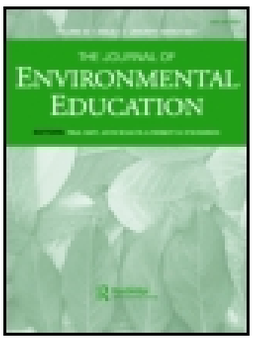

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RESEARCH ARTICLE

How combinations of recreational activities predict connection to nature among youth

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ABSTRACT

Connection to nature (CTN) can help promote environmental engagement requisite for addressing extreme environmental challenges. Current generations, however, may be less connected to nature than previous ones. Spending time in nature can counter this disconnect, particularly among children. In relation to CTN, this study evaluates the relative predictive power of solitary and social time in nature, specific recreation activities (e.g., camping), and diverse backgrounds (e.g., ethnicity) through a classification tree analysis with 9-to-12-year olds in the southeastern USA ($n = 1{,}285$). Solitary time in nature was the most important predictor of high CTN, and social time in nature was a secondary component of high CTN. In addition, in the context of this study, hunting and fishing were the most important activities predicting high CTN. Based on these results, we suggest providing solitary outdoor activities reinforced by environmental socialization to promote CTN for all.

KEYWORDS

Outdoor recreation; children; social environment; youth leisure; nature-based recreation

Introduction

As the planet continues to face more extreme environmental issues, environmental engagement is imperative, and connection to nature (CTN) can help promote this (Chawla, 2015). Current generations of Americans may be less connected to nature than in the past, which poses potential problems for human health and well-being, as well as environmental engagement (Kellert et al., 2017). For instance, research has linked spikes in obesity and mental health disorders in children with less time outdoors (National Wildlife Federation, 2010; No Child Left Inside: Reconnecting Kids with the Outdoors, 2007), and children were found to be more likely to correctly identify Pokémon characters than native wildlife (Balmford et al., 2002). However, high connection to nature (CTN) can lead to increased motivation to care for it and increased environmental behaviors (Arendt & Matthes, 2016; Frantz & Mayer, 2014).

Although definitions of CTN vary, most include both affinity for and comfort in nature (Cheng & Monroe, 2012; Nisbet et al., 2009). Affinity for nature focuses on positive, affective emotions toward nature which ranges from feelings of love to awe, wonder, and care. Comfort in nature includes ideas of safety – both physical and emotional, knowledge of nature, and physical comfort. Literature reviews on CTN define the term more broadly to include the diverse ways people relate to and identify with natural environments (Restall & Conrad, 2015). Cultures and worldviews, especially those embedded deeply in nature including those among indigenous tribes and communities shape CTN. Urban nature experiences, like pocket parks and window boxes may even impact CTN (Restall & Conrad, 2015). CTN has also been defined as having nature as part of one's identity – such as identifying with specific species of plant and animal or including nature protection and conservation as a core part of identity (Nisbet et al., 2009;

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Schultz et al., 2004). For the purpose of this study in the context of youth – and in light of previous CTN research with youth – we chose to focus specifically on the most common definition (affinity and comfort) versus expanding the concept to include less established definitions that may be less relevant among children. For example, worldviews are still forming during childhood (Vollebergh et al., 2001) so measuring worldview-related aspects of CTN may be inappropriate among youth.

Spending time outdoors in nature, and specifically time alone, may help foster CTN among children, potentially setting them on lifelong paths of environmental engagement. Thus, increased time in nature may promote CTN. Research suggests that time in nature helps children build positive emotions and attitudes toward nature (Cachelin et al., 2009; Chawla, 2015; Cheng & Monroe, 2012), and studies have shown that time alone in nature is a particularly important part of fostering environmental behaviors. A host of retrospective studies have revealed the importance of solitary outdoor experiences in childhood for forming environmental behaviors as an adult (Chawla, 1999; Cheng & Monroe, 2012; Corcoran, 1999; Ewert et al., 2005; James et al., 2010; Tanner, 1980). Retrospective research on significant life experience research, in particular, has revealed the importance of solitary time outdoors for environmental engagement. Here, we refer to "solitary" as time experienced alone, allowing for direct experiences in nature unmediated by social interactions with others (Hammitt & Madden, 1989). Particularly among children, these solitary experiences often occur during free play (Burdette & Whitaker, 2005) and direct exploration of nature (James et al., 2010), which in turn often predict connection to nature (Cheng & Monroe, 2012), environmental sensitivity (Chawla, 2015), and developmental pathways to continued engagement with the environmental careers and hobbies (Vadala et al., 2007). Especially with young children, solitary experiences may be at least somewhat supervised (e.g., adjacent adult supervision of nature play with limited interventions: (Moore & Cooper, 2014). This limited social interaction still allows for free choice and free play in which children may develop connections with nature (Moore & Cooper, 2014).

