable on another and to identify the nature and direction of causality.

199

### 200 *Study selection*

201

202 We based our search terms on a previous meta-analysis on a similar topic ([Barragan-Jason et al., 2021](#))  
203 with search terms corresponding to the three main factors of interest (nature  
204 welfare, human welfare and connections with nature). We used the following search terms:

205 meta-analys\* AND conservation, meta-analys\* nature, meta-analys\* AND well-being, meta-  
206 analys\* AND welfare, meta-analys\* AND pro-environment\*, meta-analys\* AND natur\*  
207 AND connect\* (WoS format) with ‘Title word’ and ‘English language’ options. We obtained  
208 359 records identified through database searching and 4 records identified in other published  
209 papers (see Figure 1). Title, authors, year of publication, abstract and full references were  
210 extracted in an excel file.

211

### 212 *Data screening*

213

214 One researcher with high expertise in the topic screened all the records from “title and  
215 abstract” (Figure 1). After removing duplicates (N=15) and articles out-of-the scope (e.g., not  
216 about physical or psychological connection with nature; not English), we obtained 19 records.  
217 One full text was not available even after emailing the corresponding author. The remaining  
218 18 full-texts were then screened. At the end of the screening, four records were removed: two  
219 records were out of scope, one record was qualitative and one was not a meta-analysis of  
220 independent studies but a meta-analysis of original data. Three additional records were  
221 identified from a previous study (pre-screened papers; Figure 1).

222

### 223 *Data extraction and coding*

224

225 At the end of the process, **16 meta-analyses** met our eligibility criteria (Figure 1). These 16  
226 meta-analyses covered 832 independent studies with a total of 1876 effect sizes (Table 1).  
227 Following previous meta-analyses (e.g. Barragan-Jason et al., 2021; Mackay and Schmitt,  
228 2019), we identified “age”, “sample size”, “world region” and “type of outcome” as factors  
229 that might explain heterogeneity in effect sizes. We therefore extracted the following factors  
230 from the 16 meta-analyses: number of participants, number of studies included, world region  
231 where the studies have been conducted (Africa, Asia, Europe, North America, South America  
232 and Oceania), age group (children: below 18 years-old, adults: more than 18 years old), type  
233 and measure of connection with nature (physical or psychological) and sustainable outcome  
234 (e.g. physiological health, self-report well-being; pro-environmental behavior; Tables 1 and 2;  
235 Table A1 in online appendix). We also extracted information about the conservation  
236 strategy/framework in which the meta-analysis was done. Meta-analyses that focused on the  
237 benefits of nature for humans only were coded as “nature for people” while those which  
238 focused on pro-environmental attitudes were coded as “nature despite people.” Studies that  
239 mentioned the terms biophilia or interdependency were coded as “people and nature” (Table 1  
240 and 2). We also listed potential limitations and biases (Table 2). Finally, we extracted effect  
241 size estimates for each meta-analysis; zero-order Pearson correlations for correlational studies  
242 and standardized Means Difference for experimental data that we both transformed into R  
243 estimates (Table A2 and A3 in online appendix).

244

## 245 **3. Results**

246

### 247 *Geographic and Bibliographic Location of studies*

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249 Studies were mostly conducted in countries located in North America (42%), Europe (28%)  
250 and Asia (25%) while only 3% were conducted in Oceania and South America, and none in  
251 Africa (Figure 2; Table 2). Additionally, 80% of the studies were conducted on adults,  
252 children were under-represented (Table 2). Most of the meta-analyses (N=11) were in social  
253 science journals (health: 5; psychology: 5; economics: 1) while five were in biological  
254 publications (Table 1).

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### *Categorization of studies*

Among the 16 meta-analyses included, half of the papers reported experimental studies while the other half reported correlational studies (Table 1 and Table A1 to A3 in online appendix). Nine meta-analyses were conducted within the “nature for people” framework in which the utilitarian value of nature for human health is central while five meta-analyses investigated the impact of nature connection on nature conservation within the framework of “nature despite people.” Three meta-analyses discussed their results within an evolutionary framework in which the biophilia hypothesis was used to explain the relationships between nature connections, human welfare and nature conservation. The remaining meta-analyses included multiple frameworks (“nature for people” and “people and nature”).

### *Summary of conclusions*

Experimental studies. Meta-analyses of experimental studies showed significant positive effects of physical connection with nature on physical, mental and social health and on socio-cognitive abilities (details and references in Table 1). One meta-analysis showed that physical connection with nature, especially through nature-based mindfulness, improved psychological connection with nature (Barragan-Jason et al., 2021). In turn, psychological connection with nature had a positive impact on pro-environmental behaviors (Mackay and Schmitt, 2019 Figure 2 and Tables 1, 2, A1 to A3).

The physical connections used in these experiments included natural sounds, outdoor activities, gardening and nature-based mindfulness intervention consisting of being outside while focusing on the present environment. Natural sounds with a higher species richness and with nature-based mindfulness had a higher impact on human health than other treatments ( $R = 0.29-0.64$  and  $R = 0.19-0.97$ , respectively; Buxton et al., 2021; Djernis et al., 2019).

Effect size varied widely between experimental studies (Figure 3). A number of potential explanations are listed in Table 2; they include small sample sizes and absence of controls for quality and for confounding variables as well as a wide variety of well-being measures. Measures of effects on physical health included vitality, stress, cortisol level and pulse rate, while measures of mental health included positive affect, mood, and anxiety. We also observe a lack of experimental studies showing causal relationships between psychological connection with nature and human well-being and no meta-analysis, whether correlational or experimental, investigating links between physical connection with nature and nature conservation.

