AN ABSTRACT OF THE DISSERTATION OF

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Abstract approved:

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SueAnn I. Bottoms Lynn D. Dierking

Abstract

Community science (also called citizen science) has become an increasingly popular data collection technique for scientists researching nature at a large scale. Many ecologists have also looked to community science as a method for educating the public about science. Over the past several decades, researchers have attempted to define an ecoliteracy framework, frequently centered on ecological concepts and science competencies. Unfortunately, few ecoliteracy studies discuss socioecological values (e.g. respect for others) as a main component of ecoliteracy. Because of this, tools for measuring ecoliteracy focus on concepts and competencies associated with specific community science projects. There is currently no agreed upon framework for or definition of ecoliteracy. Proposed ecoliteracy frameworks, as with most science, are rooted in colonial/western epistemologies and ontologies. To address this, this exploratory study is divided into three manuscripts: Manuscript 1) explores ecoliteracy in Oregon avian community scientists. To do this, I used the Pitman and Daniels (2016) ecoliteracy

tool designed to explore ecoliteracy, in the context of south Australian and global ecosystems, among environmental professionals. In this study, I modified the Pitman and Daniels (2016) tool to represent Oregon ecosystems. Manuscript 2) using four ecoliteracy frameworks, Critical Pedagogy of Place (CPP), and Critical Indigenous Pedagogies of Place (CIPP), I further modified the Pitman and Daniels (2016) ecoliteracy tool to reflect a critical socio-ecoliteracy framework (CSEF). This included the addition of sense of place, nature connectedness, and open-ended questions about ecological knowledge, ecosystem descriptions, ecosystem change, and bird community changes. From these data, I developed a CSEF that provides an understanding of ecoliteracy grounded in CPP/CIPP, centering on self, construct, and place. These components are joined in relationship with one another, connected by relationships, epistemology, and land (as pedagogy). Manuscript 3) with this CSEF I used open-ended questions about fire ecology and fire ecology scores from the ecoliteracy tool to explore birder fire ecoliteracy. The CSEF provided an understanding of the factors that influence birder fire ecoliteracy and beliefs about fire. This modified tool was effective in measuring ecoliteracy among Oregon avian community scientists. Though, they demonstrated a lower ecoliteracy than environmental professionals in Australia. Findings from this study demonstrate that participation in community science can increase ecological knowledge, although education (regardless of education level), may play a greater role. Another interesting aspect of this study is the clear connection between 'becoming birds,' place, ecoliteracy, and this CSEF. This is particularly the case when analyzing the qualitative data.

Becoming Birds: Community Scientists, Place, and Critical Socio-ecoliteracy

by
Teresa 'Bird' Wicks

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APPROVED:

Co-Major Professor, representing Environmental Sciences

Co-Major Professor, representing Environmental Sciences

Director of the Environmental Sciences Program

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Teresa 'Bird' Wicks, Author

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Lemlents (thank you) to the first peoples of Oregon, on whose lands this study occurred on. The 9 Tribes of Oregon, the Confederated Tribes of Warm Springs, Confederated Tribes of Siletz, Confederated Tribes of Grand Ronde, Confederated Tribes of Umatilla Reservation, Burns Paiute Tribe, Klamath Tribes, Coquille Indian Tribe, Cow Creek Band of Umpqua Indians, and the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians. These are the original stewards of this land. Their removal from their territories to reservations, so that settlers can be here today, forever changed the landscapes upon which we live.

This written document, the representative whole of my dissertation, signifies an end to my incredible journey. This journey may not reflect the physical flights of endurance undertaken by birds traveling from south to north, and south again, in their annual migratory cycle. It does, however, reflect the metaphorical ups and downs, trials and tribulations of the journey from plentiful winter to fertile summer grounds. As with any migratory endeavor, I could not have made this journey without the following members of my ‘stopover’ flocks:

Acorn Woodpeckers are ecosystem engineers, creating habitat for myriad species through the construction of cavities and acorn ‘granaries.’ Acorn Woodpeckers are also communal birds, living in large and boisterous family units. To my Acorn Woodpecker family, thanks for making home, home; for the sustenance and moral support along the way. ḿestḿ uł túḿ (dad and mom), lemlents for being my biggest fans. To hin łccʔups (my younger sisters), Bina, Bug, and Calvin, lemlents for providing hours of laughter (and tears), and for standing by me when it mattered most.

To my flock of chickadees (A, C, F, J, W, C, M, M, & M) lemlents for the countless hours of entertainment and joy. You 9 make the rough patches easier to navigate and nourish my soul.

When an internal compass won't suffice, many migratory birds rely on landscape maps and stars to guide them. Throughout this journey, Dr. SueAnn Bottoms served as the North Star, constant in her guidance and patience, never failing to remind me which way I was headed. Dr. Lynn Dierking provided a map of the constellations, making the written version of this dissertation stronger. Dr. John Bailey provided the warmth and guidance needed to bolster my leadership skills and stay on course. Dr. Jenny de la Hoz always encouraged me to find my song. Dr. Nicole Duplaix sustained my vision when I thought I had lost it.

Crows and ravens prove to be calculative and insightful guides. Like crows and ravens, Kelsey () and Dr. Mark Needham provided helpful analytical advice, guiding this exploratory study forward.

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Finally, sandhill cranes are long-legged bastions of loyalty and resilience. To my wife, Janelle, my sandhill, I owe more thanks than I have words. For the countless hours of sustenance and support...lemlents. Onward to the next journey.

It is the diversity of bird song that brings a landscape to life. While the silence of winter can be good for internal reflection, it is by becoming Bird that I have learned to fly.

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DEDICATION

I dedicate the dissertation in loving memory of J. David Siddon, who told 16-year old me that he believed I could accomplish anything I put my mind to. It was these words that boosted my confidence whenever I felt unsure of this process.

CHAPTER 1: INTRODUCTION

Bird by bird, I have come to know the Earth – Pablo Neruda

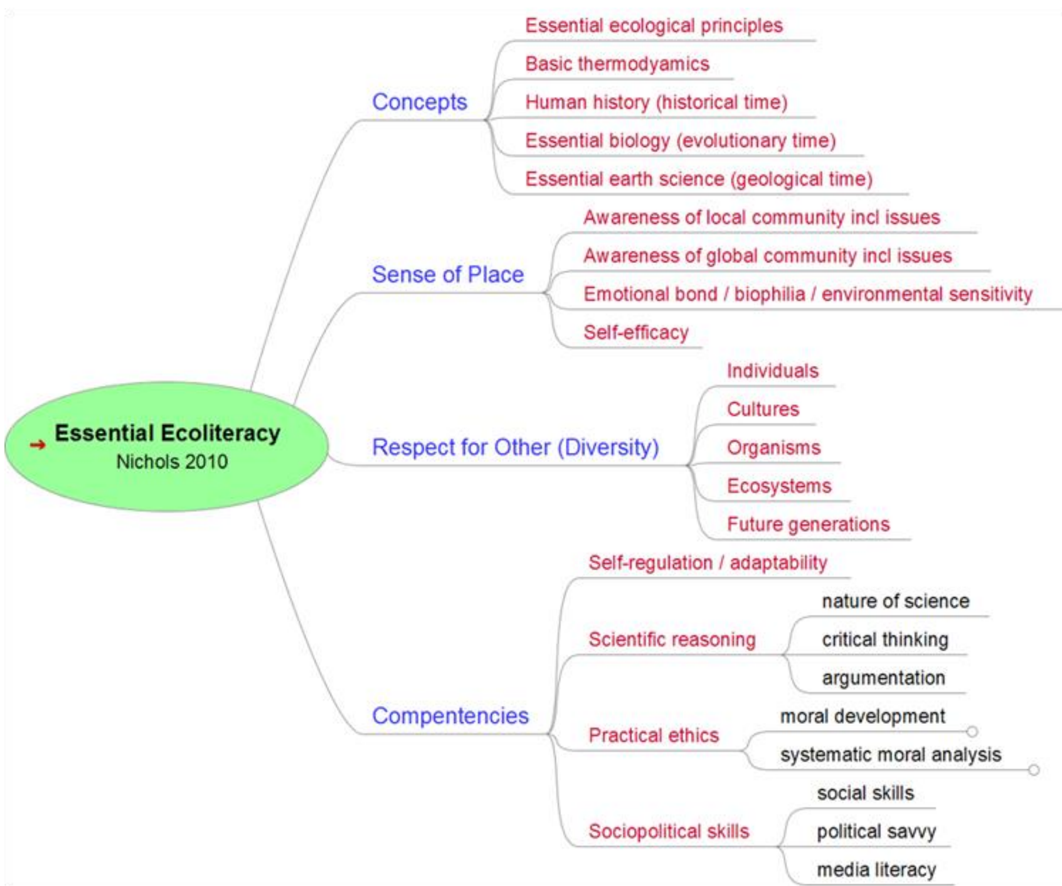
Background and Rationale

As the global human population races toward 9 billion, the need for an ecoliterate populace becomes increasingly important. The question of what makes an ecoliterate populace has plagued social scientists and ecologists for decades (Jordan, Singer, Vaughn, & Berkowitz, 2009; Nichols, 2010; Pitman & Daniels, 2016). One approach to answering the question 'what does it mean to be ecoliterate?' is working to clearly define a broad, yet cohesive, definition of ecoliteracy that will satisfy a diverse suite of stakeholders (McBride, Brewer, Berkowitz, & Borrie, 2013). As a result of the quest to identify a definition, ecoliteracy as a concept has gone through many iterations (McBride et al. 2013), beginning with the first descriptions of environmental literacy (Roth, 1968), then ecological literacy (Risser, 1986), sustainable ecological literacy (Orr, 1992), and finally ecoliteracy (Cabra, 1997). Debates about ecoliteracy's 'home' (e.g. environmental vs. ecological) originated with Orr's (1992) situating of ecological literacy in environmental education. The merging of these two fields led many to question the relationship between environmental and ecological literacy (Berkowitz, Ford, & Brewer, 2005; Jordan et al. 2009; McBride et al. 2013), with some describing environmental literacy as encompassing ecological literacy (Berkowitz et al., 2005) and others arguing for their separation into different categories of knowledge (McBride et al., 2013).

Included in the effort to define ecoliteracy, many scientists and educators have worked on developing frameworks for ecoliteracy (Berkowitz et al., 2005; Jordan et al., 2009; Nichols, 2010). Some frameworks focus on elements of ecological knowledge and scientific competencies (Berkowitz et al., 2005; Jordan et al., 2009; Pitman & Daniels, 2016). Other frameworks developed by educators, social scientists, and others focus on "psychosocial aspects, human agency, or the environmental harm caused by humans worldwide" (Jordan et al., 2009; p. 496). Despite the varied frameworks for, and definitions of, ecoliteracy few include foundations in diverse epistemologies, sense of place, or environmental justice. In his framework for Essential Ecoliteracy (Fig. 1.1), Nichols (2010) attempts to include more inclusive topics, combined with scientific and ecological knowledge. In 2012, Nichols refined the Essential Ecoliteracy to develop an 'Earth Smarts' Framework for ecoliteracy (Nichols, 2012). This refined 'Earth Smarts' framework is more complex, and includes 'Values,' which merges respect for others with moral development and justice.

Figure 1.1

Framework for Essential Ecoliteracy developed by Nichols (2010).



As part of an inclusive society diverse ontologies and epistemologies, identities, and environmental justice are important elements of ecoliteracy. This is, in part, because cognitive diversity, "the multiplicity of perspectives that are drawn from different ways of knowing, arising from a variety of livelihood activities, life experiences, and cultural backgrounds" (p. 100), has been identified as an important factor in problem-solving complex resource issues (Kassam, Avery & Ruelle, 2017). As a result, frameworks for ecoliteracy need to represent cognitive diversity, including science, local, and Indigenous ecological knowledge.

In recent years, attempts to describe and measure ecoliteracy have evolved to incorporate ideas about how ecoliteracy develops (McBride, et al. 2013), and methods ecologists and educators can employ to increase ecoliteracy. One of the proposed pathways for developing ecoliteracy is participation in citizen science (Jordan, et al. 2011). Because citizen science can be a socially problematic phrase (discussed further in the next section), I use the phrase community science throughout this dissertation. Community science has been shown to increase ecoliteracy in participants (Evans et al., 2005; Crall et al., 2012; Jordan, Gray, Howe, Brooks, Ehrenfeld, 2012; Ceccaroni, Bowser, and Brenton, 2017). However, few studies have measured broad ecological concepts and processes, instead focusing on content-specific information, e.g. bird nest ecology (Evans et al., 2005) or invasive plants (Crall et al., 2012; Jordan, Gray, Howe, Brooks, Ehrenfeld, 2012). Most studies have found increased ecological knowledge and increased awareness of western science methodologies (e.g. Bonney et al., 2009; Dickinson et al., 2012).

The case for community science rather than citizen science

Despite the increasing popularity of community science, there are still issues of exclusion inherent in discourse around and terminology regarding community science. Many western scientists question the validity of data collected by citizen scientists (Dickinson, Zuckerberb, & Benter, 2010), though other scientists have embraced community science monitoring as an important part of exploratory work and in identifying environmental and population trends (Dickinson et al., 2010). Additionally, there are increasing calls for transitioning terminology surrounding citizen science participation to language that will create a more inclusive environment (Eitzel et al., 2017).

The Merriam-Webster Dictionary (2018) defines a citizen as "a legally recognized subject or national of a state" or "an inhabitant of a city or town." As a result, the term citizen science is an exclusionary term, implying participants must be legal citizens, or that urbanites are the focus of these projects. While alternative terms may also be considered off-putting by a range of people (Eitzel et al., 2017), community science is generally believed to be a more inclusive term (National Audubon Society, 2018). This is, in part, because community can refer to legal citizens, residents, members of Indigenous Nations, rural residents, and/or other marginalized folks. It is because of the inclusivity of this term that I use the phrase community science or community scientist in this study.

Problem Statement and Research Questions

Many community science participants are motivated to participate in data collection projects because of an interest in the content (e.g. birds) and/or a desire to contribute to science and conservation (Evans, Abrams, Reitsma, Roux, Salmonsen, & Marra, 2005). While learning new things is also a reason that individuals give for participating in community science, this quest is typically content-specific (e.g. bird identification). Most studies appear to collect information about ecological knowledge that is content specific, rather than about general ecology, which does seem in line with participant interest. Thus, while scientists and educators may strive to increase ecoliteracy through community science, there is little understanding of the depth or breadth of community scientists; ecoliteracy that may result from participation. To understand the complexity of ecoliteracy, and the influence of community science participation, including both cognitive and socio-ecological components, it is important to have a robust framework from which to work.

The following research questions guide this study:

1. What are the reasons that Oregon birders choose to participate in bird community science projects, such as the Christmas Bird Count, Breeding Bird Survey, or eBird?
2. What do Oregon birders that participate in community science projects focused on birds know about birds, ecological issues that affect the habitats in which they collect data (e.g., impacts of fire, drought, etc.), and about broader local and global ecological constructs?
3. Do Oregon birders that participate in community science identify with the places in which they collect bird data for community science projects? If so in what ways? Ecologically? Emotionally? Historically?
4. Do Oregon birders that participate in community science understand the views, perspectives and Indigenous Ecological Knowledge (IEK) of Tribes that have lived in the habitats in which they collect their data since time immemorial?

Structure of Dissertation

To address these questions, this dissertation was conceptualized as a series of three manuscripts with interrelated questions that are nested within each other to build upon the ideas and work in each previous paper. The manuscripts are structured as three chapters. The goal of these chapters is to explore broad understanding of ecological constructs among Oregon's avian community scientists, and to develop an argument for using a critical socio-ecoliteracy framework for guiding future conversations about ecoliteracy. This effort includes testing a tool for measuring broad ecological (non-project specific) concepts, measuring ecoliteracy among avian community scientists, developing a critical socio-ecoliteracy framework (CSEF), developing and testing a survey questionnaire to measure critical socio-ecoliteracy, and then testing a 'wicked problem,' problems that seem intractable because of the many perspectives that influence discourse around them. In the case of Oregon ecosystems, one such issue is the role of prescribed and natural fire in Oregon ecosystem management and conservation.

Manuscript 1 (Chapter 2)

In Manuscript 1 I discuss how I tested the effectiveness of a tool created to measure ecoliteracy among South Australian environmental professionals (Pitman & Daniels, 2016), modified to represent Oregon ecosystems. I used the ecoliteracy (ECOS) tool to explore the relationship between ecoliteracy and participation in avian community science projects. This paper also specifically discusses data from open-ended questions describing ecosystems and changes in bird communities and ecosystems over time. Questions about ecology are compared to motivation and participant psychographic and demographic information such as education, employment, and community science participation (e.g. number of years participated). This paper provides a general understanding of how participation in avian community science projects may influence ecoliteracy. These research questions guide this specific aspect of the overall study:

- Can a modified Pitman and Daniels (2016) ecoliteracy instrument successfully measure ecoliteracy in Oregon birders?
- What do Oregon birders know about birds in general, and the ecological issues that affect the habitats in which they collect data?
- What motivates birders to participate in community science and how does this influence ecoliteracy?
- What other factors (e.g. education) influence ecoliteracy in Oregon birders?

Ecoliteracy and community science

Community science is an increasingly common way that adults and youth engage in repeated free-choice/informal, science-based experiences outdoors (Brossard, Lewenstein, & Bonney, 2005; Bonney, 2007; Bonney et al., 2009; Dickinson, et al., 2012). Additionally, community science has also become a common way for scientists to collaborate with communities in research design and data collection. Today, community science is used by scientists and educators as a method for increasing ecoliteracy, educating the public, and changing science identity and behavior (Dickinson, et al. 2012; Jordan, Gray, Howe, Brooks, & Ehrenfeld, 2012). Several studies have found an increase in ecoliteracy as a result of participating in community science projects (Brossard, Lewenstein, & Bonney, 2005), but as noted by Jordan, et al. (2009), there is no standard framework for establishing ecoliteracy. This makes evaluating these studies in tandem difficult, because it is not clear how each study operationalized ecoliteracy (e.g. avian ecology vs broad ecology). Jordan et al. (2009) propose a framework for ecoliteracy that includes ecological knowledge, and an awareness of self, place, and personal and social values. Nichols (2012) proposes a framework for essential ecoliteracy that includes concepts, competencies, sense of place, and respect for other (diversity).

Community science provides a well-established social context in which to understand ecoliteracy as conceptualized by Nichols (2010). For example, winter 2017 marked the 117th annual Audubon Christmas Bird Count (CBC). This popular, long-running community science program has origins in competition and wildlife "collection." Today, participants frequently engage in potlucks, dinners, and other celebrations while totaling their species numbers for the day (personal obs.). Friendly competition is common (Cooper & Smith, 2010; Audubon 2018), and birders of all skill levels are welcome (Audubon, 2018). Additionally, data collection for the annual CBC nearly always occurs in pairs or groups, although solo observations are noted on occasion. This is a very different context from the Breeding Bird Survey (BBS). BBS are surveys conducted by individual birders, all with advanced skill levels (United States Geological Survey, 2018).

These two contexts alone potentially influence ecoliteracy in several ways. For example, CBC participants, in part because of the social nature of the CBC, may include individuals with stronger social skills, higher respect for others, and greater external motivation (Nichols, 2012), than BBS participants. CBC participants may also build a different ecological awareness than BBS participants, in part because of their interactions with other participants.

Manuscript 2 (Chapter 3)

Manuscript 2 uses Critical Pedagogy of Place (CPP) and Critical Indigenous Pedagogies of Place (CIPP) to explore critical socio-ecoliteracy (CSE), including a framework that best reflects CSE. I use this paper to build upon the modified ecoliteracy tool in Paper 1. I added the Place Attachment Inventory (PAI; Williams & Vaske, 2003) and the Inclusion of Nature in Self (INS; Schultz, 2002) tools. In this paper, open-ended questions designed to measure epistemology (e.g. the nature of ecological knowledge and how is it formed) are used to help develop a critical socio-ecoliteracy framework (CSEF). The following questions guide this specific aspect of the overall study:

- Can existing ecoliteracy frameworks and Critical Indigenous Pedagogies of Place (CIPP) be used to develop a critical socio-ecoliteracy framework (CSEF)?
- What is the role of sense of place in a critical socio-ecoliteracy framework (CSEF)?
- Does the relationship between ecoliteracy, community science, and motivation change with a critical socio-ecoliteracy framework (CSEF)?

- Can place attachment and inclusion of nature in self provide a proxy for ontology and epistemology in a tool for measuring critical socio-ecoliteracy (CSEF)?

Ecoliteracy frameworks

Despite nearly two decades of working on a unified framework for describing ecoliteracy, a unified framework still has not been developed. This is largely because of the diverse conversations around ecoliteracy definitions and ecoliteracy's roots in ecology, education, and environmental literacy (Orr, 1992; Capra, 1997; McBride, et al., 2013). Scientists working in the ecological field began attempting to define a framework for ecological literacy in the mid- to late-1980s (McBride et al., 2013). In 2009, a group of ecologists attempted to develop a unified definition of ecoliteracy, primarily focusing on ecology-related disciplines (Jordan, Singer, Vaughn, & Berkowitz, 2009). In their review of ecoliteracy definitions, Jordan, et al. (2009) identified three components of an ecoliteracy framework: 1) Ecological habits of mind, 2) Ecological connectivity and concepts, and 3) Human actions-environmental linkage.

Nichols (2010, 2012) built on the work of Jordan, et al. (2009) using a concept analysis of transdisciplinary literature about ecological and environmental literacy to develop a unified framework of ecoliteracy that considers the human, emotional, ecological, and scientific opinions and expectations of/for ecoliteracy. The result of this analysis is the development of an 'Earth Smarts' Framework, comprised of cognitive and socio-ecoliteracy components. While this framework includes respect for other cultures, it doesn't include other types of knowledge (e.g. Indigenous Knowledge), reconnecting humans to ecosystems, or the idea that increasing ecoliteracy requires a diversity of sources of ecological knowledge (Berkes, 2004).

As with other ecoliteracy frameworks (e.g. Jordan, et al., 2009) the implied acceptance for other ways of knowing in Nichols (2012) maintains western knowledge and perspectives as the center of ecoliteracy. This 'othering' of Indigenous and local knowledge is common throughout western scientific communities (Harding,1998; Deloria, 1999; Kimmerer, 2010; Lam, 2014). Indeed, Nichols (2012) describes Indigenous Knowledge within 'sustainable cultural practices' maintaining Indigenous Ecological Knowledge (IEK), as a mythology/stories rather than real and tangible knowledge and management. Deloria (1999) describes this tendency of western scientists to discuss the importance of IEK, while maintaining that IEK is 'less than' western knowledge, as one of the risks of trying to integrate IEK and western knowledge, efforts that are often, but not always, led by western scientists.

Despite the possible risk of IEK being treated as mythology rather than knowledge, Lam (2014) proposes that the combination of western science and IEK is an effective way to make science more diverse. Additionally, as proposed by Kimmerer (2012), the integration of IEK and western science can bring about deeper knowledge and understanding of ecosystems, climate change, and landscape management. One possible way to resolve the 'othering' of IEK by western scientists is for Indigenous peoples to maintain control of *how* their knowledge is incorporated with western science (Deloria, 1999).

It is also critical to note that there is no single IEK. In North America alone there are 600+ tribes, 573+ of which are federally recognized (NCAI 2019). Thus, IEK is more accurately described as a diverse suite of Indigenous Knowledges that are developed in a place and are therefore intimately connected to the lands from which they are developed.

Critical Indigenous Pedagogy of Place (CIPP)

Place attachment is identified as an important component of pro-environmental behavior (Halpenny, 2010), identity (Gruenewald, 2003), and of some ecoliteracy frameworks (Nichols, 2012, Pitman & Daniels, 2016). As the awareness of the importance of place in environmental and sustainability education has increased, so too, has the concept of place-based education (Sobel, 2004). Thus, it seems important to understand some of the problems associated with concepts of place. Place devoid of human and colonial histories ignore the Indigenous management that have occurred since time immemorial.

Gruenewald (2008) proposed using a Critical Theory lens to examine place-based pedagogies, to deal with this very issue, creating Critical Pedagogy of Place (CPP). CPP includes the concepts of *rehabitation* and *decolonization*. Rehabitation is the act of reconnecting people to places, including places that have been changed through colonization, extractions, or otherwise altered through settlement, in order to recreate intimate connections with and knowledge of place. Decolonization, as described by Gruenewald (2008) is the process of unlearning elitist and colonial narratives about ecology and a place. While rehabitation and decolonization are important for connecting/reconnecting people to place in a less colonial way, CPP does not go far enough in decentering settler-colonial and western narratives (Trinidad, 2012).

As a result, Trinidad (2012) proposed the creation of a Critical Indigenous Pedagogy of Place (CIPP), to address the need to decenter settler-colonial narratives. CIPP includes rehabitation, but instead of focusing on decolonization centers on *indigenization*. Indigenization is the process of centering Indigenous experiences, stories, and knowledge. Through a combination of CPP and CIPP, place becomes a living thing, complete with its own Indigenous stories, histories, and knowledge; colonial narratives, and connections to people, rather than existing solely as a geographic concept.

Manuscript 3 (Chapter 4)

Finally, in Manuscript 3 I build on the work in Manuscripts 1 and 2 to apply the CSEF to a 'wicked problem,' fire in Oregon's ecosystems. I do this in order to understand how a CSEF can help fire ecologists and educators resolve issues around support for and understanding of natural and prescribed fire. The following research questions guided this part of the overall study:

- What do Oregon avian community scientists (birders) know about fire in the ecosystems in which they collect data?
- Are birders more knowledgeable about the role of fire in ecosystems in which they collect bird population data than in other Oregon ecosystems?
- How do the components of a critical socio-ecoliteracy framework inform our understanding of fire ecoliteracy and attitudes toward fire in Oregon birders?

Fire suppression efforts, combined with forest management practices, have changed forests and ecosystems throughout much of the west, altering forest structure and fire regimes (Agee, 1998; Saab & Powell, 2005). Snags and injured life trees are important parts of forest complexity, and provide roosting, denning, and nesting habitat for myriad species of mammals, reptiles, amphibians, and birds (Aitken & Martin, 2004). Forest management practices, both fire suppression and timber harvest, have reduced snag density and early-seral habitat (early successional stages in ecosystems, typically dominated by grasses, forbs, and shrubs) on the landscape, decreasing habitat for cavity-nesting and early-seral species (Kotliar et al., 2002; Russell, Saab, & Dudley, 2007). This loss of habitat has been linked with declines in several woodpecker species in Oregon and the west, including Black-backed (*Picoides arcticus*) and Lewis's (*Melanerpes lewis*) Woodpeckers (Bond, Siegel, & Craig, 2012; Rich et al., 2004, respectively).

To restore habitat for these species, many land managers have reintroduced, or are attempting to reintroduce, fire on the landscape using prescribed or natural wildfire management plans that include 'let it burn' policies (United States Forest Service, 2018). To gain public support for increasing fire on the landscape will likely require more than disseminating science information to the public (Doremus & Tarlock, 2003). Merely presenting scientific information, without understanding socio-cultural context and preconceived ideas can create cognitive dissonance in individuals (McGuire, 2015). Cognitive dissonance is a type of psychological tension created when an individual "holds two psychologically inconsistent cognitions" (McGuire, 2015; p. 699), such as individuals that hold views that fire is 'bad' for forests being told by scientists that fire is helpful for managing healthy forests.

Because of the aversion that some communities have to fire, it could be beneficial to passively teach the public about fire, through a focus on another subject, such as teaching Oregon birders about fire and landscape management through bird species and communities.

