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Exploring University Student Perceptions of Climate Change Using Connection to Nature and Psychological Distance

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EXPLORING UNIVERSITY STUDENT PERCEPTIONS OF CLIMATE CHANGE USING CONNECTION TO NATURE AND PSYCHOLOGICAL DISTANCE

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ABSTRACT

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The central goal of my dissertation is to better understand undergraduate biology students' perceptions of climate change specifically using a localized lens. Research relating to climate change perceptions and understanding is common in the K-12 setting; however, there have been far fewer studies that use undergraduate student populations. Undergraduate students represent a new age of the voting populus and are therefore an important demographic to target for inducing environmental change. To foster climate change awareness, concern, and willingness to act in our undergraduate students, we must first understand how they perceive it. Using both quantitative and qualitative approaches I explored what factors influence students' perceptions of climate change locally by sampling 410 undergraduate biology students. I generally concluded that the framing of climate change (e.g., local vs. global) influences our students' awareness of its impacts in their local area. By interviewing 16 students, I found that the relationship or connection a student has with natural areas is a strong predictor of students' awareness of climate change locally. Further, I found that students' personal experiences in nature contributed to their connection to nature and increased environmental awareness. In my final study, which included 471 undergraduate biology students, I found that some students perceive climate change as distant spatially, socially, and temporally which lowers their environmental awareness of climate change locally and their perception of how it impacts

themselves; however, this distance seems to be fluid and can be changed through purposeful classroom instruction. I suggest that instructors reframe their coverage of climate change in the classroom to be more place-based to increase the personal relevance of climate change and reduce its perceived distance.

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CHAPTER I

INTRODUCTION

Climate Change Education

The ever-present threat of climate change has increased the interest in and need for instructors to include climate change in undergraduate student curricula (Intergovernmental Panel on Climate Change [IPCC], 2021; Monroe et al., 2019). However, the global and interdisciplinary complexity of climate change can create barriers for instructors making it difficult to incorporate the topic into their existing classroom curricula (Monroe et al., 2019). In the classroom, instructors often frame climate change primarily within a global context, focusing climate discussions on examples that occur remotely from human population centers, including the extinction of polar bears due to ice loss (Born, 2019), the loss of coral reefs due to bleaching (IPCC, 2021), and the loss of glaciers and sea ice due to rising global temperatures (IPCC, 2021; U.S. Global Change Research Program [USGCRP], 2017). While these visceral images may bring to light these global atrocities (O'Neill & Nicholson-Cole, 2009), most people are not directly impacted by these effects in their everyday lives. Instead of presenting climate change as a distant problem in the classroom, researchers suggest making climate change more personally relevant, by providing examples of how climate change directly impacts a student or their local environment, which may lower the perceived distance between them and climate change (Clayton et al., 2014; Devine-Wright, 2013; Devine-Wright & Batel, 2017; Scannell & Gifford, 2013; Spence et al., 2012).

Theoretical Background

Psychological Distance

The construct of psychological distance (PD) was adapted from Trope and Liberman's (2010) construal-level theory that was initially used to describe the relationship between an individual and a particular object or event. Four main scales of distance are described by Trope and Liberman (2010) and have been applied to the PD construct in climate education, including spatial (location of climate change), temporal (timing of climate change), social (whom climate change is impacting), and hypothetical (uncertainty of climate change; Keller et al., 2022). Individuals might experience one or multiple levels of psychological distance at any given time. Individuals experiencing high PD may believe that climate change is/will 1) only affect(ing) other people (high social distance), 2) occurr(ing) far from their location (high spatial distance), 3) occur in the future, but is not impacting them now (high temporal distance), or 4) uncertain and therefore not worrisome (high hypothetical distance) (Spence et al., 2012; Trope & Liberman, 2010).

Increased psychological distance is considered a barrier to climate change action (Van Lange & Huckelba, 2021). Lowering a person's PD can lead to an elevated concern for climate change (Busch & Chávez, 2022; Gubler et al., 2019; Spence et al., 2012) and sometimes increased performance of sustainable actions and behaviors (Maiella et al., 2020). Significant research examines how making climate change more personally relevant to local areas (Devine-Wright, 2013; Devine-Wright & Batel, 2017; Scannell & Gifford, 2013; Schweizer et al., 2013) can help lower one's PD by decreasing its abstraction (Van Lange & Huckelba, 2021) and reducing one's spatial and social distance with climate change (Loy & Spence, 2020; Spence et al., 2012). While personal experience and proximizing climate change can lead to increased concern (Akerlof et al., 2013; Spence et al., 2011; Zaval et al., 2014), it does not always translate into climate change action or motivation (Brügger et al., 2015, 2016). Prior beliefs may bias an individual's perception that climate effects are actually attributed to climate change (McDonald et al., 2015; Sambrook et al., 2021). Further, intense emotional experiences with climate change may increase fear associated with future climate change events, thus leading some to further distance themselves from the problem instead of increasing their concern or action (McDonald et al., 2015). Studies have shown that an individual's PD is not static and can change when new information is presented (Chu, 2022; Keller et al., 2022). If true, targeting psychological distance through curricula and classroom activities could be an effective strategy for increasing students' concern for climate change.

Connection to Nature

The construct of connection to nature is another factor potentially influencing whether an individual perceives climate change (Clayton, 2003; Mayer & Frantz, 2004). Connection to nature is rooted in Wilson's (1984) theory of Biophilia which describes how and why humans interact with nature. Kellert and Wilson (1993, p.42) suggest that "human identity and personal fulfillment somehow depend on our relationship to nature". Wilson (1984) posited that a human's relationship with nature is "innate", suggesting that one's connection to the natural world, conscious or not, is rooted in the evolutionary history of *Homo sapiens* as a species and their reliance on these natural systems, current and past, for survival.

This founding work argued that fostering nature connectedness through exposure and experience is necessary to ensure the persistence of biophilia in human populations (Kellert, 2008; Kellert & Wilson, 1993; Wilson, 1984). Later, Chang et al. (2022) contributed that genetics partially contributes to human's nature orientation and their experiences in nature, although environmental factors like access to nature seem to be more important when describing an individual's level of connection and experience with nature. Although the construct of

Connection to Nature is rooted in evolutionary history, the development of a connection to nature in an individual arises from the psychological and physiological benefits they gain through personal experiences with nature (Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2008; Schultz, 2002).

Connection to nature has been cited as a predictor of multiple personal health attributes, including increased well-being (Martin et al., 2020; Mayer et al., 2009) and happiness (Barrera-Hernández et al., 2020; Cui & Yang, 2022; Zelenski & Nisbet, 2014). These connections suggest that spending time in natural areas benefits humans' physical and mental health and may be a reason some people seek experiences in nature. Further, connection to nature has been cited as a predictor of multiple behaviors that impact human interest and public policy. Performance of pro-environmental behaviors has been linked to connection to nature, suggesting that individuals who are more connected to nature care more for the environment and strive to protect it through sustainable behaviors (Cheng & Monroe, 2012; Clayton, 2003; Martin et al., 2020; Mayer & Frantz, 2004; Nisbet et al., 2009), although other factors such as cost (time and financial; Whitburn et al., 2020) and feelings of guilt or eco-grief (Longo et al., 2019; Pihkala, 2020) could act as barriers, diminishing the performance of sustainable actions. Other research has shown that connection to nature is related to increased environmental awareness (Barros & Pinheiro, 2020; Nisbet et al., 2009; Schultz et al., 2004). Further, individuals with a higher connection to nature may also have lowered psychological distance associated with climate change based on their more frequent experiences in local natural settings (Gubler et al., 2019).

Clayton (2003) argues that fostering an environmental identity in an individual can act as a “guiding force” toward increased social, political, and personal concern for the environment and an increase in conservation-minded behavior. The relationships between an individual’s connection to nature with personal well-being, happiness, sustainable behaviors, and environmental awareness suggest that understanding why humans are connected to nature is an important tool for both public and environmental health.

Place-Based Practices and Transformative Experience

To communicate the concepts and severity of climate change to our students more effectively and encourage engagement with the topic, researchers suggest that instructors incorporate local examples of climate change effects in the classroom (Monroe et al., 2019; Wibeck, 2014). One way to situate climate change locally in course curricula is through a place-based educational approach (Devine-Wright, 2013; Devine-Wright & Batel, 2017; Monroe et al., 2019). Place-based education focuses on how students identify emotionally and cognitively with their local geographic area, often fostering critical thinking, concern, and local engagement (Clayton et al., 2014; Deringer, 2017; Scannell & Gifford, 2013). Place-based approaches to climate change education have been incorporated effectively in classroom settings through centering local places in classroom materials and discussions (Theobald et al., 2015), use of visuals and maps (Altinay, 2017; Fox et al., 2020; Littrell et al., 2022), and field-based experiences (Karpudewan & Mohd Ali Khan, 2017; Khadka et al., 2021).

Place-based educational practices can encourage students to engage with their local environments in new and novel ways, potentially allowing them to re-see the curriculum through a new lens (Pugh et al., 2017). These authentic and personal educational experiences can result in deeper and transformative learning, allowing students to relate classroom content to their personal lives (Pugh, 2011). The Teaching for Transformative Experiences in Science (TTES) model provides a framework for educators to design curricula to encourage motivated use, expansion of perception, and experiential value (Pugh et al., 2017). The construct of transformative experience is rooted in the concept of personal relevance describing student experiences as “a learning episode in which a student acts on the subject matter by using it in everyday experience to more fully perceive some aspect of the everyday world and finds meaning in doing so” (Pugh, 2011, p. 111). Meaningful student learning is achieved through genuine experiences that can be directly applied to the student’s life, allowing more value to be placed upon the content learned (Hickman, 2009; Pugh, 2011).

Littrell et al. (2022) found that using a place-based approach and components of TTES to teach climate change resulted in a transformative experience for middle and high school students in their study through their changed perspectives, motivated use of the content, and increased value for the topic. Work is lacking that reports on climate change curricula for higher education contexts that couple these models (i.e., place-based education, TTES).

Study Significance and Broader Impacts

Research relating to climate change perceptions and understanding is common in the K-12 setting; however, far less research focuses on these questions using undergraduate student populations. We believe students, particularly voting-age, university students, are an important demographic to target for inducing environmental change. The goal of my dissertation is to better understand undergraduate students' perceptions of climate change and determine ways to develop effective curricula based on these perceptions.

Project 1 will compile a list of factors that help predict whether undergraduate biology students see the effects of climate change locally or not, which can be used by instructors when creating their climate change curricula, by teaching and learning centers to facilitate faculty workshops, and government or private entities when developing public outreach initiatives. Project 2 will result in a rich description of how students describe other individuals' connection to nature, while also determining the frequency with which students predict their own connection to nature and what factors contribute to discrepancies in their predictions. This information will further aid instructors and policymakers by offering insight into how our students think about their own and others' connection to nature which could be used to create purposeful programs designed to increase our students' connectedness to natural realms. Project 3 will build a classroom intervention that seeks to promote student spatial and social awareness of localized climate change. If effective, this intervention could be used as an integral tool for higher education STEM instructors hoping to increase local climate change literacy for their students and potentially be adapted for use by K-12 STEM instructors. In addition, each project will allow students to engage with the topic of climate change in a personally relevant way, potentially allowing them to increase their overall understanding of the spatial and social aspects of climate change.

CHAPTER II

SEEING CLIMATE CHANGE: PSYCHOLOGICAL DISTANCE AND CONNECTION TO NATURE

This chapter has been previously published or accepted for publication in *Environmental Education Research*.

Contribution of Authors and Co-Authors

Manuscript in Chapter II

Author: Jessica R. Duke

Contributions: Conceived study topic and design. Collected, organized, and analyzed data. Wrote first draft of the manuscript.

Co-Author: Dr. Emily A. Holt

Contributions: Conceived study topic and design. Provided feedback on analyses and earlier versions of draft.

Abstract

To develop targeted climate change curricula, it is imperative to understand how students perceive and observe the localized effects of climate change. Our work used a quantitatively driven, parallel mixed methods research design to study potential factors that contribute to undergraduate biology students seeing the local effects of climate change. Our research questions asked students to provide examples of climate change occurring in their state and examined the predictive power of connection to nature, psychological distance, and other factors on whether students see climate change or not. Our quantitative data show a student's connection to nature, their spatial climate awareness, and their geographic location were the three most important factors in predicting a student seeing and discussing climate change occurring in their state. Further, our qualitative data support our quantitative findings indicating that personal experiences in nature are integral for students connecting with nature and seeing climate change at scales smaller than their state.

Introduction

Climate change affects every landscape globally, including non-visible abiotic effects (e.g., increased average temperatures and drought), and visible abiotic effects (e.g., increased frequency and severity of fire and flooding from sea-level rise; IPCC, 2021; USGCRP, 2017). Biotic effects are often visible, including changes in species' ranges (Walther et al., 2002; Warren et al., 2018; Weiskopf et al., 2020), increased species extinction, and phenological mismatches (i.e., spatial or temporal mismatch of key life-history events between species that interact) (IPCC, 2021; USGCRP, 2017). These impacts also affect people through decreased access to fresh water, increased damage to property from fire and flooding (USGCRP, 2017), loss of livelihood, and increases in disease spread (IPCC, 2021).

Ironically, climate effects that occur remotely from human population centers are often the focus of climate discussions, including the extinction of polar bears due to ice loss (Born, 2019), the loss of coral reefs due to bleaching (IPCC, 2021), and the loss of glaciers and sea ice due to rising global temperatures (IPCC, 2021; USGCRP, 2017). While these visceral images may bring to light these global atrocities (O'Neill & Nicholson-Cole, 2009), most people are not directly impacted by these effects in their everyday lives. Many argue that the severity and urgency of climate change cannot be fully grasped if individuals do not think that climate change will or has affected them (Devine-Wright, 2013; Devine-Wright & Batel, 2017; O'Neill & Nicholson-Cole, 2009; Scannell & Gifford, 2013; Spence et al., 2012). Instead of presenting climate change as a distant problem in the classroom, researchers suggest making climate change more personally relevant, by providing examples of how climate change directly impacts a student or their local environment, may lower the perceived psychological distance between them and climate change (Clayton et al., 2014; Devine-Wright, 2013; Devine-Wright & Batel, 2017; Scannell & Gifford, 2013; Spence et al., 2012).

Psychological Distance

The construct of psychological distance (PD) was adapted from Trope and Liberman's (2010) construal level theory that was initially used to describe the relationship between an individual and a particular object or event. Four main scales of distance are described by Trope and Liberman (2010) and have been applied to the PD construct in climate education, including spatial (location of climate change), temporal (timing of climate change), social (whom climate change is impacting), and hypothetical (uncertainty of climate change; Keller et al., 2022). Individuals experiencing high PD recognize climate change as a problem occurring far away in both space and time that is affecting other people but not themselves (Spence et al., 2012).

A volume of existing literature demonstrates the factors that contribute to one's PD. Significant research examines how making climate change more personally relevant to local areas (Devine-Wright, 2013; Devine-Wright & Batel, 2017; Scannell & Gifford, 2013; Schweizer et al., 2013) can help lower one's PD by decreasing its abstraction (Van Lange & Huckelba, 2021) and reducing one's spatial and social distance with climate change (Loy & Spence, 2020; Spence et al., 2012). While personal experience and proximizing climate change can lead to increased concern (Akerlof et al., 2013; Spence et al., 2011; Zaval et al., 2014), it does not always translate into climate change action or motivation (Brügger et al., 2015, 2016). Prior beliefs may bias an individual's perception that climate effects are actually attributed to climate change (McDonald et al., 2015; Sambrook et al., 2021). Further, intense emotional experiences with climate change may increase fear associated with future climate change events, thus leading some to further distance themselves from the problem instead of increasing their concern or action (McDonald et al., 2015).

Gubler et al. (2019), on the other hand, suggest that a person's PD is a significant predictor of climate change concern amongst adolescent students. Most studies focused on manipulating PD examine how lowering PD affects an individual's willingness to act to prevent climate change impacts (Maiella et al., 2020; McDonald et al., 2015). Research is lacking that examines the association between one's PD and their observations of localized climate change.

Connection to Nature

The construct of connection to nature is another factor potentially influencing whether an individual perceives climate change (Clayton, 2003; Mayer & Frantz, 2004). Connection to nature is rooted in Wilson's (1984) theory of Biophilia which describes how and why humans interact with nature. Kellert and Wilson (1993, p.42) suggest that "human identity and personal fulfillment somehow depend on our relationship to nature". Wilson (1984) posited that an individual's connection to nature is genetically tied to human existence. Although the construct of Connection to Nature is rooted in evolutionary history, the development of a connection to nature in an individual arises from the psychological and physiological benefits they gain through personal experiences with nature (Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2008; Schultz, 2002).

Several scales of connection to nature define unique psychological aspects of this construct, such as environmental identity (Clayton, 2003) or one's emotional connection to nature (Mayer & Frantz, 2004). Time spent in nature (Clayton, 2003) and experiences with nature (Nisbet et al., 2008) are often important predictors of how connected an individual is to natural environments. Chawla (2020) found that children who have greater access to and spend more time in nature are more connected to nature in both childhood and adulthood. Likewise, the literature suggests that those more connected to nature have greater contact with nature (Clayton, 2003; Wilson, 1984), thus we propose that they would be more likely to notice environmental changes (which may include the effects of climate change). Further, individuals with a higher connection to nature may also have lowered psychological distance associated with climate change based on their more frequent experiences in local natural settings (Gubler et al., 2019).

Student Perceptions of Climate Change

Most studies examining student perceptions and understanding of climate change have been done with K12 populations (Wachholz et al., 2014) with most research referencing student misconceptions of the phenomena (Rajeev Gowda et al., 1997; Shepardson et al., 2009). A recent study by Barros and Pinheiro (2020) examined elementary student perceptions of localized climate change and found that students primarily mention changes in temperature as the effects they observe in their local area. Some research has focused on university students' beliefs, understanding, and misconceptions associated with climate change (Huxster et al., 2015; Lombardi & Sinatra, 2012; Wachholz et al., 2014). These studies provide students with a checklist of climate change effects from which to agree or disagree instead of allowing them to recall information organically, which could be limiting our understanding of what students perceive about climate change effects.

Research Questions

We aimed broadly to describe and explore predictors of whether biology students observe climate change in their local environments. Our study had two key research questions:

Q2.1 What examples of climate change do undergraduate biology students describe occur in their local area (i.e., their home state)?

Q2.2 Which variables help predict whether students see the local effects of climate change (e.g., psychological distance, connection to nature)?

Materials and Methods

We used a mixed methods quantitatively driven, parallel research design to address our research questions (Tashakkori et al., 2021). This approach allowed us to, 1) use validated instruments or adaptations thereof to measure connection to nature and psychological distance to explain whether or not students could provide examples of climate change occurring in their local area, and 2) gain a deeper understanding of how potentially relevant predictors explain a student's ability to "see" climate change through interviews. Data collection of quantitative and qualitative data occurred concurrently. Our analysis occurred post-collection of both strands of data, but the qualitative elements were designed to complement and help explain expected patterns in the quantitative data. Interpretation of the two strands of data occurred after separate analyses to answer our research questions and provide a more comprehensive explanation for how students see climate change and the role of various predictor variables (Creswell & Plano Clark, 2017; Tashakkori et al., 2021). Connection to nature was the central variable explored in the qualitative interviews because previous research suggested it to be a valuable predictor of engagement in environmentally responsible behaviors, and we believed it would also help predict how student's see climate change (Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2008).

Sites and Participants

Data collection for this study was conducted with permission from the Institutional Review Board where the two primary investigators are affiliated (IRB # 2012018874; Appendix A). Consent was secured from all participants before the completion of the survey and follow-up interviews. We recruited students from several higher education institutions in Colorado (CO) and North Carolina (NC). We chose institutions from these locations, first, because the researchers had greater accessibility to recruiting instructors with whom they had personal contacts (Creswell & Plano Clark, 2017). Second, we suspected that geographic location would influence students' views of climate change, thus contributing to maximum variation in our responses (Cutler et al., 2020; Howe et al., 2015). Our goal was not to directly compare responses between NC and CO, but instead, we were hoping such a sample might better represent students whose longest residence spanned different regions of the US.

We used purposeful sampling to identify instructors of university-level biology courses (Creswell & Plano Clark, 2017). We chose to sample biology courses because we assumed that these students would have a greater understanding of climate change along with a higher connection to nature. We contacted 17 instructors across 4 institutions in both CO and NC, and 11 instructors across all institutions agreed to recruit students by offering either course or extra credit for completion of an online survey. Two of these instructors agreed to recruit in two of their courses for a total of 13 unique classes. We successfully recruited 410 student participants for the survey portion of the study from major and non-major biology courses (Table 2.1). We sampled both majors and non-majors' biology courses to determine whether "major" helped explain why some students observe climate effects while others do not.

Of the participants that reported demographics, the majority identified as women (n = 277; men: n = 117; non-binary: n = 9; prefer not to answer: n = 7) and were White (n = 296; Hispanic and Latinx: n= 56; Black: n = 17; Asian or Pacific Islander: n = 14; Multi-racial: n = 13; American Indian or Alaskan native: n = 4; prefer not to answer: n = 10). Participants' self-reported major was primarily Biology (n = 210; Psychology: n = 32; Environmental Science: n = 17; Chemistry: n = 16; Other, n = 135), and most identified their political affiliation as Democrat (n = 142; Independent: n = 98; Republican: n = 78; other: n = 92).

Table 2.1

Courses, States, and Institutions from which Participants Were Recruited

Course	Course Level	State	Institution[1]	Removed	Sample Size
Ecology	Upper	CO	A	0	33
Evolution	Upper	CO	A	0	23
Non-majors General Biology	Lower	CO	A	0	32
Intro Biology II (majors)	Lower	CO	A	2	55
Intro Stats for Biologists (majors)	Lower	CO	B	1	88
Ecology	Upper	NC	C	1	14
Landscape Ecology	Upper	NC	C	1	7
Ecology and Evolution	Lower	NC	C	1	37
Herpetology	Upper	NC	C	0	11
Human Biology (Non-majors)	Lower	NC	C	17	15
Intro Biology I (majors)	Lower	NC	C	6	88
Intro Biology II (majors)	Lower	NC	D1	0	5
Intro Biology II (majors)	Lower	NC	D2	1	2

Notes. Multiple universities were sampled in each state and are anonymized and noted with letters. Some students were removed from the dataset for incomplete surveys. Sample size indicates the final sample from each course population after removals.
[1]Numbers next to institution letters denote multiple sections of the same course.