Correlational studies. Meta-analyses of correlational studies supported the relationships revealed in experimental work and, in addition, documented moderate to strong positive associations between human welfare, psychological connections with nature and pro-environmental behaviors (references and details in Table 1). It is questionable to deduce cause and effect from correlational data. However, several authors of correlational studies have used either structural equation models or path analysis to suggest cause-effect relationships, in particular that psychological connection with nature directly affects pro-environmental values, human well-being and health and pro-environmental behaviors. Barragan-Jason et al. (2021) listed these studies, questioned their attributions of cause-effect and called for further experimental studies to confirm causation.

## **4. Discussion**

305 Our systematic review includes several experimental studies which show that (1) being  
306 physically connected with a natural environment is beneficial for human health and improves  
307 psychological connection with nature and, (2) being psychologically connected with nature is  
308 beneficial for nature conservation. Understanding these relationships and acting on them  
309 should assist societies in achieving sustainable outcomes.

310  
311 However, geographical and age-class analyses reveal an important bias toward adults from  
312 the northern regions of the world. In the global North, childhood experiences with the natural  
313 world have been shown to predict future sustainable practices (Rosa et al., 2018; Windhorst  
314 and Williams, 2015). Determining whether the same relationships hold in the global South is  
315 therefore required since countries situated in the South contain hotspots of biodiversity where  
316 relevant local values and traditions are particularly important to study. If we are able to  
317 understand and predict the impact of global changes on the development of human values,  
318 norms, and behaviors, we shall be better able to implement concrete actions to maintain  
319 connections with nature throughout life.

320  
321 Experimental studies have been conducted by researchers from various disciplines with  
322 different frameworks, methodologies, statistical analyses and key variables -for example,  
323 different types of contact with nature. A scoping review on effects of contacts with nature  
324 described different types of such contact, namely indirect (e.g. viewing nature on a video or  
325 through a window), incidental (e.g., encountering a tree while going shopping) or intentional  
326 (recreational activity such as hiking). Keniger et al. (2013) highlighted the need for  
327 conducting experiments to “design landscapes that promote high quality interactions between  
328 people and nature in a rapidly urbanizing world.” Similarly, in an opinion review, Soga and  
329 Gaston (2020) highlighted a lack of studies that include negative interactions with nature,  
330 such as being bitten by mosquitoes, along with the more well-studied positive  
331 interactions such as recreational activity. Physical connections with nature involving different  
332 aspects of the natural environment, such as biodiversity, degree of wildness, and air quality  
333 may have diverse effects, mostly positive but some negative. If we are to understand this  
334 diversity, future research should include high-quality experimental studies with large sample  
335 sizes and sophisticated analyses that would allow distinguishing between the effects of  
336 different aspects of the environment.

337  
338 We note the paucity of experimental studies seeking relationships between connection with  
339 nature and nature conservation; Figure 3 shows only one work in this category, Mackay et al.  
340 (2019). This situation may be due to a general anthropocentric bias that has led researchers to  
341 concentrate more on human health than on the health of other living beings (Figure 3). It is  
342 unfortunate that the several positive associations between nature connections and  
343 Conservation found in correlational studies (Figure 3) are not yet appropriately supported by  
344 experiment, and that robust conclusions about cause and effect cannot yet be drawn. We  
345 believe that ecologists and social scientists should collaborate and join forces to fill this gap, a  
346 gap that constrains our ability to explore in depth the potential benefits of connecting with  
347 nature as a driver of sustainability. The IPBES and the IPCC would likely agree, since both  
348 have called for integrating more diverse worldviews into conservation policies, including  
349 non-monetary benefits of nature and interdependency between human health and the health of  
350 ecosystems (Díaz et al., 2019).

351  
352 From the present review, two main aspects seem to be particularly beneficial in developing  
353 behaviors and values that promote nature conservation/sustainability-and improve human  
354 health: a high level of biodiversity (acoustic biodiversity in Buxton et al., 2021; landscape

355 wilderness in Djernis et al., 2019) and practicing nature-based mindfulness. These results  
356 have substantial implications for devising educational and health policies that are more  
357 effective at promoting sustainable development (Huynh et al., 2022; Lumber et al., 2017). As  
358 an example, greening urban centers and schoolyards will not only improve urban biodiversity  
359 (Filazzola et al., 2019) but will also improve human health, reduce inequality in providing  
360 access to nature for all whatever their socio-economic status (Bikomeye et al., 2021;  
361 Stevenson et al., 2020; van Dijk-Wesseliuss et al., 2018) and will improve sustainable values  
362 and behaviors (Barragan-Jason et al., 2021). Several initiatives such as the Paris “Oasis”  
363 Project in France or the Chicago's Auburn-Gresham in the US have already started in big  
364 cities, as well as numerous more local environmental programs (Phenice and Griffore, 2003).  
365 Conducting longitudinal studies to evaluate this type of projects as well as developing new  
366 efficient long-term research interventions are important considerations for educational and  
367 societal policy makers.

368

### 369 5. Conclusions

370 Reinforcing physical and psychological connection with nature is an important component for  
371 achieving conservation goals that can be achieved at moderate cost by greening schoolyards,  
372 urban centers, indoor rooms and by promoting nature-based mindfulness in schools and  
373 workplaces. Incorporating human behavior and values into conservation planning is an  
374 underestimated leverage point for achieving sustainability (Hiller and MacMillan, 2021;  
375 Travers et al., 2021). We hope that our synthesis will spur increasing valuation of human-  
376 nature connections in citizens’ daily lives (Nisbet and Zelenski, 2011). To do this should  
377 aid in the development of health, educational and conservation policies, and in the forging of  
378 desirable and sustainable relationships between humans and other living beings.

