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Defining Earth Smarts: A Construct Analysis for Socioecological Literacy Based on Justly Maintaining Quality of Life

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Defining Earth Smarts: A Construct Analysis for Socioecological Literacy Based on
Justly Maintaining Quality of Life

by

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A dissertation submitted in partial fulfillment of the requirements for the degree of
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Abstract

This paper describes the creation and validation of a new educational construct. Socioecological literacy, or earth smarts, describes the qualities we need to justly maintain or improve our quality of life in a changing world. It was created using construct analysis techniques and systems tools, drawing on an extensive, transdisciplinary body of literature. Concepts related to environmental, ecological and scientific literacy, sustainability and citizenship were combined with educational frameworks, new research in science education, and modern cognitive psychology. After the initial formulation, the results were considered by a variety of experts and professionals from the fields of ecology, environmental science and education, using surveys, conference presentations and interviews. The resulting qualitative and quantitative feedback was used to refine and validate the framework. Four domains emerged from the analysis: concepts, competencies, sense of place, and values. The first two are common in formal education, although many of the more specific components that emerged are not adequately addressed. The second two domains are unlikely to be achieved solely in traditional educational settings, although they emerged as equally important. Sense of place includes affective components such as self-efficacy, while values includes moral development, respect, and justice as fairness. To make culturally and ecologically appropriate localization as accessible as possible, the earth smarts framework (www.earthsmarts.info) is deliberately nonpartisan and was designed using free and open-source software. It can help educators, policy makers, and researchers
interested in more resilient, just and adaptable communities to coordinate their efforts, particularly in the nexus between formal and informal education, which have different strengths and weaknesses.
Chapter 1: Introduction

For the first time, more than half the world now lives in a city (United Nations, 2006). While urbanization and technology have provided numerous benefits, they are superficially insulating us from natural systems we rely on, and contributing to an unprecedented worldwide loss in ecological awareness and knowledge. This growing ignorance contributes to poor decisions that jeopardize local and global ecosystems and the quality of life they support. Unfortunately, our education systems are failing to adequately address this loss of knowledge, continuing to produce graduates at all levels who are “ecological illiterates”, a phrase used by Orr (1992) seventeen years ago, and one that more recent studies have shown remains at least as relevant today (e.g., NWF, 2008). Weilbacher (2009) suggests four educational issues that contribute to environmental ignorance in the United States: disconnection from the environment itself, the No Child Left Behind Act's emphasis on testing, uneven interest in the environment by individual teachers, and teaching by nonprofit organizations that includes, “...activity-based education that is designed to serve as an appetizer for environmental literacy but ends up becoming the main course” (para. 16).

Related problems occur in science education, where efforts to increase scientific literacy have been disappointing. Teaching science as content, with little or no context, contributes to this failure – for students, science without social context can seem useless or even harmful. Science, technology, and society (STS) based educational efforts (Aikenhead, 1994; Yager, 1996) have attempted to address the issue of context but have
not lived up to their promise, even after explicit addition of the environment (STSE: Hodson, 2003; Pedretti, 2003). By incorporating moral and affective aspects in science education, pedagogical techniques involving socioscientific issues (SSI) are beginning to show potential for increasing scientific literacy (Ratcliffe & Grace, 2003; Zeidler, Sadler, Simmons, & Howes, 2005), but such techniques can be challenging to employ and have been slow to enter practice.

Communities of *Homo sapiens* have relied on various forms of ecoliteracy to sustain themselves throughout our existence; societies that were not able to adapt to environmental changes, self-inflicted or otherwise, were prone to collapse (Diamond, 2005). As our species evolved and adapted to new habitats, knowing where certain plants and animals lived and how to harvest or hunt them sustainably was essential to survival in a direct way. It was obvious why memorizing the locations of reliable springs, knowing the right time of year to plant, or studying how animals moved with the seasons were important. Recently however, urbanization has insulated us from such ecological awareness. While carefully planned, high-density urban living can be sustainable, many city dwellers have no idea where basics such as their water, food or power actually come from. Although scientists know more than ever about how the world works, the general public's, alarming loss of local ecological knowledge is compounded by emerging global environmental challenges that make even the best local knowledge insufficient, even for those still living outside of cities. We are facing global changes like never before – our impacts in just the last fifty years are completely unprecedented (Moran, 2007). Change may be inevitable, but it need not be disastrous – provided we are able to adapt.
Overview of the Problem

Environmental and ecological literacy have been defined in various ways for decades, but there is little agreement on specific components or even the fundamental theories involved. Nearly 20 years ago, Roth summarized the roots and evolution of environmental literacy, writing:

Unfortunately there became almost as many perceptions of the nature of environmental literacy as there were people who used the term... The result has been that the term was used in so many different ways or was so all encompassing that it had very little useful meaning (C. E. Roth, 1992, p. 7).

Since then, and despite an increasing awareness of the global nature of the environmental challenges we face, no efforts to define ecological or environmental literacy conclusively have stuck. Part of the problem may result from varying usage of the concept of literacy itself, as the “...indiscriminate and theoretically undefended use of the term ‘literacy’ in relation to the environment has resulted in a range of neither competing nor cohering definitions of environmental literacy” (Stables & Bishop, 2001, p. 93). Further complicating the matter, as Mueller and Bentley note, “Many people considered by Western standards to be illiterate are actually quite literate in terms of scientific understandings and environmental management” (2009, p. 56). Scientists from the Ecological Society of America have been working on the issue recently; noting:

... there is, at present, no complete and broadly applicable framework to guide both the formal and the informal educators who we expect to be our primary promoters of ecological literacy. We have no materials that provide an outline of
core concepts or habits of mind, or that can be used as a rubric for assessment of ecological literacy (Jordan, Singer, Vaughan, & Berkowitz, 2009, p. 2).

The resulting confusion and lack of direction affects researchers, who, despite interesting developments in educational technology and pedagogy, often fail to make a convincing case they are increasing some form of environmental literacy because their definition of it is vague, muddled or nebulous (e.g., Christenson, 2008; Cutter-Mackenzie & Smith, 2003; Lo, Affolter, & Reeves, 2002). The lack of consensus also affects policy and education; despite increasing concern over global climate change, a survey of higher education by the National Wildlife Federation (NWF, 2008) recently found that compared to 2001, students in 2008 were LESS likely to be environmentally literate when they graduate. The journal Educational Leadership concurs, noting:

Even though there are more centers for environmental education and more college degree programs in environment-related fields than ever, and even though building green schools has suddenly emerged as an important idea (pre-economic meltdown), we are perhaps even farther from environmental literacy than we were in 1969 (Weilbacher, 2009, para. 18).

**A potential solution.**

A simple but profound context to combine progress in scientific literacy with related work in environmental education and social studies would be designing education to give individuals and societies the knowledge and skills to maintain or improve their quality of life beyond the short term, thus providing an apolitical, globally-applicable “why” context for education. An important step to realizing this goal would be the development of a construct that encompasses the essential knowledge, skills, and
affective factors (e.g., attitudes, behaviors, sensitivities) involved. Such a construct, something that might be called socioecological literacy, has yet to be convincingly synthesized. Colloquially, these qualities might be considered as earth smarts, a more global and ecological version of the street smarts that urban residents rely on. In an age of increasing environmental awareness and concern for sustainability, an examination of what earth smarts really are, based on the premise of maintaining or improving quality of life, will help develop it as a construct that is useful to researchers, policy makers, and educators. As envisioned, earth smarts (www.earthsmarts.info) is more than just a subset of scientific literacy or laundry list of concepts from ecological science; it is a transdisciplinary mix of scientific, social, ethical, and political knowledge and skills, a mix that explicitly incorporates the underlying cognitive and affective components. Socioecological literacy and the more colloquial earth smarts will be used interchangeably throughout this paper.

**Problem statement.**

The primary purpose of this study was to formulate and conceptually analyze a new construct, earth smarts or socioecological literacy, that can address the question: What qualities do we need to justly maintain or improve our quality of life beyond the short term? The construct needs to be structured in a way that is useful in modern, standards-based educational contexts. This will be achieved by analyzing a wide range of literature to compile a parsimonious set of components that will facilitate an informed pedagogical understanding and model of earth smarts. The derived model will then undergo systematic validation and refinement through the input of academic experts, professionals, and practitioners. This conceptual analysis will be guided by the simple
and pragmatic idea that the desire to maintain or improve quality of life is a nearly universal, nonpartisan human motivation, so teaching the knowledge and skills to do it should be an overall goal of all education, particularly science, social, and environmental education.

The secondary purpose of this study is to address the question: How does earth smarts relate to socioscientific issues and education for ecojustice, including potential benefits and practical implications? While there is certainly overlap between these new frameworks, it is not clear how much overlap exists, how complimentary they are, or if there are areas that conflict theoretically or practically.

Rationale.

Developing the framework for socioecological literacy and examining its potential to inform SSI and ecojustice education is worthwhile because in many countries, science education and environmental education share a similar problem; they are failing to produce citizens with even basic levels of science literacy (e.g., Bybee, Fensham, & Laurie, 2009) or environmental literacy (Weilbacher, 2009). Socioscientific issues (Mueller, Zeidler, & Jenkins, 2011; Zeidler et al., 2005) and education for ecojustice (Bowers, 2001; Mueller, 2008) are two of the more interesting and potentially fruitful areas of research in science education right now, but both involve considerable pedagogical and political challenges. At the same time, many societies are recognizing the importance of sustainability and sustainability education, but struggling to implement it (Corcoran & Wals, 2004). Part of the reason for these failures is a plethora of overlapping and potentially conflicting definitions for each of these literacies; this is undoubtedly related to a fundamental and often controversial aspect of all education—the
underlying “why”. Why are students in Western countries expected to take over a decade of formal education? This study examined that often controversial question by providing a simple, nonpartisan context for science, social & environmental education: teaching so individuals & societies can justly maintain or improve their quality of life beyond the short term. Such teaching would benefit from an educational construct that incorporates what people & societies need to know & be able to do to maintain their quality of life, a construct that had yet to be convincingly synthesized. Figure 1 summarizes this argument from the perspectives of scientific and environmental education.
Figure 1. A summary of the case for earth smarts from the perspectives of environmental and science education.
As Figure 2 illustrates, operationalizing earth smarts would help clarify the relationships between a host of educational processes and products, which in turn would help reduce redundancies and promote more holistic research and learning across disciplines. What is the relationship between education for sustainability, science literacy, citizenship or ecojustice? How do they contribute to science literacy, social justice, or sustainable societies? The construct of earth smarts would help address many questions in education, policy, and research by clarifying overlap and differences, providing a nonpartisan rationale for education, and offering an education-friendly framework to build upon.
Theoretical Framework

Societies worldwide are facing daunting environmental challenges that our education systems may actually be contributing to, rather than helping to solve. This section provides the theoretical background and justification for pursuing earth smarts, beginning with a summary of the environmental challenges themselves, then covering some of the potential benefits that earth smarts would provide, and finally examining the potential intersection of earth smarts and two of the more interesting progressive movements in science education, socioscientific issues and education for ecojustice.

Figure 2. Some of the educational processes and products that should benefit from the operationalization of earth smarts.
Environmental challenges.

Though a few critics of the environmental movement continue to argue that the future looks rosy (e.g., Brown, Green, Hansen, & Fredricksen, 2004), there is increasingly little doubt that we are facing serious new environmental challenges on scales that have moved from local and short term to global and long term. Kirby (2004) provides a summary entitled “Planet Under Pressure”, analyzing six areas where experts agree we may be facing environmental crises: food, water, energy, climate change, biodiversity & pollution. These issues are all related, and all have the potential to degrade our quality of life, if they are not already doing so. Nature (Rockstrom et al., 2009) discusses “planetary boundaries”, lines that we must not cross without risking catastrophe. The authors note that although civilization developed in a period of relative environmental stability, “...human activities have reached a level that could damage the systems that keep Earth in the desirable Holocene state. The result could be irreversible and, in some cases, abrupt environmental change, leading to a state less conducive to human development” (para. 2). As more and more evidence suggests, climate change is not something to be taken lightly, and may have significantly contributed to both “golden ages” and socioeconomic catastrophes in human history (D. D. Zhang et al., 2011).

Paul Ehrlich (2009) summarizes the problems from an ecologist's perspective, stressing the importance of cultural evolution as a potential solution. Unfortunately, the ability of the public to address these problems may be decreasing. Coyle (2005) writes:

We are moving past the time when we can rely on a cadre of environmental experts to fix our environmental problems. With most environmental issues becoming more complex and difficult to manage, and with the preponderance of
pollution shifting toward problems caused by individuals and small entities, a
stronger and wider public understanding of environmental science and related
issues is a growing necessity. We are also moving into a time when direct contact
with the natural world is being markedly scaled back. Comprehensive
environmental education is the only real answer (p. V).

An interdisciplinary team of professors at Indiana University came to a similar
conclusion while working on environmental literacy, noting that “In industrialized
countries, the biggest consumers are those with the economic means to make responsible
choices, and the main limitation is education” (Reynolds, Brondizio, & Robinson, 2009,
p. 21).

Education may be the answer, but it is important to note that although we face
some daunting environmental challenges, education and awareness campaigns based on
crises and doom may contribute to hopelessness and marginalization. Mueller (2009)
reflects on some of these pedagogical implications from the perspectives of ecojustice
and sustainability. Our loss of ecological awareness has a parallel in many schools, where
urbanization and a culture of litigation have left both teachers and children increasingly
cut off from nature or any other aspect of world outside the classroom, something Pyle
(2001) calls the extinction of experience, and what may be contributing to something
increasingly well-known as nature-deficit disorder (Louv, 2008). These trends are not
limited to children; there is evidence from the United States and Japan that we are
experiencing a fundamental shift away from outdoor activities such as hunting, fishing,
and visits to public lands (Pergams & Zaradic, 2008). These studies suggest that our
decreasing contact with nature, combined with degraded local environments and
decreasing diversity, may result not just in ecological ignorance, but also alienation, apathy and a host of troubling psychological and developmental issues.

**Earth smarts & scientific literacy.**

There has been considerable tension, both philosophical and practical, between modern science and the environment, ranging from a perceived technological “mastery” over nature to an assortment of Luddite-like, back to the land entreaties. This tension has spilled over into education, where environmental education rarely finds a comfortable fit in formal curricula, even as the importance of science waxes and wanes, particularly in the earlier grades. In 1995, many of the world's top scientific and environmental thinkers considered how science could be harnessed “for the Earth” (Wakeford & Walters, 1995). Wallace (1998) wrote:

> The bulk of scientific problems are simple enough that Dobzhansky's assertion holds: most reasonable persons arrive at the same conclusion when confronted with adequate relevant data. Unfortunately, environmental literacy involves such complex, interacting elements that most persons lack the insight and experience that is needed for their resolution. Furthermore, such literacy requires that each person exhibit empathy towards others – especially those of other cultures, races and (economic) class (p. 367).

Since then, mechanistic, deterministic views of science and science education have gradually given ground to more holistic ones, bridging many, but certainly not all, of the rifts between science and nature, in theory if not in practice. While surveying environmental literacy, Roth (1992) spoke of considerable overlap and shared evolution of scientific and environmental literacies. Mueller and Bentley (2009), examining
ancestral knowledge in the context of environmental and science education in Ghana, argue that environmental literacy and scientific literacy are reciprocal; they speak of a growing synergy between them, despite some scientific resistance to environmental education's recognition of spirituality, beliefs, and values. Whatever the tensions, students of all types seem to be interested – one study of over 800 undergraduates on three continents found about two thirds supported an environmental literacy requirement (Aighewi & Osaigbovo, 2009).

Surveying definitions of scientific literacy, Roberts (2007) divides them into Vision I, which focuses on the products and processes of science, and Vision II, “in which considerations other than science have an important place at the table” (p. 730). Vision II scientific literacy, which includes progressive pedagogical approaches such as Science, Technology and Society (STS) and socioscientific issues (SSI), overlaps more with most formulations of environmental literacy. As scientific and environmental literacy have each evolved, they have moved beyond memorizing lists of facts to incorporate cognitive skills and acknowledge affective components. Many iterations of environmental literacy have made these additional aspects overt from the beginning, but scientific literacy is catching up; Koballa & Glyn (2007) provide a good summary of attitudinal and motivational constructs that have been linked to science education.

Tan (2009) argues that science teachers can use environmental education to make science more socially responsible. Gruenewald (2003) argues for a related combination, synthesizing a critical pedagogy of place by combining critical pedagogy and its focus on social justice with ecological principles and place-based education. This concept is both supported and critiqued in a series of recent articles in Environmental Education.
Research (Reid, 2008). Science education researchers in Europe have explored the mix of sustainability and pedagogies involving complex and controversial socio-environmental issues (Colucci-Gray, Camino, Barbiero, & Gray, 2006), noting that science education needs to do a better job of addressing complexity and uncertainty (Gray, Colucci-Gray, & Camino, 2009). Earth smarts will share important characteristics with new socioscientific visions of scientific literacy that emphasize moral aspects (Zeidler & Nichols, 2009; Zeidler & Sadler, 2011). Political background is yet another potential factor in environmental SSI's (L. Simonneaux & Simonneaux, 2009) as most, if not all decisions regarding the environment involve potentially difficult compromises between stakeholders, human or otherwise.

Bybee (2008) links scientific literacy and the environment when discussing the Programme for International Student Assessment (PISA) 2006 Assessment of Scientific Literacy, emphasizing the environment and resources as important contexts for scientific literacy. PISA's model for scientific literacy (OECD, 2007, p. 35) is an interesting one; it shows context (situations that involve science and technology) requiring scientific competencies that are influenced by both knowledge and attitudes, a perspective that SSI researchers find promising in theory, although somewhat troubling in execution (Sadler & Zeidler, 2009). As a result of this model, PISA surveys attitudes, including environmental attitudes, as well as testing knowledge and competency.

Good environmental education offers a chance to examine complex, difficult issues from different perspectives; value judgments are inevitable as compromises have to be made that affect a wide variety of stakeholders, including non-humans and ecosystems. Christenson (2004) found that teaching multiple perspectives on
environmental issues in elementary classrooms is beneficial, noting, “These findings are gratifying because teaching children to identify different perspectives and to think critically about issues could be the real beginning of environmental literacy, which will result in future successful environmental problem solving” (p. 14). A school movement to frame the entire curriculum around the environment, or Using the Environment as an Integrating Context for Learning (Lieberman & Hoody, 1998), found a variety of benefits, from improved scores on standardized tests to more responsible behavior.

Examining related issues, Zeidler & Sadler (2011) consider the terms functional scientific literacy and socioscientific reasoning, emphasizing complex issues, multiple perspectives, ongoing inquiry, and skepticism. Further blurring the distinctions, the role of socioscientific issues and functional scientific literacy in ecojustice education is examined in a new book chapter (Mueller & Zeidler, 2010). As these ideas continue to be fleshed out in theory and incorporated into practice, both scientific and ecological literacy move farther from the simple transmission of basic content. This operationalization of socioecological literacy, or earth smarts, will help researchers from science education, social studies and environmental education improve their collaborations, reduce redundancies, and bring more vibrant, fair, and sustainable forms of scientific and ecological literacy closer to reality.

**Study significance: the benefits of earth smarts.**

Educators, researchers, individuals, and communities will all benefit from a clear definition of earth smarts, one that includes components operationalized in a framework conducive to education. As individuals, knowing what qualities will help us to improve our quality of life is an important part of self-regulation, metacognition, and lifelong
learning. A recent paper by scientists from the Ecological Society of America argues that, “Given the rapid growth and development facing communities, ecological literacy must be part of a citizen’s lifetime learning experience, beginning in the primary grades and continuing through informal adult learning experiences (Jordan et al., 2009, p. 1).

The concept of literacy need not be limited to individuals, an idea relevant to both environmental and scientific literacies. Roth and Barton (2004) consider scientific literacy from a community perspective – ecoliteracy at the community, national or even planetary level is equally interesting. For example, satellite technology can be very helpful for detecting, understanding, and monitoring global environmental changes, but obviously every individual does not need to know how to build and launch such satellites to benefit from them. However, as deploying satellites requires collective expertise and effort, individuals should at least be able to understand why they are important. For communities and nations, operationalizing the components of socioecological literacy will help to discover missing skills, fill gaps in curricula, and serve as a road map or adaptive management tool for policy makers and educators alike. Responding to environmental crises is only part of the picture; crisis prevention is at least as important, and prevention is an area where affective components become more relevant. In order to learn and care about critical environments that city life insulates us from, we need to nurture and draw strength from our connection to nature, rather than simply respond to environmental ills and catastrophes (Sobel, 1996).

For researchers, educators and policy makers, a validated list of components for earth smarts will be an invaluable tool. Sustainability in one form or another is popular right now, but most definitions of it are too vague to be useful in education or policy,
including the consideration of what exactly is to be sustained. While discussing sustainability literacy and the importance of language, Stibbe (2008) notes “...there is a danger that over-generalized definitions can lose their meaning by being all-encompassing” (p. 2); he then goes on to defend a definition that appears to be very vague indeed, on the grounds that it will include students from more disciplines. Such vague definitions are common; from a more critical perspective, Kahn (2003) argues that...
critical ecoliteracy means being able to recognize one’s own critical ecoliteracy as a form of ethical epiphany that individuates the state of planetary ecology as a whole at any given time, and which contains within itself a range of transformative energies, life forces, and liberatory potentials capable of affecting the future (p. 13).

Although the intentions are noble, this sort of framework is rather difficult to put into practice, particularly given the educational constraints the vast majority of the world deals with. The problem is not limited to educational researchers. The journal *Environmental Politics* contains a lengthy discussion of the limitations and problems with the World Commission on Environment and Development definition of sustainable development, but the proposed solution is a three-circle Venn diagram (place, person, and permanence), confusingly defined as the five dimensions of sustainability (Seghezzo, 2009). While there may be some theoretical value to such formulations, they are too vague or confusing to be of much practical use for policy or education.

