SCREENS IN THE FIELD: USING DIGITAL TECHNOLOGY TO FOSTER LEARNING AND SENSE OF PLACE

By

Julie Markiewicz

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ABSTRACT

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Digital learning has rapidly developed within the past decade and today's students have a fluency with digital technology that has led many educators to utilize digital learning techniques. Research indicates that this constant presence of technology can alienate students from the natural world, the opposite of what field-based environmental education hopes to accomplish, making it critical to investigate how digital technology impacts learning outcomes, especially in the field of environmental education.

I explore the integration of digital technology in environmental education from two angles: Chapter One of this thesis addresses the relationship between student engagement and digital technology-usage through empirical research on learning and place engagement during an environmental science, arts, and humanities educational experience at a Long-Term Ecological Research site. The field-based learning experience, mediated by digital technology (tablets), aims to balance student engagement with both the curriculum and the natural landscape. I conducted an exploratory, mixed methods study to investigate the impacts the tablets have on learner engagement with both content and place. Results indicated both benefits and challenges to when using the tablets, however, the content and structure of the curriculum were more influential on engagement than the delivery medium. Chapter Two of this thesis provides a description, review, and synthesis of currently available research regarding the concept of "virtual sense of place".

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KEY TO ABBREVIATIONS

DT	Discovery Trail
eSAH	Environmental science, arts, and humanities
HJA	H.J. Andrews Experimental Forest
LTER	Long-term Ecological Research
NGSS	Next Generation Science Standards
STEM	Science, technology, engineering, mathematics
VFT	Virtual field trip
VLE	Virtual learning experience
VSoP	Virtual sense of place

INTRODUCTION

Background

While I worked as a biological field technician on the shoreline of Sleeping Bear Dunes National Lakeshore, I often encountered curious visitors. I was a member of the "plover crew", a dedicated team that worked to manage a population of endangered shorebirds called piping plovers that nest along the Lakeshore every summer. The equipment I carried with me daily attracted a lot of attention, especially the large spotting scope on a tripod, and visitors typically had questions about what I was doing. I grew to look forward to these interactions in the field; I loved telling people about these special birds and how our work was helping to recover the species. However, some of these conversations became frustrating when I realized just how little some people knew about endangered species or conservation in general. I also wished I was more capable at conveying the importance of conserving the species and why certain park policies are put in place to protect the piping plovers. After three seasons on the plover crew, I decided that I wanted my role in conservation to be a bridge: a bridge between people and the places around them; a bridge between science and the public; and a bridge that builds a connection between people and the natural world.

My thesis research reflected these interests: an exploratory study investigating the impacts of a digitally-mediated curriculum on student engagement conducted at the H.J. Andrews Experimental Forest (HJA). The HJA is home to a digitally-mediated educational experience called the Discovery Trail (DT), which is the focus of my research. Today, the constant presence and use of digital technology are frequently challenged, often due to a visceral reaction and cultural sense that today's students are using screens too much and it can impede outdoor activities and interactions (Louv 2012). As digital technologies become more common and less expensive, they are being used more widely in outdoor, place-based environmental education programs that aim foster meaningful connections between learners and the natural world through direct experiences, while also teaching ecological concepts and encouraging pro-environmental action (Anderson et al. 2015; Kacoroski et al. 2016). Chapter One focuses on my research on the DT at the HJA which was designed to be exploratory with the intention of producing both scholarly and practical outcomes. Research on the use of digital technology in environmental education programs is limited, so the results from investigating the impacts of iPad-use on content and place engagement on the DT can inform curriculum and other experience modifications to the DT while also providing useful information to other environmental educators.

The intention was to return to the HJA with fine-tuned data collection tools that focused more on content and place engagement and have the capability of identifying more nuanced results. However, these plans were pushed aside due to the COVID-19 pandemic. With widespread virus mitigation efforts such as physical distancing and quarantine measures, traveling to Oregon to collect more student data on-site was no longer an option. This unexpected situation forced me to pivot and consider other directions to pursue virtually.

The COVID-19 pandemic rapidly increased the speed of integration of digital technology into our daily lives, with new innovative technologies emerging constantly (Vargo et al. 2021). In a rapid review of the literature surrounding technology-use during COVID-19, researchers concluded that healthcare professionals were the largest group of digital technology-users during the pandemic, with however, teachers and students coming in second (Vargo et al. 2021). The spread of COVID-19 resulted in most students across the U.S. being sent home to continue their education online, meaning educators were forced to quickly embrace various digital platforms and digital learning techniques (Armstrong-Mensah et al. 2020). My research about the relationship between digital technology and content and place engagement on the DT felt very relevant since digital learning had become the norm for much of the pandemic. Anecdotally, I saw countless other outdoor environmental education programs transition to a virtual format which led me to begin brainstorming what a virtual DT could look like. On the DT, digital technology is used to facilitate learning and connection-building, but is it possible to do the same from afar?

Much of the DT is multi-sensory and relies on the in-person experience to build a relationship with place and forge an emotional attachment. This left me with two questions that inspired Chapter Two: is it possible to facilitate place relationships with *only* digital technology? And what are the best practices for using digital technology to foster connections when field-based experiences aren't an option? These questions led me to further consider what a virtual experience could look like if it attempted to maintain similar outcomes as the in-person experience. A significant advantage that virtual versions of a field-based experience have is that they broaden the audience of learners by making the place more accessible regardless of a learner's ability or health (Palaigeorgiou et al. 2017). This applies to any field-based experience including the DT at the HJA, a place that is remote which can make travelling to the site time-consuming and costly.

Although they look through different lenses, both chapters aim to address a few of the complicated and challenging questions that environmental educators often find themselves having to confront in today's digital world:

- How do we reconnect today's students to nature in a world where digital technology is seemingly everywhere?

- How can digital technology be used to enhance learning outcomes and place relationships rather than impede?

Chapter One informs a quantitative and qualitative understanding of the impact that digital technology, i.e. iPads, have on learning and place engagement during an outdoor environmental science, arts, and humanities educational experience. The results contribute to a growing body of literature revolving around digital technology-use in field-based environmental education and can be used to inform similar interdisciplinary environmental education experiences. They'll also have a direct impact on the DT curriculum by informing future revisions and modifications to the experience. Chapter Two provides a review and synthesis of currently available research regarding "virtual sense of place" (VSoP) which includes relevant concepts such as virtual learning, virtual field trips, and sense of place. This review describes the VSoP, evaluates the state of this emerging topic in the literature, and suggests best practices for facilitating sense of place in virtual learning experiences. Since many of the frameworks and ideas discussed in this review, such as sense of place, are written about at length elsewhere, this review intends to be broadly representative of the literature surrounding the concept of "virtual sense of place". In combination, Chapters One and Two aim to provide relevant information regarding the state of digitally-mediated environmental education today for both scholars and practitioners.

Brief Literature Review

Digital Technology

Increased technology-use is often cited as the leading cause of an "alienation from nature" that can cause a disconnect between people and the natural world (Anderson et al. 2015; McClain & Zimmerman 2016; Ruchter et al. 2010). The incorporation of mobile digital technologies into the education system has grown significantly in recent years due to teachers desiring new ways to communicate with the digital generation and design more appealing and engaging learning experiences (Hougham et al. 2015; Manuguerra & Petocz 2011; Prensky 2001). One example is the Apple iPad, a commonly used tablet in classrooms (Manuguerra & Petocz 2011) and more recently, in outdoor environmental education experiences (Kacoroski et al. 2016). The COVID-19 pandemic has further catalyzed a rapid shift to digital technologies. Online platforms, electronic devices, and other forms of digital technology are now used in almost every facet of everyday life, including activities like shopping, working, socializing, and learning, an integration that has led to significant changes in human behavior and our livelihoods, especially in education (Vargo et al. 2021).

Sense of Place

Sense of place refers to a relationship that a person has with a place and a sense of belonging in that place (Kudryavtsev et al. 2012). Researchers in environmental describe sense of place as a combination of two concepts: place attachment and place meaning. The literature describes place attachment to be the relationship between a person and place, often including how strongly a person connects with and values a place (Ardoin 2006; Kyle et al. 2003; Scannell and Gifford 2010). Place meaning refers to what a place means to a person or the ways a person ascribes value to a place (Arora and Khazanchi 2014; Kudryavtsev et al. 2012). In other words, a sense of place is the culmination of the strength of a relationship between a person and place (place attachment) and the meaning and reason behind the relationship (place meaning) (Arora and Khazanchi 2014; Kudryavtsev et al. 2012). Studies demonstrate linkages between place attachment and place meaning with pro-environmental behavior (Kudryavtsev et al. 2012; Hungerford & Volk 1990): the idea is that people are more motivated to take action in conservation efforts if something threatens the meaning a person has assigned to a place (Stedman 2003). Place attachment occurs when an emotional connection is motivated by place taking on a personal meaning (Cuba & Hummon 1993; Kollmuss & Agyeman 2002; Scannell and Gifford 2010), and this relationship with place can serve as a driver to adopt responsible environmental behaviors and build feelings of care and responsibility for place (Goralnik et al. 2016; Mayer & Frantz 2004; Smith 2007).

One way of fostering a sense of place is through direct experiences in the natural world. A direct experience in nature has more influence over one's actions and environmental attitude than indirect experiences and can lead to stronger connections to nature and influence their perceptions of environmental issues which can ultimately increase interest in environmental protection (Akerlof et al. 2013; Ardoin 2006; Perkins 2010; Rajecki 1982). This suggests that to be motivated to participate in pro-environmental actions, one must have first-hand experiences within the natural world (Perkins 2010; Rajecki 1982). Experiential education is a framework within the broad field of education that is defined by direct experiences in the real world (Kolb 1984). It's often applied in environmental education contexts, and a pedagogy within the broader field of experiential education is place-based education. Although place-based education isn't specific to environmental education contexts, it is often applied to them. It's typically interdisciplinary, focusing on all aspects including the biological, cultural, social, and historical aspects of a place (Gruenewald 2003; Sobel 2004). It’s also characterized by learners having direct experiences in the field, applying learned concepts to the real-world, and hands-on activities (Sobel 2004, Woodhouse & Knapp 2000). Place-based education can increase the value that students put on the natural world, enhance academic achievement, and cultivate a stronger sense of commitment to the community and ability to serve as an active citizen (Sobel 2004). The DT is an example of a place-based framework in practice, with lessons that include content from a range of long-term work being conducted at the HJA.

CHAPTER ONE:

Technology on Trails: Student Content and Place Engagement During a Digitally-Mediated Environmental Science, Arts, and Humanities Experience*[1]

Introduction

Deep valleys and high peaks, towering Douglas firs, a floor of moss, and swift, clear mountain streams all characterize the HJA, one of 28 sites in the U.S. Long-Term Ecological Research (LTER) network (LTER 2017). The LTER network is a collection of field sites across a range of biomes that are supported by the National Science Foundation for long-term study of place (HJA 2017a). Located in the Cascade Mountain range of central Oregon, the HJA's landscape is dominated by old growth forests blanketed in moss, the canopy of which is home to many charismatic species like the northern Spotted Owl (HJA 2017a).

In the HJA, environmental science, art, the humanities, and education intersect with the study of long-term change in the forest. This is the heart of the DT, an environmental science, arts, and humanities (eSAH) educational experience for middle and high school field trips in the HJA. Developed in 2015, the DT interpretive learning experience was designed to introduce learners to the landscape and to topics such as forest management and place-based ecology, as well as foster personal reflection about one's own place relationships and associated responsibilities. Through the integration of place-based ecological research, arts, and humanities, the interdisciplinary DT curriculum aims to facilitate both the development of knowledge about

[1] *A version of this chapter has been accepted for publication:
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the ecosystem, as well as care for the natural world through interaction, reflection, curiosity, and wonder.

During the DT experience, student groups are guided through a series of stops along a half-mile forest trail. The inquiry-based curriculum is formatted on portable tablet computers, Apple iPads, which are shared by groups of two to three students. The use of digital technology allows for the inclusion of multimedia elements in the curriculum, including videos and audio clips. This format enables a place experience across time and season, providing learners access to critters, places, and events they typically wouldn't see on a forest visit, including the high canopy and the creek at flood volume. The digital platform accompanies learners' personal interactions, self- and group-reflections, and sensory explorations of the forest. The tablets also provide a non-invasive way to archive student assessment data and provide a means for increased student on-trail hours at a site with limited staff capacity.

Digital technology use in STEM (science, technology, engineering and mathematics) learning environments has numerous benefits (Lakshminarayanan and McBride 2015). However, the use of digital technology in field settings is less studied, and likely has some limitations, including the simple intrusion of screens as a mediator of an immersed nature experience and the potential distraction they can cause (Hougham et al. 2015). To explore the use of digital technology as a delivery medium for an innovative field-based eSAH curriculum, we have been researching the impacts of the tablets on learner engagement with place and content on the DT. Content engagement is important for overall learning, particularly for encouraging persistence and maintaining motivation during learning experiences (Fredricks et al. 2004; Henrie et al. 2015; Kuh et al. 2018; Reeve and Tseng 2011). Place engagement, as we use the term, describes the depth with which a learner interacts with the storied built and natural landscape, a critical element of building relationships with places, and thus a central element of biocultural conservation. While scholarship on technology use in the field is limited, there is some hesitation in the literature about the use of screens on the trail because of the potential for distraction or a philosophical tension with taking technology outdoors to mediate the place experience (Anderson et al. 2015; Hougham et al. 2015). If this is the case, then the learning medium on the DT - iPads - would prevent our learning objectives, i.e. connection to place and biocultural conservation and education.