Seen Effects and Climate Change Survey

We developed a survey to quantitatively address our research questions and help identify interview participants. Our survey included several published and validated instruments measuring participants' connection to place and nature and their acceptance and perception of the scale of climate change (Appendix B). This survey was part of a larger project and included some scales that were not analyzed for this study (Appendix B). Our survey included the Environmental Identity Scale (EID) that measures an individual's connection to nature and is valid with university populations (Clayton, 2003; Olivos & Aragonés, 2011). In our pilot work, the EID was more reliable (Cronbach's α = 0.93) than other similar measures (i.e., Connection to Nature Scale and the Nature Relatedness Scale) (Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2008), thus we opted to use the EID in this study. The EID instrument includes 24 5-level Likert scale items. Students who did not complete every item on this instrument were removed from the study (n = 28). We summed responses for each student (Clayton, 2003), and composite scores ranged from 24 to 120, where higher scores indicate a greater connection to nature.

Our survey also included three scales and one open-response item related to climate change acceptance and understanding (Appendix B). The first climate change scale included three items modified from Barnes et al.'s (2019) 100-point instrument of evolution acceptance to detect participant acceptance, belief, and thinking about the truth of climate change (Appendix B). These three items were consolidated through arithmetic averaging into an Acceptance scale (Cronbach's α = 0.92). Participants were then asked to identify the "area [they] have lived the longest" by providing their ZIP code (or indicating country, if they lived outside the US) and use this place as an anchor for the next two scales. The second climate change scale included four 5-level Likert items that quantified their perceived geographic and social distance of climate change (Appendix B, Spence et al., 2012). Our participants' responses showed low reliability (Cronbach's α = 0.63) to the Spence scale, so in accordance with common social science practices, we excluded this scale from further analyses (Bland & Altman, 1997; Tavakol & Dennick, 2011).

For our third climate change scale, we adapted Spence et al.'s (2012) item of "My local area is likely to be affected by climate change," and created four new items by replacing "local area" with "city", "county", "state", and "country" to more specifically detect students' spatial perception of the effect of climate change relative to the ZIP code they reported, at various local scales (Appendix B). These four items were consolidated through arithmetic averaging into a novel scale we call the Spatial-Climate-Awareness Scale (Cronbach's $\alpha = 0.94$). The highest score, i.e., 5, would represent a student who perceived that climate change was likely to affect the place they lived longest, at all geographic area scales. High SCAS = low PD (or high closeness)

The final climate-related item, which was used as the key response variable in the present study, was a novel open-response item. Reflecting on student interviews from a related study (Holt et al., 2021) and pilot responses of this survey, we asked "Have you seen the effects of climate change in your state? If so, please specify below. If you have not, please respond with 'No Effect'". Participants that failed to respond to this question were removed from our analysis ($n = 18$). Students that responded with "no effect" or otherwise described not seeing the effects of climate change in their state were placed in a category that we labeled No Effect. Responses where students claimed to have seen or observed climate change were placed in a category labeled Seen Effects.

We hoped to seek general trends between the region of longest residence and students' ability to see the local effects of climate change. Our participants reported 312 unique ZIP codes, which limited replication for analysis. Therefore, we collapsed ZIP code data into ten geographic regions denoted by the first digit or ZIP prefix. A total of nine participants did not provide a ZIP code, thus these responses represent missing data in our dataset leaving us with 402 participants in our analysis.

The final section of the survey collected demographic information including gender, race/ethnicity, declared major, state, course-level, university in which they were being recruited, and political party affiliation, most of which were collected to describe our population. In preliminary analyses, we found no differences in our response variable by gender, race/ethnicity, major, state, or course-level, so these factors were not included in any of our models. Our response variables differed only by political party affiliation and university, which is why they were included in our models and because the former predictor was noted as a strong predictor of climate change acceptance by prior research (Gregersen et al., 2020; McCright et al., 2016; Pew Research Center, 2006).

Follow-Up Interviews

At the end of the survey, we asked participants if they were interested in participating in a follow-up interview, 154 of whom agreed. Sixty participants were contacted for a follow-up interview to achieve maximum variation in EID scores and responses to the open-response item where they described whether they had or had not seen the effects of climate change in their state. Fifteen of the total sixty participants contacted responded and agreed to be interviewed. All interviewees were compensated with a $10 Amazon gift card for their participation. Our sample of 15 students primarily attended institutions in Colorado (n = 12; NC: n = 3), identified as female (n = 8; male: n = 6; non-binary: n = 1), were White (n = 13; Black: n = 1; Hispanic or Latinx: n = 1), reported being a biology major (n = 12; other major = 3), and reported seeing the local effects of climate change in their state (n = 10; No Effect = 5). Upon completion of the 15 interviews, we noticed saturation amongst participant responses so no further recruitment was sought.

Semi-structured interviews were conducted, recorded, and transcribed by a member of the research team. To more richly describe the best predictors that explained one's ability to recognize climate change locally, we analyzed several questions from these interviews (see Appendix C1, bolded items). Student participants were asked to reflect on their connection to nature, their ideas about climate change, and explain the relationship between the two (Appendix C1). Pseudonyms were assigned to each interviewee by the research team using a random name generator. The gender and ethnicity of each pseudonym does not necessarily reflect those of each participant; however, each name was selected to represent a diversity of voices (Lahman et al., 2015).

Quantitative Data Analysis

All quantitative data analyses were conducted using the statistical program R (R Core Team, 2020). Reliability analyses of the EID instrument and all climate change scales were conducted using the "psych" package (Revelle, 2020).

To examine the predictive capacity of an individual's connection to nature and their scores on our two reliable climate change scales as to whether a student reported having seen the local effects of climate change, we converted our open response question to binary data as described above (1 = indicated that they had seen the effects of climate change in their state, 0 = stated no effect or had not seen the effects in their state). We chose a binary logistic regression to model the binary response variable using several potential predictor variables (Acceptance scale, EID, Political party, Spatial-Climate-Awareness Scale, University, and ZIP prefix). Because of the exploratory nature of our study, we included all six predictors in our model and then performed a stepwise model selection by AIC (Yamashita et al., 2007) to select the best subset using the "bestglm" package (McLeod et al., 2020). We used the Variance Inflation Factor (VIF) value to estimate possible multicollinearity among predictors, of which this model assumes a lack thereof, using the "car" package in R (Fox & Weisberg, 2019). All our predictors had VIF <1.5, indicating no correlation (Dodge, 2008; Everitt & Skrondal, 2010), thus was not a concern in our analyses. McFadden's pseudo-R-squared (McFadden, 1973) was used to assess model fit utilizing the package “pscl” in R (Jackman, 2020). An analysis of predictor variable importance was conducted in R using the package “caret”, with higher values indicating greater variable importance (Kuhn, 2021).

Qualitative Data Analysis

Content Analysis of Open Response Item

To more fully describe the Seen Effects reported by our sample, we conducted a content analysis of responses that described some effect to the open-response question, “Have you seen the effects of climate change in your state? If so, please specify below. If you have not, please respond with ‘No Effect’”. We formulated thematic codes of detected climate effects through inductive coding (Creswell, 2013; Merriam & Tisdell, 2016).

Thematic Analysis of Interviews

We thematically analyzed two of our interview questions (Appendix C1) via deductive and inductive coding, respectively, using NVivo software (Creswell, 2013; Merriam & Tisdell, 2016). These questions were selected based on their relevance to our research questions and to help describe the significance of our best predictor variables. First, to describe the relationship more richly between connection to nature and Seen Effects, we analyzed Q17 from our interview (Appendix C1). We used predefined codes representing different explanations for why someone might better see the effects of climate change locally based on patterns observed in our quantitative analysis and relevant theories (Linneberg & Korsgaard, 2019). The three predefined themes or explanations for this analysis were “emotional”, “innate or evolutionary”, and “willingness to act”.

We coded student responses that discussed experiences/memories, identity, and well-being as the rationale for why someone might better see climate change effects locally under the "emotional" explanation. An individual's emotional well-being (Mayer & Frantz, 2004; Mayer et al., 2009) and identity (Clayton, 2003) are frequently associated with connection to nature in the literature (Cervinka et al., 2012; Chawla, 2020; Nisbet et al., 2008; Perkins, 2010; Schultz, 2002). Alternatively, responses that used the essential tie of humans to nature, explained by the evolutionary history of our species (Wilson, 1984), to justify greater recognition of climate effects were coded under the "innate or evolutionary″ explanation. Finally, responses that discussed a desire to protect the natural environment as the explanation for one's greater capacity to see these effects were coded under "willingness to act". Leopold (1989) alludes to this explanation in his moral code for actionable steps to care for the land upon which one relies. Following this coding of these explanations, we then numerically summarized the occurrence of codes in each theme (Braun & Clarke, 2006).

Second, to describe Seen Effects more richly at different scales, we analyzed Q13 from our interviews (Appendix C1). The interviewer asked participants to describe effects of climate change at scales larger and smaller than their state of longest residence. Three themes emerged from analysis of this question. We coded student responses that discussed climate effects using personal experiences/memories as "first-hand experiences". Responses that seemed to reflect information students had read, learned, or seen through media, were coded as "second-hand experiences". Finally, responses that indicated uncertainty about the effects of climate change at these scales were coded as "unsure".

Results

Research Question 2.1

Q2.1 What examples of climate change do undergraduate biology students describe occur in their local area (i.e., their home state)?

Of our 410 participants, 264 reported having seen the effects of climate change in their state. For students that purported to have Seen Effects, the majority noted changes in average temperatures, changes in precipitation patterns, increased forest fires, and an increase in storm intensity/frequency (n = 123, n = 91, n = 35, n = 19, respectively). A small proportion of students provided Seen Effects that were environmental effects conflated with climate change, such as pollution and other forms of human disturbance (n = 15, n = 13, respectively). Of our 410 survey participants, 43 were not included in this analysis for either failing to respond to the question (n = 18) or providing an ambiguous response that could not be coded by the researchers (n = 25).

Research Question 2.2

Q2.2 Which variables help predict whether students see the local effects of climate change (e.g., psychological distance, connection to nature)?

The best-fitting model included our Spatial-Climate-Awareness Scale, ZIP prefix, EID score, and Acceptance scale (Table 2.2). The stepwise algorithm eliminated political party and university as poor performing predictors (Appendix D). McFadden's pseudo-R-squared of the final model was 0.316, indicating excellent model fit (Hensher & Stopher, 1979).

Our Spatial-Climate-Awareness Scale was the best predictor of whether a student had seen the effects of climate change in their state and was nearly twice as important as the next most important predictor (Table 2.2). Generally, students who believed climate change would affect their local area at multiple scales (i.e., had higher Spatial-Climate-Awareness scores) were more likely to report Seen Effects (Figure 2.1).

A student's connection to nature, as measured by their EID scale, was the second most important predictor of Seen Effects (Table 2.2). Students with a higher EID score tend to see the effects of climate change at the state level compared to those who report No Effect (Figure 2.2).

The final significant predictor in our model was students' reported ZIP prefix (Table 2.2). While our sample was biased by oversampling areas in which our sample institutions occurred, the proportion of those reporting Seen Effects from each ZIP prefix region was uneven across regions (Figure 2.3). Overall, students whose longest residence occurred in the Western US more frequently reported Seen Effects in their state compared to those in the Central and Eastern US (Figure 2.3).

The Acceptance Scale was the least important and only non-significant ($\boldsymbol{\alpha}$ = 0.06) predictor in our best fit model (Table 2.2). Students that scored low on the Acceptance Scale more frequently reported No Effect when asked if they had seen the effects of climate change in their state (Figure 2.4).

Table 2.2

Model Output for the Full Logistic Regression Model Examining Predictors of Seen Effects of Climate Change

Variable	**Coefficient**	**Std error**	**z value**	**P-value**	**Predictor Importance**
Intercept	-9.741	1.167	-8.345	< 0.001	
Spatial-Climate-Awareness Scale	1.410	0.238	5.932	<0.001	5.932
ZIP Prefix	0.142	0.047	3.055	0.002	3.055
EID	0.029	0.009	3.146	0.002	3.146
Acceptance Scale	0.016	0.008	1.885	0.06	1.885
AIC	341.1				
McFadden's pseudo-R^2	0.316				

Figure 2.1

Plots Comparing Participants' Spatial-Climate-Awareness Scores to Whether They Have Seen Effects of Climate Change in Their State

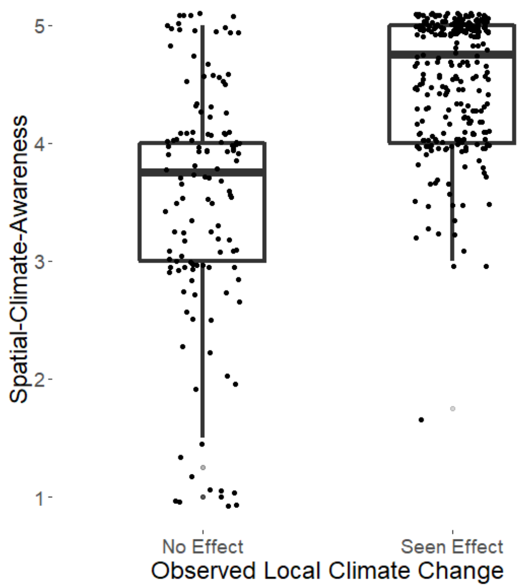


Figure 2.2

Plots Comparing Participants' Environmental Identity Scores to Whether They Reported Seen Effects of Climate Change or Not

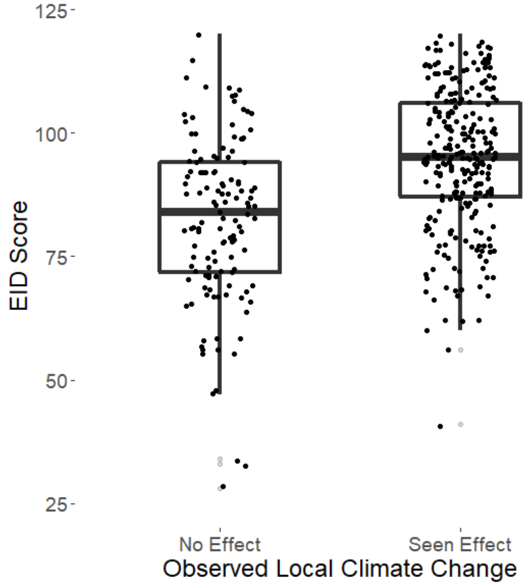
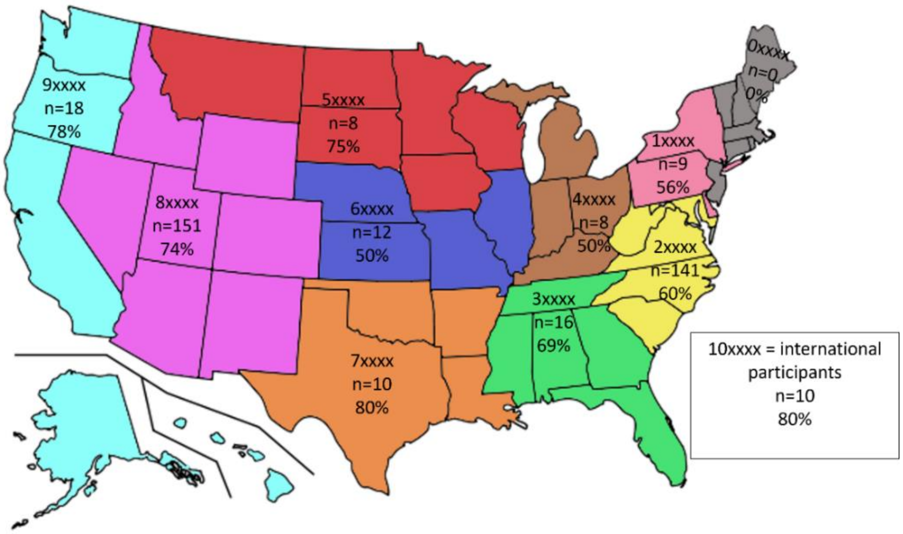


Figure 2.3

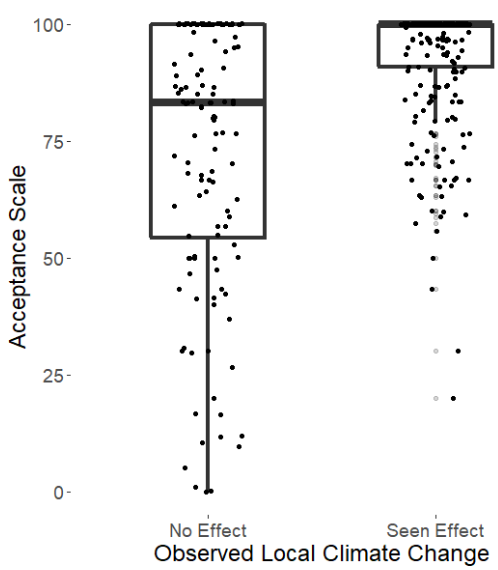
U.S. Map Depicting Participants in Each ZIP State Prefix by Region



Notes. ZIP Regions noted in different colors. Map demonstrates the pattern of greater proportions of students recognizing climate change effects in the Western US versus central U.S. The "*n*" references the number of participants sampled from that particular ZIP State Prefix and the "*%*" refers to the percent of these students that reported they had seen the effects of climate change in their state.

Figure 2.4

Comparing Participants Reported Seen Effects of Climate Change to Their Acceptance of Climate Change



Environmental Identity Scale and Spatial-Climate Awareness Scale as Predictors

All 15 interviewees, regardless of EID score on their survey, agreed during their interview that an individual who is more connected to nature would be more likely to observe the localized effects of climate change. Students most frequently explained this relationship within an "emotional" context (*n* = 12; Table 2.3). The two explanation categories of "innate or evolutionary" and "willingness to act" were less frequently mentioned by students (Table 2.3).

Additionally, all interviewees, regardless of whether they reported local Seen Effects of climate change on the survey or not, were able to provide examples of climate change occurring at larger scales than their state (Table 2.4). Most students' responses of large-scale impacts reflected "second-hand experiences" (*n* = 13, "first-hand experiences" = 5; Table 2.4) and described primarily abiotic effects (large scale "second-hand experiences" abiotic effects, *n* = 10, large scale "second-hand experiences" biotic effects, n = 3). Only 11 students were able to provide examples of climate change at a smaller scale than their state, and most used "first-hand experiences" (*n* = 10 "second-hand experiences" = 1; Table 2.4) and described primarily abiotic effects (small scale "first-hand experiences" abiotic effects, *n* = 9, small scale "first-hand experiences" biotic effects, n = 1). Six of our interviewees claimed that they were "unsure" of whether or not they had seen the effects of climate change at smaller scales, which included one student who expressed uncertainty but was able to eventually provide an example at a smaller scale (Table 2.4). No students were "unsure" of the effects of climate change at larger scales (Table 2.4). Most students that scored a 4.5 or higher on the Spatial-Climate-Awareness Scale were also able to provide examples of climate change at both smaller and larger scales than their state (*n* = 8; Figure 2.5).

Table 2.3

Explanations Describing the Relationship Between Connection to Nature and Ability to See Local Climate Change, Definitions, Example Quotes, and Frequency

Explanations	Number of Participants	Definition	Example Quotes
"Emotional"	11	Students explain that those highly connected to nature better recognize climate change locally because they have a deeper emotional connection to nature through memories, experiences, self-identity, and how it impacts their overall well-being leading them to be more aware of changes in the environment.	"Yeah, I mean, obviously, the more time you spend in nature, the more time you think about nature, [the] more you value it, the more you'll care about, about restoring and maintaining it. So, I'd said it's all super interconnected." – *Brendon*
"Willingness to Act"	4	Students explain that those highly connected to nature better recognize climate change locally because they are more willing to act to help protect natural environments through seeking education, establishing career goals, volunteering, donating money, reducing their footprint, or acting politically.	"A person who has these better relationships with nature... [pays] more attention, they're more curious about [climate change] and they're more inclined to, you know, take action because they care about it, and they have a connection, so they want to protect the resources. So, if they see that there's a change in their environment, whether or not it's connected to like, you know, climate change or just like a local impact, they are definitely going to be more inclined to take action no matter the cause" – *Makena*
"Innate or Evolutionary"	3	Students explain that those highly connected to nature better recognize climate change locally because they realize that humans are not separate from nature.	"Yes, I definitely think that [people more connected to nature, more readily recognize climate change locally]. Because they don't make that distinction between the natural and the civilized world. They see the civilized world is just the natural world civilized. So, they can make that connection [and easily see the effects of climate change]" – *Damion*

Notes. Explanations are ordered by frequency. Quotes are lightly edited for clarity and flow

Table 2.4

Scales and Themes Describing the Extent of Students' Seen Effects of Climate Change and How They View These Changes, Definitions, Relevant Theories, Example Quotes, and Frequency

Scale	Theme	Example Quotes
Smaller Scale	"First-Hand Experiences" 10	"Yeah, well also we usually go on canoe trips out in Moab every year on the Green River. And if there's not enough water, you just can't go because your canoe is going to be dragging on the bottom the whole time.... I obviously haven't gone for long, but my dad's been going for years and years. And it's a lot more years of, there's not enough water to go in anymore. It's just like, Colorado's getting drier and drier, we're having more and more wildfires, you know, you can't light fireworks anymore." – *Olivia*
	"Second-Hand Experiences" (1)	"I guess [climate change] is something that technically happens in Concord...like weather shifts every now and again. Where it'll be really cold. And like the summer there's something weird going on." – *Damion*
	"Unsure" (6)	"I mean it's not like where I didn't feel I was educated, or I have scientific studies to back up [my claims of climate change effects] because I didn't want to misstep because misinformation or mis-education can be one of our greatest opponents... So, for me, it was hard for me to personally identify what I saw because there are definitely human impacts, but I wasn't sure, like, if those would count towards the definition of climate change..." – *Makena*
Larger Scale	"First-Hand Experiences" (5)	"I'm definitely well aware that a lot of places are having very similar problems to Colorado like Australia--their fires and stuff. I guess I'm just less personally invested in those stories. Well, yeah, I just don't live in a lot of those places. And it's just easier for me to understand Colorado because I have a good idea of the economy and the culture and the wildlife and everything here. But from knowing it here, it allows me to sympathize with other places as well because I can understand where I live and can see how it can translate to other diverse areas." – *Weston*
	"Second-Hand Experiences" (13)	"Oh, yes, of course. like Brazil, for instance. The Amazon rainforest is being hit both by deforestation, the logging companies, but also climate change is forcing a lot of animals out of their natural habitats and either they're moving farther north or farther south. And so, there's just all these kinds of events that climate change is forcing... So, it's definitely affecting the whole world." – *Carlos*
	"Unsure" (0)	N/A

Notes. Number of interview participants is noted in the themes column. Quotes are lightly edited for clarity and flow.