On the other hand, overly prescribed, disciplinary “solutions” may seem colonial, or fail dismally despite their good intentions due to cultural, temporal or ecological incompatibilities. Earth smarts, based on the near universal desire for a better quality of
life, will help address the tension between these two ends of the spectrum by carefully balancing 1) an open, pluralistic viewpoint that is necessary to incorporate the numerous ways that quality of life might be sustained over cultures, ecosystems, and time; and 2) a practical, modular framework that can be easily adapted to standards-based educational systems with limited resources. Theorizing and validating a list of components for earth smarts will aid researchers, inform interdisciplinary science, guide policy makers, and contribute to education that engages students and improves societies. On all levels, improving earth smarts has the potential to help us change behaviors and social structures that have been needlessly degrading our environments and the quality of life they support.

Socioecological literacy will be considered here in the strong sense of environmental literacy (Stables & Bishop, 2001), where literacy connotes more than the ability to read and write. The world is more than a text to be read, so semiotics might be a more accurate term, as people interact with socially constructed symbols of the biophysical world, something each culture and even individual does differently. Socioecological semiotics is something of a mouthful, but regardless of the semantics, the advantage of this diverse, pragmatic approach is that it doesn't matter if you use ancient indigenous wisdom or cutting edge technology to tackle a problem; whatever works is worth considering. Nor does it matter if your challenges are local or global; natural or anthropogenic, or any combination thereof. Whatever your political inclination, however skeptical you are about the current cause or scope of environmental change, an increased level of earth smarts will help you and your community recognize and adapt in ways that conserve or improve your own quality of life, and minimize harm to that of others.
Figure 3 shows two logic models that illustrate how operationalizing the components of earth smarts can facilitate achievement for individuals or societies. Defining earth smarts will allow us to use responsibility matrices, systems tools that help individuals and communities decide which organizations will be responsible for teaching or learning individual components. This in turn will allow us to streamline the way we, as individuals, communities or nations, achieve earth smarts.

![Logic models showing how earth smarts and responsibility matrices could help individuals and communities.](image)

Figure 3. Logic models showing how earth smarts and responsibility matrices could help individuals and communities.

A final, related point concerns sustainability literacy and education for sustainability or sustainable development, numerous versions of which will be grist for
The idea of sustainability has become very popular both in and out of the academy over the past decade, and while it is undoubtedly related to earth smarts, I deliberately chose not to use a version of sustainability as the name of this construct. The key lies in the goal; earth smarts has an explicit goal, justly maintaining or improving quality of life. As Wals and Jickling note when examining the use of sustainability in higher education, “Both the knowledge base and the value base of sustainability are variable, unstable and questionable” (Wals & Jickling, 2002, p. 222). They argue that this non-prescriptive vagueness can be useful in higher education, if carefully handled, but it seems more problematic in typical standards-based K-12 settings. Setting aside the thorny issues surrounding sustainable “development” for later, the problem with using sustainability is the problem of deciding just what should be sustained. Are we sustaining habitat, diversity, cultures, lifestyles, languages or ecosystems? What about individuals or species in zoos and seed banks? Are present climate patterns worth sustaining, or is that even possible? Global-scale science is making it increasingly clear that conditions on Earth change dramatically, and species either adapt or disappear. Although they remain common, static world views that depend on an unchanging planet are failing us, just as they have failed numerous societies in the past (e.g., Diamond, 2005). To complicate matters, many people in the world are striving for something more than they presently have; for them, sustaining the status quo is not enough. To avoid the potential for confusion that “sustainability” may invoke, I chose socioecological literacy, rather than sustainability literacy, as the label for this construct.
Overview of Inquiry Framework

The purpose of this study was to design, analyze, and validate a construct, socioecological literacy or earth smarts, using a conceptual analysis framework. In education, constructs are typically concepts for which there is no direct, physical referent (Krathwohl, 1993), things like happiness, literacy or intelligence. Although theoretical dissertations are presently uncommon in education research, construct design and analysis can be a useful tool:

... when a construct is fuzzy, when its meaning differs markedly from person to person or instance to instance, when we use the same term in different ways, then it can be a source of difficulty and misunderstanding. A conceptual analysis of constructs removes the “fuzz” and clarifies how the term is being used (Krathwohl, 1993, p. 148).

Krathwohl suggests four steps to analyzing a construct: 1) find examples of the construct; 2) test the defining examples; 3) ask if the set is complete and 4) ask what must be added if it is not. This study will adopt a similar structure, although theorizing earth smarts will require a flexible framework, as it is a pragmatic construct that crosses numerous disciplines within academia (including the natural and social sciences, ethics, education, and psychology) and without as well (policy, culture, management, applied education). Also based in education, the process therefore draws on the idea of educational connoisseurship (Eisner, 1998), a combination of enlightened consideration and critique useful in more holistic, qualitative consideration of work from different disciplines.
Krathwohl's framework will be set in the context of theory-building spiraling research (Berg, 2007), shown in Figure 4, which features data collection integrated into feedback loops that include theory building along with design and analysis. Bacharach's (1989) work on evaluating theories, constructs, and variables will also be considered; particularly the importance of time, space and value assumptions in setting boundaries. Table 1 shows his evaluation framework; note that constructs, which Bacharach discerns from variables because they are not directly observable, must still be both falsifiable and useful.

Table 1: A Framework for Evaluating Theories, Adapted from Bacharach, 1989

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<thead>
<tr>
<th></th>
<th>Falsifiability</th>
<th>Utility</th>
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<td>Variables</td>
<td>measurement issues</td>
<td>variable scope</td>
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<tr>
<td>Constructs</td>
<td>construct validity</td>
<td>construct scope</td>
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<td>Relationships</td>
<td>logical adequacy</td>
<td>explanatory potential</td>
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<td></td>
<td>empirical adequacy</td>
<td>predictive accuracy</td>
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</table>

For this study, a two-stage design will be used, detailed in Figure 6 in the methods section. The initial stage is an intensive, wide-ranging literature review, incorporating writings from numerous academic disciplines as well as political and practical documents from outside academia. The results of this review will be subjected to theoretical analysis techniques including the graphical mind mapping of essential elements, an ethical matrix (Mepham, 2000), a responsibility matrix, a component analysis table, and a modified
system matrix (Nadler, 1981). From these analyses, a set of preliminary domains and components for earth smarts will emerge.

The second stage will use the preliminary domains and components as a framework to solicit qualitative and quantitative input from experts and practitioners, primarily in the form of interviews and surveys. The analysis of this input will help to further build and validate components. Such input will help generalize components, in order to make the construct academically productive, and but also provide examples of localization, which will show how earth smarts can be useful in a variety of ecological, social and cultural contexts. Due to the varied nature of the inputs (academic and other literature, expert interviews, surveys, and online collaboration), this will be a mixed methods study with a theoretical focus. Chapter three will thoroughly cover the methodology.

Study Boundaries

Theories and constructs may be bounded by time, space and their underlying, potentially value-laden assumptions (Bacharach, 1989). To help disclose the inevitable value assumptions, Appendix A describes relevant aspects of the researcher's biography. As for the scope of the literature considered, topics such as environmental literacy and quality of life are problematic as there are far more than a few key academic journals in a single discipline to consider. The transdisciplinary nature of earth smarts means that important information might be found across numerous disciplines and cultures, both within and beyond the realm of academia. Nor is this a static issue – advances in a range of natural sciences are showing us that the world changes, often dramatically, and the pace of change appears to be accelerating right now, so we will need to adapt. What
works now may not work in the future, but what worked in the past just might, so there is much to be learned from history, archeology, and even paleontology as well. All of which is to say there is no way this study can cover everything it might benefit from. Beyond the obvious cultural (North American) and linguistic (English) limitations, lines must be drawn. While a number of international journals were incorporated, much of the ongoing validation and localization of EEL components will need to be done by others.

As a result, whenever possible the project used open educational resources (OER), free and open source software (FOSS), and new collaborative technologies, so that the limitations of the researcher and the restricted number of experts and professionals involved in the initial analysis may expand to include individuals, including stakeholders, from a wide range of countries and cultures, ultimately becoming a strength rather than a limitation. My hope is that earth smarts will provide both an inspiration and an nonpartisan framework that others may benefit from and build upon. Earth smarts is intended to be flexible and valid across time and space, but the underlying assumptions are potentially value-laden, and must be therefore be made explicit to minimize cultural boundaries. It is therefore important to address two of the concepts that provide the structure that this analysis will be based on: the transdisciplinary nature of earth smarts, and quality of life.

Transdisciplinary.

The idea that earth smarts is a transdisciplinary construct needs clarification. The sense of transdisciplinary being used here is adapted from Godemann (2008), who uses it to examine the importance of knowledge integration. In this sense, transdisciplinary research deals with real world problems and crosses disciplines; it therefore integrates
different types of knowledge and develops practical solutions as well as generating new academic research and issues. Godemann invokes the participation of both academics and practitioners in transdisciplinary work; Polk and Knutsson (2008) include a variety of non-academic stakeholders and organizations in knowledge production, and make the point that understanding and balancing the different value rationalities that stakeholders may have is also essential. Given the public nature of many environmental resources and threats, stakeholders are an important and potentially numerous group; who doesn't have a stake in clean air or safe drinking water? As the failure of numerous top down attempts to address environmental issues suggests, it is important that stakeholders are able to participate in the validation and especially the localization and implementation of earth smarts.

Transdisciplinary thinking is a key point; Edwards (2006) reviews numerous perspectives and concludes that effective education for sustainable development may be impossible from within the disciplinary nature of our education systems, and the mechanistic world views upon which they are based. Newell et al. (2005) argue that integration of knowledge across disciplines is key to sustainability, writing:

Our efforts to develop effective policies need support from almost all forms of human knowledge. In particular, we urgently need to improve our understanding of the interactions between people and their biophysical environment—interactions that are driven by human aspirations and social and cultural institutions, but that are ultimately constrained by the laws of nature (p. 300). They go on to provide a conceptual template for such work based on six conceptual clusters, and point out that researchers from different fields must first discover shared but
potentially hidden antonyms and synonyms in the initial stages of integrative work. Clarifying such patterns will be one of the benefits of this study.

An example of the sort of transdisciplinary thinking that will provide the framework for earth smarts is the emerging field of historical ecology, which incorporates humanity into ecological science, the Earth system into history, and then blends them together, bridging the gulfs between the natural sciences, the social sciences, and the humanities. Historical ecology “...traces the complex relationships between our species and the planet we live on, charted over the long term...The goal of historical ecologists is to use scientific knowledge in conjunction with local knowledge to make effective and equitable management decisions” (Crumley, 2007, p. 16). A second example of transdisciplinary thinking would be ecological economics (Røpke, 2005) and related attempts to define the concept of ecosystem services. For years, ecologists have theorized and discussed the idea of valuing natural features like wetlands for the services they provide for us, but ecosystem services haven't become a major factor in real-world economics. New transdisciplinary efforts to make them both credible and sustainable involve cooperation between natural and social scientists, non-governmental organizations, economists, and governments (Daily et al., 2009).

**Quality of life.**

Despite the pragmatic nature of earth smarts, basing a construct on something as philosophically slippery as quality of life is not without its hazards, as definitions of wellbeing and quality of life (used interchangeably here) can be problematic. Diener and Seligman (2004), examining the issue from a psychological perspective, suggest that high wellbeing can at least partly be achieved if we:
• Live in a democratic and stable society that provides material resources to meet needs.
• Have supportive friends and family.
• Have rewarding and engaging work and an adequate income.
• Are reasonably healthy and have treatment available in case of mental problems.
• Have important goals related to one’s values.
• Have a philosophy or religion that provides guidance, purpose, and meaning to one’s life (p. 25).

They note that traditional economic measures are therefore not adequate for measuring well-being once basic needs have been met, and much better measures are needed. Gross domestic product or consumer spending indices do not equate to happy citizens, nor do they begin to represent the well-being of the millions of other species we share the planet with, many of which may deserve our moral consideration (e.g., Gert, 2004). The Earth Charter addresses the human side of this idea, noting in the preamble that the “...well-being of humanity depends upon preserving a healthy biosphere with all its ecological systems, a rich variety of plants and animals, fertile soils, pure waters, and clean air” (Earth Charter Initiative, 2000, para. 2).

If maintaining or improving quality of life is to be as close to a universal human goal as possible, our definition must remain basic and flexible. While philosophers, psychologists and theologians will always quibble about the nature of long-term happiness, there is enough common ground to work from. Noddings (2003), considering happiness in the context of educational goals, notes that educators don't need an exact definition, but she argues that “Happiness and education are, properly, intimately related:
Happiness should be an aim of education, and a good education should contribute significantly to personal and collective happiness” (p. 1). Most of us would agree that achieving an acceptable quality of life relies on a set of basic requirements including clean air, clean water, safe and nutritious food, shelter from the elements, freedom from violence and crime, and opportunity, the last of which gets especially complicated, and all of which must be balanced by the needs of others. Opportunity is not opulence; speaking to issues of consumption, the Earth Charter notes that “…when basic needs have been met, human development is primarily about being more, not having more” (Earth Charter Initiative, 2000, para. 4). On the other hand, quality of life doesn't mean getting back to some mythological natural paradise or Garden of Eden; science and technology have indisputably allowed many of us to live longer, more comfortable lives. Urbanization, suburbanization, and agriculture have had a huge impact on the environment (Johnson, 2001), but with more awareness and better planning, their impacts need not be so negative in the future.

For the purposes of this paper, a consideration of quality of life will acknowledge there may be no simple or universal environmental values we can rely on. Examining some of the problems with utilitarianism, consequentialism, and egalitarianism, O'Neill, Holland and Light (2008) suggest a kind of value pluralism for environmental decisions, a view that takes local history and narratives into account. It is also problematic, both scientifically and ethically, to draw moral lines between humans and non-humans when discussing well-being, although it seems reasonable to allow that individuals of more intelligent species (e.g., dolphins and chimpanzees) deserve more moral consideration than individuals of less intelligent species (e.g., mosquitoes and turnips). Environmental
philosophy (e.g., M. E. Zimmerman, Callicott, Clark, Warren, & Klaver, 2005) continues to address these prickly issues in depth, notably the tensions between human, animal, and ecosystem rights.

For the less philosophically inclined, there are a number of pragmatic new ways to measure quality of life that go beyond gross national product. For instance, the Happy Planet Index from the New Economics Foundation attempts to combine well-being with environmental impact, so “...nations that score well show that achieving, long, happy lives without over-stretching the planet’s resources is possible” (NEF, 2006). Other recent measures include the quality-of-life index (Economist Intelligence Unit, 2005), the sustainable society index (Van de Kerk & Manuel, 2008), the American Human Development Index (Burd-Sharps, Lewis, & Martins, 2008), and Bhutan's index of Gross National Happiness. Lawn (2003) examines the theoretical underpinnings of the index of sustainable economic welfare and the genuine progress indicator, while the New Economics Foundation discusses the importance of well-being indicators and some of their latest results (NEF, 2009).

**Summary**

Although we are becoming increasingly aware of the environmental challenges we face, urbanization and dysfunctional education are contributing to an unprecedented loss of ecological knowledge and literacy. Part of the reason is confusion as to what environmental, social, ecological, and scientific literacy really entail. It would therefore be useful to build and analyze a construct describing the qualities that will allow us to justly maintain or improve our quality of life in the face of new environmental challenges. Such a construct could provide education not only with a pedagogically
useful framework, but also a nonpartisan goal based on a near-universal human desire. Using construct analysis techniques followed by interviews and surveys of experts and practitioners, this theoretically based, mixed methods study unearthed the combination of knowledge, skills and other attributes of socioecological literacy, or earth smarts. The following chapter will review the literature and examine some of the numerous definitions and formulations of ecological and environmental literacy, along with many related terms and concepts.
Chapter 2: Review of the Literature

This section reviews a wide variety of literature related to ecological and environmental literacy, in order to provide a basis for the initial selection of components for earth smarts. Drawing on Eisner's (1998) notions of educational connoisseurship, concepts were chosen from a range of academic disciplines, as well as professional and local knowledge. Due to the diversity of the sources, including many from outside of academia, a complete review would be impossible; older works were included here based on their subsequent influence, or representation of a particular line of reasoning. The papers are divided into sections based on their focus, starting with definitions of ecological and environmental literacy, moving to definitions of other environmental and ecological concepts, then to the variety of concepts based on sustainability and sustainability, followed by an assortment of terms that do not fit into the previous categories. Three further sections follow: the first covers government declarations and documents, some of which have been highly influential. The second summarizes select educational frameworks, including an updated version of Bloom's taxonomy that will help provide insight and structure to the emerging components. The educational section also takes a closer look at socioscientific issues, as the relationship of earth smarts to socioscientific issues and education for ecojustice underlies the secondary focus of this study. Finally, there is a section on formal educational standards, including national standards from a range of disciplines.
The papers in this review are not simply summarized; to provide grist for the theoretical analysis, I have attempted to extract the underlying theories, domains, and components of these treatments of environmental literacy and its relatives. As a result, the review section and subsequent analysis are best considered alongside the earth smarts analysis mind map (ESAMM), an expandable graphic organizer of the key components arranged in a hierarchical structure.

**The Earth Smarts Analysis Mind Map**

The earth smarts analysis mind map (ESAMM) provides a way to visualize some of the different views of ecological literacy and related terms that will be covered. Due to its size when fully expanded (there are dozens of definitions including hundreds of domains, concepts, and components), the ESAMM is best experienced on a computer where individual concepts and subconcepts can be explored by clicking on them to expand and contract the branches. In keeping with the philosophy that earth smarts should be available to everyone for use and input, the ESAMM was created using Freeplane (freeplane.sourceforge.net), free and open source software, and can be exported to Javascript which is also free and part of most web browsers. Figure 5 is an image of the fully contracted base of the ESAMM; when fully expanded, it would probably reach several stories tall.
A Collection of Constructs

A rose by any other name is still a rose, but a transdisciplinary review of literature regarding ecological literacy isn't so straightforward at all. Rather than reading a few writers in a few key journals, important work on ecological literacy comes from a wide variety of academic disciplines, as well as technical, literary, and popular sources. The task of navigating this vast, occasionally thorny bramble is made more difficult by the abundance of names for related concepts that may have identical meanings, overlapping components or even philosophical conflicts. Helping to clarify these relationships by clearly defining earth smarts is one of the primary reasons for this study. Environmental literacy is probably the most common and wide-ranging term used in the literature, but as we shall see there are numerous alternatives. The definitions run the gamut from vague and/or simple to complex and specific. Table 2 lists the terms that are covered in this analysis, along with some select references. For clarity, terms that are used for this analysis and appear in the ESAMM are initially set in italics.
Table 2: Alphabetical list of key terms covered in this analysis along with select references

<table>
<thead>
<tr>
<th>Term</th>
<th>Select References</th>
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<tbody>
<tr>
<td>21st century skills</td>
<td>Hilton, 2010</td>
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<td>consciousness of interdependence</td>
<td>Daloz, 2004</td>
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<td>contextual sustainability education</td>
<td>Verhagen, 2004</td>
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<td>critical pedagogy of place</td>
<td>Furman &amp; Gruenewald, 2004</td>
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<td>deep ecology</td>
<td>Devall &amp; Sessions, 1985</td>
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<td>ecocomposition</td>
<td>Grant, 2009</td>
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<td>eco-ethical consciousness</td>
<td>Martusewicz and Edmundson, 2005</td>
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<td>ecojustice</td>
<td>Center for Ecojustice Education, 2008</td>
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<td>ecoliteracy</td>
<td>Center for Ecoliteracy, 2008</td>
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<td>ecological citizenship</td>
<td>Dobson, 2004</td>
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<td>ecological consciousness</td>
<td>O Sullivan &amp; Taylor, 2004</td>
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<td>ecological education</td>
<td>Hautecoeur, 2002</td>
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<td>ecological economics</td>
<td>Røpke, 2005</td>
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<td>ecological literacy</td>
<td>Orr, 1992; Jordan et al., 2009</td>
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<td>ecological naturalism</td>
<td>Code, 2006</td>
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<td>ecological thinking</td>
<td>Berkowitz, 2000</td>
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<td>education for sustainability</td>
<td>The Cloud Institute, 2009</td>
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<td>educating for the commons</td>
<td>Bowers, 2006</td>
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<td>education for sustainable development</td>
<td>UNCD 1992</td>
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<td>educating for pluralistic life</td>
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<td>education for sustainable living</td>
<td>Center for Ecoliteracy, 2008</td>
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<td>environmental citizenship</td>
<td>Berkowitz, Ford, &amp; Brewer, 2005</td>
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<tr>
<td>Term</td>
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<td>integral peace education</td>
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<td>natural guides</td>
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<td>permaculture principles</td>
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<td>political ecology</td>
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<td>Kates et al., 2001</td>
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<td>sustainable development</td>
<td>UNSD, 1993</td>
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<td>transition movement</td>
<td>Hopkins, 2008</td>
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Ecological and environmental literacies.

Even amongst ecologists themselves, there is limited agreement as to what ecological literacy might entail. Klemow (1991) acknowledged this and published 11 ecological concepts that might form the backbone of basic ecological literacy, along with a request for input to the Ecological Society of America. He also acknowledged that an approach taken from ecological science itself may not be adequate. While discussing challenges for ecological education programs, he notes:

First, as most ecologists realize, ecology itself is highly interdisciplinary and intergrades into other areas of biology like systematics, physiology, genetics, behavior and evolution, as well as into physical sciences like chemistry, meteorology, physics and earth science. Moreover, ecology relates to many applied areas such as resource management, agronomics, forestry, environmental toxicology, and wildlife biology. Thus, the definition as to what exactly comprises "ecology" is often difficult to delineate from that which is "not ecology". (para. 2)

Laundry lists of scientific concepts have their limitations, but at the opposite end of the spectrum are the numerous vague or all-inclusive definitions that celebrate the breadth of ecology as a concept, but tend to be less than helpful in practical terms. A UNESCO project on literacy (the ALPHA series) finishes with this definition:

It is a very different kind of literacy that is the aim of ecological education: discovery of the abundance of our heritage and the fragility of our environment; speech which is both respectful of others and creative; and a recreation in our lives of sanctified spaces, with ethical, civic, and aesthetic meaning... Its title might be 'Learning the Art of Living'... (Hautecoeur, 2002, p. 258).
The art of living indeed; the English working-group provided this definition of ecological education: “a continuous process of learning, including education and training, enabling people to think and act more responsibly and creatively in the context of their environment, their culture, and their community” (p. 254). Though mired in generalities, lengthy paragraphs and policy speak, the international project did come up with some interesting characteristics of ecological education. Some the relevant aspects of their definition include its spatial scope, from local to global, and its temporal perspective that includes future generations. They contrast ecological education with formal education both in its holistic, rather than disciplinary approach, and its focus on civil society rather than formal institutions.