In 2019, we conducted an exploratory study on the DT to investigate the impacts of digital technology use on the learner experience. We asked the question: *What are the impacts of a digital curriculum on learner engagement with place and content?* Our results reveal both benefits and challenges to tablet-use on the trail, with the positive impacts to biocultural conservation outweighing the logistical hurdles associated with using technology on the trail. In this chapter, we will describe our research with 108 middle school learners from central Oregon on the DT, as well as provide suggestions for content delivery and group preparation that can address potential challenges of employing this innovative pedagogy for biocultural conservation.

The H.J. Andrews Experimental Forest

Sites within the U.S. LTER network have the shared mission to "provide the scientific community, policy makers, and society with the knowledge and predictive understanding necessary to conserve, protect, and manage the nation's ecosystems, their biodiversity, and the services they provide" (LTER 2017). Inquiry across the network is primarily ecological, though a number of sites (21 of 24 total sites in 2014) also host social science and/or arts and humanities inquiry (Goralnik et al. 2015). All sites are committed to education and outreach as central goals and some, including the HJA, also conduct research on these activities. The HJA in particular aims to “support research on forests, streams, and watersheds, and to foster strong collaboration among ecosystem science, education, natural resource management, and the humanities” (HJA 2017a). The HJA comprises 16,000 acres of mountainous old growth and managed forested terrain within the Lookout Creek watershed. The forest is co-administered by the USDA Forest Service’s Pacific Northwest Research Station, Oregon State University, and the Willamette National Forest. Foundational research at the HJA includes important studies on forest and stream ecology and forest management; ongoing long-term data collection includes climate, water quality, and forest succession.

The HJA also hosts a long-running arts and humanities residency program in collaboration with the Spring Creek Project for Ideas, Nature, and the Written Word at Oregon State University. Visual artists, writers, philosophers, and musicians spend two weeks in the forest to reflect on place, interact with scientists, and conduct their own scholarly and creative work. Since 2004, over 90 artists, writers, and humanities scholars have participated as residents in the HJA and many of their works are featured on the DT today.

The Discovery Trail

In 2012, the DT loop was developed near the HJA headquarters to provide an opportunity for visitors to observe the characteristic ecosystems of the HJA forest. The HJA hosted close to 1,800 total visitors in 2018, and because much of the landscape is difficult to navigate due to steep terrain and active scientific studies, the DT provides these visitors an accessible outlet for exploration. In 2015, an eSAH digital interpretation of this trail was created specifically for visiting middle and high school field trip groups. In 2017, an additional quarter-mile trail extension was added to the original DT, and this un-interpreted section is used for a silent sensory walk by field trip groups, whereby learners walk quietly and spaced apart to observe the forest with their senses.

The five-hour DT field trip experience begins with a brief orientation by HJA staff, who share a poem about the relationship between science and art, part of “Art of Science” by Vicki Graham, a 2006 HJA writer-in-residence (Fig. 1). After the poem, the students are then invited to participate on the solitary sensory walk on the un-interpreted trail. The students are sent into the forest one-by-one and are strongly encouraged to engage all of their senses, for instance, by touching tree bark, smelling the fresh air, or listening for animals. This experience effectively primes students for the DT learning experience by focusing their attention on place and the environment around them.

Begin with love, a composite of science, art, imagination, and the pure world of the senses– with the things the hand can touch: the peeling papery bark of a yew, the curve of a snail shell, the beard lichen’s wiry hair– with color and taste and smell and the call of a thrush at dusk, the velvet glide of a spotted owl	Begin with love and the questions the heart asks: why stones arrange themselves in lapped patterns on a gravel bar. How old growth trees resist the quickly mutating pathogens that attack them. Where the orchid lacking chlorophyll gets its sugars. Let the body then the heart learn the forest and remember: Data collection, computer analysis, digitized imaging begin with hand and eye, tongue, nose, and ear	And while the pencil hovers Over the page or the hand grips A water gauge, the scientist Has time to stroke the willow leaf’s silk, Breathe in the lemon scent Of chanterelles, follow the arc Of a swallow’s flight. The artist, too, has time to taste and touch.

Figure 1: The final three stanzas from “Art of Science” (Brodie et al. 2016 p 71-73) by Vicki Graham, a 2006 HJA writer-in-residence.

After a short debrief and instructional period at the DT trailhead, student groups of two or three are assigned three of the ten interpretive stations, with each grouping of three stops designed to provide equivalent learning activities and objectives (Table 1). Then, each student group is given an iPad to share before heading to their first station. Throughout their three lessons, students experience content related to HJA science, forest management, and forest dynamics, as well as reflective activities and creative content from HJA artists- and writers-in-residence (HJA 2017b). In addition to interviews with scientists and content from the long-running ecological inquiry at the HJA, the DT curriculum also includes writers reading poems and essay excerpts they have written during their forest residencies and artist interviews about their creative process and HJA-related work. The intention is to provide opportunities to get to "know" the HJA through multiple modes of inquiry, as well as scales of perception: near and far; past, present, and future; ground and sky; interpreted and personal; human and animal; science and art. Ultimately, we hope that attention to both cognitive and affective learning outcomes - both learning and feeling - will lead learners to deeper understanding and potentially care and responsibility for the forest.

Learning Objective/Activity	**Example Activity**
Place reflection and observation	Observing tree species.
Creative activity	Drawing plant leaves.
Personal reflection	Reflecting on how the growth that occurs in a forest after a disturbance is similar to how one changes after a disturbance in their own life.
Values reflection	Reflecting on what the learner appreciates about forests.
Mindfulness activity	Reflecting on what life is like for animals that live in HJA, meditation while listening to forest sounds.
Creative writing	Reading aloud a short story about the relationship between a Native American tribe and salmon, then interpreting the meaning of the story.
Graph or diagram	Interpreting graphs of average rainfall, reading a diagram of the carbon cycle.
NGSS: Stability and change	Learning how logjams and flooding impact normally stable water bodies.
NGSS: Cause and effect	Learning how a forest disturbance changes plant communities.
NGSS: Patterns	Comparing graphs of average rainfall to time lapse photos of Lookout Creek.
NGSS: Systems	Learning about nutrient cycling and forest food webs.

Table 1: The 11 learning objectives and activities of the DT, including four Next Generation Science Standards (NGSS) cross-cutting concepts, and an example of a DT task or activity that fulfills that objective.

The field philosophy (Goralnik et al., 2012, 2014a, 2014b, 2015, 2016, 2017) framework of our study is rooted in relational and care-based ethics, driven by the notion that right action derives from acting in ways that support the maintenance and wellbeing of our relationships (Warren 1990, 2000; Noddings 1984, 2002, 2005). As learners come to understand themselves to be in relationship with place(s), or to view place as a relational other worthy of moral consideration, they may also start to shift their actions in ways that reflect their responsibility within that relationship (Goralnik et al 2020). Our approach aligns with Field Environmental Philosophy (FEP) (Tauro et al. 2021) in the shared focus of addressing the 'extinction of experience' common in contemporary educational settings (Anderson et al. 2015). The DT experience bridges the divide between mediated knowledge – the scientific, artistic, and literary narratives shared in the curriculum on the tablets – and direct encounters with the natural world, through guided meditations, sensory activities, reflection, observation, imaginings, and experiences in the forest (see Rozzi et al. 2006, 2008). Similar to FEP, we also hope to facilitate deeper connections between humans – in our case middle and high school learners – and the natural world, or rather place, which includes the intersection of the natural world with layers of human relationships with the landscape over time, e.g., scientific, artistic, storytelling, land management, subsistence, political, recreational, psychological, emotional, and spiritual.

We have designed the DT learning experience around an environmental pedagogy of care (Goralnik et al. 2012), which bridges care-based ethics with scholarship in experiential and place-based learning (Gruenwald 2003; Knapp 2005), environmental education (Hungerford and Volk 1990; Goralnik and Nelson 2011), and emotional engagement (McCuen and Shah 2007; Skinner et al. 2009). This pedagogical foundation can lead to critical thinking and moral imagination in longer-term field philosophy experiences, as documented by Goralnik and colleagues in their work in Isle Royale National Park (Goralnik et al. 2014a; 2014b; 2015; 2017).

An environmental pedagogy of care and programming that has been guided by this framework is rooted in other examples of humanities-based field learning (Algona and Simon 2010; Johnson and Frederickson 2000), as well as foundational scholarship in environmental, place-based, and experiential learning. It uses empirical tools to describe learning and moral awareness in response to integrated field-based eSAH curriculum.

Background

Digital Learning

Digital learning has become the most rapidly developed method of learning in the past decade (Sebastian et al. 2012) due to a fluency with technology that today's middle and high school students have. This has led many educators to use digital learning techniques in their classrooms to capitalize on student interest and strengths (Manuguerra and Petocz 2011). A 2012 meta-analysis about the relationship between digital technologies and student academic achievement found that positive impacts of technologies have been consistently identified by researchers in many different learning contexts (Higgins et al. 2012; Lakshminarayanan and McBride 2015). Examples include the ability of digital technology to foster deeper learning through guided critical thinking and problem solving (Kim et al. 2008); support student autonomy by allowing students to learn at their own pace and take ownership of the inquiry process, which can increase interest in learning (Kim et al. 2008; Lakshminarayanan and McBride 2015); and increase understanding of science and mathematics (Higgins et al. 2012). Digital technology also has features that improve learning facilitation, including portability and the ease of using multimedia elements like videos (Kukulska-Hulme et al. 2007).

The research on digital technology-use in outdoor education contexts is limited, but while we might assume that many of the same benefits of technology in the indoor classroom apply, there are also reasons to proceed with caution when embracing technology in the field (Hougham et al. 2015). Research - not specifically focused on environmental learning or field-based experiences - suggests that student dependence on technology can contribute to “alienation from nature” (Ruchter et al. 2010), the opposite of what we hope to accomplish with field-based environmental education. Richard Louv, author of *The Nature Principle: Reconnecting with Life in a Virtual Age*, echoes Leopold (1949) when he writes: “we cannot protect something we do not love, we cannot love what we do not know, and we cannot know what we do not see. Or hear. Or sense.” (Louv 2012 p. 104). In other words, a relationship with nature is critical to the development of the motivation to care or protect it. Do screens inhibit these relationships in field-based learning? Or, is it possible to use digital technologies in the outdoor classroom in ways that do not *distract* from nature, but rather *enhance* connection-building? Our work on the DT is a step toward answering these questions.

Growing up surrounded by digital technology has changed the way learners think and process information (Prensky 2001; Selingo 2018). Incorporating digital technology into the curriculum represents an innovation that accommodates the strengths and preferences of some learners (Prensky 2001) and learning according to one’s preferred learning style improves learners’ motivation to learn and to understand content (Wolf 2003; Kacoroski et al. 2016). While students are comfortable with technology use in general, the use of digital technologies in the field environment is likely an unfamiliar experience for most learners. Novel experiences like this - using a familiar tool in an unfamiliar context - can create excitement and motivate students to learn (Anderson et al. 2015). However, there are limited studies on the use of digital technology in field-based contexts like the DT to assess how it might support or detract from the outdoor learning experience (Kacoroski et al. 2016; McClain and Zimmerman 2016). Since learners today are increasingly disconnected from nature (Ruchter et al. 2010), it is crucial to find ways to integrate digital tools in the field learning experience that balance the learning benefits and potential distractions.

Recent scholarship suggests that it is, indeed, possible for learners to be engaged both with place and content in the digitally-mediated outdoor education classroom. McClain and Zimmerman (2016) describe their study of a tablet-guided nature trail experience for students aged 8-11 and offer suggestions for thoughtful digital field-based curriculum development. This includes prompts that require “heads-up” or “tactile investigation” actions that provide opportunities for students to engage directly with nature. This kind of activity encourages learners to engage with the landscape beyond the screen, instead of solely engaging with the technology (Hougham et al. 2015; McClain and Zimmerman 2016). Being thoughtful about the integration of digital technology and these kinds of sensory activities can elevate the benefits of technology on the trail while addressing limitations (Hougham et al. 2015).

Learning and Place Engagement

Engagement is a widely studied educational construct that can be applied across learning contexts (Connell 1990). It consists of three primary components: cognition, emotion, and behavior (Reeve and Tseng 2011) (Table 2). How a learner engages with content depends on many conditions, including the difficulty or simplicity of the material, the educator’s or student’s attitude, and the motivation to learn associated with perceived control and relatedness (Reeve and Tseng 2011). When a learner is fully engaged in all three areas, many positive outcomes such as increased persistence and motivation have been documented (Fredricks et al. 2004; Henrie et al. 2015; Kuh et al. 2018).