Figure 2.5

Comparing Interviewee Responses from Q13 (Appendix C1) to Their Spatial-Climate-Awareness Scale Score.

		Freq. of Reported Experiences[1] Small Scale			Large Scale		
Participant	Spatial-Climate-Awareness	"1"	"2"	"U"	"1"	"2"	"U"
Carlos	3.00	1	0	0	0	1	0
Makena	3.25	0	0	2	0	1	0
Olivia	3.25	1	0	0	0	1	0
Damion	4.00	0	1	2	1	2	0
Connor	4.00	0	0	1	0	1	0
Tori	4.00	0	0	2	0	1	0
Weston	4.50	1	0	0	2	0	0
Sophia	4.75	1	0	0	0	1	0
Molly	4.75	2	0	0	1	1	0
Claire	4.75	1	0	1	0	1	0
Dave	5.00	0	0	1	1	0	0
Kiera	5.00	1	0	0	0	1	0
Brendon	5.00	1	0	0	1	1	0
Zara	5.00	1	0	0	0	1	0
Patience	5.00	1	0	0	0	1	0

[1] Reported experiences at each scale, "1" refers to first-hand experiences, "2" refers to second-hand experiences, and "U" refers to students that were unsure if they had seen climate change in their state.

Notes. Participants are ordered by their Spatial-Climate-Awareness Scale scores. The cell shading indicates the frequency of participant responses to each scale and theme. The heavy black outline indicates the cluster of students at the higher end of the Spatial-Climate-Awareness Scale score (i.e., scores above 4), who tended to use more "first-hand experiences" at both scales and were less "unsure" of climate change at scales smaller than their state).

Discussion

Climate Change Seen by Undergraduate Biology Students

Nearly two-thirds of the students sampled in our study were able to provide examples of climate change effects in their home state, with changes in abiotic factors being cited most frequently. Barros and Pinheiro (2020) reported similar findings for adolescent students in Brazil indicating that they perceive increases in temperature (*n* = 41%) as the primary impact of local climate change. Few students in our study reported seeing biotic outcomes of climate change in their local areas, which was surprising given that most of our sample were biology majors. Other studies report that students describe both abiotic and biotic consequences of climate change (Shepardson et al., 2009); however, their work prompts students to discuss both ideas. Notably, our work asked students to describe local effects they had seen, without such prompting, thus it is novel that our population of biology students organically focused primarily on abiotic impacts.

Our data further hints at alternative conceptions that these university students hold. As noted elsewhere in the literature (Lombardi & Sinatra, 2012; Rajeev Gowda et al., 1997), some of our student's confounded climate with weather (e.g., "*Inconsistent weather patterns such as extremely cold winters or warm winters*"; "*We have experienced hotter temperatures during winter this year than any other winter I can remember*."). Several of our student participants also reported pollution or deforestation (*n* = 34) as effects of climate change they had seen. These misconceptions are not uncommon, where general environmental degradation caused by humans is conflated with climate change (Huxster et al., 2015; Wachholz et al., 2014) and the consequences and causes of climate change are confused (Lombardi & Sinatra, 2012; Rajeev Gowda et al., 1997).

We suspect that some of the local Seen Effects described by our survey sample are more a retelling of facts rather than observations they personally made. These students may be experiencing weather anomalies, such as unusually high temperatures, and overestimating their occurrence instead of actually seeing repeated patterns of change (Zaval et al., 2014). We noted a similar retelling of facts from our interview data in the preponderance of "second-hand experiences" used to describe large-scale climate effects. These findings are important for educators so they can better address students' retellings of facts by focusing on the importance of long-term patterns of climate data and the differences in visible vs invisible abiotic and biotic effects. This information and clarification will give students the tools needed to understand the relevance and applicability of these facts and how to recognize effects of climate change in their local areas.

Connection to Nature Predicts Students' Observation of the Local Effects of Climate Change

In our sample of undergraduate biology students, those who are more connected to nature are more likely to "see" the local effects of climate change in their state of longest residence (Figure 2.2) and the EID was a significant predictor of Seen Effects in our model (Table 2.2). Barros and Pinheiro (2020) reported a similar significant relationship between middle and high school student's perception of the consequences of local climate change and their attribution of responsibility to their connection to nature score (as measured by the Connection to Nature Scale (CNS)), but this relationship has not been reported in university student populations. Previous research has demonstrated that one's connection to nature, as measured by the EID, is a valid predictor of environmentally responsible behaviors (Clayton, 2003), while our study suggests that the EID also predicts a student's likelihood to see climate change effects within their state. Therefore, the EID instrument and its core construct of connection to nature is a critical predictor of students' behavior and awareness of climate change, which could be leveraged in classroom settings.

Additionally, all 15 of our interviewees agreed that an individual who is more connected to nature would be more likely to see climate change locally, further validating this relationship. Most interviewees used arguments framed within an "emotional" context to explain this relationship and described how past experience or one's personal identity likely drives this connection (Table 2.3). Fewer interviewees explained this relationship using one's perception of an "innate" connection or their" willingness to act" against climate change (Table 2.3). Many other studies have examined one's connection to nature and its positive impact on the emotional well-being and self-identity of individuals (Cervinka et al., 2012; Chawla, 2020; Clayton, 2003; Mayer & Frantz, 2004; Mayer et al., 2009; Nisbet et al., 2008; Perkins, 2010; Schultz, 2002). Our study extends these investigations to suggest the benefit of being connected to nature transcends the self to external awareness of natural phenomena (e.g., climate change occurring locally). Other studies have highlighted the importance that emotion and attachment have in how a person cares about the effects of climate change (Wang et al., 2018) suggesting that individuals who have more contact with nature and are more connected to it are also more attached emotionally to these natural places they frequent which could impact how they view climate change.

Importance of Psychological Distance in Seeing the Effects of Climate Change

Our second research question sought to investigate other predictors that may explain whether a student sees the effects of climate change or not. Elsewhere greater psychological distance, the dissociation of climate change from self either spatially, temporally, or socially, often leads to declines in concern about climate change and willingness to act (Akerlof et al., 2013; Gubler et al., 2019; Spence et al., 2012). Notably, our Spatial-Climate-Awareness Scale, which was adapted from Spence et al.'s (2012) work, was the best predictor of Seen Effects and was twice as important as a student's connection to nature score (Table 2.2; Figure 2.1). Further, our qualitative results indicate that students more frequently recognize climate change at larger scales (i.e., beyond their state) than at smaller scales (Table2. 4). These findings underscore the importance of the spatial aspect of psychological distance and how it can affect students' capacity, even those dedicated to learning biology, to recognize the local effects of climate change.

We noticed students with higher Spatial-Climate-Awareness scores tended to identify climate change effects more commonly at scales smaller (i.e., city or county) than those with lower Spatial-Climate-Awareness scores (Figure 2.5). While this relationship was not surprising, these findings bring new insight to the students who minimally recognize climate effects at multiple spatial-scales (city, county, state, country), reflected in low Spatial-Climate-Awareness scores, that may narrowly identify climate change effects at large scales alone. We found that students who see climate change at smaller scales reflect on these effects using primarily “first-hand experiences” (Table 2.4; Figure 2.5). This pattern suggests personal experience and recognizing the impact of climate change across multiple scales are linked with lower psychological distance associated with climate change at smaller scales. These personal experiences can include experiencing local weather anomalies clearly linked to climate change (Spence et al., 2011), seeing or experiencing climate change effects in local areas (e.g. backyards, local trails, parks; Devine-Wright, 2013; Devine-Wright & Batel, 2017; Reser et al., 2011; Scannell & Gifford, 2013) and participation in outdoor activities (Clayton, 2003), all of which were mentioned by some of our interview participants when describing climate change events at small scales.

Our qualitative results also indicate that some students are “unsure” whether climate change has affected their local area at smaller scales (Table 2.4) suggesting a “hypothetical distance” associated with climate change (Trope & Liberman, 2010) because of greater abstraction (Trope & Liberman, 2010; Van Lange & Huckelba, 2021). Most of our interviewees that were “unsure” about small scale effects of climate change were unable to provide concrete examples at this scale (Figure 2.5) suggesting that these students are simultaneously experiencing spatial and hypothetical psychological distance or that there is an interactive relationship between the two. Contrarily, those participants who described climate effects at smaller scales mostly discussed these effects in terms of personal relevance. This suggests that "first-hand experiences" may be critical to reduce spatial and hypothetical psychological distance in some populations (Brügger et al., 2016; McDonald et al., 2015), which may lead to greater ability to see local climate change effects.

Importance of Geographic Region in Seeing the Effects of Climate Change

ZIP prefix was our third most predictive factor of Seen Effects (Table 2.2). Many studies have examined how geographic region at the national level (Brulle et al., 2012; Lee et al., 2015; Poortinga et al., 2019) affects climate change perspectives; however, few studies have examined this relationship sub-nationally (i.e., among states or regions) (Howe et al., 2015). Our study uniquely identified a pattern of differing incidence of students seeing local climate effects with geographic regions, where students from Western states observed effects more commonly than students from Eastern and Central US states (Figure 2.3).

Other studies have reported geographic differences due to personal experiences with extreme weather events (Allan et al., 2020; Cutler et al., 2020; Hamilton & Keim, 2009) and public political ideology (Howe et al., 2015) associated with climate change concern. Research suggests that these political and regional relationships are complicated, even suggesting geographic differences within political groups (Mildenberger et al., 2017). Further, prior beliefs and ideologies may shape the way individuals perceive extreme weather events they experience, either confirming prior skepticism (Hamilton et al., 2016; Sambrook et al., 2021; Shepard et al., 2018) or solidifying concern (Sambrook et al., 2021; Shepard et al., 2018) and feelings of vulnerability (Shepard et al., 2018). We were surprised that political party was not included in our best-fit model; however, the homogeneity of our sample may have contributed to its poor performance as a predictor and future studies would benefit from greater variance in political ideology among participants to better clarify the role of this factor in university populations.

Implications for Instructors

Our findings are encouraging for biology educators seeking to increase climate literacy in their classrooms. The high incidence of Seen Effects in our student sample suggests university populations may be aware of local climate change effects, but that they may also have alternative conceptions and lingering uncertainty about these effects (Huxster et al., 2015; Rajeev Gowda et al., 1997; Wachholz et al., 2014). Notably, our sample of biology students overwhelmingly reported seeing abiotic effects of climate change. This omission of biotic outcomes of climate change may simply reflect a curriculum that is similarly biased, and biology instructors should consider greater emphasis on biotic implications of climate change to remedy this bias.

Our research found a student's connection to nature was an important predictor of seeing local climate change. It is unclear whether this relationship is developed over one's lifetime (Cleary et al., 2020), if critical development occurs in childhood (Cleary et al., 2020; Rosa et al., 2018; Windhorst & Williams, 2015), or if it can be taught or fostered through instruction (Carr & Hughes, 2021; Ernst & Theimer, 2011). If the latter is a viable route to increase a student's connection to nature, the implications for improving climate literacy through education are considerable. Elsewhere, outdoor learning activities or field experiences help foster a connection to natural areas (Clayton, 2003; Mayer et al., 2009), and may be a pedagogical intervention worth exploring to build climate literacy. However, it is unclear as to the length of time spent in nature that is needed for these experiences to achieve a lasting connection (Carr & Hughes, 2021;

Lumber et al., 2017). Framing climate change using place-based communication has successfully increased climate change awareness and concern (Devine-Wright, 2013; Devine-Wright & Batel, 2017; Scannell & Gifford, 2013; Schweizer et al., 2013), but its success may be population-dependent (Halperin & Walton, 2018). Beyond simply spending time in natural areas (Clayton, 2003), focusing on creating meaningful and personal experiences centered on how climate change is impacting their community (Loy & Spence, 2020) may build a lasting emotional connection (Blatt, 2014; Knapp & Benton, 2006; Lumber et al., 2017; Williams & Chawla, 2016) that increases awareness and perhaps leads to eventual action. Further these experiences may help students, like the third of our sample, that do not report "seeing" the effects of climate change in their local environments.

Limitations

Our study provides insight into important factors that help predict a student's ability to see localized climate change, including their connection to nature, geographic location where they have lived longest, and their "psychological distancing" across multiple spatial scales. While the participant pool for our study was large (survey = 410 & interviews = 15), we acknowledge that our limited geographic diversity, political party affiliation (Democratic Party = 35%), and demographic representation of participants (White = 72%; Female = 68%) affect the generalizability of our study and patterns we describe may not be reflective of all undergraduate biology student populations. More research is needed to understand whether these same patterns occur in student populations composed of more people of color or from different types of institutions (e.g., community colleges, historically black colleges and universities, Hispanic serving institutions, tribal colleges, and universities). We also acknowledge the impact of the record-setting fire season that occurred in the fall of 2020 in Colorado that directly impacted the visible air quality in all the sampled institutions in that state (Allan et al., 2020; Hamilton & Keim, 2009) may potentially bias our participants' responses (Akerlof et al., 2013; Spence et al., 2011; Zaval et al., 2014). However, we believe this bias was limited because we noted that only 35 participants' noted fire as an outcome of climate change in their responses to our survey.

Our quantitative analysis was dependent on our translation of an open response question into a binary response, which treats all Seen Effects equivalently when some are more accurate or detailed than others. Additionally, one of our qualitative analyses of the interview data was limited by the predefined explanations and theories we used in our deductive coding. While we felt our interview was rich enough to address our research questions, there were only two questions in a larger protocol which constrained time dedicated to collecting responses to these questions. Further, we recognize the potential bias in the wording of our interview questions (particularly the leading nature of Q17 may have resulted in more students describing a positive relationship between the two factors leading to an overrepresentation in our data); however, we still feel that patterns in our data are revealing (Appendix C1).

Conclusions and Future Research

The results from our study provide new insight into what factors predict whether undergraduate biology students see the effects of climate change locally or not. Clearly, one's connection to nature contributes to seeing the local effects of climate change, and our data intimates that personal experiences are a bridging factor. Further, our findings suggest that students who see climate change at smaller scales frame these Seen Effects within a personal context. One's connection to nature could be used as a method for reducing the spatial distance associated with climate change by potentially increasing the personal relevance of and emotional connection to climate change locally through purposefully designed classroom interventions or field-experiences (Clayton, 2003; Mayer et al., 2009; Van Boven et al., 2010).

Future research could explore additional factors out of the scope of this current work, including how course-level may impact this relationship. Our preliminary analyses did not find a difference in Seen Effect between lower and upper-division courses for our population, so we did not include course-level in our model. Research on learning progressions states that a student's ability to understand complex scientific concepts, including climate change (Parker et al., 2015), changes and progresses overtime (Corcoran et al., 2009; Scott et al., 2019), warranting further studies to focus on how course-level interacts with one’s connection to nature and observation of the effects of climate change in the local environments.

CHAPTER III

CONNECTION TO NATURE:
A STUDENT PERSPECTIVE

This chapter has been previously published or accepted for publication in *Ecosphere*.

Contribution of Authors and Co-Authors

Manuscript in Chapter III

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Contributions: Conceived study topic and design. Collected, organized, and analyzed data. Wrote first draft of the manuscript.

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Abstract

Connection to nature has been linked to increased physical and mental health and increased performance of sustainable behaviors for individuals more connected to nature. Understanding why humans, especially younger generations, are connected to nature is an important tool for both public and environmental health. Our work used a qualitative, phenomenological study design to examine university biology students' descriptions of others' connection to nature, the frequency that students predict their own connection to nature, and student descriptions of the discrepancies between their prediction of their own connection to nature and their score on the Environmental Identity Scale. We found that students descriptions of both their own and others' connection to nature centered around 1) beliefs, characteristics, looks, or other qualities of a person's identity that describes their relationship to nature and 2) specific behaviors or actions taken by a person that either directly or indirectly affect the environment. Further, most students accurately predicted their own connection to nature. Our study provides a novel analysis of students' perceptions of connection to nature that could inform programs and curricula designed to increase connection to nature in university students.

Introduction

> Being connected to nature means you have respect for it. Like a mutual understanding, where you don't see nature as something you can use, abuse, profit off… It's more something you can spend time in, enjoy, love, take care of, you know. We as humans are part of nature.
>
> —Carlos

> I feel like, [nature is] just a part of my identity in a lot of ways.
>
> —Weston

Wilson (1984) described a human's relationship with nature as being "innate", suggesting that one's connection to the natural world, conscious or not, is rooted in the evolutionary history of *Homo sapiens* as a species and their reliance on these natural systems, current and past, for survival. This genetic predisposition, commonly referred to as the *Biophilia Hypothesis*, helps partly explain human's tendency to move toward and immerse oneself in nature (Leopold, 1989; Wilson, 1984). Kellert and Wilson (1993) outlined nine dimensions of biophilia values (e.g., moralistic, aesthetic) to support the evolutionary basis of the *Biophilia Hypothesis* and described the universal affinity and complexity of the human-relationship.

This founding work argued that fostering nature connectedness through exposure and experience is necessary to ensure the persistence of biophilia in human populations (Kellert, 2008; Kellert & Wilson, 1993; Wilson, 1984). Later, Chang et al. (2022) contributed that genetics partially contributes to human's nature orientation and their experiences in nature, although environmental factors like access to nature seem to be more important when describing an individual's level of connection and experience with nature. Beyond genetics, individuals seek out nature for a variety of physiological and psychological benefits including recreation, happiness, well-being, and solitude (Clayton, 2003; Kellert, 2003; Kellert & Wilson, 1993; Leopold, 1989; Mayer & Frantz, 2004; Nisbet et al., 2009; Soga & Gaston, 2020; Wilson, 1984).

Despite our evolutionary ties to nature and the other benefits we receive by connecting with it, research shows that human contact with nature has decreased over the past 30 years as we become more technologically advanced, a phenomenon that has been coined "extinction of experience" (Pyle, 1993) or the "reduced experience" (Gaston & Soga, 2020). Further, experiences with nature (which is synonymous with connection to nature) are fundamentally different than interactions with nature. Interactions deal with the direct contact humans have with nature from a sensory perspective (e.g., visual, olfactory) and are precursors to the more emotional and personal aspect of experiences with nature (Gaston & Soga, 2020).

Individual experiences with nature are variable and complex, thus rarely generalizable, or universal across human populations and cultures (Kellert & Wilson, 1993). For example, people experiencing environmental injustices (e.g., living in war) may have reduced contact with nature. More commonly, diminished experiences with nature are related to increased reliance on and access to technology or decreased access to natural areas in urban and suburban areas (Larson et al., 2019; Nabhan & St Antoine, 1993; Soga & Gaston, 2016). Frumkin et al. (2017) highlight the need for research examining socioeconomic, ethnic, and cultural variations in nature connectedness (e.g., differences in access, exposure, benefit) to better understand the variation in nature experiences that exist.

Regardless of reason, the consequences of reduced contact with nature are potentially vast including reduced well-being and physical health (Shanahan et al., 2015), diminished oral traditions and spread of traditional ecological knowledge (Nabhan & St Antoine, 1993), and decreased investment in environmental protection (Soga & Gaston, 2016). To combat this issue, biophilic design incorporates nature into modern human environments and building design (Kellert, 2008) to enhance well-being, emotional connection, and experiences (Kellert, 2018). More recently, Colléony et al. (2017) suggest that landscape management of natural spaces could play an important role in establishing more desirable natural areas to increase human interaction and motivation to experience nature. The complexities of why humans connect to nature, how they connect to nature, and what they gain from this connection warrant continued exploration.

Previous Research on Connection to Nature

Connection to nature has been cited as a predictor of multiple personal health attributes. Mayer et al. (2009) found that exposing participants to both physical and virtual nature led to an increase in participants' overall well-being. Similarly, Martin et al. (2020) found when individuals visited nature at least once per week they had increased well-being and health. Additionally, a significant, positive relationship between nature connectedness and happiness has been documented in children (Barrera-Hernández et al., 2020; Cui & Yang, 2022) and adults (Zelenski & Nisbet, 2014). These connections suggest that spending time in natural areas benefits humans' physical and mental health and may be a reason some people seek experiences in nature.

Further, connection to nature has been cited as a predictor of multiple behaviors that impact human interest and public policy. Performance of pro-environmental behaviors has been linked to connection to nature, suggesting that individuals who are more connected to nature care more for the environment and strive to protect it through sustainable behaviors (Cheng & Monroe, 2012; Clayton, 2003; Martin et al., 2020; Mayer & Frantz, 2004; Nisbet et al., 2009). Clayton (2003) argues that fostering an environmental identity in an individual can act as a "guiding force" toward increased social, political, and personal concern for the environment and an increase in conservation-minded behavior. Alternatively, a higher level of connection to nature does not necessarily lead individuals to increase their pro-environmental behaviors. Whitburn et al. (2020) completed a meta-analysis of connection to nature instruments and found a significant and positive, albeit moderate, relationship between nature connectedness, pro-environmental behavior, and environmental concern. They suggest that although individuals may have increased concern for environmental issues, barriers such as cost (both financial and time commitment), knowledge of sustainable practices, and city infrastructure (e.g., recycling centers, public transportation) may prevent people from performing sustainable behaviors (Whitburn et al., 2020). Feelings of guilt, hopelessness, and eco-anxiety regarding environmental conservation can further muddy the relationship, preventing individuals from acting sustainably regardless of their level of connection or concern for natural environments (Longo et al., 2019; Pihkala, 2020).

Additionally, a person's increased connection to nature has been associated with greater awareness of and concern for environmental problems (Nisbet et al., 2009; Schultz et al., 2004). Duke and Holt (2022) found that university students who are more connected to nature had greater awareness of the effects of localized climate change in their state. Barros and Pinheiro (2020) reported a similar significant relationship between middle and high school students' level of connection to nature and their perception of the consequences of local climate change. The relationships between an individual's connection to nature with personal well-being, happiness, sustainable behaviors, and environmental awareness suggest that understanding why humans are connected to nature is an important tool for both public and environmental health.