Although retrospective findings broadly state the importance of solitary time outdoors, there are several research areas worthy of expansion. First, in most research, more solitary activities have not been isolated from other types of outdoor experiences, defined by social interactions with family or friends (Chawla, 1999; Tanner, 1980). As Hammitt and Madden (1989) and contemporaries argue, solitary time may provide unique opportunities for CTN. Further, much of this research focuses on specific constructs involved with building CTN (e.g., wonder, emotional connection: Cheng & Monroe, 2012), and a focus on activities may shed light on specific actions parents and organizations can take to build CTN. Second, despite several calls to move beyond retrospective methods (e.g., Vadala et al., 2007) most studies center on adults reflecting on their childhood experiences. One study by Stevenson et al. (2014) did analyze the link between time alone in nature and children's (11–13 years old) environmental behaviors and found a weak positive relationship. Third, there is a lack of information on how solitary outdoor activities influence CTN, rather than environmental behaviors. Cheng and Monroe (2012) found that previous experiences in nature were related to high CTN in children, but this study did not differentiate between types of experiences (e.g., more solitary vs. social). These differences should be considered, as some studies suggest location and type of play can lead to different outcomes. For instance, research indicates childhood (i.e., less than 10 years old) play in wildlands increased environmental competencies, preferences, and outdoor activities among adolescents (Bixler et al., 2002) and that childhood involvement in appreciative (e.g., bird watching) or consumptive (e.g., foraging) outdoor activities increased environmental behaviors (Ewert et al., 2005). Collado and Corraliza (2015) found similar results (i.e., frequent experiences in nature predict positive environmental attitudes) when differentiating across residential areas (rural mountain, rural agricultural, urban).

Although solitary time in nature likely promotes CTN and environmental engagement, social interactions in natural settings may be important as well. Social practice theory suggests certain behaviors (e.g., outdoor recreation, environmental behaviors) emerge from identification with a group, and interactions within social groups reinforce lifelong commitment to the behaviors (Kempton & Holland, 2003). Thus, participation in outdoor activities with others may reinforce or augment CTN among children. Retrospective studies additionally support this theory. For instance, significant life experience research

suggests outdoor experiences with others, such as family, friends, or scouting groups, promote environmental behaviors (Chawla, 1998). Research with young environmental activists (i.e., 18–35; Arnold et al., 2009) suggests peer socialization promotes CTN and subsequent environmental engagement. Bixler et al. (2002) found, through retrospective interviews with adolescents (ages 13–18), that nature play in early childhood (i.e., before the age of ten) predicted not only engagement in other outdoor recreation activities such as fishing and tent camping but also comfort in wilderness settings. These findings laid the groundwork for James et al. (2010) environmental socialization model wherein early childhood experiences in nature (e.g., fantasy play, collecting rocks) build CTN, and social experiences outdoors during adolescence and early adulthood (e.g., volunteering at nature centers) encourage persistence in outdoor recreation activities, development of new skills, and solidification of CTN and environmental engagement into adulthood (James et al., 2010).

Current study

Solitary and social outdoor activities

We build on foundational CTN studies by exploring the relative importance of solitary and social time in nature for building CTN. Specifically, we model how time in nature, specifically engagement in outdoor recreation activities (by activity type and frequency) might predict high CTN. We also consider diverse outdoor activities and whether these occur individually or collectively. This study builds on previous qualitative research focused on single recreational activities or groups of activities by quantitatively evaluating: (1) the impact of a variety of outdoor activities (e.g., hiking, playing sports, fishing) on CTN, (2) the significance of solitary versus social time outdoors on CTN, (3) the relative importance of one activity over another for predicting CTN, and (4) the effects of ethnicity, and gender on CTN. We suggest that for elementary children, certain outdoor activities are more important that others for developing CTN. We hypothesize that:

(1) solitary time in nature is a primary driver for CTN; and
(2) time spent in a group in nature is a secondary support of high CTN.

These hypotheses reflect two critical contributions to research on CTN. First, we measure the relative importance of time alone and with others in nature in building CTN through an investigation of specific outdoor recreation activities. Further, no studies that we are aware of analyze the impact of a range of outdoor activities (e.g., hiking, playing sports) on CTN or the relative importance of one activity over another. When studying how life-long environmental engagement develops in children, it is important to acknowledge their participation in wide range of activities. This allows for research on the interplay between activities and the relative importance of each. Further, some children's activities have received limited attention in CTN and environmental affinity studies due to their assumed conflict with environmental values (Holland, 2003). In particular, consumptive wildlife recreation activities, such as fishing and hunting, have not been considered in association with CTN but may be important activities shaping CTN. Motivations for hunting and fishing vary by location, culture, and the species that are targeted (Bashari et al., 2018; Castilho et al., 2018; Young et al., 2016), but in the United States and similar cultural contexts, hunters and fishers are typically motivated by a desire to spend more time in nature, spending time with family and friends, and securing food (Decker & Connelly, 1989; Fedler & Ditton, 1994). Hunting and fishing require intense observation and knowledge of nature (James et al., 2010; Vadala et al., 2007), which may help explain correlations found between these activities and engagement with the environment. For instance, hunting participation predicts biodiversity knowledge among 10–11-year-old children (Peterson et al., 2017), environmental behaviors of college students (Ewert et al., 2005), and environmental attitudes within households (Peterson et al., 2017). These outdoor recreation activities may also mediate the relationship between environmental attitudes and behaviors (Peterson et al., 2017). Another study revealed that adult hunters were four times more likely to engage in conservation behaviors than outdoor recreationists other than bird watchers (Cooper et al., 2015).