The term ecological literacy is probably most associated with David Orr's (1992) book of the same name. Orr provides several perspectives on what ecological literacy might be, most notably a nod to economist Garret Hardin's statement that “…the ecologist insists that we ask the time-binding question 'And then what?'” (Hardin, 1980, p. 63). Orr sees ecological literacy as more than just scientific knowledge, applied or otherwise, writing “…ecology is the basis for a broader search for pattern and meaning. As such it cannot avoid issues of values…and…ethical questions…” (1992, p. 94). After chastising our education systems for continuing to produce ecological illiterates, Orr provides some thoughts on what ecological literacy might actually entail. He writes:

Ecological literacy, further, implies a broad understanding of how people and societies relate to each other and to natural systems, and how they might do so sustainably. It presumes both an awareness of the interrelatedness of life and knowledge of how the world works as a physical system. To ask, let alone
answer, “What then?” questions presumes an understanding of concepts such as carrying capacity, overshoot, Liebig’s Law of the minimum, thermodynamics, trophic levels, energetics and succession. Ecological literacy presumes that we understand our place in the story of evolution it is to know that our health, well being, and ultimately our survival depend on working with, not against, natural forces. The basis for ecological literacy, then is the comprehension of the interrelatedness of life grounded in the study of natural history, ecology, and thermodynamics (p. 92).

Unfortunately, rather than providing a list of essential concepts, Orr is more inclined to helpful generalities (such as thinking to ask, what then?) and scattershot specifics like Leigbig's Law of the Minimum, the principle that growth is controlled by the scarcest resource or limiting factor (Taylor, 1934). An example of the trouble that can entail when constructs are too general in education can be seen by considering a direct descendent of Orr's ecoliteracy, the highly evolved eco-literacy of Cutter-Mackenzie and Smith (2003). This definition is sparse with specifics when it comes to knowledge and skills, but requires a “communalist” or eco-socialist philosophy moving into a so-called Gaia ecocentric perspective, something unlikely to win many adherents in much of the world.

Berkowitz (2000) made an attempt to define ecological literacy by developing the idea of ecological thinking. He sees this as, “...defining the 'how?' for thinking about ecological phenomena that runs perpendicular to the 'what?' of ecology” (para. 2). The underlying ideas are both familiar and interesting – his subsequent work has focused on ecological thinking and environmental citizenship, terms covered later. From Australia,
Wooltorton (2006) adopts a more expansive view of ecological literacy, explicitly including a domain that attempts to capture a spiritual side – her “ecological self” includes care and compassion, expansiveness of soul, and respect for difference.

Balgopal and Wallace (2009) mentioned recent attempts to link the work of the Ecological Society of America (ESA) and the National Association of Researchers in Science Teaching (NARST). Although they could not find a standard instrument to measure ecological literacy, they unconvincingly noted the term had replaced environmental literacy. Their definition states “An ecologically literate person can recognize the relevance and application of ecological concepts to understanding human impacts on ecosystems” (p. 14). A potential problem with this definition, like many others, is that it doesn't address why such knowledge might be desirable. In this case, there is also no concern for how we might need to adapt to changes that are natural or externally forced, a related reversal, perhaps – the impact of ecosystems on humans.

The term ecoliteracy is occasionally used interchangeably with ecological literacy, most notably in work coming from the Center for Ecoliteracy (2008) in Berkeley, California. Their guiding principles for sustainable schooling include nature as teacher, community practice, real world learning and knowledge of place (Stone & Center for Ecoliteracy, 2009). Their website mixes the terms ecoliteracy, sustainability, and “education for sustainable living” freely. Co-founder Fritjof Capra notes:

We do not need to invent sustainable human communities. We can learn from societies that have lived sustainably for centuries... Since the outstanding characteristic of the biosphere is its inherent ability to sustain life, a sustainable human community must be designed in such a manner that its technologies and
social institutions honor, support, and cooperate with nature's inherent ability to sustain life (Center for Ecoliteracy, 2008, para. 2).

The Center breaks down their vision of ecoliteracy into four competencies: head, heart, hands and spirit, and there is some additional work in the areas of ecology and systems thinking, making this one of the best realized definitions available. While catchy, the primary domains don't all hold up well to analysis, particularly the “hands” domain, the components of which read more like applied or pragmatic cognition (head) skills than actual physical skills.

Like ecological literacy, *environmental literacy* can be conceived of in mainly scientific terms, or much more expansively. Frank Golley attempts to do the former in a text based on an environmental ethics course at the University of Georgia. His book, *A Primer for Environmental Literacy* (1998), defines environmental literacy as an organized way to think about the environment, built on a foundation of scientific concepts. He admits the limitations of that approach from the beginning, noting it leaves out the humanities, spiritual aspects, and an emphasis on action. He writes “This is a serious drawback because so many representations of environmental consciousness are derived from human thought, imagination, belief, and prayer” (p. xiii). The ESAMM attempts to represent his structure for environmental literacy, however it is not clear how his concept clusters relate to the foundational concepts he mentions, one of which doesn't match his chapter headings like the other three do. The conceptual water is muddied even more in his conclusion, which adds that four features characterize environmental concepts: dynamism, connectedness, creativity, and limitations. It's not clear how these
mesh with his previous framework, and the creativity aspect is poorly justified at best, reading more like an attempt to fit Christian beliefs into the construct.

The Campaign for Environmental Literacy (2007) takes a different tact, dividing environmental literacy into five components, the last of which is action, noting that, “...environmental literacy is the capacity to act in daily life on a broad understanding of how people and societies relate to each other and natural systems, and how they might do so sustainably” (p. 7). Their vision of environmental literacy is an overlapping but hierarchical ladder of the five steps: awareness, knowledge, attitudes, skills, and action. They note that all steps are necessary to achieve literacy. Charles Roth, one of the first to write about environmental literacy in the 1960's, also defines it from an action perspective, as “...the capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore or improve the health of those systems” (Disinger & Roth, 1992, p. 3). Roth's (1992) survey of the evolution of environmental literacy examines how conceptions of environmental literacy have evolved up to the early 1990's. After examining a variety of views from the literature and international documents, especially the 1977 Intergovernmental Conference on Environmental Education in Tbilisi (Unesco, 1978), he proposes three levels of environmental literacy: nominal, functional, and operational. Each is measured in terms of four familiar sounding strands: knowledge, skills, affects, and behavior. As he provided some specific characteristics or requirements at each level, his work provides an excellent basis for considering some of the individual components of earth smarts. To examine schoolteachers in Taiwan, Hsu and Roth (1998) operationalized a variety of frameworks into ten *environmental literacy variables*, which are action and attitude
focused, and appear in the ESAMM. This work was partly based on the environmental literacy framework described by Marcinkowski and Rehring (1995), which also focuses on action strategies.

Writing for the National Environmental Education & Training Foundation (NEETF), Kevin Coyle (2005) provides some insights into 10 years worth of survey data in the United States. Also using three levels, he differentiates “true” environmental literacy from environmental awareness (a basic level) and the next step of personal conduct knowledge. Using data from the survey he estimates that only 1-2 percent of American adults have achieved true environmental literacy. While the NEETF's definition remains vague, Coyle cites six principles from an earlier study (Hungerford & Volk, 1990) as the basis for true environmental literacy, and mentions that they have held up well under scrutiny and testing and found their way into the guidelines for excellence by the North American Association for Environmental Education (NAAEE, 2004).

Joy Palmer's (1998) survey of environmental education provides an interesting view of environmental literacies. The plural is important, and her overlapping Venn diagram framework does not translate well to the hierarchical design of the ESAMM, so only the upper level domains are represented. The tree background may be a bit gimmicky, but the roots provide a worthwhile metaphor for context and constructivism. However, the most interesting elements are in the three circles and their associated qualifiers: empirical (education about the environment), ethical (for it), and aesthetic (in or from it). The three mesh to produce concern, experience and action, and at the center of it all are knowledge, concepts, attitudes, and skills. While this arrangement may not work perfectly, it provides an interesting alternative to the hierarchical structure of the
ESAMM, highlighting an important point: the theories, domains and components that make up earth smarts are unlikely to be independent of each other at any level. They may combine synergistically as Palmer's diagram shows, but in many cases interactions may be antagonistic as well. In other words, the components don't necessarily all get along; for example, some knowledge will conflict with certain attitudes, and affective elements or strong moral stances may negatively influence a variety of cognitive skills such as critical thinking. There is interesting work being published in this area in the science education literature (e.g., Sadler & Zeidler, 2004) that will help inform the integration of domains in earth smarts.

An interdisciplinary effort at Indiana University produced an interesting definition of environmental literacy, as “An understanding of the environmental, social, and economic dimensions of human-environment interactions, and the skills and ethics to translate this understanding into life choices that promote the sustainable flourishing of diverse human communities and the ecological systems within which they are embedded” (Reynolds et al., 2009, p. 18). There's a lot going on in that definition, and it is part of a book on ways to achieve environmental literacy in college teaching. Their central organizing themes appear in the ESAMM, but the actual components do not break down well, forming more of an interconnected cloud emphasizing sense of place.

At the other end of the education scale, Sabiha Daudi (2008) points out that environmental literacy needs to work for the significant percentage of the world whose reading and writing skills are limited. She summarizes some of the previous definitions of environmental literacy and education, stressing the behavioral aspect that proponents of environmental education often emphasize. As we shall see, emphasizing behavior may
not be the best way to consider earth smarts, but her point that low and non-literate
learners, who have considerable life experience and learning, would benefit most from a
participatory approach is important. Earth smarts should not be a binary state; working
towards it should benefit any individual or community.

A final look at environmental literacies is another pluralistic view, taken from a
book that deliberately seeks to integrate science and environmental education (Azeiteiro,
Goncalves, Pereira, Pereira, & Filho, 2007). Deriving their construct from a five-year
curriculum project in Portugal, Lenacastre and Leal (2007) start with three
transdisciplinary environmental literacies. Functional literacy entails a basic
understanding of ecosystems and environmental topics; cultural literacy takes in socio-
cultural meanings and practices, while critical literacy involves a capacity for debate and
action. They go on to define nine key dimensions, which can be seen in the ESAMM.

**Other ecological and environmental terms.**

There are numerous terms with ecological and environmental roots that relate to
ecoliteracy. Conceptualizations of *ecojustice* and its relatives (environmental justice &
socioecological justice) are becoming an increasingly important aspect of scientific and
environmental education. In describing *socioecological justice*, Furman & Gruenewald
(2004) make the case that social justice, which has been written about extensively in the
education literature, must be embedded in an ecological context. They advocate the use
of a *critical pedagogy of place*, a combination of critical pedagogy and place-based
education, the latter being a familiar concept in environmental education. Although
discussing the matter from a higher education perspective, they provide suggestions for
pedagogical techniques including a return to natural history, cultural journalism (a kind
of social natural history), and action research, arguing that education must be set in an ecojustice context that is culturally, ecologically and politically aware. In an earlier paper, Gruenewald (2003) notes that critical pedagogy invokes decolonization, while place-based education emphasizes reinhabitation, or living better in a place. Where ecojustice is concerned, both involve a tension between what aspects of a society or culture should be conserved and what should be transformed.

The term ecojustice has found a place in both environmental and science education circles, as well as with some Christian groups. The Lutheran Web of Creation is one example of the religious adoption of the term – they define ecojustice as “any effort that promotes ecological integrity with social justice as a central focus of religious understanding” (Web of Creation, n.d., para. 3). Chet Bowers has been a prominent writer and provocateur on ecojustice issues; the affiliated Center for Ecojustice Education seeks to “reduce the impact of the industrial/consumer dependent culture on everyday life while at the same time ensuring that people are not impoverished and limited in terms of equal opportunity” (Center for Ecojustice Education, n.d., para. 1). As with most permutations of ecojustice, there is a strong moral element: “ecojustice provides the larger moral and conceptual framework for understanding how to achieve the goals of social justice” (para. 1). This version seems to be conceived in terms of globalization, eco-racism, cultural colonization, and a revitalization of the commons (Hardin, 1968), the latter being a topic Bowers has written about extensively (e.g., Bowers, 2006). One of the more interesting issues that Bowers raises is summarized in his book *Educating for Ecojustice and Community* (2001). He stresses the importance of examining and supporting cultural traditions that contribute to sustainability. This notion of supporting certain
traditions can set ecojustice apart from some anti-tradition views of social justice that emphasize emancipation, “progress”, and individual rights without examining how these views may work against the sustainability of community-based cultures.

Most versions of ecojustice emphasize the dangers of thinking exclusively in Western cultural or scientific contexts. A version that has appeared in the science education literature (Mueller & Bentley, 2007) emphasizes the importance of pluralism and educating for “life”. They write “We believe that an education focused on the existence of humankind is a much needed literacy and should be embraced as an overarching construct for science education” (p. 335). For the purposes of this analysis, such pluralistic perspectives don't provide much help with defining specific components of earth smarts, but like most of Bowers' work, they help remind us that neither Western culture nor Western science are the only source of knowledge and wisdom for living well on the Earth, and the construct of earth smarts must remain flexible enough to encompass other views, old and new.

Another construct based on ecology is ecological intelligence, the subject of a recent book (Goleman, 2009) that describes domains of knowledge, intelligence, and empathy. The intelligence domain is the most complex, and includes components such as pattern recognition, adaptability, and an evolution of our abilities to include new sensitivities to threats and better shared or social intelligence. Goleman ties his framework to a better knowledge of the economic and ecological connections implications of the things we buy. Not to be left out of the push for sustainability, rhetoricians are considering the notion of sustainable literacies and ecocomposition; a topic in which words do not simply describe or represent the environmental reality, but
actually recreate it, so discourse can have an effect on the world. “It is not a kind of literacy about the environment, it is literacy in and with the environment” (Grant, 2009, p. 215).

*Political ecology* comes from a geographic and social science perspective (Zimmerer & Bassett, 2003), balancing the two with varying degrees of success. Stonich and Mandell (2007) compare it to sustainability science, questioning whether the concepts are really different at all, and suggesting ways to enhance collaboration. They also note that although research in the field of political ecology has been booming, there is an ongoing tension between environment first and society first perspectives. This tension exists in many interdisciplinary constructs related to ecological literacy; they suggest it may be related to underlying and possibly irreconcilable differences between materialist & idealist perspectives; or scientific and postmodern world views.

*Environmental citizenship* (A. R. Berkowitz, Ford, & Brewer, 2005) combines ecological literacy with civics literacy. The authors note that the two literacies together could serve as the basis for the North American Association of Environmental Education's definition of environmental literacy (NAAEE, 2004); they go on to envision environmental citizenship by adding values awareness, self-efficacy, and practical wisdom to the two literacies. The resulting model of overlapping circles seems a bit murky and unwieldy as a practical construct. However, concerned with the role of ecological science in environmental education, they note that educators:

... can at times ignore, misinterpret, or take a strong oppositional stance towards the science component of environmental education. This problem is exacerbated by the marginalized nature of environmental education within formal education,
the persistent challenges of scientific literacy, and the urgency of current environmental issues (p. 227).

To address this, they discuss components specific to ecological literacy itself, including an interesting “ecological thinking toolkit”. This work is quite detailed and proved helpful in designing and validating some of the content and cognitive components for earth smarts.

Other versions of environmental citizenship have been discussed by political theorists; Dobson & Bell (2005) gather many of these together. It is also worth mentioning ecological citizenship, which Dobson (2004) differentiates as a new, post-cosmopolitan citizenship characterized in four ways: it includes non-reciprocal responsibility, it is based on our ecological footprints, rather than national or other political boundaries, it is private as well as public, and its virtue has specific ecological obligations. There are other variations (e.g., sustainability citizenship, ecological stewardship) as well, and the differences between all of them can be fundamental and conflicting, depending on what political tradition they draw upon. Melo-Escrihuela (2008) summarizes some of the conflicts and examines the role of the state and civil society in promoting ecological citizenship. From a practical and theoretical perspective, this is fertile territory for earth smarts, as the rights, duties, traditions, and responsibilities of citizenship contribute to our environmental attitudes and willingness to act, and would play a key role in implementing earth smarts in different cultures and countries.

Hungerford (1996), working on environmental citizenship behavior, describes critical educational components to achieve it, within the entry, ownership, and empowerment domains. The components appear in the ESAMM.
In the context of a social foundations course for teachers, Martusewicz and Edmundson (2005) make the case for an *eco-ethical consciousness*, defining it as “...the awareness of and ability to respond carefully to the fundamental interdependence among all forms of life on the planet” (p. 73). Drawing heavily on ecojustice and the work of Bowers, they contrast a pedagogy of liberation with one of responsibility, and frame their teaching in terms of diversity, democracy, and sustainability, while emphasizing local connections to place. Wenden (2004) examines the role of values in the context of educating for a perspective on social and ecological realities, noting that values can be valid predictors of both attitudes and behaviors. Although she makes pedagogical suggestions, she notes that perspectives and the values they are based on are not easily changed. Her core values and related cognitive skills for peace and environmental education, a *socio-ecological perspective*, are in the ESAMM; note that they are closely related to the values expressed in the Earth Charter (Earth Charter Initiative, 2000).

Many proponents of *deep ecology*, a founding branch of environmental philosophy, subscribe to eight principles put together by Arne Naess and George Sessions in the 1980's (Devall & Sessions, 1985); an adaptation of those principles appears in the ESAMM. Deep ecology has plenty of detractors, and the principles suggest some potentially controversial possibilities for earth smarts, most notably the obligation to take action and the underlying moral valuation of all life, not just humanity. Canadian philosopher Lorraine Code provides a less radical view with her book *Ecological Thinking: The Politics of Epistemic Location* (2006), which engages ecology with feminism, social justice, and the politics of knowledge. This mix of natural science and the humanities, an alternative to the ethos of mastery that Code believes pervades the
Western world, is one of the more useful philosophical underpinnings for earth smarts.

Code writes that *ecological thinking* is a:

...revisioned mode of engagement with knowledge, subjectivity, politics, ethics, science, citizenship, and agency that pervades and reconfigures theory and practice. It does not reduce to a set of rules or methods; it may play out differently from location to location; but it is sufficiently coherent to be interpreted and enacted across widely diverse situations (p. 5).

This is a dense book and a relatively new idea, but hopefully Code and other philosophers, environmental and otherwise, will continue to develop the idea of *ecological naturalism*, as there are obvious links to the components of earth smarts that emerged from this analysis. Speaking to many of the aspects we have covered, including the underlying notion of quality of life, she writes:

Ecological naturalism builds on the relations of organisms with one another and with their habitat, which comprises not just the physical habitat or the present one, but the complex network of locations and relations, whether social, historical, material, geographical, cultural, racial, sexual, institutional, or other, where organisms – human or nonhuman - try to live well, singly and collectively (Code, 2006, p. 90).

**Sustainable development and sustainability.**

Some of the more interesting conflicts amongst modern environmental thinkers have arisen with the popularity of the concept of *sustainable development*, a term which some find contradictory, while others (e.g., Jickling & Wals, 2008) tie it to the problems of globalization. Nonetheless, businesses, governments, and international organizations
have all embraced the idea of sustainable development, perhaps because it appeals to the
growth-based economic ideologies still prevalent in much of the world. The Rio
Declaration on Environment and Development (UNCED, 1992) is a widely cited
document; it refers to quality of life but unfortunately provides mostly vague guidance.
Principle 8 states, “To achieve sustainable development and a higher quality of life for all
people, States should reduce and eliminate unsustainable patterns of production and
consumption and promote appropriate demographic policies” (para. 14).

Fortunately, Agenda 21 (from the same so-called “Earth Summit” at Rio) is much
more comprehensive and detailed. Hundreds of pages long, it does not refer specifically
to environmental or ecological literacy, but does address the importance of education,
noting it:

...is also critical for achieving environmental and ethical awareness, values and
attitudes, skills and behaviour consistent with sustainable development and for
effective public participation in decision-making. To be effective, environment
and development education should deal with the dynamics of both the
physical/biological and socio-economic environment and human (which may
include spiritual) development, should be integrated in all disciplines, and should
employ formal and non-formal methods and effective means of communication
(UNSD, 1993, p. 36.3).

That's quite a mix of components, though it is quite similar to the Campaign for
Environmental Literacy's view, with the notable and prominent inclusion of development
throughout. In Canada, the NGO Learning for a Sustainable Future describes a series of
learning outcomes for education for sustainable development, based on knowledge, skills,
and values. There are some interesting elements, as well as some that seem naïve, most notably an appreciation of the “equal importance of all life forms” (LSF, n.d., para. 3) and knowledge of the “....sustainable relationship of native societies to the environment” (para. 1). The first puts our efforts to wipe out smallpox to shame, and the second has long been shown to be an oversimplification of the vast diversity of indigenous cultures, some of which were considerably more sustainable than others.

The Earth Charter (Earth Charter Initiative, 2000) offers a framework for sustainability education that incorporates the Charter's 16 principles, which are grouped into four parts: respect and care for the community of life, ecological integrity, social & economic justice, and democracy, non-violence and peace. Sustainable development features prominently throughout the charter, though the preamble contains a very interesting qualifier: “We must realize that when basic needs have been met, human development is primarily about being more, not having more” (p. 4). Peter Corcoran (2004, 2007) has written more about the educational possibilities of the Earth Charter. An interesting adaptation of these principles is contextual sustainability education (CSE: Verhagen, 2004). It is comprised of two domains – foundations and values. Helpfully, the educational implications of the components are explicitly addressed, and the author even goes on to define and explain a middle school standard based on the construct, making this one of the most educationally practical constructs this analysis covers. The foundations of CSE include three interesting concepts: cosmogenesis, biocentricism, and biogregionalism. The values are equally interesting: ecological sustainability, participatory decision making, active nonviolence, and social justice. Cosmogenesis and a biocentric world view speak to the inadequacy of world-views, religious or otherwise,
that do not incorporate scientific advances related to evolution and our place in nature. Bioregionalism is the organization of societies (and their education) around local environmental principles, and connecting those to global ones. It therefore overlaps with place-based education.