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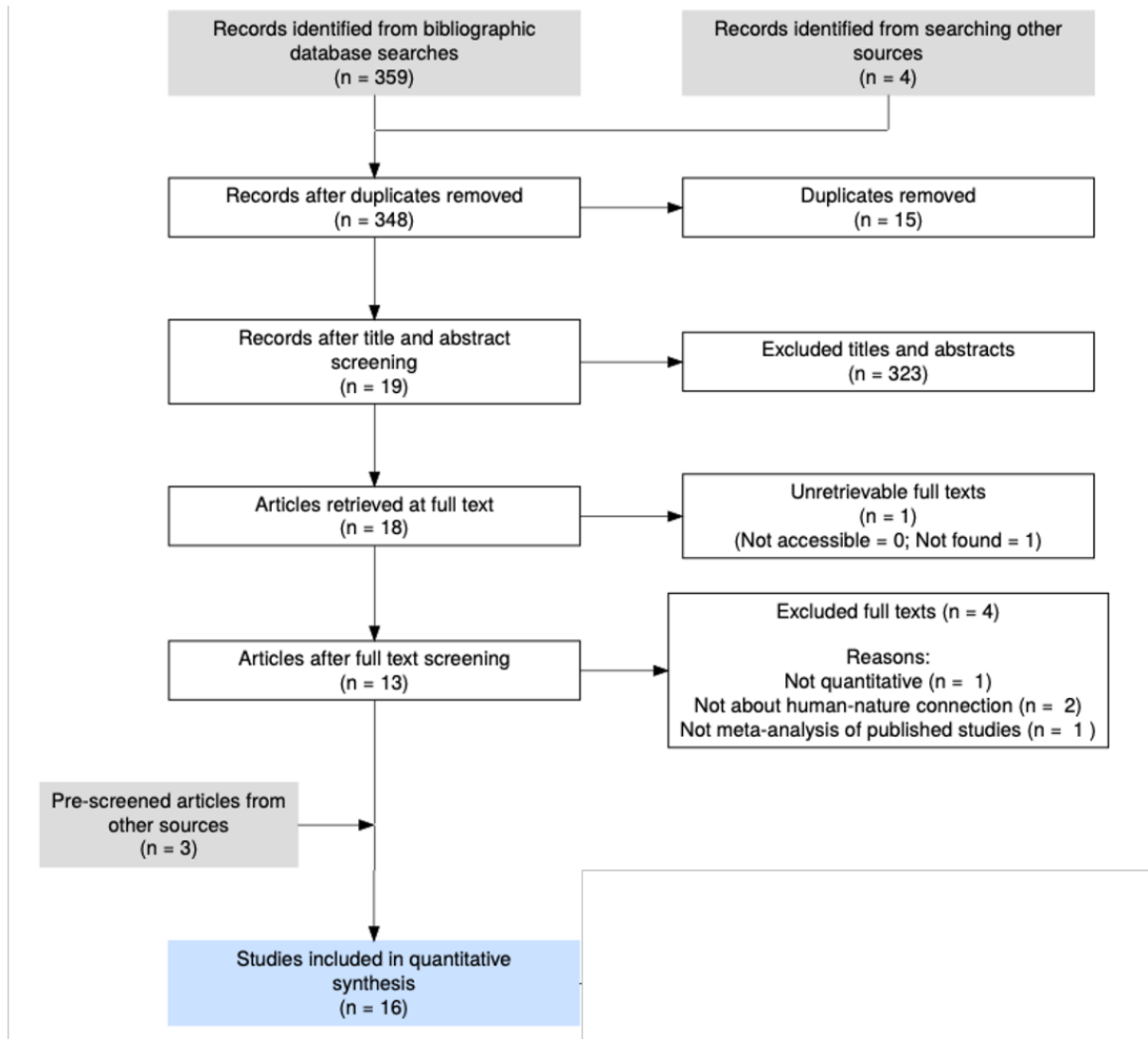
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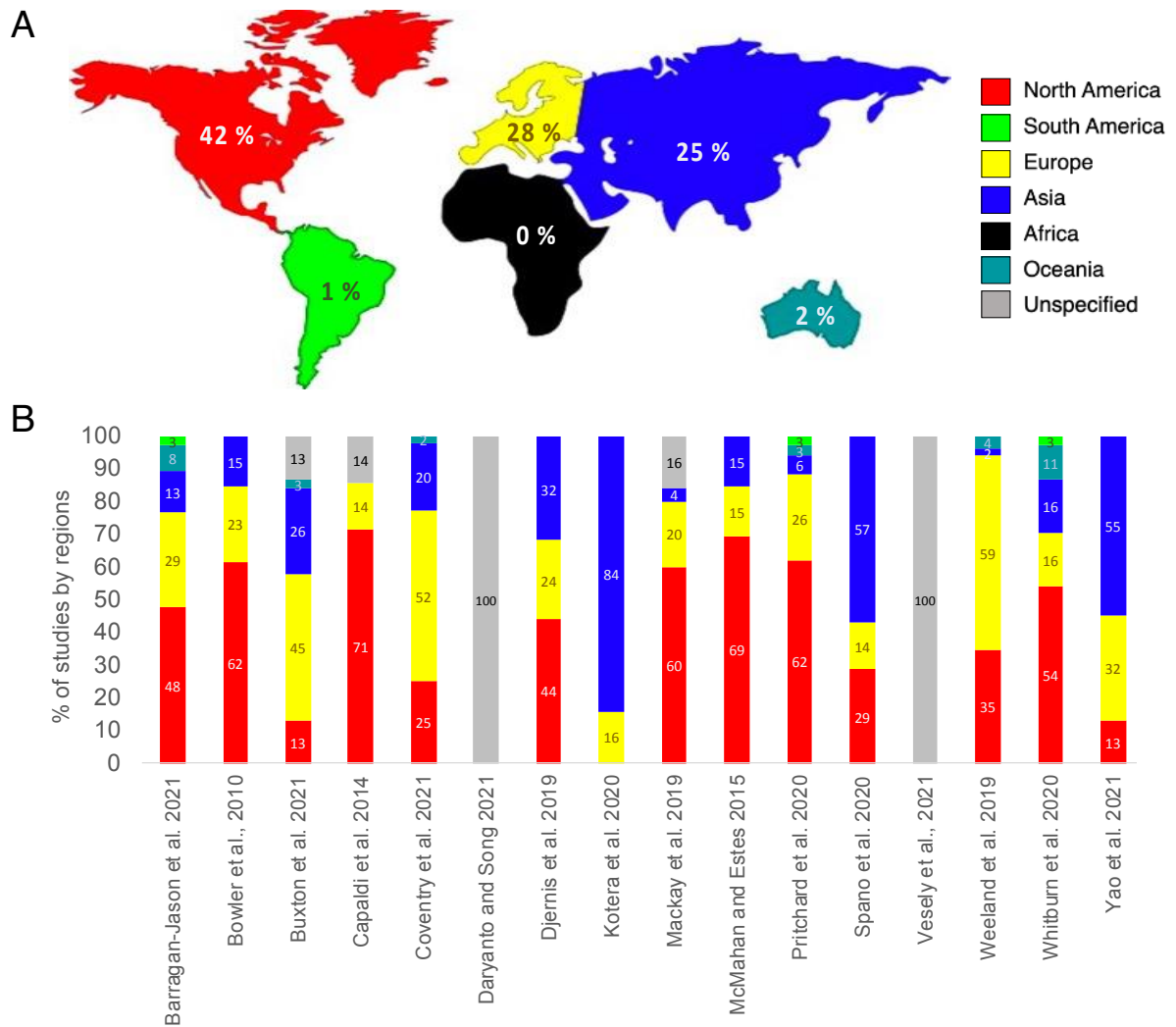
557 **Figures**  
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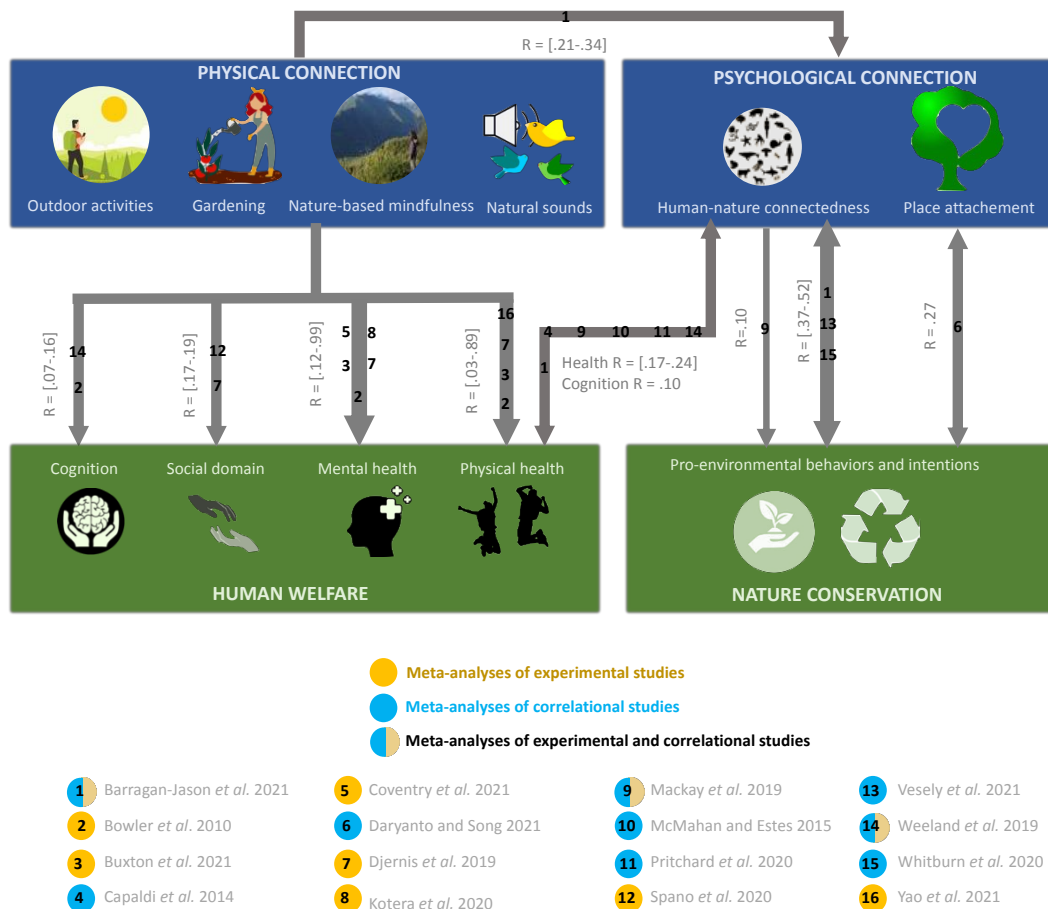
Figure 1. PRISMA flow diagram describing the different steps of the systematic review, from identification to inclusion.