Gender and ethnicity

We also focus on diverse youth in the last stages of middle childhood (i.e., 9–12 years old), particularly focusing on effects of gender and ethnicity. We acknowledge the enormous complexity and cultural difficulties of analyzing these constructs through a single study but hope to offer insight from which others can build. Seminal CTN studies relied on retrospective studies where adults were questioned about their childhood (Chawla, 1999; Tanner, 1980). However, studies with children help overcome self-assessment and recall–bias related limitations of retrospective studies (Golden et al., 2013) and avoid potentially confounding effects of cultural changes, including increases in technology and decreases in perceived safety of the outdoors (Larson et al., 2019). We also contribute to previous research (Braun & Dierkes, 2017; Cheng & Monroe, 2012; Ernst & Theimer, 2011) by accounting for an array of individual demographic (age, ethnicity, and gender) variables. Several studies have found that women and girls have more proenvironmental attitudes than boys (Stevenson et al., 2013; Zelezny et al., 2000). Explanations for these differences include that girls are socialized to be more nurturing and relational, which makes them predisposed to feeling emotionally connected to the environment (Zelezny et al., 2000). Communities, including children, of color have been found to be less connected to nature than their white counterparts (Larson et al., 2019; Rigolon, 2016). This has been explained by a variety of factors, including lack of access to the outdoors, perceived or experienced discrimination, or cultural exclusion (Pease, 2011). Accordingly, we also consider two additional hypotheses:

(3) Students who identify as girls will be more connected to nature than students who identify as boys; and
(4) Student who identify as white will be more connected to nature than students who identify as nonwhite.

We acknowledge that analyzing race and ethnicity into a binary variable is socially problematic. Although we attempted to examine these questions at a more granular level (see "Methods"), small sample sizes prevented meaningful statistical comparisons between individual racial or ethnic minority groups. Further, although experiences across these groups are undoubtedly diverse, there is support for some level of commonality of experience among populations of color with respect to the outdoors (Pease, 2011; Rigolon, 2016). As few have examined predictors of CTN among diverse groups of students, we view this approach as a first step in understanding how demographics may be predictive of CTN when accounting for outdoor activities. Looking for generalized differences first can help highlight specific areas for future research.

Methods

Sampling

Our sample consisted of 1,285 fifth-grade students, ages 9–12 years old ($M = 10.5$, SD = 0.65), in North Carolina, USA. We focused on fifth-grade students since they are in the late stages of middle childhood (6–12) and approaching adolescence (12–18), a critical period for developing ethical and ecological knowledge necessary for environmental engagement (Kellert et al., 2017) and outdoor recreation interests (James et al., 2010). Teachers administered online surveys in school during September and October 2016. Although our analysis unit was students, the lack of an adequate sample frame required us to sample in two stages – teachers and students. As this study was part of a larger project evaluating an environmental education program, most teachers were recruited through this program in western North Carolina and upstate South Carolina (34 teachers, 896 students). The remainder was randomly selected from the same geographic area (17 teachers, 387 students; Figure 1). Although this paper utilizes pretest data (i.e., before intervention of the EE program), we included a variable for whether students would participate in the environmental education program or would not (i.e., were in a randomly selected classroom) in all analyses to control for any differences between these two samples of students. We did not find this variable significant in our models. Although self-selection bias may exist among teachers, the unit of analysis,