<table>
<tr><th>Engagement type</th><th>Component</th><th>Definition</th><th>Descriptions</th><th>Example from the Discovery Trail</th></tr>
<tr><td>Content engagement</td><td>Cognitive (a)</td><td>Being thoughtful and willing to invest the psychological effort required to comprehend material and master skills.</td><td>Active self-regulation to sustain engagement, the use of strategic learning strategies to organize, monitor, and evaluate progress.</td><td rowspan="4">At Station 9: Sounds Maps students listen to an interview recording of an HJA researcher explaining how she uses sound in her research on birds in the forest. Students are then asked inquiry-based questions about the content of the interview (a) before being prompted to set the tablet down and quietly listen to the forest (d). After a few minutes, the voice narration instructs students to pay attention to the variety, direction, and strength of sounds around them (c,d), then to map the sounds on paper using images, arrows, text, or symbols (a,c). Afterward, students are asked to reflect with their group on how they felt while listening to the forest (b,d), and then consider other times in their lives they have felt similarly (b). The station wraps by asking learners to notice any connections between the scientist's bird research and their own sound mapping activity (a).</td></tr>
<tr><td></td><td>Affective (b)</td><td>The emotional reactions to learning, such as how pleasurable and enjoyable learners find an experience, and their identification and sense of belonging with place.</td><td>Learners are enthusiastic, anxious, sad, happy, curious, feel like they belong and are valued.</td></tr>
<tr><td></td><td>Behavioral (c)</td><td>The amount of active participation and effort demonstrated by learners in learning tasks and in the classroom.</td><td>On-task, paying attention, persistence at tasks, following directions, no conduct issues, asking questions, contributing to discussions.</td></tr>
<tr><td>Place engagement</td><td>Holistic (multi-sensory) (d)</td><td>The depth to which a learner interacts, considers, and connects with a place as a built and natural storied environment.</td><td>Tactile investigations of landscape elements, spiritual connections to or an expressed feeling of ease in place, pointing out objects to peers, immersing oneself in a sensory experience in the landscape, or remarking on landscape features or observations.</td></tr>
</table>

Table 2: Descriptions for each of the three constructs of engagement (cognitive, emotional, behavioral) and place engagement in an environmental education context, including definitions and examples of what each component looks like in an education setting. These components are collective, not summative, and the DT aims to engage all components often at the same time throughout the experience. The example of Station 9 shows how all four engagement components are woven together in practice on the DT. Definitions and examples are borrowed from Fredricks et al. (2004), Dienno and Hilton (2005), and Reeve and Tseng (2011).

In our work in environmental education, we also consider engagement a metric to describe the depth with which a learner interacts with a place. We call this “place engagement.” It might also include interactions that take place *within* a learner, the internal experience of forest immersion, including the emotional connections learners make during creative or reflective activities. The DT experience aims to strike a balance between student engagement with both content and the place, with the goal of both imparting ecological knowledge as well as fostering feeling and emotional connections to the forest through the development of place relationships (Goralnik et al. 2020).

The emotional, or affective, component of engagement refers to students’ beliefs, feelings, attitudes, and their emotional reactions to the learning experience (e.g., curious, excited, bored, or frustrated). Positive emotions increase affective engagement, while negative emotions decrease it (Fredricks et al. 2004; Reeve and Tseng 2011). Affective engagement is also particularly critical to the development of responsible environmental behaviors, one of the main goals of environmental education (Hungerford and Volk 1990; Littledyke 2008). This is because of its role in fostering a positive attitude towards the environment (Iozzi 1989) and its ability to cultivate a connection and a sense of respect, awe, and understanding of our place in the world (Littledyke 1996, 2008), as well an internal locus of control, or the feeling that one’s actions have an impact. On the DT, one way we engage the affective domain is through the integration of arts and humanities in the curriculum, which invites observations and expressions of feeling and emotion in the learning process more than science alone often encourages (Davis 2008; Goralnik et al. 2020).

Recent scholarship on eSAH learning experiences shows that this kind of deeply interdisciplinary learning can contribute to changed attitudes about the natural world, a better understanding of complex socio-ecological systems, and emotional engagement with environmental issues, which can in turn foster pro-environmental intentions or action (Goralnik et al. 2016; Goralnik et al. 2020). Additionally, eSAH integration can increase learner capacity for creative and innovative thinking and decision-making, which are important skills for STEM-based problem solving and applying scientific concepts in the real world (Daughtery 2013). On the DT, art and humanities content - including poems, essays, visual art, Indigenous stories, values discussions, history, reflection and drawing - is integrated alongside place-based science curriculum, so that feeling and imagining about the natural world is rooted in actual landscape dynamics. “Writers see the research work itself, such as long-term field experiments, in emotive terms the scientists themselves seldom use, such as faith, empathy, and love” explains Fred Swanson, an HJA scientist and eSAH collaborator (Swanson 2015 p. 18). This distinction is important, as Robin Kimmerer, an HJA writer-in-residence explains, because “The data may change our minds, but we need poetry to change our hearts.” (Kimmerer 2004). Together, these creative perspectives can facilitate affective engagement in ways science, often presented as objective, cannot. The idea at the heart of the DT is that weaving environmental science, arts, and humanities together nests cognitive and affective learning on the trail. This is important for broad learner engagement, including content and modes of learning that appeal to all kinds of learners, and for facilitating feeling (and doing) in the process of learning.

Methods

Participants included the students and teachers from four eighth grade classes from a single middle school in Eugene, Oregon. The two teachers taught all of the students, but in different subjects (science and language arts). We used an exploratory, mixed methods approach, which enabled us to work with a large sample size, while at the same time provide rich context about the learner experience.

Four groups of students visited HJA on four separate days during May of 2019. Two control classes used the standard iPads, and two experimental groups used an adapted equivalent paper version of the curriculum that we developed for the study. Translating the curriculum between a digital medium that featured multimedia elements to a paper version required some content and format modifications, including replacing open-ended questions with multiple choice, streamlining and condensing text, replacing videos with screenshot images and text, and replacing audio clips with text transcripts. Some content was adapted specifically for the different medium, so that the paper copy was not just a less dynamic version of the digital version, but a purposeful representation of the curriculum in its own right. The learning objectives for each station remained the same in the paper version, so while the two experiences were not identical, they covered the same concepts and material, making them equivalent versions of the same curriculum.

We used a pre- and post-survey consisting mostly of five-point scale Likert-type questions to measure 1) affective attitudes; 2) connection to nature; 3) engagement; and 4) content knowledge. The affective attitude section asked students to what degree they agree or disagree with prompts asking about their feelings regarding four prominent themes within the DT experience: science, nature, art, and digital technology. The connection to nature section combined items from the Connectedness to Nature Scale, a commonly used scale that was developed to measure an adult's emotional connection to the natural world (Mayer and Frantz 2004), and a modification of this scale that was adapted for fourth grade participants (Cheng 2008). The combination of items designed for adults (Mayer and Frantz 2004) and for fourth grade students (Cheng 2008) were chosen to tailor our study for middle and high school learners.

The engagement section, on the post-survey only, consisted of Likert prompts that I designed for this study to assess how students perceived their own engagement. Items were based on the definitions of each component of engagement (adapted from Cheng and Wu 2015) and included statements like "the lessons on the trail were enjoyable" and "I often found my mind wandering from what I was supposed to be focusing on." The content knowledge section was designed to assess student understanding of four Next Generation Science Standards (NGSS) crosscutting concepts that are integrated into the DT curriculum: stability and change, cause and effect, patterns, and systems (NGSS 2013). The pre-surveys also collected basic demographic information and contained one open-ended question asking the students what they hoped to learn on the DT. The post-surveys included an additional section asking about specific activities on the DT, and three open-ended questions about what students learned, what they enjoyed, and what they disliked during the field trip. Illegible responses were not included in the analysis.

We also conducted participant observation and recorded extensive field notes during the trail experience. I stationed myself at several stops along the trail - enough out of the way so as not to distract the students yet within hearing range of student conversations - and observed groups as they engaged with the inquiry and content at that stop. Field notes focused on engagement-specific behaviors, for example: "heads-up observations," when the learner responded to the curriculum by observing their natural surroundings; "pointing," which indicates the learner is connecting a concept learned in the program to their natural surroundings, "tactile investigation," which indicates a learner is using touch to investigate a natural object that is referenced in the curriculum (McClain and Zimmerman 2016). Additionally, observations noted distraction, socialization about off-task topics (when heard), and non-curriculum focused behaviors.

We also interviewed both teachers before and after the field trips. These interactions contributed insights about the DT experience as a whole, while also capturing additional information about the teachers' expectations and experience with the tablets, expectations for and observations of student learning and engagement during the experience, observations of field trip impacts in the classroom, and overall satisfaction and perceived usefulness of the DT experience.

Method	Participants	Details	Objective/Purpose
Pre-surveys	N = 104 8th-grade students	*Quantitative* ● 32 Likert-style items ● 5 multiple choice content questions *Qualitative* ● One short-answer question ○ What is one thing you would like to learn about?	*Quantitative* To measure pre-experience: ● Affective attitudes ○ Science ○ Nature ○ Art ○ Digital technology ● Connection to Nature ● Forest-ecology knowledge. *Qualitative* ● Identify forest-related topics that students are most interested in learning about
Post-surveys	N = 104 8th-grade students	*Quantitative* ● 32 Likert-style items ● 18 yes or no ● 5 multiple choice *Qualitative* ● Three short-answer questions ○ What is one thing you learned about? ○ What was your favorite part? ○ What was your least favorite part?	*Quantitative* To measure post-experience: ● Affective attitudes ○ Science ○ Nature ○ Art ○ Digital technology ● Connection to nature ● Student perception of engagement ● Forest-ecology knowledge *Qualitative* ● Identify what topic students most remember learning about and their thoughts and opinion regarding what features they liked and disliked
Pre-experience interview	N = 1 Teachers	● *Length:* 25 minutes ● Semi-structured ● Participants interviewed together	● Identify teacher attitudes regarding digital technology-use ● Determine amount of preparation students are receiving in the classroom ● Identify teacher motivations ● Answer any remaining logistic questions
Post-experience interviews	N = 2 Teachers	● *Length:* 17 and 24 minutes ● Semi-structured ● Participants interviewed separately	● Obtain teacher feedback on experience effectiveness and field trip logistics ● Solicit details about observations teachers had during the field trip ● Identify post-attitudes regarding digital technology-use
Participant observation notes	14 student groups	Notes taken according to the definition of "engagement" and examples of engaged and disengaged behaviors described in the literature.	● Observe displays of engagement or disengagement, with both the content and place, while students are on the Discovery Trail

Table 3: Breakdown of methods used in study, including the type of method, details about how it was conducted, and the research objectives/goals for each method.

Statistical analysis of the Likert survey data was completed using the statistical software SPSS (IBM 2019). All negative Likert items were reverse coded to match the other items (Kuo et al. 2018).). For the affective attitude section on both the pre- and post-surveys, a principle component analyses was used to find clusters in the data (Kamarainen et al. 2013) and a Cronbach's alpha test was used to measure the reliability and consistency of each of the latent constructs created (Cheng 2008). The shift in mean for each between the pre- and post-surveys was calculated for each section and component. Unpaired t-tests using the change of mean between the pre- and post-surveys were used to identify statistical differences in pre- to post-survey shifts depending on medium, iPads or paper books. Paired t-tests were used to find differences between the pre- and post-surveys, which allowed us to see whether any of the measured constructs changed before and after the DT experience regardless of the instructional medium used (Kamarainen et al. 2013).

Short-answer survey responses, interviews, and field notes were coded using an emergent thematic analysis (Hesse-Biber and Leavy 2008). Transcripts were read multiple times, noting themes in the margins. Themes were then condensed into codes to eliminate redundancy and a codebook was created for each data source. All data were then re-coded with the associated codebook, and codebooks were adapted if/when new themes arose. Data were deductively analyzed with the final codebooks when no new themes arose. All results reflect categories of related codes that emerged in this final stage of the analysis.

Results

Surveys

For each of the constructs measured (affective attitudes, connection to nature, engagement, and content knowledge), Likert scores were aggregated into a single mean (Kamarainen et al. 2013) and checked for internal-consistency reliability with Cronbach's alpha reliability coefficient. A score of 0.7 was required for the results to be reliable. Knowledge questions, each worth one point, were scored right or wrong out of five. Only participants that responded to at least 75% of the questions within a section were included in the analysis for that section.

The threshold for statistical significance is p-value < 0.05. Results from the paired t-tests showed a significant increase in content knowledge after the DT experience across all students. Before the DT experience, the average score out of five questions was 3.36, whereas the average score post-experience was 3.62 ($p = 0.028$). These results indicate that both versions of the curriculum are effective at facilitating content engagement, at least enough that students are learning concepts. However, we did not find any statistically significant differences between the students that used iPads ($n = 51$) versus the students that used paper books ($n = 43$) (Table 4).

This result indicates that neither medium seems to be better or worse than the other, at least statistically. However, the survey likely did not capture the whole picture. The qualitative participant observation data shows a more nuanced and different result than the survey, and thus provides a richer understanding of student engagement.