Conceptual Framework

I used four existing ecoliteracy frameworks, Bonney et al. (2009), Jordan et al. (2009), Nichol's (2011) Earth Smarts, and Pitman and Daniels (2016) in this study to frame my research questions, conceptualize a CSEF, and develop a CSE survey questionnaire. These four frameworks include several components. In this study, I used the components that best represent these frameworks, while also de-centering western knowledge. The components that informed my work include *concepts*, *competencies*, *sense of place*, *values*, and *human interactions with environment*.

Based on these decisions, the resulting questionnaire differs in two significant ways from other efforts: the inclusion of western ecological knowledge and socio-ecological ways of being. Tenets of ecological knowledge guided questions about community science participation, avian and fire-related ecological knowledge, and general ecological knowledge. Sense of place and values, as described by Nichols (2012), guided the socio-ecological components of this study.

Although three of the four frameworks include awareness of the scientific process, to maintain the grounding of this study in diverse knowledge and ways of knowing, I did not include awareness of the scientific process as part of the framework for this study. For similar reasons, I did not include most competencies. However, I did include motivation, which Nichols (2012) includes as a competency. Instead of classifying motivation as a competency, I included it as a component of *self*. Because epistemology/worldview influence our interpretations of ecology and ecological processes, I renamed *concepts* to *constructs*. Finally, *human/environment interactions* are separate from concepts in the four frameworks. I include awareness of human/environment interactions in *constructs* in this study. The components of this study are discussed in detail below. In Nichols (2012), values describe social justice, respect for others, and other morals. Respect for other cultures is discussed by Jordan et al. (2009) and Pitman and Daniels (2016), though it is not included in their frameworks. In this study, I explored using epistemology/ontology as proxies for respect for others. While epistemology/ontology are not specific to values, they may provide a proxy for acceptance of/respect for other ways of knowing.

Constructs

Nichols' (2012) constructs are grouped by general ecological principles, basic thermodynamics, and human, geological, and biological timelines. Pitman and Daniels (2016) include constructs that can be grouped in similar categories, though they also specify the importance of understanding local and global ecology, and how these ecologies interact (e.g. global climate change and how it influences local fire years). Bonney, et al. (2009) does not specify which constructs are important for an ecoliterate populace, and Jordan, et al (2009) specify only ecological processes and human/environment interactions are important.

Multiple-choice questions on the questionnaire include constructs associated with ecological processes, local and global ecology, human/environment interactions, and 'earth and all its part' (climate, energy cycles, water cycle, basic thermodynamics, and ecosystem). Open-ended questions attempt to measure knowledge of avian community ecology, population dynamics, and ecological processes particularly those associated with fire ecology, ecosystem plasticity, and human influences on ecosystems. The intent here was not to measure complex understandings of fire ecology, but rather what participants knew about fire, particularly in association with community dynamics, succession, human and biological histories, and birder support for natural or prescribed fire on the landscape.

Self

Indigenous epistemologies/ontologies include not only connection to nature, and interactions with place but also self (Deloria Jr, 1999; Simpson, 2004). Individuals, including their relationship with/to the world around them, are part of the learning process (Deloria Jr, 1999). As a result, self is used in this study to represent the individual and their role in CSE. In this study, I explore self through open-ended questions about motivation for participating in avian community science, sense of place, and how individuals increase their ecological knowledge. Quantitative data about nature connectedness were also used to inform participant conceptualizations of self.

Epistemology/Ontology

> "*Different actors define knowledge, ecological relations, and resources in different ways and at different geographic scales*." (Berkes, 2004; pg. 627)

In general, western scientific perspectives and worldviews are well represented in politics, policies, and land management activities (Harding, 1998; Deloria, 1999; Smith, 2012). These perspectives and worldviews are also well represented within social science and ecology discourse (Harding, 1998; Smith, 2012), in ecoliteracy research, and community science. Currently, western science faces increasing criticism for its lack of representation of marginalized perspectives and voices, particularly those of Indigenous peoples (Harding, 1998; Deloria, 1999).

To incorporate the perspectives/knowledges held by Indigenous peoples, particularly the ecological knowledge associated with specific places, this studied was guided by Critical Indigenous Pedagogies of Place (CIPP; Trinidad, 2012) and Tribal Critical Theory (TribalCrit; Brayboy, 2005). Although CIPP was derived from Critical Pedagogy of Place (CPP) and place-based pedagogies, and TribalCrit was derived from Critical Race Theory, CIPP and TribalCrit are grounded in the epistemologies and ontologies of geographically and historically situated Indigenous communities (e.g. the Modoc of the Klamath Basin). Because of this, CIPP and TribalCrit maintain roots in the commonalities found in Indigenous epistemologies and ontologies while also recognizing the variation between and within Indigenous communities (Trinidad, 2012; Brayboy, 2005, respectively). As mentioned above CIPP was developed to reconnect people to the land while centering Indigenous stories, histories, and cultures (Trinidad, 2012). Where Critical Race Theory evolved to address the deep-seated nature of racism in society (Brayboy, 2005) TribalCrit emerged to address issues specific to Indigenous peoples, particularly issues associated with colonialism and its endemism in society, imperial and white supremacist policies toward Indigenous peoples, tribal sovereignty, and the awareness that stories are not separate from theory, rather they inform Indigenous theories (Brayboy, 2005).

Whereas TribalCrit motivated the development of this study and the development of a CSEF, it was not incorporated into the CSEF. Conversely, while CIPP was not part of the motivation of this study, it was incorporated into the development of the CSEF. CIPP was incorporated into the CSEF in the form of epistemology/ontology (what does it mean to know/be), nature connectedness, and as a component of sense of place (e.g. whose land are you on?).

Sense of Place

Sense of place is characterized several ways in ecological and social science literature, including as an emotional attachment to a place, strongly held values that 'outsiders' may not recognize (e.g. the freedom of enterprise in the rural west), qualities that 'insiders' may not recognize (e.g. staging of migratory birds in the Silvies Floodplain in Harney County, OR), place meanings actively constructed by individuals or social groups/cultures, and the awareness of the context in which meanings are created (Williams & Stewart, 1998). Of the different definitions of sense of place, 'the emotional bonds that people form with places (at various geographic scales) over time and with familiarity with those places' and 'the awareness of the cultural, historical, and spatial context within which meanings, values, and social interactions are formed' (Williams & Stewart, 1998, p. 19) most closely reflect the components of place as discussed in the four frameworks, and helped guide this study. Specifically, place attachment (Williams & Vaske, 2003) was used to understand how participants experience and identify with the places in which they conduct community science.

Sample

In this study, I focused on Oregon birders who participate in local Audubon Chapters and several state and/or regional communities organized by listservs. Many of these birders contribute their leisure time to collect data for community science projects, including Christmas Bird Counts (National Audubon Society), Breeding Bird Surveys (USGS), Raptor Routes (East Cascades Audubon Society), and eBird (Cornell Laboratory of Ornithology). Many birders participate in more than one of these Community Science projects, which require varying levels of time commitments and skill requirements (e.g. identifying most birds by sight and sound).

To recruit participants for this study, I contacted birders throughout Oregon via the Oregon Birders Online Listserv (OBOL), Midvalley Birders, and Central Oregon Birders Online Listserv (COBOL); and through local Audubon Chapters and bird clubs (e.g. Prineville Birding Club). Statistically, birders that participate in Community Science, or are members of Audubon Chapters, are more likely to be retired (e.g. over 55). To reach younger birders, I also sent my recruitment letter to the OSU Bird Nerds, a student birding club at Oregon State University (OSU). I was unable to identify similar clubs at other Oregon universities, so I only directly recruited students at OSU.

Survey questionnaire development

To conduct this mixed methods study, I created a 58-item ecoliteracy survey questionnaire (Appendix A) with closed-ended and open-ended questions. Closed-ended questions were designed to measure participant understanding of biology concepts, global ecological principles, and ecosystems in Oregon (Constructs). Open-ended items were designed to capture an understanding of participant motivations, sense of place (how do participants describe the place(s) they spend time in), ontology, and epistemology. Open-ended items also assessed psychographic variables such as education level and academic subject, career, experience with science, and bird identification skills, to capture an understanding of participant education background and experience birding. Bird identification skills may be associated with the amount of time an individual spends observing birds, which can be reflective of their place attachment, and possibly their ability to learn about a place through time and experience. Closed-ended questions were modified from validated instruments measuring ecological knowledge, sense of place, and nature connectedness. All open-ended psychographic information was used to interpret data throughout this dissertation. Data from open-ended items asking participants to describe the relationship between fire and birds, and the role of fire in Oregon ecosystems were only used in the third manuscript.

To measure ecological knowledge, I used the ecoliteracy tool (ECOS) developed by Pitman and Daniels (2016) to assess ecoliteracy among South Australian environmental professionals. This is a 30-item, multiple-choice tool divided by local ecosystem-related questions (e.g. Oregon ecosystems) and global ecological questions. Each question has five responses to choose from, one 'most correct' response worth 4-points; two 'correct' response, each worth 2-points; one 'least correct' response worth 0-points; and one 'incorrect' response worth -2-points. Participants can only select one response and are asked to select the response they think mostly correctly answers the question. Data from this tool were used to explore ecoliteracy and understanding of ecological constructs throughout this dissertation.

There are many tools available for measuring sense of place. For this study, I determined that place attachment, the emotional bonds an individual creates with place, created by time in and familiarity with that place (Williams & Stewart, 1998), best represent sense of place. As a result, I choose the Place Attachment Inventory (PAI) developed by Williams and Vaske (2003), to measure place attachment. The PAI consists of 12 items that measure place identity and place dependence, two important components of place attachment. These items are measured using a 5-point Likert-scale, 1 = strongly disagree, 5 = strongly agree, for a total value of 60 points. The last item in the tool is reverse-scored. Data from this tool were used to explore critical socio-ecoliteracy (CSE) and the role of place attachment in CSE in the second and third manuscripts.

As with sense of place, there are many tools available to measure nature connectedness. I selected the Inclusion of Nature in Self instrument (INS; Schultz, 2002) for this study. This tool is one multiple choice item, consisting of seven images of two circles, one representing 'self' and the other representing 'nature.' In each image the two circles are at varying degrees of connection, with the circles completely separated in the first image and the circles completely overlapping in the final image (Appendix 1). Participants are asked to select the image that best represents how they view ‘nature’ and ‘self.’ While this tool has some limitations, primarily because it is only one item, it has been well-tested and seems like it has the most potential to represent ontology (what it means to *be* connected to nature). Data from this tool were used to explore nature connectedness and ontology in the second and third manuscripts.

Modifications of the ecological knowledge instrument were focused on making the questions regionally appropriate, while maintaining the spirit of each question. Grammar and language were not modified from the original questionnaire. All questions were checked against the conceptual framework modified from Bonney, et al. (2009), Jordan, et al. (2009), Nichols (2012), and Pitman and Daniels (2016) to ensure alignment between questions and the framework for this study.

I originally planned to facilitate focus groups to develop a better understanding of ecoliteracy and the role of socio-cultural context, science identity, and place in ecoliteracy. Unfortunately, the sample of research participants willing to be in a focus group was too small. A lack of funding for this project also made it difficult to use incentives, such as books about birds or birding to recruit research participants.

I developed the questionnaire in Qualtrics, a web-based survey program (Qualtrics, Provo, UT). Once a questionnaire is developed, Qualtrics offers several options for recruiting and administering a survey. In the case of this study, I wrote a recruitment letter and email for Oregon Audubon Chapters and bird listservs to distribute to their members. Birders interested in participating in the study were asked to contact me so that I could send instructions and a link to the questionnaire to them. There was a problem with Qualtrics while I was developing the questionnaire and several questions were accidentally deleted. I was able to restore most of the deleted questions, adding them back to the questionnaire. Unfortunately, I did not realize that the question about gender-identity had been deleted. Because the Qualtrics software does not collect participant names automatically, and to maintain anonymity I did not ask for participant names or email addresses in the survey, I do not have a way to match surveys with demographics of birders that contacted me to participate in this study. Additionally, it would be inappropriate to assume gender-identity based on name alone. Thus, no information about gender-identity was collected in this study.

Positioning the study

As with any study, personal perspectives and experiences are critical to report up front. I am a queer, two-spirit, white-coded, Scotch-Irish and sp'q'n'i' (Spokane) descendant. I grew up poor, in rural southwestern Oregon on Takelma, Latgawa, and Dakubedetede territory, and am a first-generation college graduate. My father works as a reforestation contractor and wildlife surveyor and I spent much of my youth and adult life following or working with him in the woods. Because of the time I spent in the forests of southern, central, and eastern Oregon as a youth, I developed a strong appreciation for, and understanding of, the ecosystems of the Rogue, Klamath, and John Day river basins. As a small child, some of my first interests centered on birds, and that interest never waned, leading me to pursue education and careers that included researching, protecting, and educating through birds. My early affection for birds earned me the childhood nickname 'Bird,' a nickname that has followed me throughout my adulthood. It is my relationship with birds, spending endless hours observing and talking with them, that led me to believe in birds as pedagogy, the belief that I can teach anybody anything through birds (Fig. 1.1).

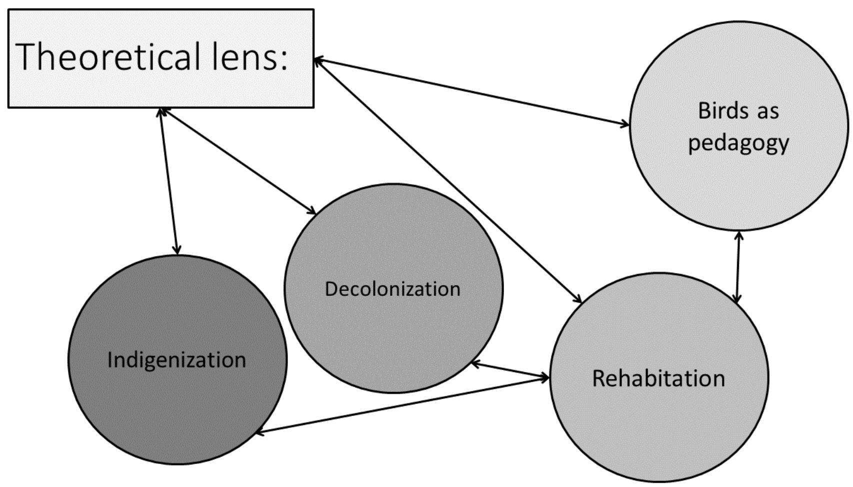
My first experience with conservation and environmental education was as a teenager, when I worked at a wildlife rehabilitation center. I grew up during the "timber crash" of the 1990s and remember well the anger many people directed at the species they perceived as responsible for the crash, the Northern Spotted Owl (*Strix occidentalis caurina*). At the time, any owl in an education program was likely to spark controversy and angry conversations. It was in those formative years that I began to understand the importance of understanding other experiences, cultures, and ways of knowing in conservation and outreach. It was not until my first official job as an educator with AmeriCorps, that I realized my own propensity for seeking and understanding multiple perspectives and experiences with nature. While working on my M.S. in Environmental Education, I learned about place-based pedagogies and began applying the idea of multiple perspectives to any place-based education I facilitated. Currently, as a conservation biologist and advocate for Portland Audubon, based in Burns, OR, the lessons from my early experiences are particularly relevant to my work and to this dissertation.

My own approach to teaching, biological work, and research closely aligns with Critical Pedagogy of Place (CPP) and Critical Indigenous Pedagogies of Place (CIPP). This lens of rehabitation, decolonization, and indigenization, combined with my personal experiences and beliefs about science and environmental education shaped this study, positioning it well within a CPP/CIPP theoretical lens. My theoretical lens is also influenced by Tribal Critical Theory (TribalCrit). TribalCrit emerged from Critical Race Theory (Brayboy, 2005). Critical Race Theory was developed to address the endemism of racism and colonialism in education and society. TribalCrit also addresses racism and colonialism but specifically focuses on issues associated with tribal sovereignty, anti-Indigenous rhetoric, and Indigenous theories and knowledges (Brayboy, 2005).

As a conservation biologist and environmental educator, I have always found discourse around wilderness, conservation, and science problematic because it typically excludes Indigenous knowledge and perspectives from the conversation. Scientists and educators have even told me that Indigenous stories and histories are irrelevant to present conservation practices and science. An interest in changing discourse around science, education, and knowledge, and an interest in reconnecting people to the histories of place and the role of fire in Oregon's ecosystems led to this study.

Figure 1.2

Theoretical lens guiding this study



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Chapter 2: First manuscript

Birds, community science, and ecoliteracy: does counting birds influence the ecoliteracy of Oregon birders?

Teresa ‘Bird’ Wicks

Intended for publication with the following authors:
SueAnn I. Bottoms and Lynn D. Dierking

Abstract

Citizen science (more inclusively called community science) has become an increasingly popular data collection technique for scientists researching nature at a large scale. In addition to the increased data collection possibilities, many ecologists have looked to community science as a method for educating the public about western ecological knowledge and scientific processes. Despite the popularity of community science as a data collection and outreach activity, there is still no standardized definition of, framework for, or tool to measure ecoliteracy. Over the past several decades, scientists and educators have agreed that scientific knowledge is an important component of ecoliteracy. Other agreed upon components include awareness of the scientific method and scientific processes. More recently, scientists have begun to include socio-ecological components, such as sense of place, in ecoliteracy frameworks. Unfortunately, few proposed ecoliteracy frameworks include socio-ecological components other than sense of place as a main component of ecoliteracy. Even fewer include components of social or environmental justice as part of ecoliteracy. Though, some studies do include discussions about 'other cultures' or things like Indigenous Knowledge that are not reflected in their ecoliteracy frameworks.

In this study, four proposed ecoliteracy frameworks, produced over the past decade, guided the creation of an ecoliteracy framework. This framework includes ecological constructs, self, sense of place, and epistemology/ontology (what does it mean to know/be?). I modified an ecoliteracy tool developed in South Australia to explore ecoliteracy in Oregon avian community scientists (birders). Open-ended questions were used to explore psychographics (e.g. education and bird id skills), self (i.e. motivation), and sense of place.

Birders that participated in this study were white, predominantly over 45, had a bachelor's degree or higher, identify as having intermediate bird identification skills. Most birders in this study participate in the Christmas Bird Count (CBC) and/or eBird and are

intrinsically motivated to participate in community science. Oregon birders appear less ecoliterate (mean = 88.7, s.d. = 0.88) than environmental professionals in South Australia (mean = 93, s.d. = 0.31).

Participation in community science does appear to positively influence ecoliteracy. However, education may have a more positive influence on ecoliteracy as individuals with master's degrees of above or that work in natural resources/science careers have higher ecoliteracy scores than participants that do not. Qualitative data indicate an awareness of local changes in bird communities and ecosystems, particularly those associated with the effects of climate change. This study provides support for community science as a tool for increasing ecoliteracy, though further exploration of the relationship between sense of place and ecoliteracy is necessary to understand the nuanced relationship between sense of place, regional, and global ecoliteracy.

Introduction

In the past several decades, scientists and educators identified ecoliteracy as an important part of combating dwindling resources, climate change, and other ecological issues associated with an increasing human population. To create a common understanding of what makes an ecoliterate populace, researchers attempted to create a definition of ecoliteracy broad enough to satisfy diverse stakeholders (McBride, Brewer, Borowitz, & Borrie, 2013). Jordan, Singer, Vaugh, and Berkowitz (2009) provide a definition of ecoliteracy that includes three components: 1) ecological connectivity and concepts, 2) ecological habits of mind (scientific reasoning), and 3) human/environmental linkages. As part of the development of ecoliteracy frameworks and definitions, ecologists and educators have developed theories of and methods for ecoliteracy development (McBride et al., 2013).

One of the proposed pathways for developing ecoliteracy is participation in citizen science (Jordan, Gray, Howe, Brooks, & Ehrenfeld, 2011; Reynolds & Lowman, 2013); I use community science, a common and more equitable term, in this study. Ceccaroni, Bowser, and Brenton (2017) define community science as “work undertaken with citizen communities to advance science, foster a broad scientific mentality, and/or encourage democratic engagement, which helps society address complex modern problems” (p. 8).

Many studies have measured ecoliteracy associated with participation in community science (e.g. Evans, Abrams, Reitsma, Roux, Salmonsen, & Marra, 2005; Sullivan et al., 2009). However, for the most part these tools are project specific and evaluation oriented, thus do not provide a broad and comprehensive tool for comparing ecoliteracy between studies, projects, and participants (Pitman & Daniels, 2016).

Many participants in community science are motivated to join in projects because of their specific interests in the content (e.g. birds) and a desire to contribute to science and conservation (Evans et al., 2005; He, Parrish, Rowe, & Jones, 2019). In this aspect of my overall study, I examined ecoliteracy among birders who participate in community science (I use 'birders' for ease of reading and to reflect the identity most often expressed by this community), modified the ecoliteracy tool (ECOS) developed by Pitman and Daniels (2016), and evaluated the effectiveness of the modified ECOS tool for measuring ecoliteracy in Oregon birders. Specifically, I explored the following questions:

- Can a modified ecoliteracy instrument successfully measure ecoliteracy in Oregon birders?
- What do these birders know about birds in general, and the ecological issues that affect the habitats in which they collect data?
- What motivates birders to participate in community science and how does this influence ecoliteracy?
- What other factors (e.g. education) influence ecoliteracy in Oregon birders?

Community Science

While the origins of community science grew out of the scientific need for data collection at a landscape scale, and as a counterpoint to shrinking research budgets (Greenwood, 2007), community science is also an increasingly popular informal outreach activity. Outcomes include educating the public with a goal to increase ecological knowledge, expand civic engagement, provide learning opportunities (Turrini, Dörler, Richter, Heigl, & Bonn, 2018), and influence science identity and behavior (Jordan, et al., 2011; Dickinson et al., 2012; Bonney et al., 2014; Ballard, Harris, & Dixon, 2018). Reinforcing the recent trends in community science are the number of studies examining the trends in community science.

These studies include Greenwood's (2007) report on the history of public participation in ornithology and bird conservation; an analysis of educator and environmental professional community science goals in Germany (Turrini, Dörler, Richter, Heigl, & Bonn, 2018); and the National Academy of Sciences, Engineering, & Medicines (NASEM, 2018) report on community science. The NASEM (2018) report discusses the scope of community science efforts, including their common traits; how they engage participants; help advance western science; and how they improve understanding of western science concepts and processes.

From the perspective of participants, community science is an increasingly popular free-choice learning (FCL) activity, providing community members with varied opportunities to engage in the science process (Bhattacharjee, 2005; Dickinson et al., 2012). *Free-choice learning* tends to be "non-linear, personally motivated, and involves considerable choice on the part of the learner, as to what to learn, as well as when, where, how and with whom to learn" (Falk & Dierking, 2018; p. X). FCL experiences occur in and from places such as museums, as well as while watching TV, reading a newspaper, talking with friends, attending a play, or surfing the internet (Falk & Dierking, 2018). Finally, scientists use community science as a means of collaborating with communities, and with the general populace (e.g. eBird, which is targeted at the general birding community) in research design and data collection (Bonney, 2007; Chari et al., 2017).

Part of the appeal of community science, as an educational and outreach tool, is that it makes science more accessible to individuals lacking academic training in Western Science methods (Eitzel et al., 2017). Indeed, community science functions in much the same way that ornithology, as a discipline, did historically (Greenwood, 2007); that is, ornithology was historically supported largely by 'amateurs,' individuals like John James Audubon, who were trained in a non-science subject, but spent their free time studying birds. An elevation of 'professional' scientists over amateur scientists occurred approximately 200 years ago. It has only been within the past several decades that community science has once again emerged as a way for naturalists and the public to contribute to scientific knowledge (Greenwood, 2007).

Ecoliteracy

Despite nearly two decades of working on a unified description of an ecoliterate populace, a unified theory is still lacking. This is largely because of ecoliteracy's diverse roots in ecology, education, and environmental literacy (Orr, 1992; Capra, 1997; McBride et al., 2013). Scientists working in the ecological field began attempting to define a framework for ecological literacy in the mid- to late-1980s (McBride et al., 2013). In 2009, a group of ecologists endeavored to develop a unified definition of ecoliteracy, primarily focusing on ecology-related disciplines (Jordan et al., 2009). In their review of ecoliteracy definitions, Jordan et al. (2009) identify three components of ecoliteracy ecology, science inquiry, and human effects on the environment. In his analysis of ecoliteracy literature, Nichols (2010) identified four components of ecoliteracy: 1) competencies, 2) concepts, 3) sense of place, and 4) respect for others. Pitman and Daniels (2016) identify several components important to describing ecoliteracy, including: 1) ecological processes, 2) human/environment interactions, 3) local place-based knowledge, 4) global/local ecological connections, and 5) the Earth and all its parts.

Community science and ecoliteracy

Community science provides a well-established socio-cultural context in which to understand ecoliteracy as conceptualized by Nichols (2010) and Pitman and Daniels (2016). For example, winter 2019 marked the 120th annual Audubon Christmas Bird Count (CBC). This popular, long-running community science program has origins in competition and wildlife "collection." Today, participants frequently engage in potlucks, dinners, and other celebrations while totaling their species numbers for the day (personal obs.). Friendly competition is common (Cooper & Smith, 2010; National Audubon Society, 2018), and birders of all skill levels are welcome (National Audubon Society, 2018). Additionally, data collection for the CBC nearly always happens in pairs or groups, though solo observations are recorded on occasion, particularly at feeders. This is a very different context from the Breeding Bird Survey (BBS). BBS are surveys conducted by individual birders, all with advanced skill levels (United States Geological Survey, 2018). These surveys are conducted during the bird breeding season, along roadways throughout the United States.

These two contexts alone potentially influence the development of ecoliteracy in Oregon birders in several ways. For example, because of the social nature of the CBC, CBC participants may include individuals with stronger social skills and with higher respect for others than BBS participants (Nichols, 2010). CBC participants may also build a different ecological awareness than BBS participants, in part because of their interactions with other participants. Additionally, motivation to participate in the CBC compared to BBS is potentially different, in that CBC participation may be more extrinsically motivated, while BBS may be more intrinsically motivated.

Methods

Sample Size

To estimate an ideal sample size, I used totals from Oregon's Christmas Bird Counts (CBC). The CBC is one of the most popular community science projects in Oregon. Participant numbers from Oregon's largest count totals about 700 participants (Audubon, 2018). If we assume that smaller counts across the state account for an additional 100 individuals participating, that is about 800 participants in the overall Oregon CBC total. If we also assumes some individuals do not participate in Oregon CBCs, but do participate in other community science projects, we can assume that Oregon has no more than about 900 birders that participate in community science, which is about 0.10% of the estimated birding population (United States Fish and Wildlife Service, 2013).

Because of technological advances, it is possible that eBird (a digital method for maintaining bird lists and collecting community science data) has more Oregon participants than the CBC. Despite this, I chose approximate CBC numbers to estimate an ideal sample size rather than eBird because eBird is not used exclusively for community science. Additionally, birders from around the world can post lists in Oregon, making it difficult to formulate an accurate estimate of Oregon birders using eBird.