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571 Figure 2. Geographical description of the studies included in the review. A) Overall  
572 percentage of studies by region (North America, Europe, Asia, Oceania, South America,  
573 Africa). B) Percentage of studies by world regions for each meta-analysis. Grey color refers to  
574 unspecified regions. Most of the studies are strongly biased toward North regions.  
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R = [.07-.16]    R = [.17-.19]    R = [.12-.99]    R = [.03-.89]

R = .10    R = [.37-.52]    R = .27

● Meta-analyses of experimental studies  
● Meta-analyses of correlational studies  
● Meta-analyses of experimental and correlational studies

1 Barragan-Jason <i>et al.</i> 2021	5 Coventry <i>et al.</i> 2021	9 Mackay <i>et al.</i> 2019	13 Vesely <i>et al.</i> 2021
2 Bowler <i>et al.</i> 2010	6 Daryanto and Song 2021	10 McMahan and Estes 2015	14 Weeland <i>et al.</i> 2019
3 Buxton <i>et al.</i> 2021	7 Djernis <i>et al.</i> 2019	11 Pritchard <i>et al.</i> 2020	15 Whitburn <i>et al.</i> 2020
4 Capaldi <i>et al.</i> 2014	8 Kotera <i>et al.</i> 2020	12 Spano <i>et al.</i> 2020	16 Yao <i>et al.</i> 2021

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Figure 3. Results from the systematic review of the 16 meta-analyses. Each round and number represent a published meta-analysis with meta-analyses of experimental studies in yellow and correlational studies in light blue. Connections with nature (physical and psychological) are represented in dark blue while positive outcomes (human welfare and nature conservation) are in green. Single headed arrows refer to causal relations from experimental data while double headed arrows refer to correlations. The thickness of the arrows represents the size of effect. Minimum and maximum averaged effect sizes R reported over the 16 meta-analyses are indicated into brackets when several meta-analyses have been done on the same outcome category. A single R value is provided when only one effect size has been reported (e.g., meta-analysis 6 and 9). All values are reported in Tables A1 to A3.