Construct	N	Pre-α	Post-α	iPad-Users Pre- to Post-Survey Difference M (SD)	Paper Book-Users Pre- to Post-Survey Difference M (SD)	p-Value
Attitude toward *science*	84	0.947	0.934	0.131 (.530)	-0.026 (.566)	.183
Attitude toward *nature*	84	0.885	0.844	0.103 (0.347)	0.038 (0.473)	.471
Attitude toward *art*	84	0.891	0.890	-0.048 (.386)	.0179 (.447)	.474
Attitude toward *digital technology*	84	0.820	0.864	0.0159 (.016)	-.0519 (.495)	.531
Connection to nature	84	0.847	0.892	0.170 (.358)	0.0003 (.601)	.170
Content knowledge	64	-	-	0.353 (.884)	0.133 (1.008)	.357
Construct	**N**	**Pre-α**	**Post-α**	**Pre-survey M (SD)**	**Post-Survey M (SD)**	**p-Value**
Engagement	85	0.663	0.678	3.362 (.492)	3.334 (0.569)	.809

Table 4: Statistical results from unpaired t-tests conducted on the mean pre- to post-survey shifts and on mean post-survey engagement scores between iPad and paper book-users. Threshold for significance is $p < 0.05$.

Participant Observation

Participant observation data showed that there were indeed barriers to engaging with content and place on the DT, though different barriers were associated with the iPad and the paper books. For example, groups using the tablets expressed frustration when experiencing technology issues, such as slow Wifi. Negative emotions, like frustration due to technology not working properly, can negatively impact a student's affective engagement (Reeve and Tseng 2011). Although students using paper books did not experience technology-related frustration, we did observe them skipping entire sections of the lesson, shuffling past some pages of instruction, a clear sign of being disengaged from the content. This is a challenge specifically associated with the paper books because the iPads require responses on each page before advancing the screen. Therefore, iPad-users needed to participate with the content on each page at some level. There were also barriers observed across the iPad and paper book groups. Regardless of medium, students frequently expressed frustration with the number of questions embedded in the lessons and the difficulty of the questions and content. When a lesson is too challenging for a student, they often disengage (Turner et al. 1998).

Students were also observed disproportionately engaging with the *content* rather than the *place*. Examples of place engagement, such as tactile investigation of objects in the forest or pointing out forest features to group members (McClain and Zimmerman 2016), were rarely observed in any student groups. Students were frequently observed spending a majority of their time at each station looking down at the iPad or paper book. Since this was seen across all groups, the curriculum itself could be the most significant barrier to place engagement, not the medium of transmission. While this detail was not reflected in the survey data, it is an important result.

Teacher Interviews

The pre- and post-interviews with the two teachers gave further insight into the DT experience, teacher perceptions of student engagement, and teacher thoughts on tablet-usage in general. The teachers stated convenience, ease of use, and multimedia capabilities as the main benefits to using iPads on the DT. They did not perceive any significant limitations.

When asked to identify key differences between how students engaged with the digital versus paper curriculum, neither teacher observed major differences in the level of commitment students were putting forth to complete the lessons. This result is notable because psychological investment to learn a lesson is one sign of cognitive engagement (Fredricks et al. 2004). One teacher said that regardless of medium, the students: “were engaged with [the experience]. They were curious. They paid attention.” Both teachers also expressed positive feelings toward using the iPads and thought the multimedia elements were exciting and novel for the students, feelings that can increase engagement (Fredricks et al. 2004). In the interview after the field trips, one teacher cited the multimedia capabilities as one of the main benefits to using iPads over the paper books, explaining that "[T]he pictures and the qualities of videos bring something that the paper didn’t have." Alternatively, when asked to identify potential downsides to using iPads on the trail, one teacher said, “I guess they could drop it on a rock and shatter it, but they lose their pencils when we’re on field trips, and we always gotta go around with a bag of pencils and pencil sharpeners. And then you gotta worry about write-in-the-rain paper… so yeah, the iPads are good." She followed her comments about the iPads’ fragility by reemphasizing their convenience, which makes them overall more appealing than the paper books. The teachers did not perceive any significant content engagement limitations with the iPads and perceived the two mediums as equal. One stated: “[The students] seemed equally committed to answering ... I didn’t notice a difference in level of engagement.”

However, both teachers had concerns about the difficulty of the curriculum for middle school-aged students, a concern divorced from the content delivery method. This finding also was reflected in the participant observation field notes. One teacher explained that her “concern is just that students [were] getting frustrated with some of the vocabulary, [because] it’s really advanced.” To mediate this concern, one teacher suggested two different versions of the DT curriculum, one for middle school students and another for high school students. They also had insightful ideas about how to modify the curriculum to increase engagement specifically for middle school learners and thereby improve the student experience, such as the option to use voice-to-text when entering their answers while on the trail and shortening each stop so the students have time to go to more than three stops. Both suggestions are useful when determining best practices for iPad-usage and when modifying the DT curriculum in the future.

Open-Ended Survey Questions

The four short open-ended questions on the surveys also provided deeper insight about the student experience. Two primary themes emerged, the first being a disconnect between what the students *wanted to learn about* and what they *actually learned* on the DT. For example, “forest animals” was the most frequent answer to the pre-survey question “what do you hope to learn about at H.J. Andrews?” (36%). The second most common response was “climate change” and what they can do in their personal lives to mitigate environmental damage (24%). Currently, neither of these subjects are prominent in the curriculum. Students are more likely to be cognitively engaged in the content when they are interested in the subject matter, so adding more material in line with student expectations and interests, or better preparing learners for the experience and what to expect, could increase their overall engagement (Fredricks et al. 2004).

The second theme that emerged was that the experience was too much work and too little fun. When asked what their least favorite part of the DT experience was, 33 of 73 responses (45%) indicated *doing the work on the DT*. More specifically, students noted that there were too many questions, the videos and readings were too long, and the stations included too many activities.

Notably, when asked about their favorite part of the experience, the highest number of learners mentioned the silent sensory walk (23%). Other common responses described being present in the forest, for example: being outside, smelling and hearing the forest, walking on the trails, and being in a peaceful and quiet environment. Having a positive emotional reaction to the experience is a critical component of being affectively engaged, so if the experience featured a more satisfactory balance between focused learning and free exploration in the forest, the students might not only learn more, but also have a more positive experience (Fredricks et al. 2004). When students are cognitively engaged in work, but not provided sufficient opportunities to fully engage with the forest to facilitate other kinds of engagement, their overall engagement level will likely be sub-optimal. The challenge with responding to this critique is that teachers cannot justify a forest field trip if the experience does not satisfy classroom learning objectives. At the same time, conservation goals are not accomplished if the students are disengaged in the experience. We will have to negotiate this balance moving forward. Longer field trips would offer one solution, allowing us to provide equal time doing structured learning activities and unstructured exploring, though the remoteness of the site makes longer trips challenging unless they are overnight.

Discussion

Upon triangulating the results from the surveys, observation notes, and teacher interviews, we draw three main conclusions. First, some differences exist in engagement between students that use tablets and students that use paper on the DT, but neither greatly outweighs the other in contributing to engaged/disengaged behaviors. Second, on the DT, engagement with content and place depend more on the curriculum itself rather than the medium that is used to deliver the curriculum. Third, tablet-led experiences can be modified to increase both content and place engagement to facilitate an overall more enjoyable and beneficial experience, thereby supporting broader learning goals. Making thoughtful modifications to the curriculum can contribute to a more enjoyable experience for the students while also increasing their engagement. This effort will allow a better balance between place and content engagement, and ultimately positively impact place relationships, affective engagement with the forest experience, and biocultural conservation outcomes.

The study described here applies our previous field philosophy work in a new direction by exploring the impacts of short-term experiences in place and with younger learners, who are less steeped in the theoretical and popular culture dialogues about environmental issues, responsibility, and history. Recent scholarship on the DT demonstrates that these types of short-term, ethically grounded approaches to field based eSAH learning can catalyze both passive and active place relationships (Goralnik et al. 2020), whereby learners either feel cared for by the forest, or even develop the motivation to care for the forest, as a result of their eSAH trail experience. This is a novel finding, as most place relationship literature focuses on repeated interactions with place over time. While longer-term immersive experiences in place are likely preferable for a host of reasons (Ardoin 2006; Kudryavstev et al. 2012; Semken et al. 2009; Wattchow and Brown 2011), they are not always feasible for broad audiences, and may not even be appropriate for learners with little experience in the natural world, who need to acclimate to the sensory experience and uncertainty in learning beyond the classroom. The present study narrows the focus of our previous work on the DT to begin to understand more concretely why and how students engage during the eSAH trail experience. This work is important because engagement, especially emotional engagement, is integral to the learning process, and also a key ingredient in the development of care for the natural world. Therefore, it is a necessary step toward biocultural conservation.

Limitations

All participants were middle school students belonging to a single middle school. While our results are relevant for this age group, our sample is small and the research is exploratory. More research is necessary to understand engagement across audiences, including high school learners, who are a target audience for the DT. We also experienced some incomplete data due to survey logistics and miscommunication between the teachers and the research team. In future studies on the trail, we will mediate these challenges with more streamlined and focused data collection tools and processes.

Suggestions for best practices and next steps

While our results are exploratory, they do address novel and relevant questions related to innovative field philosophy methods. By identifying barriers to content and place engagement, we can revise the curriculum to provide a more meaningful, personal forest experience that engages and immerses students in place and with the forest ecology, art, and humanities content. Our sense is that there are more subtle differences between the tablet and paper curriculum experiences that are not reflected in our data, therefore we intend to further develop the qualitative data protocol (perhaps including interviews with student participants) to better capture the student experience. This insight will help us revise the curriculum in a way that it increases both content and place engagement by including more "heads up" prompts. These activities will reduce the time students spend looking at the tablet screen and encourage deeper engagement with place. In practice, these prompts can involve asking students even more frequently to look for and observe specific objects in the forest, as well as encouraging them to engage in more tactile or sensory investigations. We can also incorporate additional audio narration into the curriculum that invites students to set down their tablets and fully sense their surroundings without the screen. Currently there are several activities like this in the DT curriculum, including the sound mapping activity, as well as a color observation activity and a drawing activity. This kind of passive tablet-use simultaneously facilitates both content and place engagement and offers an effective way to balance the benefits and limitations of technology use in field learning environments for biocultural conservation.

CHAPTER TWO:

Virtual Sense of Place (VSoP): An Integrated Literature Review

Introduction

Digital technology has become ubiquitous in everyday life and virtual learning has exploded across K-12 schools and higher education within the last year due to the COVID-19 pandemic (Decker et al. 2020). By March 16, 2020, over half of students in the U.S. were impacted by school closures (Decker et al. 2020), with even more closures within the following weeks, forcing educational institutions across the world to pivot away from in-person instruction to virtual teaching and learning (Armstrong-Mensah et al. 2020). This switch to virtual learning will have a lasting impact on education, as COVID-19 only catalyzed a transition that was already in motion (He et al. 2021). Digital technology-use in education has steadily been growing due to improved accessibility and affordability of digital technologies and student familiarity with, and often preference for, technology (Prensky 2010; Stogner 2009). The integration of digital technology into learning environments has quickly given rise to innovative and modern virtual learning pedagogies and concepts, and this Chapter aims to describe one of these new concepts. This is a literature review and synthesis of post-2000 research relating to sense of place in virtual environmental education settings, or in other words, virtual sense of place (VSoP). This review is not intended to be exhaustive. Since many of the theories and concepts discussed in this review are written about at length elsewhere, this review intends to be broadly representative of the literature surrounding the concept of “virtual sense of place”.

Today’s students, nicknamed Gen Z, includes people born after 1995 and they’re characterized by their frequent use of digital technology and the ease with which they switch back and forth between the real and virtual worlds (Selingo 2018). The constant exposure to and use of digital technology has completely changed the way Gen Z learners think and process information (Prensky 2001; Selingo 2018). Their thinking patterns are no longer linear; instead, they are capable of taking in and giving information very quickly, but in a disjointed way (Turner 2015; Wallis 2010). Research suggests that these learners embrace more flexible and customizable learning experiences that include a mix of technology-led and more traditional lessons (Selingo 2018), so innovative teachers have adapted their practices to better suit these learners and their preferred style of learning (Prensky 2001). However, today's Gen Z learners are increasingly disconnected from nature, often fueled by the constant presence of digital technology (Anderson et al. 2015). At a time when catastrophic environmental problems like climate change are steadily increasing in severity and breadth of impact, society must figure out ways to address these issues and prevent further damage (Akerlof et al. 2013; Nisbet 2009). In addition to an awareness about environmental issues, people must have a connection to nature to care enough about taking action to preserve it and environmental education is one way to build that connection with the natural world. However, within environmental education, there are often gaps that persist between environmental knowledge, awareness, and pro-environmental behaviors (Kollmuss and Agyeman 2002), and many education researchers argue that "the ultimate aim of education is shaping human behavior" (Hungerford and Volk 1990 p. 257).

A pedagogy often employed to reduce the gap and influence pro-environmental behaviors is experiential education, which is a broad framework characterized by direct experience (Kolb 1984) that is often applied in the field of environmental education. The focus on direct, hands-on experiences can help foster connections with nature, a critical component in the development of pro-environmental behaviors (Hungerford and Volk 1990). Under the wide umbrella of experiential education is place-based education; a framework that often used in the field of environmental education because of its capability to reconnect alienated students to nature (Knapp 2005; Woodhouse and Knapp 2000). The term was defined by environmental educator David Sobel in 2004 as “the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science and other subjects across the curriculum.” (Sobel 2004 p. 6). Like experiential education, place-based pedagogies are not specific to environmental education. The curriculum is interdisciplinary and includes the ecology, geology, sociology, and history of a place; it often involves the collaboration between learners, teachers, researchers, and community partners; and it is experiential and involves hands-on activities (Sobel 2004, Woodhouse and Knapp 2000).