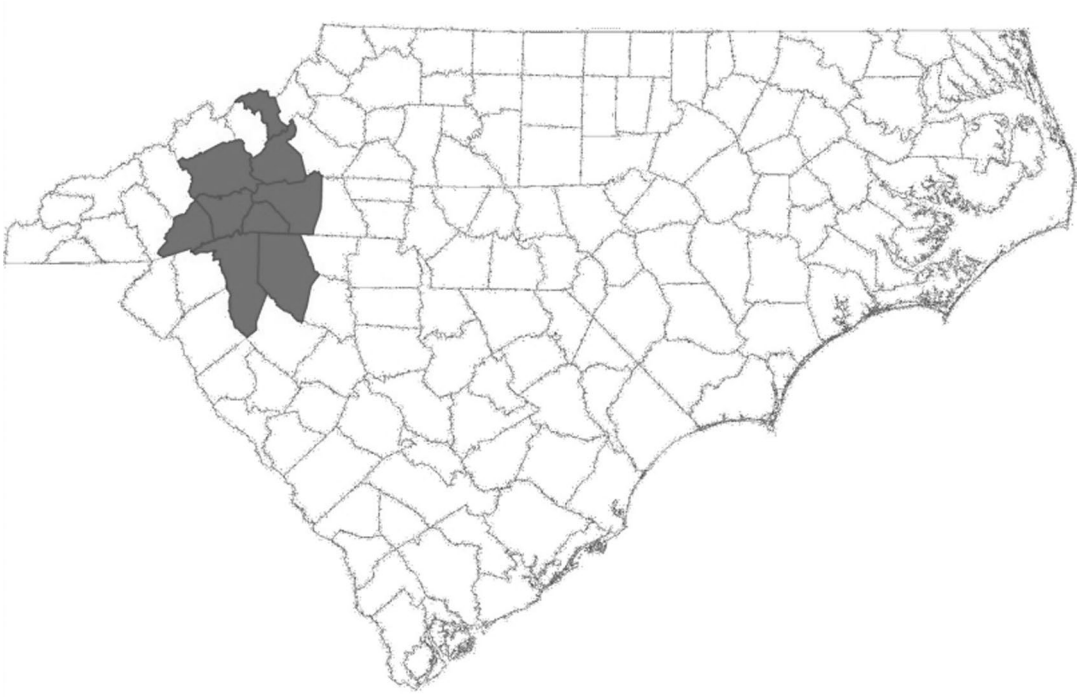

Figure 1. Study area in western North Carolina and upstate South Carolina.

students, should not be affected as students are assigned to teachers in schools regardless of their environmental views or recreation behaviors. We tested our sample versus the true United States' population using z tests for proportions to compare gender (i.e., male versus female) and a binary indicator of ethnicity (i.e., white versus nonwhite) and found no significant differences ($p = 0.71$ and $p = 0.70$, respectively (U.S. Department of Education, 2015). Fifty-percent were females. Fifty-two percent of students identified as white/Caucasian, 9% as black/African American, 12% as Hispanic/Latino, 2% as Asian/Pacific Islander, 7% as Native American, 8% as other, and 10% as two or more.

Instrument development

We measured CTN using a six-item, five-point, Likert-type scale (Table 1) adapted from previously validated CTN scales that address environmental affinity and comfort in nature (Cheng & Monroe, 2012; Martin & Czellar, 2016). Responses ranged from "strongly disagree" (1) to "agree" (5). Pilot testing with 609 students in spring 2016 revealed the scale went to one factor and was reliable ($\alpha = 0.813$). Frequency of outdoor activities were measured on a five-point scale ranging from "never" (1) to "once a week or more" (5). Outdoor activities included camping, fishing, hunting, hiking, playing sports, playing outside, and spending time outside with family, in a group, and alone. Outdoor activities were selected based upon three criteria: (1) had been used in past instruments (McBeth et al., 2008), (2) accounted for a gradient of socialization levels (e.g., alone versus in a group), cultural groups, and interests (e.g., hunting versus playing sports outside), and (3) identified in the pilot test as a common outdoor activity among our population (i.e., playing sports outside). These activities represented both general levels of solitary versus social experiences (e.g., alone, with family, in groups), as well as specific activities that could be placed on a solitary to social gradient (Figure 2). Although it may be unlikely for children to participate in any of these activities completely alone, the activities that are more solitary (i.e., hunting, fishing: Figure 2) involve arguably less social interaction than activities requiring high levels of verbal communication and collective action (i.e., team sports) and may require more focused attention to the natural world (James et al., 2010). Validity and reliability tests were not assessed for frequency of outdoor

activities, since the items were not intended as a summative scale; see Table 1 for the CTN scale and Table 2 for the outdoor activity scale.

Variables

We modeled high CTN through a variety of explanatory variables using a classification tree analysis (see Classification tree analysis section). To investigate the factors that are associated with high or low levels of CTN, we considered only the upper quartile of CTN (which corresponded to scores of 27–30), and the lower quartile of CTN (scores 6–21). The upper and lower CTN quartiles help to highlight the activities, frequency of activities, and combination thereof, that lead to high and low CTN. This resulted in using 706 students. We then defined a new binary outcome variable indicating high CTN. This binary variable was determined as high (score 27–30; represented by 1) or low (score 6–21; represented by 0) (Table 3). We included six outdoor activity variables: camping, fishing, hiking, hunting, playing outside, and playing sports outside. We additionally included variables for level of socialization when spending time outdoors: spend time outside by myself, spend time outside with family, and spend time outside with a group. We chose to measure alone time and social time in nature in two complementary ways. First, we included self-assessment questions measuring time in nature alone, with family, and with larger groups (Table 2). Second, we asked about participation in activities that logically promote more solitary

Table 1. Results for upper and lower quartiles of CTN scale.

Item	Upper quartile *M* (SD) Upper quartile *M* (SD)	Lower quartile *M* (SD)	*M* (SD)	Cronbach's alpha	Factor loadings
I feel comfortable in nature	4.85 (0.37)	3.39 (1.01)	4.19 (1.03)	0.88	0.82
When I'm in nature, I pay close attention to different plants and animals	4.54 (0.56)	3.03 (1.13)	3.87 (1.14)	0.89	0.72
I'd rather play outside than inside	4.70 (0.55)	2.97 (1.18)	3.93 (1.24)	0.88	0.76
If I have free time, I like to be in nature	4.63 (0.52)	2.48 (0.98)	3.67 (1.31)	0.86	0.87
Being in nature makes me happy	4.82 (0.38)	3.00 (0.97)	4.00 (1.15)	0.87	0.86
Being in nature makes me feel peaceful	4.80 (0.43)	3.06 (1.11)	4.02 (1.18)	0.87	0.82

Note. Prompt given: How much do you agree or disagree with the following statements? Answers range from strongly disagree (1) to strongly agree (5).