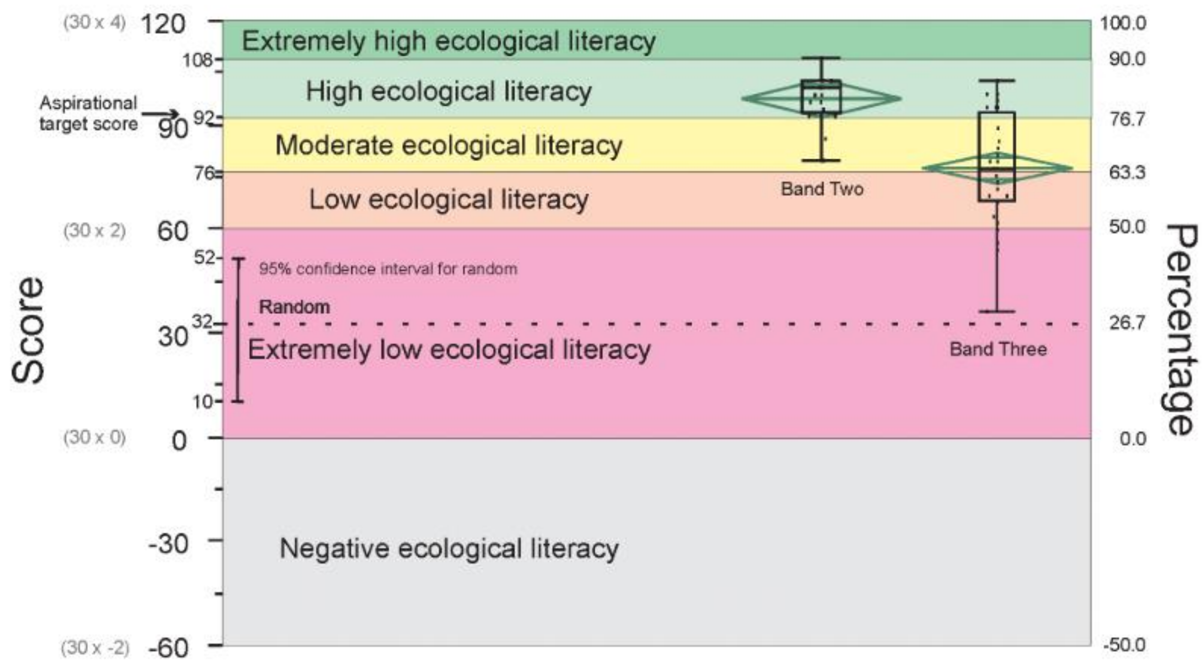
Survey Development

Pitman and Daniels (2016) developed a 30-item survey questionnaire to measure ecoliteracy among South Australians. This 30-item, 120 point, survey questionnaire is multiple-choice. Rather than measuring ecoliteracy in terms of 'right' or 'wrong,' these multiple-choice questions provide a more nuanced understanding of ecoliteracy; the 'most correct' answer is scored 4-points, two 'correct' answers are scored 2-points, the one 'least correct' answer is scored 0-points, and the 'incorrect' answer is -2=points. The questionnaire was developed with the assistance of environmental and ecological scientists in Australia and consists of a combination of regionally specific ecological questions, general biology, and globally applicable questions. To construct a survey applicable in Oregon, I modified the eight regionally specific ecological questions. All modified questions, with the exception of question #30, were kept topically related to the original question (e.g. a question about fire ecology in Australian ecosystems was modified to fit Oregon ecosystems).

Question #30 was modified topically from a question with five photos of sustainable ecosystems in South Australia to a question with five photos of sustainable forest ecosystems in Oregon. These five photos included forests that were overgrown with dense ladder fuels, forests that had been thinned and burned, and forests that had burned at high intensities and are currently shrub fields. I chose these photos because of my interest in research participants perceptions of fire ecology in Oregon forest ecosystems, and because a question about 'sustainable ecosystems' seemed too broad, given Oregon's many diverse ecosystem types (Appendix A). The target score, 92, and several 'ecoliteracy bands' were developed by Pitman and Daniels (2016) during the creation of the questionnaire (Fig. 2.1).

Figure 2.1

Ecoliteracy bands and target score developed by Pitman and Daniels (2016).

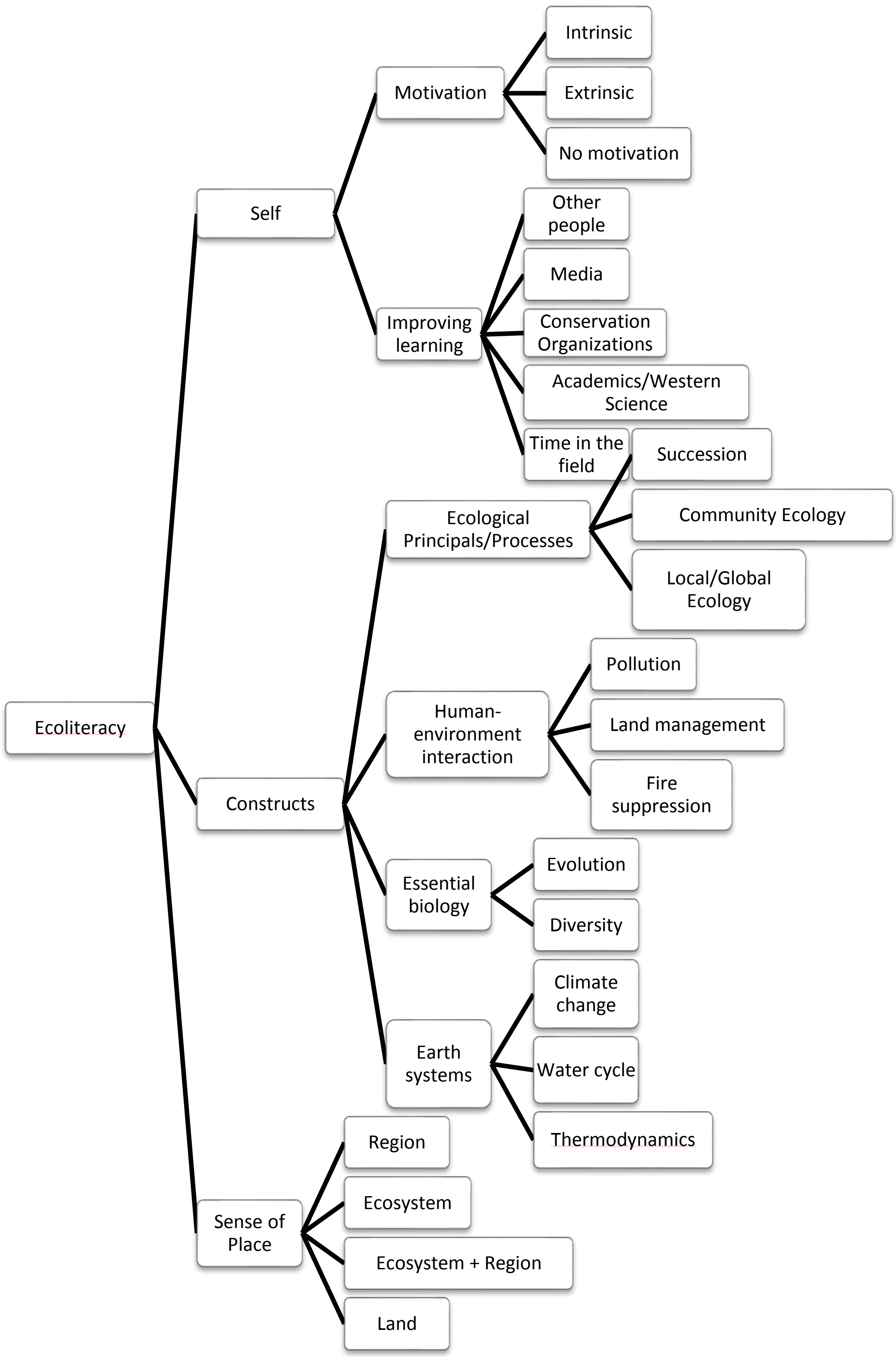


Analysis

This exploratory study collected and analyzed qualitative and quantitative data. Qualitative data from inductive coding (Fig. 2.2) were analyzed in Dedoose (Sociocultural Research Consultant, LLC, 2018). All quantitative data were analyzed in R (R Core Team, 2018) using exploratory analysis, including boxplots, scatterplots, and correlation coefficients, calculated with the cor() function in R (R Core Team, 2018). Means from this study were compared to means from Pitman and Daniels (2016) using a one-sample t-test. Ecoliteracy (ECOS) scores reflect the ecoliteracy score from the modified Pitman and Daniels (2016) survey questionnaire.

Figure 2.2

The ecoliteracy framework used to guide this study and analyze qualitative data.



I used inductive coding to develop the codes for analyzing qualitative data. After an initial reading of open-ended data, I used in-vivo and holistic coding, as described by Saldaña (2015). Holistic and in-vivo codes were grouped into root codes and condensed as much as possible into categorical themes. The resulting 'new' codes were then reapplied to the open-ended data in Dedoose (2018). Finally, codes were separated into frames developed from Jordan, et al. (2009), Nichols (2011), and Pitman and Daniels (2016) frameworks (Fig. 2.2). Codes and frames were analyzed in Dedoose (2018) with the mixed methods analyzer, a tool developed by Dedoose (2018) for comparing qualitative and quantitative data.

Results

Sample

One-hundred birders (approximately 11% of the estimated Oregon avian community scientists) birders expressed interest in participating in this study. Of these, 92 visited the online survey and 66 completed it. Twenty did not fully complete the survey, and six opened the survey link but did not complete the questionnaire at all. Approximately five participants sent emails expressing concern that their answers did not submit properly. Of the 20 birders that didn't complete the survey, several could have been the result of technological errors rather than a conscious decision not to participate. Because the Qualtrics (2018) surveys were designed to be fully anonymous, research participants had to complete the survey in one sitting (i.e. they could not stop-and-start the survey). As a result, it was impossible to 'fix' these issues.

Sixty-six complete responses represent 66% of individuals that expressed interest in participating in the study, and about 11% of the estimated number of birders that participate in community science in Oregon. I was unable to find information about total number of birders that received and read the recruitment letter. As a result, I was unable to estimate a more accurate response rate.

Demographics

Research participants from the >45 age group represented a disproportionately higher percentage of the sample than the proportion of individuals in this age group that identified themselves as birders in a 2011 U.S. Fish and Wildlife Service (USFWS) birding survey (Carver, 2013). This may reflect the demographics of birders that frequent the Oregon Birders Online Listserv (OBOL) and that are members of Audubon Chapters. Increasingly, younger birders are moving away from birding groups like Audubon (Oregon Audubon Council, personal comm.). Additionally, retired individuals are more likely to have time to participate in research projects than individuals still in the workforce.

All research participants in this study self-identified as white, disproportionately high compared with the proportion of white-identified individuals that participate in birding at the national level, 24% according to the USFWS (Carver, 2013). This may be representative of the racial demographics of Oregon; about 85% of the population of Oregon is white, non-Latinx, while only about 61% of the U.S. population identifies at white, non-Latinx. If we include white Latinx individuals in these numbers, the U.S. population of white individuals is 76% (US Census Bureau, 2016). If we add the 17% of birders in the USFWS (Carver, 2013) who identify as Latinx to the 24% identifying as white, the proportion of 'white' birders could rise to 41%, still well below the proportion of white birders in this study. This disparity could be attributed several things, including the distribution method for the survey. It is possible that racially diverse birders are less likely to be members of Audubon or to join the OBOL community, thus using these listservs and chapters for distribution may have missed places that birders of color use for connecting with other birders. It is also possible that because I didn't have the ability to offer the survey in Spanish, I missed Spanish-speaking birders.

Unfortunately, because of a technological issue the questions about gender identity was left off the survey questionnaire for this study. Thus, I cannot comment on gender-related metrics for individuals that completed the questionnaire. Of participants that expressed an interest in participating in this study, it appears the majority, 60%, are female. This is also true for individuals that contacted me to let me know that they had completed the survey. It is important to note that this information cannot substitute for gender-identity data during analysis, because I cannot match research participant emails to answers. More importantly, it would be inappropriate for me to assume gender-identity based on names and emails of participants. Further work needs to be done to understand patterns in race/ethnicity, education, and gender in community science and birders in Oregon.

Research participants in this study all completed at least a Bachelor's Degree and nearly half (47%) completed a Master's degree or above; 25 birders received at least one degree in Natural Resources, Ecology, or Conservation; 12 received at least one degree in the medical field, 10 in another science (e.g. physics or chemistry), and 19 received degrees in another non-science field. Fifty-five percent of research participants identified their bird identification skills at an Intermediate level, 18% at a beginner level, and 27% as advanced or expert levels. Nearly 75% of research participants reported participating in one or more CBC, 60% use eBird for maintaining species lists and/or for collecting data for community science projects, 15% participate in the BBS, 9% participate in a community science project *other* than these three projects, and 6% don't participate in community science.

Finally, most birders that participated in this study (> 75%) mentioned using media (e.g. books, online articles, television shows, etc.) to learn ecological information. Approximately 25% seek new information from other friends, colleagues, or local professionals. Seventeen percent of birders reported reading academic journals or other publications from universities or western science; while 11% contact local conservation organizations, such as Audubon society chapters, to gain new ecological knowledge. This total is great than 100% because participants tend to use more than one source for increasing ecological knowledge.

Ecoliteracy

The mean ecoliteracy score (ECOS) for birders in Oregon was 88.7 (Table 2.1), significantly lower than research participant scores from South Australian environmental professionals (mean = 93; p = 0.0001). Birders with educational and career backgrounds in the ecological field, including biology, and natural resources (mean = 91.2) and birders with educational and career backgrounds in the medical field, such as doctors or anesthesiologists (mean = 92.4) are as ecoliterate (p = 0.07, 0.60, respectively) as environmental professionals in South Australia (Pitman & Daniels, 2016).

Table 2.1

Ecoliteracy among Oregon birders compared to environmental professionals (Pitman & Daniels, 2016).

ECOS statistic	Oregon birders	Pitman & Daniels (2016)
Max	98.00	114.00
Min	56.00	42.00
Mean	88.70	93.00
Standard error	0.88	0.31

All participants scored higher than 32/120, the expected score if participants randomly answered questions (Pitman & Daniels 2016). Sixty-one percent of participants scored under 92, the aspirational target score (equivalent to the lower bound of high ecoliteracy), and no participants scored below 60, the lower bound of low ecological literacy. Approximately 6% of participants scored in the 'low ecological literacy' range. No participants scored over 108, the lower bound of extremely high ecoliteracy, thus, 43% of participants scored in the 'high ecoliteracy' range.

As shown in Fig. 2.3, this exploratory analysis suggests that community science participation may influence an individual's ECOS score. Although the number of years and number or type of projects that an individual participates in do not appear to factor in their ECOS score. Education appears to have the greatest influence on ECOS, through bird identification skills also appear to influence ECOS, which may be an artifact of other variables (e.g. time spent collecting community science data). Individuals with terminal degrees and self-identified expert bird identification skills having the highest ECOS scores (Fig. 2.3).

The qualitative data shows no apparent relationship between place (e.g. sense of place) and ECOS. The disconnect between place and ecoliteracy is reflected in the difference between birder knowledge of Oregon ecological knowledge and global ecological knowledge (Table 2.2). Birders scored higher on questions about global ecosystems than they did on questions about Oregon ecosystems ($P < 0.001$). ECOS scores are strongly correlated with global (cor = 0.93) and moderately with Oregon ecological knowledge scores (cor = 0.57).

Figure 2.3

ECOS scores compared to education level, community science participation, motivation, and bird identification skills.

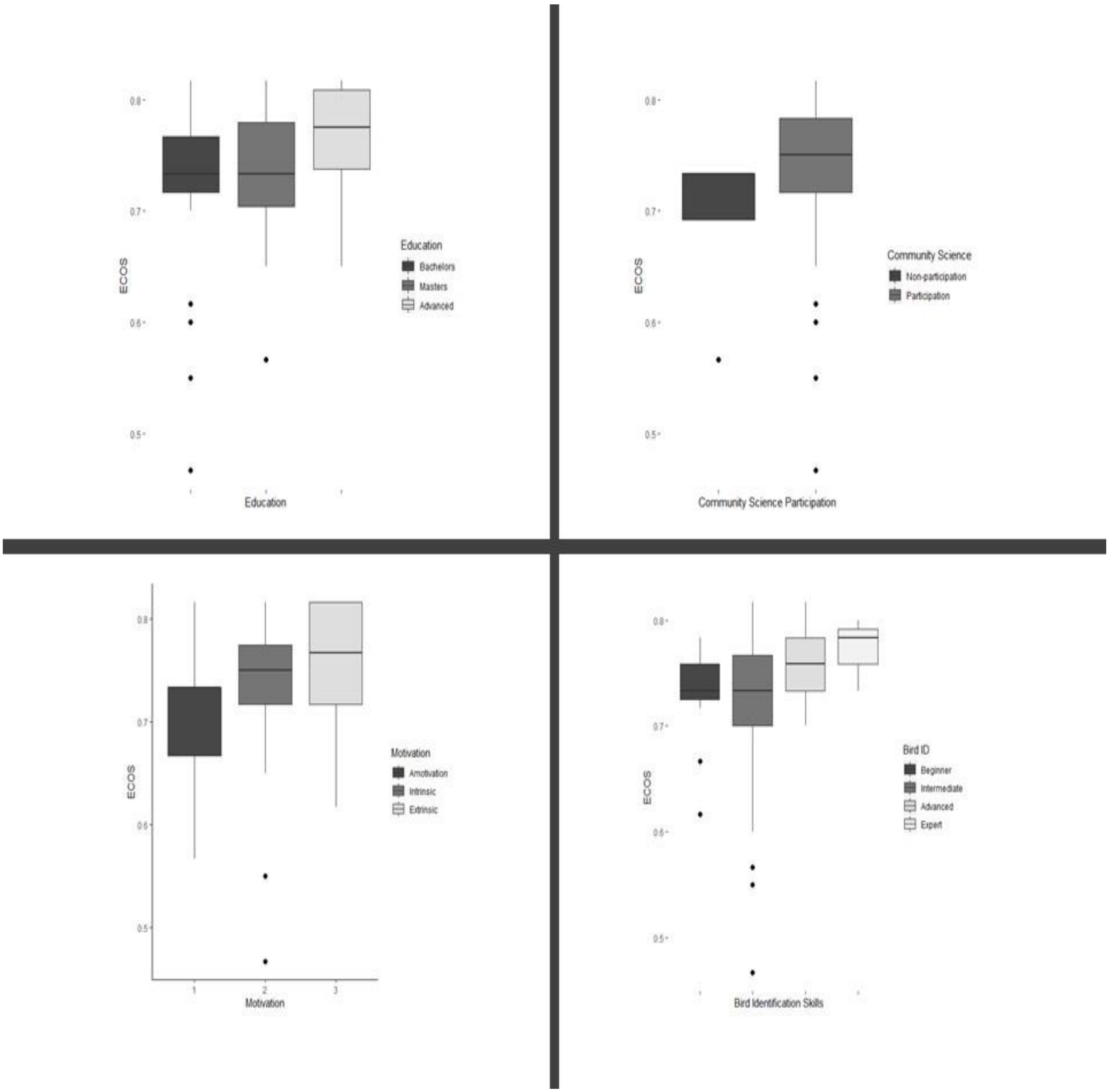


Table 2.2

Oregon, global, and overall ecoliteracy statistics with correlation coefficients.

	OR ecoliteracy	Global ecoliteracy	Overall ECOS
Max	26	78	98
Min	12	42	56
Mean	20	68.2	88.7
Correlation	0.57	0.93	--

Motivation

The majority of participants (79%) reported intrinsic reasons (e.g. contributions to science) as their motivation to participate in avian community science (Table 2.3). Of these, more than half (54%) reported affective motivation, with most expressing love of nature or appreciation of birds; the remainder mentioned cognitive reasons, such as contributing to science or improving bird id skills, as motivation to participate. The remaining participants reported no motivation or extrinsic reasons (11% and 12% respectively), such as supporting a spouse/partner or spending time with friends. Participants that that reported no motivation appear to have the lowest ECOS scores. Birders with extrinsic motivation appear to have the highest ECOS scores.

Quantitatively, motivation has a moderate correlation (cor = 0.54) with participation in community science. Qualitatively, there appears to be a possible relationship between motivation and the number of years of participation in community science, but not the number of community science projects in which a birder participates. In particular, the number of years of participation in community science appears highest in participants that reported ‘contributing to science/conservation/knowledge,’ ‘love for birds/science/nature,’ or ‘care/concern for environment’ as their motivation.

Table 2.3

Subthemes (root codes) and holistic codes for motivation to participate in avian community science.

Subtheme	Holistic Code	Count	Mean ECOS score
No motivation	No response/none	7	84
Intrinsic	Contribute to science/conservation	16	88.8
	Increase knowledge/bird ID	6	
	Listing birds	2	
	*Love of nature	8	
	*It is fun	9	
	*Care/concern for environ	1	
	*Affection for birds	8	
	*Personal interest	2	
Extrinsic	Support partner/spouse	2	90
	Conservation organization	2	
	Job	1	
	Time with friends	2	

* indicates intrinsic: affective motivation

The only project that seemed associated with motivation was eBird, as it is the only project that appears associated with 'Listing birds.' Bird identification skills do not appear to influence motivation type (e.g. intrinsic vs extrinsic). However, individuals in this sample that reported intermediate bird identification skills, were the only participants to include listing birds as their motivation for participating in community science. Intermediate and advanced birders were the only participants to mention motivation to increase knowledge about birds and/or bird identification skills as their motivation for participating in community science.

Ecosystem and ecoliteracy - patterns revealed

Question # 12 on the survey asked participants to describe the ecosystem in which they conduct community science. The types of answers varied from thorough descriptions of the land, including plants and canopy layers, to one-word descriptions of a region or ecosystem type. Despite the differences in detail, most participants that provided some ecosystem description (e.g. didn't leave this question blank or provide an answer that was not an ecosystem description) had average scores within 1-3 points above the mean. Individuals that left question #12 blank had an average ECOS score nearly 10 points lower than the mean. Two-thirds of participants that did not provide an ecosystem description also do not participate in community science.

Participants reported collecting data in multiple ecosystems more often than any singular Oregon ecosystem type (Table 2.4). It appears forests, including westside and eastside forests, but not juniper woodlands, are the most common ecosystem type in which birders collect data, though only five birders reported collecting data in only forests. This is because most birders appear to collect data in multiple ecosystem types. I grouped juniper woodlands with other high desert ecosystems because of their elevation, precipitation, and association with the ecology of the high desert. Participants reported collecting data the least in grassland and marine-associated ecosystems (e.g. near-shore).

Average ECOS scores of participants that collect data in forests were higher than participants that collect data in other ecosystems, including multiple ecosystem types. Scores were lowest for participants that collect data in "human-made" ecosystems. However, there is not a clear relationship between the themes (e.g. region or land) used to describe ecosystems (sense of place). Though, participants that name the region in which they collect data do appear to have higher ECOS scores. From this, it appears that participation in community science has a stronger relationship to ecoliteracy than sense of place.

Table 2.4

Ecosystem themes and holistic codes derived from open-ended responses.

Theme	Holistic Code	Count	Mean ECOS score
Region	City/Town	1	92.6
	PNW, SW, etc.	3	
	Willamette Valley	2	
	Klamath Basin	1	
	OR	1	
Ecosystem Type	Aquatic	2	88.2
	Coastal Areas	6	
	Human-made	3	
	High Desert	7	
	Forest	5	
	Multiple	10	
Ecosystem + Region	Columbia gorge + rangeland	1	88.9
	Willamette Valley + wetlands/prairie	7	
	CA coast + redwoods	2	
	Klamath Mtn ecoregion	1	
Land	Plant species, structure	6	89
	Wildlife + Plants	2	
None	No description/no participation	6	83

Bird population and ecosystem changes

Participants that scored below the target ecoliteracy score (ECOS < 92) appear to have an awareness of bird communities and habitat change that show an understanding of avian ecology not reflected in their quantitative scores. That is, average scores for closed-ended bird-related questions were generally lower than the target score, while open-ended responses indicate a higher understanding of avian ecology than one would expect based on the quantitative scores.

> “We live in a much poorer natural world today than the one I first knew. . .in the 1950’s”
> “There are species that birders feel are less numerous, but without data it can be hard to confirm these impressions.”

Participants were asked to describe changes in the ecosystems in which they collect data, and to describe bird communities in those ecosystems. About 25% of birders who responded said they either have not noticed changes in populations or that they do not feel qualified to answer questions about changes in bird communities. Nearly 50% of the birders sampled said that they noticed expansions in breeding range, changes in migration timing, or declining populations. Responses about bird communities varied markedly, including species-specific responses, e.g. “increasing Eurasian Collard-Doves, declining Mourning Doves,” and more general population examples, e.g. “shift in breeding range in response to warming in general.” Birders that mentioned expanded breeding ranges and/or changes in migration appear to have the highest ecoliteracy, while birders that left the question blank appear to have the lowest ecoliteracy scores.

There appears to be a relationship between participant awareness of the effects of climate change on birds and ecosystems and ECOS. Participants that mentioned climate change and its effects on birds and ecosystems appear more likely to score over the target ECOS score of 92, than participants that mentioned other changes in ecosystems. Most participants that provided answers associated with climate change referenced either an expansion of breeding ranges of birds that historically bred in California or southern Oregon or shifts in migration timing (e.g. birds arriving earlier and/or leaving later).

Discussion

The demographics of this study follow similar trends in community science demographics. Pandya (2012) found that community scientists overwhelmingly represent white, educated individuals. Additionally, community scientists are generally educated at a bachelor's level or higher, over the age of 45, and female. This is largely reflected in the demographics in this study, though the proportions all seem skewed more toward retirement aged and college-educated individuals. The disparity between birders and community scientists is not surprising, particularly since birding is an activity that doesn't have to be expensive and is great for getting outside/connecting with the land.

On the surface, this study supports the findings of other community science and ecoliteracy studies (Evans et al., 2005; Greenwood, 2007; Bonney et al., 2009; Jordan et al., 2011; Crall, Jordan, Holfelder, Newman, Graham, & Waller, 2012). Birders in this study appear more ecoliterate than non-community scientists. Birders appear particularly knowledgeable about bird communities and their relationship to ecosystems and ecosystem changes. However, when ecoliteracy concepts are expanded to include global or general ecological concepts identified as important by western scientists (Pitman & Daniels, 2016), the benefit of participating in community science appears less clear. In fact, in this study education appears to play a larger role in ecoliteracy than participation in avian community science. In particular, individuals with a master's degree or above, even in non-ecological subjects, appeared more ecoliterate than individuals without a master's degree or above. This relationship is worth further exploration, with a larger sample size, perhaps expanded to a region (e.g. the Pacific Northwest), rather than limiting it to a state, as this study did.

While some patterns regarding bird identification skills (a proxy for amount of time spent studying birds/birding), motivation, and ecoliteracy show similar patterns in terms of education level, but more data are needed to confirm this. It appears that birders in this study that identify themselves as experts in bird identification have higher ECOS scores.

Expert birders also identified reasons associated with intrinsic motivation for participating in community science. This may be a function of birders spending time out in ecosystems and observing birds over greater lengths of time. However, this also may be a function of education and/or career. Participants that identified themselves as expert birders also have master's or terminal degrees (e.g. PhD) in biology/ecology/natural resources and worked in these fields. Further research into motivation and bird identification skills will be required to unpack this possible relationship.

Motivation for participating also appears to possibly influence ECOS scores. As with bird identification skills this may reflect a connection between motivation and education. A larger sample size is necessary to determine whether there is a possible relationship. The connection between motivation type (no motivation, intrinsic, and extrinsic) and decision to participate in community science supports the findings of other research (Evans et al., 2005; Crall et al., 2012; Pitman, Daniels, & Sutton, 2017; Tyson, 2019), although in this study the relationship appears mostly associated with no motivation and *not* participating in community science. Barriers to participating in community science (e.g. lack of confidence in bird identification) could be associated with the relationship between no motivation and not participating in community science (Alexandrino et al., 2019). More research, with a larger sample size and exploration into the relationships between birds and individuals who do not participate in community science will help clarify this relationship. Another apparent relationship is that between motivation and the number of years of participation in community science. Other studies have found similar positive relationships between continued participation in community science and motivation (Eveleigh, Jennett, Blandford, Brohan, & Cox, 2014; He et al., 2019). This relationship is worth further exploration in birders, and in other community science projects.