590 **Table 1. Description of the meta-analyses included in the review.**

	<b>Authors</b>	<b>Nature connection</b>	<b>Outcomes</b>	<b>Study design</b>	<b>Research area</b>	<b>Framework</b>
	Barragan-Jason <i>et al.</i> 2021	Psychological (HNC)	PEB, mental and physical health	Corr & Exp	Conservation	People and nature: biophilia
	Bowler <i>et al.</i> 2010	Mixed contact with nature	Cognition, mental and physical health	Exp	Health	Nature for people: health benefits (SRT)
	Buxton <i>et al.</i> 2021	Natural sounds	Mental and physical health	Corr & Exp	Interdisciplinary	Nature for people: health benefits (SRT, ART); People and Nature: biophilia
	Capaldi <i>et al.</i> 2014	Psychological (HNC)	Mental health	Corr	Psychology	People and Nature: biophilia
	Coventry <i>et al.</i> 2021	Outdoor activities	Mental health	Corr & Exp	Health	Nature for people: health benefits (SRT, ART)
	Daryanto and Song 2021	Psychological (PA)	PEB and intentions	Corr	Economics	Nature despite people: landscape management
	Djernis <i>et al.</i> 2019	Nature-based mindfulness	Mental and physical health; social domain	Exp	Health	Nature for people: health benefits (ART)
	Kotera <i>et al.</i> 2020	Nature-based mindfulness	Mental health	Exp	Health	Nature for people: health benefits (SRT, ART)
	Mackay <i>et al.</i> 2019	Psychological (HNC)	PEB	Corr & Exp	Psychology	Nature despite people: landscape management
	McMahan and Estes 2015	Outdoor activities	Mental health	Exp	Psychology	People and nature: biophilia; Nature for people: health benefits (SRT, ART)
	Pritchard <i>et al.</i> 2020	Psychological (HNC)	Mental health	Corr	Psychology	People and nature: biophilia; Nature for people: health benefits (SRT, ART)
	Spano <i>et al.</i> 2020	Gardening	social domain	Exp	Health	Nature for people; health benefits (therapy)
	Vesely <i>et al.</i> 2021	Psychological (HNC)	PE intentions, PEB	Corr	Conservation	Nature despite people: landscape management
	Weeland <i>et al.</i> 2019	Mixed contact with nature	cognition	Corr & Exp	Psychology	People and nature: biophilia; Nature for people: health benefits (SRT, ART)
	Whitburn <i>et al.</i> 2020	Psychological (HNC)	PEB	Corr	Conservation	Nature despite people: environmental management; People and nature: biophilia
	Yao <i>et al.</i> 2021	Mixed contact with nature	Mental and physical health	Exp	Conservation	Nature for people; health benefits (SRT, ART)

591 *\*Note: HNC: Human-nature connectedness; SRT: Stress Recovery Theory; ART: Attention Restoration Theory; PA: Place attachment; Corr:*  
592 *correlational studies; Exp: experimental studies. The Attention Restoration Theory (ART) suggests that exposure to nature attracts humans'*

593 attention spontaneously and without cognitive cost which allow individuals to develop other costly cognitive abilities (e.g. self-regulation in  
594 Wealand et al., 2019) while the Stress Reduction Theory (SRT) suggests that being exposed to nature decreases acute stress and negative  
595 thoughts and feeling (Ulrich et al., 1991). Detailed effect size values are provided in Table A1 and Table A2 in online appendix.

596 Table 2. Description of the limitations and biases identified in the meta-analyses.

Publications	Geographical bias	% of children	k; s	Limitations
Barragan-Jason <i>et al.</i> 2021	North America (43%), Europe (32%)	14%	k=1 019; s= 69736	geographical and population biases; no quality control
Bowler <i>et al.</i> , 2010	North America (61%), Europe (23%)	4%	k=45; s=3674	no confounder adjustment; small sample sizes; geographical and population biases
Buxton <i>et al.</i> 2021	Europe (44%), Asia (26%)	Unsp.	k=116; s=5369	small sample sizes; geographical and population biases
Capaldi <i>et al.</i> 2014	North America (71%)	Unsp.	k=48; s=8523	inclusion of unpublished data; geographical bias
Coventry <i>et al.</i> 2021	Europe (52%), North America (25%), Asia (20%)	0%	k=24; s=4268	small sample sizes, geographical and population biases
Daryanto and Song 2021	Unsp.	Unsp.	k=124; s=26273	unspecified geographical or population information
Djernis <i>et al.</i> 2019	North America (44%), Asia (32%), Europe (24%)	27%	k= 35; s=2990	small sample size; geographical and population biases
Kotera <i>et al.</i> 2020	Asia (84%)	0%	k=59; s=2062	small sample size, geographical and population biases
Mackay <i>et al.</i> 2019	North America (60%)	18%	k=92; s=4758	small sample size, no quality control, inclusion of unpublished data, geographical and population biases
McMahan and Estes 2015	North America (69%)	Unsp.	k=51; s=2356	small sample size, no quality control, geographical biases
Pritchard <i>et al.</i> 2020	North America (61%), Europe (26%)	3%	k=50; s=16396	no quality control, geographical and population biases
Spano <i>et al.</i> 2020	Asia (57%), North America (28%)	0%	k=11; s=825	no quality control, very small sample size, geographical and population biases
Vesely <i>et al.</i> , 2021	Unsp.	Unsp.	k=83; s=414282	no quality control, no geographical or population description
Weeland <i>et al.</i> 2019	Europe (60%), North America (35%)	100%	k=31; s=110277	no quality control, geographical and population biases
Whitburn <i>et al.</i> 2020	North America (54%)	17%	k=37; s=13237	no quality control, geographical and population biases
Yao <i>et al.</i> 2021	Asia (54%) and Europe (32%)	0%	k=51; s=1842	no quality control, geographical and population biases