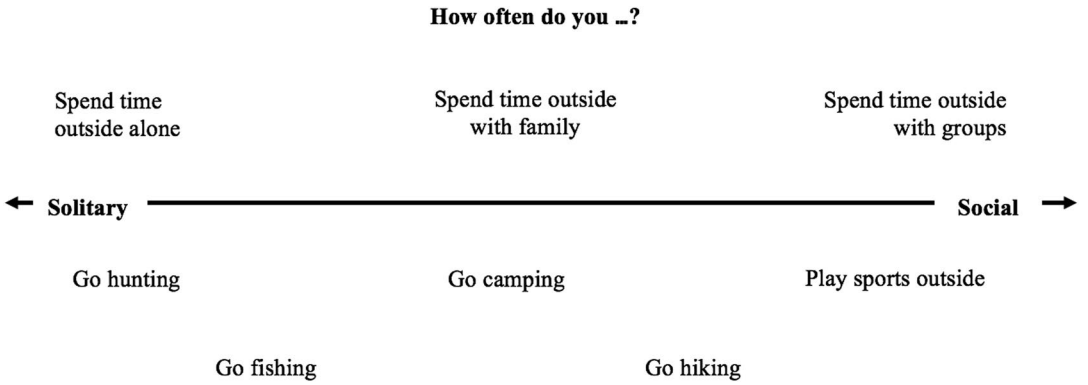

Figure 2. Proposed conceptual model of social interaction level of recreation activities predicting connection to nature in children. Level of socialization from solitary to social represented on the axis. Specific recreation activities given below axis and general outdoor socialization level given above.

Table 2. Descriptive statistics for outdoor activities.

Activity	*M*	SD
Hunt	1.91	1.39
Fish	2.73	1.43
Hike	2.73	1.43
Camp	2.22	1.22
Play outside	4.74	0.77
Play sports outside	4.34	1.25
Spend time outside by myself	3.74	1.62
Spend time outside with family	4.24	1.17
Spend time outside with a group	3.74	1.48

Note. Statistics given for all students ($n = 1{,}279$). Prompt given: How often do you do the following? Frequency of activity reported from never (1) to once a week (5).

experiences (e.g., hunting) and more group focused experiences (e.g., playing outdoor sports; Table 2, Figure 2). The latter approach provided a way to evaluate the role of alone and group time in nature with less reliance on self-assessment of time alone (Lew et al., 2010). We included demographic variables that may be associated with CTN, including ethnicity, gender, and age. Girls can have higher levels of CTN than males (Frantz & Mayer, 2014; Kollmuss & Agyeman, 2002), and children often have higher CTN that adults (Braun & Dierkes, 2017). Previous research also identified different levels of comfort and affinity in nature among ethnicities, notably low levels of comfort in the outdoors among African Americans (Carlone et al., 2015; Finney, 2014). We ran analyses with multiple racial demographics (i.e., black/African American, Hispanic/Latino, Asian/Pacific Islander, Native American, white/Caucasian, other, two or more), and there were no significant relationships between ethnic groups. In order to reduce type II error, we aggregated all racial minority groups and compared to students identifying as White/Caucasian. All variables included in the analysis were discrete variables.

The role of family in solitary time outdoors

Although interest in hunting and fishing often develops through families (Ryan & Shaw, 2011), we chose to classify these as activities as scaffolded solitary time for children, rather than another form of social time outside (Figure 2). Scaffolding is an educational technique that can help learners accomplish a task; the method involves practices such as: modeling the activity, dividing the activity into easier tasks, and providing structures and guidelines (Ormrod, 2016). When children are beginning to hunt or fish, parents or role models will likely utilize scaffolding to encourage participation and engagement, such as teaching close observation of nature in order to better track an animal. In this way, parents generate not only interest in fishing and hunting, but also skills and interest in eventually engaging in the activity independently. This aligns with findings from outdoor and environmental education programing which found that programing including self-directed learning and observations increases situational interest (Ardoin et al., 2014). In adulthood, actual fishing and hunting experiences can be solitary outdoor experiences (Kuehn et al., 2006; Manfredo et al., 2004; Metcalf et al., 2015). Furthermore, these activities often are more personal, even spiritual, than social in nature (Snyder, 2007; Wells & Lekies, 2006). Although the preparations for hunting and fishing involve social activities and family time, the actual outdoor activity of hunting and fishing promotes contemplation and solitude compared to more active outdoors activities, such as playing sports, that often have no time for nature contemplation, quiet, or solitude. Thus, we see these activities as another example of reflective and observational learning outdoors which are typically linked to children's solitary time in nature.

Classification tree analysis

We relied on classification tree analysis to assess our hypotheses. Classification trees iteratively divide a sample into binary responses, and with every division, the subsamples are increasingly similar in terms

of the outcome variable (e.g., in upper quartile of CTN; Breiman et al., 1984; Ma, 2005). Classification trees have at least two advantages over traditional models. First, classification tree analysis provides a visual representation of how the data can be divided into smaller subgroups with varying CTN levels based on frequency of outdoor activities (Davidson & Bush, 2016). Second, classification trees build a hierarchy of explanatory variables and avoids isolating a few variables to explain an outcome (Breiman et al., 1984).