There has been some effort over the years to reconcile traditional environmental education with sustainability education. Tilbury (1995) described *environmental education for sustainability* as a new direction for environmental education, with a complex set components that include affective, moral, and behavioral elements as well as critical thinking and sociopolitical skills. A more recent, extensive summary of sustainability in education (Nolet, 2009) includes nine themes for *sustainability literacy* that emerge from the literature; unfortunately the themes and their components are conceptually mixed and often vague. Efforts continue to distinguish or merge environmental education and education for sustainability. The Cloud Institute develops *education for sustainability* (EfS) curricula, working with community partners and schools. They consider habits of mind as well as content standards relating to knowledge and action (The Cloud Institute, 2009); both appear in the ESAMM. Although mostly unpublished in the academic literature, their framework is influential due to its use in numerous curriculum workshops.

A recent European effort to integrate education for sustainable development into teacher training institutes (Sleurs, 2008) has developed a model for teacher education that combines six dimensions: values/ethics, action, knowledge, systems thinking, and emotions; with two orientations; towards the future, and local/global. The complex, dynamic structure of their model, a colorful combination of circles and triangles, doesn't
translate well to the hierarchical ESAMM. Nonetheless, the key points are familiar and indicate that while models may be assembled in different ways, many of the essential components of earth smarts appear in environmentally themed literacy and competency models all over the world. Another recent effort, this one from Berlin, also speaks to education for sustainable development. The Transfer-21 (2007) program strives for the deliciously German *gestaltungskompetenz*, where people are able to:

...draw conclusions from studies into the present or future in the areas of ecological, economic and social development in their varying relations of interdependence, and take decisions on the basis of these conclusions, understand these decisions and apply them individually, as part of a community and politically in order to further sustainable development processes (p. 12).

While I probably won't be renaming earth smarts as gestaltungskompetenz, they are certainly related concepts. Transfer-21 breaks gestaltungskompetenz down into 10 parts, which appear in the ESAMM. Analyzing sustainable development documents from the perspective of learning outcomes in higher education, Svanstrom, Lozano-Garcia & Rowe (2008) conclude that there are many commonalities across countries and cultures, particularly amongst knowledge and skills. They agree that documents include attitudes and values, but provide a muddled summary of what those might be.

Not everyone appreciates the idea of development as fundamental to sustainability, particularly since development is often mistakenly conflated with progress. Many concepts based on the idea of sustainability deliberately omit the idea of development, despite its popularity amongst governments and business. For the purposes of earth smarts, classic economic development does not seem essential to maintaining
quality of life. Jickling and Wals (2008) have recently argued that globalization forces are converting traditional environmental education into education for sustainable development. They note concerns that this neo-liberalist process may “...leave less space for reflective self-determination about educational outcomes, autonomous thinking, and exploration of more contextual pathways towards a ‘better’ world” (p. 5). The importance of sustainability is not lost on the scientific community; Science Magazine itself summarized the idea of sustainability science, examining key questions and suggesting research directions (Kates et al., 2001).

Stibbe describes sustainability literacy as “the skills, attitudes, competencies, dispositions and values that are necessary for surviving and thriving in the declining conditions of the world in ways which mitigate that decline as far as possible” (Stibbe, 2010, p. 2). Unfortunately the actual components are not organized that way, appearing instead as a simple list of “skills” in the form of a collection of chapters by different authors. While they contain interesting ideas, such compilations are often structurally confusing; complex constructs such as ecological intelligence appear alongside components such as community gardening, cultural literacy and advertising awareness. Nonetheless there are some interesting ideas, many of which relate to the Transition Movement which is discussed in the next section. Also important is the notion that in a rapidly degrading world, sustainability applies to our own wellbeing as well as that of future generations.

**Other terms.**

There are a variety of other ways that people have considered our knowledge of, and relationship to, the natural world. A Native Alaskan perspective comes from an
anthropological study of the Koyukan people (Nelson, 1983), notable for the concept of a spiritual world that is always watching and commands respect. The major tenets of this belief system appear in the ESAMM, anchored by the idea that the natural and spiritual worlds are inseparable, and this interaction profoundly affects human behavior. David Sobel, in a series published by the Orion Society, links environmental education and ecological literacy with the increasingly popular notion of place-based education, a term he mentions is often less contentious as it carries less baggage. The ESAMM shows some of the key components of place-based education; Sobel defines it as “...the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science and other subjects across the curriculum” (2004, p. 7). The Transition Movement expands education to involve communities, striving to make them more resilient to changes related to peak oil and climate change. Avoiding most of the environmental doom and gloom, the movement's founder notes “There is no reason why a lower-energy, more resilient future needs to have a lower quality of life than the present... including a happier and less stressed population, an improved environment and increased stability” (Hopkins, 2008, p. 135).

Six principles, incorporated into the ESAMM, summarize the movement that is spreading rapidly amongst communities in the United Kingdom and beyond: future visioning, inclusion, awareness-raising, resilience, insights from psychology, and credible and appropriate solutions. The transition movement is based on earlier work done in permaculture, and Hopkins acknowledges the influence of permaculture principles put forward by Holmgren (2002). Permaculture is a sort of systems thinking, and incorporates several environmental themes including change, diversity, and renewable
resources. A related effort, also from the UK, is the movement to a steady state economy (CASSE, 2010), championed by the Center for the Advancement of the Steady State Economy. It focuses on quality of life by dumping the growth model of economics and concentrating on sustainable scale, fair distribution and efficient allocation of resources.

Daloz (2004) provides another interesting way to consider ecoliteracy, as a consciousness of interdependence. This vision relates to an earlier description of earth smarts as something we used to rely on, something we have lost in modern times. Daloz writes:

For as long as humankind has lived in close proximity with the natural world – which is to say our entire evolutionary history – we have known in some sense that all things are connected. It would be truer to note, in fact, that it is only in very recent times that we have lost this awareness, that we have developed the conceit that we are separate from the rest of the living planet, a conceit that has nearly brought the planet and us to our knees. In this sense, interdependence is a fact of existence. Our job is to learn it again, or really, in a new way, adequate to the particular configuration that it has taken in our time (p. 31).

Daloz describes five ways of being that will help us move towards a consciousness of interdependence – they appear in the ESAMM along with additional detail for one, the evocatively named dance of nature.

Cheryl Charles, co-founder of the Children & Nature Network, describes natural guides, ecological lessons or parallels that can be used to help reconnect children to nature (Charles, 2009). They include several common themes such as diversity, self-regulation, and connectedness, along with niche, cooperation, optimization, and
community. She advocates leveraging these principles to encourage cultural change that will increase the wellbeing of children and societies, describing this as the ecology of hope. In Great Britain, Oxfam Education advocates for global citizenship, which “enables pupils to develop the knowledge, skills, and values needed for securing a just and sustainable world in which all may fulfil their potential” (Oxfam GB, 2006, p. 1). While the elements are arranged somewhat arbitrarily (e.g., respect for people and things appears as a skill, rather than a value or attitude), the documents provide pedagogical tips and suggestions along with a six step progression up to ages 16-19, making the framework much more practical to teach than many. The domains and elements appear in the ESAMM. In the Netherlands, an interdisciplinary team designed a framework and modules to promote pluralistic views of nature (Lijmbach, Arcken, Van Koppen, & Wals, 2002). The result included sociological and philosophical domains as well as emancipatory education, and testing the modules revealed some of the problems involved in getting multiple perspectives across effectively in the classroom. Finally, some modern views of peace education explicitly acknowledge the importance of environmental health and understanding. For instance, Brenes-Castro (2004), using the Earth Charter as a guide, suggests a circular model for integral peace education based on three parts: peace of mind, peace with nature, and peace with others. The components, adapted to hierarchical form, appear in the ESAMM, and includes topics such as ecological consciousness and biodiversity.

**Government documents.**

A number of national and international documents have played key roles in how governments see the environment, and education related to it. One of the earliest was the
Intergovernmental Conference on Environmental Education (Unesco, 1978), often referred to by the name of the town it was held in, Tbilisi, in what is now Georgia. The final document does not speak directly of environmental literacy, but does address the purpose of environmental education, including its role in improving living conditions. It highlights awareness, knowledge, attitudes, skills, and participation as critical. In the 1980's, The United Nations convened the Brundtland Commission, which produced Our Common Future (UN WCED, 1987), an influential report that provided one of the most cited definitions of sustainable development, and explicitly recognized the interdependent nature of environmental and social challenges. The 1990's produced the aforementioned Earth Summit and the resulting Rio Declaration (UNCED, 1992) and Agenda 21 (UNSD, 1993), key sustainability documents.

A more recent and helpful international document is the Earth Charter, a “declaration of fundamental ethical principles for building a just, sustainable and peaceful global society in the 21st century” (Earth Charter Initiative, 2000, para. 1). Composed of four main principles and an assortment of sub-principles, the Charter's focus on respect, ecology, justice and democracy were very helpful in informing earth smarts, and should be equally helpful to work in socioscientific issues and education for ecojustice. The next section looks specifically at educational frameworks and their potential to help structure earth smarts.

**Education.**

One of the goals of this analysis is to create a construct that has practical value in real-world educational contexts. A balance must therefore be struck between inclusiveness, which can lead to overly broad or vague formulations, and specificity,
which can result in rigid definitions that may seem artificially imposed in contexts they do not apply to well. To help formulate earth smarts in a manner conducive to the standards-based educational systems that are increasingly common throughout the world, a number of educational frameworks and education-based concepts are built into the analysis. The New Taxonomy of Educational Objectives (Marzano & Kendall, 2007, 2008), an updated conception of the more famous Bloom's Taxonomy designed with standards in mind, will be included in the analysis to help refine components. It involves a system of educational domains (psychomotor and mental procedures, information) and educational levels (from simple retrieval to metacognition and motivation in self-system) that can be seen in the ESAMM.

Conceptual clusters (Newell et al., 2005) provide another model to help provide structure to earth smarts, as they were designed to blend concepts from different disciplines. Their model is based on six high level concepts that facilitate the discovery of synonyms, or nexus concepts, between disciplines. The concept clusters, which appear in the ESAMM, are (a) dynamics & system, (b) organization & scale, (c) controlling models, (d) management & policy, (e) adaptation & learning, and (f) history. This is considered a reasonably complete basis to build connections between disciplines when integrating social and biological knowledge for sustainability.

The PISA 2006 (OECD, 2007), designed to compare scientific competencies across a variety of countries, provides another interesting framework to help structure earth smarts. As PISA is an assessment, it is particularly interesting considering the push for accountability in education; PISA 2006 considers four domains: contexts, competencies, knowledge, and attitude. The domains and their subheadings appear in the
ESAMM, and represent a more nuanced view of science literacy than many large-scale assessments. However, the PISA may not achieve what it strives for when testing some of the more complex aspects of scientific literacy, including reflection, civic engagement and empowerment, issues that are crucial to progressive, socio-scientifically-based education (Sadler & Zeidler, 2009). Another framework from science education that is worth considering is science education for citizenship (Ratcliffe & Grace, 2003). After examining the overlap between science education, education for citizenship, STS, SSI, and environmental education, they propose a model with three domains: conceptual knowledge, procedural knowledge, and attitudes and beliefs. Each of these is broken down in secondary, and sometimes tertiary components, all of which can be seen in the ESAMM. Blumstein and Saylan (2007) argue that environmental education is failing, and have seven diverse suggestions to improve it. Noted in the ESAMM, they include programs that can be evaluated, critical thinking, and specifically teaching respect and self-sacrifice.

A number of educational initiatives strive to make the world a better place. Facing the Future: People and the Planet is a nonprofit organization that develops curriculum resources; they consider global issues and their sustainable solutions in one of their core publications (B. Wheeler, Wheeler, & Church, 2005). In their view, global issues are based on many of the same components that feature in sustainability and environmental literacy definitions, and as their materials are designed as curricula, they are immediately useful in educational contexts, including many that are made freely available on the Internet. From a communication perspective, Monroe, Andrews and Biedenweg (2007) describe a framework for environmental education strategies that focuses on the
objectives of the intervention: to convey information, to build understanding, to improve skills or to enable sustainable actions.

The Institute for Habits of Mind strives to educate for a more thoughtful world by describing 16 habits of mind (Costa & Kallick, 2009) used by people to successfully solve difficult problems. While not environmentally focused, the overlap with both science literacy and earth smarts is obvious, as overcoming environmental challenges to improve your quality of life is an ongoing, complex and difficult problem. The 16 habits appear in the ESAMM, and include recurring themes such as empathy and self-regulation. A related effort comes from EdSteps (EdSteps.org, 2009), an organization that seeks to provide guidance for educators seeking to assess skills that are important but difficult to assess. Their skills are writing, creativity, analyzing information, problem solving and global competence, all of which overlap with scientific and environmental education. While most are still early in development, they may become helpful to educators assessing aspects of earth smarts in the future - their global competence components appears in the ESAMM.

Part of the movement towards better accountability in higher education, the Lumina Foundation is working on the degree qualification framework (Lumina, 2011), which includes knowledge (both specialized and integrative), a set of intellectual skills, as well as applied and civic learning. Hilton (2010) summarizes the results of a National Research Council workshop examining the intersection of so-called 21st Century Skills and science education, including science standards. Although the skills are focused on employment, most of them can easily be considered from a citizenship perspective as well, at least in modern democracies. There are some interesting parallels with ecological
literacy in a changing world, including adaptability, non-routine problem solving skills, and systems thinking.

An analysis of past and current instruments used to assess environmental literacy in educational contexts could provide insight into earth smarts and help construct new instruments based on it. One such compilation (Hungerford, Bluhm, Volk, & Ramsey, 1998) was categorized by domains; not surprisingly, the instruments were nearly as variable as the terms, theories, and domains they represented, and most only claimed to measure one or two particular aspects of environmental literacy. Since then, few instruments have been rigorously reviewed in the literature or deployed extensively; next to none have involved significant longitudinal studies, and the details of many have yet to be published. Nonetheless, a climate of educational testing favors instrument design and implementation now, so tracking down researchers, making them aware of earth smarts, and seeing how their instruments might measure aspects of it will help make the construct, and ultimately any instruments that incorporate it, more useful.

The idea that science taught without context is insufficiently effective at increasing scientific literacy is not new; one of the purposes of this study is to examine the shared and potentially conflicting domains between earth smarts and two of science education' s more interesting new pedagogical lines of research: socioscientific issues (SSI) and ecojustice education. We have covered ecojustice in an previous section; Zeidler and Nichols (2009) provide a succinct summary of socioscientific issues theory. Mueller and Zeidler (2010) begin to examine the links between ecojustice education, SSI, and moral development, rich territory for earth smarts, as balancing the wellbeing of a variety of stakeholders is a necessity in nearly every environmental issue. As
environmental challenges become more ecologically and socially complex, keen moral reasoning skills become increasingly essential; fortunately, SSI research indicates such skills can be nurtured in formal education settings (Zeidler, 2006). Dealing with our shared environments in ways that sustain or improve wellbeing may be the ultimate socioscientific issue; it is certainly shaping up to be the greatest challenge of the next generation. Given the results of the last few decades, the ability of our education systems to meet this challenge without substantial change, in theory and in practice, is dubious indeed.

**Standards.**

Most national standards documents are designed around content and skills, and are therefore potentially useful in informing those aspects of earth smarts. The US Partnership for Education for Sustainable Development has developed the National Education for Sustainability K-12 Student Learning Standards (USPESD, 2009), which provide benchmarks for K-12 students to become sustainability literate. Unfortunately their benchmarks and essential understandings remain conceptually muddled and hard to follow. For instance, a “respect for nature” concept appears within the ecological systems component right before biomimicry, and its performance indicators seem to suggest an affective connection to nature rather than an ethical respect. Although some of the concepts may be undertheorized, there are some interesting additions, particularly in the economics component, and the grade 9-12 benchmarks were incorporated into the ESAMM.

The analysis also included the key U.S. standards in science education: the Project 2061 *Benchmarks for Scientific Literacy* (Science, 2009), and the *National
Science Education Standards (National Research Council, 1995). The 2061 Benchmarks, originally released in 1993 and updated in 2009, are detailed and especially interesting as they specifically address the components of science literacy. From environmental education, the analysis included the North American Association of Environmental Education's *Excellence in Environmental Education: Guidelines for Learning (Pre K-12)* (NAAEE, 2004), as well as Ontario, Canada's *Standards for Environmental Education* (Ontario Ministry of Education, 2008). The NAAEE standards in particular are thoughtful and comprehensive, and include links to other subjects that make them helpful in interdisciplinary lessons. From social science education comes the *Curriculum Standards for Social Studies: Expectations of Excellence* (NCSS, 1994), an interesting combination of politics & economics that are light on science and environmental issues.

In the Internet age, we certainly haven't seen the end of standards documents; the increasingly popular AP Environmental Science themes and topics (College Board, 2010) were included, as well as the new *Earth Science Literacy Principles* (Earth Science Literacy Initiative, 2009). The seven essential principles of Ocean Literacy (Ocean Literacy Network, 2006) were considered as well, although their focus on awareness is generally too specific to be of much use in this context. Each of these was broken down into key components in the ESAMM, added to the component matrix and filtered using the system and ethical matrices. Although the study bias is clearly towards documents produced in the English language, it is hoped that through ongoing validation and localization, standards documents from other languages and a wider range of countries will contribute to ongoing localization and validation.
Findings and Summary

The literature review of constructs related to ecological and environmental literacy reveals a wide range of views from within and beyond academia. While dozens of definitions and hundreds of individual components were considered, four concepts emerged as particularly useful due to some combination of their insight, practicality, and completeness, and it is worth mentioning them again here. New work by members of the Ecological Society of America (Jordan et al., 2009), a 95 year old institution with over 10,000 members, represents their attempt to define ecological literacy in a way that is achievable by all but moves beyond just an understanding of basic ecological concepts. The North American Association for Environmental Education (NAAEE), a 38 year old organization with approximately 1300 members from dozens of countries, has developed an excellent set of interdisciplinary benchmarks for Pre K-12 education (NAAEE, 2004). The Center for Ecoliteracy, founded in Berkeley, California in 1995, has been actively involved in promoting ecological literacy in K-12 setting, most notably through school lunch and garden programs. Their sustainability competencies (Center for Ecoliteracy, 2008) manage to capture some of the aesthetic and spiritual aspects of ecoliteracy in a more practical, education-oriented framework. Finally, the Earth Charter, a “global consensus statement on the meaning of sustainability” (Earth Charter Initiative, 2000, History page), provides an excellent set of international principles that incorporate ecology, democracy, and social justice.

Although there is considerable diversity in underlying theories, some key themes or domains common to many of them emerge after breaking down the constructs into their components. These domains include: (a) a set of concepts (knowledge) including
ecological principles, (b) a sense of place that includes an awareness of and affective attachment to the land, (c) a moral component that incorporates respect for other cultures and species, and (d) a set of competencies that include the scientific, political and social skills necessary to take action. Action itself, i.e. a behavioral component, features prominently in many formulations, but its inclusion is controversial.

As we have seen, there are many different formulations of ecological and environmental literacy and their ilk, as well as a similar diversity views related to ecojustice, sustainability and Vision II scientific literacy. While this plurality might be helpful in some respects, it is also poses problems for researchers, educators, and policy makers; it is more difficult to improve sustainability education, for example, if no one can agree on what it is. Socioecological literacy can serve as a bridge between educators, researchers and community partners, linking and helping to justify related scientific, environmental, and civics education. This literature review has examined some of the possibilities with its breadth, and extracted their underlying domains and key components. The next section will discuss the methodology this study used to analyze this wide-ranging review.
Chapter 3: Methodology

Theorizing a pragmatic construct requires a flexible approach, particularly when it involves numerous disciplines within academia, as well as input from a variety of professions and policy documents. This study used a form of theory building spiraling research, shown in Figure 4, which features data collection as part of feedback loops that include theory building, design, and analysis. Due to the varied nature of the inputs (academic and professional literature, expert interviews, surveys and online collaboration), this was a mixed methods study with a strong theoretical component. Figure 6 shows the two-stage research model that was used. It begins with a theoretical construct analysis of the literature review that produced preliminary domains and components. For the refinement stage, the preliminary domains and components were used to solicit input from experts and practitioners to further build and validate components. This input was also helpful to both generalize and localize components, to help make the framework useful in a variety of ecological, social, and cultural contexts.
Initial Stage

The initial literature review and analysis included the following steps:

1. Find and summarize references to ecological & environmental literacy.
2. Find and summarize references to the numerous related terms (see Table 2).

3. Extract key domains & components from the various treatments and assemble them into graphical form. This was done using Freeplane (freeplane.sourceforge.net) to visualize the components in the earth smarts analysis mind map (ESAMM).

4. Code and categorize the domains and components to produce a more parsimonious set. This was achieved by coding with the R Package for Qualitative Data Analysis (RQDA, rqda.r-forge.r-project.org), and the Visual Learning Environment (VUE, vue.tufts.edu) to group and categorize components.

5. Tabulate the different components in the earth smarts component table (ESCT) for basic quantitative analysis.

6. Using VUE again, develop the domains and components for earth smarts using the underlying vision (justly maintaining quality of life) with the help of modified systems (Nadler, 1981), ethical (Mepham, 2000), and responsibility matrices.

Steps one and two used a purposeful, stratified approach to gathering ideas by deliberately seeking review papers and top journals from a variety of disciplines and professional organizations. This involved a form of educational connoisseurship (Eisner, 1998), a holistic methodology derived from the arts that is more amenable to complex topics spread across a variety of disciplines. It was augmented by presentations and networking at a variety of national academic and professional conferences, including:
Earth smarts analysis mind map.