It is worth noting that the approximately 25% of birders that mentioned bird populations as 'stable' or 'okay,' or that mentioned needing more data to confirm population trends, may have responded differently if these data were collected in 2019, rather than 2018. A paper by Rosenburg, Dokter, Blancher, Sauer, Smith, et al. (2019) about declining bird populations in North America was released in 2019 that was shared widely among news outlets, bird groups, and conservation organizations, e.g. Science Friday or Audubon. Because many birders mentioned learning about birds and bird populations through various media sources it seems inevitable that they would have come across one of the many articles published about this study, which may have influenced their responses.

The possible relationship between ecoliteracy and understanding of bird community changes is worth further exploration. As is the connection between ecoliteracy and understanding the effects of climate change. While these aspects of community ecology and ecoliteracy seem like they would be a function of sense of place/place attachment, there does not appear to be a relationship between understanding of the ecosystem birders collect data in (sense of place) and ECOS. The relationship between ECOS, bird community ecology, and climate change may be a coincidence, or a function of the small sample size in this study. Regardless, these relationships support the idea that personal interest in a subject (e.g. birds) may be an important component of learning and building ecoliteracy.

Measuring Ecoliteracy with the ECOS Tool

Overall, participants in this study have a lower ECOS score than Pitman and Daniels (2016) found among environmental professionals in Australia. There are several possible reasons for this finding. First, unlike in the Pitman and Daniels (2016) study most participants in this study did not major in an ecology-related discipline in college, nor do they work in a natural resources or ecology-related field. However, when looking at participant ECOS scores based on education/career, individuals that work in the medical field or biological/ecological field had scores similar to the mean ECOS score in Pitman and Daniels (2016). It would seem that the modified ECOS tool is measuring ecoliteracy equally as effectively in Oregon as in South Australia.

What this may also indicate is that participation in avian community science projects supports some increase in ecological knowledge. While participation in avian community science appears to have some influence on ecoliteracy, there does not appear to be an effect based on the number of years of participation or in number of projects in which a person has participated. Crall, et al. (2012) found a similar relationship between participation in an invasive species community science project and ecoliteracy. However, participants that have achieved advanced degrees in science fields, such as medicine, or studied/work in biological or ecological fields appear more likely to meet the target score for ecoliteracy identified by Pitman and Daniels (2016). This relationship between education and ecoliteracy is supported by other ecoliteracy studies (Pitman & Daniels 2016; Pitman et al. 2017) and community science studies (Evans et al. 2005; Sullivan et al. 2009; Crall et al. 2012; Pandya 2012). In order to understand how education and participation in community science relate to ecoliteracy, and how these variables might interact, further research is needed.

When findings from coded open-ended responses were compared with quantitative data, no apparent patterns between the type of description, or language used in the description, and ECOS scores emerged. Findings for open-ended items indicated more understanding than ECOS scores along. This may be due to the nature of quantitative tools, which are not always sensitive enough to capture all that a person knows.

There is some possible connection between the ecosystem type in which participants conducted community science and their ECOS scores (a more general sense of place appears associated with a higher ECOS), though this connection may reflect the broad content in the ECOS test, as compared to specific content associated with some ecoliteracy studies (Evans et al. 2005; Crall et al. 2012; Bonney et al., 2014). Data showed that participants in this study selected the correct, or most correct, responses on questions about global ecosystems more often than they did on questions about Oregon ecosystems, which may be evidence of this claim. Therefore, in studies focused on a specific ecosystem type or project (e.g. the COASST survey on the Oregon coast) it is possible that the ECOS score will not accurately reflect ecosystem specific knowledge gained from participation. However, if the goal of community science is an increase in overall ecoliteracy, the ECOS tool as modified from Pitman and Daniels (2016) appears to provide a robust assessment.

Limitations

The major limitation of this study is the sample size. Oregon does not seem to have a large population of birders that participate in community science, who also participate in online listservs and are members of Audubon chapters. Because of this, the sample size was likely to be small regardless of recruitment effort. Additionally, without funding for this project, I had to depend on participants that could be reached through email, social media, or Audubon newsletters. A project with funding, that could increase the sample size will provide better information about the relationships between variables (e.g. motivation) and ecoliteracy.

One caveat that should be mentioned here is that several participants emailed me after taking the survey to provide feedback about a few issues with the ECOS tool. The first issue participants mentioned was the format of the questions. In the current format, participants are asked to select the most correct answer for each question. They have five options, four of which are varying levels of correctness (one of these is the most correct) and one of which is incorrect. Participants are scored -1 point for an incorrect answer, 0 points for a mostly correct answer, 2 points for a correct answer, and 4 points for the most correct answer. Several participants noted that they found it frustrating to select one correct answer, rather than ranking the answers. One participant noted that he wanted to know the "right answer" once the questionnaire closed, because he struggled to decide which of the correct answers was most correct. In future studies, it might be helpful to explore scoring methods that will allow participants to rank answers. Though, it is also worth noting that this type of uncertainty is an important part of science. Reducing uncertainty may make participants feel more comfortable, but it may also reduce the ability to understand scientific uncertainty and nuance. Because 82% of participants answered questions with some level of correctness (i.e. answered no questions incorrectly), it seems that this scoring method works well for measuring ecoliteracy, so ranking may not be needed. Meaning the benefit of a ranking system for answering questions largely centers on the comfort of participants.

Another issue mentioned by participants is the grammar and wording of the questions. Specifically, the Australian dialect of English is different enough from the U.S. dialect that some participants found the wording difficult to comprehend in some instances. My goal in this study was to keep the questionnaire as similar to the original as possible. This included only modifying the questions that were specific to South Australian ecosystems and attempting to maintain the grammar and wording throughout the questionnaire. In the future, it would be beneficial to modify the language used in the questionnaire to better reflect U.S. dialects, including English dialects specific to various regions of the U.S. It also would be beneficial to translate the questionnaire into other languages, such as Spanish, to ensure the questionnaire is accessible to a more diverse group, perhaps lending to a more diverse sample.

Conclusions

In summary, an ecoliterate populace is an important part of combating the effects of climate change and an ever-expanding human population (Jordan et al., 2009). To measure ecoliteracy at a large-scale, scientists and educators need a consistent tool, rather than project-specific tools that tend to measure content associated with specific programs or research projects. Pitman and Daniels (2016), created an ecoliteracy tool that measures a broad range of ecological processes, biological information, and human/environment related content. This tool was used to measure ecoliteracy in environmental professionals in South Australia.

I modified the ecoliteracy (ECOS) tool created by Pitman and Daniels (2016), for this study, changing the location specific questions to fit Oregon ecosystems. The modified ECOS tool appears effective at measuring ecoliteracy in Oregon birders. Oregon birders appear less ecoliterate than environmental professionals in South Australia, and more ecoliterate than birders that do not participate in community science. This provides some support for the claim that participation in community science increases ecoliteracy. Though this increase appears largely dependent on the ecosystems in and species with which people spend time.

Birders demonstrate a general understanding of bird community ecology including changes I breeding range and migration timings associated with climate change. Birders also appear knowledgeable about the impacts of humans on the environment. This includes the effects of an increasing population, deforestation, and fire suppression. The broad ecological impacts of climate change were mentioned most often by birders and appears related to an increased ECOS score.

The desire to contribute to science and conservation appears to be the most common motivation for participating in avian community science. Though, motivation doesn't appear to influence ecoliteracy. Intrinsic motivation appears to be a factor in the decision to continue participating in community science. Other factors that indicate time spent in an ecosystem, such as perception of place, or time observing birds, such as bird identification skills, also appear to influence ecoliteracy. Future research into the relationships between education, time spent outside observing birds and/or in a place, community science, and ecoliteracy will help develop and refine projects and programs for promoting ecoliteracy.

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Chapter 3: Second manuscript

Making ecoliteracy less Eurocentric: The development of a critical socio-ecoliteracy framework

Teresa ‘Bird’ Wicks
Intended for publication with:
SueAnn I. Bottoms and Lynn D. Dierking

Abstract

Common frameworks for understanding ecoliteracy include ecological knowledge, science competencies, and, increasingly, a sense of place. To date, few researchers have acknowledged the importance of multiple epistemologies (what does it mean to know something about ecosystems?) in ecoliteracy, and no attempt has been made to measure different ways of knowing, e.g. Indigenous Knowledge, as part of ecoliteracy. Efforts to combine Indigenous, local, and science ecological knowledge still maintain knowledge as an objective effort to find the Truth about ecology/ecosystems.

To better understand a critical socio-ecoliteracy, it is important to explore ecoliteracy through a non-western science lens. In this study, I used a modified ecoliteracy tool to measure socio-ecoliteracy in Oregon birders who participate in community science. Then, using a Critical Pedagogy of Place (CPP), Critical Indigenous Pedagogies of Place (CIPP), and data from Oregon birders, I develop a critical socio-ecoliteracy framework (CSEF); consisting of self, place, and constructs. The data from this study support the inclusion of these three components in a critical socio-ecoliteracy framework. Additionally, CPP and CIPP guided the inclusion of 'relationship,' land (as pedagogy), and epistemology in the CSEF.

Birders that collect data for community science projects in Oregon had low ecoliteracy and moderate socio-ecoliteracy. CSE appears more influenced by psychographic factors, including education and bird identification skills. Perhaps the clearest and most interesting relationship is that between place (place attachment and sense of place). Participants had high place identity, no place dependence, and had slight place attachment. Overall, most birders describe the ecosystem in which they collect data by name (e.g. wetlands or forests). Birders that had the strongest place attachment also appear most aware of changes in bird communities and changes in habitat structure and composition, particularly in response to climate change and human activities.

Introduction

The pursuit of knowledge about nature and the world around us is a characteristic of cultures around the world. In Western epistemologies, i.e. *empiricism*, there is a general belief that with enough empirical study, specifically through the scientific method, the ‘one truth’ of nature and knowledge can be discovered and shared with the public, typically in a “top down” manner (Harding, 1998; Smith, 2012). Because of this, western science tends to privilege objective phenomena over subjective experiences (Harding, 1998; Deloria, 1999; Honderich, 2005; Smith, 2012) This quest for western knowledge, and a desire to share it motivates discussions around ecoliteracy and conservation (Jordan, Singer, Vaughan, & Berkowitz, 2009; Grincheva, 2013; Turrini, Dörler, Richter, Heigl, & Bonn, 2018).

Community science is viewed as an effective method for developing an ecoliterate populace, combating the negative effects of an increasing human population, and largescale destruction of ecosystems (Bonney, et al. 2009; Ceccaroni, Bowser, & Brenton, 2017). To understand the depth and complexity of ecoliteracy it is important to have a robust framework and tool from which to work (Jordan, et al., 2009). Currently, there are multiple ecoliteracy frameworks used by researchers and educators for describing ecoliteracy. While some researchers, e.g. Jordan et al. (2009) propose an ecoliteracy framework that includes socio-ecological components, not all proposed ecological frameworks include ‘non-science’ components (e.g. Bonney et al., 2009). Socio-ecoliterate components are typically centered on the individual, e.g. “ecological habits of mind” in Jordan et al. (2009), and generally reflect western epistemologies and ontologies. That is, these frameworks generally focus on scientific reasoning and empiricism as ways of understanding the world (Smith, 2012; Grincheva, 2013). Ecoliteracy frameworks that are grounded in an empiricist view of the world perpetuate the idea that humans can create a “mirror image” of nature (Harding, 1998; Cajete, 1999).

Missing from many of the conversations about ecoliteracy is a discussion about alternative ways of knowing and the role of culture and/or place in the development of knowledge. Science is frequently presented as monocultural (i.e. western) and is typically exclusionary of other epistemologies and cultures (Harding, 1998; Smith, 2012), or maintains control of how other types of knowledge are included in western science. In an effort to decolonize science and knowledge systems, it is important to develop a more inclusive ecoliteracy framework.

In this aspect of my overall study, I used the frameworks created by Bonney, et al. (2009); Jordan, et al. (2009), Nichols (2011), and Pitman and Daniels (2016), along with Critical Pedagogies of Place (CPP) and Critical Indigenous Pedagogies of Place (CIPP), to guide the development of a critical socio-ecoliteracy framework. To do this, I created a diagram of the four frameworks. I then developed a socio-ecological framework to guide this study. CPP and CIPP provided a lens for data analysis and for the development of a critical socio-ecological framework (CSEF). Specifically, this paper addresses the following questions:

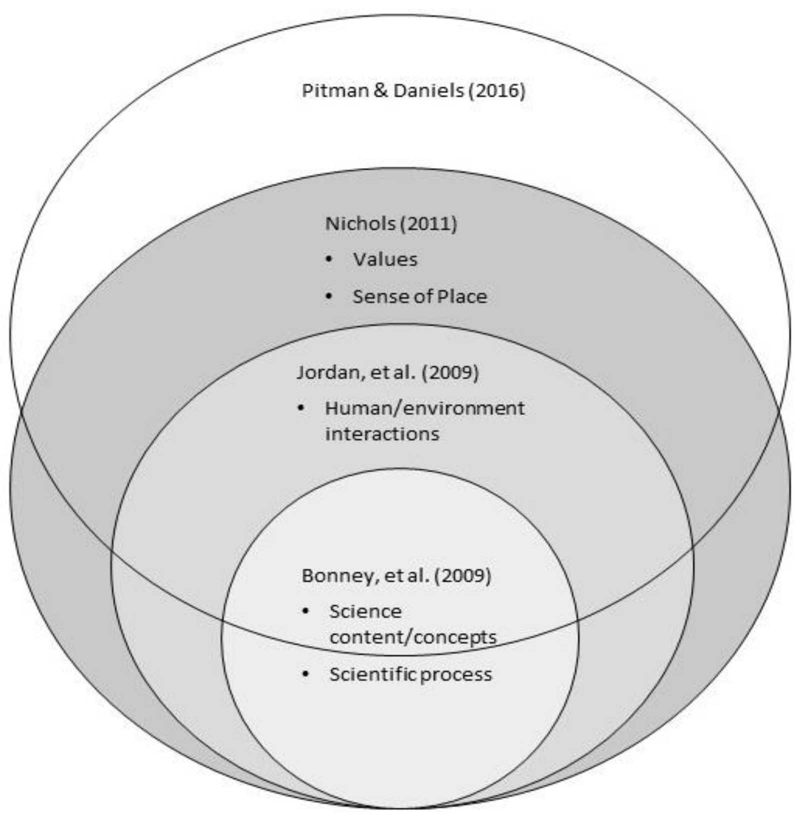
- Can existing ecoliteracy frameworks, Critical Pedagogies of Place, and Critical Indigenous Pedagogies of Place be used to develop a critical socio-ecoliteracy framework?
- What is the role of place in a critical socio-ecoliteracy framework?
- Do the relationships between understanding of ecological concepts, conceptualizations of self, sense of place and community science seem more evident with a critical socio-ecoliteracy framework?
- Does nature connectedness provide a proxy for understanding ontology?

Ecoliteracy frameworks

Ecoliteracy frameworks evolved overtime, eventually incorporating socio-ecological components. Bonney et al. (2009) provide a basic framework for understanding ecological and science knowledge (Fig. 3.1), which includes content/concepts and an understanding of the scientific process. Jordan et al. (2009) developed a framework for ecoliteracy grounded in a western view of ecoliteracy, that includes the interactions of humans and the environment.

Figure 3.1

Combined ecoliteracy frameworks from Bonney, et al. (2009), Jordan, et al. (2009), Nichols (2011), and Pitman and Daniels (2016).



Though, Jordan, et al. (2009) recognize the importance of "cultural background" in interpreting information, they do not include this in their framework of ecoliteracy, rooting their framework in an empiricist epistemology. Pitman and Daniels (2016) do not include scientific processes in their framework, creating an opportunity for the inclusion of other epistemologies in their conceptualization of ecoliteracy.

Nichols (2010) built on the work of Jordan, et al. (2009), using a concept analysis of transdisciplinary literature to develop an expanded concept of ecoliteracy. From this, Nichols (2010) expanded ecoliteracy to include the human, emotional, ecological, and scientific expectations for ecoliteracy. Nichols (2012) built on his "Essential Ecoliteracy" framework (Nichols, 2010) to develop a more detailed "Earth Smarts" framework, that has four components two, of which have a socio-ecological focus, values and sense of place (Fig. 1). While providing a more pragmatic and socio-ecological view of ecoliteracy, this framework still supports an atomistic ontology, dividing the world into smaller, separate, knowable and objective 'Truths.'

The framework created by Pitman and Daniels (2016) is similar to other proposed ecoliteracy frameworks (Bonney et al., 2009; Jordan et al., 2009; Nichols, 2011), in that Pitman and Daniels (2016) mentioned a need to understand/respect others (e.g. cultures), while providing an empirical understanding of ecological concepts focused on western/white perspectives. However, unlike other frameworks, Pitman and Daniels (2016) do not include an understanding of the scientific process as an important part of ecoliteracy (Fig. 1). This gives the appearance that their ecoliteracy framework is grounded in a more pragmatic epistemology (there is no single Truth, and there are multiple paths to 'knowing'). This is further supported by their survey design, which includes a scale of correct answers, from 'incorrect' to 'most correct' (Pitman & Daniels, 2016).

To create a more representative understanding of, and tool for measuring, ecoliteracy it is essential to develop a critical socio-ecoliteracy framework (CSEF), that is inclusive of other ontologies/epistemologies. First, we must understand how place (including geographic places and sense of place), epistemology, and ontology can be incorporated into a critical socio-ecoliteracy.

Sense of place

Indigenous epistemologies include an understanding of knowledge as coming from a place (geographic location) through personal interactions with the land, including knowledge passed on to individuals from the land (Deloria, 1999; Ball, 2002; Smith, 2012; Grincheva, 2013; Simpson, 2014). Nichols (2011) and Pitman and Daniels (2016) identify Sense of Place, or place knowledge/understanding as important components of ecoliteracy. Place as a western concept often refers to a space, a politically defined area, or a geographic location (Johnson, 2012). Because of this, when educators and scientists, using western perspectives, mention place in their research, theories, or curriculum, it is not always clear to which "place" they are referencing. Johnson (2012) describes place as:

> "a way of understanding, knowing and learning about the world; and second, as the embodied location of everyday struggle for meaning; political, cultural and economic" (Johnson 2012, p. 830).

Johnson's (2012) descriptions of place are more characteristic of an Indigenous or local understanding of place, than they of names or place meanings as typically meant by scientists and educators. That is, settlers, like Indigenous peoples, share an experience of place that is "embodied in the everyday struggle for meaning," whereas scientists and educators tend to experience place as either an emotional experience or attachment to a geographic location, or as an ecosystem for learning about the world (Johnson, 2012).

Williams and Stewart (1998) describe sense of place as “the emotional bonds that people form with places (at various geographic scales) over time and with familiarity with those places" and "the awareness of the cultural, historical, and spatial context within which meanings, values, and social interactions are formed.” Thus, sense of place can refer solely to the emotional connections someone feels to a place. It can also mean an awareness and understanding of the history of a place, the changes in of floral and faunal communities, and histories and stories of human inhabitants of that place; including settlement/colonization and the removal of Indigenous people from the land.

One way of understanding sense of place is to measure place attachment (Williams and Steward, 1998). Place attachment often refers to the person-to-place emotional bond a person develops when spending time in a place. This includes constructing an understanding of ecosystems and places by spending time in them. Place attachment also includes elements of place identity and place dependence, important components of sense of place (Williams & Steward, 1998; Semken & Freeman, 2008).

Critical Pedagogies of Place

While learning in and from a place is important for developing place attachment, place-based education and learning typically promotes a colonial narrative (Gruenewald 2008). A Critical Pedagogy of Place (CPP) approach mandates that place-based education includes reconnecting individuals to places while acknowledging the colonial histories of these places. While this is an improvement over many place-based pedagogies, in many ways CPP still fails to address larger historical and current issues faced by Indigenous peoples (Bowers, 2008; Trinidad, 2011; Trinidad, 2012).

To address this issue, Trinidad (2011) proposed combining CPP with Indigenous epistemologies the develop a Critical Indigenous Pedagogies of Place (CIPP). These combined pedagogies expand the concepts of sense of place and place attachment to promote a deeper connection with, and knowledge from the land, and an awareness of potentially harmful colonial narratives. CPP and CIPP promote the concept of *rehabitation*, the re-establishment of intimate connections with and knowledge of a place, particularly the exploitation, colonization, and/or development of that place (Gruenewald, 2008; Trinidad, 2012).

CPP calls for the pairing of rehabitation and *decolonization*, which Gruenewald (2008, p. 9) describes as "unlearning much of what dominant culture and schooling teaches and learning more socially just and ecologically sustainable ways of being in the world." CIPP pairs rehabitation with *indigenization*, the placing of "Indigenous knowledge, worldviews, and concerns at the center of practice" (Trinidad, 2012, p. 5). By combining CPP and CIPP, individuals must think critically about how they live in, and exploit natural spaces, and the built environment (rehabitation); the colonial and elitist ways of thinking that cause harm to people and places (decolonization); how to reclaim Western narratives that have been used to harm or oppress Indigenous peoples; and center Indigenous knowledge, stories, and culture as essential to community ecological knowledge (indigenization).

Indigenous knowledge and epistemologies

Over the past several decades, western scientists have advocated for the incorporation of traditional ecological knowledge (TEK) into western knowledge systems (Deloria, 1999; Kimmerer, 2012; Grincheva, 2013). Lam (2014) proposes that the combination of science and TEK is an effective way to address different ways of knowing within science and society. The term TEK has varied definitions of whose knowledges and epistemologies are included

(Kim, Asghar, & Jordan, 2017), and is often comprised of Indigenous and non-Indigenous knowledge (Huntington, 2000; Kim, et al., 2017).

In many instances western scientists define what TEK matches western knowledge, what knowledge is considered traditional, how TEK is used in management and decision making, and maintain TEK as knowledge separate from canonic science knowledge (Kim et al., 2017). Because of these factors, TEK as a concept is still often grounded in western epistemologies (Deloria, 1999; Ball, 2002; Grincheva, 2013) or maintained as a "lesser" form of knowledge (Deloria, 1999; Smith, 2012). In this study, I am exploring Indigenous Knowledges, epistemologies, and ontologies; and their role in ecoliteracy. To remove possible confusion between Indigenous ecological knowledge (IEK) and local ecological knowledge, I will use IEK to reference TEK, and the worldviews that provide the foundations of IEK.

As proposed by Kimmerer (2012), the integration of IEK and science ecological knowledge (SEK), knowledge developed and held by western scientists, can bring about deeper knowledge and understanding of ecosystems, climate change, and landscape management. SEK is rooted in empiricism/atomistic ontology, the Truth is knowable only through objective exploration and by dividing the world into parts. Conversely, IEK is rooted in interpretivism/relational ontology (Deloria., 1999; Smith, 2012; Grincheva, 2013; Redekkop, 2014), the belief that knowledge is constructed by individuals, through interacting with the land. However, this does not mean interacting with a non-living landscape. Indigenous epistemologies include the understanding that the land gives us knowledge, stories, and ceremony (Ball, 2002; Kimmerer, 2012; Simpson, 2014). It is our relationship with the land (relational ontology), community, and family that help us understand the world and how to 'be' (Smith, 2012; Redekkop, 2014; Simpson, 2014).

Thus, one must take care when incorporating IEK into conservation and land management, particularly because western science mandates objective truths, while IEK mandates an understanding of the world and the relationship within it (Deloria, 1999; Smith, 2012; Redekkop, 2014). Additionally, because there are more than 600 Indigenous Tribes in the United States alone, it is important to note that there is no singular IEK (Kim, et al., 2017). Therefore, it is irresponsible to generalize IEK into ecoliteracy tools. Instead, understanding IEK via ontology (what does it mean to be connected to nature?) and epistemology (how is ecological knowledge developed?) may provide a method for understanding Indigeneity, or representation of Indigeneity, in ecoliteracy, rather than assessing specific knowledge held by a Tribe.

Place relationship and land as pedagogy

The differences between Indigenous conceptualizations of place and western/settler-colonial conceptualizations of place largely stem from ontological perspective (Redekkop, 2014). Indigenous ontologies reflect the relativity – relatedness – reality – relationship understanding of the world described by Deloria. (1999). Relationship defines not only what it is to be connected to a place, it also describes what knowledge is, i.e. relationships between species, or ourselves and species (Deloria, 1999; Kimmerer, 2002; Simpson, 2014). These relationships help individuals to construct their knowledge of a place/landscape/ecosystem. IEK includes place as a part of learning. Grincheva (2013) describes the development of IEK as:

> "knowledge or wisdom is generated inside the communities through individuals' experiences in relation to particular geographic localities which legitimize the past and serve as the main historical evidence for the truthfulness of the stories happened in these places." (Grincheva, 2013; p. 156)

Though, the reality of IEK and place is deeper than described by Grincheva (2013). LeAnn Betasamosake Simpson (2017; p. 155) describes the development of Nishnaabeg knowledge as originating "in the spirit realm, coming to individuals through dreams visions, and ceremony and through the process of gaa-izhi-shaawendaagoziyaang – that which is given lovingly to use by the spirits" of the land.

This pedagogical view of learning and teaching is best described as land pedagogy and is reflected in a Nishnaabeg (also called Anishinaabe, a diverse group of culturally and linguistically-related Tribes and peoples found in the Great Lakes region of what is now known as Canada and the U.S.) story told by Leanne Betasamosake Simpson (Mississauga Nishnaabeg; 2017) in *As We Have Always Done*. In this story, a child watches a squirrel chewing on a maple tree. Curious about what the squirrel is up to, the child observes the squirrel for long enough to realize that it is gnawing holes in the maple that are filling up with sweet sap for the squirrel to drink. This is how the Nishnaabeg peoples began to harvest and consume maple sap. In this story, the squirrel is credited with teaching the child about eating maple sap. For Indigenous peoples, the relationship the child has with the squirrel, and the squirrel with the tree, is an important part of learning, knowing, and 'being' part of a maple forest. This is different from learning *in* a place, which likely still promotes colonial narratives of knowledge and 'Truth' (Ball, 2002; Gruenewald, 2008; Simpson, 2017).

Methods

Recruitment

Birders who collect data for at least one community science project in Oregon were recruited for this study. Research participants were primarily recruited through a recruitment email sent to the moderators of several Oregon bird-themed listservs, such as the Oregon Birders Online Listserv (OBOL). I also sent recruitment emails for distribution to members of

Oregon's 12 Audubon Society Chapters. All birders that received the recruitment email were encouraged to contact me if they were interested in participating in the survey. Birders that expressed interest received instructions and a hyperlink for the online survey questionnaire.

Survey development

I developed the framework that guided this study through the combination of the four ecoliteracy frameworks mentioned previously, into a singular socio-ecoliteracy framework. Because three (Bonney, et al., 2009; Jordan, et al., 2009; Nichols, 2011) of the four frameworks I used divide ecoliteracy into components, I kept the framework divided into separate components, rather than focusing on the relationships between components, as emphasized by relational ontologies and Pitman and Daniels (2016). Though *competencies* are included in most ecoliteracy frameworks, I did not include them in this study, because these competencies tend to emphasize western epistemologies. I included *motivation* as part of this study (Fig. 2), which Nichols (2012) describes as a competency. However, I grouped motivation as a component of self/identity, rather than a competency. This is because other ecoliteracy studies that include competencies focus on methodology and the scientific process, rather than components of self, such as motivation (Bonney, et al., 2009; Jordan, et al., 2009). Self is also included in this framework because it is part of Indigenous conceptions of knowledge, place, and connection to nature (Deloria, 1999).

I measured *concepts* using the modified Pitman and Daniels (2016) ecoliteracy tool (ECOS). This tool is a 30-item, multiple choice survey questionnaire that measures global ecological constructs (22-items), e.g. climate change, and local/regional constructs (8-items), e.g. fire and knobcone pine in Oregon. Research participants are provided five options, one 'most correct' answer (4-point value), two 'correct' answers (2-point value), one 'least correct' answer (0-point value), and one 'incorrect' answer (-2-point value); and asked to select the option they think most correctly answers each question (Pitman & Daniels, 2016).