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598 \*Note: Unsp.: Unspecified. *k* refers to the total number of effect sizes while *s* refers to the  
599 number of participants included in the meta-analyses.



## **Highlights**

- Analyses of roles of human-nature connections are scattered among research fields
- Gathering these studies together, we create a novel review, showing the following:
- being connected to nature is beneficial for human health and nature conservation
- reinforcing human-nature connections can improve sustainability more than expected
- these relationships are neglected by current public policies

## Abstract

Despite growing evidence that “connectedness” of humans with nature creates multiple benefits for both humans and nature, these benefits are not fully considered by health and conservation policymakers. Studies are scattered across scientific disciplines including health, education, psychology and biology, making it difficult to get a complete overview. Here, we conduct a systematic review, focused on recent meta-analyses that investigate impacts of psychological and/or physical connection with nature on human health and well-being and on attitudes and actions that promote nature conservation. By “psychological connection” we mean the extent to which people see themselves as part of nature and by “physical connection” we mean contact with natural areas. We identified 16 relevant meta-analyses covering 832 independent studies. We found consistent conclusions across geographically diverse experimental studies that physical connection with nature improved human cognition, social skills, physical and mental health, and psychological connection to nature. Experiments also showed that psychological connection with nature had significant positive impact on pro-environmental behaviors and values. Correlational studies supported experimental results and, in addition, found psychological connection with nature positively correlated with mental and physical health. Studies are biased toward adults rather than children and away from southern regions (Africa, Oceania and South America). Overall, our review suggests a critical role for psychological and physical human-nature connections in developing a sustainable future. Although experimental studies are rare, conducting cross-cultural experimental research is needed if governmental and non-governmental stakeholders, researchers and citizens are to develop appropriate actions towards achieving United Nations Sustainable Development Goals.

**Keywords:** human-nature interactions; health; people and nature; sustainability; pro-environmental behavior; nature-based conservation

1 Psychological and physical connections with nature improve both human well-being and  
2 nature conservation: A systematic review of meta-analyses  
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5 **Type: Perspectives**  
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7 **Running title:** Human-nature connection and sustainability  
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Figure 1