The earth smarts analysis mind map (ESAMM) represents an attempt to distill the wide-ranging literature review into key concepts. This process corresponds to Krathwohl's (1993) first step of construct analysis, which involves examining many examples of how a construct is used, and speculating about its defining characteristics. In some cases this was relatively straightforward, while in others the concepts had to be teased from prose that was lengthy, convoluted, obtuse or some combination of the three. Searching out all the related terms (step 2) and distilling the wide variety of documents down to their essential theories, domains, and components (step 3) allows progress to step 4: assembling them into a graphical form that helps make relationships clearer. The process of extracting key components is not always clear, and it is sometimes difficult to strike a balance between choosing only explicitly stated components or domains, and ones that may be inferred from or implied by the descriptions. Many definitions are vague; when in doubt, I erred on the side of explicitness, in order to avoid inadvertently seeing things that weren't really intended by other authors.
**Tabular component analysis.**

The numerous domains and components that emerged from the literature review and become part of the ESAMM were categorized in VUE and assembled into a table for basic quantitative work. VUE, which is an aptly named Visual Understanding Environment, allows components to be rearranged and grouped by location, color and linkages. This is very helpful when considering complex ideas, particularly when a large display is available, and VUE was used at several stages of this analysis. The earth smarts component table (ESCT) consists of the definitions as rows, and domains and components as columns. Summary statistics appear in the next chapter (Table 6), and were used to help consider the results of the analysis and clarify the importance of certain components across different categories of definitions.

**Matrices.**

The next step was to decide upon the key domains and components for sociological literacy by seeking out essential parts of the various definitions and attempting to place them into a hierarchical structure, one that addresses the raison d'etre of earth smarts – justly maintaining or improving quality of life. Three matrices, described below, contributed to this process. The matrices are systems analysis tools that facilitated the parsimonious selection of components. By balancing unity and diversity, they helped the construct become unified and coherent enough to be useful, but flexible enough to allow for the vast diversity of global ecosystems and the wide variety of cultural approaches to dealing with them. The use of matrices, common in systems analyses in business as well as academia, forces the consideration of facets and combinations of complex issues that might otherwise slip through the analytical cracks.
The earth smarts systems matrix was adapted from the systems analysis work of Nadler (1981). It is a solution framework with eight specific rows (e.g., purpose, inputs, outputs) and six specific columns (e.g., values, measures, control). Filling in the 48 resulting cells forces the consideration of some key issues that may not be immediately apparent, which in turn provides a useful tool for examining complex systems and their ramifications. Table 3 illustrates a snapshot of the early consideration of socioecological literacy in the earth smarts systems matrix. Note the values column; entries here indicated the importance of underlying values to the framework from the start, despite the fact that values were inconsistently covered in other definitions as well as formal education. The fundamentals column was also important to the early stages of this analysis, as it encouraged a focus on refining and making explicit the underlying purpose of the construct. Having a clear purpose helped immensely as more definitions were included in the analysis and parsimony became increasingly challenging.
### Table 3: Earth Smarts Systems Matrix

<table>
<thead>
<tr>
<th>Fundamental</th>
<th>Values</th>
<th>Measures</th>
<th>Control</th>
<th>Interface</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>to improve or at least maintain the quality of life of this and subsequent generations</td>
<td>a respect for other peoples, generations and ecosystems</td>
<td>quality of life indices</td>
<td></td>
<td>this is a worthy goal now and in the future</td>
</tr>
<tr>
<td>Inputs</td>
<td>environmental problems, lifestyle choices</td>
<td>community vs. individual rights; the rights of other species</td>
<td>various surveys</td>
<td>government, media, NGO's and corporations can &quot;spin&quot; the inputs</td>
<td>environmental problems may become worse, and more global in nature</td>
</tr>
<tr>
<td>Outputs</td>
<td>environmental solutions, sustainable lifestyle choices</td>
<td>respect for others</td>
<td>are quality of life indices improving or deteriorating?</td>
<td>measure the success of actions and choices</td>
<td>solutions &amp; choices much mesh with social &amp; political interfaces</td>
</tr>
<tr>
<td>Sequence</td>
<td>attitudes, skills, awareness, knowledge &amp; action (no particular order)</td>
<td>are these compatible with religious beliefs? with political ideologies?</td>
<td>instruments can measure some of the components with dubious accuracy</td>
<td>curricula must be adaptable to local conditions</td>
<td>probably won't change</td>
</tr>
<tr>
<td>Environment</td>
<td>each individual's local and more global context, including natural, social, ethical &amp; political</td>
<td>how supportive is your social environment? do their values clash?</td>
<td>are quality of life indices improving or deteriorating?</td>
<td>a semblance of control over local environments can make things seem ok in the short term</td>
<td>various literacies of community</td>
</tr>
<tr>
<td>Human Agents</td>
<td>the person and their social context</td>
<td>social and political ethics, locally &amp; globally</td>
<td>polls, political and social research</td>
<td>may need to be enforcement or neighborhood</td>
<td>literacies of educators, peers</td>
</tr>
<tr>
<td>Physical Catalysts</td>
<td>food, water &amp; shelter</td>
<td>self-preservation triumphs unless basic needs are met</td>
<td>poverty index, basic needs being met?</td>
<td>limited resources (oil, water, food) will force change</td>
<td>natural, political and social systems all interact</td>
</tr>
<tr>
<td>Information Tools</td>
<td>courses, texts, new scientific information</td>
<td>training and references on how to make difficult ethical choices</td>
<td>instruments to measure the various components</td>
<td>curricula, laws</td>
<td>curricula, training materials, media literacy</td>
</tr>
</tbody>
</table>

The earth smarts ethical matrix was adapted from a more generic matrix designed for rational ethical analysis (Mepham, 2000). It is based on the work of John Stuart Mill (utilitarianism), Immanuel Kant (rights), and John Rawls (justice). Instead of examining
issues from a systems perspective, this matrix explores the perspective of stakeholders, other cultures, future generations, different species, and ecosystems. While this can get philosophically complex indeed, some of the key conclusions of these three philosophers were useful to an analysis such as this. Mill's work on utilitarianism considers wellbeing, measuring morality by the observable, and therefore empirical, consequences of actions (Mill, 1906). Kant (1785) takes a different view, arguing for a pure moral philosophy, derived from reason. This categorical imperative gives rise to the importance of individual autonomy, and therefore individual rights, at least for human beings. Rawls, seeking to balance freedom and equality in a society, theorized and more recently updated the idea of justice as fairness (Rawls & Kelly, 2001), focusing on social cooperation and the political and legal frameworks that make it happen.

While philosophers have argued about morality for millennia, examining issues in the light of these three perspectives was helpful, particularly as they may conflict with each other and therefore provide a variety of viewpoints on difficult issues. Many of the constructs in the analysis directly or indirectly considered the tension between individual rights and freedoms, as well as our responsibilities to our communities and environments. Table 4 shows the earth smarts ethical matrix in a snapshot of the process. Use of the ethical matrix eventually helped lead to the emphasis on justice as fairness, rather than utilitarianism or rights, as considerations of fairness seemed to be the best way to balance the potential conflicts the other two value systems produced, and meshed well with Noddings (2002) notions of caring about. For example, it is nearly impossible to find ecosystem rights enshrined in legal terms, yet considerations of intrinsic value and
whether it is fair (or just) to needlessly degrade an ecosystem helps to move towards respect and care when dealing with them.

Table 4: Earth Smarts Ethical Matrix

<table>
<thead>
<tr>
<th></th>
<th>respect for wellbeing (heath and welfare)</th>
<th>autonomy (freedom &amp; choice)</th>
<th>justice (fairness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholders</td>
<td>living conditions, opportunities</td>
<td>freedom of action</td>
<td>fair laws and practices</td>
</tr>
<tr>
<td>Other people &amp; cultures</td>
<td>living conditions, opportunities</td>
<td>democratic, informed choices</td>
<td>achieving our quality of life must not unduly degrade others</td>
</tr>
<tr>
<td>Future generations</td>
<td>living conditions, opportunities</td>
<td>our rights versus their potential ones</td>
<td>balancing constraints on our society with potentially negative impacts on theirs</td>
</tr>
<tr>
<td>Other species</td>
<td>animal welfare</td>
<td>biocratic decisions, behavioral freedom</td>
<td>intrinsic value</td>
</tr>
<tr>
<td>Ecosystems</td>
<td>conservation</td>
<td>maintenance of biodiversity</td>
<td>sustainability &amp; intrinsic value</td>
</tr>
</tbody>
</table>

The earth smarts responsibility matrix (Table 5) requires a consideration of what part of a society should be responsible for the domains and select components. This, in turn, necessitated the consideration of how components might be achieved. For example, knowledge content components are traditionally considered to be the realm of formal K-12 education, but assigning responsibility for moral or affective elements is more complex, and potentially controversial. Societies and communities will need to carefully consider the columns that are most relevant to them before using this matrix; it also makes it clear that something as complex as socioecological literacy cannot be achieved by a single entity (i.e., K-12 education) within a society; it must be a coordinated effort. The specific consideration of how components might be achieved, for an individual or a
society, also discouraged noble but overly vague or impractical components from inclusion. Table 5 shows an example of an earth smarts responsibility matrix, with the four domains included.

Table 5: Sample Earth Smarts Responsibility Matrix

<table>
<thead>
<tr>
<th>domain or component</th>
<th>parents</th>
<th>K-12</th>
<th>Higher Education</th>
<th>Informal Education</th>
<th>Organized Religion</th>
<th>Local Gov.</th>
<th>National Gov.</th>
</tr>
</thead>
<tbody>
<tr>
<td>concepts</td>
<td>yes</td>
<td>yes</td>
<td>maybe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sense of place</td>
<td>some</td>
<td>some</td>
<td>maybe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>values</td>
<td>yes</td>
<td>maybe</td>
<td>maybe</td>
<td>maybe</td>
<td>yes</td>
<td>maybe</td>
<td>maybe</td>
</tr>
<tr>
<td>competencies</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Refinement Stage

The literature review and construct analysis provided preliminary domains and components for earth smarts, but more work needed to be done to develop the components, validate them, and make this information available for localization. It is worth noting again that earth smarts is meant to be geographically, culturally, and temporally adaptable; it was never intended to remain fixed in space or time. This is a pragmatic requirement; the world is diverse and dynamic, so individuals, communities, and nations will need to be adaptable to maintain their quality of life in the midst of local and global changes. Fortunately, new communication and education technologies facilitated both validation and adaptation.

While the initial stage was primarily theoretical, the refinement stage involved a mixed methods triangulation design (Creswell & Clark, 2006), using both qualitative and quantitative data to validate and, when appropriate, further develop the initial domains
and components. The qualitative data included discussions at conferences, semi-structured interviews with experts, answers to open-ended questions from surveys, and input from collaborative software. Quantitative data came from an online survey instrument focusing on the parsimony of the components, distributed to a variety of experts and practitioners, some selected purposely (see below), others by convenience and self-selection on the Internet. As all data collection was voluntary and collected from experts or professionals, the study received an Institutional Review Board exemption. Details on data recording, collection, and analysis are organized by source below, followed by a section on analysis.

**Expert and practitioner surveys.**

Survey data collected from experts and professionals working in science and education were quantitatively analyzed to help validate construct components. The survey instrument was based on the preliminary domains and components, and allows a broader audience to provide input than face to face discussion or interviews alone; in future research, local stakeholders will be included as well. Initially helpful mainly in a research context, continued use of these techniques will also help keep earth smarts up to date and regionally relevant.

A text version of the instrument itself appears in Appendix B; the key quantitative elements are a Likert scale consideration of the importance of each initial domain and major component, as well as a question that asks participants to rank a range of components, as many are inclined to simply agree that everything should be included. To encourage careful consideration and new thoughts, open-ended questions were included as well, focusing on components that participants felt were necessary but missing from
this list. The instrument also encouraged participants to provide standard demographic information, as well as potentially relevant details of their locale, culture, and expertise. Although partly a convenience sample, there was a purposeful aspect as well, by recruiting from different professional organizations including the Ecological Society of America, the North American Association of Environmental Education, the Association of Science Teacher Education, and the Association for the Advancement of Sustainability in Higher Education. For this study, the goal was to have at least 30 experts from a range of disciplines (including ecology, environmental education, science education, and environmental studies) complete the instrument. Conference presentations, conference contacts, professional listservs, personal contacts were all used to recruit survey participants; it is impossible to know how each participant became aware of the survey, as there was no related question, and awareness of it spread through social marketing and word-of-mouth. Once enough surveys came in, the Likert data were converted to a number from 1 (strongly disagree) to 5 (strongly agree). For the ranking question, the tallies were summed and the spread was calculated.

**Collaborative software.**

Due to its focus on quality of life, respect, and justice as fairness, cultural diversity and ecojustice are fundamental to earth smarts. Despite issues associated with the digital divide (e.g., Selwyn, 2004), the Internet facilitates gathering more diverse, global information. This study used several new communications technologies, notably social networking, an online open-access journal, a web-based survey, and an interactive website and blog. An initial version of earth smarts, then called essential ecoliteracy, was written up with a request for input and published in the inaugural edition of the Journal of
Sustainability Education, a peer-reviewed, open access transdisciplinary e-journal (Nichols, 2010). All of these techniques were used to facilitate input, especially where face-to-face interaction was limited by distance or other logistics.

**Website/blog.**

Information about earth smarts was made freely available to the public by licensing an appropriate domain and creating a website: [www.earthsmarts.info](http://www.earthsmarts.info). As validation proceeded, the website and an associated blog ([www.earthsmarts.info/blog](http://www.earthsmarts.info/blog)) were used to keep those interested up to date, as well as to encourage more qualitative input. Social networks, including professional electronic mailing lists, newsletters, and conference connections, were used to solicit input by directing those interested to the website. Earth smarts is meant to be global and inclusive, so in future work, social networks could be used to elicit input from outside academia as well. As long as they have a direct or indirect online presence, information could be networked and gathered from groups as diverse as U.S. hunting organizations, European organic farmers, Rwandan park rangers, Malaysian commercial fishers, and so on, the sort of empathic communication envisioned by some (e.g., Rifkin, 2009) as being essential to meeting global environmental challenges.

**Interviews with experts.**

More detailed qualitative data was obtained by conducting semi-structured interviews. Following Krathwohl's (1993) steps for construct analysis, the primary guiding questions for the interviews were:

1. What is missing from this iteration, and
2. What is included but not necessary?
Other questions derived from the initial coding framework followed, including:

3. Are components expressed in the clearest, most concise way possible? Do any overlap or duplicate?

4. Are components compatible with an educational framework? Where do they fit? Are they testable?

5. Is achievement of components practical for most citizens? How would people acquire them?

Further questions related specifically to the utility of the construct in the interviewee's field were also included when appropriate. As they are key to the definition of the framework, justice as fairness, quality of life, and educational practicality were used as focal points to help keep responses as parsimonious as possible. Interviews were of varying length, and conducted face-to-face, online and by telephone. To avoid overly narrow input, an interdisciplinary range of experts was selected, including individuals with expertise and experience in ecology, science education, environmental activism, environmental studies, and outdoor/spiritual education. The following experts were interviewed, specifically chosen as they were colleagues or conference contacts working on related topics:

1. Ecology: Rebecca Jordan, Ph.D.; Associate Professor, Rutgers University; behavioral ecologist and researcher helping to define ecological literacy for the Ecological Society of America.

2. Science education: Mike Mueller, Ph.D.; Assistant Professor, University of Georgia; ecojustice and citizen science expert.

4. Environmental studies: Alison A. Ormsby, Ph.D.; Associate Professor of Environmental Studies, Eckerd College; an expert in people-park interactions who conducts research in Madagascar, Florida, and sacred forests in Ghana and India.

5. Outdoor/spiritual education: Alison Peticolas, PhD; Camp Director for the Adventure Unlimited, a 50+ year old international Christian Science organization focused on providing inspiring recreational, social, education, and service activities.

**Analysis.**

Both qualitative and quantitative data were used to re-examine the initial domains and components of earth smarts. Quantitative, Likert-style data (from the online survey instrument) were converted to a numerical rank (1-5) based on perceived importance. In addition to allowing the study to draw input from more experts and practitioners, the quantitative data helped support and validate the qualitative input. Lower ranking components were more carefully considered for clarification or removal, and high ranking components were confirmed and expanded upon by follow up with individual experts.

The qualitative data (open-ended survey questions and discussions) were transcribed when necessary and prepared for analysis in qualitative software. To increase the potential for collaboration, RQDA (Huang, 2011) was used in conjunction with an Excel spreadsheet. RQDA is an extension to the powerful, open source R Project for Statistical Computing. Analysis focused on four points:
1) Is a convincing theoretical and/or empirical case made for the necessity (or removal) of the component?

2) Is the component expressed in the clearest, most concise way possible? Does it overlap with or duplicate another component?

3) Is the component compatible with the educational framework? Where does it fit? Is it testable?

4) Is achievement of the component practical for most citizens? How would people acquire it?

All of this information, collected from sources with a variety of expertise, allowed for a more careful reexamination of the components. Once again, Eisner's (1998) concepts of educational connoisseurship and critique are relevant here, as the earth smarts framework is variable and widely distributed across disciplines. For the purposes of education in particular, building a big-picture expertise, an “enlightened eye”, is critical, although it has been overshadowed by the focus on specific standards and high-stakes assessment. This construct analysis, with its wide-ranging literature analysis and input from a variety of experts, used Eisner's notions of connoisseurship, and the sophisticated critique it makes possible, to help validate the most parsimonious and practical set of components.

Limitations

Earth smarts is a pragmatic construct, meant to be continually validated and localized geographically, temporally, and culturally. This study was designed to begin the process with an extensive literature analysis, then refine and validate it with select interviews and surveys. However, validation and localization should continue, so the refinement steps were designed to encourage continued input. The initial steps were
limited by cultural (North American) and linguistic (English) considerations; the researcher biography in Appendix A will help provide insight into these. However, a collaborative and open design was incorporated from the start, to encourage and facilitate the two-way transmission of knowledge from other cultures and languages. The desire to maintain or improve quality of life was chosen because it is nearly universal, and earth smarts will become increasingly relevant if Earth's climate is changing as rapidly as some of the evidence and models suggest.

As with any educational construct, there is considerable room for alternative formulations and counter-arguments, indeed, one of the reasons this project was undertaken was an abundance of vague, ill-defined, and even conflicting ideas on environmental and ecological literacy from different disciplines. This analysis and the resulting framework are different for some key reasons: 1) they are based on a clearly defined, unifying and nonpartisan goal (justly maintaining quality of life); 2) they draw on thinking from a range of academic disciplines and professions, rather than just one; 3) there were refined using systems analysis tools and construct analysis; 4) they are open (Creative Commons licensed) and freely adaptable to local considerations; 5) they were designed specifically for education, and avoid overly vague or general components.
Chapter 4: Results and Analysis

This section describes the results of the initial and refinement stages, including a brief description of the initial construct and its components. The final domains and components of earth smarts will be discussed in detail in Chapter 5.

Initial Stage Results

The initial stage of the construct analysis for socioecological literacy was theoretical, consisting of an extensive transdisciplinary literature review and analysis, followed by the synthesis of the construct using graphical organizers and systems analysis tools to facilitate the process. The results appear in below, in the order in which they were compiled.

The earth smarts analysis mind map.

Components distilled from the numerous definitions and concepts covered in the literature review were added to the earth smarts analysis mind map (ESAMM), to make organization more practical. The ESAMM (collapsed in Figure 5) provides a helpful summary and visual guide to the dozens of definitions and related concepts that were distilled into their key domains and components. Mentally managing the numerous, diverse and often conflicting concepts was challenging, and it is worth clicking through the ESAMM (either the Freeplane or JAVA versions) to get a sense of the scope. It is an example of visual, computer-aided thinking that does not translate well to linear prose, or paper. With dozens of concepts and hundreds of components, the final version is huge when fully expanded; Appendix C captures all of the text, compressed to fit in a
reasonable number of pages, while Figure 7 shows just the initial definition level of one category, expanded to provide a sense of the scope. Keep in mind that many definitions each had three of four nested levels of components.
Figure 7. The earth smarts analysis mind map (ESAMM), with the environmental and ecological literacy category expanded to the definition level. The fully expanded map is far too large for a page but the text is available in Appendix C.
Visual Understanding Environment analysis and reorganization.

In order to simplify the large number of components, key definitions were coded using qualitative analysis software (RQDA), and the codes were then mapped in the Visual Understanding Environment (VUE), open source software developed by Tufts University (vue.tufts.edu). Arranging codes into spatially-divided conceptual categories helped facilitate the grouping of similar components, an iterative process which ultimately led to a more parsimonious set of domains and components to work with. Figure 8 shows a screen grab of the process taken from VUE. The categories that emerged from this stage of the analysis helped generate the columns of the earth smarts component table. Such a process cannot be considered the only way to categorize such diverse concepts; it can only serve as one of numerous potentially helpful organizing schemes. The domains and components that emerged from this process are briefly characterized here; many of the components map to the more encompassing domains, although not perfectly. The domains and components ultimately chosen are described below. Note that many constructs included more detailed points, particularly regarding content, that are perhaps best left to professional organizations, local school boards or regionally-based curriculum designers to specify.
The earth smarts component table.

After being mapped in the ESAMM and analyzed in VUE, the domains and components that emerged were entered into a large table to facilitate some basic quantitative summaries, most notably to examine the percentage of concepts that they appeared in. The point of the earth smarts component table (ESCT) was not to select the most popular components for inclusion, but rather to indicate which concepts appeared, often under various guises, in a broader range of definitions and constructs. Components were counted in the table if they appeared as part of a definition or initial description of the construct; if they were merely mentioned later in the text or article, they were only added if their role was reasonably explicit. While the ESCT itself is too large to be included in full here, the key results appear in Table 6, including the domains and
components that were ultimately chosen to make up its columns, along with a brief
description.