Measuring Connection to Nature

There are many instruments that quantitatively measure an individual's level of connection to nature using a series of questions or graphics. Examples of instruments include the Environmental Identity Scale (abbreviated EID; Clayton, 2003), the Nature Relatedness Scale (NR; Nisbet et al., 2009), the Connection to Nature Scale (CNS; Mayer & Frantz, 2004), the Inclusion of Nature with Self (INS; Schultz, 2002), and the Connection to Nature Index (CNI; Cheng & Monroe, 2012). A person's connection to nature is shaped by a variety of factors including personal experiences, society, and culture. These instruments were created to measure connectedness to nature through these different lenses including how emotion impacts one's connection (Mayer & Frantz, 2004), the degree of human-nature relatedness (Nisbet et al., 2009), the relationship between self or identity and nature (Clayton, 2003; Schultz, 2002), and how children are connected to nature (Cheng & Monroe, 2012). Beyond content, each of these instruments varies in the type of items (e.g., images (Schultz, 2002), Likert scale (Nisbet et al., 2009)) and number of questions used to calculate an individual’s connection to nature resulting in a variety of metrics used to denote an individual's connection to nature score (e.g., EID scale 24-120 (Clayton, 2003), CNS scale 14-70 (Mayer & Frantz, 2004)).

The instrument development process and the intended population for each metric also differs. Most of the instruments include novel questions developed by the researchers (Cheng & Monroe, 2012; Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2009), although Schultz (2002) created the INS by adapting an existing metric. For instruments that include novel questions, the development process included literature examination (Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2009), survey validation of questions (Cheng & Monroe, 2012; Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2009), and interviews with participants (Cheng & Monroe, 2012). While some instruments were developed with a population in mind (e.g. primary school children; Cheng & Monroe, 2012), most instruments do not identify a specific population which they are targeting (Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2009; Schultz, 2002).

These quantitative scales offer valuable insight into how connection to nature is related to various aspects of the human condition. However, through these instruments, a person's connection to nature is relegated to a number based only on a series of prompts bounding participants' relationship with nature by the questions asked through instrumentation. In the connection to nature literature we reviewed, few used qualitative approaches with most focusing on K-12 populations (Barthel et al., 2018; Michaelson et al., 2020; Tugurian & Carrier, 2017). Hamby et al. (2022) conducted interviews with adults exploring their connection to nature;

however, this work narrowly focused on how the participants' childhood experiences shaped their "eco-connections".

Although few studies have directly examined the construct of connection to nature qualitatively, there are abundant examples of qualitative approaches to understanding environmental identity (Blatt, 2014), place-attachment (Beery & Jönsson, 2017; Duvernoy & Gambino, 2021), view of or experiences with nature (Chambers & Poidomani, 2022; Cobern et al., 1999), and outdoor educational pursuits (Carrier et al., 2013; Williams & Chawla, 2016). These studies highlight the importance of qualitative data in its ability to explore complex constructs, such as connection to nature, directly through the voices of participants.

Our Study

Previous research on connection to nature has used quantitative metrics to measure different psychological aspects of an individual's connection (e.g. Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2009). While quantitative measures are informative, few researchers have examined how individuals, particularly undergraduate student populations, think about their own and others' connection to nature using a qualitative, phenomenological research approach.

Research Questions

Our study seeks to fill this gap in the literature by investigating two research questions using in-depth, semi-structured interviews:

Q3.1 How do biology undergraduate students describe individuals that are highly connected to nature and those who are not very connected to nature?

Q3.2 How frequently do these students accurately predict their own connection to nature and what factors contribute to discrepancies in students' prediction of their own connection to nature?

Materials & Methods

Methodological and Theoretical Frameworks

We chose to use a phenomenological approach in our methodology to describe the lived experiences of and between individuals (Creswell & Plano Clark, 2017; Crotty, 2015), which aligns with our research goals of providing an in-depth analysis of undergraduate student relationships with nature and describing how they perceive other individuals' connection to nature. More specifically, our design combined aspects of descriptive and interpretative phenomenology throughout our study. We also used bracketing or setting aside of our own feelings and experiences with nature to 1) prevent the repression of student thought and expression during our interviews (e.g., allowing them to define nature themselves); and 2) avoid our own expectations and assumptions from guiding the data analysis (Alhazmi & Kaufmann, 2022; Crotty, 2015).

Our research examines student reflections about their own connection to nature and richly describes student perceptions of how they characterize someone highly connected (or not at all connected) to nature. Our lens of student perceptions about these connections is founded on a constructivist framework. Crotty defines constructivism as “the view that all knowledge is contingent upon human practices being constructed in and out of the interaction between human beings and their world” (Crotty, 2015). Through exploration of these lived experiences, we hope to better understand student perceptions of how people are connected to nature. We also recognize culture and society impact students' view of the world around them and shape their views of and relationships with the natural world. Crotty (2015) describes how an individual born into a “logging town” views the natural world differently than another individual who grows up in an urban environment and these perspectives can be carried with them into adulthood shaping their knowledge through social constructivism.

While constructivism helps define how undergraduate biology students may assemble their understanding of being connected to nature, E.O. Wilson's theory of biophilia helps articulate an individual's innate and emotional relationship with nature that is rooted in the evolutionary history of our species (Wilson, 1984). Other researchers have elaborated on this theory by describing the emotional impact of human interaction with nature and how it shapes their connection to it (Clayton, 2003; Kellert & Wilson, 1993; Mayer & Frantz, 2004; Nisbet et al., 2009; Schultz, 2002). Both social constructivism and biophilia provided the theoretical foundation for our work.

Sites and Participants

Data collection for this study was conducted with permission from the Institutional Review Board where the investigators are affiliated (IRB # 2012018874; Appendix A). Consent was secured from all participants before conducting interviews and collecting survey data. The data collected for this study were part of a larger project that examined the relationship between connection to nature, psychological distance, and local climate change awareness and included additional survey questions and interview questions that were not analyzed for the present study (Appendix B and C2; Duke & Holt, 2022).

We used purposeful sampling to recruit students from several higher education institutions in Colorado (CO) and North Carolina (NC) for a broad sample representing different areas of the US. We sampled students in biology classes to focus on participants that may have more experiences with nature. For our initial study, we successfully recruited 410 students, from 13 biology classes at four institutions to complete an online survey. The final survey question asked participants if they were interested in participating in a follow-up interview, 154 of the 410 survey participants agreed. We used purposeful sampling to select sixty participants based on their connection to nature score and their willingness to participate. The interview selection criteria were based on work for our larger study and students were selected to achieve variation in participant EID scores and responses to an open-response item where they described whether they had or had not seen the effects of climate change in their state. All 60 participants were contacted for an interview. Interviews and preliminary coding were done in a parallel manner and data saturation was reached after 16 interviews meaning that no new ideas or themes were being presented by participants (Fusch & Ness, 2015). All 16 interviewees were compensated with a $10 Amazon gift card for their participation.

A small sample size (saturation can often be achieved with 10-20 individuals; Guest et al., 2006; Vasileiou et al., 2018) can accurately capture the complexity of the phenomenon of interest that is represented in a rich and more personal data of fewer participants (i.e., in-depth interviews; Vasileiou et al., 2018). Based on thematic data saturation and the rich data obtained during our semi-structured, in-depth interviews, our sample size for this present study consists of the 16 interviewed participants. With a qualitative sample size of 16 participants, our findings are not generalizable, which is not the goal of qualitative studies. Instead, our goal was transferability of our findings to similar populations (Merriam & Tisdell, 2016). The numerical summaries we provide are meant to describe the frequency of patterns in our dataset, not to generalize our results.

Our sample of 16 students primarily attended institutions in Colorado (n = 13; NC: n = 3), identified as female (n = 8; male: n = 7; non-binary: n = 1), were White (n = 13; Black: n = 2; Hispanic or Latinx: n = 1), and reported being a biology major (n = 13; other major = 3). These descriptive data are provided to identify our participants and were not analyzed as part of the present study. We assigned pseudonyms to each interviewee using a random name generator to represent a diversity of voices (Lahman et al., 2015). The gender and ethnicity of each pseudonym do not necessarily reflect those of each participant.

Data Collection

For this study, we examined how students describe others' connection to nature, quantitatively measured their personal connection to nature, and asked them to explain any discrepancies between their predicted and actual connection to nature score. We assumed that variation in how students define nature would exist and encouraged students to use their own definition of nature when discussing their connection to it; therefore, we do not provide our own definition of nature here but allow our students voices to provide this context in our data. We developed a survey in Spring 2021 for a larger project examining the relationship between connection to nature and climate change awareness (Duke & Holt, 2022). This survey included the Environmental Identity Scale (EID) to measure their connection to nature (Clayton, 2003), and several other scales and items not analyzed in the current study (Appendix B). We chose the EID scale because, 1) it is a validated instrument used to measure connection to nature, 2) it has been used in university student populations, and 3) in our pilot study, it showed high reliability (Cronbach's $\alpha = 0.93$) compared to other scales (i.e. Connection to Nature Scale and the Nature Relatedness Scale) (Clayton, 2003; Mayer & Frantz, 2004; Nisbet et al., 2009). The EID scale measures connection to nature through the lens of personal identity, group membership, shared group ideology, emotional ties, and experiences with nature (Clayton, 2003). Participants completed the survey one to two months prior to their follow-up interview. During the interview, participants did not receive their EID score until midway through the follow-up interview to ensure that students were reflecting on their connection to nature during the interview separate from the quantitative metric score.

The EID instrument includes 24 5-level Likert items. Per Clayton's (2003) use of the scale, we summed responses for each student, and composite scores ranged from 24 to 120, where higher scores indicate a greater connection to nature. For our interviews and analysis, the EID scale was simplified into a 10-point scale to allow for easier communication of scores to participants. The conversion from the EID raw score to a 10-point scale used the below equation and unrounded integers:

[(composite EID - 24) + 10]/10 = 10-point score, so the lowest set of EID scores between 24 and 33 would all equate to a value of one of the 10-point scale.

Our interview protocol was created iteratively and based largely on student responses to the survey. Questions were created and pilot interviews conducted to ensure that wording and question interpretation were consistent; final revisions were made prior to data collection. All interviews were conducted and recorded by a member of the research team during the Spring 2021 semester and our interview questions were based on student survey responses to the connection to nature instrument (Appendix B). Each interview lasted between 30-60 minutes, and all were conducted virtually due to COVID-19 precautions, the geographic spread of participants, and to ensure similar interviewing experiences for all participants. The subset of four interview questions included in this study (Table 3.1, Appendix C2) were chosen based on students' descriptions of both their own and others' connections to nature.

Table 3.1

Interview Protocol Asking Students About Their Own and Others' Connection to Nature[1]

We converted the connection to nature scale[2] to a 1 to 10 scoring system with 10 indicating an individual that is highly connected to nature and 1 indicating an individual that is not very connected to nature.
Q3: Where do you think you fall on the 1 to 10 connection to nature scale?
Q4: Describe a person that scores a 10 on the connection to nature scale. What do they do? What do they look like?
Q5: Describe a person that scores a 1 on the connection to nature scale. What do they do? What do they look like?
Q6: [Interviewer tells participant their translated score on the EID scale–scaled 1 to 10.] Explain this score? Tell me about the difference between your actual and projected score?

Notes. [1]This interview protocol was a part of a larger study. The entire protocol can be viewed in Appendix C2.
[2]This scale, referred to throughout the interview, is the Environmental Identity Scale (Clayton, 2003).

Data Analysis

Formal analysis of our quantitative data for our 16 participants was not the central focus of this study, rather these data were included to inform our interviews and analysis thereof. Our decision to not analyze our quantitative data for this study was founded in our relatively small sample size for quantitative analysis; however, we do provide participant scores for descriptive context for the qualitative analysis (see Duke & Holt, 2022 for the full quantitative analysis of 410 survey participants). We used thematic analysis to analyze our qualitative data (Table 3.1). Interviews were transcribed from audio recordings and then manually checked by the research team. We noticed data saturation amongst participant responses after completing the 16th interview, so no further recruitment was sought.

To help answer our first research question, we coded interview questions 4 and 5 (Table 3.1) using a hybrid approach (both deductive and inductive coding; Fereday & Muir-Cochrane, 2006; Swain, 2018) into common, richly described themes using *NVivo* software (released January 2022). The hybrid approach for RQ3.1 allowed for themes to emerge from the data naturally using inductive coding while also using the literature to guide these themes using deductive coding (Creswell, 2013; Merriam & Tisdell, 2016). First, three main themes (Identity, Behavior, and Ethics) were identified during a thorough review of connection to nature literature using deductive coding (Table 3.2 and Figure 3.1). Next, we read and reviewed each interview transcript which allowed us to confirm our choice of three main themes and for subthemes to emerge inductively.

While these themes and their nested subthemes were primarily used to code our interviews, we also used them to code each item in the EID scale (Appendix E). Additionally, we noticed incidental trends in the language students used to describe individuals connected to (and not connected to) nature. We took note of these word choices and described anecdotal patterns in student descriptions below, although these trends were peripheral to this research question.

For our second research question, we compared students' predicted scores, collected during the interview, with their actual score, collected via the survey, and created three categories: *accurate prediction* (prediction ±1 point of actual score), *overprediction* (prediction >1 point of actual score), *underprediction* (prediction <1 point of actual score). Since this is not a quantitative analysis, we chose an arbitrary buffer of ±1 point because we knew there would not be perfection in alignment of students predicted versus actual score. We recognize that there are multiple ways to create this buffer (e.g., linearly as we do; with wider or narrower bands) and we opted for this simple way to create three bins for discussing student's general prediction patterns. Due to our low sample size, we examined the frequency of our student sample in each category but did not conduct further analyses beyond these descriptive summaries. Finally, we used a deductive coding approach using predefined codes generated during our coding for RQ3.1 (Table 3.1) to analyze Q6 from our interviews (Table 3.1). J.D. created the preliminary codebook using the literature to guide our choice of main themes and allowing new codes to emerge inductively (Fereday & Muir-Cochrane, 2006; Swain, 2018). To increase the reliability of our study, E.H. conducted a coding consistency check (Elliott, 2018) using the preliminary codebook to independently code the interview data for each interview question (Table 3.1). We then reviewed any discrepancies in our coding to create a final codebook. The use of investigator triangulation improved the reliability of our analysis, despite having only two researchers reviewing and analyzing the data (Creswell, 2013).

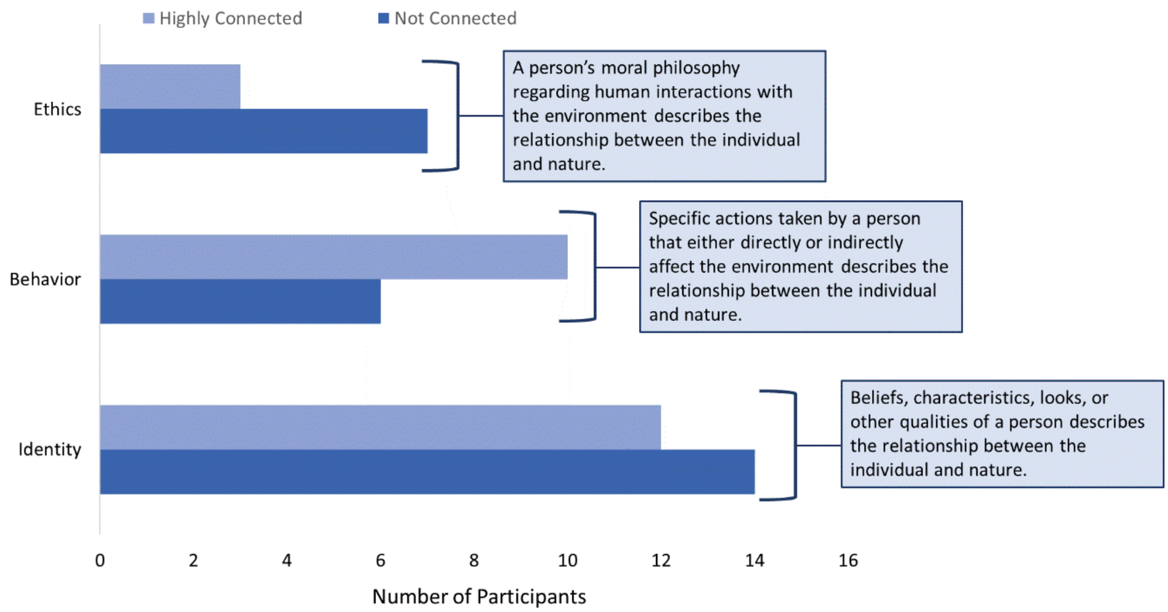
Table 3.2

Definitions for the Identity and Behavior Themes and Their Subthemes

Theme	Definition	Subtheme	Definition
Identity	Beliefs, characteristics, looks, or other qualities of a person describes the relationship between the individual and nature.	Environmental Perspective	Someone's knowledge and awareness or lack thereof of humans' place in nature and their impact upon it helps describe their connection to nature.
		Passions	Someone's excitement and interest in the environment and their own interaction with it and their non-spiritual beliefs about it help describe their connection to nature.
		Physical Description	Someone's looks (e.g., clothes, physique, hair) or possessions (e.g., house, car, outdoor gear, electronics) help describe their connection to nature. Also includes a physical description of known personas (i.e., hippie, mountain man vs. oil tycoon, banker) or actual people (e.g., Steve Irwin vs. Steve Jobs).
		Personality	Someone's personality or attitudes (e.g., easy-going, agreeable vs. uptight) helps describe their connection to nature.
		Spirituality	Someone's spirituality or lack thereof helps describe their connection to nature.
Behavior	Specific actions taken by a person that either directly or indirectly affect the environment describe the relationship between the individual and nature.	Sustainable Behaviors	The actions an individual takes that impact the environment directly (e.g., does not recycle, throws trash on the ground vs. recycling, reducing waste) or indirectly (e.g., lack of action vs. voting, protest) helps describe their connection to nature.
		Recreation	The types of leisure activities and hobbies a person participates in (e.g., playing video games, watching television vs. hiking, camping) helps describe their connection to nature.
		Time Spent Outdoors	The amount of time someone spends in nature helps describe their connection to nature.

Figure 3.1

Themes Explaining How Students Describe Someone on Either End of the Connection to Nature Scale, Definitions, and Frequency That each Theme was Mentioned by Participants for "1's" vs. "10's"



Notes. Some references were double-coded when appropriate.

Findings and Discussion

Research Question 3.1

Q3.1 How do biology undergraduate students describe individuals that are highly connected to nature and those who are not very connected to nature?

Overall, students' descriptions of individuals at both extremes of the connection to nature scale were organized into three main themes: Identity, Behavior and Ethics, each noted with capitalization throughout the text (Table 3.2 and Figure 3.2). Student quotes included below are lightly edited for clarity and readability.

Identity as a Descriptor of One's Connection to Nature

Findings. Identity was the most common theme used to explain how an individual is either highly connected to nature ("10" on translated scale) or not connected to nature ("1" on translated scale). Several subthemes, noted throughout in italic font, of Identity also arose, offering a more detailed understanding of the different aspects of a person's identity that could contribute to their level of connection to nature (Figure 3.2). First, an individual's Environmental Perspective (similar to Nisbet et al. (2009) Nature Relatedness - Perspective) or lack thereof was mentioned to describe someone highly or not at all connected to nature (Table 3.2 and Figure 3.2). Olivia noted that a person scoring a "10," thus highly connected to nature, would, "try to fight for, like, environmental issues and kind of understands their impact on the ecosystem… someone who's at least aware of their impact on the environment and the environmental issues that might need help." In contrast, Carlos described a "1," a person not connected to nature, as someone, "that has very little understanding of how their actions might affect nature. And they sort of see [nature] less as a living system, and more something that can be used and abused…". Second, a person's *Passion* was another subtheme of Identity noted in our sample to explain why someone is highly or not at all connected to nature (Table 3.2 and Figure 3.2). We conceptualized Passion as someone's interest or enthusiasm for nature, which is part of how people see them or how they see themselves. Brendon describes that those not connected to nature,

> ...derive minimal satisfaction from being outside and feeling that intuneness with nature. Or just not feel [satisfaction] at all, or claim [being outside is] a nuisance… [it may tie to] how deeply saturated an individual is with capitalism and their love for material objects.

A person's *Physical Description* was the third subtheme used to differentiate between those highly connected to nature and those not connected to nature within the Identity theme. Students typified people highly connected to nature as a "hippie" or "mountain-man", often using these physical descriptors to describe their own family or friends (e.g., "I would describe my dad. My dad is a mountain man. If you saw him, you'd be like, yeah, he's a mountain man. He's very much always in hiking boots, always in hiking pants…" - Zara) or celebrities (e.g., "I would automatically think of, like, Steve Irwin…" - Makena). Students focused on professions to describe individuals not connected to nature (e.g., "...oil tycoons, forest loggers, company CEOs, and stuff like that…" - Carlos), while also mentioning famous people (e.g., "I usually picture like Bill Gates, or Jeff Bezos..." - Tori).

Personality was a less frequently used subtheme of Identity to describe an individual's level of connection to nature. Those highly connected to nature were described as intellectual (e.g., "...highly introspective, intelligent…" - Brendon) and relaxed (e.g., "...go with the flow kind of person just easy-going, laid back…" - Molly), while people not connected to nature were characterized as uneducated (e.g., "my gut reaction was someone that is ignorant…" - Connor) or egocentric (e.g., "a person that is a little bit more selfish…" - Molly).

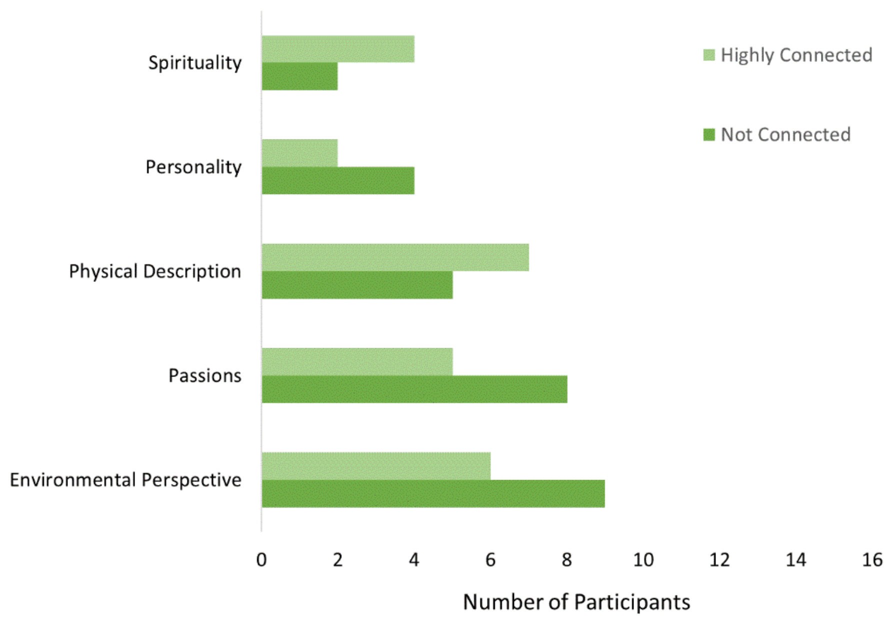
Spirituality was the final subtheme of Identity used to describe individuals highly connected to nature or not at all connected to nature. Olivia discussed how a person's religious beliefs may lead to being not connected to nature:

> Isn't there that principle in Christianity where humans are at the top [of the hierarchy of life] and then other animals [are] below us. So probably a person who believes [in this idea…might believe] it's their right to do whatever they want to nature, and they don't really think about how they're connected to it...