To run a classification tree analysis, we utilized RPART in R software (Therneau & Atkinson, 2019). RPART constructs a classification tree by continually splitting the sample into two groups to make the proportions as close to 0 and 1 as possible (that is, as close to all individuals being in either the lower or upper quartile). The software begins with the entire sample (i.e., root node) and searches through each explanatory variable (i.e., outdoor activity and/or demographic variable) to find which one best splits the sample into two groups with different proportions of the outcome variable (i.e., high/low CTN). The criteria for choosing which variable best splits the sample is the Gini index, a node impurity criterion employed by the RPART software (Loh, 2014). The Gini index measures how often a randomly chosen data point (i.e., student) from the sample would be incorrectly categorized (e.g., predicted as low CTN when it is truly high) if the data point was categorized according to its explanatory variables (i.e., activity frequency or demographic information). The explanatory variable (i.e., outdoor activity and/or demographic variable) that has the smallest Gini index[1] will split the sample first (Therneau & Atkinson, 2019). This split results in two child nodes that are very different in terms of the chosen explanatory variable (i.e., high/low CTN). These two child nodes are then split again based on the node impurity criterion. This splitting continues until the impurity criterion is not met or until a chosen sample size is reached (Therneau & Atkinson, 2019). When this occurs, the splitting ends and the remaining sample is called a terminal node.

We ran a classification tree analysis on the binary variable indicating whether a student had a high or low level of CTN ($n = 706$). For our study, the branches represent potential predictors of CTN (i.e., outdoor activities and/or demographic variables) while the nodes denote the proportion of the sample that had high CTN (score above 26). Every node has a distinct path made up of one or more branches. We analyzed each branch and associated child node for every terminal node. We refer to terminal nodes with both a large proportion of students and high CTN values as key terminal nodes. Key terminal nodes have a subset of students where more than 75% of that specific sample has high levels of CTN.

Results

Students' CTN scores ranged from 6 to 30 ($M = 23.68$, SD = 5.72). Upper and lower quartile ($n = 706$) statistics are provided in Table 3. Frequency of outdoor activities varied widely (Table 2). Hunting was the least frequent outdoor recreation activity, and playing outside was the most frequent activity.

Description of classification tree

Figure 3 shows the classification tree analysis for frequency of outdoor activities, channeling students into nodes based on proportion of high CTN. The first split among 706 students in the upper and lower quartile for CTN created nodes for spending more time alone in nature versus less time alone in nature. Thus, spending time alone in nature was the most predictive activity for having high CTN. The left child node (Node 1) contained 324 students who spent time in nature once a month or less (36% of sample

Table 3. Connection to nature descriptive statistics for upper and lower quartiles.

	n	Range	*M*	SE	CI
Lower quartile	318	0–21	17.82	0.21	17.41–18.22
Upper quartile	391	27–30	28.34	0.06	28.23–28.26

had high CTN). The right child node (Node 2) contained 382 students who spent time in nature once a week or more; this subsample had 71% of students with high CTN values; see Figure 3 for the full classification tree.

Description of child node characteristics

We found support for hypothesis one, as the most predictive spilt was on time spent in nature alone. Students who spent time alone in nature weekly (Figure 3, Node 2) had roughly one-third (34.8%) more students with high CTN than those who spent time alone less frequently (Figure 3, Node 1).Students spending time outside alone weekly are 34.8% more likely to have high CTN than those spending time outside alone less frequently. Further, the second division associated with Nodes 4 and 6 suggests students who participate the most in the more solitary activities (hunting and fishing, respectively) were more likely to be in the upper CTN quartile than other students. The proportion of students in the upper CTN quartile who spent time in nature alone once a week or more and fished three times a year or more (Figure 3, Node 6) was 24.3% higher than those who did not fish (Figure 3, Node 5). Students who spent time outside alone less frequently (once a month or less) but hunted (Figure 3, Node 4) had 13.1% more students with high CTN than students who went outside less frequently and did not hunt (Figure 3, Node 3).

Our results supported hypothesis two. Time spent outside in social activities was a secondary predictor of CTN (Figure 3, Nodes 8, 10, 12, 14, 16). For instance, spending time outside with my family was found to be a significant predictive split for predicting high CTN, after accounting for time spent alone in nature. Students who spent time outside with their families once a month or more had 33.0% more students in the upper CTN quartile than those who spent time outside with their families four times a year or less. After accounting for time alone in nature, students spending time outside with their families were more likely to have high CTN than those rarely spending time outside as a family. Similarly, we