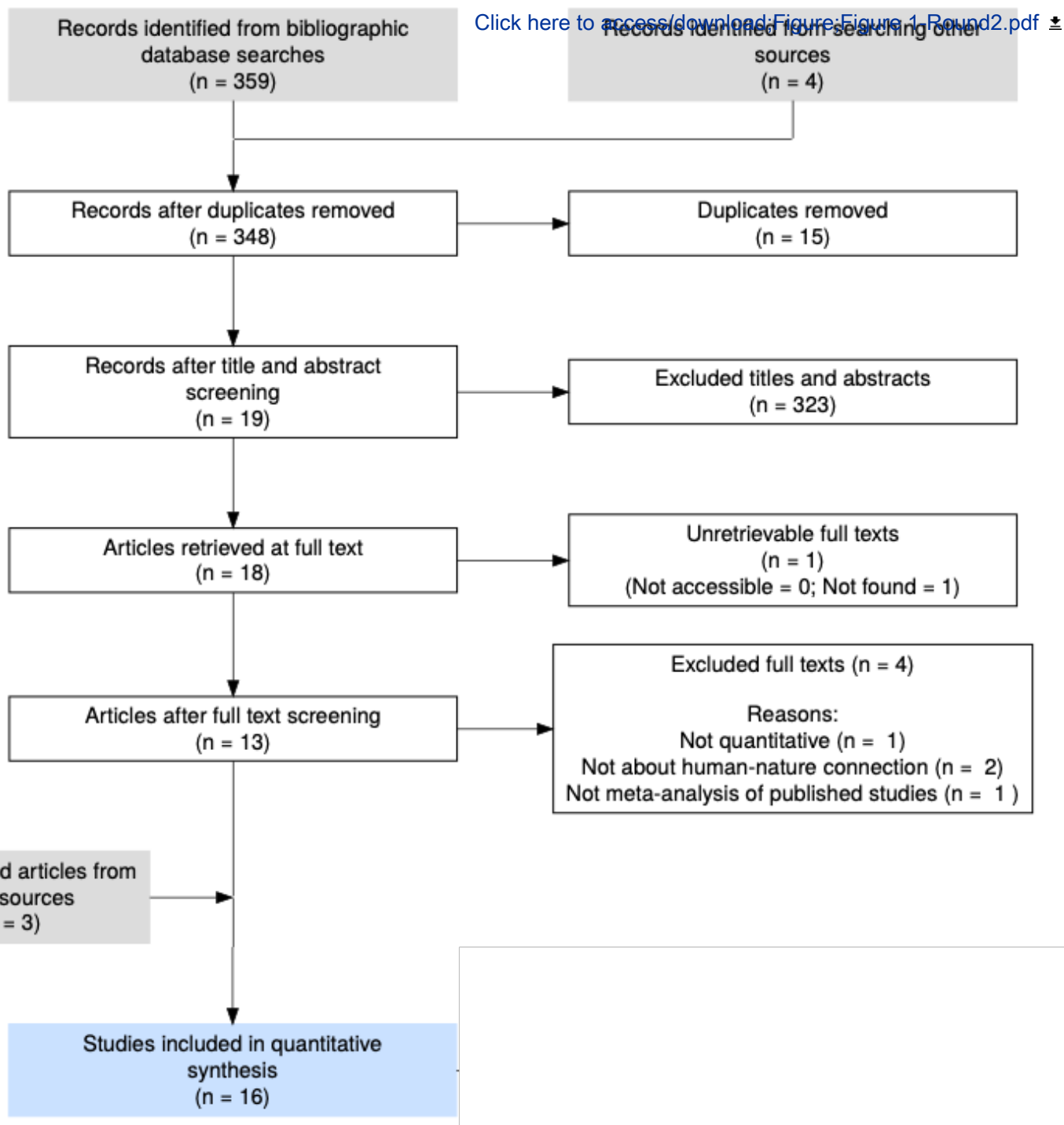
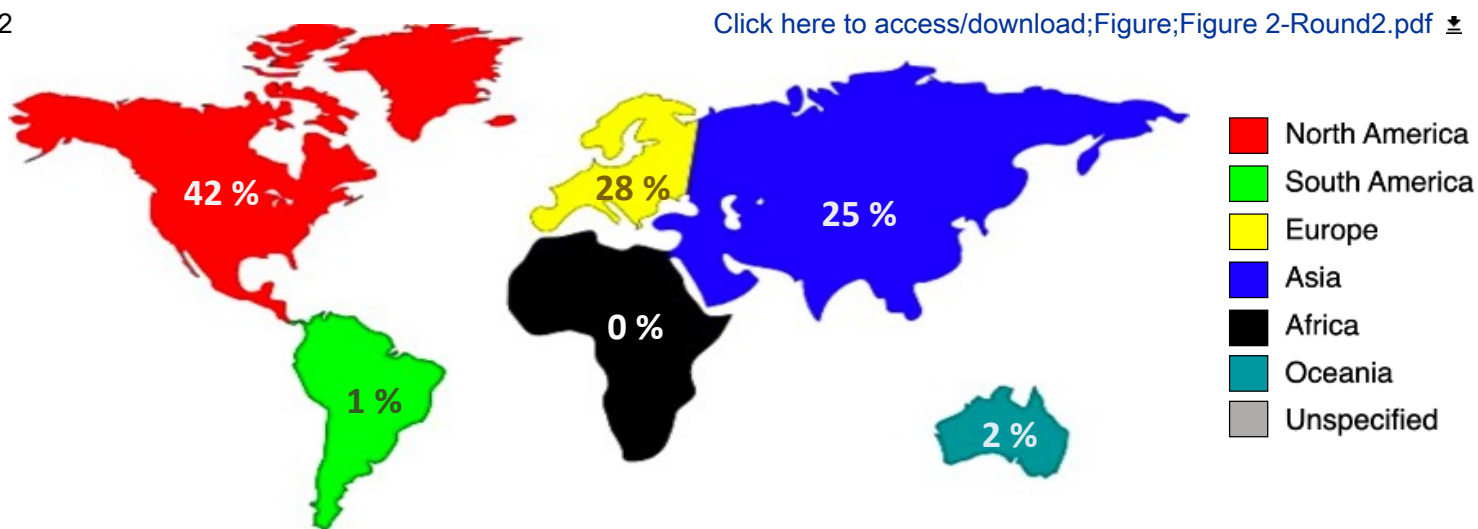