Researchers have identified strong relationships between place-based education and a sense of place (Semken and Brandt 2010). A sense of place, which will be described in-depth later in the chapter, is when an individual feels a connection to a landscape or environment, typically motivated by the place taking on a significant, personal meaning (Ardoin 2006; Cuba and Hummon 1993; Kollmuss and Agyeman 2002). These relationships with place are critical in developing connections to nature, which refers to an individual’s self-perceived relationship with the natural world and how they see themselves fitting into it (Mayer and Frantz 2004; Restall and Conrad 2015). Connectedness to nature theory states that due to a high frequency of positive, direct interactions with nature, people with strong connections have increased levels of love, care, and appreciation for the natural world, thus increasing their sense of responsibility to become involved in environmental protection efforts (Louv 2008; Perkins 2010; Restall & Conrad 2015; Tauber 2012). A combination of a connection to nature and an attachment to place have been shown to be significant drivers for pro-environmental action (Restall & Conrad 2015).

But today, when adopting more environmentally-responsible behaviors is becoming increasingly important, how can environmental educators help to reconnect today's students to nature and bridge the divide when we live in a world seemingly run by digital technology?

In the context of place-based field experiences, current research states that one significant benefit virtual learning has is its capability to increase accessibility to place (Palaigeorgiou et al. 2017). While it doesn't lead to identical learning outcomes as in-place field experiences, is it allows for wider audiences to 'visit' special places and conduct inquiry in landscapes they may never get to spend time in, whether due to distance, a global pandemic, or other accessibility issues such as health problems or disabilities (Çalişkan 2011; Palaigeorgiou et al. 2017). It's important, then, as we think about creating accessible and inclusive learning environments to consider how these experiences can best be designed to foster meaningful impacts and maintain some learning outcomes. This literature review on VSoP provides a roadmap of sorts for how to begin this process.

The COVID-19 pandemic and the widespread shift to virtual learning has made this literature review particularly relevant today (He et al. 2021). The purpose of this review is to integrate and synthesize currently available research regarding virtual learning, virtual field trips, sense of place, and fostering a sense of place in virtual environmental education contexts. Three objectives for this review are to: 1) describe the term "virtual sense of place"; 2) evaluate the state of this relatively new topic in the literature; and 3) recommend best practices based on the literature for facilitating sense of place in virtual learning experiences.

Methodology and Search Methods

I conducted the literature search on virtual sense of place specifically in environmental and experiential learning with the goal of providing a resource for educators and researchers working in this area. The review will also help to shed light on existing research regarding the concept of VSoP and, concurrently, illuminate gaps (Ardoin et al. 2018). I conducted a variety of search in two different search engines: Google Scholar and ERIC (Education Resources Information Center). These two sources were chosen for their accessibility, ease of use, and because they're very commonly-used search engines for academic research *and* by practitioners. Virtual sense of place is a relatively new topic in both conceptual and empirical research, for this reason, our literature review will focus on recent relevant (post-2000) literature. This 21-year timeframe was selected because it captures both recent research as well as older literature that is still relevant (Ardoin et al.2020). I used guidelines from Stern et al. (2014) to conduct the systematic literature search by starting with the term "virtual sense of place" then evaluating the search results to determine the extent to which we had surfaced relevant articles and identify additional search terms to use. This step informed the remaining literature search (Ardoin et al. 2018). Since this literature search was not intended to be exhaustive, eight search terms were used resulting in 47 recent articles that together, provide an overview of the concept of VSoP (Table 5).

Search Terms	Associated Articles
Virtual sense of place	Arora & Khazanchi (2010); Arora & Khazanchi (2014); Aucoin (2011); Barbour et al. (2014); Berry (2019); Chueng & Marsden (2002); Clark & Maher (2005); Cohn et al. (2014); Fischer (2020); Gautreau et al. (2020); Hougham et al. (2015); Knistern & Klassen (2016); Martin (2019); McCall et al. (2004); Serafin & Serafin (2004); Turner et al. (2003); Turner & Turner (2006); Turner et al. (2013)
Sense of place	Ardoin (2006); Ardoin (2018); Hoke et al. (2020); Kukkakorpi & Pantti (2020); Semken & Brandt (2010); Scannell & Gifford (2010)
Place attachment	Vaske & Kobrin (2001)
Virtual field trip	Çalişkan (2011); Clark et al. (2002); Haris & Osman (2015); Keane & Design (2016); Klippel et al. (2019); Mead et al. (2019); Pierantozzi (2008); Puhek et al. (2012); Schott (2017); Sriarunrasmee (2015); Stoddard (2009); Zanetis (2010)
Science field trip	Behrendt & Franklin (2014); Lei (2010a); Lei (2010b)
Measure sense of place	Semken & Freeman (2008); Semken et al. (2009); Shamai & Ilatov (2005); Williams & Vaske (2003)
Virtual environmental education	Palaigeorgiou et al. (2017); Tudor et al. (2018)
Virtual place creation	Jung & Dieck (2017)

Table 5: List of articles used in VSoP literature review.

Literature Review

Sense of Place in Environmental Education

Place is much more than just a physical location (Vaske and Kobrin 2001), at its core, places are social constructions: “spatial localities imbued with meaning by the human experience.” (Semken and Brandt 2010 p. 288). Physical aspects of a place are important - physical attractiveness of a place is linked to motivation and task performance of those in the place – but the meaning that a person assigns to a place and the affective component involved in building a relationship with place are equally as important (Vaske and Kobrin 2001).

Sense of place can have both direct and indirect impacts on learning outcomes and connection-building, so it's important for it to be considered, especially in virtual learning contexts (Arora and Khazanchi 2014). Sense of place is also often applied in diverse fields, which has led to many different definitions. Throughout the literature, it's generally defined and described as how we experience and engage with the places we occupy (Clark and Maher 2005; Turner et al. 2013). Environmental psychologists think of sense of place more as an attitude and similar to content engagement, they divide sense of place into cognitive, affective, and behavioral components (Arora & Khazanchi 2010). The cognitive components refer to the relationship between self and place; affective refers to the feelings towards place; and behavioral refers to the exclusivity of the place compared to other places (Arora & Khazanchi 2010).

Sense of place is further described by Semken and Freeman (2008) as being equal to place attachment plus place meaning. Place attachment is a concept strongly associated with a sense of place and, in a broad sense, is the bond between individuals and places (Semken et al. 2009; Scannell & Gifford 2010). A favorite beach because you grew up visiting frequently with family, a desire to protect a natural area are both real-life examples of place attachment in action. Place meaning, the other half of the sense of place equation, is socially constructed and refers to the symbolic meaning that a person attaches to a place and it's always contextually bound to the place itself (Semken and Freeman 2008; Semken et al. 2009). This means that the meaning a person assigns a place is created and modified by people (Kudryavtsev et al. 2012). Similar to place attachment, developing place meaning is primarily accomplished through either direct experiences in places and/or learning place meanings from engaging with written, oral, and other sources of material about a place (Kudryavtsev et al. 2012). Some researchers suggest that experiencing the most unique features of a place – for instance, a towering waterfall or historically-significant site– can facilitate the development of place meanings (Kudryavtsev et al. 2012).

Measuring sense of place can be challenging because of its complexity. According to Semken et al. 2009, sense of place has a large range of depth and intensity and it can vary greatly from complete alienation to a feeling of complete belonging. Quantifying this range of a person's sense of place is possible and typically accomplished through the use of surveys. Currently, there are valid and reliable survey instruments available in the literature that measure each of the two components of sense of place: place attachment and place meaning (Semken et al. 2009). In order to accurately measure these very nuanced and complex concepts, these instruments "should be developed empirically and locally, with items emergent from the set of meanings held by those who variously inhabit, promote, visit, or consider the place." (Semken et al. 2009 p. 140).

In the field of environmental education, the literature points to a strong connection between sense of place with both pro-environmental behaviors and improved learning outcomes (Clark and Maher 2005; Kudryavtsev et al. 2012). The idea is that people are more motivated to take action in conservation efforts if something threatens the meaning a person has assigned to a place (Stedman 2003). In one study, Clark and Maher (2005) found that in the context of VLEs, a learners' perceived sense of place has an indirect effect on learning outcomes. They concluded that a sense of place is crucial for the overall learning experience, especially in the context of virtual learning (Clark and Mayer 2005). There are many different frameworks, techniques, and tools that can be utilized to foster sense of place, one of the most common in the field of environmental education being direct experience in the natural world which have been shown in the literature to have significant influence over one's actions, environmental attitude, and connection to nature (Akerlof et al. 2013; Ardoin 2006; Perkins 2010). However, inherently, VLEs in the field of environmental education are *indirect* experiences in the natural world. Replicating a direct experience in nature is not possible through an entirely virtual lens, but research indicates that carefully developed VLEs can maintain some of the same learning and connection-building outcomes (Arora and Khazanchi 2010; Klippel et al. 2019).

Virtual Learning Environments (VLEs)

A VLE is defined as "a set of integrated components put together for management and facilitation of a range of student learning activities, along with the provision of content and resources required to help make the activities successful for learners separated by time and/or space." (Arora and Khazanchi 2014 p. 2). There are two different conceptualizations of VLEs. The first is mainly used for learning facilitation and management when learners and educators are apart from one another (Arora and Khazanchi 2010). Commonly-used examples of this first kind of VLE are Blackboard or D2L. The second conceptualization of VLEs, which are standard in the field of environmental education, are designed to replicate real experiences and are often used in environmental education (Arora and Khazanchi 2010). Pedagogies used in this kind of VLE typically include experiential learning, inquiry-based learning, and guided exploratory learning “in” visual representations of real places with authentic-looking settings. These VLEs typically have a goal of imparting a sense of place in learners, which educators usually accomplish by “developing educational context and content for different learning tasks and providing first order experience to learners ‘virtually’ by leveraging different technology capabilities” (Arora and Khazanchi 2014 p. 2).

Under the umbrella of VLEs are virtual field trips (VFTs) which are experiences that integrate technology into a curriculum for the purpose of experiencing a place through a virtual lens (Clark et al. 2002). A VFT should be much more immersive than just a web-based presentation of a location, the VFT curriculum should enable learners to experience the field trip in a way that is similar to actually taking the field trip (Clark et al. 2002). An authentic and thoughtfully developed VFT has the ability to grow a learner's understanding of the world through the exploration of places they otherwise not have a relationship with (Clark et al. 2002; Giamellaro 2014).

VFTs are often used in place of field-based experiences which can lead to issues because STEM learning greatly benefits from in-place experiences and fieldwork (Stoddard 2009; Tudor et al. 2018). Field trips are commonly integrated into STEM learning because they facilitate in-place experiences and research shows that field trips can increase overall learner engagement and interest in science subjects (Behrendt & Franklin 2014). In-place experiences can make learning material more personal for students because they can connect the field trip experience to prior knowledge from the classroom and it allows for deeper understanding of the subject material (Kamarainen et al. 2013; Lei 2010a, Lei 2010b), leading to increased knowledge gains and for students to develop more positive attitudes about the material (Behrendt and Franklin 2014). Learning on an outdoor field trip can also enhance sense of place, learner engagement, and connection to nature, all of which are significant motivators in encouraging pro-environmental action (Morag and Tal 2012; Tudor et al. 2018). However, how do these outcomes change when the field trips are moved to a virtual place?

Researchers have identified several benefits to VFTs, the primary being improved access to places, including temporal and spatial freedom and the ability to "visit" any place at any time, in the past, present, or future (Palaigeorgiou et al. 2015; Sriarunrasmee et al. 2015; Stoddard 2009). Compared to in-place field trips, VFTs are typically cheaper and less time-consuming when travel isn't involved (Behrendt & Franklin 2014; Sriarunrasmee et al. 2015) while also allowing for learners to visit a place regardless of external factors such as proximity to place and financial difficulties (Çalişkan 2011; Tudor et al. 2018). VFTs also create the opportunity for learners to interact with peers in novel settings, which can increase cultural understanding, social and communication skills, and self-confidence (Maher et al. 2001; Tudor et al. 2018). Most researchers agree that field trips and VFTs are not equivalent, but it's possible to create VFTs in a place-based way to minimize disadvantages. Using multimedia elements such as videos, live footage, web-based interactive experiments, and three-dimensional simulations, VFTs have the ability to improve the effectiveness of a physical fieldwork experience (Palaigeorgiou et al. 2015).

However, VFTs have disadvantages because they typically have high start-up costs and certain features can impede learning outcomes such as the potential of technical difficulties which can interrupt learning (Palaigeorgiou et al. 2015). The literature also suggests that VFTs are less effective at teaching field-based skills than actual in-place experiences and therefore VFTs are often thought of as being complementary to actual field-based experiences, not replacements (Palaigeorgiou et al. 2015). "Students in the VFT are unable to use their total sensory system as part of their learning experience. Virtual field trips do not convey the non-visual and aural feelings of touch and smell. Researchers claim that especially in environmental education, teaching must be based on the contact of students with nature." (Palaigeorgiou et al. 2015 p. 339). How can educators develop VFTs and other VLEs so they maintain some of the benefits of field-based experiences? More research is needed (Tudor et al. 2018), but the literature suggests that a place-based framework could help minimize the downsides.