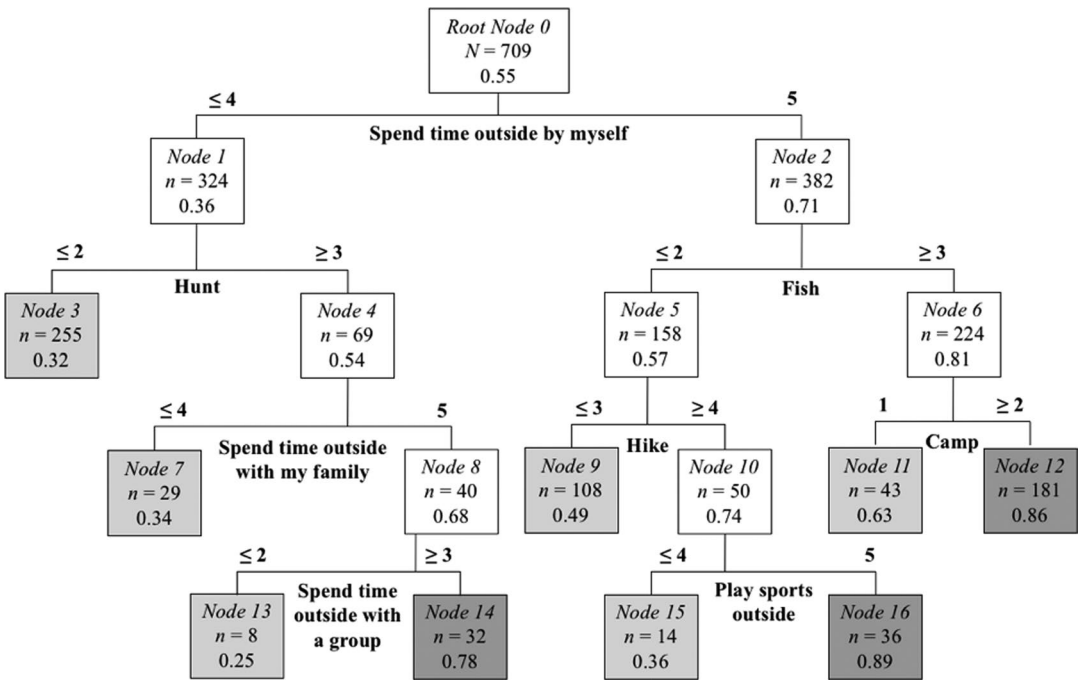

Figure 3. Classification tree showing frequency of outdoor activity predicting connection to nature (CTN) for upper and lower CTN quartiles. Sample size provided for all nodes. Proportion of sample in the upper quartile provided on third row. Shaded boxes represent terminal nodes. Dark boxes (Nodes 12, 14, 16) represent key terminal nodes. Numbers on branches indicate frequency of activity: never (1), one or two times a year (2), three or four times a year (3), once a month (4), and once a week or more (5).

found that spending time outside with a group and several outdoor activities that are inherently group activities for students (e.g., camping) were found to be significant splits for predicting high CTN.

Because most terminal nodes reflected social activities in nature, the classification tree suggests alone time in nature by itself does not lead to the highest proportion of students with high CTN. Terminal nodes with the largest proportion of students in the upper CTN quartile (Figure 3, Nodes 12, 14, and 16) included paths through nodes with both solitary (e.g., hunting) and social activities (e.g., playing sports). For instance, 85.6% of the sample in node 12 had high CTN. Terminal node 12, camping once a year or more, also included fishing three times a year or more (Figure 3, Node 6) and spending time outside by myself once a week or more (Figure 3, Node 2). Likewise, terminal node 14 (78.1% percent of students in upper CTN quartile) also included solitary activities, hunting once a year or more (Figure 3, Node 4), and social activities, spending time outside with family (Figure 3, Node 8). Terminal node 16, playing sports outside once a month or more, had the largest proportion of high CTN of any node (88.9%). Node 16 included a solitary activity (spending time outside by myself once a week or more), a social activity (playing sports outside), and a semisocial activity (hiking once a month or more) which falls in the middle of the range of social interaction for outdoor recreation activities (Figure 2). Outdoor activities were predictive of CTN as described above regardless of whether students identified as boys or girls or whether they identified as white or as a person of color. No effects for gender or race were detected.

Discussion

Our results suggest solitude in nature may operate as a key predictor of CTN among youth. Broadly, the results reinforce previous research findings on the importance of alone time in nature (Chawla, 1999; Tanner, 1980), and align with research on significant life experience that indicates solitude is a formative influence for some environmentally engaged adults (Tanner, 1980). We add to this significant life experience work and previous studies that emphasize the value of alone time outside in childhood (Hsu, 2004; Stevenson et al., 2014) by documenting an association independent from, and stronger than, social time in nature. Our results indicate that nonsocial or solitary activities may have greater impact than is apparent from retrospective interviews with adults. In particular, outdoor activities that explicitly provide more solitary time outside (Ormrod, 2016), such as hunting and fishing, may have an important role in fostering connection to nature. Although hunting and fishing can occur in diverse ways and hold unique meaning for different cultural groups

Bashari et al. (2018), Castilho et al. (2018), Young et al. (2016), this study suggests forms of hunting motivated by spending time in nature, securing food, and spending time with family may play a critical role in developing CTN among children. The idea that hunting and fishing promotes CTN has been popular for decades (Ortega & Smith, 1972; Peterson, 2004), but additional research is needed to establish which types of hunting and fishing promote CTN, and how strong the relationship is in broader contexts.