Students' descriptions of people highly connected to nature were less consistent. Several students mentioned that an individual that is highly connected to nature would have a deeply spiritual connection to nature (e.g., "I kind of imagine…Tibetan monks [who] are completely in tune with the world. They completely understand their place in it, who they are, how they relate to everything" - Carlos), while others mentioned those highly connected to nature might lack *Spirituality* or religious beliefs (e.g., "probably not a super, super religious individual…" - Brendon).

Figure 3.2

Subthemes of Identity to Further Explain How Students Described Individuals' Identities at Either End of the Connection to Nature Scale and Frequency that Each Subtheme was Mentioned for "1's" vs. "10's"



Notes. See Table 3.2 for definitions of each theme and subtheme. Some references were double-coded when appropriate.

Discussion and Interpretations. Identity is a central concept of the Environmental Identity (EID) Scale, which was used in our study to measure participants' connection to nature (Clayton, 2003). Clayton (2003) describes Environmental Identity as both a product (developed through genetic inheritance, experiences with nature, and social interactions) and a force (a motivator for individual environmental behavior). Similar to our findings, Schultz (2002) describes individuals' understanding of their place in nature or their Environmental Perspective as a key component of nature connectedness positing that a person who sees themselves as directly a part of nature will be more connected to it. A person's Passion for nature arises through their direct interactions with nature and their sociocultural influences (Chan et al., 2016). Individuals who harbor deep emotional attachment (Mayer & Frantz, 2004; Perkins, 2010) and experience increased levels of well-being when spending time in nature (Cervinka et al., 2012; Martin et al., 2020; Mayer & Frantz, 2004; Mayer et al., 2009) tend to value nature more. Our students' ideas mirrored these claims and further described individuals with low connections to nature as gaining no satisfaction from spending time in nature and instead placing more value on materialistic objects.

Further, Nisbet et al. (2009) found a link between Personality and nature connectedness, suggesting that individuals that are more connected to nature are more "easy-going" and "adventurous", matching language used by our participants. Schultz (2002) also mentions that individuals with a lower connection to nature care more for themselves than nature. Our student responses mirror these findings with students describing individuals that are connected to nature as being laid back and those not connected to nature as more selfish. Spirituality is most often discussed within the context of well-being in the connection to nature literature (Trigwell et al., 2014); meanwhile, several connection to nature instruments assess the relevance of this factor by asking how time spent in nature enhances one's personal spiritual beliefs (Clayton, 2003; Nisbet et al., 2009). Our participants' descriptions of Spirituality provide a novel contribution to the literature suggesting that Spirituality may be a core element of some individual's connection to nature.

Finally, Physical Description was a novel subtheme that arose in our findings, which we did not find mentioned in the connection to nature literature. We acknowledge that our wording of prompt questions (Table 3.1) potentially led our students to describe the physical descriptions of individuals highly connected to nature (10) and not connected to nature (1). However, this wording was added through revisions of our interview protocol using reflections of pilot data, where participants needed additional examples of how to describe one's connection to nature. Regardless, students seemed to have very clear delineations of individuals connected to nature and not connected to nature and were thus able to provide examples of people around them, famous or familiar.

Behavior as a Descriptor of One's Connection to Nature

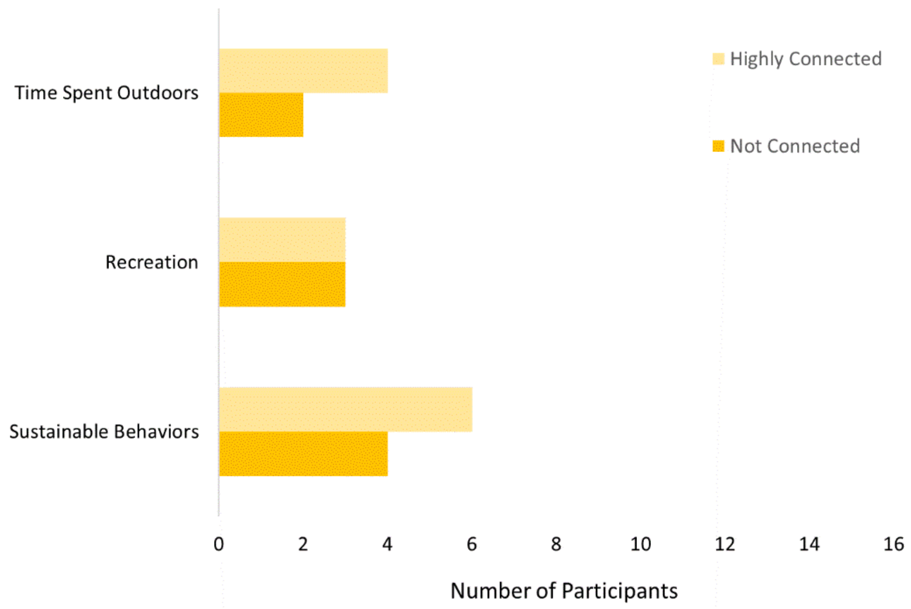
Findings. Behavior was the second most common theme students used to describe how someone is or is not highly connected to nature (Table 3.2). Several subthemes, noted in italic font, also arose, which helped more richly describe these behaviors (Table 3.2 and Figure 3.3). Students most frequently mentioned the practice of *Sustainable or Non-sustainable Behaviors* as a way to differentiate between people who are highly connected ("10" on translated scale) vs. people who are not connected ("1" on translated scale) to nature (Table 3.2 and Figure 3.3). Molly noted that Someone highly connected to nature, "...uses nature to their advantage, like, helps save the planet, helps our ecosystem and you know, cares about recycling." Students described people not connected to nature by identifying their practice of unsustainable behaviors (e.g., "They throw trash out of their car when they're on the highway." - Kevin) or their direct avoidance of sustainable behaviors (e.g., "They don't [feel the need] to help contribute to make it [Earth] a better world or to help protect the environment." - Makena).

Students also mentioned *Recreation* as a Behavior that describes an individual's level of connection to nature (Table 3.2 and Figure 3.3). Dave expressed that someone very connected to nature would participate in, "...a lot of camping, a lot of hiking, a lot of activities that are involved outdoors, as opposed to indoors so like, I guess, hiking, rock climbing, fishing, hunting stuff that where you're actually out in nature, active and involved in [those activities].” Meanwhile, this same participant described someone not at all connected to nature as spending more time recreating indoors, and “glued to their phone or … their TV screen.”

Time Spent Outdoors was the third Behavior-based explanation given by students to describe behaviors of someone highly or not at all connected to nature (Table 3.2 and Figure 3.3). Students described people highly connected to nature as those who spend more time outdoors and seek out those opportunities (e.g., “Someone who [spends] more time outside and makes more of an active effort to go outside”- Claire), while people not at all connected to nature were described as spending more time indoors or avoiding time outside (e.g., “[they] don’t get as much time outdoors” - Dave).

Figure 3.3

Subthemes of Behavior to Further Explain How Students Described Individuals’ Behaviors at Either End of the Connection to Nature Scale and Frequency that Each Subtheme was Mentioned for “1’s” vs. “10’s”



Notes. See Table 3.2 for definitions of each theme and subtheme. Some references were double-coded when appropriate.

Discussion and Interpretations. Behaviors, including Time Spent Outdoors (Clayton, 2003; Cleary et al., 2020; Nisbet et al., 2009; Wilson, 1984), experiences in nature (Brügger et al., 2011; Nisbet et al., 2009; Schultz, 2002), and performance of environmentally responsible or Sustainable Behaviors (Clayton, 2003; Martin et al., 2020; Mayer & Frantz, 2004; Nisbet et al., 2009), are frequently cited in the literature as an important predictor of a person's connectedness to nature. Much of the literature on connection to nature and many of the scales created to measure it are focused on the link between connectedness to nature and pro-environmental behaviors and attitudes (Clayton, 2003; Martin et al., 2020; Mayer & Frantz, 2004; Nisbet et al., 2009) suggesting that individuals who are more connected to nature have a greater tendency or "willingness to act" to save natural environments. Our student responses reflected these relationships described in the literature. A novel contribution is our participants' juxtaposition of Recreation to one's connection to nature and their rich description of behaviors of individuals who are not connected to nature, as much of prior research focuses on the higher end of connection to nature scales and related Sustainable Behaviors.

Ethics as a Descriptor of One's Connection to Nature

Findings. Ethics was the final theme reflecting student ideas to explain the difference between people on either end of the connection to nature scale (Figure 3.1). Unlike the other two themes, no subthemes therein arose during our analysis. All three students that mentioned Ethics when describing a person highly connected to nature referenced these peoples' increased respect for nature (e.g., "They have full respect [for] nature" - Carlos), while people not connected to nature were described as lacking both care and respect (e.g., "So it's the lack of any need to care. And it's the lack of fundamental understanding of why they should care." - Sophia).

Discussion and Interpretations. Ethics, or the moral philosophies that drive individuals, are an important component of environmental conservation (Leopold, 1989; Wilson, 1984). While some connection to nature instruments include questions that refer directly to individuals' morality concerning nature (Clayton, 2003), the majority of instruments reference environmental care (Mayer & Frantz, 2004; Schultz, 2002) which focuses more on affection or concern for nature rather than one's respect for it. All of our student responses within this theme mentioned either care or respect (or lack thereof) when describing individuals on either end of the connection to nature scale.

Trends in Frequency of Themes

Identity was the most common theme mentioned by participants when describing both individuals not connected to nature ("1" on translated scale) and individuals highly connected to nature ("10" on translated scale) (Table 3.2). Within Identity, the subthemes Environmental Perspective and Passions were most referenced when describing those not connected to nature ("1"), while Physical Description, Environmental Perspective, and Passions were the most common descriptors of an individual highly connected to nature ("10") (Table 3.2 and Figure 3.2). Behavior and Ethics were used equally by participants to describe those not connected to nature, while Behavior was more commonly used to describe individuals highly connected to nature (Figure 3.1). Within Behavior, all three subthemes were almost equally used when describing individuals not connected to nature, while Sustainable Behaviors was the most common subtheme used when describing people highly connected to nature (Table 3.2 and Figure 3.3).

While coding student interviews, we discovered incidental patterns in words students chose when describing individuals not connected to nature compared to individuals highly connected to nature. When describing a person not connected to nature, many of our students described these individuals using negative words such as “selfish” or “ignorant”. Additionally, most students described individuals considered highly connected to nature in either a positive (“easy-going” and “caring”) or neutral tone (“outdoorsy” and “spends more time outside”). Only one student, Riley, used negative language to describe individuals highly connected to nature saying,

> I think…completely encompassing yourself in [nature] is also an unhealthy thing…And, like, I think more [of] a happy medium, [in the middle of the connection to nature scale], is a better place to be. So, I think, I would say [I have] a negative opinion of them, and that they're kind of being silly, and just pretending to be something that they're not..

While these anecdotal trends in student language describing people on either end of the EID scale are interesting, intentionally coding for these differences was not part of our original research goal and is beyond the scope of this study.

To better understand the alignment of the EID quantitative scores and patterns in participants’ qualitative responses about connection to nature, we coded and compared the frequency of themes and subthemes that arose during our study within individual items on the EID scale (Appendix E). We identified all three interview-derived themes predominated as themes within the EID scale items (Identity *(n= 16),* Behavior *(n=7),* and Ethics *(n=1)*) (Appendix E). The frequency with which these themes are utilized within the EID scale aligns with the frequency that participants mentioned these themes when describing other individuals’ connection to nature (Figure 3.1). Further, we were able to identify three of the five subthemes of Identity (Passions *(n=11),* Environmental Perspective *(n=4),* and Spirituality *(n=1))* and all three subthemes of Behavior (Time Spent Outdoors *(n= 2),* Sustainable Behaviors *(n=2),* and Recreation *(n= 2))* when coding the EID scale (Appendix E). The emphasis, in our participants' interview responses, on Identity in describing someone's connection to nature aligns with the content of the Environmental Identity Scale (Clayton, 2003), specifically the explanation of how someone's Passions influence their connection to nature (Chan et al., 2016; Clayton, 2003; Schultz, 2002). Two subthemes of Identity (Physical Descriptions and Personality) noted in analysis of the interviews were not represented within the EID scale (Table 3.2 and Figure 3.2).

Research Question 3.2

Q3.2 How frequently do these students accurately predict their own connection to nature and what factors contribute to discrepancies in students' prediction of their own connection to nature?

Accuracy Findings

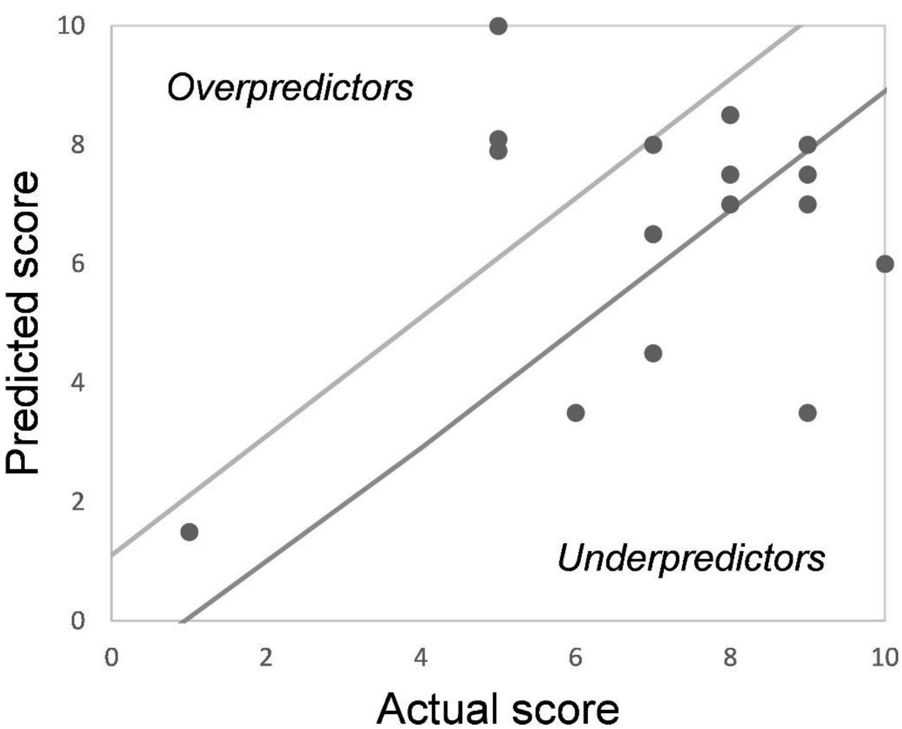
Many of our participants predicted their score on the EID instrument within one point of their actual score (*n* = 7; Figure 3.4). The remaining participants either scored higher or lower on the EID (*n* = 3, *n* = 6 respectively) compared to their actual score (Figure 3.4).

Accuracy Discussion and Interpretations

Students did not receive their actual score on the Environmental Identity Scale (EID) until after they gave their descriptions of individuals highly connected to nature ("10) and individuals not connected to nature ("1") (Table 3.1). We see distinct differences in the way under and over-predictors described a person not connected to nature, described above in RQ3.1. Specifically, over-predictors all use ideas captured in the Behavior theme, some in conjunction with other themes, while under-predictors all reference Identity, with some also mentioning other themes. We suggest that students who are over-predicting their scores may be focusing on behaviors that those not connected to nature may do, in which they themselves do not engage, leading them to over-inflate their predicted score. In contrast, under-predictors may see elements of Identity associated with people disconnected from nature within themselves and subsequently score themselves lower on their prediction.

Figure 3.4

Student-Predicted Scores from Interviews and Matched Actual Scores from the Environmental Identity Scale



Notes. Diagonal grey lines represent the bounds of accurate student score predictions (i.e., ±1 from the 1:1 line). Students falling above both light grey lines overpredicted their scores, while students falling below both dark grey lines underpredicted their scores.

Behavior and Identity as Descriptors of One's Own Connection to Nature

Discrepancy Findings. Overall, students' explanations of discrepancies between their predicted and actual EID scores fell into two main themes: Identities and Behaviors (Table 3.2 and Figure 3.5). Student quotes included below are lightly edited for clarity and readability.

Behavior was the most common theme students used to explain discrepancies between their predicted and actual connection to nature scores (i.e., translated EID). *Time Spent Outdoors* was the most common explanation used by participants to describe discrepancies in their scores (Table 3.2 and Figure 3.5), and notably, over-predictors overwhelmingly mentioned their own lack of available time to spend in nature (e.g., “I don't get to spend as much time in nature as I would like to. Not to say that I don't ever [spend time outside] ...I definitely still do. Just I used to be [in nature] every day and now I’m not.” - Patience) as the main reason for their lower-than-predicted scores. Participants described their lack of Time Spent Outdoors as stemming from their occupation as a student, with an increased focus on school (e.g., “I think maybe I'm not so involved in nature quite so much now that I'm in college.” - Zara) or lowered accessibility to nature while in school (e.g., “I really think accessibility is a big one. I don't think my value of nature has really, like, gone down since I've been here in [college]...But my actual time spent in places like that [natural environments] has definitely gone down…” - Brendon).

Participants also explained discrepancies in their actual and predicted connection to nature scores reflecting on their *Sustainable Behaviors*. Most students explained that they had predicted a lower score for themselves because they engaged in unsustainable behaviors or were not doing enough sustainable ones. Sophia explained her lower-than-predicted score saying,

> I think one of the things I'm hard on myself about is the fact that I know my car is very gas [inefficient].... But there are some things that I do try [to do sustainably] and if I can shop at more stores that are more eco-friendly, which is hard. And if I garden, I try and make sure it's native…There are some things I try and do but I try and be realistic about the things I can't change and not be hard on myself for the things that you know, there's

no point in being hard on myself for that. But it's still like sticks in the back of your mind…

Finally, several students mentioned *Recreation* when describing their connection to nature scores. This theme primarily explained higher-than-predicted scores. Dave mentioned, "I'm a pretty big hunter and fisher so I spend a lot of time outside especially over my summer", which aligns with his descriptions of other individuals highly connected to nature.

Identity was also referenced by participants when explaining discrepancies in their connection to nature scores. *Physical Descriptions* was the only subtheme that did not arise in their reconciliation between their actual and predicted scores (Table 3.2). *Passions* was the most common subtheme participants used to explain discrepancies in their scores (Table 3.2 and Figure 3.5). Some students described their higher-than-predicted scores based on their enjoyment for nature (e.g., "I really do derive a lot of enjoyment from being out in nature." - Brendon), while others explained their lower-than-predicted scores based on their lack of enjoyment in or for nature (e.g., "And so enjoying nature is just not what I could see myself passionately doing for the rest of my life." - Connor) or their interest in "other" activities (e.g., "I don't think that my prime interest is in nature. I think I am connected to nature, but only in certain areas." - Zara).

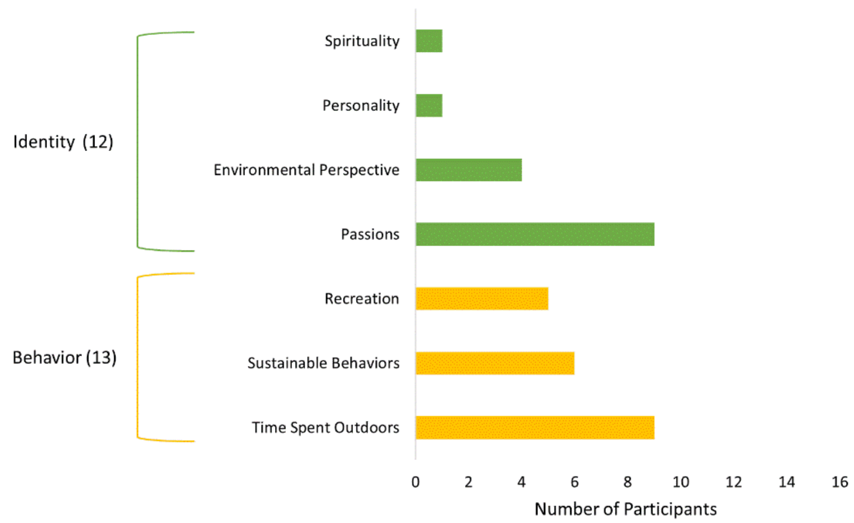
Participants also mentioned their *Environmental Perspective* when explaining differences in their actual and predicted scores. Three of the four participants that mentioned Environmental Perspective explained their predicted scores through their perceived role and place within the natural environment (e.g., "I think an 'eight' [the actual score she received on the EID] is someone that's kind of self-aware of their role in the outdoors, they have that relationship with nature…they see their role in the bigger picture, and like how they can help have a better impact." - Makena). Kevin explained that his actual score may have been lower than his prediction because of his beliefs regarding how humans relate to other organisms and the natural environment saying, "...we are part of nature, but we're not. At least, I don't think I'm part of any other species. I mean I would like to say [I'm] a little more dignified. Like...I'm not an accident…".

Personality was only mentioned by one participant to partially explain his overprediction. Kevin mentioned how some people think of him as a "hippie" or "tree-hugger", which may have biased his self-perspective, resulting in him over-predicting his score. Kevin further explained that his actual score may have been lower because he does not identify with these terms used by others to describe him.

Spirituality was also only mentioned by one participant when explaining her overprediction. Olivia viewed her ideas of connection to nature as different from those measured with the EID scale, of which the latter she believed was rooted in a spiritual connection to nature saying, "I probably would have pulled towards the one [score, or not connected to nature,] because I don't believe in that kind of maybe spiritual aspect [of one's connection to nature] ...".

Figure 3.5

Themes and Subthemes Used by Participants to Explain Differences Between Their Predicted and Actual Environmental Identity Scores Ordered by Frequency



Notes. See Table 3.2 for definitions of each theme and subtheme. Some references were double-coded when appropriate.