Students are often disengaged from science, struggle to understand connections between STEM disciplines and the real world, and have difficulty applying science concepts outside of the classroom (Giamellaro 2014). Modern science education calls for "deeper, more conceptually rooted knowledge that students can relate to and apply to real world problems" (Giamellaro 2014 p. 2), making place-based education a frequently-used framework. A place-based pedagogy also contributes greatly towards a learner's sense of place, which becomes even more crucial in the context of VLEs since there is an automatic disconnect with place (Arora and Khazanchi 2010; Arora and Khazanchi 2014; Giamellaro 2014). Invoking a sense of place virtually can present many challenges to educators, but it's an incredibly important outcome in place-based environmental education and must be at the forefront when developing VFTs and other virtual learning curricula.

Best Practices for VSoP in VLEs

There is a general consensus among researchers that digital technology *can* foster deeper connections and relationships to a place through its multimedia capabilities, but it must be done appropriately (Hougham et al. 2015). It's also important to note that while the design and content of VLEs have direct impacts on VSoP, other pedagogical components like the quality of content and activity design, use of appropriate tools, and personalization features, are equally important in fostering VSoP (Arora and Khazanchi 2014).

Throughout the literature are suggestions for best practices when integrating digital technology into educational experiences to facilitate learning while limiting the distractions often associated with technology in the field. The primary takeaway is the importance of thoughtful curriculum development to make the virtual experience as similar as possible to the in-place experience (Hoke et al. 2020). Authenticity is the key, and a virtual place should be as immersive (Hoke et al. 2020), bringing as many significant features as possible of the place to the virtual world and employ place-based methods to foster a sense of place within the learner. Arora and Khazanchi (2010; 2014) argue for "truly realistic reproductions of real environments" (p. 3) and authentic experiences; similarity of the virtual space and natural space and learning activities that simulate realistic experiences are of utmost importance when fostering a virtual sense of place.

Another important characteristic for a sense of place, whether in-place or in a virtual place, is the need for multiple integrated sensory aspects (Cheung and Marsden 2002). When present in a natural environment, our experience tends to be dominated by one sense: sight (Cheung and Marsden 2002). Being able to see a place and observe natural features are important for sensory-engagement, however, engaging a learner’s other senses can increase their sense of presence in virtual learning environments, in particular, sound (Serafin and Serafin 2004). Hearing and sound are useful sensory channels that “convey a wide range of information about events and surroundings, providing timely information and constant awareness of people and background events.” (Cheung and Marsden 2002 p. 2). One study (Gilkey and Weisenberger 1995) involving deafened adult participants found that not being able to hear in a place can elicit a feeling of disconnect from that place, providing further evidence that utilizing sound is crucial in VLEs. Developing innovative ways to engage multiple senses during a VLE can be a critical piece in imparting a VSoP in learners.

The literature also suggests novel ways to embrace modern technology to create more realistic and engaging virtual spaces, including incorporating drones, live webcams, and virtual worlds and video games (Hoke et al. 2020). Integrating these kinds of advanced technology into the design of VLEs can further improve the sense of place learners have for a distant place by creating more authentic, immersive experiences which provide the context necessary for both learning and fostering a sense of place (Arora and Khazanchi 2014; Hoke et al. 2020). In a study

(Palaigeorgiou et al. 2015) that investigated the differences between a traditional field trip and one mediated by a drone, a class of undergraduate students (n = 41) was split into two groups: one that visited a town and one that watched a live broadcasted video of the drone. Results indicated that the drone version was more enjoyable to the students than the traditional field trip and the novelty of using the drone made it more intriguing to learn. The use of drones also allowed for views from a high altitude which gave a better overview of the place, a feature not available to students on the traditional field trip. On the other hand, students on the field trip were able to see details on the ground that were not visible from the drone. The researchers concluded that the two approaches led to similar outcomes, and each has its own advantages and shortcomings. Drones have a 'wow factor' (p. 342), but their learning efficiency in the different educational contexts need to be studied further (Palaigeorgiou et al. 2015).

Another strategy for fostering VSoP is to build on pre-existing connections that learners have with their local areas, including everything from the playground outside the school to their own backyards (Hoke et al. 2020), which is also a characteristics in place-based education frameworks. Hougham et al. (2015) suggest that educators allow students to explore the socioecological places where they live first, then apply a corresponding virtual experience afterwards. The social component is also very important in developing a sense of place and there's a host of learning benefits associated with interacting with peers and instructors, however, it's often ignored in VLEs (Arora & Khazanchi 2010; Sriarunrasmee et al. 2015). Integrating opportunities for peer discussions and activities throughout a VLE can elevate the overall experience while also contributing towards learning outcomes and the development of a sense of place (Arora & Khazanchi 2010; Sriarunrasmee et al. 2015).

Future Scholarship

The literature indicates that although VLEs in environmental education are not identical to field-based experiences, and don't share the same outcomes, new approaches are emerging that minimize the differences. However, since virtual learning is still a relatively new concept in the field of environmental education, many gaps in the literature remain. More research is needed to further enhance our understanding of VSoP and the relationship between sense of place and digital environmental education. Future research contributions in the field of VSoP have the potential to support and inspire innovative pedagogical approaches and tools that improve upon our ability to foster sense of place in VLEs.

APPENDICES

APPENDIX A:
Example of Paper Book Adaption (Station 3: Stream Crossing)

Stop 3: Stream Crossing

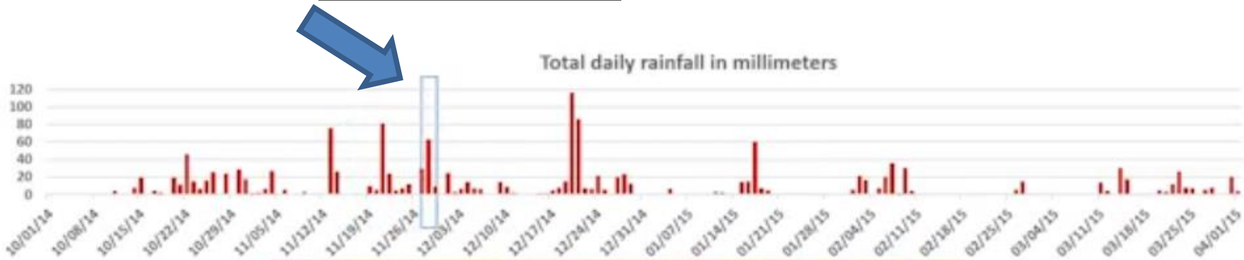
Part One: Stream Bed
Inquiry, Observe, and Respond

1. **Why do you think there is a stream bed here?**
   - A. Thousands of years ago, the climate was wetter and there was a stream flowing here.
   - B. Water flows here sometimes.
   - C. A big flood carved out this channel.
   - D. A landslide caused the stream to change course, leaving this dry channel.
   - E. It is a stream with water flowing through it right now. Why would you ask this question?

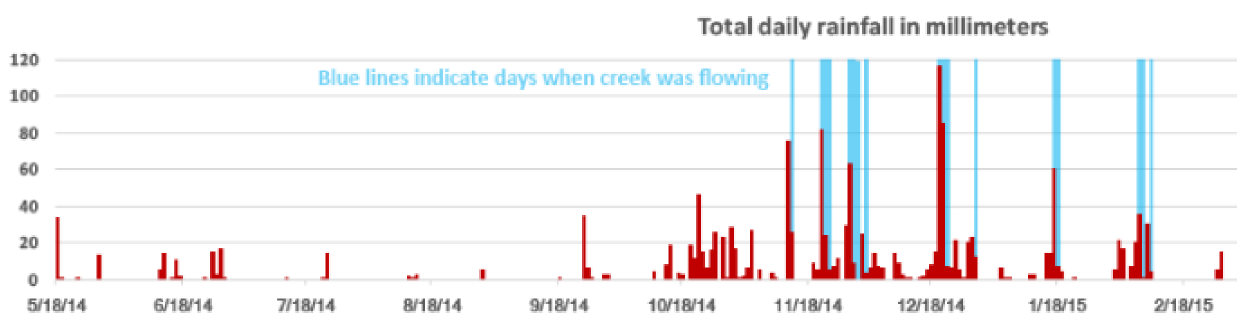
Directions:
Look at the graphs of rainfall and corresponding pictures of the streambed below. Notice the relationship between the light blue box on the graph and what you see in the streambed pictures.

<u>Graph and picture 1</u>: October 12, 2014

Graph and picture 2: November 29, 2014



Graph 3: Amount of rainfall (red bars) and days the creek was flowing (blue bars)

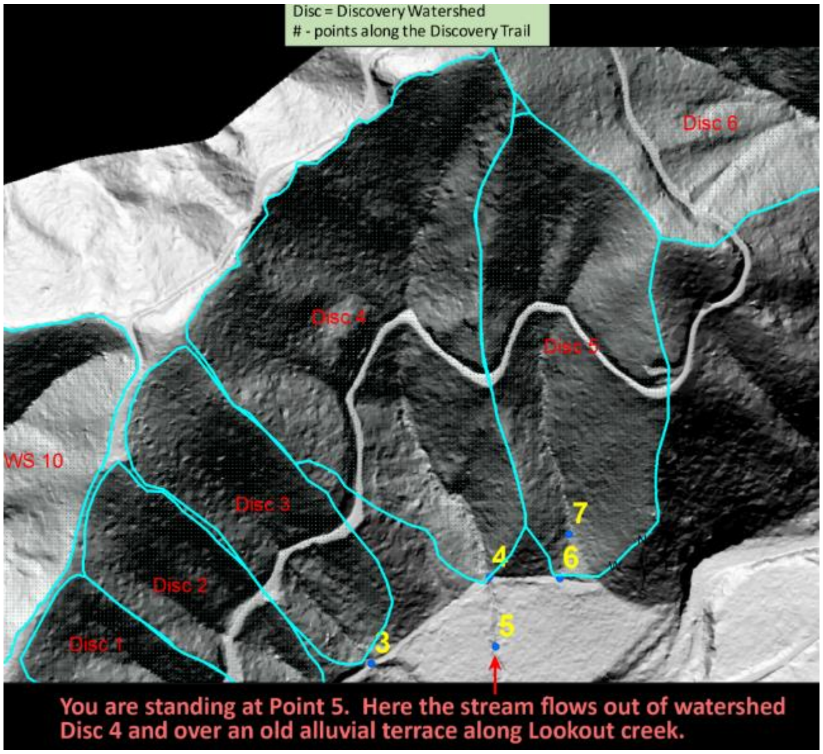


2. What is the relationship between stream flow and rainfall?

A. When there is *a lot* of rain, the stream *does not* flow.
B. When there is *a lot* of rain, the stream *does* flow.
C. When there is *not a lot* of rain, the stream *does* flow.

3. Can you predict whether the stream will be flowing on any given day, based on the day's rainfall? Mark your answer.

_____ YES   ______NO



You are standing at Point 5. Here the stream flows out of watershed Disc 4 and over an old alluvial terrace along Lookout creek.

You are standing in a large watershed that supplies Lookout Creek. But this watershed is made up of many smaller watersheds, like the one that supplies the streambed where you are standing.

Rainfall that falls on the slope above you, within the blue boundary on the image, either evaporates, is used by plants, or flows through the soil and eventually into the channel where you are standing.

Surprisingly, although we see water flowing in this streambed shortly after prolonged periods of winter rain, the water we see may have fallen at the top of the watershed months or years before. It takes that long for water to flow through the soil and into the stream channel.

4. In 1-2 sentences, explain your answer to the last question. Why can (or can't) you predict whether the stream is flowing based on the rainfall for that day?

Part Two: What is a Watershed?
Inquiry and Observations

5. What is a watershed?

A. A human-made facility for storing water (like a tower that holds water).
B. A natural feature that stores water (like a pond).
C. The path of a single river flowing from the mountains to a stream.
D. The cycle of evaporation, condensation, and precipitation.
E. An area of land from which all of the water flows to a common outlet.

6. Where does the water that sometimes flows in this streambed come from?

7. Where does the water from this streambed go?

____

You are standing in a large watershed that supplies Lookout Creek. But this watershed is made up of many smaller watersheds, like the one that supplies the streambed where you are standing.

Rainfall that falls on the slope above you, within the blue boundary on the image, either evaporates, is used by plants, or flows through the soil and eventually into the channel where you are standing.

Surprisingly, although we see water flowing in this streambed shortly after prolonged periods of winter rain, the water we see may have fallen at the top of the watershed months or years before. It takes that long for water to flow through the soil and into the stream channel.

Part Three: Interview with a Watershed
Listen and Respond

Directions:
Out-loud with your group, take turns reading excerpts from "Interview with a Watershed" by H.J. Andrews writer-in-residence Robin Wall Kimmerer, which she wrote while visiting the forest

“The elders used to say that you could learn a lot from listening to water. It will tell you what you need to know. What has happened before, and what is on the way. My friend, Frank Lake, tribal member from the mountains to the south of here, tells me that his people still make a circuit to all the springs and stream in their homelands, to check on the health of the land. They taste the water, watch its flow, see how thick the plants grew, they clear any sediment from the springs and look for the Pacific Giant Salamander, a sign of wellbeing of the waters. At each pool, they offer prayers of thanksgiving for the waters and hope that they will continue to run.