To reflect the socio-ecoliteracy framework used in this paper, I added tools for measuring sense of place and nature connectedness. I chose Williams & Vaske's (2003) Place Attachment Inventory (PAI) for measuring sense of place because it is a well-tested tool, and because place attachment is considered an effective measure of sense of place as it is generalizable across places, and because the PAI includes measures of place identity and place dependence, elements of which play a role in sense of place (Williams & Vaske, 2003; Semken & Freemen, 2008).

The PAI consists of 12 questions, six about place identity and six about place dependence. These questions are on a Likert-scale, with 1 = strongly disagree, 5 = strongly agree. The last question is reverse scored, for a maximum score of 60. Questions are divided into place identity (PI) and place dependence (PD), each having a maximum score of 30. The target PAI score is 36 and indicates some place attachment. PI and PD target scores are 18, indicating some place identity or place dependence.

Ontology and epistemology are more difficult to assess with a quantitative tool. In this study, I chose to use nature connectedness and open-ended questions to explore ontology. In the open-ended items, I used questions that sought to understand the epistemologies of avian community scientists by asking where individuals seek out new ecological information and how individuals believe ecological knowledge is developed (Appendix A).

To measure nature connectedness, I chose Schultz's (2002) Inclusion of Nature in Self (INS) This tool is an effective measure of nature connectedness (Schultz, 2002). Additionally, INS may serve as a proxy for measuring ontology (what does it mean to 'be' connected to nature), primarily because to include nature in self may require a belief about the world that aligns with Indigenous ontologies and epistemologies (Ahn, Bostick, Ogle, Nowack, McGillicuddy, & Bailenson, 2016). The INS consists of seven images with two circles, one circle represents 'self' and one represents 'nature.' In the first image, the circles are separate, getting closer to each other in each image until the seventh image, in which the circles completely overlap. Selecting the first image is scored with 1-point, selecting the seventh image is scored as 7-points. Open-ended questions in this questionnaire were used to evaluate the usefulness of INS to measure ontology.

Analysis

Quantitative data were analyzed using R (R Core Team, 2018). Open-ended questions were coded using holistic codes and in-vivo codes (direct quotes from participant response). In-vivo codes were generally applied to answers that were difficult to describe with holistic codes. As recommended by Saldaña (2015) holistic and in-vivo codes were grouped into themes, then themes were grouped into frames. Frames were determined by the CSEF used to guide this study (Fig. 3.2). I used Dedoose (Sociocultural Research Consultant, LLC, 2018) to conduct mixed methods analysis, comparing coded and quantitative data. For more details about the analysis, please see Wicks, unpublished dissertation, Chapter 2).

The CSEF scores were created by combining the ECOS, PAI, and INS scores. To calculate correlation coefficients, I converted all point values to the equivalent of 1 point, for a CSEF total of 3-points. For example:

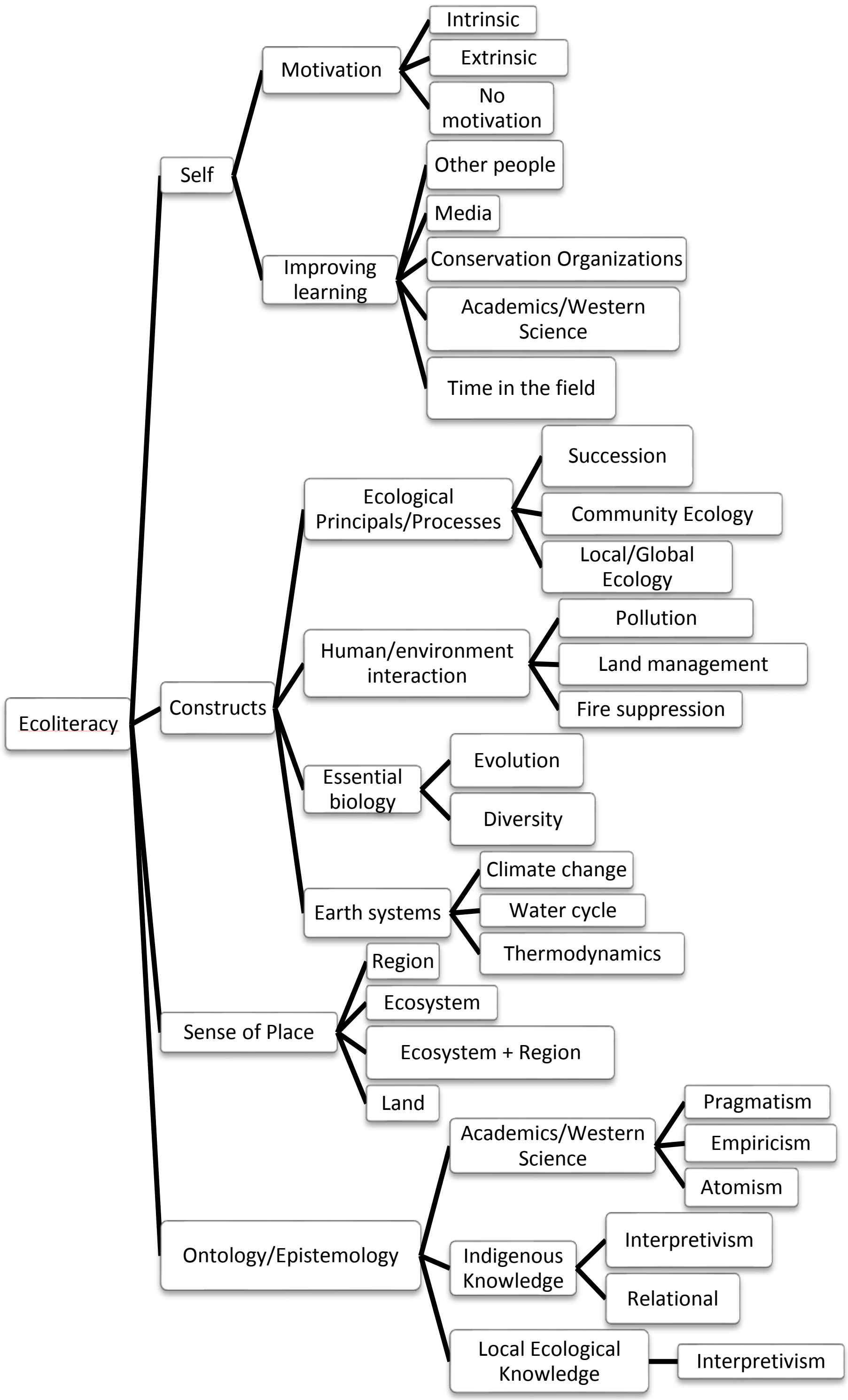
$$\text{CSEF} = (120/120) + (60/60) + (7/7) = 1 + 1 + 1 = 3$$

$$\text{Individual 1: } (94/120) + (33/60) + (5/7) = 0.783 + 0.55 + 0.714 = 2.047$$

Mean converted scores were compared using paired t-tests. For the purpose of clarity, raw scores were used for presenting and discussing results.

Figure 3.2

The Critical Socio-Ecoliteracy Framework (CSEF) developed to guide qualitative analysis.



For the Mixed Methods Analysis, I examined relationships between Codes and Themes, and quantitative scores for PAI, INS, ECOS, and CSEF. PAI scores were analyzed by place identity and place dependency. Individuals that scored below 36 were considered "place averse" while participants that scored 36 and above were considered at least partially "place attached" (Williams & Vaske, 2003; Semken & Freeman, 2008). Individuals that had ECOS scores over 92 demonstrate ecoliteracy (Pitman & Daniels, 2016) and individuals that had CSEF scores over 132 (92 + 36 + 4 = 132) demonstrate critical socio-ecoliteracy (CSE).

Results

Sample size and psychographics

Sixty-six of 100 birders (66%) that expressed an interest in this study, completed the online questionnaire. Based on participant estimates from Oregon bird-related community science projects, this represents approximately 7% of the population of Oregon avian community scientists, and less than 0.01% of Oregon birders.

Participants in this study identified as white, are educated at a bachelor's level or higher, and predominantly over the age of 45. This is a common trend in community science programs (Pandya, 2012) and while it isn't a reflection of birder demographics across North America (Carver, 2013) it is generally reflective of Audubon chapters and bird groups in Oregon (Oregon Audubon Council, personal comm.). Most birders identified their bird identification skills as intermediate; and the Christmas Bird Count (CBC) is the most common community science project for which research participants collect data. Four participants indicated that they do not participate in community science. Thirty-eight percent of birders reported at least one degree in Natural Resource, ecology, or a related field. For more psychographic information, please see Wicks, unpublished dissertation, Chapter 2).

Motivation

The most common reported motivation is intrinsic motivation (e.g. 'Love of nature'). No motivation to participate in community science was primarily reported by birders that do not participate in community science, though three community scientists also reported no motivation for participating in community science. For more information about specific codes, please see Wicks (unpublished dissertation, Chapter 2).

It appears that motivation is influenced by place attachment (PAI), but not by nature connectedness (INS; Table 3.1). Motivation to participate in community science may influence ECOS scores. Birders that reported no motivation to participate (including those that do not participate in community science) in community science have the lowest ECOS score.

Table 3.1

Motivation root codes by quantitative scores components of critical socio-ecoliteracy.

Root code	Count	Mean PAI	Mean INS	Mean ECOS	Mean CSEF
No motivation	7	36.9	4.4	84.3	125.6
Intrinsic: affective	28	38.8	4.7	88.6	132.1
Intrinsic: cognitive	24	32.9	4.8	88.3	126.1
Extrinsic	7	40.7	4.9	90	135.6

Nature connectedness/ontology (INS) does not appear correlated with motivation to participate in community science. Extrinsic motivation (e.g. 'support a partner/spouse') and affective intrinsic motivation appear most likely to motivate birders to participate in community science; cognitive intrinsic motivation appears least influenced by place attachment. CSEF appears highest in birders that reported affective intrinsic and extrinsic motivation, and lowest in birders that reported no motivation to participate in community science.

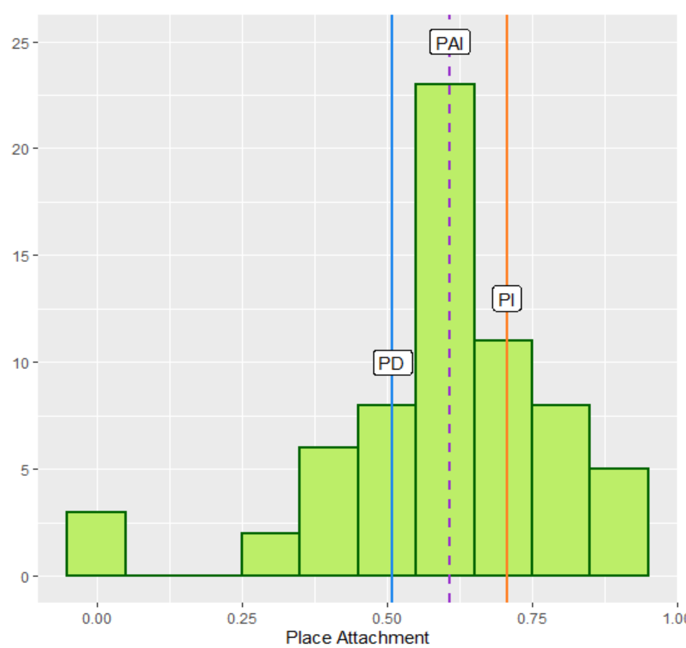
Sense of Place/Place Attachment

The mean PAI score is 36.5, with a nearly normal distribution (Fig. 3.3). Twenty-five participants (38%) demonstrated "place aversion" (Williams & Vaske, 2003) and 41 participants demonstrated some level of place attachment, 20% of which demonstrate strong place connection. Only three participants show an extremely strong place attachment (PAI > 54). More specifically, participants demonstrated a 'place-identity' (mean = 21.2) but no 'place-dependence' (mean = 15.3).

Participants demonstrated greater awareness ($p < 0.0001$) of ecological issues at a global scale (mean = 68.2; max = 88) than at an Oregon focused scale (mean = 20.0; max = 32). Self-described bird identification skills do not appear correlated to place attachment or time spent collecting data in an ecosystem. Participation in community science appears to be positively correlated with place attachment.

Figure 3.3

Place attachment, place identity, and place dependence in Oregon birders



Themes that emerged from qualitative ecosystem descriptions provided insight into how sense of place and place attachment might be related (Table 3.2). PAI scores were highest in birders that provided in-depth descriptions of the land on which they participate in community science. Birders with the lowest PAI do not participate in community science. This may reflect an actual relationship between community science and connection to place but may also reflect the amount of time community scientists spend in the place in which they collect data. While birders whose sense of place appears rooted in the land had the highest PAI score, they did not appear to have higher CSEF scores than participants that described their ecosystems in less detail (e.g. Region).

Table 3.2

Themes in birder ecosystem descriptions compared with scores for ecoliteracy (ECOS), place attachment (PAI), nature connectedness (INS), and critical socio-ecoliteracy (CSE).

Theme	Count	Mean ECOS	Mean PAI	Mean INS	Mean CSE
Region	7	92.6	37.6	5.1	135.9
Ecosystem Type	34	88.2	38.4	5.0	131.6
Ecosystem + Region	11	88.9	33.9	5.1	127.9
Land	8	89.0	42.9	4.6	136.5
No participation	4	83.0	30.3	3.3	116.5

Participants that described the effects of climate change on ecosystems in which they spend time appear to have a stronger place attachment and nature connectedness. Birders that described changes in ecosystems associated with climate change (Table 3.3), and birders that answered questions about changes in bird communities (Table 3.4) by describing population changes (increases or decreases), had the highest PAI scores. Birders that mentioned the effects of climate change on bird populations appear to have higher nature connectedness, while birders that mentioned general population shifts had higher place attachment.

Table 3.3

Ecosystem change codes compared to quantitative data.

Theme	Code	Count	PAI	INS	CSE
Ecosystem Process		*6*	*35.2*	*3.6*	*121.3*
	succession	3			
	erosion	2			
	seasonal change	1			
Human/environment interactions		*25*	*35.7*	*4.7*	*131.4*
	ag increasing	1			
	diversity decreasing	5			
	habitat loss	10			
	increased pollution	3			
	disturbance	2			
	restoration	4			
Climate change		*18*	*42.2*	*5.4*	*139.2*
	changing climate	14			
	increased temp	2			
	decreased precipitation	2			
No		*7*	*32.8*	*4.8*	*125.3*
	no change	3			
	need more data	4			
Blank		*10*	*37.3*	*5.2*	*128.5*

Table 3.4

Changes in bird populations observed by birders in areas they conduct community science compared to quantitative data.

Theme	Code	Count	PAI	INS	CSE
Climate change		*11*	*40.9*	*5.7*	*142.5*
	migration shifts	2			
	breeding shift	9			
Population shift		*24*	*44.3*	*4.7*	*135.8*
	decreasing	11			
	change with habitat shift	11			
	increasing	2			
No		*24*	*36.2*	*4.6*	*131.1*
	cycle, not trend	2			
	need more data	8			
	no change	14			
Blank		*7*	*27.6*	*3.1*	*114.7*

Inclusion of Nature in Self (INS)/Ontology

The mean INS score in this study was 4.7. Forty-four participants (approximately 2/3) selected images that indicate at least some nature connectedness. In general, self-identified bird identification skills do not appear to correlate with nature connectedness. Individuals that participate in community science had higher nature connectedness scores than those that do not participate in community science. If INS is reflective of one's ontology (what does it mean to 'be' connected to nature), then INS scores reflect an ontology that views nature as separate from self. This likely reflects a western epistemology/ontology, dividing the world into parts, rather than focusing on relationships.

INS appears higher in birders that mentioned the effects of climate change on bird populations and ecosystems in which they conduct community science. If INS is an accurate reflection of ontology, birders that mentioned climate change have relational ontologies, while birders that noticed no changes in bird populations or mentioned ecological processes when describing ecosystem changes, have atomistic ontologies.

Participants that demonstrated strong INS and PAI do not necessarily have non-western ontologies/epistemologies. For example, in their answer about ecosystem changes, one participant noted '*People are hard on ecosystems.*' This participant has quantitative scores that demonstrate a strong place attachment and nature connectedness, and an average ecoliteracy. Despite their INS and PAI scores, this participant is demonstrating a *colonial* view of nature and place, grouping all people into the settler-colonial understanding of humanity, land management, and epistemology/ontology. Additionally, the tendency to name things (e.g. plant species) in an ecosystem rather than describing their relationships to each other/the system indicates a need to categorize nature that is common in western epistemologies/ontologies.

Epistemology

The majority of birders that participated in this study have empiricist or pragmatic epistemologies (Table 3.5). Participants with interpretivist epistemologies have the highest PAI and CSEF. As with other components of this study, PAI appears to have a relationship to epistemology; birders who have higher PAI have an interpretivist epistemology. Eight participants described personal interest as a component of ecoliteracy. Though Indigenous epistemologies include self as part of developing knowledge, personal interest appears to be a cognitive motivation rather than a separate component of ecological knowledge. Most of these participants also described the development of ecological knowledge through an empiricism epistemology. Because of this, I left personal interest in the 'other' category, rather than trying to group it within an epistemology.

Table 3.5

Epistemology codes compared with quantitative data.

Theme	Code	Count	PAI	INS	ECOS	CSE
pragmatism		*32*	*36.7*	*4.2*	*88.4*	*131.8*
	experience outdoors	13				
	outdoor school	11				
	birding	1				
	interactions with others	7				
empiricism		*35*	*38.5*	*5.1*	*88.8*	*132.8*
	academics	19				
	sci method	4				
	community sci	3				
	education	9				
	books	3				
interpretivism		*4*	*42.3*	*4.5*	*89.5*	*136.3*
	generational	2				
	local knowledge	2				
other	blank	1	34.0	4.0	92.0	130.0
	personal interest	8	32.8	4.9	86.5	125.4

Critical socio-ecoliteracy

The target critical socio-ecoliteracy score is 133. This is based on an ECOS target of 92, 36 as an indication of some place attachment, and 4 as a score that indicates some level of nature connectedness (92+36+4 = 132). On a converted scale, this is equivalent to a score of 2.1 out of 3 possible points. Forty-two percent of participants scored over the target CSE score. When converted to a one-point scale, CSE scores are lower than ECOS scores (Table 3.6), the same as INS scores, and higher than PAI scores. The mean converted (3-point) CSE score for this sample was 2.0, while the mean raw score was 129.4 (187 points possible).

Quantitative analysis shows a strong positive correlation between CSE and INS (correlation coefficient = 0.89) and PAI (correlation coefficient = 0.81). CSE scores were not correlated with ECOS (correlation coefficient = 0.45). Other than INS and CSE, all converted scores are significantly different ($p < 0.05$).

Table 3.6

Components of CSE converted to a 1-point scale and evaluated for correlation

Component	Mean	PAI	INS	ECOS
CSE	0.69	0.80 **	0.89 -	0.45 **
ECOS	0.74	0.19 **	0.31 *	
INS	0.68	0.48 *		
PAI	0.61			

- indicates a non-significant p-value; * indicates $0.01 < p < 0.05$; ** indicates $p < 0.0001$

As with ECOS scores, CSE scores differed based on community science participation, although a larger sample is required to confirm this possible relationship (Fig. 3.4). There is no apparent relationship between CSE and self-identified bird identification skills. Education appears to have a possible positive influence on CSE.

When CSE scores are compared with themes from the qualitative data some interesting patterns emerge. First, participants that provided 'Land' descriptions when asked to describe the ecosystem in which they spend time observing birds and bird communities appear to have higher CSE scores than other participants, though not higher ECOS scores. As with INS and PAI, birders that mentioned the effects of climate change on bird communities and ecosystems had the highest CSE scores. More broadly, patterns in data become a little less clear, though the influence of place (PAI and sense of place) seems apparent throughout the data. Participation in community science, bird identification skills and education level appear to have a greater influence on CSE than ECOS (Table 3.7).

Figure 3.4

Psychographics of Oregon birders compared with critical socio-ecoliteracy scores.

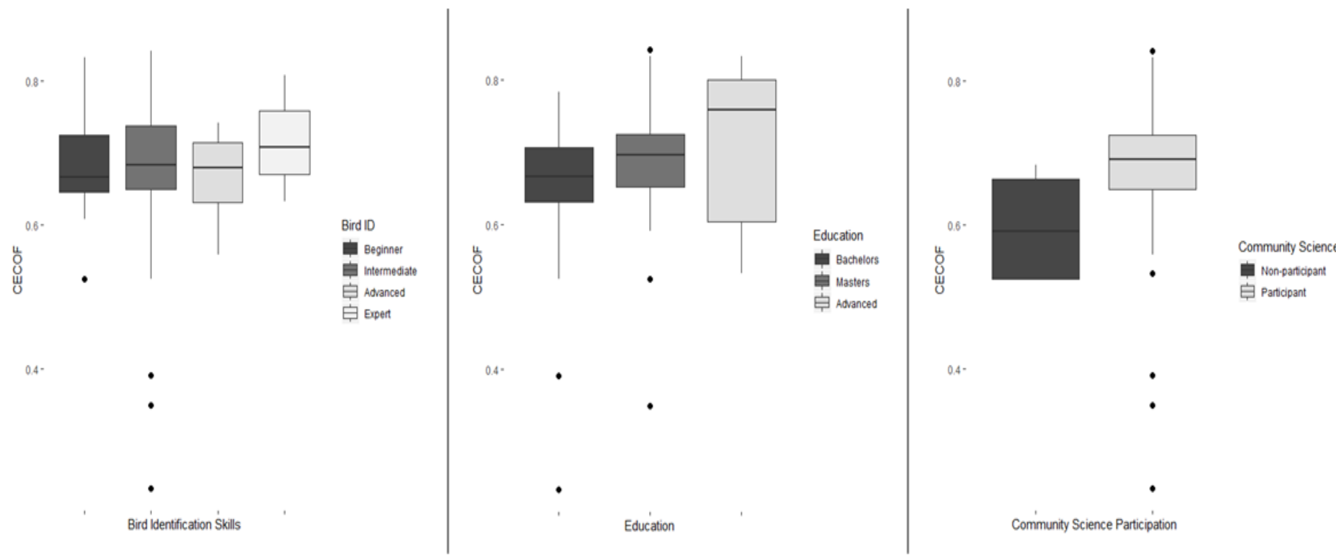


Table 3.7

Psychographic factors that appear to influence critical socio-ecoliteracy

	Community Science Participation		Education Level			Bird Identification Skills			
	Yes	No	Bachelor's	Master's	Terminal	Beginner	Intermediate	Advanced	Expert
ECOS	89.1	83.0	88.0	88.4	91.6	87.5	87.9	90.7	92.7
CSEF	132.9	116.5	130.1	132.6	136.0	130.1	132.0	130.2	138.0

When looking at self (motivation and identity) and how worldview may or may not be influence CSE the possible patterns seem nuanced. For example, one participant described their motivation (intrinsic: affective) as wanting "to collect data for future generations," which is a component of local ecological knowledge. Because local knowledge is constructed in a place, is passed down through generations, and is constructed by individuals and communities, and passed down through generations (Huntington, 2000), I classify local knowledge as interpretivism. However, this participant's epistemological paradigm appears more pragmatic based on their beliefs about how knowledge forms ('time spent in nature, exploring ecosystems'). Finally, this birder provided detailed examples of climate change-related changes in bird communities and changes in habitat associated with human activities.

In another instance, an individual that described "love of birds and science" as their (intrinsic: affective) motivation to participate in community science, but an appears to have an empirical epistemology, stating that ecoliteracy is formed through 'reading publications' and 'data, it is always data.' This birder largely focused on science as a way of understanding ecosystems. Thus, this birder demonstrates a worldview that is more empiricist than the previous birder, though they had similar motivation type. Finally, this birder reported needing more data to describe changes in bird communities and did not describe changes in the ecosystem in which they collect data.

These birders both reported having a master's degree in the sciences, have similar place attachment, nature connectedness, sense of place (ecoregion). The first birder was born before 1965, reported their bird identification skills as advanced, and participates in the CBC and eBird; while the second birder was born before 1980, reported their bird identification skills as intermediate, and only participates in eBird. Despite the similarities in their motivations, psychographics (other than age), place attachment, and nature connectedness, the first birder is highly ecoliterate and highly socio-ecoliterate (96 and 138, respectively). The second birder is moderately ecoliterate and moderately socio-ecoliterate (88 and 130, respectively). By all counts, these birders have similar understanding of place, though the first birder demonstrated a more intimate understanding of the place in which they collect data and the plant and bird communities in that place.

Discussion

The modified ECOS tool (Pitman & Daniels 2016), effectively measured ecoliteracy in Oregon avian community scientists, although it provides only a narrow framework in which to understand ecoliteracy. More specifically, the ECOS framework provides a tool for measuring understanding of western concepts how humans impact the environment. These components are considered important parts of ecoliteracy by ecologists and educators (Jordan at al., 2009; Turrini et al., 2018), making the tool a useful resource for scientists and educators interested in assessing ecoliteracy using a non-critical theory approach.

As in other studies, participation in community science appears correlated with ECOS, however education may have a stronger correlation than community science participation. Knowledge of the ecology of Oregon ecosystems was lower than global ecological knowledge, which may be associated with the fact that 'place dependency' was low, even in birders with some level of place attachment. For researchers interested in measuring and understanding general ecoliteracy, rather than participant knowledge of a specific place, this tool provides a good option.

Place relationships and nature connection

Quantitative analysis shows a stronger correlation between nature connectedness and CSE than other components of the framework. Because the nature connectedness tool is designed to measure an individual's conceptualization of nature in self, it seemed Inclusion of Nature in Self (INS) would be an appropriate measure for ontology (what does it mean to 'be' connected to nature?). Unfortunately, this study does not provide clear support for the use of INS to measure ontology. INS appears to have a mixed relationship with epistemology and with qualitative data.

Possibly the most interesting relationship that emerged through mixed methods analysis, is the relationship between place and CSE. Gruenewald (2008) describes our connection to place as part of our cultural and ecological experience, stating that:

> "cultural experience is 'placed' in the 'geography' of our everyday lives, and in the 'ecology' of the diverse relationships that take place within and between places" (Gruenewald, 2008; p. 137).

In this study, quantitative data show some attachment to place, most of which appears associated with place identity, rather than place dependence. Further exploration of the relationship between place and ecoliteracy components show a different picture, though. Birders that have higher place attachment describe the land on which they conduct community science in greater detail and provide accurate and often in-depth descriptions of ecosystem changes and bird community changes and appear to have interpretivist epistemologies. Because the relationship between place attachment and other elements of critical socio-ecoliteracy, place is clearly an important part of a critical socio-ecoliteracy framework (CSEF), and this study confirms this.

While these data show interesting associations between place attachment, the land, and birder understanding of ecosystems and bird communities, no birders described the land in a way that demonstrated *their own* relationship with place. Instead, participants generally divided ecosystems into their parts (e.g. biotic, abiotic, or species names). Birders seemed to describe relationships only when prompted to describe changes in ecosystems and bird communities. In those instances, the relationships described were superficial, focusing on how bird species composition change with habitat changes, or how climate driven processes are influencing bird population shifts.

Findings do suggest that birders that have higher place attachment pay more attention to the land, and the species that have relationships with the land. However, this does not describe how these birders with higher place attachment live *in* relationship with the land, or how these birders learn *from* the land. The fact that birders seem to connect to the from the ecosystems in which they collect data, more western ways, is supported by birder INS and PAI scores, both of which were marginally higher than the target scores (some nature connectedness and some place attachment, respectively).