Table 6: The Domains and Components of the Earth Smarts Component Table, with the
Percentage of the 89 Concepts Analyzed That They Occurred In

<table>
<thead>
<tr>
<th>Item</th>
<th>%</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domains</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>70</td>
<td>Knowledge in a variety of forms, including facts, concepts and familiarity</td>
</tr>
<tr>
<td>Mental Skills</td>
<td>59</td>
<td>Cognitive skills or competencies.</td>
</tr>
<tr>
<td>Ethical</td>
<td>46</td>
<td>Moral or values-based.</td>
</tr>
<tr>
<td>Affect</td>
<td>36</td>
<td>Emotions, attitudes, feelings.</td>
</tr>
<tr>
<td>Action/Behavior</td>
<td>35</td>
<td>Calls for action or behavioral outcomes.</td>
</tr>
<tr>
<td>Place</td>
<td>28</td>
<td>Including sense of place, attachment to the land.</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>19</td>
<td>Aesthetic and artistic references to the environment.</td>
</tr>
<tr>
<td>Spirituality</td>
<td>11</td>
<td>In relation to the environment.</td>
</tr>
<tr>
<td>Physical Skills</td>
<td>7</td>
<td>Specific or general skills of the body, rather than mind.</td>
</tr>
<tr>
<td><strong>Content Components</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td>43</td>
<td>The importance of social factors when considering the environment.</td>
</tr>
<tr>
<td>Eco Content</td>
<td>43</td>
<td>Calls for ecological knowledge of various types.</td>
</tr>
<tr>
<td>Local/Global</td>
<td>35</td>
<td>References to the importance of either or both.</td>
</tr>
<tr>
<td>Interactions</td>
<td>34</td>
<td>Any general mentions of the importance of interactions.</td>
</tr>
<tr>
<td>Systems</td>
<td>34</td>
<td>Knowledge of systems or systems processes.</td>
</tr>
<tr>
<td>Issues</td>
<td>32</td>
<td>An awareness of socioenvironmental issues at a variety of temporal and geographical scales.</td>
</tr>
<tr>
<td>Economics</td>
<td>30</td>
<td>The importance of economics as it relates to the environment.</td>
</tr>
<tr>
<td>Diversity</td>
<td>22</td>
<td>Familiarity, awareness or appreciation of biological and/or cultural diversity.</td>
</tr>
<tr>
<td>Resource Management</td>
<td>21</td>
<td>Knowledge of natural resources and their use.</td>
</tr>
<tr>
<td>Time</td>
<td>20</td>
<td>An understanding or familiarity with historical and/or geological time scales.</td>
</tr>
<tr>
<td>Item</td>
<td>%</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Human/Nature Interaction</td>
<td>19</td>
<td>Specific mentions of the two interacting, especially those emphasizing both directions.</td>
</tr>
<tr>
<td>Change</td>
<td>19</td>
<td>An awareness the world has, and continues to undergo, significant biological, geological or climactic changes.</td>
</tr>
<tr>
<td>Risk/Precaution</td>
<td>6</td>
<td>Risk management, awareness of risks including principles of precaution.</td>
</tr>
<tr>
<td>Complexity</td>
<td>6</td>
<td>Implications of the complexity of life, earth and social systems.</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>5</td>
<td>Scientific understanding and its implications.</td>
</tr>
<tr>
<td>Commons</td>
<td>5</td>
<td>Knowledge and appreciation for the concept of the commons (Hardin, 1968).</td>
</tr>
<tr>
<td>Affective Components</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locus/Efficacy</td>
<td>24</td>
<td>Locus of control, self-efficacy, or related concepts of our affect on the environment.</td>
</tr>
<tr>
<td>Sensitivity/Empathy</td>
<td>20</td>
<td>Variations of the two, especially references to environmental sensitivity.</td>
</tr>
<tr>
<td>Biophilia/awe/wonder</td>
<td>14</td>
<td>The related positive feelings we get when experiencing nature.</td>
</tr>
<tr>
<td>Mental Skills Components</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Politics</td>
<td>34</td>
<td>Political ability and skills.</td>
</tr>
<tr>
<td>Investigation/Problem</td>
<td>23</td>
<td>Skills related to investigation and problem-solving.</td>
</tr>
<tr>
<td>Citizenship/Democracy</td>
<td>21</td>
<td>Being effective; often cast as a value as well.</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>18</td>
<td>References to the various formulations.</td>
</tr>
<tr>
<td>Creativity</td>
<td>13</td>
<td>Anything related.</td>
</tr>
<tr>
<td>Nature of Science (NOS)</td>
<td>13</td>
<td>An understanding of how science works in the real world</td>
</tr>
<tr>
<td>Multiple Perspectives</td>
<td>12</td>
<td>The desire or ability to consider and utilize a variety of perspectives on problems and issues.</td>
</tr>
<tr>
<td>Self-regulation/ Metacognition</td>
<td>10</td>
<td>Including references to effective or life-long learning, and adapting to new situations.</td>
</tr>
<tr>
<td>Peace/Conflict Resolution</td>
<td>9</td>
<td>Resolving problems without violence.</td>
</tr>
</tbody>
</table>

Ethical Components
<table>
<thead>
<tr>
<th>Item</th>
<th>%</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Justice</td>
<td>29</td>
<td>Social or environmental.</td>
</tr>
<tr>
<td>Responsibility</td>
<td>22</td>
<td>Including stewardship.</td>
</tr>
<tr>
<td>Nonhumans</td>
<td>19</td>
<td>Consideration of other species.</td>
</tr>
<tr>
<td>Respect</td>
<td>17</td>
<td>Varied calls for all forms of respect.</td>
</tr>
<tr>
<td>Future Generations</td>
<td>16</td>
<td>Including the consideration and rights of.</td>
</tr>
</tbody>
</table>

There were several domains that didn't break down into components easily, including aesthetic, spiritual, action/behavior, and place. The others did; the components of the content, mental skills, ethical, and affective domains are arranged and sorted appropriately in the table. Some of their key components are worth a bit of elaboration. Consideration of natural (and subsequently cultural) commons arises from *The Tragedy of the Commons*, the influential ecological article (Hardin, 1968). As the heartbreaking demise of wide-ranging species such as bluefin tuna shows, mismanagement of common resources is as much a problem today as it was over four decades ago. The locus/efficacy component represents mentions of both locus of control (Rotter, 1975), and self-efficacy (Bandura, 2001), two related concepts from psychology that describe our perceived effectiveness. From an environmental perspective, self-efficacy can be considered as the realization that our actions affect the environment (for better or worse). The nature of science represents an understanding of how science works in the real world, based on work from science education (Lederman, 2007). Finally, the self-regulation or metacognition component incorporates strategies for effective learning, and includes references to lifelong learning or the ability to effectively learn and adapt to new situations. In addition to helping organizing the numerous domains and components, the ESCT allowed basic quantitative summaries to be calculated, providing insight into how
widespread some of the components were, which components featured in the most definitions, and how important sub-components were within domains.

**The initial construct.**

Figure 9 shows the initial domains and components of earth smarts, then called essential ecoliteracy, created after considering the results of the ESAMM and ESCT in the light of the core definition (justly maintaining quality of life) and the responsibility, systems, and ethical matrices. This framework was used to design the initial online survey instrument and guide the semi-focused interviews for the refinement stage, both of which were updated as new information and ideas came in and the construct was continuously refined and validated.
Refinement Stage Results

This section describes the results of the refinement stage, which included quantitative data from the online survey, and qualitative data from the survey and interviews. The online survey data also included self-reported demographic data as well as information related to the expertise of the participants.

Quantitative data.

At the time the survey data were compiled, 43 experts and professionals had taken the earth smarts survey. Input came from the United States, Canada, Brazil, Cyprus, New Zealand, Israel, and Mexico. While most participants who chose to note their race/ethnicity were Caucasian, some identified as Hispanic, Middle Eastern, African-American, Native American, Jewish, and Metis. They were split evenly between male
and female, with a mean and median age of 44 and a range of 23 to 61 years old. Many were involved in education, and their expertise included environmental and science education, as well as biology, chemistry, geology and geography. Those that chose to note their religious affiliation include participants who selected none (Atheist or Agnostic), Buddhist, Christian – Evangelical/Pentacostal, Christian - Protestant/Non Denominational, Christian - Roman Catholic, Christian Scientist, Jewish, Process Theology and Animist.

For the Likert-style survey questions, responses were converted to a number from 1 (strongly disagree) to 5 (strongly agree). The results for the domains appear in Figure 10. Although an independent t-test indicates that the values (highest rated) and competencies (lowest rated) domains are statistically distinct (t(80)=1.99, p=.02) for this sample, note the scale on the X axis; every domain was ranked as important, although not to the same degree. This is to be expected, as it is typically much easier to add components to an educational framework than subtract them, particularly when a diverse group of people are contributing. What is more interesting is what the relative rankings indicate; somewhat surprisingly, the values domain came out on top, above even concepts/knowledge, and well above competencies/skills. This is clearly not something that is presently representative of formal classroom settings, particularly with the recent push for standardized assessments. Values are inconsistently addressed in public school systems, in part because they are seldom made explicit in educational standards, and they may not be amenable to high-stakes testing.
The results for the more specific components, organized by associated domain, appear in Figure 11. It is interesting to note that participants ranked respect for ecosystems, something that is not reflected in many laws worldwide, higher than respect for culture or individuals. It is also interesting to see how systems thinking compared to scientific reasoning.
For the ranking question on the survey, the tallies were summed and the spread was calculated. Table 7 shows the domains in descending order of importance. Note the rankings break down into three groups—the almost identically ranked moral and sense of place domains at the top, the second tier of respect, content, affect, skills, and action; and finally spiritual, physical skills, and aesthetics trailing sharply off. For those who think education should be dominated by facts on standardized tests, the ranking of the moral and affective domains in this survey should be an eye-opener. However, this ranking is not as shocking when considered in the light of more progressive pedagogies, such as

Figure 11. The earth smarts survey results ranking the importance of the components by the mean of the responses, where 5 indicates participants strongly agree the component is important, and 1 indicates they strongly disagree.
place-based education (Sobel, 2004) or those that explicitly include moral components, such as socioscientific issues and education for ecojustice.

Table 7: Results from the Earth Smarts Survey Ranking Question, in Decreasing Order of Importance Including the Distance from the Top Ranked Domain

<table>
<thead>
<tr>
<th>Domain</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethical / Values / Moral</td>
<td>0</td>
</tr>
<tr>
<td>Sense of Place / Environmental Sensitivity</td>
<td>1</td>
</tr>
<tr>
<td>Respect (for Diversity)</td>
<td>69</td>
</tr>
<tr>
<td>Content / Knowledge / Concepts</td>
<td>71</td>
</tr>
<tr>
<td>Affect / Emotions / Attitudes</td>
<td>78</td>
</tr>
<tr>
<td>Cognitive Skills / Abilities</td>
<td>90</td>
</tr>
<tr>
<td>Behavior / Action</td>
<td>94</td>
</tr>
<tr>
<td>Spiritual</td>
<td>162</td>
</tr>
<tr>
<td>Physical Skills</td>
<td>195</td>
</tr>
<tr>
<td>Aesthetic</td>
<td>216</td>
</tr>
</tbody>
</table>

**Qualitative data.**

Qualitative data from the online survey, the interviews, and comments received online were coded for patterns in RQDA; codes were developed by grouping the comments into related topics. Figure 12 shows the number of times each code appeared in the analysis of the survey data. The first three codes represent issues that were resolved by more detail or a disagreement about content and relevance; the most common issue was participants mentioning components that were already covered by the construct,
often in deeper levels. The other major factor that emerged involved issues or components that required clarification; these comments were incorporated into the design of the earth smarts framework, to improve the components and the relationships between them. Participants occasionally suggested components not included in the initial literature review and analysis – while most of these were rejected due to relevance or achievability issues, some led to alterations that made it into the final construct. The more interesting discussions and topics included in the qualitative data are reflected in the discussion of the final components in the next chapter.

![Figure 12](image.png)

Figure 12. The number of occurrences of the codes used in the qualitative analysis of the surveys and online comments.

Another source of high-quality, interdisciplinary qualitative input for earth smarts came from presenting the initial and refined stages at conferences, taking questions, and discussing it with disciplinary experts and others who were interested. This input helped move socioecological literacy from the initial stage towards the final stage, and shaped
aspects of the survey and interviews. Various iterations of earth smarts were presented at the following national or international academic and professional conferences:


Summary

This section first described the results of the initial literature analysis, including a glimpse of the extensive earth smarts analysis mind map, which appears in compressed form in Appendix C. It also described the design of the earth smarts component table, using the Visual Understanding Environment software to decide upon parsimonious columns. Quantitative results derived from the ESCT appear in Table 6. The initial construct, then called essential ecoliteracy, was briefly described, followed by the results of the refinement stage, including the survey and interviews. Quantitative results from the surveys appear in Table 7 and Figures 10 and 11, and suggest strong support for systems thinking, values and sense of place, topics not always covered well in formal education or scientific and environmental literacy frameworks. Finally, qualitative data from the online surveys and expert interviews was considered, including a summary of coding. The refined earth smarts framework that derived from these results is discussed in the next chapter.
Chapter 5: Discussion

This section will discuss the revised earth smarts framework, beginning with some underlying philosophy before covering each of the domains and components of socioecological literacy that emerged from the quantitative and qualitative data of the refinement stage. It will justify why behavior, a domain that occurs in many environmental literacy definitions, was deliberately left out of the construct, and also consider ongoing validation and localization.

Philosophy

One of the key problems that emerges from a wide consideration of the literature is philosophical. Educational constructs involve epistemic and ontological assumptions, although they are not always made clear. Many of the constructs and definitions available to educators are under-theorized; they offer specific content or skills, but do not address the assumptions underlying either the components themselves, or the implications of choosing them over others, an important consideration in education. Making the epistemology and ontology more explicit can help reduce confusion, conflicting components, and unnecessary debate. On that note, the debate over the need for so-called environmental values is a complex one; the largely anthropocentric moral frameworks we are used to need to more carefully consider the non-human world and issues related to the intrinsic value of species and ecosystems (O’Neill et al., 2008).

Two philosophical frameworks emerged as especially relevant to earth smarts. In the first, Canadian philosopher Lorraine Code (2006) suggests ecological naturalism as a
helpful epistemology, contrasting it with the more pervasive ethos of mastery. It is relational rather than reductionist, using evidence from ecology and the social sciences to ensure and enhance our survival. Code envisions our habitat as including sociocultural relationships as well as geography and history, nothing that such ecosystems aren't inherently good or bad, and “ecological thinking is as available for feeding self-serving romantic fantasies as for inspiring socially responsible transformations” (p. 6). A complementary view comes from ecologists Reiners and Lockwood (2009), who argue that ecological science has a murky philosophical base. They offer constrained pragmatism as a productive framework, a way to navigate the “false dilemma... and pedagogical obstacle of absolutism and relativism” (p. 173). For their purposes, and for the purposes of this study, constrained pragmatism is a socially negotiated reality that is constrained by an objective reality – while we may never understand objective reality exactly, good science balances it with our subjective interests.

While addressing ontology and epistemology are important, educational frameworks can also become mired in esoteric philosophical quagmires, becoming too complicated, vague or all-encompassing to be useful. Although fraught with some of the issues that make standardized curricula and tests problematic, earth smarts will be a more practical educational construct if the components (or proxies for them) can be specifically described and tested. Individual components ended up being a combination of global and local factors that change over time, and some were more amenable to quantification (and therefore instrument design and standardized testing) than others. Specific components were considered using The New Taxonomy of Educational Objectives (Marzano & Kendall, 2007), an updated version of Bloom's taxonomy. This framework, which was
built into the ESAMM, uses a two dimensional system of educational domains (psychomotor, mental, & information) and levels of processing (from simple retrieval to self-system) to specify what level of skill goals and objectives require.

**The Earth Smarts Framework**

This section describes the revised domains and components of earth smarts, including key background information on how and why certain components were designed or chosen. A quick look at the domains will reveal content (knowledge) and competencies (skills), both of which are common elements of literacy definitions and educational standards. However, researchers are increasingly recognizing the role that emotions and values play in both environmental and science literacy, as well as learning in general. For example, discussing their collective research, Rickinson, Lundholm & Hopwood (2009) consider both affective and moral elements to be critical to environmental learning. In earth smarts, moral and affective elements appear within the respect and sense of place domains. The four domains (concepts, competencies, sense of place, and values) and their primary components appear as headings below; for clarity, secondary components are indicated by bold type, and tertiary components (the deepest level) are listed with bracketed letters. The earth smarts mind map (Figures 13 and 14) makes this structure much easier to visualize, and clicking through the expandable computer version is even more enlightening. It is worth emphasizing that sacrifices need to be made in order to make such a complex construct practical in education. The hierarchical structure used here lends itself well to creating standards and testable components, but misses many of the connections between components. This is especially true for affective and moral components; here they are grounded in sense of place and
respect, but they undoubtedly influence other components across all four domains. Nonetheless, while a nebulous cloud of interconnected components might be more realistic, it certainly isn't more practical, and educational constructs need to be useful to survive.
Figure 13. The first half of the earth smarts framework for sociological literacy: concepts and values expanded. See www.earthsmarts.info for the interactive, clickable computer version.
Figure 14. The second half of the earth smarts framework for socioecological literacy: competencies and sense of place expanded. See www.earthsmarts.info for the interactive, clickable computer version.
The concepts domain can also be thought of as knowledge or content, and is the domain on which traditional education has largely focused. In earth smarts, mastering concepts is more than just memorizing facts; there are important ideas about how the world works that we need to understand, at least in broad terms, if we are to adapt to its changes. In-depth, highly specialized understandings are not the point; a more holistic grasp of the concepts and their implications is key.

**Basic thermodynamics.**

An understanding of the first and second laws of thermodynamics forms the basis for understanding many of the other components dealing with energy flow, as well as contributing to competencies such as systems thinking. Understanding basic thermodynamics also helps dispel some common and problematic misconceptions related to the environment and our place in it. Especially important are an understanding of entropy, energy transfer in the form of work and heat, and key differences between open and closed systems.

**Ecological principles.**

Not surprisingly, socioecological literacy includes some key principles from ecological science. An understanding of energy flow through living and non-living systems is critical; it is remarkable how many city-bound adults and children have no idea where the power they depend on every day really comes from, particularly when fossil fuels are involved. Along with energy, some basic knowledge of biogeochemical cycling is also important, especially key elements like carbon, oxygen, and nitrogen. It wouldn't be ecology without population dynamics, some important aspects of which aren't particularly intuitive and are therefore prone to misconceptions. Finally, some
basics about **ecosystems** are critical, most notably a) carrying capacity, b) food webs, and c) resilience as it relates to ecosystems and communities. All of these components include a basic level of knowledge that should be supplemented with locally relevant information and examples, as well as global implications.

*Historical ecology.*

Ecology has become more than a specialized topic of biological science, and there are numerous ways to bridge the gap between the natural and social sciences with ecological frameworks. Human impacts on ecosystems worldwide have become so pervasive that considering completely natural environments is probably pointless; we are entering a new era, the anthropocene (Zalasiewicz et al., 2008), where our impact is so extensive it is showing up in the geological record. Historical ecology (e.g., Crumley, 2007) is an interdisciplinary field that describes the ongoing, two-way interactions between humans and their environments. Many older conceptions of environmental or ecological literacy considered the effects we have on the environment, but newer ones acknowledge **ongoing human-environment interactions**, examining the two way, interactive nature of the relationship. Although our environment certainly shapes our bodies and cultures, we in turn are able to change it, and not just locally. For earth smarts, an emphasis on how some societies achieved and sustained a higher quality of life, while others did not, is especially important. To learn from history we must have a sense of **historical time** on a variety of scales, especially a) short-term events, b) decadal cycles, and c) patterns over centuries. The **ecojustice** component explicitly considers values in these interactions. While ecojustice has focused on issues such as unequal exposure to
pollution and environmental degradation, there is increasing work being done on the
effects of globalization on local ecosystems and cultures.

We often make unfortunate or oversimplified assumptions about economics and
the environment, which can be addressed by considering **ecological economics**,
especially the importance of a) environmental services, the complexities of b) resource
management, and the implications of c) the commons, or commonly shared resources.

**Pollution and health** are also concepts we need to have a basic understanding of,
particularly given the increasing numbers of chemicals that are widespread but not easy
to detect, and may combine for effects we can only guess at. It is worth noting that when
we have the right combination of public awareness and political will, we can make
dramatic improvements, from the cleanup of massive toxic waste hotspots to the
reduction of ozone-depleting chlorofluorocarbons in the atmosphere. An understanding of
key iterations of **precaution** and their socioeconomic implications helps frame all of the
aspects of historical ecology.

**Essential biology.**

This component includes some key concepts from biology, the study of life.
While it may not be necessary for everyone to understand which beetle lives in which
tree or exactly how the leg bone is connected to the knee bone, familiarity with the
following concepts helps us understand our place in the world and our relationship with
other living things. An understanding of **evolutionary processes**, both macro and micro,
is critical to understanding life past and present, as well as how organisms with short life
cycles are able to evolve in time scales we can more readily understand, something that is
especially important when considering pathogens and pests. An understanding of
evolution also provides important insights into how human cultures change (Mesoudi, 2011). A grasp of evolutionary time scales is important here, which can move well beyond historical time and are thus harder for our brains to comprehend. A basic awareness of the diversity of life, past and present, is important, including the uneven distribution of species and their remarkable range of forms, from archaic bacteria to the great whales, exotic fungi and deep sea invertebrates. A complementary awareness of the unity of life helps put this diversity into perspective, including a sense of the shared molecular and cellular building blocks that lie beneath life's awe-inspiring diversity.