Long ago and into the present day, our people did not turn to sacred texts for understanding. We understood back then that wisdom lived in the land.

Set in a cleft between two slopes is a two-story dollhouse painted red with a moss-covered roof. We stand on its miniature porch and John describes the weir below. A broad concrete ‘V’ that passes beneath the stream. The water flows right from the mossy stream across the weir into a rocky pool, and then again into its native stream bed of rocks and fallen logs on its way downhill to join with Lookout Creek.

He uncaps the cover on the water sampler that stands in the middle of the room. Water samples are automatically sucked in from the stream, through tubing running up through the floor to an intake port in the pool outside. A nest of wires is fixed to the wall, radioing stream data from the sensors, flow rate and volume from the weir, temperature and oxygen levels.

Day after day, data streams from this stream, and the flow of electrons, representing the flow of water. It used to be that they harvested trees from these slopes. But today they harvest data. Input to the forest is measured as precipitation, output from the forest as stream flow at the weir. Creating a hydrologic balance sheet.

Water is a storyteller and listening to that story helped to write a new one in which old-growth forests have a rule. It is a story nearly too late in being heard, but now there's a chance. Our people say that long time ago, we could all speak the same language. The trees, the birds, the wolves, and the water. But we have long since forgotten. Human capacities have been so reduced that we can only understand our own tongue.

In the right hands, I like to think of scientific research as a conversation, an interview of sorts, between two parties that don't speak the same language. The sensors and the weir, I think of as a microphone, amplifying the voice of the water and translating it into numbers so we can try and understand. But there's danger in thinking that we do understand. We cannot say to the forest, "did you suffer terribly when the trees were all gone?" But we can measure the hemorrhage of nitrate, washed away. We might want to ask about forgiveness, but instead, we measure the increasing clarity and oxygen of the stream and hope it will suffice. Data alone does not bring understanding. You can collect data in a day, information over a year, knowledge over a decade, but wisdom, that takes a lifetime.

A column of data doesn't leave much room for surprise. The sensors and their numbers can only answer the questions that we ask, and in the limited way we ask them. That might not be all that the land has to say. Can you really understand a place without kneeling in the humus, or standing quietly to watch the Alder leaves drift down the stream? Being there, doing the field work, is a way of becoming intimate with a place. Really listening to the land. It makes for better science because the land will suggest new questions. It makes for better scientists, too, because the land is more than data, and we are more than data and analysts. Most scientists are drawn to their work not because of love of data, but by love of the land.

It's a hopeful thing, when scientists look to the land for knowledge. When they try to translate into mathematics, the stories that water can tell. But it is not only science that we need if we want to understand. Lewis Thomas identified a fourth and highest form of language: that language is poetry. The data may change our minds, but we need poetry to change our hearts. Rich as they are, conversations, mathematics, and poetry are but human languages. And we, I think there is another language, the forgotten language of the land. Its alphabet is the elements themselves: carbon, hydrogen, nitrogen, oxygen. The words are living beings and its syntax is connection.

There is a flow of information, a network of relationships conveyed in the rising sap of cedars, and tree roots grafted to fungi, and fungi to orchids, orchids to bees, bees to bats, bats to owls, and owls to bones, and bones to the soil for the cedars. This is the language we have yet to learn, and the stories we must hear. Stories that are simultaneously material and spiritual. The archive of this language, the sacred text, is the land itself. In the woods, there is a constant stream of data, lessons on how we might live, stories of reciprocity, stories of connection. Species far older than our own show us daily how to live. *We need to listen to the land, not just for data, but for wisdom.*

8. Why does Kimmerer think we should listen to water and to the land?

A. It has wisdom.
B. It can tell us about the weather.
C. It makes beautiful music.

9. In 1-2 sentences, how is water a storyteller? What story is it telling? What story is water, or the absence of water, telling here in this streambed where you are standing?

____

____

____

How do different stories help us understand, respect, or care for water or land in different ways? What kind of responsibilities do we have to water and why?

The following list includes multiple factors in the environment that impact the water we see in streams, lakes, and rivers.

Sunshine	
Annual rainfall	
Pollution	
Home water use	
Beavers, or other critter activity	
Population density	
Agriculture	

10. In the above table, choose two of the environmental factors and mark them by putting a check in the corresponding column. Then, explain how these two factors impact water below.

1.____

____

2.____

____

APPENDIX B:
Pre-Survey Instrument

1. **Create a code name for yourself using the instructions below.** You will use this same code on the survey that you take after the field trip (the same instructions will be provided again).

   What is the first initial of your first name, first three letters of your birth month, and birthday day (as two digits)? Enter as one word. (Ex: Mary, born September 4, would enter MSEP04. John, born May 21, would enter JMAY21).

   ____

2. **With which gender do you most identify? Circle your response.**

   Male Female Other Prefer not to respond

3. **Which racial or ethnic group(s) do you identify with? Circle all that apply.**

   American Indian or Alaska Native

   Asian

   Black/African American

   Caucasian/white (non-Hispanic)

   Latinx/Latino/Latina or Hispanic

   Multi-racial

   Native Hawaiian or other Pacific Islander

   Do not wish to reply

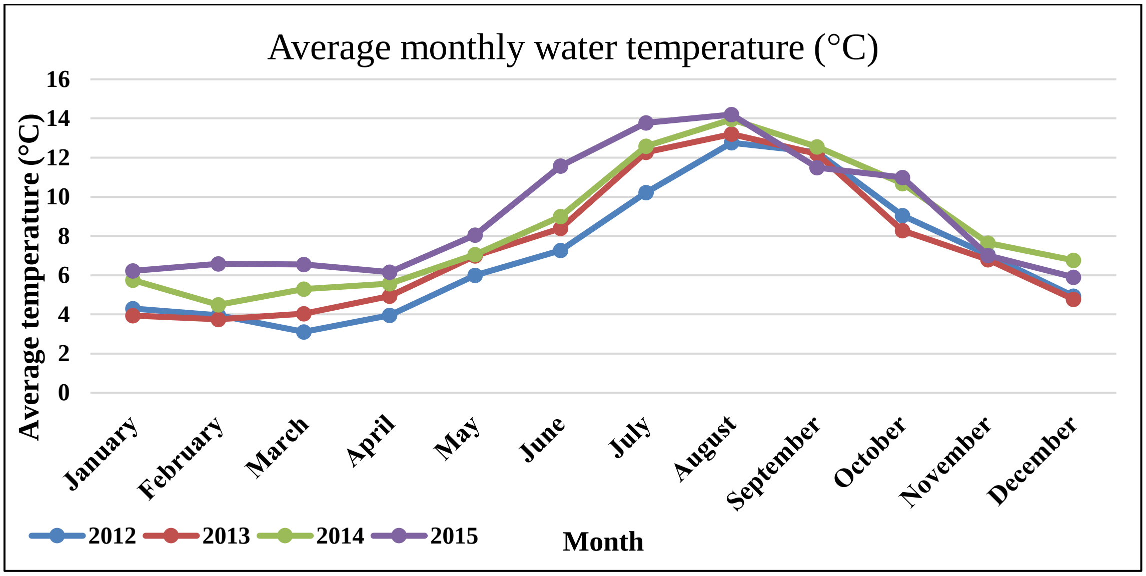
   Other (please list) ________________________

Questions 5-19						
How much do you agree or disagree with the following statements? *Circle your answer.*		**Strongly disagree** ⟵⟶ **Strongly agree**				
		Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
5	I like learning science.	1	2	3	4	5
6	I like learning about nature.	1	2	3	4	5
7	Creating art when I'm learning is fun.	1	2	3	4	5
8	I like using digital technology such as computers, cell phones, and tablets.	1	2	3	4	5
9	I find science to be really interesting.	1	2	3	4	5
10	Nature is boring.	1	2	3	4	5
11	I like creating art.	1	2	3	4	5
12	I often find using digital technology to be frustrating.	1	2	3	4	5
13	I get excited when I am learning about science.	1	2	3	4	5
14	It's important to learn about nature in school.	1	2	3	4	5
15	I like being creative.	1	2	3	4	5
16	I like using computers, cell phones, and tablets when I'm learning.	1	2	3	4	5
17	I like science.	1	2	3	4	5
18	I am interested about things in nature.	1	2	3	4	5
19	Making art is boring.	1	2	3	4	5
20	Using digital technology while learning makes learning enjoyable.	1	2	3	4	5

Questions 21-28						
How much do you agree or disagree with the following statements? *Circle your answer.*		**Strongly disagree Strongly agree**				
		Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
21	I work hard in school.	1	2	3	4	5
22	I actively participate in the learning process.	1	2	3	4	5
23	I learn best when I am working alone.	1	2	3	4	5
24	I am often focused and attentive in school.	1	2	3	4	5
25	I enjoy learning in school.	1	2	3	4	5
26	I get frustrated when I am learning things that I am not interested in.	1	2	3	4	5
27	I enjoy being with my friends at school.	1	2	3	4	5
28	I am often bored in school.	1	2	3	4	5

Questions 29-37						
How much do you agree or disagree with the following statements? *Circle your answer.*		**Strongly disagree Strongly agree**				
		Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
29	Nature is a community that I am part of.	1	2	3	4	5
30	When I feel sad, I like to go outside and enjoy nature.	1	2	3	4	5
31	I often feel a connection with plants and animals.	1	2	3	4	5
32	I have a deep understanding of how my actions affect nature.	1	2	3	4	5
33	Being in a forest makes me feel peaceful.	1	2	3	4	5
34	People are part of the natural world.	1	2	3	4	5
35	People cannot live without plants and animals.	1	2	3	4	5
36	My actions can change the natural world.	1	2	3	4	5
37	Picking up trash can help the environment.	1	2	3	4	5

Questions 37-42



Researchers at H.J. Andrews have been collecting water temperature data in the forest for many years. Above is a graph that displays the average water temperature, by month, from the years 2012-2015.

37. True or false? The pattern in the data supports the conclusion that, on average, the water temperatures are rising each year. Circle your answer.

True False

38. The patterns that you see in the data allow you to draw the conclusion that:

A. Every year, the water is coldest in February.
B. Every year, the water is warmest in August.
C. Every year, the temperature is 6° C in May.
D. Every year, the temperature decreases from February to March.

			
Producer: Big-leaf Maple	Primary consumer: Townsend's Chipmunk	Secondary consumer: Western Spotted Skunk	Apex predator: Great Horned Owl

Above are organisms that can be found in the H.J. Andrews Forest. Big-leaf Maple is a primary producer and Townsend's Chipmunk often eat their seeds. Chipmunks are commonly eaten by the Western Spotted Skunk. The Great Horned Owl is considered an apex predator, since they often eat skunks and are at the top of the food chain.

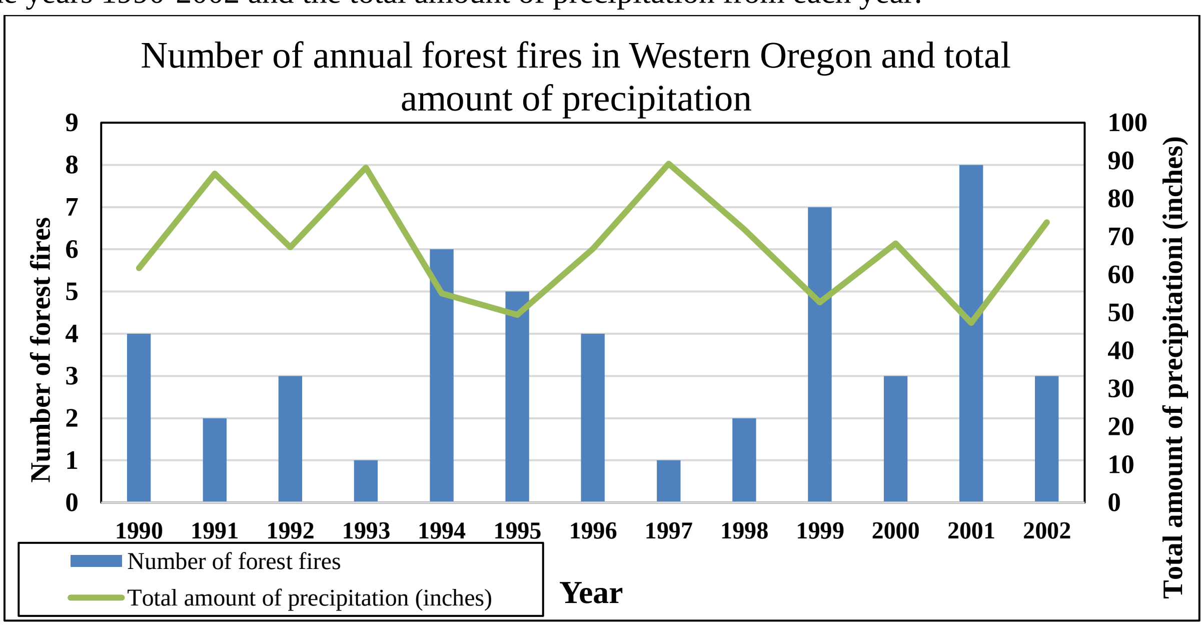
39. What would happen to the other organisms in this ecosystem if the population of Great Horned Owls suddenly increased?