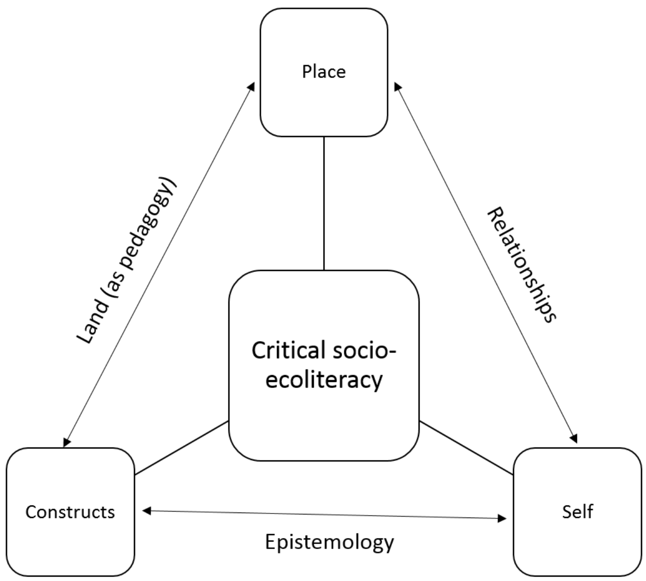
Making ecoliteracy less Eurocentric: a critical socio-ecoliteracy framework

The frameworks supported by ecologists and educators are Eurocentric, focusing on western science methodologies, constructs, and understanding of environmental impacts. Even participants that mentioned value in generational or local knowledge, mentioned that ecoliteracy is formed through largely Eurocentric methods. The difference between the acceptance of these types of knowledge, and the value placed on them, is largely the result of the push for objectivity in science, and the civilizational belief that "modern science is trans – or a-cultural, and thus could not be multicultural or androcentric in any fundamental way" (Harding, 1998, p. 14).

To try to support a more inclusive ecoliteracy, this aspect of the overall study explored the creation of a critical socio-ecoliteracy framework that provides an understanding of ecoliteracy grounded in CIPP. In this framework (Fig. 3.5), the components are all in relationship with each other, rather than distinct components. Each part of the framework is connected to one another, influences each other, and are influenced by each other. Relationships represent ontology in that how one views relationships, and their importance influences perceptions of self and sense of place. These relationships were conceptualized through *indigenization*, *rehabitation*, and *decolonization*, and are currently captured as land (as pedagogy), relationships (relational ontologies), and epistemology.

Figure 3.5

The critical socio-ecoliteracy framework developed from this study.



This study supports the inclusion of three main components: place, constructs, and self (inclusion of nature in, motivation, etc.) in a less Eurocentric, critical socio-ecoliteracy framework. Critical Pedagogy of Place (CPP) and Critical Indigenous Pedagogies of Place (CIPP) guide the conceptualization of relationships between place, constructs, and self. *Rehabitation* insists that we connect people not just to places, but to the land. This study does support the inclusion of land (as pedagogy) in a CSEF.

Decolonization, as described by Gruenewald (2008) insists that we unlearn western ideologies and learn to live in a more sustainable way. Sustainability is part of our relationship with ecosystems/nature. While participants tended to not discuss their relationships with the land, relationships appeared to play an important role in their understanding of ecosystems. This study supports the inclusion of relationships in a critical socio-ecoliteracy framework.

Indigenization, the centering of Indigenous histories, cultures, and knowledges; and acknowledgement of anti-Indigenous rhetoric, was not measured in this study. However, Indigenous epistemologies, which include land and self as part of knowledge, are reflected in many components of this study. Epistemology was also reflected in various data in this study, supporting the inclusion of epistemology in the CSEF.

Limitations

A major limitation of this study is the length of the questionnaire. Because no tools for measuring a more inclusive ecoliteracy framework exist, and because the ecoliteracy tool developed by Pitman & Daniels (2016) had not been used outside of South Australia before, this study had to depend on preexisting tools for measuring an expanded ecoliteracy. It is possible that participants that expressed interest in participating in this study, but did not fill out or complete the questionnaire, decided not to participate after seeing its length.

More work in developing a concise tool for measuring CSEF will be necessary for future studies. This will include possibly reducing the number of items used to address constructs. It is possible that providing a cluster analysis on the items in the ECOS tool will provide information about questions that appear to be measuring similar constructs, ways of thinking, or ecosystems.

A better tool for measuring epistemology may also be helpful. While attitudes do not necessarily measure epistemology, Ugulu et al. (2013) provides a tool for measuring attitudes toward Traditional Knowledge, called the Traditional Knowledge Attitude Scale. This tool includes 'attitudes toward traditional medical knowledge,' 'attitudes toward plant and animal knowledge,' 'and attitudes toward general environmental knowledge.' However, this tool may need some modification from its current form as it is longer than the INS tool and will only add to the burdensome length of the CSEF tool in its current form.

Conclusions

Participants in this study demonstrated weak place attachment and nature connectedness, and moderate ecoliteracy and critical socio-ecoliteracy. The relationship between place and CSEF is most apparent in open-ended items. Findings suggest that strong place attachment relates to place awareness, epistemology, and self/identity. Weak place attachment appears associated with higher global ecoliteracy. Stronger place identity and attachment appear correlated with participation in community science, but participation in community science did not appear correlated with place dependence. This relationship between place, how birders perceive ecosystems, and how ecological knowledge is constructed is reflective of a non-western epistemology. However, this overall pattern may not hold across individuals. For example, individuals that demonstrate strong place attachment, land connection, and interpretivist epistemologies may still uphold colonial narratives of place. An exploration of a specific ecological phenomenon, i.e. participant understanding of, and relationship with fire in Oregon ecosystems, may provide more clarity about these relationships.

In summary, a critical socio-ecoliteracy framework that is not embedded in western science provides a more equitable understanding of ecoliteracy, with the potential to reveal multiple ontological/epistemological perspectives. Multiple perspectives are an important for addressing contentious conservation and natural resource issues, contributing to cognitive diversity, and reducing the likelihood of cognitive dissonance (Kassam, Avery, & Ruelle, 2017). Future work exploring how other intersectional epistemologies, e.g. femme black epistemologies (Hoskin, 2019) can inform a CSEF and strengthen its usefulness for combating the effects of an ever-growing population, and of colonial and elitist narratives in science, education, and ecology. As Roth and Lee (2004, p. 4) note, “science is not a single normative framework for rationality," and neither is ecoliteracy a single, normative framework.

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Chapter 4: Third Manuscript
What do birds teach avian community scientists about fire?

Teresa 'Bird' Wicks
Intended for publication with:
SueAnn I. Bottoms, Lynn D. Dierking, and John D. Bailey

Abstract

Fire suppression efforts, combined with forest management practices, have changed forests throughout much of the west, altering forest structure and fire regimes. Climate change is predicted to increase the likelihood of large fires, particularly without the reintroduction of natural and prescribed fires to the landscape. To gain public support for, and understanding of prescribed burns, forests and climate change, researchers need to find a way to communicate with the public that does not involve merely "spitting the facts" at people. Many ecologists believe that community science provides an effective way for researchers to gather and share information about landscape-level questions, and to teach participants about ecological concepts. Because some communities have an aversion to embracing fire, it could be beneficial to teach the public about fire through a focus on a subject that they have an emotional attachment to, such as birds. This paper explores the fire ecological knowledge of avian community scientists in Oregon using a critical socio-ecoliteracy framework to better understand what birders know and how they know it. I then suggest some methods for creating fire ecology-related community science projects.

Through quantitative data, birders in this study showed only moderate fire ecoliteracy. Qualitative data showed higher fire ecoliteracy, particularly among birders that had higher place attachment and birds that ‘became birds’ (understood habitat, ecosystem changes, and landscape needs through bird communities and populations). Participation in community science appeared to play a greater role in fire ecoliteracy than time spent collecting data in fire-adapted and post-fire habitats.

While fire ecoliteracy appears influenced by place and conceptualizations of self, birders still demonstrated colonially influenced fire narratives, in that Indigenous peoples were either bystanders to fire on the landscape, or managed fire as part of the past, rather than as an ongoing cultural/stewardship practice. To teach people about fire, and to make science

and management less colonial, will require the use of Critical Pedagogy of Place (CPP) and Critical Indigenous Pedagogies of Place (CIPP): rehabitation (reconnecting people to the land), decolonization (removing colonial and elitist narratives from place), and indigenization (the prioritizing of Indigenous knowledge, stories, and histories of the land).

Introduction

Fire plays a crucial role in forest structure and floral and faunal succession in Pacific Northwestern forests (Agee, 1998). Snags (standing dead trees) and injured live trees provide important roosting, denning, and nesting habitat for myriad species of mammals, reptiles, amphibians, and birds (Davis, Goodwin, & Ockenfels, 1983). Before timber extraction and fire suppression began in the late 1800s and early 1900s, dry western forests in Oregon most often experienced low-severity or mixed-severity fires, with moist-higher elevation forests experiencing high-severity fires (Saab & Powell, 2005). Fire suppression efforts in dry western forests have caused fire regimes to shift from frequent low-intensity fires to less frequent high-intensity fires (Agee, 1998). This shift in western fire regimes has led to increased forest stand density and has generally homogenized forest stands and associated landscapes (Agee, 1998; Saab & Powell, 2005). Coupled with fire suppression, salvage logging and fuels treatments (e.g. the removal of dead wood or removing trees from forest stands to thin them) have decreased snag density and availability, decreasing habitat for cavity nesting and early seral (species found in early successional stages in ecosystems, typically dominated by grasses, forbs and shrubs) species (Kotliar et al., 2007). This change in forest structure and composition has created concern for several cavity nesting bird species, including Black-backed (*Picoides arcticus;* Bond, Siegel, & Craig, 2012) and Lewis's (*Melanerpes lewis*) Woodpeckers and Mountain Bluebirds (*Sialia currucoides*) in the interior forests of the western United States (Saab et al., 2007). To restore habitat for these species, many land managers have reintroduced, or are attempting to reintroduce fire to the landscape, through prescribed fires and wildfire management plans that include "fire use" policies rather than the previous fire suppression only policies.

In order to combat the likelihood of large fires, land managers in California have started partnering with Indigenous peoples to combine Indigenous Ecological Knowledge (IEK) and western science, reintroducing Indigenous fire management knowledge, strategies, and methods of forest management (Kimmerer & Lake, 2001; Kimmerer, 2012; Ray, Kolden, & Chapin, 2012; Lake et al., 2017). In many of these instances IEK remains rooted in Indigenous Epistemologies, with Indigenous peoples maintaining control of their knowledge and practices, rather than being incorporated into a fully Western system.

To gain public support for, and understanding of, prescribed burns, forests, and climate change, researchers are seeking ways to communicate with the public that are different from "spitting the facts" and that connect people to fire ecology and landscapes in meaningful ways (Xing, 2012; DellaSala et al., 2015; Newman et al., 2017). One possible strategy for accomplishing this goal is through experiential, place-based learning (Sobel, 2004). For example, through participation in citizen science (Jordan, Singer, Vaughn, & Berkowitz, 2009), more inclusively called community science (e.g. Ballard, Harris, & Dixon, 2018; for more on this, please see Wicks, unpublished dissertation, Chapter 2). However, aversion to promoting fire on the landscape, and the possible public pushback associated with prescribed and wildfires (McCaffrey, 2006), may create a barrier to developing community science programs specifically focused on fire ecology. Experiential learning in a place can provide an opportunity for personal meaning-making (Sobel, 2004). Thus, a community science project that focuses on studying a specific topic, such as bird communities, could provide learners an opportunity to develop an understanding of fire ecology through experience in post-fire landscapes. Personal knowledge development could possibly avoid issues associated with cognitive dissonance, tensions created when individuals hold “two psychologically inconsistent cognitions” (McGuire, 2015), e.g. ‘fire is bad for forests’ and ‘fire is an important part of forest systems.’

Birders that participate in community science spend time in ecosystems, learning about where and when to find various bird species. Because some birds, e.g. Black-backed

Woodpecker, it seems possible some birders have learned about the role of fire ecosystems. This connection to birds may influence their beliefs about the value of fire on the landscape. In this aspect of my overall study, I explore what birders know about fire in Oregon ecosystems, using the CSEF framework to explore the how the parts of a CSEF might influence fire ecoliteracy, and perceptions of fire's relationship to the places in which birders spend time collecting data. I specifically asked:

- What do Oregon avian community scientists (birders) know about fire in the ecosystems they collect data in?
- Are birders more knowledgeable about the role of fire in ecosystems in which they collect data than in other Oregon ecosystems?
- How can this information be incorporated into future community science projects?
- How do the components of a critical socio-ecoliteracy framework inform our understanding of fire ecological knowledge in birders?

Fire in Oregon

Pre- and during-settlement of the West, ponderosa pine forests and oak woodlands of Oregon were dominated by large open forests with a variety of shrubs, grasses, and herbaceous vegetation in their understory. These conditions were generally maintained by the diverse Indigenous Tribes/Nations that lived in or near these forests (e.g. Kalapuya in what is known today as the Willamette Valley, and the Molalla in the ponderosa pine forests of what is known today as central and eastern Oregon). Pacific Northwest Tribes used either naturally ignited (from lightning strikes) or human ignited fires to burn the understory of these forests, reducing ladder fuels (fuels that carry fire into the crown of a tree), promoting the growth of herbaceous plants (e.g. *Camassia spp*), and creating forage for game animals, such as mule deer (Kimmerer & Lake, 2001). Indigenous management of Oregon's ecosystems, including the use of fire, was not an end-point, or example of humans "dominating" nature, rather it was viewed as a reciprocal act of caring for the relatives that sustained the People (Deloria, 1999; Kimmerer, 2000; Simpson, 2014).

Post-settlement, Oregon's forests were largely managed under a policy of fire suppression (United States Forest Service, 2018), which led to increased tree density and an increase in ladder fuels, particularly in ponderosa pine forests and oak woodlands (Agee, 1998). Other fire-adapted forests in Oregon, e.g. Douglas fir (*Pseudotsuga menziesii*) dominated forests, were frequently clear-cut and maintained as even-aged monocultures for future harvest (Allen, et al., 2019). These management decisions came from the western belief that humans can, and should, shape nature to fit their desires, as a material for meeting human needs (Deloria, 1999; Calderon, 2014; McCoy, 2014).

Indigenous peoples and fire

Fire is an important management tool used by Indigenous peoples throughout the world (Huffman, 2013). Enmeshed in this reciprocal relationship (plants sustain us, we sustain them) with fire is an in-depth understanding of the link between fire, fungus, plants, and animals; seasonality of fire, fire severity, time-since-fire, and place. Inherent in this knowledge of fire, is Indigenous land-education, and land-relationships. That is, Indigenous peoples learn about fire and how to care for the land from the land (Kimmerer, 2000; Kimmerer & Lake, 2001; Tuck, McKenzie, & McCoy, 2014; Simpson, 2017). Indigenous Ecological Knowledge (IEK) includes learning how to manage the forests, prairies, and woodlands of Turtle Island, the Americas (Lake et al., 2017) and the use of fire-spreading as a hunting strategy by raptors in Australia (Bonta et al., 2017).

When Europeans colonized the Americas, they saw Indigenous fires as destructive forces and outlawed these Indigenous-prescribed burns (Kimmerer & Lake, 2001; Lake et al., 2017). More than 60 years after Indigenous burning was ended by settlers, the fire season of 1910 was particularly bad, burning more than 5 million acres (Egan, 2009; Forest History Society, 2020). Land managers, specifically the U.S. Forest Service (USFS), implemented an 'out by 10' fire suppression policy. According to this policy, the USFS required that all fires be contained or suppressed by 10:00 a.m. the morning after they start (US Forest Service 2018). These fire suppression efforts, combined with European forest management practices, effectively removed fire from much of the western landscape, allowing fuels to build up, changing the structure of forested ecosystems, and altering fire regimes throughout the Americas (Agee, 1998; Kimmerer & Lake, 2001; Bilbao, Leal, & Mendez, 2010; Crawford, Mensing, Lake & Zimmerman, 2015; Allen, Chin, & Zhang, 2019). Current forest management efforts still include fire suppression, though USFS and other agencies are attempting to introduce more prescribed fire on the landscape, including 'prescribed' wildfires, also called a 'let it burn' policy (USFS, 2018). Climate change is predicted to increase the likelihood of large fires, particularly without the reintroduction of fire to the landscape (Abatzagolou & Williams 2016).

Ecoliteracy and community science

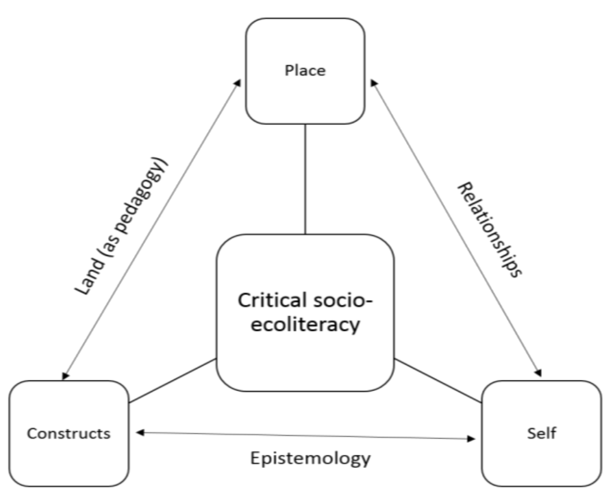
An ecoliterate society is increasingly acknowledged as an important component of a sustainable future (Jordan et al., 2009; Nichols, 2010). This requires community members that understand 1) ecological concepts and connectivity, 2) diverse ecological issues and knowledge systems 3) the human-ecosystem connection, and 4) social and environmental justice (Jordan et al., 2009; Nichols, 2011; Pitman & Daniels, 2016; Wicks, unpublished dissertation, Chapter 3). Many frameworks for ecoliteracy include an understanding of the scientific method and scientific ways of thinking (Evans et al., 2005; Jordan et al., 2009; Reynolds & Lowman, 2013). These frameworks tend to privilege western ways of knowing over other ways of knowing, which can conflict with understanding social and environmental justice and valuing/respecting other ways of knowing.

One method for increasing ecoliteracy, and diversifying ecological knowledge is through community science. Participants in community science projects demonstrate increased ecoliteracy associated with content specific to their projects (Evans, et al., 2005; Bonney et al., 2009; Jordan, Gray, Howe, Brooks, & Ehrenfeld, 2011), though education may influence overall (non-content specific) ecoliteracy more than participation in community science (Wicks, unpublished dissertation, Chapter 2). Community science and education appear to play a similar role in critical socio-ecoliteracy (Wicks, unpublished dissertation, Chapter 3).

Critical socio-ecoliteracy (CSE; Fig. 4.1) is a socio-ecoliteracy grounded in Critical Pedagogy of Place (CPP) and Critical Indigenous Pedagogies of Place (CIPP) and includes three components: place, self, and constructs. These components are influenced by epistemology, land (as pedagogy), and relationships. In this framework, the three components are all in relationship, rather than distinct components, since the components influence each other and are influenced by each other. In this framework, relationships represent ontology, in that how one views relationships and their importance influences perceptions of self and sense of place.

Figure 4.1

Diagram of a critical socio-ecoliteracy framework (CSEF).



Ecological Knowledge

The belief that community scientists, such as birders, learn about ecosystems from spending time in a place is one that has become an important part of science and education discourse over the past 20 years or so (Sullivan, Reynolds & Lowman, 2013). Several studies have identified the importance of including Traditional Ecological Knowledge (TEK) in management decision making, conservation, and education (Huntington, 2000; Kimmerer, 2000; Moller, Berkes, Lyver, & Kislaliogh, 2004; Pandya, 2012). Within the science community, TEK includes Local Ecological Knowledge (LEK) passed down through generations by non-Indigenous individuals (Huntington, 2000) with Indigenous Ecological Knowledge (IEK), knowledge that comes from the land, passed down through generations, that comes from living in a place since time immemorial. The combination of LEK and IEK potentially removes Indigenous epistemologies as the basis of TEK, promoting the inclusion of Western epistemologies as a form of tradition, ignoring land-based pedagogies. Because this study emphasizes Critical Indigenous Pedagogies of Place (CIPP), as an important component of fire education and community science, I focused on IEK over TEK or LEK.

Critical Indigenous Pedagogies of Place and land education

Place, as used in environmental education and outreach, is an idea that frequently expresses the land ethics of settler colonial groups (Calderon, 2014), largely because even place-based education is often rooted in western scientific epistemologies presenting knowledge as something objective and nature as something knowable and separate from humans (Deloria, 1999). Indeed, historic definitions of place, which include affective attachments or relationships and an individual's "lived experiences" (Newman et al., 2017), don't go far enough in engaging Indigenous pedagogies (Calderon, 2014). Gruenewald's (2008) Critical Pedagogy of Place (CPP), calls for re-establishment of intimate connections with and knowledge of the land (*rehabitation*) and shifting our epistemologies and pedagogies from the dominant culture and colonial or elitist narratives, to epistemologies that are more socially and ecologically just (*decolonization*), still tends to avoid the centering of IK, experiences, and histories (*indigenization*) that are necessary for truly understanding a place (Trinidad, 2012; Calderon, 2014). Land education, rather than place-based education, meets the goals of decolonizing and indigenizing place, and requires an acknowledgment of the inexorable link between place, settler colonialism, and genocide of Indigenous peoples (Calderon, 2014).

Land education differs from place-based education in several ways. The primary difference is that places are not defined the same way by all stakeholder groups. Place can be defined by geographic boundaries, e.g. the Harney Basin; political boundaries, e.g. Harney County; or by cultural boundaries, e.g. Wadatika Paiute homelands of present-day southeastern Oregon. Because of this, not all people are describing the same thing when they talk about place. Land education centers land as teacher (Simpson, 2017). In Indigenous epistemology this is a literal interaction. The land might transfer knowledge, or ceremony, through a squirrel (e.g. teaching a Nishnaabeg youth to harvest and eat maple syrup; Simpson, 2017) or might learn how to manage a landscape through First Foods ceremonies and a reciprocal need to care for the ones that take care of you (Quaempts, Jones, O'Daniel, Beechie, & Poole, 2018).

Methods

Recruitment

To explore what Oregon birders know about fire and how a CSEF might provide insight into this 'fire ecoliteracy,' I developed an ecoliteracy tool, a survey questionnaire that could be administered online. I recruited research participants through email, social media, or Audubon newsletters. Recruitment letters were sent to Audubon Society chapters, regional bird listservs (e.g. mid-valley birders online), and the Oregon Birders Online (OBOL) group.

Birders were instructed to email me if interested in participating in the survey. Individuals that expressed an interest in participating in this study were sent instructions and a link to the Qualtrics (Qualtrics, Provo, UT) survey questionnaire.

Approximately 100 individuals expressed an interest in participating in this study (Wicks, unpublished dissertation, Chapter 2). Of these, 92 accessed the survey and 66 completed the survey. Twenty individuals started the survey but did not complete it and six opened the survey but did not complete any of the survey questionnaire. This may have been a result of confusion associated with technological difficulties (e.g. some participants reported that the survey did not display in a user-friendly way on their tablets).

Survey development

The survey questionnaire consisted of 58 items (Appendix A). Items 1-8 asked about demographics and psychographics, community science participation, and bird-identification skills. Open-ended items, 9-15 centered on participant perceptions of the ecosystems in which they spend time, observed changes in bird communities and ecosystems, understanding of fire ecology, science experience, where research participants seek new ecological information, and participant views of how science knowledge is developed. Items 16-45 consisted of 30 multiple-choice items designed to measure ecological constructs (ECOS), modified from Pitman and Daniels (2016), and items 46-58 Likert-scale items that measured sense of place and nature connectedness.

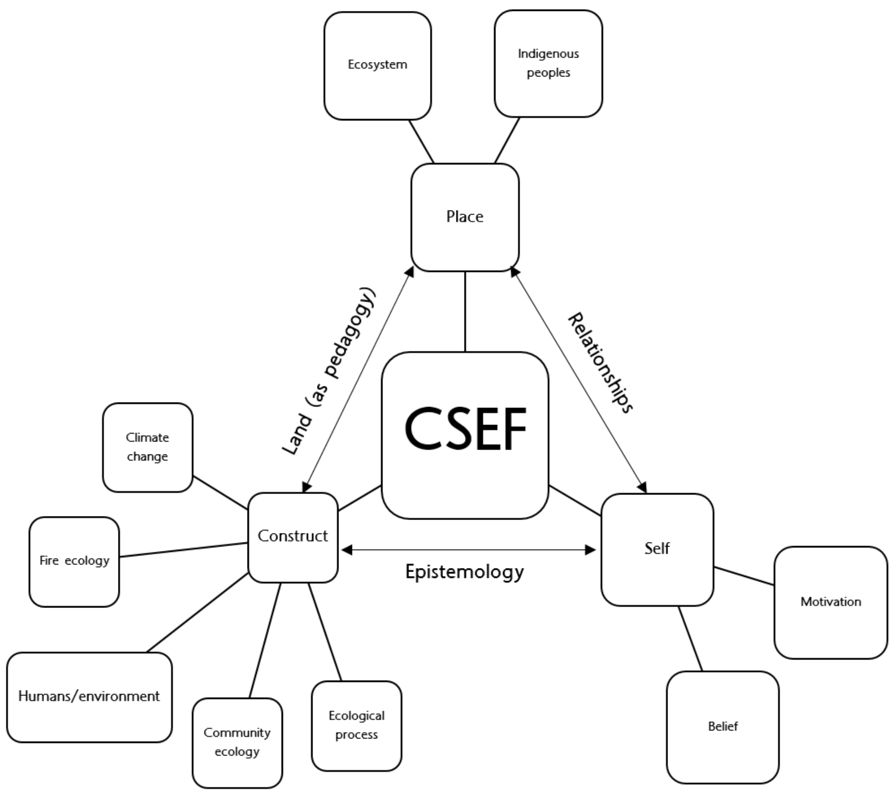
I used the Place Attachment Inventory (PAI) from Williams and Vaske (2003) to measure sense of place and Inclusion of Nature in Self (INS) from Shultz (2001) to measure nature connectedness. Six of 30 ecoliteracy questions modified from Pitman and Daniels (2016) directly or indirectly measure participant understanding of fire ecology and the role of fire in Oregon’s ecosystems.

Analysis

I coded open-ended questions with holistic and in-vivo codes as described by Saldaña (2013). In-vivo codes were assigned to participant answers, or parts of answers, that didn't seem to fit into holistic codes. Holistic codes were grouped into themes, which were grouped into frames from the CSEF, i.e. constructs, self, and place (Fig. 4.2). Codes were not grouped into frames associated with land (as pedagogy), self, and relationships as they describe how culture and worldview influence the links between components.

Figure 4.2

Coding frame generated from open-ended items and the critical socio-ecoliteracy framework.



Close-ended questions were analyzed using exploratory analysis in R (R Core Team, 2018). Open-ended and close-ended answers were compared using mixed methods analysis in Dedoose (Sociocultural Research Consultant, LLC, 2018). Mixed methods included comparing quantitative scores with holistic codes, themes, and frames to determine patterns in the data. The maximum possible fire ecoliteracy score is 15, with a score >10 indicating a "fire literate" individual and <10 indicating low fire ecoliteracy.

Results

Participant demographics and psychographics

Sixty-six research participants completed the online survey questionnaire. Research participants identified as white, predominantly over 45, and all reported having at least a bachelor's degree. Twenty-five (38%) research participants majored in an ecology or natural resources-related field. The majority of participants categorized their bird identification as intermediate and 62 research participants collect data for at least one community science project, the most common of which was the Christmas Bird Count (for more detailed information, please see Wicks, unpublished dissertation, Chapter 2).