James et al. (2010) environmental socialization model may explain why the highest levels of CTN are predicted by groups of activities that include social activities, even those less obviously related to nature, such as playing sports. This environmental socialization model combines ideas from significant life experience research, child development models, and social practice theory. Environmental socialization posits that adult environmental engagement develops through a childhood and adolescence filled with various environmental activities occurring across multiple social contexts (i.e., peer groups to solitary). This model mirrors concepts from social practice theory which asserts that individuals need to participate in environmental behaviors within a social group in order for them to be consistently environmentally engaged (Holland, 2003). Our results suggest youth need social support for developing environmental behaviors and strong CTN during middle childhood (6–12 years old), adding to literature suggesting the importance of such support even before adolescence, in establishing pro-environmental habits and lifelong CTN (James et al., 2010; Kellert et al., 2017).

Our classification tree results suggest demographic variables may not influence CTN directly, rather, demographics may simply correlate with the degree to which youth spend time alone in nature and participate in key outdoor recreation activities. Although previous research suggests gender and ethnicity influence environmental attitudes and recreation behaviors (Finney, 2014; Prévot et al., 2018), we did not detect relationships between CTN and either gender or ethnicity. Although future research is needed, our results, however, indicate gender and ethnicity may only predict CTN indirectly by predicting low exposure to consistent and varied outdoor activities identified in ongoing recreation research (Bixler et al., 2011; Kellert et al., 2017). Once participation in nature-based recreation was accounted for, there were no significant differences in CTN between youth identifying as different races/ethnicities. While multiple contextual and cultural factors are at play, if youth are given the same opportunities to recreate outdoors both in social and secluded settings, then, they may develop similar levels of CTN. This aligns with research that found varied leisure participation regardless of ethnicity or socioeconomic status (Floyd et al., 1994) and varied outdoor recreation preferences regardless of ethnicity or gender (Williams, 2017). While gender and ethnicity may influence the outdoor recreation experience (Parker & Green, 2016; Shores et al., 2007), our findings indicate all students can develop similar levels of CTN if they are given the same exposure to nature. Initiatives to reduce constraints to social and nonsocial outdoor recreation, such as the United States' Every Kid in Outdoors Act (Dingell Jr., 2019) those designed to increase the representation of those identifying as Black or African American (Outdoor Afro, 2020), Latinx (Latino Outdoors, 2020), Asian (Outdoor Asian, 2020), or Native American (Center for Native American Youth, 2020) in outdoor recreation; or campaigns like #ReThinkOutside (BlueSky Funders Forum, 2019), may help address these inequities by encouraging broader participation in nature-based activities. Future evaluation of these efforts and associated research should investigate the degree to which these programs do indeed promote CTN across diverse audiences.

Our results imply efforts to build CTN among students may benefit from programing supporting more solitary activities (e.g., fishing, exploration, meditation) reinforced by social (e.g., playing sports, camping) activities outdoors. Programing for parks and recreation providers as well as environmental and educational institutions is typically oriented to group contexts (North American Association of Environmental Education, 2003). Although some studies have argued that solitude during play hinders child development (Bowker & Raja, 2011), others suggest nonsocial play aids childhood development and happiness (Goossens, 2013; Luckey & Fabes, 2006). There are several barriers to solitary outdoor activities that need to be overcome in order to facilitate high CTN development among children, including: competing priorities for time and attention (Kellert et al., 2017), increased tendency to see being in nature as risky (Kurka et al., 2015; Rader et al., 2015), and urbanizing populations (United Nations Environment Programme, 2016). These barriers are associated with children having less time outdoors overall, less time unsupervised by parents outdoors, and decreased access to outdoor spaces that facilitate alone time in nature, respectively (Kellert et al., 2017). Improving infrastructure (Kurka et al., 2015), implementing community policing strategies (Rader et al., 2015), supporting initiatives that provide opportunities for both solitary and social experiences in nature (e.g., forest schools or nature preschools: Carter, 2016) and reducing perceived cost of outdoor recreation (Kellert et al., 2017) may provide general strategies for promoting CTN. Similarly, our results suggest scaffolding activities that are not literally alone – but promote quiet, contemplation, and solitude – may provide outcomes similar to being alone, while children still have direct adult supervision. Our results suggest strategies which may complement these efforts to build strong CTN among diverse youth in middle childhood: promoting alone time in nature, reinforcing lessons learned through alone time through social outdoor activities – such as camping and hiking, encouraging hunting and fishing, and prioritizing engagement with underserved groups.

Conclusion

This study adds to the growing body of literature around CTN through examining the various recreation activities, and combinations thereof, that build strong CTN. Our results indicate a possible pathway for supporting CTN through providing youth a combination of both solitary and social activities in nature,

with a particular emphasis on solitary activities, as they appear to be critical in building CTN as well as one of the more rare activities formally facilitated by parents and organizations. Additionally, the results show possible areas for further research around the potential for these activities to develop CTN uniformly across genders and ethnicities, despite some groups having been treated as having lower CTN in the past. Future experimental research is needed to establish directionality of causal relationships suggested by this study and other research on how CTN is developed.

Note

1. Therneau and Atkinson (2019) provide a detailed introduction to Gini index and recursive partitioning in RPART.

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