Discrepancy Discussion and Interpretations. Identity and Behavior were equally mentioned by participants when describing their connection to nature scores; however, the number of references within Behavior was higher. This focus on Behavior is interesting given the EID scale's strong focus on environmental identity (Clayton, 2003; Appendix E) suggesting that students may consider their behaviors and interactions with the environment as more or equally as important as their identity when reflecting on their connection to nature. Our participants frequently discussed their lower-than-predicted or actual connection to nature scores based on their perceived lack of Time Spent Outdoors, while individuals that scored higher on the EID, purported to spend a lot of time outdoors. The literature supports these patterns suggesting that people who are more connected to nature tend to spend more time outdoors (Brügger et al., 2011; Clayton, 2003; Cleary et al., 2020; Mayer & Frantz, 2004; Nisbet et al., 2009), with reduced experiences in nature leading to decreases in connection (Gaston & Soga, 2020; Larson et al., 2019; Soga & Gaston, 2016). The majority of the literature focuses on quantifying how or why individuals may choose to spend time in nature including seeking happiness (Brügger et al., 2011; Nisbet et al., 2009; Zelenski & Nisbet, 2014), improving well-being (Frumkin et al., 2017; Martin et al., 2020; Mayer et al., 2009), or recreating (Cleary et al., 2020; Kellert & Wilson, 1993; Lin et al., 2014; Mayer & Frantz, 2004), while our students primarily described how the actual amount of time they chose to spend or are able to spend in natural areas influences their connection to nature. Fretwell and Greig (2019) found similar results in a study asking participants to identify barriers to their connection to nature, with lack of time available to spend in nature being cited as the primary barrier. Financial cost was also mentioned as a barrier to performing sustainable behaviors, which was not surprising given our population was university students and has been documented in the literature as a potential reason for why individuals connected to nature may not always participate in pro-environmental behavior (Whitburn et al., 2020). We did not prompt students to elaborate on how or why they either spend time in nature or avoid spending time in nature, which may have contributed to their descriptions. Within Identity, students mainly described how their *Environmental Perspectives* and *Passions* contributed to their connection to nature or discrepancies in their predictions. Unlike student descriptions of other individuals' connection to nature, students never self-described their own connection to nature using explanations related to *Personality* and *Spirituality*, and no participants mentioned their *Physical Description* when explaining their own connection to nature. This aligns with the themes and subthemes we found to exist within the EID instrument itself (Appendix E).

Summary and Future Implications

Conclusions

The results from our study provide a novel, in-depth description of how undergraduate biology students view their own and others' connection to nature. When asked to describe people both connected to and not connected to nature, students focused on three important themes, Identity, Behavior, and Ethics (Table 3.2 and Figure 3.1). Two of these same themes, Identity and Behavior, were also mentioned by students when reflecting on their own connection to nature and used to explain discrepancies between their own actual versus predicted scores on the EID scale (Table 3.2 and Figure 3.5). Overall, when asking students to describe their connection to nature and others' connection to nature, we see convergence with themes discussed in the literature (Chan et al., 2016; Clayton, 2003; Schultz, 2002) and reflected in the EID (Appendix E). Further, many students accurately predicted their EID score (n=7; Figure 3.4). We noted distinctions between how over- and under-predictors described individuals not connected to nature, with over-predictors focusing more on the Behaviors of these people and under-predictors focusing more on these individuals' Identity.

Limitations

Our participant pool was large enough for us to reach data saturation (n=16); however, we acknowledge that the limited demographic and geographic representation of our participants may affect the transferability of our study, and the patterns we describe may not be reflective of all undergraduate student populations (Carminati, 2018). More research is needed to understand whether these same patterns occur in student populations composed of more people of color, from different types of institutions (e.g., community colleges, historically black colleges and universities, Hispanic serving institutions, tribal colleges and universities), and from different geographic regions within and outside of the United States. Further, the nature experiences described by our population may not encompass the experiences of individuals in all socioeconomic, cultural, or ethnic groups and more targeted research is needed to understand diverse populations (Frumkin et al., 2017).

We also recognize the potential bias in the wording of our interview questions (particularly the leading nature of the prompts associated with Q4 and Q5 which may have resulted in more students mentioning specific themes and subthemes); however, we still feel that our student descriptions are novel and revealing (Table 3.1). Finally, we acknowledge the potential impact of self-selection bias on the outcomes presented in this study and recognize that participants who volunteered to be interviewed could have been influenced to participate by their interest in the topic or small cash incentive ($10 gift card).

Broader Impacts

Understanding how students think about their own and others' connection to nature in their own words has been sparsely explored in the literature thus far. With the planet facing a historic climate crisis and increased environmental degradation, it is important to find ways to increase awareness of these problems and commitment to protecting natural environments. Other studies have proposed links between connection to nature and these factors and suggest increasing a person's connection to nature could increase pro-environmental behavior (Clayton, 2003; Martin et al., 2020; Mayer & Frantz, 2004; Nisbet et al., 2009). We believe students, particularly voting-age, university students, are an important demographic to target for inducing environmental change. The results from our study offer insight into how our students think about their own and others' connection to nature which could be used by policymakers and educators to create purposeful programs designed to increase our students' connectedness to natural realms. Time spent in nature and personal experiences with nature are important variables impacting connectedness and could be targeted through the implementation of outside learning activities (Carr & Hughes, 2021; Mayer et al., 2009). Work is needed, however, to clarify the duration of successful curricula. Additionally, our results suggest that what students are passionate about plays a significant role in a student's connection to nature. Making environmental issues more personally relevant to students through discussion of environmental values and sustainable behaviors, both in the classroom and through public policy campaigns, could further increase university students’ connection to nature (Lankenau, 2018). Finally, our results show a convergence between common themes mentioned by students and those reflected within the EID scale. These results could be expanded in future studies to provide additional psychometric validation for the EID scale (Clayton, 2003).

CHAPTER IV

PLACE-BASED CLIMATE CHANGE: LOWERING STUDETS PSYCOLOGICAL DISTANCE THROUGH A CLASSROOM ACTIVITY

Contribution of Authors and Co-Authors

Manuscript in Chapter IV

Author: Jessica R. Duke

Contributions: Conceived study topic and design. Collected, organized, and analyzed data. Wrote first draft of the manuscript.

Co-Author: Dr. Emily A. Holt Contributions: Conceived study topic and design. Provided feedback on analyses and earlier versions of draft.

Abstract

Psychological distance (PD) can be a barrier to how students perceive climate change impacts and severity. Localizing climate change using place-based approaches is one-way instructors can structure their curricula to help combat students' PD, especially from a spatial and social viewpoint. We created a novel classroom intervention that incorporated elements of place-based education and the Teaching for Transformative Experiences in Science model that was designed to lower undergraduate biology students' spatial and social distance of climate change. Our research questions sought to determine whether students' PD changed following our intervention and whether variables beyond our intervention might have contributed to changes we identified. To measure the efficacy of our intervention, we administered a survey that contained several instruments to measure students' recognition and psychological distance of climate change pre- and post-intervention. We found that students' psychological distance to climate change decreased after participating in our classroom intervention. Additionally, course level was the only outside variable we identified as a predictor of students' post-activity scores. Participation in our activity lowered our students' spatial and social-psychological distance, which could have impacts beyond the classroom as these students become the next generation of scientists and voters.

Introduction

The ever-present threat of climate change has increased the interest in and need for instructors to include climate change in undergraduate student curricula (IPCC, 2021; Monroe et al., 2019). However, the global and interdisciplinary complexity of climate change can create barriers for instructors making it difficult to incorporate the topic into their existing classroom curricula (Monroe et al., 2019). In the classroom, instructors often frame climate change primarily within a global context, which can impact how students understand climate change and perceive its severity (Busch, 2016; Gubler et al., 2019). Further, this globalized framing can increase the distance in which students perceive the impacts of climate change (Devine-Wright, 2013; Scannell & Gifford, 2013; Spence et al., 2012). The construct of psychological distance (PD) is often used to describe the perceived distance between an individual and climate change across multiple scales (e.g., spatial, social, temporal, and hypothetical) (Trope & Liberman, 2010; Figure 4.1). Individuals might experience one or multiple levels of psychological distance at any given time.

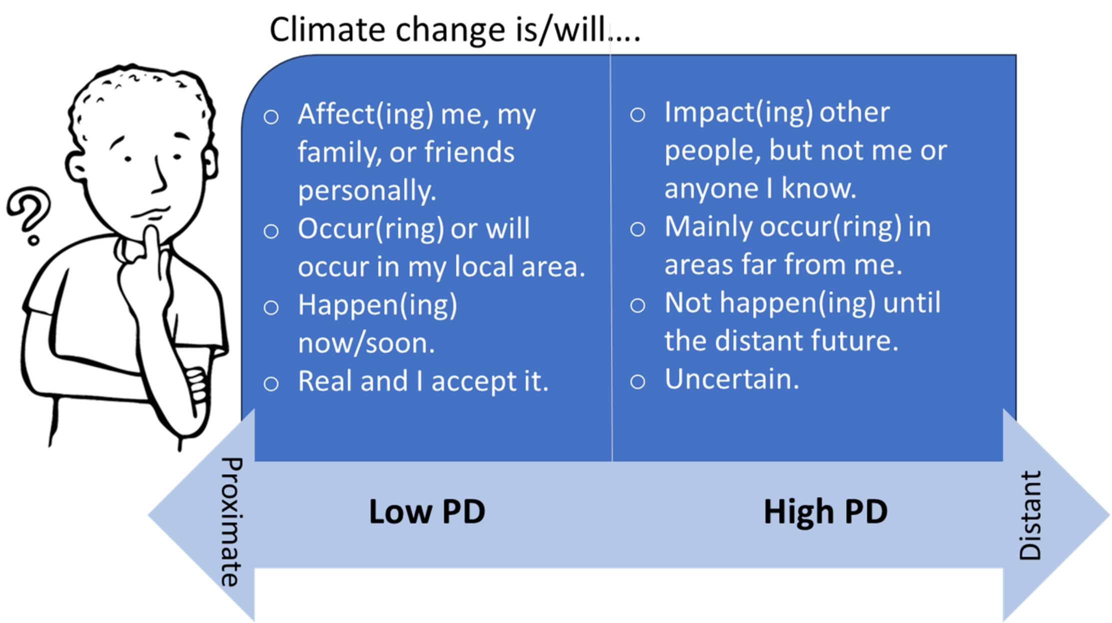
Increased psychological distance is considered a barrier to climate change action (Van Lange & Huckelba, 2021). Lowering a person's PD can lead to an elevated concern for climate change (Busch & Chávez, 2022; Gubler et al., 2019; Spence et al., 2012) and sometimes increased performance of sustainable actions and behaviors (Maiella et al., 2020). Some research suggests that proximizing climate change, or making it more personally relevant, can lower an individual's psychological distance leading to increased concern and action (Loy & Spence, 2020; Van Lange & Huckelba, 2021). However, other research indicates that simply personalizing climate change may not have the desired effect (Brügger et al., 2016) and can sometimes lead to lowered concern for climate change (Mildenberger et al., 2017). Prior beliefs regarding climate change may also contribute to the decreased effect that proximizing climate change has on an individual (Halperin & Walton, 2018). Additionally, intense experiences with climate-related disasters can lead to increased fear associated with climate change impacts leading some individuals to further distance themselves from climate change problems instead of increasing their concern or action (McDonald et al., 2015).

Duke and Holt (2022) found that university students who had lower levels of spatial psychological distance were more aware of localized effects of climate change and were able to provide observational examples suggesting that PD could be a valuable construct to utilize in educational settings. Further, Gubler et al. (2019) found that PD is an important predictor of climate change concern in student populations. Studies have shown that an individual's PD is not static and can change when new information is presented (Chu, 2022; Keller et al., 2022). If true, targeting psychological distance through curricula and classroom activities could be an effective strategy for increasing students' concern for climate change.

Strategies to create personally relevant curricula are frequently discussed in the literature, especially in relation to climate change education (Devine-Wright, 2013; Devine-Wright & Batel, 2017; Monroe et al., 2019; Scannell & Gifford, 2013). Place-based education (PBE) is used to engage students in their local communities, including local environments, and is often targeted by instructors seeking to increase environmental awareness in their students (Schild, 2016; Yemini et al., 2023). In addition to PBE, the teaching for transformative experience model offers a way to further personalize climate change for students. The construct of transformative experience is rooted in the concept of personal relevance describing student experiences as "a learning episode in which a student acts on the subject matter by using it in everyday experience to more fully perceive some aspect of the everyday world and finds meaning in doing so" (Pugh, 2011, p. 111). Meaningful student learning is achieved through genuine experiences that can be directly applied to the student's life, allowing more value to be placed upon the content learned (Hickman, 2009; Pugh, 2011). Through these transformative experiences, students begin to see the content in new ways and use this new information to expand their perceptions of the phenomena of interest (Pugh et al., 2017). There is limited research that uses these constructs (i.e., place-based education, TTES) in tandem to effectively personalize course curricula (Littrell et al., 2022).

Figure 4.1

Figure Depicting Proximal Versus Distant Levels of Psychological Distance



Research Questions

Our study aimed to determine the efficacy of a purposefully designed classroom intervention to lower the spatial and social-psychological distance of climate change among biology undergraduate students. To better localize climate change, our activity takes a novel approach by combining concepts from place-based education (PBE) and the Teaching for Transformative Experiences in Science (TTES) model. Our study included two key research questions.

Q4.1 Following a classroom intervention, does biology students' spatial and social psychological distance (PD) associated with climate change change?

Q4.2 What factors (political party, gender, other PD scales, etc.) best predict students' spatial and social PD?

Methods

Data collection for this study was conducted with permission from the Institutional Review Board at the University of Northern Colorado where the primary investigators are affiliated (IRB # 2208042211, Appendix A). We used convenience sampling (27) to recruit biology instructors from two higher education institutions in Colorado (CO) and Georgia (GA) to include our intervention in their classrooms in either the Fall 2022 or Spring 2023 semesters. We chose biology students because, 1) we assumed these students would have a basic understanding of climate change, and 2) previous research suggested that this population shows variance in their psychological distance to climate change (Duke & Holt, 2022).

Sites and Participants

We contacted ten instructors across four institutions in CO and GA, and five of these instructors representing two institutions agreed to use our intervention in their classrooms and collect pre- and post-activity survey data (Table 4.1). All undergraduate biology students in recruited classes ($n = 685$) participated in a four-part classroom intervention in their respective course (lab, lecture, or hybrid setting; see *Climate Change Intervention Overview* for further details); however, only students who provided consent for the use of their data and those who completed both the pre- and post-surveys are included in the present study ($n = 471$). Consent was secured from each student participant before completing the pre- and post-intervention survey. Our final sample of 471 participants primarily resided in Georgia ($n = 392$), were sophomores ($n = 128$), identified as female ($n = 309$), and were white ($n = 251$) (Appendix F).

Table 4.1

Courses, States, and Institutions from Which Participants Were Recruited

Courses	Course Level	Course Taught	State	Institution[1]	Removed	Final Sample Size
Ecology	Advanced	Lab	CO	A1	12	31
Ecology	Advanced	Lab	CO	A2	3	34
Ecoclimatology	Advanced	Lecture	CO	A	12	14
Intro Biology II (majors)	Intro	Lab	GA	B	199	335
Ecology	Advanced	Hybrid	GA	B	6	57

Notes. Multiple universities were sampled in each state and are anonymized and noted with letters. Some students were removed from the dataset for incomplete surveys (n=72), duplicate data (n=21), completing the activity in multiple courses (n=3), completing the pre survey early (n=13), or not consenting to their data being used in the study (n=105). Sample size indicates the final sample from each course population after removals.
[1]Numbers next to institution letters denote multiple sections of the same course.

Climate Change Intervention Overview

The full climate change intervention activity is available in Appendix G. This intervention specifically targets students' spatial and social psychological distance (PD) of climate change, with the goal of lowering students' PD across each scale (Spence et al., 2012; Trope & Liberman, 2010). We chose to target students' spatial PD because it was a significant predictor of students seeing the effects of localized climate change in another study (Duke & Holt, 2022). Next, we selected social PD because research suggests that students are often unaware of how climate change impacts humans, including themselves (Busch, 2016). Focusing on spatial and social PD also allowed us to make our activity more localized, personally relevant, and meaningful to our student population by using place-based approaches to orient our intervention in the students' local area (Clayton et al., 2014; Monroe et al., 2019; Scannell & Gifford, 2013; Spence et al., 2012). Finally, we incorporated elements of the TTES model to foster "reseeing" of climate change effects in our students' local environments (Pugh, 2020;

Pugh et al., 2017) and support our students' expansion of perception of how climate change affects their local areas (Pugh, 2011).

The intervention is divided into three scaffolded activities, followed by small group share sessions, designed to address our research questions and student learning objectives (Appendix G). Part 1 aimed to make climate change more personally relevant; students collaborated in small groups to explore local impacts of climate change on natural systems at different spatial scales and shared their findings with other groups. Part 2 targeted both spatial and social psychological distance and making climate change more personally relevant; students collaborated in small groups to explore local impacts of climate change on humans and shared their findings. Part 3 allowed students to "resee" and expand their perception of climate change effects on local communities. Through a campus walk, students predicted how climate change currently impacts their local environment currently and in the future.

Pre- and Post-Intervention Survey

Since our RQ 1 sought to determine the impact of our intervention on students' social and spatial PD, participants were given an online pre-survey immediately before the activity and a post-survey the week following the activity. Students were awarded no compensation for sharing their data as part of the study. The pre and post-surveys were identical to allow for comparison. Our survey combined several validated instruments (Appendix H) adapted from Spence et al. (2012) and Gubler et al. (2019, p.133), and we analyzed four of the scales for this study (Figure 4.2). Each scale included several statements that were rated by students with a 5-level Likert scale, and then later consolidated through arithmetic averaging. The first two scales measured spatial PD and the latter two scales measured social PD. First, one of the spatial scales we call the Geographic Climate Awareness Scale (GeoCC), was highly reliable with university students in a previous study (Duke & Holt, 2022), and our data were also highly reliable with this scale (Pre-Survey Cronbach's $\alpha = 0.89$; Post-Survey Cronbach's $\alpha = 0.95$).

Second, we created the Ecosystem Impacts of Climate Change Scale to measure spatial PD through a novel lens, focusing on whether students' perceived specific ecosystems in the state where their university is located are "likely to be impacted" by climate change. The ecosystems chosen for this scale were tailored to the state where the intervention was conducted (Figure 4.2). The number of items on the ecosystem scale varied by location (CO = 6, GA = 7; Figure 4.2). This novel scale was highly reliable for our population (EcoCC; CO Pre Survey Cronbach's $\alpha = 0.90$; CO Post Survey Cronbach's $\alpha = 0.94$; GA Pre Survey Cronbach's $\alpha = 0.93$; GA Post Survey Cronbach's $\alpha = 0.95$).

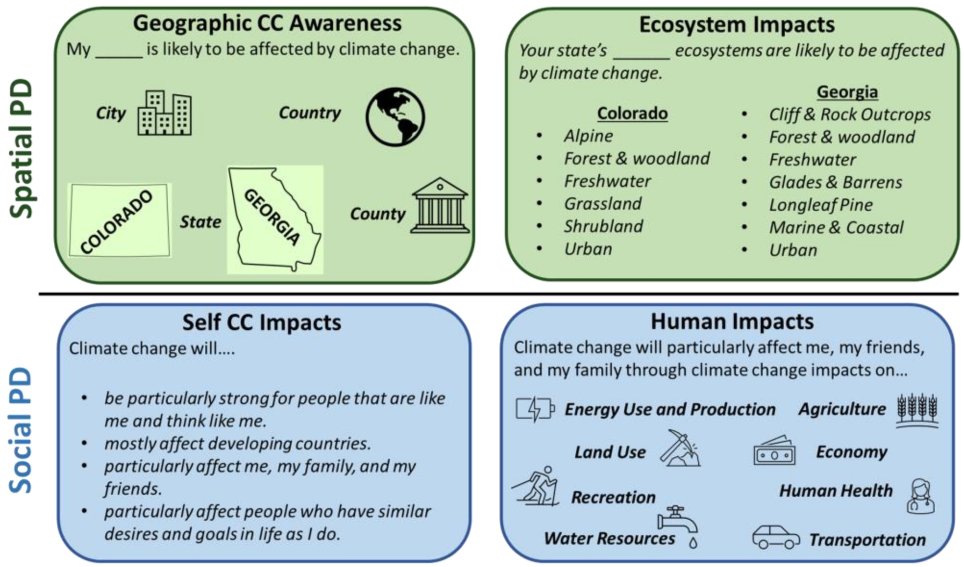
Next, we used two scales to capture social PD. Our third metric, which measured students' social PD, we called the Self Climate Change Impacts Scale (SelfCC; Pre Survey Cronbach's $\alpha = 0.76$; Post Survey Cronbach's $\alpha = 0.86$). Finally, we created a Human Impacts of Climate Change Scale for social distance. This scale allowed us to further measure our students' social PD through a personal lens to determine how they (or their friends and family) have been impacted by climate change (e.g., economy, recreation; Figure 4.2). This scale was also reliable for our population (HumCC; Pre Survey Cronbach's α= 0.90; Post Survey Cronbach's $\alpha = 0.96$).

In the final section of the survey, we collected student information including gender, race/ethnicity, region, course level, academic level, political identity (e.g. conservative, liberal), and political party affiliation, most of which were collected to describe our population. Additionally, we hoped to seek general trends between the students' region of longest residence and their spatial and social PD of climate change. We provided students with a map of the United

States and asked them to indicate the regional area where they have lived most of their lives (Appendix H; Question #1).

Figure 4.2

Four Psychological Distance Scales Included in Our Student Pre- and Post-Survey



Notes. Each question was scored on a 5-point Likert Scale (1 = strongly disagree; 2 = disagree; 3 = neither agree or disagree; 4 = agree; 5 = strongly agree).

Data Analysis

Student data were deidentified prior to analysis. Most analyses were conducted using the statistical program R (R Core Team, 2020). Cronbach's alpha was utilized to determine the reliability of the psychological distance scales and was conducted using the "psych" package (Revelle, 2020). Before choosing the statistical tests for our study, we ran a Shapiro-Wilk test and examined Q-Q plots, which indicated that our data did not follow a normal distribution (p-value = <0.05), so non-parametric tests were chosen to analyze our data. Further, many of our response variables and predictors were multicollinear, thus we used models for which these are not an assumption. Each of the four scales measuring aspects of PD were analyzed as response variables in separate models. A Wilcoxon Signed Rank test helped identify paired differences in pre- and post-survey scores across each of our response variables. Effect sizes were calculated for any significant relationships (p-value < 0.05) using the "wilcox_effsize" function in the "coin" package in R (Hothorn et al., 2006).