**Earth systems.**

While essential biology helps us understand our place in the living world, there are some key concepts about how the world works that are also important to understand. Earth systems science includes cosmological, geological, atmospheric and oceanic processes; once again for earth smarts, the emphasis is on a holistic overview of these systems, their interactions and their implications for our quality of life. To understand Earth in context, some basic cosmology is important, including familiarity with a) the big bang, b) solar system formation and c) the star cycle. The third time scale important to socioecological literacy (beyond historical and evolutionary) is geological time, which helps put earth processes in perspective, particularly plate tectonics and the rock cycle. A sense of the complex workings of climate, weather & atmosphere is important, particularly given the global nature of climate change and pollution. The role that oceans play in earth systems is also critical to understand, regardless of how close to the coast we live. Tied closely to all of the above are the basics of the water cycle, an elementary
school favorite that becomes increasingly important as rain patterns change and ancient aquifers are mined out.

**Competencies.**

In addition to concepts or knowledge, a second domain, competencies, should also be familiar in education. Consisting of a set of cognitive skills, it includes of a variety of pragmatic abilities and “manner of thinking”, including scientific reasoning, systems thinking and community skills, the latter of which will vary considerably across cultures, and require careful consideration of local/indigenous knowledge. As these are skills, they all require practice and mental development; when nurtured, they contribute to the ability to make reasonable decisions regarding complex, ill-structured problems. Environmental issues often involve numerous stakeholders with differing, even conflicting values, so just solutions are seldom straightforward.

**Self-regulation/adaptability.**

Incorporating modern research on cognition, the competencies domain includes self-regulation (Schraw, Crippen, & Hartley, 2006). Self-regulated learning encompasses **metacognition, motivation, and strategic action**, all of which are important to real learning and acting effectively on new knowledge. From an ecological perspective, self-regulated learners might be considered as adaptable; they are able to respond to changes. In educational terms they are typically effective, life-long learners. To maintain our quality of life on a changing planet, individuals and communities will need to quickly adapt to both new information and varying environments, so self-regulation should be a major goal of formal education.
Community skills.

This large component attempts to capture the variety of skills that enable us to work effectively together. It encompasses a set of sociopolitical skills and strategies that make action easier and more effective in social contexts. We will need to work together to face present and future challenges; no matter how hard-working or brilliant you are, on your own you probably won't be able to design, launch, and monitor a weather satellite, run an ocean-going research vessel, or restore a large ecosystem. But communities of people working together effectively can do these things, and many others, which is why collaboration is included, especially a) group work, as well as the ability to use b) collective intelligence to solve problems, something that increased Internet access and power is facilitating in exciting new ways. This ties closely into a set of skills related to communication, including a) language, b) media, and c) argumentation/persuasion skills, all of which help to effectively transmit ideas.

As earth smarts is based on justly maintaining quality of life, it also requires skills that help us achieve just solutions to complicated environmental issues. In a diverse world, the ability to appreciate and utilize multiple perspectives & stakeholders is a skill that must be developed and practiced, particularly the ability to a) empathize with, b) involve, and c) balance different perspectives, even though they might incorporate different values. This ability is complemented by experience with conflict resolution, another area where local culture and context are immensely important. Practical ethics, a framework that involves examining moral issues in terms of a) conceptualization, and b) justification (Gert, 2004), is also important to working together justly. All of these components typically require some form of democracy/participation/citizenship. There
are several reasons to include democratic skills in earth smarts. The first is that studies have shown that there is a correlation, albeit a weak and muddled one, between democratic governance and sustainability (Ward, 2008). At least as important is the contribution to quality of life, for citizens who feel a sense of participation in their communities, who feel like there are opportunities to be involved and change things, tend to be happier (Diener & Seligman, 2004). In democratic citizenship, we again see the tension between individual rights and community responsibilities than underlies much of socioecological literacy (see the values domain). For instance, is voting a privilege, a right or a duty? Democracies address this issue, and numerous others, in a variety of ways.

**Scientific reasoning.**

This component captures a variety of skills, attitudes, and manners of thinking that relate to science. Two of them are fairly common in Western educational goals, although they are not always taught or assessed effectively. **Critical thinking** is often expressed as important; earth smarts incorporates Beyer's (1995) conceptualization, which includes understandings of a) facts versus values, b) relevance, c) source credibility, d) ambiguous claims and arguments, e) unstated assumptions, f) bias, g) logical fallacies, and h) logical inconsistencies. Like other variations, this conceptualization of critical thinking overlaps with other components of scientific reasoning, and is important to science education and literacy (Zeidler, Lederman, & Taylor, 1992). Many literacy definitions also call for **investigation** skills; under earth smarts these include the basics of a) research design, the ability to b) observe and collect data, c) data analysis, and working with d) models, be they physical, mental, computer or
otherwise. As with other skills, all of these take practice and application in a variety of situations to master.

Scientific reasoning also includes some familiarity with the **nature of science** (Lederman, 2007), an important aspect of science education that includes a) observations vs. inferences, b) laws vs. theories, c) explaining natural phenomena, d) the subjective / theory-laden aspect of science, the e) importance of social & cultural traditions & influences, and the f) durable, tentative aspects of scientific knowledge. Encouraging **creativity** is also essential, particularly given the possibilities, good and bad, that our rapid technological advances make possible. For environmental issues in particular, practice dealing with scientific **uncertainty** is also important, particularly as it relates to risks and precaution. Finally, scientific reasoning includes **open-minded skepticism**. Rational skepticism, or skeptical inquiry, is a cognitive skill related to critical thinking and inductive reasoning. As ecologists Davis and Ruddle (2010) point out, it is an important tool when considering local and/or indigenous ecological knowledge (LEK, IEK). Such traditional knowledge has met with a wide variety of responses from scientists and policy makers, from being completely ignored to vaunted as unassailable. Earth smarts is pragmatic—when IEK is incorporated, it must demonstrably work in the here and now—and rational skepticism is a tool for examining it, as well as many other claims where the empirical evidence is insufficient. For earth smarts, indigenous and local knowledge are worth such consideration because they interact directly with the sense of place domain, and also help sustain sociocultural diversity, an aspect of the values domain.
**Systems thinking.**

Although its increased importance is relatively recent, as Table 6 shows, many of the definitions of environmental and ecological literacy included a systems thinking or content component. Furthermore, survey respondents rated systems thinking as the most important cognitive skill; considering the overlap with ecological concepts, this shouldn't be too shocking. For earth's smarts, systems thinking includes the importance of **connections**, especially a) interactions, b) feedback, and c) constraints. Systems thinking also involves understanding **consequences, implications, and risk**. Another important consideration is **complexity**; oversimplifying people, communities and ecosystems has caused all kinds of problems for politicians, teachers, and scientists alike. Finally, a better understanding of **change** is essential, particularly given our new understandings of how much change our world is capable of. Once again, if we practice these aspects of systems thinking, we will become more adept at understanding and adapting to the complex systems that comprise our communities and environments. On that note, practice with all of these competencies, in formal and informal educational settings, will contribute to our ability to adapt, which is likely to become increasingly important.

As we lose the climactic stability that's marked all of human civilization, it's not as if we're going to land on some other firm plateau. The changes to our lives will be ongoing and large and will require uncommon nimbleness, physically and psychologically (McKibben, 2010, p. 147).

**Sense of place.**

This domain captures some of the things that influence how we think and feel about our environments, both local and global. It involves attitudes and emotions, often
called affective elements, which are aptly named, as this domain's components affect many of the other components of earth smarts. Although it appeared in a moderate 21 percent of the definitions, many of them deliberately avoided affective elements, particularly the older ones. However, survey respondents ranked it third above competencies. Sense of place is often a goal of environmental education, particularly the connection component below. For earth smarts, it also includes a basic awareness of environmental connections and issues, something now essential on a global as well as local scale, as even the best local knowledge will not protect a community from global changes. Summarizing the literature from an interdisciplinary perspective, Ardoin (2006) notes that sense of place has four dimensions: biophysical, sociocultural, personal/psychological, and political/economic. In earth smarts, sense of place appears as a domain, but its affective elements, our emotional connection to the land and culture we are immersed in, affect every other component. A positive sense of place may also contribute to community resilience, an interesting interdisciplinary field that seeks to understand what makes some communities more socially and ecologically resilient (Adger, 2000).

Regardless of how it is experienced, sense of place is critical. In an increasingly mobile and virtual world, the implications of cultural apathy, spiritual malaise, the extinction of experience in education (Pyle, 2001), nature-deficit disorder (Louv, 2008), and shifting baselines (Papworth, Rist, Coad, & Milner-Gulland, 2009) causing ever diminished expectations of our environments, may all be profound. Robbed of our appreciation for the world and our sense of belonging, basic education and awareness will never be enough to inspire us to learn or act. Creative, place-based education that forges
affective links to communities and environments may be one of the most important frontiers of socioecological education.

**Awareness of local community including issues.**

How we feel about the places we live is partly based on what we know about them. Knowing our neighbors, public spaces, water supplies, ecosystem services, and local plants and animals is both emotionally satisfying and logistically smart. We need to better understand our local communities and environments, particularly the factors that improve or diminish our quality of life. As has been noted, this is especially challenging in an increasingly mobile, urban world.

**Awareness of global community including issues.**

Local knowledge isn't enough; we also need a sense of our place in the world, and how we affect and are affected by issues on a global scale. Technological advances, particularly in transportation and communication, make the planet seems a lot smaller, but we all need to know more about the local impacts of global issues such as persistent pollutants, large-scale disasters, energy management, and climate change.

**Attachment/biophilia/sensitivity.**

Far too many of us have lost the emotional connection to place that our ancestors had; we need to nurture our love for the places we live, and our remarkable world. People need to feel connected to their environment in a positive way, something that has been expressed in many ways, and will likely express itself in new ways in our increasingly urban landscapes. One body of research suggests that significant life experiences in the outdoors play an important role in the formation of our environmental attitudes (Chawla, 2006). Due to the vagaries of memory and self-reporting, precise formulae for such
experiences may never emerge, and may not need to, as they are likely to vary culturally, historically and geographically. The specifics of our environmental connections are probably quite flexible; whether we consider it as biophilia, environmental sensitivity, or some other emotional or spiritual bond, the point is we need to feel connected, and our mobile, technological world makes this more challenging for educators and communities. Recent work in environmental education (Cachelin, Paisley, & Blanchard, 2009) suggests field experiences are important for both affective and cognitive changes, and affective changes may be as, if not more, important than cognitive ones. Whatever this affective connection to place is called, it is something we need to do much better, within and beyond formal education, and urban planning and green spaces will likely play a critical role.

Our attachment to the land may express itself in a variety of culturally-influenced ways. Some form of spirituality is one; many indigenous and agricultural cultures have or had profound spiritual connections to the land. Such connections are challenging to maintain in the face of urbanization, globalization, and environmental degradation, but we need to adapt and renew them. Aesthetics also play an important role; encouraging people to experience the beauty of natural places has a long tradition in environmental education. We are still moved by mountains, forests, ponds, seashores, and other ecosystems, an aesthetic connection that may be especially important for children, and one that requires considerably more thought and effort to achieve in urban centers.

_Self-efficacy._

Fatalism is a problem with some world views and some environmental messaging, and is is one of the five major barriers to environmental engagement (Pike, Herr,
Self-efficacy (Bandura, 2001), a concept from psychology, is believing that you have some control over your actions, and those actions have an effect on your environment (good or bad). It relates to systems thinking competencies, especially understanding interactions and consequences. A key aspect of earth smarts is the realization that we can have positive impacts, an empowerment that is critical at the individual and community level. Without it, we feel helpless.

**Values.**

Like emotions, our values influence much of what we think, do, and learn. The earth smarts values domain includes moral components, and incorporates moral development as well as the importance of biological and cultural diversity. Moral development can and probably should be included in science and citizenship education as well, and socioscientific issues research from science education (Zeidler, 2006) is indicating some of the ways this might happen; environmental education and earth smarts can benefit from it. Our values affect both the way we see the environment and our role in it; Barry (2009) categorizes them as a concept tetrad that envisions the environment as something to be controlled, conquered, exploited or worshiped. Considering which of these best describes our personal and societal views of the environment is an important first step to more sustainable values. As numerous studies have indicated, knowledge alone does not necessarily lead to changes in behavior. Though the models are varied and often quite complex (Kollmuss & Agyeman, 2002), it is likely that improved knowledge, combined with a careful consideration of the relevant and often conflicting values that underlay many socioenvironmental issues, will facilitate and encourage more sophisticated decision-making.
**Moral development.**

This component represents a progression (Kohlberg, Levine, & Hewer, 1983); to achieve earth smarts, we must move beyond seeing things as simply right or wrong. The first stage of moral development is preconventional, or **dualism**, where decisions are based on consequences to the individual. This is basically making decisions based on perceived punishment or reward, and is insufficient for earth smarts and democratic societies. The second stage is conventional, or **relativism**, where decisions are based on the rules and norms of the society. This level can be problematic when societies are unjust, or when environmental conditions change. The final level is post-conventional, or **commitment with uncertainty**, where decisions are based on a consideration of rules as well as the individual's abstract principles. This is ideal for earth smarts, where justice and respect are key principles. An alternative, care-based morality is worth considering here as well, although issues with reciprocity make it problematic when moving beyond human relationships. Noddings (2002) has written extensively about care in education, distinguishing between caring for, and the less meaningful caring about. Rather than acting from the top down, this form of morality begins at home; “learning first what it means to be cared for, then to care for intimate others, and finally to care about those we cannot care for directly” (p.31). This progression marks an important distinction from some of her earlier work, in which care required the one being cared for to be aware of it. This reciprocity is problematic for the non-human and ecosystem elements of earth smarts covered below, which are incapable of awareness in this sense. However, Noddings explicitly compares her concept of caring about to a sense of justice, noting that “Those who care about others in the justice sense must keep in mind that the
objective is to ensure that caring actually occurs. Caring-about is empty if it does not culminate in caring relations” (2002, p. 23).

Whatever the moral foundation might be, deliberate and effective moral development is not trivial, and education involving it can be complex (Zeidler, 2006). Post-conventional morality also involves socioecological competencies, including connections, consequences and complexity from systems thinking, as well as the ability to consider multiple perspectives. This is another area where the hierarchical view of earth smarts is a difficult compromise. Post-conventional moral reasoning is essential if we wish to live in just societies, and progression towards it is inseparably woven through the other domains of earth smarts, and many of their components.

**Respect for other (diversity).**

The quality of life that earth smarts is based upon is not just your own; it applies to other individuals, other communities, other cultures, and other species. We must, therefore, respect these “others”, and their right to maintain or improve their own quality of life. Empathizing with their existence and rights, we must seek to better our own lives without unnecessarily diminishing theirs. This domain speaks to the heart of social and environmental justice, and involves important competencies, including moral development, the ability to involve multiple perspectives, and practical ethics skills to help find compromises as we share resources and space. Biological and cultural diversity is important for both intrinsic and extrinsic reasons. While the intrinsic value is philosophical, from an extrinsic perspective, diversity tends to increase the resilience of systems (Elmqvist et al., 2003), so it is worth protecting from a selfish perspective as well. This component asks that we respect a variety of others; the most obvious is other
individuals, as increasing our own quality of life must not unduly jeopardize the wellbeing of other people. Scaling that respect upwards, there are many ways to achieve wellbeing, and cultural practices may be socially or ecologically appropriate in one area but not others. Within the context of respect and justice, this cultural diversity should be nurtured, with special respect for the sustainable aspects of traditional and indigenous cultures.

We also cannot ignore the wellbeing of other organisms; it is problematic, both scientifically and ethically, to draw stark moral lines between humans and nonhumans. While this is a deeply complicated topic, in theory and in practice, it still seems reasonable to allow that the wellbeing of individuals of more intelligent species (e.g., dolphins and chimpanzees) deserves more careful consideration than that of individuals of less intelligent species (e.g., mosquitoes and turnips). Scaling up from species, earth smarts includes a holistic consideration of ecosystems that will help us avoid unduly diminishing them as we work to improve our own lives. The clash between individual rights, human or otherwise, and the rights of ecosystems can also be philosophically complex, but it is going to become increasingly relevant as we are forced to consider which ecosystems are worth nurturing in a shrinking, changing world.

Finally, our children are at the heart of most definitions of sustainability, including the classic Bruntland Commission definition: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UN WCED, 1987). There are numerous appeals to the wellbeing of future generations in popular environmental literature, although serious consideration of the rights of future generations is complex. For
example, Heyward (2008) examines complications related to the all-affected principle when applied to future persons in a deliberative democracy. Nonetheless, earth smarts requires some form of basic respect for the wellbeing of future generations; we need to consider quality of life beyond the next economic or political cycle. Note that the respect component of earth smarts is not prescriptive. In practice, respect is closely linked with the complex balance of rights, responsibilities and justice, something that every just society must do consciously and carefully.

**Justice.**

Justice is a critical component of earth smarts; concerns about quality of life should not be restricted to a single person, society or species. Combined with respect for a range of others, the consideration of justice necessitates a complex, ongoing negotiation of rights and responsibilities, a process that may look quite different in the context of different cultures and bioregions, but one which must be explicitly and carefully considered. Balancing individual rights and freedoms with responsibility to various communities (family, town, country, place...) is an ongoing, complicated process, and involves consideration of a) local, b) global, c) individual, and d) community issues. Justice as fairness (Rawls & Kelly, 2001) includes an ongoing negotiation between a) liberty (rights), and b) equality (fair opportunity and difference). Although earth smarts asks us to confront these value-based tensions explicitly, it does not prescribe answers to these issues. Philosophers have been debating them for thousands of years, and will undoubtedly continue to. However, we all need a better awareness of them, as they often appear in educational or sociopolitical frameworks as unchallenged assumptions or contradictory components.
**Omitting Behavior**

As we have seen, definitions of sustainability, environmental literacy and their relatives are more inclined to include affective and behavioral components than traditional definitions of science literacy, which tend to stick to content and cognitive skills. While earth smarts does include affective components in the sense of place domain, the inclusion of behavioral components can be both theoretically and politically problematic. This section will explain why behavioral components were specifically avoided in earth smarts.

One of the most basic problems with teaching for behavioral change is measuring it. Can schools formally teach, and then assess, environmental behavior? As Ratcliffe and Grace (2003) note, in educational contexts, evaluating behavior in anything but contrived situations is difficult, particularly for controversial issues. Because the sorts of action people take may be obvious or extremely subtle, and may be strongly influenced by culture, peers, and other variables, action may be more difficult to accurately measure and compare than attitude or knowledge, and of course people may act in similar ways for very different reasons. Yet if environmental behavior itself is difficult to assess in educational contexts, can it be predicted using more reliably measured factors, such as motivation, attitude, or awareness? Though the evidence remains less than clear (L. K. Zimmerman, 1996), studies have shown environmental behavior is linked to both attitude and knowledge, but not necessarily either in isolation. Kaiser, Woelfing, & Fuhrer (1999) make a good case for linking environmental attitude and behavior using the theory of planned behavior (Ajzen, 2005); Hungerford and Volk (1990) provide critical components of education to maximize opportunities to change environmentally related
behavior. However, the literature on all this is murky, both in the environmental education and psychological fields, although it has become clear that knowledge and awareness are not sufficient to predict behavior. One of the more influential models for predicting responsible environmental behavior (Hines, Hungerford, & Tomera, 1986) includes many of the components that appear and reappear throughout the literature review in Chapter 2, including knowledge, attitudes, and locus of control. Darner (2009) notes that studies based on these factors have reported inconsistent results, and proposes self-determination theory as a potentially useful model in environmental education. Heimlich and Ardoin (2008) summarize behavior research and a variety of models for environmental educators, noting that “like the Theory of Reasoned Action and the Theory of Planned Behavior, the Integrated Model is valuable for studying behavior on a theoretical level, but its complexity makes it difficult to implement." All of this means that behavior, and proxies for it, are difficult to effectively assess in formal educational settings.

In addition to issues with assessment, if specific action is the measurable outcome of formal education, teachers become more vulnerable to charges of bias or indoctrination, which can be a serious issue in educational contexts across the world. Scientific experts and external policy makers can provide helpful information and alternative ways of valuing, but

...given that we do not know what comprises the right or best “sustainable lifestyle" in a particular context, it is argued that it would not be correct for “technical experts," or the government to prescribe to citizens how they should
behave... in the last analysis, final decisions and plans should be made within the local context by those who live there (Wals & Heymann, 2004, p. 140).

Should education be considered deterministic and guarantee behavioral change? As the Campaign for Environmental Literacy (2007) notes, environmental literacy means the learner acquires a capacity for environmental behaviors. Despite the emphasis on action in many formulations, activities with behavioral change as the primary goal are best considered as social marketing, rather than education, particularly when specific changes are sought (Monroe, 2003).

The problems of teaching for specific behaviors do not just involve issues for educators. They also relate to the conflict between encouraging causistic behaviors (routines, social norms) and teaching critical thinking. This means considering either instrumental strategies, which focus on behavior change, or emancipatory strategies (Wals, Geerling-Eijff, Hubeek, van der Kroon, & Vader, 2008). While there are arguments for both, if instrumental strategies are to be used, the issue should be clear and the behavior changes must be the best possible. This in turn requires that the underlying problem be clearly defined and the solutions strongly supported by science. For ill-defined and complex problems, or problems where the science remains insufficiently clear, it is better to teach for critical thinking, adaptability, and justice. That way, if conditions change or new information is revealed, students and their communities will not be locked into behaviors; they will be more able to respond with quick, fair solutions.

It is worth noting that this is pedagogically complex, and a case can be made for learning values and sense of place through communities of practice (Chaiklin & Lave, 1996); moving from behavior to values, rather than the other way around.
Anthropologists have shown that human development is more culturally flexible than many educators may believe (Rogoff, 2003). However, to remain as adaptive as rapidly changing environmental conditions may require, such experience-based learning would likely require very skilled and sophisticated teacher-guides, particularly when moving from local to more global knowledge and values. Such educators are not likely to be available to a majority of students.

The world appears to be entering a period of more rapid change, and environmental issues tend to involve complex, incomplete science and conflicting value systems. Therefore, the emphasis in earth smarts is not teaching behaviors, but rather teaching for capacity to act quickly, creatively, and justly. To summarize then, behavioral components were deliberately omitted from earth smarts because 1) environmental behavior is difficult to measure in educational contexts; 2) in practice, environmental behavior is difficult to model from other indicators; 3) teaching specific behaviors is open to charges of bias, coercion, and colonialism; and 4) in a changing world, acquiring the capacity to adapt is more important than learning specific behaviors.