Fire ecoliteracy

The mean fire ecology score was 8.45, with 14 individuals (21%) demonstrating fire ecoliteracy (Fig. 4.3). Understanding of fire ecology does not appear influenced by time spent in fire-adapted ecosystems, e.g. ponderosa pine forests or oak woodlands (Fig. 4.4). Twenty-four participants indicated that they collect data in areas that have experienced fire and provided answers to questions about fire with some level of correctness > 60% of the time. These participants do not appear more ecoliterate than participants that do not spend time in post-fire landscapes ($p = 0.76$).

Figure 4.3

Fire ecoliteracy scores compared with time spent in post-fire habitat.

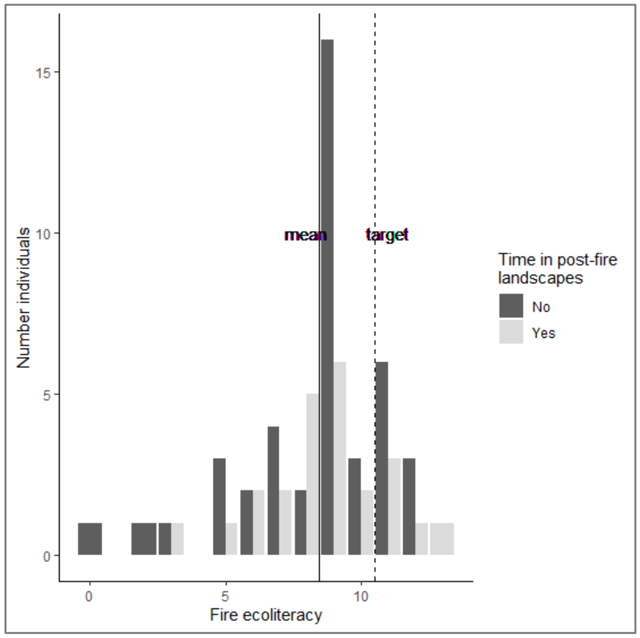
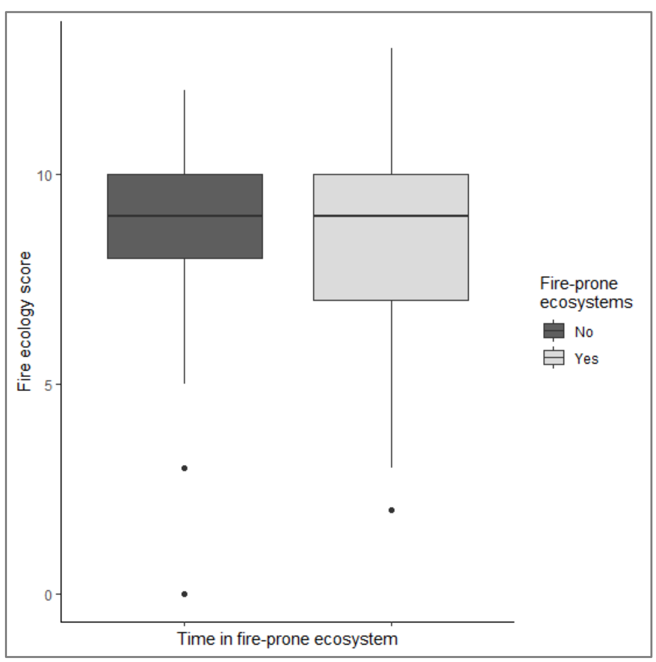


Figure 4.4

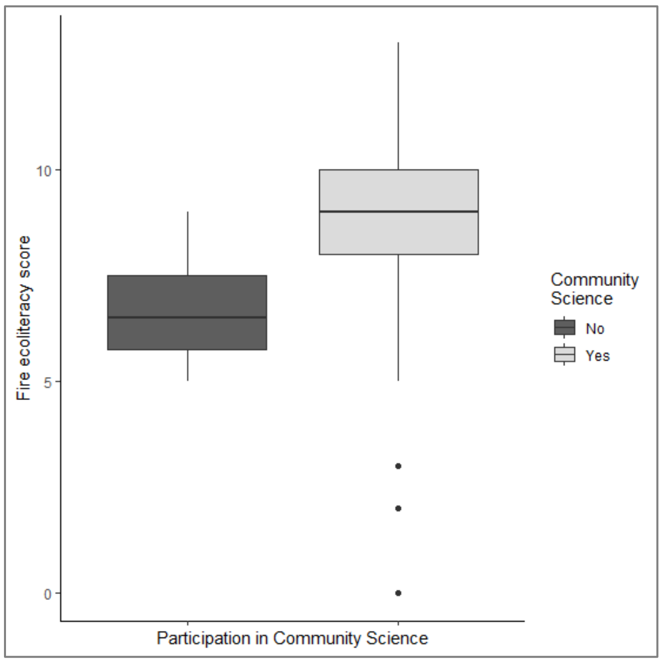
Time spent collecting data in post-fire habitat compared with fire ecoliteracy.



Thirty-six participants indicated they do not collect data in areas that experienced fire, describing fire in Oregon ecosystems in general. Individuals that participate in community science appear to have a greater understanding of fire ecology than participants that do not (Fig. 4.5). There appears to be no relationship between fire ecoliteracy and education, place attachment or nature connectedness.

Figure 4.5

Influence of participating in community science on fire ecoliteracy



Open-ended items about fire were focused on fire's relationship with birds in the places in which birders collect data and about the role of fire in Oregon ecosystems. However, several birders did not mention fire ecology, instead mentioning beliefs or attitudes about fire, such as the impacts of fire on humans.

Nine participants mentioned the pre-contact history of fire in Oregon. Approximately half of these people mentioned Natives as bystanders, e.g. 'fire is natural in this ecosystem, happening before human involvement/intervention.' The other half mentioned Native use of fire to maintain ecosystems for "forage" crops. Only one participant named the tribe associated with the place in which they collect data and no participants mentioned Indigenous Peoples in the present tense.

Codes associated with 'Natives as managers' were primarily from the Willamette Valley, where considerable work has been done to reintroduce fire to oak woodlands and prairies (e.g. prescribed burns at William L. Finley National Wildlife Refuge). As part of this reintroduction, land managers and educators have made a point to communicate the historic use of fire by the Kalapuya (personal observation).

Birder understanding of fire largely centers on post-fire habitat structure, succession, and bird community changes. There appears to be some understanding of the links between changes in fire regime and fire suppression, and between current fire intensity and size, fuels, and prescribed burns. Finally, there appears to be an awareness of the future effects of climate change on fire ecology and Oregon forests. There were a few incorrect conceptions about fire, including that it 'reduces insect outbreak.'

Constructs

When addressing open-ended items about fire in Oregon ecosystems, birders mentioned *constructs* (Table 4.1), particularly ecological processes, such as succession, and community ecology, specifically 'changes in bird communities associated with post-fire habitat.' Of the responses describing how bird species change with post-fire habitat most discussed woodpecker ecology, e.g. 'Many of our woodpeckers require fire before moving into an area.'

Table 4.1

This table shows fire ecology codes grouped by frame and compared to CSEF and Fire ecoliteracy scores.

Frame	Theme	Count	PAI	INS	ECOS	CSEF	FIRE
construct		39	39.1	4.5	90.9	133.5	8.4
	comm eco						
	eco process						
	fire ecology						
	climate change						
	humans/environment						
self		34	37.1	4.2	89.0	131.2	8.0
	motivation						
	belief						
place		12	39.8	5.2	90.5	135.6	8.0
	ecosystem						
	indigenous peoples						

Fire ecoliteracy scores to not appear influenced by the code frames (i.e. how someone described the effects, or role, of fire in the places in which they collect data. As in Wicks (unpublished dissertation, Chapter 3), individuals that described the effects of climate change on fire appear to have higher place attachment. There is no clear pattern between qualitative and quantitative fire scores. For example, one birder provided a description of fire in Oregon ecosystems by stating:

"burn areas present new ecosystem niches and can thereby increase species diversity at the landscape level."

This birder's fire ecoliteracy score was 5, which would imply this birder is not fire ecoliterate. However, their awareness of fires role in creating habitat for different species, and of the place/landscape level importance of fire suggests this birder is, indeed, ecoliterate.

Interestingly, all birder that have high fire ecoliteracy have qualitative data that supports their fire ecoliteracy.

Self

The number of individuals that described changes in ecosystems associated with fire by describing a component of *self*, such as personal interest, a belief, or attitude was similar to the number that mentioned constructs. The majority of birders that mentioned self in their descriptions of fire ecology described attitudes or beliefs. Of these individuals, about 56% (19 total) mentioned fire as an 'important part of nature.' While this code could also have been placed in the *constructs* frame, I decided to place it in *self* because the word important implies a value judgement. Similarly, I placed the code 'low severity fire is good, high severity fire is catastrophic' in *self*, because the language used to describe the effects of fire include value judgements that, while rooted in ecology, imply one type of fire is 'better' than another, regardless of ecosystem.

Birders that mentioned a personal motivation to count birds in old burns, e.g. 'woodpeckers are easier to find in burned areas,' instead of describing fire in Oregon ecosystems, had some of the lowest fire ecoliteracy scores. Motivation had the highest CSEF and CSEF-related scores in the frame labeled *self*. When comparing fire ecoliteracy to participant motivation, birders that expressed intrinsic motivation appear more fire ecoliterate (Table 4.2) than birders with extrinsic motivation or amotivation (no motivation).

Table 4.2

Motivation, constructs (ECOS), critical socio-ecoliteracy components, and fire ecoliteracy.

	ECOS	PAI	INS	CSEF	Fire
No motivation	84.3	36.9	4.4	125.6	7.4
Intrinsic: affective	88.6	38.8	4.7	132.1	8.2
Intrinsic: cognitive	88.4	32.9	4.8	126.1	9.4
Extrinsic	90.0	40.7	4.9	135.6	7.1

Place

Quantitative place attachment and nature connectedness do not appear associated with fire ecoliteracy. However, qualitative sense of place codes appear to demonstrate an interesting pattern between fire ecoliteracy and sense of place (Table 4.3). For example, the birder mentioned above, who demonstrated fire ecoliteracy in his description of the role of fire on the landscape, but not in his quantitative responses had a slight place connection, no place dependence, high place identity, and described the ecosystems in which he collects data as ‘coastal forests.’ The one question this birder answered most correct was about ecologically ‘healthy’ forests. Because of this birder’s place identity, and because of their general understanding of fire on the landscape, it would seem they have a general sense of fire that may be influenced by their time in coastal forests.

Birders that conceptualized the place(s) in which they collect data by naming a region, and birders that do not participate in community science appear to be less ecoliterate than other birders. Participants that described Indigenous uses of fire to manage the ecosystem in which they collect community science data had place attachment and nature connectedness similar to participants that described Indigenous peoples as bystanders to fire and land management. However, birders that described ‘Natives as bystanders’ had higher ecoliteracy (ECOS) and lower fire ecoliteracy than birders that described 'Natives as managers.' This indicates a possible relationship between understanding of fire in a place and the histories of Indigenous peoples from that place (decolonization and rehabitation).

Table 4.3

Sense of place, critical socio-ecoliteracy, and fire ecoliteracy.

	ECOS	PAI	INS	CSEF	Fire
Ecosystem	*88.2*	*38.4*	*5.0*	*131.6*	*8.7*
Ecoregion	88.9	33.9	5.1	127.9	8.8
Land	89.0	42.9	4.6	136.5	8.5
Region	92.9	37.9	5.1	135.9	7.1
No participation	83.0	30.3	3.3	116.5	6.8

Discussion

Constructs: What do birders know about fire?

'Fire is critically important at different temporal scales'

Participants in this study demonstrated a general understanding of fire ecology, including the historic role of fire in cycles of disturbance and succession, and the future impacts of climate change on fires in the PNW. While a few birders had an awareness of fire in ponderosa pine forests and oak woodlands, most did not demonstrate an understanding of ecosystem specific fire ecological concepts. There appears to be a possible relationship between participation in community science and fire ecoliteracy, which could be a result of the few individuals that don't participate in community science (sample size). Though, qualitative data supports the link between community science participation and fire (birders that participate in community science are more fire ecoliterate).

While there is some indication of a link between how participants view place and fire ecoliteracy, there doesn't appear to be a relationship between time spent in fire-adapted or post-fire landscapes and fire ecoliteracy. Education does not appear to influence ecoliteracy. Because of this, it appears that time spent observing birds may influence participant fire ecoliteracy. Bird identification skills don't seem associated with fire ecoliteracy, so the amount of time and skill associated with observing birds doesn't seem to influence how much participants know about fire. This supports the idea that any time spent observing birds may contribute to participant fire ecoliteracy.

"Most that I know I learned because of birding"

While this may be associated with learning from birds, it may also be associated with 'listing,' keeping lists of birds seen annually or in their lifetime. In order to add birds to their list, birders need to know where to find a diversity of bird species. Because birders mentioned woodpeckers and their link to post-fire landscapes, and how bird communities change in association with post-fire habitat more often than other ecological constructs, there is some support for the suggestion that the desire to see a diversity of birds may influence birder understanding of the relationship between birds and fire. Additionally, birders mentioned personal interests associated with post-fire habitats. These interests were mostly associated with birding, providing further support for the idea that birders are learning from birding, rather than from birds.

Another possible relationship between birds, fire, and individuals is reflected in participant acceptance of fire. Participants appear accepting of fire that burns a few trees but not fire that burns many trees. This could be associated with their understanding of the benefits of fire for woodpeckers. Though, it may also be the influence of a "not in my backyard" attitude about fire, combined with acceptance of fire for woodpecker and bird diversity. By this, I mean that participants may support fire because it makes observing some birds easier than others, but that support may not extend to fire in ecosystems they spend time in or are attached to, or to fires that "kill too many trees."

In the future, it would be good to know where this line is for birders. When does a 'good' fire become a 'catastrophic' fire? And how many birders understand the direct ecological relationship between woodpeckers and high severity/intensity fires? Also, do birders describing high intensity mean severity (number of trees killed)?

Place: fire ecoliteracy, fire-prone ecosystems, and post-fire landscapes

While I did not find a relationship between place attachment and fire ecoliteracy in this study, I did find a connection between how participants describe place (sense of place) and fire ecoliteracy. This relationship does not appear associated with time spent in post-fire habitats or in fire-prone ecosystems. From these data, and birder understanding of the relationship between birds and fire, it would seem birding and perception of place may interact to influence fire ecoliteracy. This is not quite the same as land (as pedagogy), but does support the importance of *rehabitation*, which is the first step toward land (as pedagogy). Further evidence of rehabitation is the acknowledgement of the knowledge of history of place and Indigenous history, though not necessarily colonization.

Future exploration of the relationship between participant understanding of Indigenous histories, present, and uses of fire, and understanding of the role of fire in Oregon's ecosystems will be helpful. Are participants that understand the history of Natives use of fire more likely to support prescribed burns in all ecosystems? Additionally, if individuals were presented with the current story of Indigenous Knowledge in fire and forest management (e.g. partnerships between the Yurok and US Forest Service) would their support for fire increase? It would certainly make education, communications, science, and land management more equitable.

Self: What do birders believe about fire?

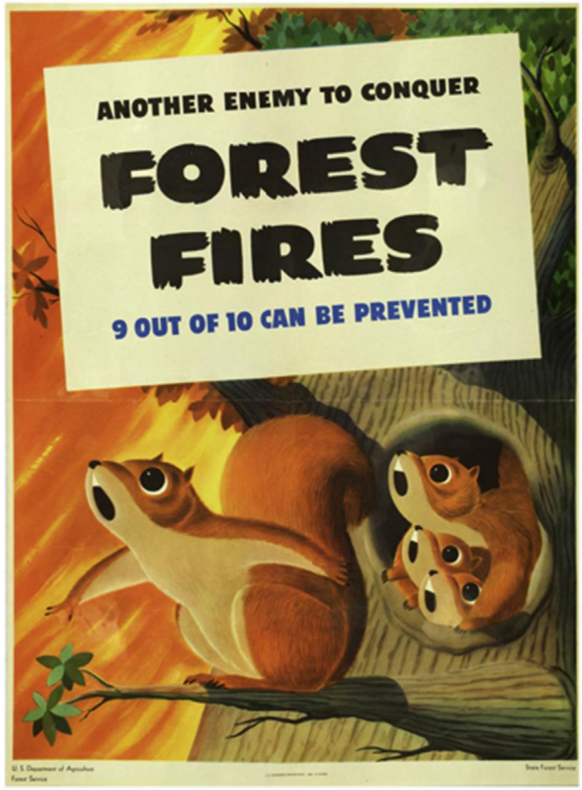
As with other studies, birders have potentially conflicting beliefs and attitudes about fire (DellaSala et al., 2015). They appear to believe that fire is important for ecosystems and species adapted to post-fire landscapes. As in Metz and Weigel (2008) there also appears to be a 'limit' to what fire is acceptable. Fire near people's homes, or towns, and fire that kills 'too many' trees (e.g. high severity/intensity) are unacceptable. Initially, this relationship seemed associated with attachment to place and to finding woodpeckers. Woodpeckers and species 'need' fire, but many dead trees are 'ugly.' With further investigation, though, birders that appear opposed to high severity fire have low place attachment. This suggests that there is some other factor influencing birder beliefs about fire.

The 'Smokey effect,' the effect of Smokey Bear anti-fire propaganda (Fig. 4.6; Minor & Boyce, 2018), may explain the apparent belief that (low severity) fire is important, and that high severity fire is catastrophic (DellaSala et al.,, 2015) in this sample of Oregon birders. DellaSala et al., (2015) described a similar understanding of fire 'clearly tempered by safety concerns.' When Smokey initially was initially introduced to the public, the conversation around fire centered on the harm fire causes ecosystems and society (Donovan & Brown, 2007; DellaSala et al., 2015; Minor & Boyce, 2018).

These anti-fire messages lacked nuanced information about variation in fire regimes (how often, how large, what severity fires typically burn), creating a homogenous perception of fire on the landscape (Minor & Boyce, 2018). Over-time, public outreach and education has changed public perceptions of fire, though this education focuses on promoting low severity fire across the landscape (DellaSala et al., 2015). Smokey Bear, and the history of colonial information about fire being bad (other than low severity fire) may influence beliefs about fire *more* than place attachment, time in ecosystems, and awareness of bird species adapted to post-fire habitat and succession.

Figure 4.6

WWII era anti-fire propaganda as part of the Smokey Bear "only YOU can prevent forest fires," anti-fire campaign (Minor & Boyce, 2018).



Fire ecoliteracy and decolonization of place

Most participants that mentioned Native use of fire did not name a Tribe to which they were referring. This may indicate an awareness of place or place history, though it is likely an awareness informed by western science and settler colonial perspectives (Calderon, 2014). This is because decolonization and indigenization require that Native histories, all 1,000+ federally and non-federally recognized nations, are the center of our conversations of place. Therefore, when an individual is asked to describe the role of fire in a place or places, acknowledgement of the First Peoples to steward our land are part of that description of fire's history in that place.

The understanding that Native people "used to use fire to manage for food crops" highlights one of the risks of combining western science and IEK, in that western science is shaping the presentation of IEK (Deloria, 1999). Participants classify Indigenous uses of fire largely in the context of producing food (nature is material), rather than as a reciprocal or spiritual responsibility (Deloria, 1999; Tuck, et al., 2014; Kimmerer, 2000). It is possible that shifting the narrative about IEK from a western science epistemology to an Indigenous epistemology, primarily through centering Indigenous knowledges, histories, and pedagogies, will provide greater understanding of, and support for, prescribed fire in Oregon's diverse fire-adapted ecosystems.

Attachment to place, Indigenous Knowledge and fire ecoliteracy

Other studies have found support for the idea that an attachment to a place or species may increase understanding of ecosystems. Xing (2012) found that individuals in Ohio observed connections between fireflies and ecosystem quality that scientists had previously not identified. Participants in this study largely noticed this connection because of their connection to fireflies. Additionally, fishers in the Caribbean and Mexico provide important local and traditional information to scientists and land managers about ideal places to locate marine reserves (Teleki, 2012). When individuals with traditional/indigenous knowledge about Mexican Mesoamerican Reefs were involved as Community Scientists in decision making about where to locate marine protected areas, such as fish spawning aggregates (FSA), efforts tended to be more successful (Fulton, Caamal-Madrigal, Aguilar-Perera, Bourillon, & Heyman, 2018). The Māori "muttonbirders" of New Zealand have used Indigenous Knowledge to help guide conservation of tītī, sooty shearwater (*Puffinus griseus*) on the islands of New Zealand (Lyver, 2002).

Implications

For fire ecologists, educators, and land managers interested in increasing public support for the reintroduction of fire in Oregon's ecosystems, it appears that engaging community members in participatory or community science, is a good place to start. As part of this effort, diverse stakeholders, including community scientists, need to be part of project development, including identifying questions and hypotheses (Pandya, 2012; Otero, Castellnou, Gonzalez, Arilla, Castell, Castellvi, Sanchez, & Nielson, 2018). Particular attention needs to be paid to methods for attracting and retaining participants (Eveleigh, Jennett, Blandford, Brohan, & Cox, 2014), specifically building on an individual's connection to place (Newman et al., 2017), or focusing on a specific topic, e.g. birds (Xing, 2012; Newman et al., 2017).

A program that fully engages participants will include a training that promotes deeper exploration of ecosystems (Tyson, 2019) and will incorporate multiple kinds of knowledge (Pandya, 2012). This exploration should include a history of the land, and of the People from the land (Trinidad, 2012; Calderon, 2014; McCoy, 2014), ideally presented by and/or from the Indigenous people whose homelands in which the project occurs. To retain participants, a program needs to include annual analyses of data collected by participants (Pandya, 2012; Alexandrino, Navarro, Paulete, Camolesi, Lima, Green, et al., 2019). Result from this analysis should be distributed to participants in the form of user-friendly reports, that summarize annual findings, and that summarizes the findings at the conclusion of the project (if there is a conclusion). This cyclical engagement with participants will provide more opportunities for learning/developing an understanding of fire ecology, and will provide feedback and support for community scientists (Alexandrino, et al., 2019).

Another important consideration for including diverse perspectives, particularly IEK, is the availability of individual researchers and their willingness to share information (Semali, Grim, Maretzki, 2006). Reciprocity of knowledge and information, from scientists and academics to stakeholders and Indigenous Knowledge keepers, rather than the one-way direct transmission from participants to scientists and academics builds trust and more thoroughly incorporates IEK (Semali, et al., 2006). Semali et al. (2006) call this in-reach, rather than outreach, creating a "community-based, place-sensitive model in which. . .experts are willing to be "on tap" in response to local community in-reach, rather than being "on top" of [the] outreach and extension process" (p. 85).

Conclusion

From this exploration of avian community scientists, critical socio-ecoliteracy, and fire, it seems like changing the public's relationship with fire is likely an important part of changing their beliefs about fire. There is some evidence that participating in avian community science projects may increase fire ecoliteracy, though support for fires that burn more than low severity fire appear to have little support. This acceptance/rejection of fire is likely because participants in these types of community science/outreach projects are often motivated to participate in these projects because of their affinity for birds and for listing birds, possibly creating cognitive dissonance: fire is important/fire is bad (McGuire, 2015). If a birder wants to find woodpeckers, they know burns are an excellent place to find many Oregon species. This claim is supported by the connection between affective intrinsic motivation, fire ecoliteracy, and birder understanding of how bird populations might benefit from post-fire habitat.

Participant knowledge appeared to center on elements of fire ecology that are often in the media, e.g. fuels or the effects of suppression, awareness associated with spending time in post-fire landscapes, e.g. post-fire succession and bird community changes. Participants expressed a belief that fire is important for habitat 'renewal,' bird species, and communities. Despite their awareness of the links between birds, habitat, and fire several birders appeared resistant to anything more than 'low severity' fire that kills few trees. There are several possible reasons for this. First, a connection to place may result in a reluctance to see that place changed in a notable or dramatic way. Second, the colonial narrative that fire is bad is pervasive in the media. With the current bushfires raging in Australia the fear of fire, and the destructive power of fire, is difficult to escape. This fear poses unique problems in moving conversations about fire forward. One important way to shift western society's relationship with fire in a more positive direction is to reconnect people to place, and the relationship between fire and the land.

Critical Pedagogies of Place demand that to create a populace of community scientists and stakeholders that are fire literate, researchers and educators need to connect the populace to the place, through *rehabitation*. Rehabitation is the act of intimately connecting people to a place, particularly to colonized and exploited places (most places in North America). Critical Indigenous Pedagogies of Place dictate the connection to Indigenous histories and the centering of IEK at the center of practice through *indigenization*. *Decolonization* connects people to the Indigenous histories of the land, and encourages them to unlearn colonial narratives about places, ecology, and the world. While an ecoliterate populace is an important part of a sustainable society, a socio-ecoliterate populace is an important part of a climate resilient and just society.

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Chapter 5: General Conclusions

REHABITATION, DECOLONIZATION, AND INDIGENIZATION: TOOLS FOR CRITICAL ECOLITERACY

This dissertation was structured as a nested research project, with the three manuscripts building upon each other in an effort to explore ecoliteracy through a Critical Indigenous Pedagogy of Place (CIPP). I recruited Oregon birders that participate in community science for this study, in part because of my own connection to birds, science, and place, and in part, because bird-centered community science projects are common throughout the U.S. and around the globe. There has also been considerable work done on understanding project-specific ecoliteracy in individuals that participate in bird-centered community science projects (e.g. Cornell Laboratory of Ornithology's NestWatch).

The first manuscript (found in Chapter 2) explored a modified tool (Pitman & Daniels, 2016) for measuring understanding of western ecological constructs. I used the modified ecoliteracy tool to survey Oregon birders that participate in community science. Their responses were then compared to ecoliteracy scores from other content-specific community science projects and the results from Pitman and Daniels (2016).

Manuscript 2 (Chapter 3) built on Manuscript 1 (Chapter 2), using Critical Pedagogy of Place (CPP; Gruenewald, 2008) and Critical Indigenous Pedagogies of Place (CIPP; Trinidad, 2011) to create a critical socio-ecoliteracy framework (CSEF) that expanded on the definition of ecoliteracy beyond western constructs. CIPP focuses on *rehabitation*, the reconnection of people to land/place including developed spaces (e.g. cities), and *indigenization*, the centering of Indigenous cultures, knowledge, and histories. CPP focuses on rehabitation and *decolonization*, deconstructing colonial and elitist narratives about ecology and places (Gruenewald, 2008). The lens of rehabitation, indigenization, and decolonization led to the creation of a framework that includes self, place, epistemology, relationships, and land (as pedagogy). When considering birder critical socio-ecoliteracy, relationships between the land, climate change, bird communities and ecoliteracy, became particularly clear.

Manuscript 3 (Chapter 4) used the CSEF, created in the previous chapter, to explore birder awareness of fire ecology and understanding of fire on the landscape. Through the CSEF some patterns became clear. Participants demonstrated an understanding that fire is important for creating post-fire habitat for some woodpecker species, and early seral habitat (early successional stages in ecosystems, typically dominated by grasses, forbs and shrubs) for shrub- and other early seral-dependent bird species (e.g. MacGillivray's Warbler, *Geothlypis tolmiei*). What was most interesting is that despite their understanding of bird, habitat, and fire relationships, many of the birders that participated in this study showed support for low-severity fire, but not fires that 'burn too many trees,' regardless of the ecosystems in which they collect data. This apparent cognitive dissonance was not explained by place attachment, in fact, birders with low place attachment seemed most concerned about fires that burned more than a few trees. Further exploration using the CSEF indicate that it is likely that colonial narratives about the ills of fire contribute to the cognitive dissonance between understanding fire is important, and since it creates bird habitat, and only supporting one type of fire on the landscape.

Throughout the remainder of this chapter, I will discuss conclusions associated with parts of the CSEF, how these components work together to create what people know and how this knowledge is associated with behavior. I will conclude with a reflection on the dissertation process.