To determine which factors (e.g., gender, political identity, other PD scales) best-predicted scores on the PD scales, we performed nonparametric multiplicative regressions (NPMR) using HyperNiche version 2.0 (McCune & Mefford, 2009). This regression type is primarily used for ecological modeling; however, its ability to model complex interactions using all possible combinations of factors is fitting for educational data (McCune & Mefford, 2009). Each model fits a local mean using a Gaussian function and separate smoothing parameters or "tolerances", for each predictor (McCune, 2006). We conducted eight sets of NPMR models, two for each scale. For our first set of four models, we forced models for each scale with matched pre-survey scores as the sole predictor of post-survey score (e.g., GeoCC Pre as the only predictor of GeoCC Post scores; Table 4.2). These models served as proxies for the effect of our intervention on each participant's social and spatial PD. The second set of four models utilized the free-search function of HyperNiche which uses an iterative process to fit hundreds of potential models in a forward, stepwise manner (McCune, 2006; McCune & Mefford, 2009). For these models, we used post-survey scores as the response variable fitted against eleven possible predictors, including pre-survey scores for that scale, post-survey scores for the other three scales, and seven student factors (e.g., academic level, course level, gender, political affiliation, political identity, race/ethnicity, and region). We evaluated each model fit using a leave-one-out cross-validated pseudo-R^2 or ,xR^2, which helps reduce model overfitting (McCune, 2006; McCune & Mefford, 2009).

Table 4.2

Best Fit Models Included for Each Response Variable

		Intervention models (pre-only)		Best fit models from eleven possible predictors				Model comparison	
Response Type	**Response Variable**	**Variable**	**xR^2**	**Variable 1**	**Variable 2**	**Variable 3**	**Variable 4**	**xR^2**	**xR^2 difference**
Post-Survey Models	GeoCC Post	GeoPre (0.20000)	0.3158	GeoPre (0.40000)	SelfPost (0.70000)	HumPost (0.40000)	EcoPost (0.60000)	0.5978	0.282
	SelfCC Post	SelfPre (0.35000)	0.2783	GeoPost (0.60000)	SelfPre (0.52500)	HumPost (0.40000)	N/A	0.4937	0.2154
	HumCC Post	HumPre (0.40000)	0.2936	SelfPost (0.35000)	HumPre (0.60000)	EcoPost (0.40000)	N/A	0.6131	0.3195
	EcoCC Post	EcoPre (0.40000)	0.2959	GeoPost (0.40000)	HumPost (0.20000)	Course (0.00000)	N/A	0.6449	0.349

Notes. Each predictor variable is included with the tolerance included in parentheses. The full name for each response variable are as follows: GeoCC = Geographic CC Awareness, SelfCC = Self CC Humans, HumCC = Human Impacts, EcoCC = Ecosystem Impacts.

Results

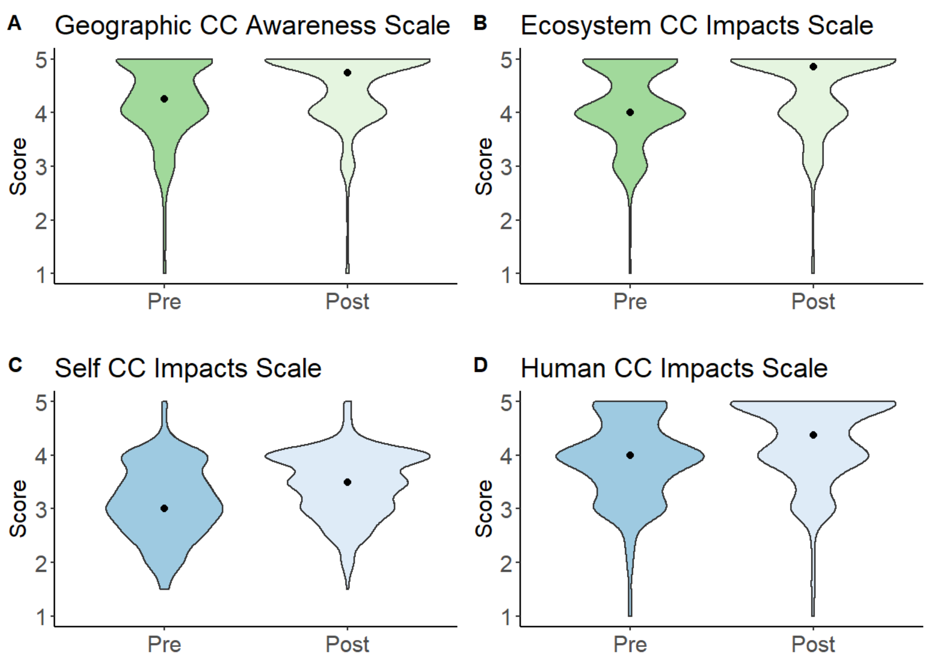
Research Question 4.1

Q4.1 Following a classroom intervention, does biology students' spatial and social psychological distance (PD) associated with climate change change?

For both pre- and post-survey scores for the two spatial metrics (Geographic and Ecosystem scales), the interquartile range was primarily above 4 on a scale of 5 possible points suggesting fairly low spatial psychological distance in our sample (Figure 4.3). Of the two social metrics, the interquartile ranges of the pre- and post-survey Human scale scores were lower than the spatial metrics but above 3 points, the mid-score value (Figure 4.3). The other social metric, Self CC scale, had the lowest scores of the four scales (i.e. greatest PD; Figure 4.3). Overall, participants scored higher on the post-survey across all four scales (i.e. lower PD following intervention). We found the paired difference in pre- and post-scores for each scale significantly differed from zero. Both spatial metrics (Geographic: $p<0.001$, $d = 0.39$; Ecosystem: $p<0.001$, $d = 0.45$) and the Self scale of the social metrics ($p<0.001$, $d = 0.48$) had moderate effect sizes of this difference (*sensu* 35). The Human scale of the social metrics ($p<0.001$, $d = 0.52$) had a large effect size, where PD was reduced following the intervention (i.e. higher scale scores on post-surveys).

Figure 4.3

Violin Plots of Averaged Categorical Data from the Two Spatial Metrics (Geogrpahic and Ecosystem, Green) and the Two Social Metrics (Self and Human, Blue)



Notes. Dark vs. Light colors indicate whether they were gathered prior to or following the climate change intervention. Figure 4.2 includes the items for each scale.

Research Question 4.2

Q4.2 What factors (political party, gender, other PD scales, etc.) best predict students' spatial and social PD?

The pre-scores only models explained ≥27% of the variance in each model (Table 4.2). Our best-fit free-search models for each of the four metrics explained ≥49% of the variance in each scale (Table 4.2). The four models with any possible predictors explained roughly two times as much variance in each scale as the pre-scores only models (Table 4.2). The best predictors in the free-search models included post-scores of other scales and pre-scores of that scale, excepting the Ecosystem CC scale (Table 4.2). Course level, which separated the introductory biology students from those in advanced biology courses, was the only student variable included as a predictor in the best-fit models of all predictors and was only included in the Ecosystem CC free-search model (Table 4.2).

Discussion

Individuals with lower psychological distance to climate change are often more concerned about climate change (Busch & Chávez, 2022; Gubler et al., 2019; Spence et al., 2012), have increased environmental awareness (Duke & Holt, 2022), and sometimes perform more environmentally responsible behaviors (Loy & Spence, 2020; Maiella et al., 2020; McDonald et al., 2015). Our biology undergraduate sample generally had moderate to low spatial and social psychological distance to climate change at the start of the semester, suggesting that these students had some understanding of how climate change impacts local human and natural environments prior to participating in our intervention. Following participation, we found positive, significant increases in students' PD scale scores, i.e., reductions in their PD with time when compared to their pre-intervention scores (Figure 4.3).

Research indicates that using visuals and maps, as used in our study, are important for communicating climate change and, when effective, can help to localize climate change, potentially leading to increased concern and engagement (O'Neill & Nicholson-Cole, 2009; Retchless, 2018; Scannell & Gifford, 2013). After completing the intervention, we saw a decrease in students' spatial and social PD, which indicates an effective localization of climate change for our participants. Other studies have used different educational approaches to lowering PD through inquiry-based learning (Brumann et al., 2019) and gamification (Fauville et al., 2020; Fox et al., 2020). Notably, Fox et al. (2020) had university students complete an activity focusing on human-induced environmental impacts (e.g., pollution and illegal dumping) on rivers using an interactive video game and found that students who interacted with local rivers in the activity experienced a decrease in their spatial and temporal distance to their local environment. In our study, we saw a similar decrease in students' spatial distance associated with local ecosystems (Figure 4.3), suggesting an increase in their environmental awareness of climate change impacts at the local level.

We noted the most significant pre- to post-survey increase and effect size for our Human PD scale following our classroom intervention (Figure 4.3). Before our intervention, most of our university students exhibited moderate social PD that decreased following participating in our activity. With younger students, Gubler et al. (2019) found that while some middle and high school students were aware that climate change was directly impacting them, the majority believed that the effects would impact people in other locations. Personal experiences with climate change effects can reduce an individual's social distance, increasing their concern and understanding of risk (Akerlof et al., 2013; Spence et al., 2011). These personal experiences develop over time, which might explain the higher social PD that Gubler et al. (2019) observed.

The relatively high average student score on the Human PD scale (i.e., moderate social PD) suggests that some of our students may already have personal experiences (i.e. recent destructive wildfires in CO) with climate change that they were able to recall during the pre-survey (Figure 4.3). Although many students in our study initially acknowledged that they are affected by climate change, they may have been unsure of the details or severity of these impacts (Fox et al., 2020; Spence et al., 2012). Our intervention may have helped solidify these personal experiences by filling in knowledge gaps, resulting in increased post-survey scores (i.e., decreased social PD).

Our NPMR models indicated that matched pre-scores and post-scores from different scales were better predictors of PD than other student variables (e.g., political identity, gender). While other research has indicated that demographic variables such as gender (McCright, 2010; Stevenson et al., 2014), political party (Hess & Maki, 2019; McCright & Dunlap, 2011), and geographic location (Duke & Holt, 2022; Poortinga et al., 2019) are important predictors of climate change acceptance, awareness, and concern among individuals, we did not observe this relationship in our data. Of the five student variables included in our NPMR models, only Course Level was a strong predictor and it only manifested in one model as the third predictor after two others (e.g., EcoCC Post; Table 4.2). The Ecosystem CC scale focuses on how different ecosystems in the participants' state are impacted by climate change, which may be challenging for introductory-level biology students whose post-scores were generally lower than those of advanced biology students, because they may not have yet developed strong ecological literacy (Lewinsohn et al., 2015). Alternatively, our ecology students' pre-Ecosystem CC scores were relatively high but their change over time may be limited by a ceiling effect (Cramer & Howitt, 2004; Šimkovic & Träuble, 2019). Overall, our results are encouraging and suggest that regardless of most student characteristics we measured (academic level, gender, political identity, race/ethnicity, and region), students' PD was positively impacted by our intervention.

Limitations

While our results are promising, we acknowledge several limitations of our study. As mentioned above, some researchers indicate that different measures of PD (e.g., spatial, social, temporal, hypothetical) overlap and are difficult to disentangle (McDonald et al., 2015). We recognize this overlap and indicate its presence in our results; however, this synergy between spatial and social PD does not detract from the cumulative reduction in PD across scales nor its overall importance in student perception at the local level. We also recognize that our limited participant demographics including geographic spread (i.e., most of our participants reside in the southern U.S.), may limit the generalizability of our findings. Future research is needed to determine if comparable patterns exist in other student populations.

Conclusions

Our results indicate that students' spatial and social PD associated with climate change can change following classroom instruction. This fluidity suggests that PD is a valuable construct for instructors to target through curricular design (Chu, 2022; Keller et al., 2022). The ability for students to understand that climate change effects are localized and capable of impacting them, their friends, and their families could be an important step in increasing concern for climate change and willingness to act sustainably to mitigate its effects (Busch & Chávez, 2022; Evans et al., 2014; Spence et al., 2012); however, these relationships are complicated and not always present (Brügger et al., 2015, 2016; Busch & Chávez, 2022; Loy & Spence, 2020; Maiella et al., 2020). Regardless, our study indicates that lowering PD can increase students' spatial and social awareness of climate change at a local level, which could have important educational implications. While our findings suggest a change in students' PD, we cannot speculate on the prolonged nature of this change nor whether this change will lead to action to mitigate climate change. More research is needed to determine whether participating in our classroom intervention results in a lasting change in students' spatial and social PD, increases their climate change concern, and leads to more sustainable actions by students.

CHAPTER V

CONCLUSION

The overarching goal of my dissertation was to better understand undergraduate biology students' perceptions of climate change. For Project 1, I explored what factors predict whether or not undergraduate biology students are aware of the effects of climate change locally (Chapter II). I found that most students in my study were able to provide examples of climate change effects in their home state with abiotic observations (e.g., temperature changes, increased frequency of severe storms) being mentioned more frequently than biotic ones. Thus, instructors may wish to purposefully address aspects of biotic climate change in their classrooms to increase this literacy in their students.

Additionally, I found that the constructs of psychological distance and connection to nature were significant predictors of students reporting observations of climate change. Students with higher connection to nature scores (as measured by the Environmental Identity Scale (EID); Clayton, 2003) more frequently provided examples of localized climate change. Further, my interviews with a subset of students indicated that their personal experiences in nature contributed to their connection to nature and increased environmental awareness (e.g., observations of climate change occurring locally). I also found that students with lower spatial psychological distance (i.e., recognize that climate change is impacting nearby areas) of climate change were more likely to report observations of localized climate change across all spatial scales (e.g., city, county, state, country).

By further investigating the construct of connection to nature through student interviews (Chapter III), I found that students descriptions of their own and others' connection to nature centered around two main themes, 1) beliefs or characteristics of a person's identity that describes their relationship to nature, and 2) specific behaviors or actions taken by a person that either directly or indirectly affect the environment. Further, I found that these student descriptions of their own and others' connection to nature align with themes discussed in the literature (Chan et al., 2016; Clayton, 2003; Schultz, 2002) and those present in the instrument we used to measure the connection to nature of our participants (i.e., Environmental Identity Scale or EID; Clayton, 2003).

Using the results from Project 1 (i.e., Chapter II), I created a climate change classroom activity designed to lower students' psychological distance to climate change across two scales (i.e., spatial and social; Chapter IV) using place-based and transformative experience practices. I found that students' spatial and social psychological distance to climate change significantly decreased following participation in my classroom activity indicating the fluidity of an individual's psychological distance. I also found that course level was the only student variable identified as a predictor of a student's change in psychological distance following the intervention. The lack of other student variables included in my predictive models of students' psychological distance is encouraging for educators, suggesting that classroom interventions alone may be effective in changing our students' perceptions of climate change at spatial and social scales. While my findings suggest a change in students' psychological distance, more research is needed to determine the prolonged nature of this change and how changes in students' psychological distance may impact their concern for climate change and willingness to act to help mitigate it.

How climate change is framed is an important theme across my research. University students may exhibit psychological distance associated with climate change which may impact their environmental awareness of the issue (Barros & Pinheiro, 2020; Monroe et al., 2019) or even their acceptance of it (McDonald et al., 2015). Localizing climate change using place-based practices is an effective method for instructors to utilize when designing classroom curricula to reduce students' psychological distance across multiple spatial scales (Devine-Wright, 2013; Devine-Wright & Batel, 2017; Monroe et al., 2019; Scannell & Gifford, 2013). Instructors may also wish to foster their students' connection to local natural areas through field experiences or outdoor learning opportunities which could further increase students' environmental awareness and concern (Clayton, 2003; Mayer et al., 2009). With the world facing a historic climate crisis and increased environmental degradation, it is imperative that we find ways to increase environmental awareness of these problems and commitment to protecting natural environments. Students, particularly voting-age, university students, are an important demographic to target for inducing environmental change and understanding their perspectives is a vital step to achieving this goal.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVALS

UNIVERSITY OF NORTHERN COLORADO

Institutional Review Board

Date:	01/29/2021
Principal Investigator:	Jessica Duke
Committee Action:	**IRB EXEMPT DETERMINATION – New Protocol**
Action Date:	01/29/2021
Protocol Number:	2012018874
Protocol Title:	Connection to Nature, Place Attachment, and Understanding Climate Change
Expiration Date:	

The University of Northern Colorado Institutional Review Board has reviewed your protocol and determined your project to be exempt under 45 CFR 46.104(d)(701) (702) for research involving

Category 1 (2018): RESEARCH CONDUCTED IN EDUCATIONAL SETTINGS. Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Category 2 (2018): EDUCATIONAL TESTS, SURVEYS, INTERVIEWS, OR OBSERVATIONS OF PUBLIC BEHAVIOR. Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects; (ii) Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation; or (iii) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by 45 CFR 46.111(a)(7).

UNIVERSITY OF
NORTHERN COLORADO

Institutional Review Board

Date:	09/09/2022
Principal Investigator:	Jessica Duke
Committee Action:	**IRB EXEMPT DETERMINATION – New Protocol**
Action Date:	09/09/2022
Protocol Number:	2208042211
Protocol Title:	Lowering the Psychological Distance of Climate Change in Undergraduate Biology Students: A classroom intervention
Expiration Date:	

The University of Northern Colorado Institutional Review Board has reviewed your protocol and determined your project to be exempt under 45 CFR 46.104(d)(701) (702) for research involving

Category 1 (2018): RESEARCH CONDUCTED IN EDUCATIONAL SETTINGS. Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Category 2 (2018): EDUCATIONAL TESTS, SURVEYS, INTERVIEWS, OR OBSERVATIONS OF PUBLIC BEHAVIOR. Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects; (ii) Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation; or (iii) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by 45 CFR 46.111(a)(7).

APPENDIX B

CONNECTION TO NATURE SURVEY

Connection to Nature Instrument: Environmental Identity Scale

1 = Strongly Disagree 2 = Disagree 3 = Neither agree or disagree 4 = Agree 5 = Strongly Agree

1) I spend a lot of time in natural settings (woods, mountains, desert, lakes, ocean).

2) Engaging in environmental behaviors is important to me.

3) I think of myself as a part of nature, not separate from it.

4) If I had enough time or money, I would certainly devote some of it to working for environmental causes.

5) When I am upset or stressed, I can feel better by spending some time outdoors "communing with nature".

6) Living near wildlife is important to me; I would not want to live in a city all the time.

7) I have a lot in common with environmentalists as a group.

8) I believe that some of today's social problems could be cured by returning to a more rural lifestyle in which people live in harmony with the land.

9) I feel that I have a lot in common with other species

10) I like to garden.

11) Being a part of the ecosystem is an important part of who I am.

12) I feel that I have roots to a particular geographical location that had a significant impact on my development.

13) Behaving responsibly toward the Earth, living a sustainable lifestyle, is part of my moral code.

14) Learning about the natural world should be an important part of every child's upbringing.

15) In general, being part of the natural world is an important part of myself image.

16) I would rather live in a small room or house with a nice view than a bigger room or house with a view of other buildings.

17) I really enjoy camping and hiking outdoors.

18) Sometimes I feel like part of nature, certain trees, or storms, or mountains, have a personality of their own.

19) I would feel that an important part of my life was missing if I was not able to get out and enjoy nature from time to time.

20) I take pride in the fact that I could survive outdoors on my own for a few days.

21) I have never seen a work of art that is as beautiful as a work of nature, like a sunset or a mountain range.

22) My own interests usually seem to coincide with the position advocated by environmentalists.

23) I feel that I receive spiritual sustenance from experiences with nature.

24) I keep mementos from the outdoors in my room, like shells or rocks or feathers.

Climate Change Instruments

Acceptance Scale

Use the slider scale below to indicate from 0-100... Not pictured below

• To what extent do you accept climate change

• To what extent do you believe in climate change

• To what extent do you think climate change is true

ZIP Code

• In what zip code have you lived the longest? If this was not in the U.S.A, please instead indicate country. ________________________

When answering questions about your "local area", please answer based on the area you have lived the longest (This may be a different area than where you are currently living).

Spatial-Climate-Awareness Scale (adapted from Spence et al. 2012)

1 = Strongly Disagree 2 = Disagree 3 = Neither agree or disagree 4 = Agree 5 = Strongly Agree

1) My city is likely to be affected by climate change.

2) My county is likely to be affected by climate change.

3) My state is likely to be affected by climate change.

4) My country is likely to be affected by climate change.

Open-Response Climate Change Question

• Have you seen the effects of climate change in your state? If so, please specify below. If you have not, please respond with "no effect". ____

Demographic Questions

1) What gender do you identify as?

- Woman
- Man
- Non-binary, genderqueer, or gender non-conforming
- My gender is not listed. Please specify below.
- Prefer not to answer

2) What is your race/ ethnicity? (select all that apply)

- American Indian or Alaska Native
- Asian or Pacific Islander
- Black or African-American
- Hispanic or Latino
- White
- Race/ethnicity not listed. Please specify below.
- Race/ ethnicity unknown
- Prefer not to answer

3)What is your current major (List undecided if no major has been chosen)? _______________

4) What is your political party affiliation?

- Democrat Party
- Republican Party
- Green Party
- Libertarian Party
- Independent
- Other
- Unknown

- Prefer not to answer

5) Please fill in your student ID for the purpose of awarding you extra credit for the completion of the survey.

6) If you are willing to be contacted about participating in a follow-up interview, please include an email contact below.

APPENDIX C

INTERVIEW PROTOCOL: CONNECTION TO NATURE FOLLOW-UP INTERVIEWS

Appendix C1: Interview Protocol Questions
Used for Chapter II

**Only the questions including an asterisk and bolded text were analyzed for this study*

Intro: Thank you for agreeing to participate in today's interview. You were selected based on your participation in a connection to nature survey that you completed in a biology course this semester. This survey asked you questions about your connection to nature, attachment to a physical place, and climate change. Today's interview will be based on this survey, and you will be asked to elaborate on some of the answers you provided. There are no right or wrong answers to the questions we will be asking you today.

<u>*Connection to Nature*</u>

1) What does it mean to you to feel connected to nature?

2) What is nature?

- Prompt - How do you know that something is nature?

We converted the connection to nature scale to a 1-10 scoring system with 10 indicating an individual that is highly connected to nature and 1 indicating an individual that is not very connected to nature.

3) Where do you think you fall on the 1-10 scale?

4) Describe a person that scores a 10 on the scale. →Prompt What do they do? What do they look like? etc…

- Intro Text: → How do they (that 10) think about climate change?

5) Describe a person that scores a 1 on the scale. →Prompt What do they do? What do they look like? etc…

- How do they (that 1) think about climate change?

Tell the student where they fall on the scale.

6) Explain this score?