Figure 2

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B

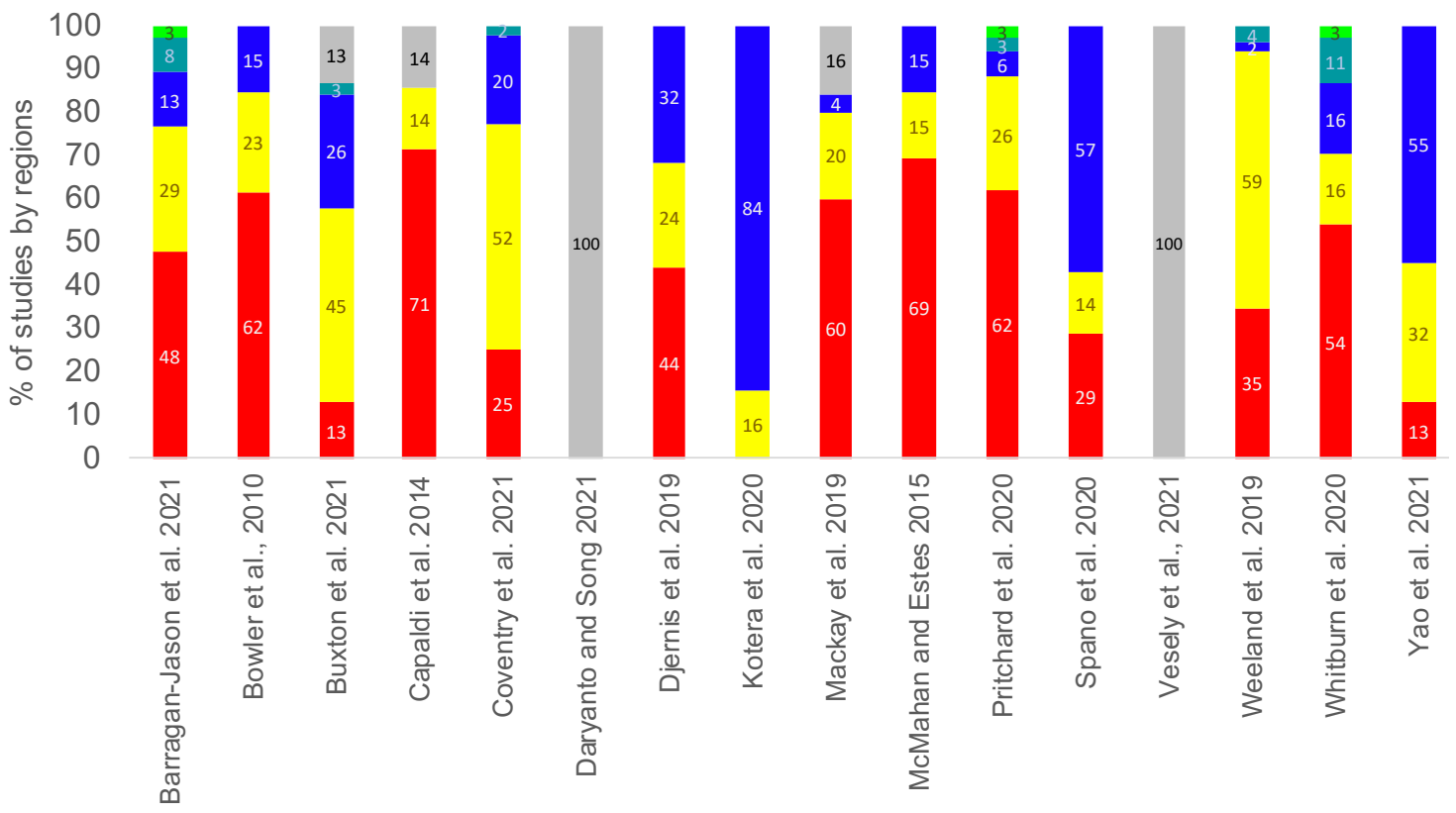
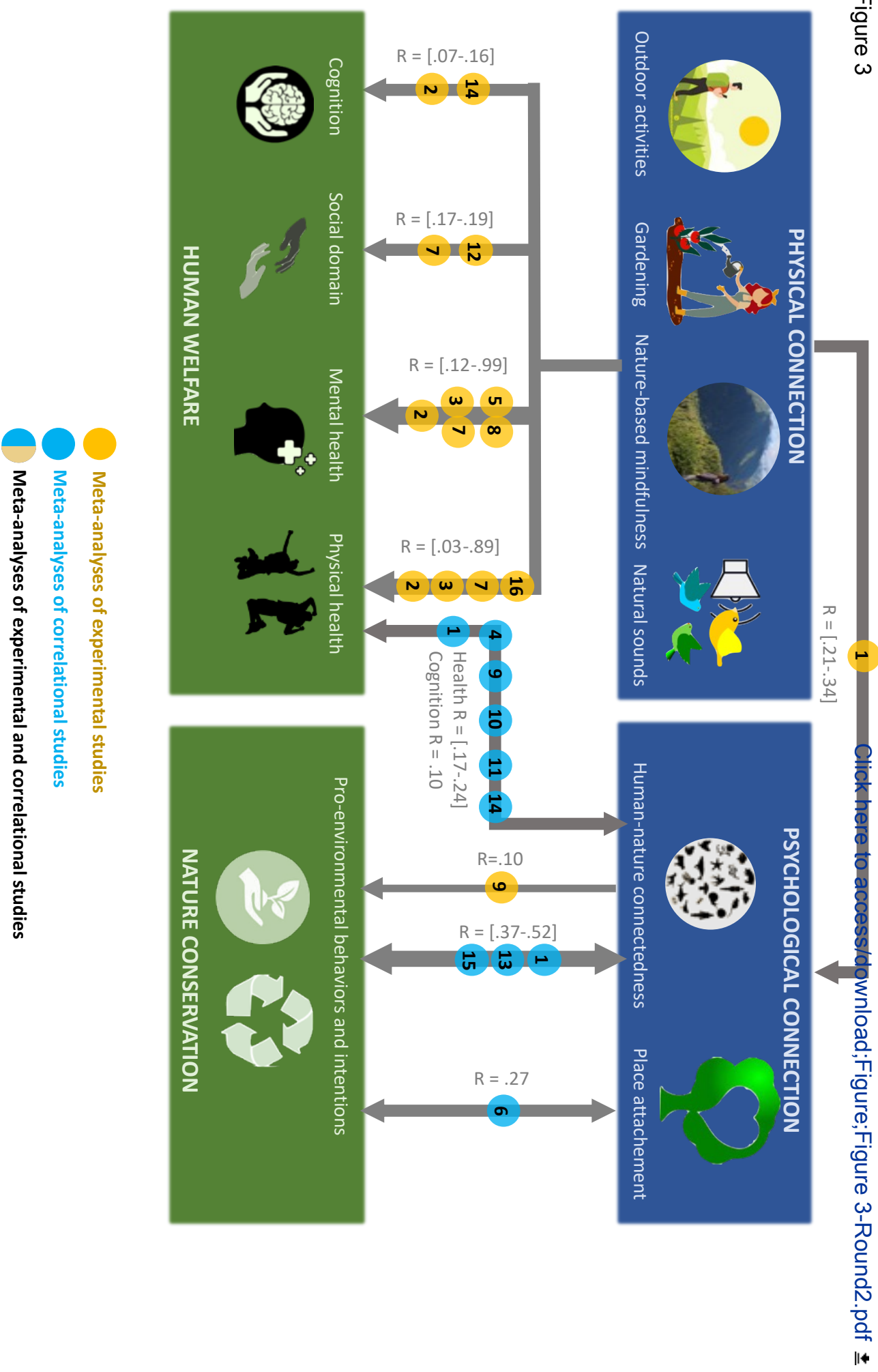


Figure 3



[Click here to access/download;Figure;Figure 3-Round2.pdf](#)

The authors have no competing interests to declare.

1 **Author contributions:** GBJ: Conceptualization, Original and final draft preparation,  
2 Methodology; CP: Conceptualization, Supervision, Writing- Reviewing and Editing; CM:  
3 Conceptualization, Writing- Reviewing and Editing; MS: Conceptualization, Writing-  
4 Reviewing and Editing; ML: Conceptualization, Writing- Reviewing and Editing  
5  
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