Constructs

In this dissertation I used the word constructs instead of the word concepts. This is, in part, because concept denotes a generalized truth or idea about something, such as ecology. While individuals from different cultures may develop similar knowledge about ecology (e.g.

salmon fry transitioning from freshwater fish to saltwater fish in estuaries before heading into the ocean) the construction of this knowledge is influenced by epistemologies and ontologies. Thus, I used the word construct to de-center western epistemologies and ontologies from ecological knowledge. Because Indigenous Knowledge is diverse and varies by tribe and landscape, I used the constructs previously identified by ecologists as important for promoting pro-environmental and sustainable behavior.

Findings from this study demonstrate that participation in community science can increase ecological knowledge, though education (regardless of education level) may play a greater role in increased ecoliteracy. Further support for the use of constructs over concepts is found within the qualitative data. Birders showed an understanding of local changes in bird communities, including the movement of southern birds into northern climes. They also appeared knowledgeable about the effects of changing climate on the ecosystems in which they spend time. This provides support for ecoliteracy frameworks that are location/content specific.

There is not a feasible way to ask quantitative questions about location specific ecoliteracy, while also keeping ecoliteracy tools comparable across studies. Because of this, an ecoliteracy tool, such as the one created by Pitman and Daniels (2016), should be used for measuring ecoliteracy *in conjunction with* open-ended questions about ecosystems and ecological constructs. Alternatively, it is possible that modifications to the local/regional ecoliteracy questions in Pitman and Daniels (2016), could be modified to represent similar constructs with a local, project-specific ecological questions.

The birder responses to open-ended questions were also important in understanding the factors that influence ecoliteracy, enabling the validation of the CSEF. There are clear patterns indicating the influence of epistemology, self (e.g. conceptualizations of self), land (as pedagogy), and place on constructs. This study did not highlight how constructs might influence conceptualizations of self or place. It is conceivable that the constructs learned, for example, at a university, might influence place attachment and how nature is incorporated into conceptualizations of self. Further work is necessary to understand *how* constructs influence other components of the CSEF.

Epistemology

Oregon birders that participated in this study all identified as white and indicated an education level of a bachelor's degree or above. Despite these similarities, open-ended questions indicated variation in epistemologies, though most participants demonstrated an empiricist epistemology (western science is the way to find the Truth). It is interesting to note that further exploration into epistemology showed a connection between interpretivist epistemologies and critical socio-ecoliteracy (CSE). Possibly the most interesting aspect of this connection is that epistemology appears to influence constructs (what individuals know), and to influence or be influenced by place attachment, but not self (e.g. motivation).

Perhaps the most interesting part of the apparent connections between epistemology and place is that Indigenous languages, cultures, and epistemologies are rooted in the places in which they developed. Ecological knowledge is reflected in language, e.g. the sp'q'n'I' (Spokane) word that represents late winter (February) is sčn'ír'm'n', the word for sagebrush buttercup (*Ranunculus glaberrimus*) which blooms in late winter/early spring. The word sčn'ír'm'n' also reflects cultural uses of sagebrush buttercup: sč – paint/body paint, n'ír' – toxic, m'n' – used for. From this we learn that sagebrush buttercup is turned into a past and painted on the body to treat some skin conditions. Cultural practices, such as first foods celebrations also reflect ecological knowledge (Quaempts, Jones, O'Daniel, Beechie, & Poole, 2018), particularly the relationships between all parts of a watershed. First foods celebrations also provide information about harvest timing and seasonal rounds traveled by PNW tribes.

Although I had anticipated being able to understand respect for other ways of knowing by measuring birder epistemology (rather than outright asking birders about this), there is no clear support for using epistemology to measure this variable. Ultimately, respect for other knowledge systems seemed less important for developing a CSEF than I had previously thought. As a next step for exploring ways to indigenize community and western science, it may be helpful to understand how perspectives of community and western scientists might create barriers for the inclusion of Indigenous Ecological Knowledge in conservation and management. Future work such as this could also help provide more information about the relationship between epistemology and self.

Self

In the CSEF, self is not used to reflect identity, per se. Rather it is used to represent how birders see themselves. In particular, self represents how birders see their interactions with nature and science. I did not measure science identity in this exploratory study. This is because science identity tools typically measure this identity based on western conceptualizations of science, and the purpose of this study is not to measure how people see themselves in relation to western science. Future work exploring how to create diverse science identity tools (e.g. tools not grounded in western epistemologies) would be helpful for better understanding science identity and epistemology. Interviews and focus groups may help elucidate further relationships between science identity and epistemology, though one should take care to keep questions and interpretation grounded outside of western epistemologies, if the goal is to understand diverse ways of knowing.

My original intention in this study was to explore self and ontology using Inclusion of Nature in Self (INS) Scale (Schultz, 2002). While there may be some support for INS as a proxy for ontology, further work is necessary to verify this. INS did help provide some understanding of how nature informs self and vice versa. One of the more interesting findings that emerged from this study is that when analyzing quantitative scores, INS correlated most strongly with individual CSE. While that may be true, during mixed methods analysis, INS did not appear to show strong patterns other than higher INS scores associated with an understanding of climate change and ecosystems.

While the quantitative place attachment and INS scores do not appear correlated, there appears to be some connection between self (INS), place, and constructs, providing further support for the CSEF created from this exploratory work. The nuance between and within the qualitative and quantitative self (e.g. motivation and INS) data is an important part of understanding the relationships between self and other CSEF components. For example, fire ecoliteracy appears associated with birding, participation in community science, and education. However, as in other studies, colonial anti-fire narratives about fire appear to influence 'how much' fire is acceptable (Kimmerer & Lake, 2001; Metz & Weigel, 2008; Minor & Boyce, 2018), more than an understanding of the relationship between fire, habitat diversity and complexity, and bird communities. Thus, while an individual's relationship to birds and/or place may influence constructs, external interactions and narratives may override other aspects of CSE.

Relationships

In this dissertation, relationships do not only apply to interactions between two people, or people and place. Relationship is also intended to address ontology. Indigenous ontologies are best represented by relational ontologies (Deloria Jr, 1999; Redekkop, 2014), centering on the relationships between species, ecosystems, etc. Western epistemologies tend to be atomistic (Redekkop, 2014), centering on an individual part of an ecosystem, rather than understanding the relationships between parts. Birders that focused on the relationships between humans and the environment, between birds or between birds and habitat generally had stronger place attachment. Understanding the relationship between changing climate, bird breeding ranges, migration timing, and communities appears associated with self and constructs.

From these data, it seems like birds and birding likely play a role in birder identity. This is an aspect of avian community science that seems important to understand, particularly for future work with CSE. This study supports the inclusion of individual perceptions of relationships (e.g. relationships matter more than individual parts or the parts matter more than relationships) and an understanding of how relationships between self (conceptualizations of self) and place are important for a CSE.

A note on language and ontology. In this dissertation, I frequently use the phrase 'in relationship with' instead of 'related to,' when talking about the interrelated parts of the CSEF and/or place, land, or individuals. This small variance in word choice can change the meaning of these phrases considerably. To have a relationship with (or relationship to) something implies a situation where two or more things are connected to and acting upon each other. To be 'related to' something implies a connection but does not necessarily denote action. Because of my understanding of the parts of the CSEF, and because of my theoretical lens, I use 'in relationship with,' unless discussing ancestors/familial relations or to imply a connection that is not an action.

Place

Possibly the most surprising and interesting component of this study is the clear connections between place, ecoliteracy, and CSEF. It is particularly interesting because quantitative data shows less of a connection between place attachment and ecoliteracy than qualitative data. Place identity and place dependence are the two components of place attachment (Williams & Vaske, 2003). Birders in this study had higher place identity than place dependence, which may explain the relationship between place attachment and awareness of the effects of changing human management efforts, bird populations, and habitat changes associated with succession (e.g. conifers crowding meadows). Further work on place identity, self, and nature connectedness could potentially elucidate the possible relationship between place identity and nature connectedness.

In this exploratory study, place was defined broadly as the ecosystem in which participants conduct community science. It is possible that participant interpretations of this definition of place influenced their quantitative place attachment scores. The variation in participant descriptions of ecosystems in which they conduct community science (sense of place) highlighted some of the different ways people describe both ecosystems and place. Some participants described their ecosystems on a geographic scale (e.g. Pacific Northwest), at the other end of the spectrum, some participants described the land from which they collect data.

Participants that do not participate in community science appear to have the lowest place attachment, which may be associated with the definition of place in this study. Birders that have a sense of place dominated by the land (e.g. providing in-depth description of the plants and animals and current management activities) have the highest place attachment. This could reflect the relationships between these birders, place, and self (place identity and INS). The connection between a sense of place grounded in the land and place attachment scores brings the conversation to the final component of the CSEF, land (as pedagogy).

Land (as pedagogy)

When I was conceptualizing this study, I had not set-out to understand pedagogy as part of CSE. My interest was in how closely birder epistemologies and ontologies aligned with western, 'local,' or Indigenous epistemologies/ontologies. In the process of understanding birder views of epistemology (how knowledge is formed), it became clear to me that pedagogy is an important part of a CSEF. Because I was using CIPP as part of my theoretical lens, it was a logical step to read some works about Indigenous pedagogies. The concept of learning from the land, rather than learning on the land, is something so nuanced that at first these phrases seem to say the same thing. But they do not.

Learning from the land means the land is teaching you something. This could be in the form of learning about the edibility of maple sap from squirrels as in LeAnne Betasamosake Simpson's (2014) telling of the Anishinaabe story of how a youth learned to tap into maple bark for the sap. This could also mean learning about some of the impacts of settler-colonial history from Sandhill Crane (*Grus canadensis*), such as the knowledge that camas (*Camassia spp.*) used to be more common in the Harney Basin and that it still blooms in small numbers at Malheur National Wildlife Refuge. Sandhill Cranes eat camas bulbs and by watching cranes foraging in the soft soils of a wet meadows, observing them eating bulbs, and visiting the location where they were eating bulbs periodically throughout the field season, I learned they were eating camas bulbs. Today, camas blooms in such small numbers in the Blitzen Valley that it is easy to miss without a crane to teach you where the camas still grows.

This is different from learning about cranes, camas, and the Blitzen Valley from books, scientists, or a human teacher in that the cranes are being assigned autonomy. The belief that these cranes chose to be in a place, and act as a teacher, so that I may learn about camas' existence in this place, separates land-education from place-education.

Mixed methods analysis provided support for the inclusion of land (as pedagogy) as part of the CSEF. This is because participants that have a sense of place that appears grounded in the land, also seem more aware of bird communities, population changes, the effects of climate change, and the use of fire by Oregon's Tribes in managing the landscape (particularly in the Willamette Valley). While individuals that have a sense of place centered on the land seem aware of the Indigenous histories of the places in which they conduct community science, they did not mention Indigenous present or futures. To indigenize the narrative around Indigenous peoples and fires requires connecting people to the history of removal, relocation, and reservations, and the understanding that Native peoples are still here. A decolonized response to questions about fire in Oregon ecosystems may include mentioning that Natives use fire, but a western lens understands that management as an action on the land, rather than a reciprocal relationship. A truly decolonized and indigenized response would include the Tribe, in the present, and an understanding that camas was more than food to Tribes of the Pacific Northwest, e.g. the Kalapuya.

Finally, I include 'as pedagogy' in parenthesis after land because using only land would not convey the importance of learning from the land. Including only pedagogy would not convey the idea of land as teacher either. However, while I could have described land as pedagogy without the parenthesis, I only measured the relationship between land and place attachment. Because I did not specifically measure pedagogy, it seemed most appropriate to include 'as pedagogy' in parenthesis.

Critical socio-ecoliteracy framework

The application of the CSEF to fire ecoliteracy in birders provided helpful information for validating the framework, and for understanding how CSE might help explain birder perceptions of fire. While nearly 30% of birders mentioned the importance of fire on the landscape, nearly 50% of these birders also mentioned that fire is acceptable to a point, and that point seems to be associated with the number of trees that are killed in a fire. While this number was not specifically defined by any participants, the consensus seemed to be that low severity fire killing a 'few' trees was acceptable, while high severity fire that killed 'a bunch' of trees is not acceptable.

From the CSEF, it became clear that birders understand the benefits of fire in promoting succession and in creating early-seral habitat. They also appeared to understand that early-seral habitat is important for or beneficial too several bird species and families. This understanding did not appear to influence acceptance for fires beyond those that kill no or only a few trees. The only aspect of CSEF that seems to possibly be associated with acceptance of the role of fire on the landscape is place and awareness of Indigenous land management using fire. Based on birder responses to fire ecology questions, it seems that colonial narratives about fire, e.g. Smokey Bear's anti-fire message of the 1940s through 1990s. Smokey's anti-fire message shifted circa the 1990s and became more nuanced, reflecting shifts in fire policy and attitudes at a national level. Because of the extent, in space and time, of Smokey's delivery, this anti-fire message may also play a role in fire ecoliteracy. Further work, including interviews with birders, will be helpful in understanding how external narratives from the media, agencies, and organizations influence CSEF. It is possible that external narratives belong within the CSEF, but this study does not provide a clear idea of where external narratives should be placed within the framework.

Reflection on the process

My personal journey toward ecoliteracy began when I was a child, between an obsession with birds, including behavior and identification, and a childhood spent exploring the forests of southern, central, and eastern Oregon. A lifetime spent learning about Oregon forests FROM Oregon forests led to an identity enmeshed with place and attachment to birds. I have always had a strong interest in conservation biology. Unfortunately, my personal ontology and epistemology have always created conflict with western science (internal and external). My ontology has always centered on relationships between and within species, communities, and ecosystems. I know who I am through my relationships. My epistemology has always been grounded in Indigenous epistemologies, primarily interpretivism.

Before diving into the ecoliteracy literature, however, I would not have known my worldview was the reason that I often felt tension with western science. While my sp'q'n'i' relatives did not pass down their knowledge or culture, my worldview has always been rooted in Indigenous epistemologies/ontologies. Reading through the literature by Indigenous scholars, such as Robin Kimmerer, Brandon Brayboy, and LeeAnne Betasamosake Simpson provided a strong sense of self, and helped clarify and refine my own theoretical perspective.

The literature review process, in general, created a bit of a sense of cognitive dissonance for me. For me, ecoliteracy, place, spending time in ecosystems, watching birds and their relationships are inseparable. I believe that I know all that I do about ecosystems because of birds. I struggled to understand why most papers only passingly mentioned anything beyond western scientific processes and western scientific knowledge in their discussions about ecoliteracy. I did not understand leaving out place or other ways of knowing, except in passing, or as something separate from ecology.

Analyzing the data from Oregon birders never quite reached the level of familiarity that I had anticipated, though there were flickers of recognition in birders' responses. Initially, the disparate experiences that other birders described felt like a hindrance to my ability to understand the data in front of me. It was not until I started reconceptualizing ecoliteracy into something that felt more familiar to me that the data began to make sense. A linear ecoliteracy framework, where components fit in their 'boxes,' wasn't something that made sense to me, through my own theoretical lens, or in the data. Once I began to conceptualize ecoliteracy as a critical socio-ecoliteracy, with a framework of interconnected components, I began to feel more comfortable with the data.

Another interesting aspect of this work has been the challenge of addressing the internalized trainings of western science, and understanding where western science, local ecological knowledge, and Indigenous knowledge overlap and where they differ. At times it has been a challenge to understand the biases associated with growing up with my dad's local ecological knowledge (influenced by relational ontologies and internalized western epistemologies) and the western ontologies and epistemologies associated with academic training, and where and how these things might conflict with my own ontologies/epistemologies and Indigenous knowledge. To date, I find myself always pausing before saying something like ‘you just need to understand the science’ to someone. Western science is not the only way of knowing and it is important to find ways to navigate the space between mistruths and colonial narratives about knowledge. I am not sure where this research will take me, but I know it is work that I will continue to incorporate into my future conservation, education, and research efforts.

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Appendix A

Part I: Demographic Information (Questions 1-8)

Year you were born:

Education level: _____ K-12 ______ Undergraduate ______ M.S. ______ PhD

Education focus:

Race/ethnicity (not required):

Please mark all community science projects that you participate in:

_____ Christmas Bird Count

_____ Breeding Bird Survey

_____ Project Feeder Watch

_____ NestWatch

_____ Great Backyard Bird Count

_____ eBird

_____ Raptor Route

_____ Celebrate Urban Birds

_____ Other, please describe below

How long have you participated in these community science projects?

What factors led to your decision to participate in these projects?

How would you describe your bird ID skills? (*please check the appropriate box*)

______ Beginner (*I can identify many birds I see by sight, and some by sound*)

______ Intermediate (*I can identify most birds I see by sight, and many by sound*)

______ Advanced (*I can identify all birds I see by sight, and most by sound*)

______ Expert (*I can identify all birds I see by sight and by sound*)

Part II: Open-ended questions (9-15). Please write your answer to the questions in the space provided:

Please describe the ecosystem(s) in which you participate in Citizen Science:

Have you birded or conducted Citizen Science in areas that have experienced fire (prescribed or wild)?

If yes, please explain your perception of those ecosystems and the bird communities found in them.

If no, please explain your perception of fire in Oregon ecosystems.

What other changes have you noticed in the ecosystem(s) in which you do Citizen Science over time?

Please describe any change you have noticed in bird communities since you started participating in community science.
Where do you go for information about local plants, wildlife, and ecosystems?
In your opinion, how is ecological knowledge developed?

Part III: Ecological Knowledge (Questions 16-45) (modified from Pitman & Daniels, 2016)

In this section, please select the option that best describes your answer to the following questions:

16. The Western Meadowlark is Oregon's state bird. These colorful members of the Icterid family avoid nest predators because they

- nest in trees. (-2)
- build partial roofs over their nests. (4)
- are well camouflaged. (0)
- nest near the base of bunch grasses. (2)
- can fly rapidly. (0)

17. In Oregon trees contribute to the health of hydrological (water) systems because they

- shade the soil. (0)
- attract rain. (0)
- stabilize waterways. (2)
- provide essential calcium to waterways. (-2)
- keep the water table from rising to the surface. (4)

18. Many marine species inhabit seagrass meadows for some or all of their lives and more fish live among seagrasses than over adjacent mudflats. This is mainly because

- dead and decaying seagrasses are the basis of the food web for many fish. (4)
- small fish are better able to escape from predators if they can hide in seagrass. (2)
- seagrass meadows are fish nurseries. (2)
- most fish living in seagrass eat seagrass. (0)
- plankton eaten by fish only live in seagrass meadows. (-2)

19. What is the major contributing factor to the endangerment of native animal species in Oregon's oak woodlands?

- Roadways (0)
- Competition with pests (2)
- Fire suppression (2)
- Loss of habitat (development) (4)

- Harvesting for pet food (-2)

20. The most important single action we can take to encourage small native birds back into parks and gardens is to
    - protect them from dogs. (2)
    - plant low and medium-sized, dense, bushy shrubs. (4)
    - plant tall gum trees and native grasses. (0)
    - provide fresh water. (2)
    - clear away understory and groundcover vegetation. (-2)

21. The removal of fire from oak woodlands and evergreen forests of Oregon have led to
    - declines in several cavity nesting bird populations. (2)
    - healthier forests. (-2)
    - an increase in forest fuels. (2)
    - a loss of postfire habitat. (4)
    - changes in forest structure. (0)

22. Fire suppression has negatively affected many Knobcone Pine trees because
    - Knobcone pines typically germinate after a fire. (4)
    - fires are hotter, killing too many pines. (-2)
    - fire provides the open habitat Knobcone pines need to grow. (2)
    - Knobcone pines need to be burned every few years. (0)
    - fire attracts the wildlife the Knobcone pines rely on. (0)

23. Fire can be important for the regeneration of native plants in Oregon. This is mainly because
    - fire eliminates the diseases that affect native plants. (0)
    - heat and smoke trigger seed germination in some plants. (4)
    - fire kills the carnivores that eat the plants. (-2)
    - fire reduces undergrowth and allows light to reach the soil. (2)
    - ash and charcoal change the soil chemistry to promote germination. (2)

24. Seaweed and seagrass washed up on beaches are important because they
    - help prevent foreshore erosion. (2)
    - help prevent high tides from reaching nesting shorebirds. (0)

- absorb methane and so help regulate greenhouse gases. (-2)
- provide food for many animals. (4)
- provide habitat for shorebirds. (2)

25. Many of the plants introduced to Oregon during the past 200 years have become environmental weeds, resulting in

- changes to fire intensity and frequency. (2)
- suitable habitat for native fauna. (0)
- reduced levels of nitrogen available in soils. (0)
- decline in the diversity and abundance of native plants. (4)
- less evaporation from soil. (-2)

26. The best habitat for sheltering hollow-dependent wildlife is found in

- dead trees. (2)
- saplings. (-2)
- live, hollow-bearing aspen or oak trees. (4)
- live, hollow-bearing exotic trees. (2)
- roofs, sheds and bridges. (0)

27. Domestic cats are having a significant impact on the environment because they

- compete with native animals for water. (0)
- consume native plants. (-2)
- threaten the survival of native birds. (4)
- help control populations of non-native rats. (2)
- move south as northern areas become hotter and dryer. (0)

28. The Earth's atmosphere is critically important for life because it

- contains the moisture that becomes rain. (2)
- traps heat, provides oxygen and protects from radiation. (4)
- allows light to reach the surface of the Earth. (0)
- allows greenhouse gases produced on Earth to be released into space. (-2)
- regulates the air pressure systems that influence weather. (2)

29. The global climate is most influenced by

- micro-climates. (0)

- the Sun. (4)
- greenhouse gases. (2)
- the temperature of the major oceans. (2)
- lightning. (-2)

30. The extent and intensity of rainfall is most affected by
    - prevailing winds. (2)
    - altitude and landform. (2)
    - ocean surface temperature and currents. (4)
    - galactic winds. (-2)
    - availability of fresh water for evaporation. (0)

31. What is the most effective way to conserve life on Earth?
    - Collect DNA from each species and freeze it for the future (0)
    - Eliminate the organisms that spread disease. (0)
    - Preserve all species in zoos and gardens. (-2)
    - Establish many large conservation parks. (2)
    - Conserve a representative proportion of ecosystems and habitats. (4)

32. Micro-organisms are invisible to the naked human eye. Micro-organisms
    - are dangerous as they infect plants and animals with disease. (2)
    - have minimal benefits for life on Earth. (-2)
    - are found mostly in water. (0)
    - always have short life spans. (0)
    - are vital for decomposition of dead matter. (4)

33. Human medicines originate mainly from
    - fungi and algae. (2)
    - peat bogs. (-2)
    - micro-organisms. (2)
    - plants. (4)
    - chemical compounds manufactured in laboratories. (0)

34. Ecosystems perform a variety of beneficial functions (sometimes called ecosystem services) through the interactions of organisms with their environments. Essential services provided by ecosystems include

- providing healthy environments for recreation, relaxation and fitness. (2)
- controlling diseases. (2)
- breaking down wastes and recycling nutrients. (4)
- providing an inexhaustible supply of materials. (-2)
- clearing away dust and smoke particles. (0)

35. Wetlands, marshes, and wet meadows provide important ecosystem services because they

- produce food and materials for human use. (2)
- recharge ground water. (2)
- absorb high levels of greenhouse gases. (0)
- filter heavy metals, toxins, and other pollutants out of the water column. (4)
- are suitable for waste dumps and can be used to form artificial land. (-2)

36. A healthy garden can be described as an ecosystem because

- it is self-contained and separate from the outside world. (0)
- it supports a web of biological relationships. (4)
- the cycling of water and nutrients, as well as the plant-animal interactions, are essential to the garden's survival. (2)
- it contains healthy plants and water. (0)
- it supports the economy by using resources. (-2)

37. Deserts are arid ecosystems that have little surface water most of the time. In deserts

- most species are concentrated in run-off areas. (2)
- species react quickly to sudden changes in water and food abundance. (4)
- dead plant and animal matter is mainly processed by earthworms. (-2)
- plants and animals are short-lived with a high population turnover. (0)
- the number of species increases after rain. (0)

38. Some ecosystems are more sensitive than others to a changing climate. In a warming and drying climate, the most sensitive ecosystems are

- woodlands. (2)

- rainforests. (4)
- savannahs. (0)
- wetlands. (2)
- deep ocean beds. (-2)

39. Carbon is most effectively absorbed by

- wooden building materials and furniture. (-2)
- marine plants and oceans. (4)
- crops and pastures. (0)
- soil. (2)
- forests. (2)

40. An urban heat island is a form of micro-climate that can develop in towns and cities. An urban heat island

- forms mainly on busy roundabouts and median strips in transport corridors. (-2)
- forms when dark, solid surfaces absorb solar radiation which is then released at night. (4)
- is only a problem in hot weather because the land and air cool in winter. (0)
- forms when heat released from factories, air conditioners and vehicles is trapped between buildings. (2)
- keeps towns and cities warmer in winter. (0)

41. Extinctions, the loss of species altogether, are a natural part of evolution of life on Earth. Current extinctions

- involve animals and plants unable to relocate when their habitat is lost. (2)
- will help reduce overcrowding on Earth. (-2)
- mainly involve species unable to adapt quickly to urban environments. (2)
- are spread fairly evenly around the Earth. (0)
- are occurring mainly in areas rich in species and where habitat destruction is high. (4)

42. Currently the greatest threat to tropical coral reefs is

- suffocation and starvation of sea life by plastic waste. (0)
- acidification of seawater affecting formation of the coral skeleton. (2)
- warming of surface water temperatures which leads to coral bleaching. (4)

- overfishing and fishing practices that use cyanide and dynamite. (2)
- cooling of surface water temperatures due to melting ice. (-2)

43. The melting of sea ice in the Arctic is decreasing seal populations. This is mainly because
    - polar bears find it easier to capture seals in larger areas of open water. (-2)
    - the roofs of seal snow dens collapse more frequently and pups are crushed. (2)
    - warmer waters bring food species that seals are not adapted to feed on. (0)
    - warmer waters bring in new predators that feed on seals. (0)
    - as ice melts more quickly, pups are exposed to predators on land and in water. (4)

44. Night light radiating from cities and towns is sometimes called light pollution. Light pollution can have significant effects on nature as it
    - leads to larger populations of bats. (0)
    - interferes with the natural behaviors of nocturnal animals. (4)
    - prevents micro-organisms from eating surface algae, leading to algal blooms. (2)
    - means that micro-organisms can spread disease more rapidly. (-2)
    - reduces the visibility of stars. (2)

45. These five pictures were taken in Oregon forests. Which shows the most balanced forest ecosystem?

Part IV: Place Attachment (Questions 46-57) (Williams & Vaske, 2003)

Please answer these questions in reference to the place(s) that you participate in your bird-related community science projects. For example, if you participate in the Christmas Bird Count, please answer these questions about the count circle that you participate in.

Please try to select Neutral only in instances where it truly best describes your feelings toward a statement.

Each of these statements refers to the place *that you now consider to be your home:*	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel that this place is a part of me.	1	2	3	4	5
This place is the best place for what I like to do.	1	2	3	4	5
This place is very special to me.	1	2	3	4	5
No other place can compare to this place.	1	2	3	4	5
I identify strongly with this place.	1	2	3	4	5
I get more satisfaction out of being at this place than at any other.	1	2	3	4	5
I am very attached to this place.	1	2	3	4	5
Doing what I do at this place is more important to me than doing it in any other place.	1	2	3	4	5
Being at this place says a lot about who I am.	1	2	3	4	5
I wouldn't substitute any other area for doing the types of things I do at this place.	1	2	3	4	5
This place means a lot to me.	1	2	3	4	5
The things I do at this place I would enjoy doing just as much at a similar site.	1	2	3	4	5
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Section V. Ontological perspective/Connection to Nature (Schultz, 2002)

58. Please indicate the picture that best describe your relationship with the natural environment. How interconnected with nature are you? Circles are numbered as follows: top row (L – R) 1, 2, 3, 4; bottom row (L – R) 5, 6, 7.