- Prompt – Tell me about the difference between your actual and projected score?

Name two natural places that you are connected to:

7) Describe them to me?

8) Describe a memory of this place.

- Prompt: Why do you feel connected to them?

9) Is climate change going to impact these two places? Tell me more about this.

- Prompt: If not now, will they be affected in the future? Tell me more about this.

Climate Change

The last portion of the survey asked you questions regarding your ideas on and experiences with climate change.

10) When I say climate change, what is the first thing that comes to your mind?

11) How would you define the term climate change to someone who doesn't know what it is?

You mentioned that you have seen the effects of climate change.

12A) Tell me the extent of these effects. (e.g., in your city, state, etc…)

OR

You mentioned that you have not seen the effects of climate change in your state.

12B) Have you seen or know of effects in other locations?

- Tell me more about why climate change is affecting other locations but not your state.

***13) Do you think that these effects of climate change impact an even smaller area than [your state] or an even larger area than [your state]?**

- **Prompt: Describe these effects.**

14) Describe how these effects have impacted you personally?

15) How do you know that climate change is causing these effects?

If the student has seen the effects of CC

16) Since you have seen the effects of climate change, do you have a desire to help protect these natural environments?

- Prompt: How could you help protect these natural environments?

Wrap-Up

***17) Do you think that someone that is more connected to nature has increased the ability to recognize climate change locally? Why or why not?**

Appendix C2: Interview Protocol Questions
Used for Chapter III

**Only the questions including an asterisk and bolded text were analyzed for this study*

Intro: Thank you for agreeing to participate in today's interview. You were selected based on your participation in a connection to nature survey that you completed in a biology course this semester. This survey asked you questions about your connection to nature, attachment to a physical place, and climate change. Today's interview will be based on this survey, and you will be asked to elaborate on some of the answers you provided. There are no right or wrong answers to the questions we will be asking you today.

<u>*Connection to Nature*</u>

1) What does it mean to you to feel connected to nature?

2) What is nature?

- Prompt - How do you know that something is nature?

We converted the connection to nature scale to a 1-10 scoring system with 10 indicating an individual that is highly connected to nature and 1 indicating an individual that is not very connected to nature.

***3) Where do you think you fall on the 1-10 scale?**

***4) Describe a person that scores a 10 on the scale. →Prompt What do they do? What do they look like? etc…**

- **Intro Text: → How do they (that 10) think about climate change?**

***5) Describe a person that scores a 1 on the scale. →Prompt What do they do? What do they look like? etc…**

- **How do they (that 1) think about climate change?**

Tell the student where they fall on the scale.

***6) Explain this score?**

- **Prompt – Tell me about the difference between your actual and projected score?**

Name two natural places that you are connected to:

7) Describe them to me?

8) Describe a memory of this place.

- Prompt: Why do you feel connected to them?

9) Is climate change going to impact these two places? Tell me more about this.

- Prompt: If not now, will they be affected in the future? Tell me more about this.

Climate Change

The last portion of the survey asked you questions regarding your ideas on and experiences with climate change.

10) When I say climate change, what is the first thing that comes to your mind?

11) How would you define the term climate change to someone who doesn't know what it is?

You mentioned that you have seen the effects of climate change.

12A) Tell me the extent of these effects. (e.g., in your city, state, etc…)

OR

You mentioned that you have not seen the effects of climate change in your state.

12B) Have you seen or know of effects in other locations?

- Tell me more about why climate change is affecting other locations but not your state.

13) Do you think that these effects of climate change impact an even smaller area than [your state] or an even larger area than [your state]?

- Prompt: Describe these effects.

14) Describe how these effects have impacted you personally?

15) How do you know that climate change is causing these effects?

If the student has seen the effects of CC

16) Since you have seen the effects of climate change, do you have a desire to help protect these natural environments?

- Prompt: How could you help protect these natural environments?

Wrap-Up

17) Do you think that someone that is more connected to nature has increased the ability to recognize climate change locally? Why or why not?

APPENDIX D

FULL STATISTICAL MODEL

Model output containing all potential predictor variables[1]. This model was completed before running a stepwise-AIC that selected a subset of the best predictors.

Variable	Coefficient	Std error	z value	P-value	Predictor Importance
Intercept	-9.639	1.501	-6.423	<0.001	
University D[2]	0.042	1.060	0.039	0.969	0.039
University A	0.194	0.427	0.455	0.649	0.455
University C	0.255	0.602	0.424	0.672	0.424
ZIP Prefix	0.16	0.097	1.653	0.098	1.653
Political Independent	-0.45	0.376	-1.199	0.231	1.199
Political Other	0.157	0.402	0.390	0.697	0.390
Political Republican Party	-0.32	0.417	-0.766	0.444	0.766
EID	0.029	0.009	3.096	0.002	3.096
Acceptance Scale	0.014	0.009	1.655	0.098	1.655
Spatial-Climate Awareness Scale	1.73	0.469	3.690	<0.001	3.690
AIC	351.8				
McFadden's pseudo-R^2	0.322				

[1]Gender, race/ethnicity, major, state, and course-level were not included in any models because of preliminary analyses suggesting poor performance as predictors.
[2]Two variables (University B and Political Democratic Party) were used as the comparison level for each factor (University and Political Party Affiliation, respectively) and are therefore not shown in the statistical output.

APPENDIX E

ALLIGNMENT OF ENVIRONMENTAL IDENTITY SCALE INSTRUMENT WITH STUDENT THEMES

Table E1: Alignment of EID items using themes and subthemes from our coding of student interviews.							
EID Item	**Identity (n = 16)**			**Behavior (n = 7)**			**Ethics (n =1)**
	V	**EP**	**S**	**TSN**	**SB**	**R**	
I spend a lot of time in natural settings (woods, mountains, deserts, lakes, ocean).				x			
Engaging in environmental behaviors is important to me.					x		
I think of myself as a part of nature, not separate from it.	x						
If I had enough time or money, I would certainly devote some of it to working for environmental causes.					x		
When I am upset or stressed, I can feel better by spending some time outdoors "communing with nature".				x			
Living near wildlife is important to me; I would not want to live in a city all the time.	x						
I have a lot in common with environmentalists as a group.	x						
I believe that some of today's social problems could be cured by returning to a more rural lifestyle in which people live in harmony with the land.	x						
I feel that I have a lot in common with other species.		x					
I like to garden.						x	
Being a part of the ecosystem is an important part of who I am.	x						
I feel that I have roots to a particular geographical location that had a significant impact on my development.	x						
Behaving responsibly toward the Earth -- living a sustainable lifestyle -- is part of my moral code.							x
Learning about the natural world should be an important part of every child's upbringing.	x						
In general, being part of the natural world is an important part of myself image.	x						
I would rather live in a small room or house with a nice view than a bigger room or house with a view of other buildings.	x						
I really enjoy camping and hiking outdoors.						x	

Table E1 Continued: Alignment of EID items using themes and subthemes from our coding of student interviews.

EID Item	Identity (n = 16)			Behavior (n = 7)			Ethics (n =1)
	V	EP	S	TSN	SB	R	
Sometimes I feel like part of nature -- certain trees, or storms, or mountains -- have a personality of their own.		x					
I would feel that an important part of my life was missing if I was not able to get out and enjoy nature from time to time.	x						
I take pride in the fact that I could survive outdoors on my own for a few days.	x						
I have never seen a work of art that is as beautiful as a work of nature, like a sunset or a mountain range.	x						
My own interests usually seem to coincide with the position advocated by environmentalists.	x						
I feel that I receive spiritual sustenance from experiences with nature.			x				
I keep mementos from the outdoors in my room, like shells or rocks or feathers.[1]							
TOTAL NUMBER OF ITEMS IN EACH SUBTHEME	13	2	1	2	2	2	1

[1.] One item that fell under behavior did not fit any of our identified subthemes and was thus not coded.

APPENDIX F

STUDENT DEMOGRAPHICS FOR CHAPTER IV

Appendix Table F1: Student demographics of 471 participants. Population frequency is the percent of students in each category, and frequency by model grouping[1] is the percent of students in each category used in variables for modeling.

Class Standing	**Number of Participants**	**Population Frequency**	**Frequency by model grouping**
Freshman	106	22.5	22.5
Sophomore	138	29.2	29.2
Junior	128	27.2	27.2
Senior	90	19.1	
Post Baccalaureate	8	1.7	
Prefer not to answer	1	0.2	21.1
Region			
Northeast	3	0.6	
South	375	79.6	80.3
Midwest	19	4.1	
West	67	14.2	18.3
International	7	1.5	1.5
Gender Identity			
Man (Cis or Trans)	153	32.5	32.5
Non-binary, Genderqueer, or Gender Non-conforming	9	1.9	
Woman (Cis or Trans)	309	65.6	67.5
Race/Ethnicity[2]			
Black or African-American	128	27.2	27.2
White	251	53.3	53.3
American Indian/Alaska Native	5	1.1	
Asian	43	9.1	
Hispanic or Latino/a/x	66	14.1	
Middle Eastern	6	1.3	
Prefer not to answer	9	1.9	27.4

	Number of Participants	Population Frequency	Frequency by model grouping
Political Affiliation			
Democrat	156	33.1	
Green Party	3	0.6	33.8
Independent	79	16.8	16.8
Libertarian Party	9	1.9	
Republican	85	18.1	20.0
Other	16	3.4	
Unknown	77	16.3	
I prefer not to say	45	9.6	29.5
Missing Data	1	0.2	Not analyzed
Political Identity			
Strongly Conservative	10	2.1	
Moderately Conservative	45	9.6	
Slightly Conservative	29	6.2	17.8
Middle of the Road	79	16.8	16.8
Slightly Progressive	30	6.4	
Moderately Progressive	97	20.6	
Strongly Progressive	51	10.8	37.8
I prefer not to say	42	8.8	
I don't know	87	18.5	26.3
Missing Data	1	0.2	Not analyzed

[1]All groups of less than 5% were merged into other relevant groups, excepting international students within the Region variable.
[2]Some participants may be included in multiple race and ethnicity categories.

APPENDIX G

FULL STUDENT ACTIVITY
COLORADO VERSION

How does climate change impact my local area?

Introduction:
Climate change refers to changes in the normal mean state of the climate or climate variability that continues over an extended period of time (decades or longer). The effects of climate change are vast and we are already experiencing these effects today. If you were asked to name a few impacts of climate change occurring globally, I'm sure you could do so. You might describe abiotic effects such as increased average temperatures, prolonged droughts, increased frequency and severity of fire and flooding from sea-level rise, or biotic effects like changes in species' ranges, increased species extinction, and phenological mismatches (i.e., spatial or temporal mismatch of key life-history events between species that interact). We also know that climate change isn't just impacting the environment, but it's also affecting human populations. You might further describe climate change impacts that affect humans such as decreased access to fresh water, increased damage to property from fire and flooding, loss of livelihood, and increases in disease spread.

What about climate change in your backyard (city, county, state)? Can you describe examples of how climate change is currently affecting or will affect your local area? Climate change often seems like it impacts places that are far from where you live or affects people that you don't know, but its impacts are closer than you might think. Today we will explore how climate change is impacting Colorado and the people who live here.

<u>Learning Objectives (LO's):</u>
1) Collaborate with group members to identify and compile examples of localized climate change (state, county, and city) affecting natural and human systems.
2) Collaborate with group members to synthesize your findings by creating a map of where your examples of climate change are occurring in Colorado.
3) Apply your findings and identify the local effects of climate change.
4) Creatively design a way to communicate your findings to the local community.

Part 1: How is climate change impacting local natural systems? (LO1 and LO2)

1. You will break into small "research groups" and research the local impacts of climate change on natural systems. You will specifically focus on the effects on organisms and natural systems occurring at different spatial scales. Each group will be randomly assigned of the following ecosystems to research, and will be the only group in the class to do this research:
    - Freshwater (rivers, wetlands, riparian areas)
    - Grasslands
    - Alpine
    - Forests and woodlands
    - Shrubland
    - Barrens
    - Urban corridor (parks, open spaces, etc…)

2. You will then compile a summary of your findings (4+ examples) being as specific as you can about the effect of climate change along with the spatial scales where these effects are occurring.

- For example, *the Mountain Pine Beetle has impacted a significant portion of Rocky Mountain National Park by killing large amounts of Lodgepole Pine. This beetle is able to reproduce more frequently now due to warming temperatures.*
- This example provides the following: 1) the impact of climate change (specific organisms affected and how they are affected) (i.e. the what and the why), and 2) a specific location in CO where the effect is occurring. (i.e. the where and the extent of the where)

3. You will be given 25 minutes to complete this part of the activity. A list of potentially helpful websites can be found at the bottom of this page, although we encourage you to find your own resources.

4. Next, each group member will be assigned to a new small "map group" to share their findings with classmates who researched different ecosystems. So it is important that all members of the "research group" understand and can explain their groups' researched impacts. Together, each new "map group" will construct a map of your state plotting out the different locations and effects of climate change within Colorado. You will be given a large piece of paper and markers to construct your map. Please use a different marker for each ecosystem. You will be given 25 minutes to construct your map.

Part 2: How is climate change impacting humans in local areas (city, county, state)? (LO1 and LO2)

1. You will rejoin your "research group" for the purpose of researching the human impacts of climate change in your local area (state, county, and city) and compiling a summary of your findings (4+ examples). Try to be as specific as you can about the effects of climate change along with the spatial scales (city, county, state) where these effects are occurring. Each group will be randomly assigned one of the following topics to research:

- Agriculture
- Recreation
- Water
- Energy
- Transportation
- Human health
- Land use
- Economy

2. You will be given 25 minutes to research how climate change is impacting humans in your local area. A list of potentially helpful websites can be found at the bottom of this page, although we encourage you to find your own resources.
3. Next, you will rejoin your "map group" to share your findings and add the human impacts you researched to your state map. As before, please use a different color marker for each human impact (you may repeat colors that you used during part 1 of the activity). You will be given 25 minutes to add these effects to your map.

Part 3: Seeing current or future climate change effects. (LO3)

1. Next, you will rejoin your "research group" to find examples of current effects or predict future effects of climate change in your immediate environment by venturing outside and walking around your local environment. Your instructor will give you a list of potential places to explore. Each group will compile information during this outside time by taking pictures of plants, animals, or other natural system elements and upload these pictures to our class Padlet (see link in the class webpage or LMS).
2. You will use the information researched during parts 1 and 2 to write about how these organisms, ecosystems, or human populations have been or will be impacted by climate change and share these findings with your classmates when you return to the classroom.
3. You will be given 30-40 minutes to explore outside before returning to the classroom to report on your findings.

Part 4: Communicate local climate change effects. (LO4)

After you have completed your outside activity (part 3), return to the classroom to report your findings. Each group will need to explain 1 of the pictures that you uploaded to the LMS or shared space. Make sure to provide the following information in your explanation:
1) What is being impacted (organism, ecosystem, human population), and how is it being impacted?
2) What is the spatial scale of this impact?
3) How will this impact affect you and your group members personally?

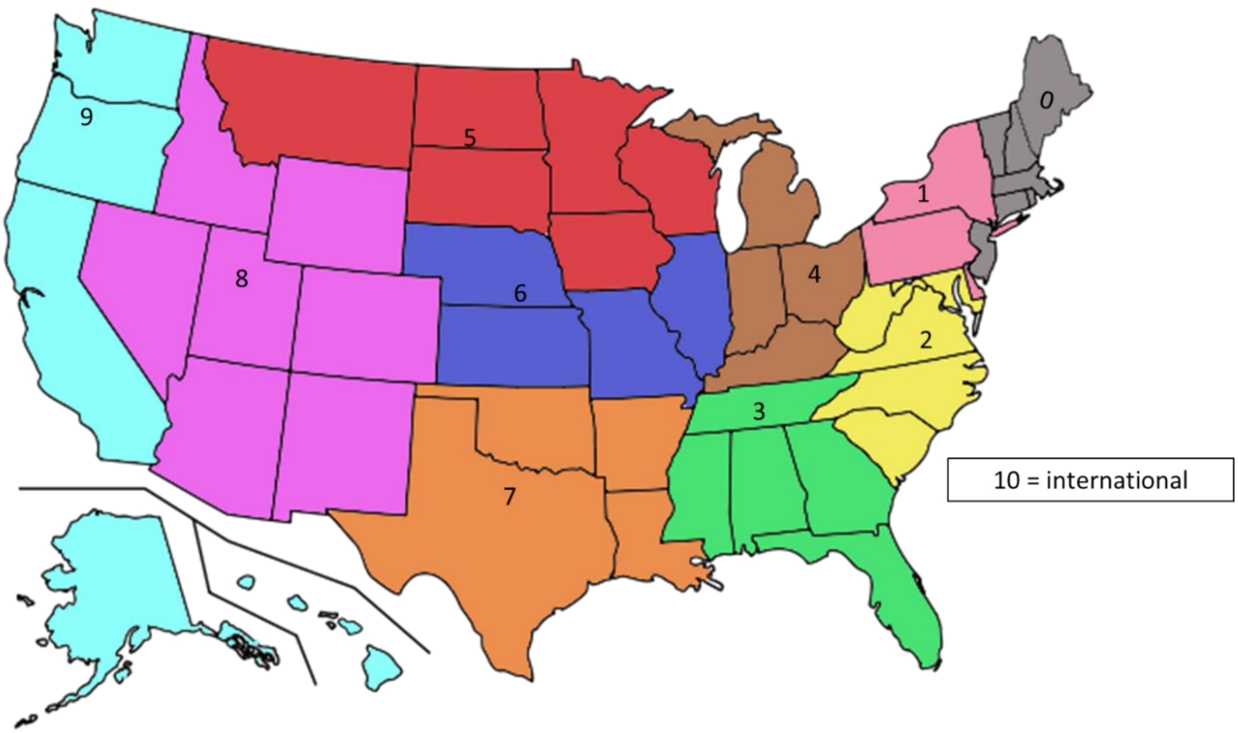
Helpful Links for Researching Local Impacts of Climate Change:

[Include weblinks for your state here]

APPENDIX H

STUDENT PRE AND POST PSYCHOLOGICAL DISTANCE SURVEY

1. Geographic Location



The map of the United States above is color and number-coded by region. Please select the area you have lived longest. For example, if you have lived most of your life in Colorado you will choose the number "8". If you live outside of the U.S.A., please select "10" for international.

2. Geographic Climate Awareness Scale (GeoCC)

Please indicate your level of agreement with the following statements. There are no right or wrong answers. When answering questions about your "local area", please answer based on the area you have lived the longest, this may be a different area than where you are currently living.

1 = Strongly Disagree, 2 = Disagree, 3 = Neither agree or disagree, 4 = Agree, and 5 = Strongly Agree

1. My city is likely to be affected by climate change.
2. My county is likely to be affected by climate change.
3. My state is likely to be affected by climate change.
4. My country is likely to be affected by climate change.

3. Self Climate Change Impacts Scale (SelfCC) - Adapted from Gubler et al. (2019)

1 = Strongly Disagree, 2 = Disagree, 3 = Neither agree or disagree, 4= Agree, and 5 = Strongly Agree

1. Climate change impacts will be particularly strong for people that are like me and think like me.
2. Climate change will mostly affect developing countries. *
3. Climate change will particularly affect me, my family, and my friends.
4. Climate change will particularly affect people who have similar desires and goals in life as I do.

*Item is reverse coded.

4. Open Response CC Question

Have you been impacted by the effects of climate change? If so, please specify what those effects are below. If not, please respond with "no impact".

5. Human Impacts Awareness Scale (HumCC)

1 = Strongly Disagree, 2 = Disagree, 3 = Neither agree or disagree, 4= Agree, and 5 = Strongly Agree

1. Climate change will particularly affect me, my friends, and my family through climate change impacts on agriculture.
2. Climate change will particularly affect me, my friends, and my family through climate change impacts on recreation.
3. Climate change will particularly affect me, my friends, and my family through climate change impacts on water resources.
4. Climate change will particularly affect me, my friends, and my family through climate change impacts on energy use and production.
5. Climate change will particularly affect me, my friends, and my family through climate change impacts on transportation.
6. Climate change will particularly affect me, my friends, and my family through climate change impacts on human health.
7. Climate change will particularly affect me, my friends, and my family through climate change impacts on land use.
8. Climate change will particularly affect me, my friends, and my family through climate change impacts on the economy.

6. Ecosystem Awareness Scale (EcoCC) – Based on Colorado Ecosystems (Should be updated based on location)

Since your institution is located in Colorado, we would now like you to think about Colorado ecosystems. Please indicate your level of agreement with the following statements. There are no right or wrong answers.

1 = Strongly Disagree, 2 = Disagree, 3 = Neither agree or disagree, 4= Agree, and 5 = Strongly Agree

1. Colorado's freshwater ecosystems (rivers, wetlands, riparian areas) are likely to be affected by climate change.
2. Colorado's grassland ecosystems are likely to be affected by climate change.
3. Colorado's alpine ecosystems are likely to be affected by climate change.
4. Colorado's forest and woodland ecosystems are likely to be affected by climate change.
5. Colorado's shrubland ecosystems are likely to be affected by climate change.
6. Colorado's urban habitat (parks, open spaces) ecosystems are likely to be affected by climate change.

The following questions will ask you about your background, so we can describe our sample of participants.

7. What gender do you identify as?

1. Man
2. Woman
3. Non-binary, genderqueer, or gender non-conforming
4. Prefer not to say
5. My gender is not listed. Please specify below. ________________

8. What is your race/ ethnicity? (select all that apply)

1. American Indian or Alaska Native
2. Asian or Pacific Islander
3. Black or African-American
4. Hispanic or Latino/a/x
5. White
6. Race/ethnicity not listed. Please specify below. ___________
7. Race/ ethnicity unknown
8. Prefer not to answer

9. What is your current academic level?

1. Freshman (0-29 credits completed)
2. Sophomore (30-59 credits completed)
3. Junior (60-89 credits completed)
4. Senior (90+ credits completed)
5. Post-baccalaureate (has completed a bachelor's degree)
6. Prefer not to answer

10. What is your political party affiliation?

1. Democratic Party
2. Republican Party
3. Green Party
4. Libertarian Party
5. Independent
6. Other. _________
7. Unknown
8. Prefer not to answer

11. What is your political identity?

1. Strongly Conservative
2. Moderately Conservative
3. Slightly Conservative
4. Middle of the road
5. Slightly Progressive
6. Moderately Progressive
7. Strongly Progressive
8. Unknown
9. Prefer not to answer

APPENIDIX I

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Institution name
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Expected presentation date
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Order reference number
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Appendix table: Questions Assessing Perceptions and Behavioral Intentions

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