A. Skunks *increase*, chipmunks *decrease*, big-leaf maples *increase*
B. Skunks *increase*, chipmunks *increase*, big-leaf maples *decrease*
C. Skunk *decreases*, chipmunks *decrease*, big-leaf maples *increase*
D. Skunk *decreases*, chipmunks *increase*, big-leaf males *decrease*

40. Looking at the previous food chain, imagine that a disease that harms Big-leaf maples has spread to the forest. Circle the arrows that show what would happen to the population of each organism.

Big-leaf Maple	⇧ ⇩
Townsend's Chipmunk	⇧ ⇩
Western Spotted Skunk	⇧ ⇩
Great Horned Owl	⇧ ⇩

Below is a graph showing both the amount of forest fires that occurred in western Oregon from the years 1990-2002 and the total amount of precipitation from each year.



41. **When precipitation levels are _______, the number of forest fires _______.**

A. High; decreases
B. Low; decreases
C. Low; stays the same
D. High; increases

42. In 1-2 sentences, what is something that you hope to learn about while at H.J. Andrews?

____

____

____

APPENDIX C:
Post-Survey Instrument

1. **What is the first initial of your first name, first three letters of your birth month, and birthday day (as two digits)?** Enter as one word. (Ex: Mary, born September 4, would enter MSEP04. John, born May 21, would enter JMAY21).

____

Questions 2-16						
How much do you agree or disagree with the following statements? *Circle your answer.*		**Strongly disagree** ⟷ **Strongly agree**				
		Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
2	I like learning science.	1	2	3	4	5
3	I like learning about nature.	1	2	3	4	5
4	Creating art when I'm learning is fun.	1	2	3	4	5
5	I like using digital technology such as computers, cell phones, and tablets.	1	2	3	4	5
6	I find science to be really interesting.	1	2	3	4	5
7	Nature is boring.	1	2	3	4	5
8	I like creating art.	1	2	3	4	5
9	I get excited when I am learning about science.	1	2	3	4	5
10	It's important to learn about nature in school.	1	2	3	4	5
11	I like being creative.	1	2	3	4	5
12	I like using computers, cell phones, and tablets when I'm learning.	1	2	3	4	5
13	I like science.	1	2	3	4	5
14	I am interested about things in nature.	1	2	3	4	5
15	Making art is boring.	1	2	3	4	5
16	Using digital technology while learning makes learning enjoyable.	1	2	3	4	5

Questions 17-24						
How much do you agree or disagree with the following statements? *Circle your answer.*		**Strongly disagree ⟷ Strongly agree**				
		Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
17	On the Trail, if my group didn't know the answer to a question, we would work together to figure it out.	1	2	3	4	5
18	I took my time when answering the questions on the Trail.	1	2	3	4	5
19	On the Trail, I often found my mind wandering from what I was supposed to be focusing on.	1	2	3	4	5
20	After the Trail experience, I am now more motivated to learn about nature than I was before.	1	2	3	4	5
21	I liked learning about the H.J. Andrews Forest.	1	2	3	4	5
22	The lessons on the Trail were enjoyable.	1	2	3	4	5
23	Being here at H.J. Andrews Forest was boring.	1	2	3	4	5
24	At times, I found the lessons to on the Trail to be frustrating.	1	2	3	4	5

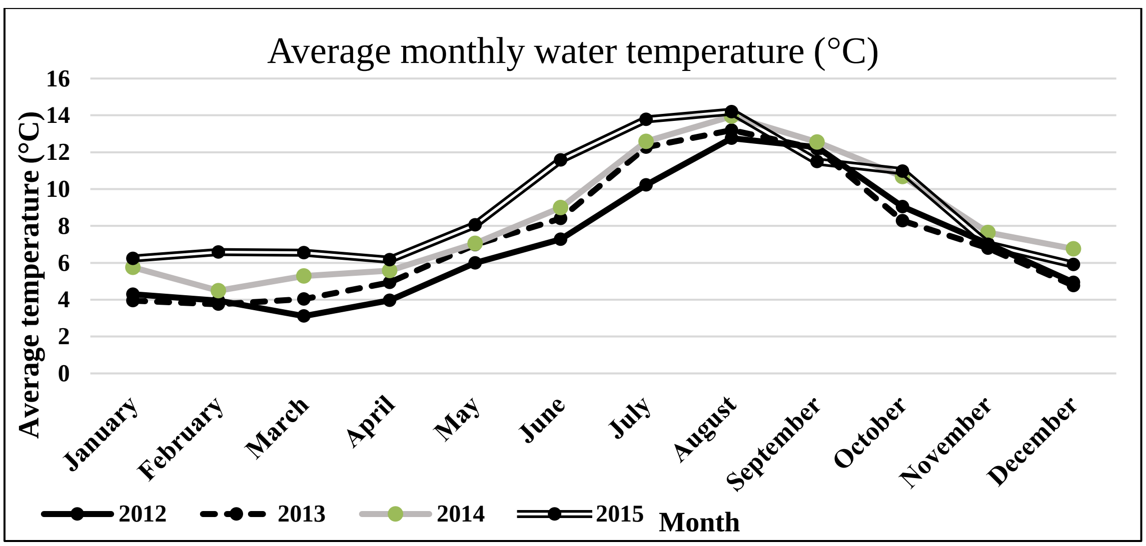
Questions 25-33						
How much do you agree or disagree with the following statements? *Circle your answer.*		**Strongly disagree ⟷ Strongly agree**				
		Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
25	Nature is a community that I am part of.	1	2	3	4	5
26	When I feel sad, I like to go outside and enjoy nature.	1	2	3	4	5
27	I often feel a connection with plants and animals.	1	2	3	4	5
28	I have a deep understanding of how my actions affect nature.	1	2	3	4	5
29	Being in a forest makes me feel peaceful.	1	2	3	4	5
30	People are part of the natural world.	1	2	3	4	5
31	People cannot live without plants and animals.	1	2	3	4	5

32	My actions can change the natural world.	1	2	3	4	5
33	Picking up trash can help the environment.	1	2	3	4	5

34. In 1-2 sentences, what did you like most about the Discovery Trail experience?

35. In 1-2 sentences, what did you like the least about the Discovery Trail experience?

Questions 36-42



Researchers at H.J. Andrews have been collecting water temperature data in the forest for many years. Above is a graph that displays the average water temperature, by month, from the years 2012-2015.

36. True or false? The pattern in the data supports the conclusion that, on average, the water temperatures are rising each year. Circle your answer.

True False

37. The patterns that you see in the data allow you to draw the conclusion that:

A. Every year, the water is coldest in February.
B. Every year, the water is warmest in August.
C. Every year, the temperature is 6° C in May.
D. Every year, the temperature decreases from February to March.

			
Producer: Big-leaf Maple	Primary consumer: Townsend's Chipmunk	Secondary consumer: Western Spotted Skunk	Apex predator: Great Horned Owl

Above are organisms that can be found in the H.J. Andrews Forest. Big-leaf Maple is a primary producer and Townsend's Chipmunk often eat their seeds. Chipmunks are commonly eaten by the Western Spotted Skunk. The Great Horned Owl is considered an apex predator, since they often eat skunks and are at the top of the food chain.

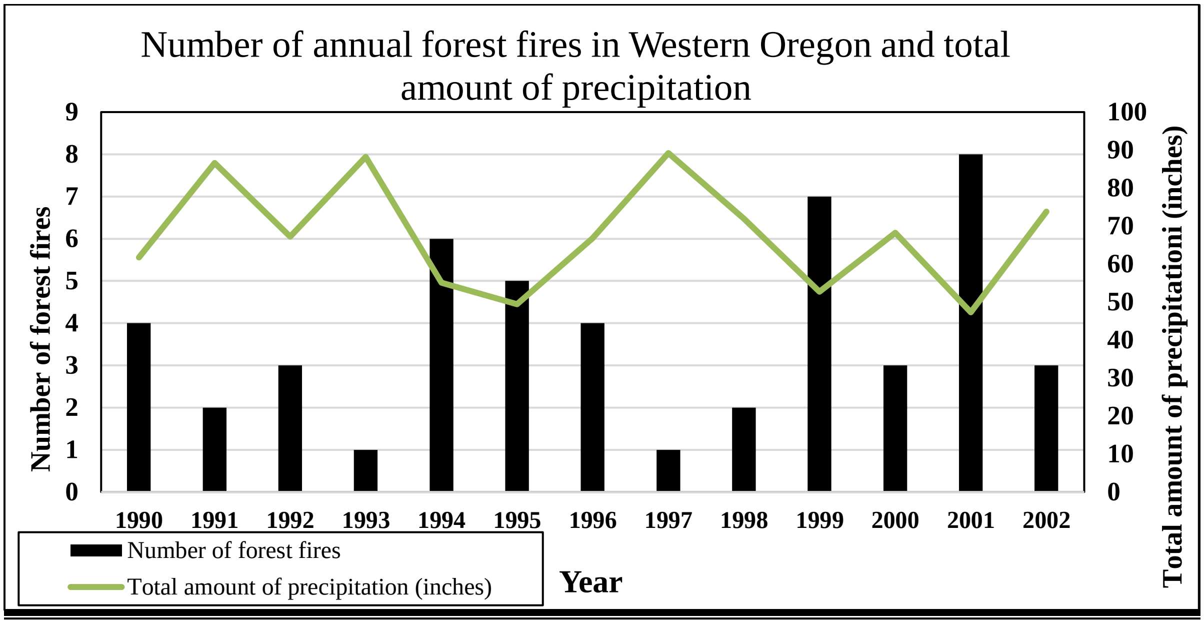
38. What would happen to the other organisms in this ecosystem if the population of Great Horned Owls suddenly increased?

A. Skunks *increase,* chipmunks *decrease,* big-leaf maples *increase*
B. Skunks *increase,* chipmunks *increase,* big-leaf maples *decrease*
C. Skunks *decrease,* chipmunks *decrease,* big-leaf maples *increase*
D. Skunks *decrease,* chipmunks *increase*, big-leaf maples *decrease*

39. Looking at the previous food chain, imagine that a disease that harms Big-leaf maples has spread to the forest. Circle the arrows that show what would happen to the population of each organism.

Big-leaf Maple	⇧ ⇩
Townsend's Chipmunk	⇧ ⇩
Western Spotted Skunk	⇧ ⇩
Great Horned Owl	⇧ ⇩

Below is a graph showing both the amount of forest fires that occurred in western Oregon from the years 1990-2002 and the total amount of precipitation from each year.



40. When precipitation levels are _______, the number of forest fires _______.

A. High; decreases

B. Low; decreases

C. Low; stays the same

D. High; increases

41. In 1-2 sentences, what is something that you learned at H.J. Andrews today?

____

____

____

APPENDIX D:
Participant Observation Form

Observer Name: ___________________________ Date: ___________________

Stop number: _____________ Time: ___________________

Group number: ___________

Description of positioning on trail (include a map-sketch, if helpful). Visibility, hearing ability, etc:.

Definitions:

- Heads-up observation: The learner responding to the DT curriculum and observing their natural surroundings.
- Pointing: The learner is connecting a concept learned in the program to their natural surroundings.
- Tactile investigation: A learner is using touch to investigate a natural object that is included in the curriculum.

Heads-up observation	
Pointing	
Tactile investigation	

Additional notes:

- Example engaged behaviors: smiling, nodding, talking to group members about lesson, doing DT activities.
- Example disengaged behaviors: talking about unrelated topics, hesitation, appears to be confused, seems distracted, doesn't talk to group

Quotes:

APPENDIX E:
Teacher Pre-DT Interview Guide

1. What motivated you to bring your students to HJA?
2. What will you do to prepare our students for the DT? Discussions, lessons, projects, etc.
3. How are you planning for the Trail to fit into your classroom curriculum, plans, or goals?
4. What are you looking forward to the most?
5. How do you feel about using iPads in outdoor education?
    a. Positives?
    b. Potential negatives?
    c. Positives about using paper books instead?
    d. How do you think the students will react?
6. Is there anything else you'd like to share regarding your expectations?
7. Are there any questions that you have for me?

APPENDIX F:
Post-DT Interview Guide

1. What did you observe during the field trip, relating to engagement (with the program or place) or learning?
   a. What did you like best?
   b. What do you think the students liked best?
   c. Do you think it was a beneficial experience for the students?
   d. Do you think the students enjoyed the experience?
2. Did you discuss the field trip experience back in the classroom?
   a. How so?

3. Did you notice any changes in any of the students after the field trip?
   a. New knowledge?
   b. Increased curiosity?
   c. New interests?

4. How do you feel the DT fit your classroom curriculum, plans, and goals?
5. Is there anything you wish was included into the DT curriculum?
6. How do you feel the iPads contributed to the experience?
   a. Positives that you observed?
   b. Negatives that you observed?
   c. What do you think the students thought about using the iPads?

7. Did you see any key differences between the experience when iPads were used versus when the paper books were used?

8. Do you think the field trip was worthwhile?
   a. For you?
   b. For the students?

9. What could have been done differently on the trail?

10. Were there any resources you wish you had before coming to the trail?

11. Was your training helpful?

12. Is there anything else you'd like to share?

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