Ongoing Validity

A number of tensions are involved when designing and validating a complex educational construct like socioecological literacy, or earth smarts. This section will briefly discuss issues related to 1) reality versus practicality, 2) simplicity versus complexity, 3) interdisciplinarity, and 4) alternative formulations. It is also worth remembering the limitations of the study design discussed in Chapter 3. Although web-based input facilitated input from beyond North America, use of the web involves issues related to the digital divide, and therefore comes with its own cultural limitations. Also,
English was the only language used to gather input. Both of these issues could be addressed by follow-up work involving scholars from other parts of the world.

In many ways, reality and practicality are conflicting issues in an educational framework. For example, earth smarts is primarily illustrated as a hierarchical mind map. However, there is a complex web of connections between domains and components, particularly the affective and moral ones, that are not represented well, or at all, by this layout. For practical reasons, the nesting, hierarchical components are easier to grasp—and to adapt to educational standards—in their present form, even though they might be more accurately described in a cloud-like model. This issue relates closely to that of balancing simplicity and complexity. The literature review turned up a wide variety of concepts that were too vague, oversimplified, or both to be practical for research or curriculum design, and some of the expert input in the refinement stage suggested information or topics that were missing. However, other experts thought the framework was too complicated and would be difficult for people to grasp. An attempt to balance these issues was made by choosing the hierarchical design in an expanding mind map. As envisioned, the concept begins simply, with just the domains, but can be explored in more detail by opening nodes containing primary, secondary and in some cases tertiary components. Although users can experience this on the web or other computer devices, it is more difficult in print.

Another validity issue arises from the interdisciplinary nature of the framework. The most strident input into components during the refinement stage came from experts in one discipline critical of concepts from another, and validity can be difficult to assess across disciplines that use a different vocabulary or do not share enough key concepts.
Even within disciplines there is plenty of disagreement between sub-groups; debate over the inclusion of behavior in many environmental constructs, dealt with in the section above, is an excellent example. However, given the quality of life goal that earth smarts is based on, combining work from different disciplines is essential; indeed, the construct is deliberately transdisciplinary, and was built with input from practitioners as well as academics. This struggle is not unique to socioecological literacy; attempts at more interdisciplinary work are underway throughout academia, although it often requires patience, a thick skin, and a sensitivity to turf wars. Ultimately the earth smarts framework may help researchers and practitioners from different fields find common ground and expose potential conflicts.

Finally, as with any educational construct, there is considerable room for alternative formulations and counter-arguments. One of the reasons this project was undertaken was an abundance of vague, ill-defined, and even conflicting ideas on environmental and ecological literacy from different disciplines. However, as noted in the methods section, earth smarts, or socioecological literacy, addresses these validity concerns in a variety of ways. This analysis and the resulting framework are different for some key reasons: First of all, earth smarts is based on a clearly defined, unifying, and nonpartisan goal: justly maintaining quality of life. The vague, missing or even conflicting goals that underlay many definitions of sustainability and literacy doom them from the start. Secondly, earth smarts draws on thinking from a range of academic disciplines and professions, rather than just one. Formulations drawn largely from a single disciplinary silo can have considerable blind spots. Just as important, although it draws on a range of disciplines, earth smarts was designed specifically for education, so it
is pragmatic and avoids overly vague or general components, although some were left deliberately broad enough to be filled in by local or discipline-specific details. In addition, the framework was designed and refined using systems analysis tools and a construct analysis, to make the process more systematic and less likely to miss critical pieces. Finally, validity was considered again by consulting experts and practitioners, in the form of conference presentations, a survey, web input, and interviews. These checks and balances, a combination of transdisciplinary literature review, theoretical analysis, and expert input, act as a kind of triangulation, and helped to make earth smarts more robust and dependable.

**Localization & Standards**

Earth smarts was designed to be flexible enough to remain compatible with a wide variety of cultures and ecosystems. Although the framework provides practical guidance for those designing programs and curricula, it allows plenty of room for local considerations and creative elements. A number of educational standards were incorporated into the initial analysis, including national and international standards from organizations involved in science, environmental, earth, and social studies education (see Chapter 2 and Appendix C). In turn, the hierarchical design of the construct lends itself to creating educational objectives, or harmonizing them with community partners. Earth smarts also incorporates the New Taxonomy of Educational Objectives (Marzano & Kendall, 2008), a helpful scheme for the design and classification of learning objectives.

Earth smarts is not prescriptive; it encourages creative local solutions that are ecologically and culturally appropriate. Localization is therefore important, and Creative Commons attribution share-alike licensing allows free use and adaptation. Furthermore, it
was designed using free and open-source software tools to facilitate input. Participants in the refinement stage came from a wide range of locales and backgrounds; in a sense, the refinement was crowd sourced, a technique that is being considered for peer review of the sciences, among many other applications. As earth smarts gains more traction, it is hoped that more people will become involved in localization, translation and ongoing validation.

**Implications**

The operationalization of earth smarts has implications for policy makers, educational researchers, and educators themselves. Policy is largely beyond the scope of this study, but it is worth reiterating that individuals or communities that are interested in improving their quality of life, or their resilience in the face of environmental change, would benefit by considering which aspects of socioecological literacy are missing or weak, and working to improve them in ways that make sense locally. The effective use of an earth smarts responsibility matrix (such as Table 5) would be especially helpful for smaller, more isolated communities as well as island nations, making it easier for them to provide pathways for learners to achieve socioecological literacy through a combination of traditional and informal education, online classes, and community projects.

**Research.**

Sociological literacy has a variety of implications for educational researchers, especially those working in science, environmental, and social studies education. Earth smarts can serve as a framework to link research programs from different disciplines, providing a shared language that will improve interdisciplinary research. As many definitions are vague or undertheorized, socioecological literacy can also provide a more
solid theoretical base, one linking the natural sciences, educational research, and
cognitive science. Incorporating the framework will also encourage those developing or
implementing research instruments to address the underlying value systems of the
constructs they are hoping to examine, something that is often implied, assumed or even
actively avoided. This failure to adequately address values can result in instruments and
interventions that are vague or even conflicting. It is worth reiterating the results of the
ranking questions on the earth smarts survey; participants considered values to be the
most important domain in two different questions, with sense of place/environmental
sensitivity close behind (see Table 7 and Figure 10). Researchers hoping to study topics
related to the nexus of education for science, social justice, and the environment cannot
ignore the importance of values and sense of place; pedagogical models that do not
address them are likely to prove inadequate. Socioecological literacy can help provide a
framework for investigation.

**Teacher Education.**

This analysis has suggested that socioecological literacy cannot be achieved by
addressing only knowledge and skills, as most teacher education programs do. As we
have seen, addressing values and sense of place is critical, although both present
considerable pedagogical challenges. Thoughtfully applied, the earth smarts framework
can help teacher educators and education schools “green” their students more effectively,
in ways that are appropriate to local cultures and ecosystems. The most obvious
application is curriculum design; earth smarts was created with modern educational
standards in mind, and the hierarchical nature lends itself to the creation of locally
relevant benchmarks. It can be used as a tool to design, adapt or evaluate educational
standards and materials, particularly for schools or programs hoping to incorporate sustainability, ecojustice, or environmental literacy into their programs. For example, Nichols (2012) describes how earth smarts can be used to encourage school policymakers to make the next generation more adaptable, while Nichols (in press) describes the use of earth smarts as a tool to critically examine textbooks (from a variety of disciplines) for environmental assumptions, distortions, and omissions. Teacher educators could model the use of the earth smarts framework to link relevant standards and local environmental issues with classroom activities and field trips.

Sense of place has become difficult to teach traditionally in many countries due to logistics and litigation; the extinction of experience (Pyle, 2001) in education is a serious and challenging problem that contributes to a troubling dissociation between the classroom and the “real” world. Community partners like nature or civics centers, parks, and local businesses can be especially helpful in addressing sense of place, and earth smarts can help link them to the classroom in more meaningful ways. Place-based pedagogies (Sobel, 2004) attempt to address this issue, and sharing the socioecological literacy framework can help organizations avoid unnecessary overlap, capitalize on strengths and cover weaknesses. This study suggests that schools need to increase and improve partnerships that allow students to learn beyond the walls of the classroom, and provides a framework to make those partnerships more effective.

Addressing values in the classroom is often more challenging, particularly when education and politics mix. Thanks to ongoing culture wars, many teachers, experienced and new, are inclined to avoid addressing values beyond basic classroom etiquette, at least in public school systems. There are several aspects of earth smarts that should help
improve this situation. First off, it does not prescribe behavior; teachers that tell students what to do or how to think are more inclined to run afoul of concerned parents and opportunistic politicians. Rather, earth smarts provides the capacity to adapt to challenges creatively, effectively, and in locally appropriate ways. The construct is also deliberately nonpartisan; conservatives wishing to maintain their quality of life can benefit from it just as much as progressives wishing to improve their own, or that of others. Although earth smarts explicitly addresses value tensions, particularly those related to individual rights and community responsibilities, it does not prescribe how individuals or societies should balance them. Despite their regular use in straw-man arguments, extremes on either end of value spectrums are seldom practical; making teachers aware of the tensions can help them negotiate what is culturally and emotionally appropriate for their own classrooms and communities. Earth smarts may not be for everyone; it is explicitly based on respect, justice as fairness (Rawls & Kelly, 2001), and participatory democracy, each of which may clash with various forms of fundamentalism and non-democratic governance. Nonetheless, research, including this analysis, has shown that values cannot and should not be ignored in education, and earth smarts can provide a clearly justified set to work with. It is tempting to envision a charter school based on the earth smarts framework, incorporating the four domains with a mix of character, place-based, technical and academic education, all with the goal of producing graduates who were more capable of adapting to the socioenvironmental challenges they will face. Earth smarts, meshed carefully with the relevant educational standards, could also form the basis for teacher education programs.
Summary

Unprecedented numbers of people are losing their connection to nature and knowledge of critical natural support systems. Education, scientific or otherwise, is failing to address this, leaving us unprepared for the global environmental challenges we face. To reduce degradation of local and global environments and the resulting deterioration of our quality of life, we need a framework for education that can help us renew our disappearing ecological knowledge and rejuvenate our connections to nature and each other. Although there have been numerous attempts to define sustainability and a wide variety of scientific and environmental literacies over the years, many of them conflict, and few have been developed enough to be useful in a wide range of educational contexts. Fortunately, recent work involving both moral and affective aspects of science education shows promise in sustainability and environmental education, where definitions of environmental literacy are more likely to include affective, ethical, and behavioral components. After compiling and distilling numerous definitions of ecological literacy, environmental literacy, education for sustainable development, ecojustice, and related terms, this analysis generated and validated the construct of earth smarts, or socioecological literacy, basing it on the qualities that individuals or societies need to justly maintain or improve their quality of life beyond the short term.

The analysis was a two-step process, beginning with a theoretical construct analysis based on an extensive, transdisciplinary literature review. The domains and components that emerged were validated using a mixed methods analysis of input from academic experts and practitioners. The refinement and validation of the components were achieved using a combination of conference presentations, directed interviews,
surveys and collaborative software. The work culminated in a new educational framework, related to environmental and civic literacy, that fills some of the voids from previous research. Socioecological literacy, or earth smarts, is a nonpartisan, pragmatic, and flexible construct, freely available for researchers, policy-makers, and educators to use and adapt under Creative Commons share-alike licensing. Designed with free, open-source software to encourage input, it can help those involved in scientific, social, and environmental education to improve their collaborations, reduce redundancies, and bring more vibrant, fair, and sustainable forms of scientific, environmental and civics literacy closer to reality.
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Appendix A: Researcher Biography

The wide-ranging and holistic nature of this research suggest that the background and potential biases of the author are relevant. I grew up throughout Canada and have a background in marine science (BSc Marine Biology, MS Marine Science); my research included the behavioral ecology of fishes, marine mammals and terrestrial predators. I also have a Masters in journalism and have written numerous articles in the popular literature on natural history and science, particularly for sea kayaking magazines. As significant life experience research (Chawla, 2006) seems to suggest, my connection to nature started early. I played in the woods behind my house in grade school, and enjoyed the Northwest seashore and ocean immensely. Camping, hiking and outdoor photography followed and developed into volunteer work in National Parks and jobs teaching scuba diving and guiding sea kayak trips in the Northwestern United States, Canada and the Caribbean. I have also been involved in the front lines of environmental education, most notably spending two years teaching at the Yosemite Institute in California and shorter stints at organizations in the San Juan Islands, Florida Keys and the Caribbean. One result of this eclectic background is that I have worked and been immersed in a wide variety of cultures, from industrial forestry in the Northwest to ecofeminism in California; from the Bible Belt in rural Tennessee to a Garifuna fishing village in Belize. Finally, I am currently part of the science education department at the University of South Florida, which is at the forefront of research into socioscientific issues.
Appendix B: Earth Smarts Survey Instrument

This is a text version of the online survey developed and deployed during the initial phase. The order of components presented to participants was randomized online to reduce bias. Where lengthy lists of countries, years or occupations occurred as drop-down lists in the survey, (list) appears.

Welcome to the earth smarts survey, part of research to help validate and localize earth smarts, a new educational construct. Participation is entirely voluntary, and you can do the survey fairly quickly, but please take your time and provide thoughtful answers – share your expertise and wisdom. Before you take this survey, background information to help explain the components is available on the Primary Domains and Earth Smarts 101 pages on the EarthSmarts.info website. The links should open in a new page or tab, so keep them handy while you take this survey. Thank you for your thoughts.

1) Earth smarts, or essential ecoliteracy, is a practical, educational construct that attempts to answer the question: How can we justly maintain or improve our quality of life, even as the world changes? It is based on four domains. Do you feel each of these domains is important?*

   Definitely not
   Probably not
   Unsure
   Probably yes
   Definitely yes

   Values
   Concepts / Knowledge
   Sense of Place
   Competencies / Skills

2) Are there any domains you feel that are necessary but missing from this list (please provide details)?

3) Please rank the following domains, including some from other sources, in order of importance (most important at top).
4) The following components are related to concepts / knowledge. Are they important to essential ecoliteracy?*

Definitely Not
Probably Not
Unsure
 Probably Yes
 Definitely Yes

Key ecological principles
Historical ecology (historical time)
Basic earth science (geological time)
Basic biology (evolutionary time)
Basic thermodynamics

5) Are there any other concepts you feel are necessary to include? Please explain why they should be added.

6) The following components are related to sense of place. Are they important to essential ecoliteracy?*

Definitely not
Probably not
 Unsure
 Probably yes
 Definitely yes

Local community awareness
Global community awareness
Emotional bond / environmental sensitivity / biophilia
Self-efficacy

7) Are there any other components related to sense of place you feel are necessary to include? Please explain why.
8) The following components are related to Values / diversity. Are they important to essential ecoliteracy?*

Definitely not  
Probably not  
Unsure  
Probably yes  
Definitely yes

Respect for individuals  
Respect for cultures  
Respect for organisms  
Respect for ecosystems  
Respect for future generations  
Moral development (beyond dualism)  
Individual rights vs. community responsibilities  
Justice as fairness

9) The following components are related to competencies / skills. Are they important to essential ecoliteracy?*

Definitely not  
Probably not  
Unsure  
Probably yes  
Definitely yes

Community skills  
Systems thinking  
Self-regulation / adaptability  
Scientific reasoning

10) Remembering the focus on maintaining quality of life, are there any components you feel are necessary but missing from this list? Please describe them, the domain that would best encompass them, and the reason they are essential.

Quick Demographics  
Thank you for your input. To assist the analysis, please answer a few quick demographic questions about yourself. These are optional of course, but appreciated. This data will be kept anonymous.

11) Gender?
( ) Male
( ) Female

12) The country you spent (most of) your first 10 years in.
   (list)

13) The country you spent (most of) your teens (11-19) in.
   (list)

14) Is there something about your childhood or youth that is especially relevant to
    your input? (e.g., raised on a farm, an island, downtown, scouts...)

15) The year you were born.

16) Your race/ethnicity (any that apply).
   [ ] Asian/Pacific Islander
   [ ] Black/African-American
   [ ] Caucasian
   [ ] Hispanic
   [ ] Native American/Alaska Native
   [ ] Decline to Respond
   [ ] Other (please specify)

17) Your occupation(s):
   (list)

18) What socio-economic group did you grow up in (your first 20 years).
   ( ) Top Fifth
   ( ) Upper Middle
   ( ) Middle
   ( ) Lower Middle
   ( ) Bottom Fifth

19) What is your religious affiliation?
   ( ) None (agnostic or atheist)
   ( ) Christian - Protestant/Non Denominational
   ( ) Christian - Roman Catholic
   ( ) Christian - Evangelical/Pentacostal
   ( ) Christian - Baptist
   ( ) Jewish
   ( ) Muslim
   ( ) Hindu
   ( ) Buddhist
   ( ) Other (please comment in next question)

20) Please describe any expertise or experience, job-related or otherwise, that you
    feel is relevant to the issue of earth smarts.
Thank You!
Thank you for your input. If you have more to say on the topic, or know someone who does, please pass on the survey link or contact Bryan Nichols, the lead researcher, at: bryanhnichols@gmail.com
Appendix C: Text Version of the ESAMM

This is a plain text version of the map, compressed to save space. The references appear in the References section of the paper. For the graphic, interactive, expandable version, available as an open-source Freeplane or HTML/Java file, please contact the author directly.

1 Analysis
1.1 Earth Smarts
socioecological literacy
1.2 Eco & Env Literacies
1.2.1 Ecological Literacy
Klemow 1991
1.2.1.1 Ecology examines
interrelationships between organisms & their environment
1.2.1.2 Physical & biological factors influence growth & reproduction
1.2.1.3 Species respond, disperse & survive in varying ways
1.2.1.4 Organisms of the same species occurring together are a population, which may grow or decline
1.2.1.5 Species with similar response to the environment form communities
1.2.1.6 Organisms at a site interact in varying ways, both helpful & harmful
1.2.1.7 Organisms at a site, combined with their environment, form an ecosystem
1.2.1.8 Ecosystems depend on energy and include producers & consumers
1.2.1.9 Nutrients cycle through ecosystems from producers through consumers & decomposers
1.2.1.10 Ecosystems are constantly changing
1.2.1.11 Humans are especially adept at changing ecosystems
1.2.2 Ecological Literacy
Orr 1994
1.2.2.1 Thermodynamics
1.2.2.2 Ecological principles
1.2.2.2.1 carrying capacity
1.2.2.3 Energetics
1.2.2.4 Least-cost end use analysis
1.2.2.5 Technological limits
1.2.2.6 Appropriate scale
1.2.2.7 Sustainable agriculture & forestry
1.2.2.8 Steady-state economics
1.2.2.9 Environmental ethics
1.2.3 Nominal Environmental Literacy
Roth 1992
1.2.3.1 Knowledge
1.2.3.1.1 Components of living/nonliving systems
1.2.3.1.2 Human/nature interactions
1.2.3.1.3 Components of societal systems
1.2.3.2 Affect
1.2.3.2.1 Appreciate nature & society
1.2.3.2.2 Sensitivity & empathy for nature & society
1.2.3.2.3 Perceptions of conflict between nature & society
1.2.3.3 Skill
Appendix C (Continued)

1.2.3.3.1 Identify & define problems
1.2.3.3.2 Recognize issues around problems & solutions
1.2.3.4 Behavior
1.2.3.4.1 Maintenance of environmental quality
1.2.3.4.2 Responding & coping
1.2.4 Environmental Literacy

Golley 1998
1.2.4.1 Foundation Concepts
1.2.4.1.1 Environment
1.2.4.1.2 Systems
1.2.4.1.3 Hierarchical organization
1.2.4.2 Land & Water Systems
1.2.4.2.1 Ecosphere
1.2.4.2.2 Energy dynamics
1.2.4.2.3 Composition of the earth
1.2.4.2.4 Biome
1.2.4.2.5 Landscape
1.2.4.2.6 Watershed
1.2.4.2.7 Ecotope
1.2.4.2.8 Species diversity
1.2.4.2.9 Primary production & decomposition
1.2.4.2.10 Ecological succession
1.2.4.3 Interaction Between Individuals & Species
1.2.4.3.1 Interactions between individuals
1.2.4.3.2 Mutualism
1.2.4.3.3 Competition
1.2.4.3.4 Predation
1.2.4.3.5 Coevolution & niche
1.2.4.3.6 Biotic community
1.2.4.3.7 Island biogeography
1.2.4.3.8 Human ecology
1.2.4.4 Population & Individual
1.2.4.4.1 Population as demographic unit
1.2.4.4.2 Life-history adaptations
1.2.4.4.3 Individual organism
1.2.4.4.4 Body size & climate space

1.2.4.4.5 Speciation & natural selection
1.2.5 Environmental Literacy Framework
Marcinkowski & Rehring 1995
1.2.5.1 Cognitive
1.2.5.1.1 Ecological foundations
1.2.5.1.2 Sociopolitical foundations
1.2.5.1.3 Issue identification analysis investigation
1.2.5.1.4 Environmental action strategy knowledge & skills
1.2.5.1.5 Action plan development & evaluation
1.2.5.2 Affective
1.2.5.2.1 Recognition of environmental quality
1.2.5.2.2 Environmental empathy
1.2.5.2.3 Willingness to help
1.2.5.3 Additional
1.2.5.3.1 Personal & collective efficacy
1.2.5.3.2 Personal responsibility
1.2.5.4 Personal/Group Involvement
1.2.5.4.1 Ecomanagement
1.2.5.4.2 Economic / consumer action
1.2.5.4.3 Persuasion
1.2.5.4.4 Political action
1.2.5.4.5 Legal action
1.2.6 Environmental Literacy Variables
Hsu & Roth 1998
1.2.6.1 Major
1.2.6.1.1 Environmental sensitivity
1.2.6.1.2 In depth knowledge about issues
1.2.6.1.3 Personal investment in issues and environment
1.2.6.1.4 Knowledge & skill environmental action strategies
1.2.6.1.5 Locus of control
1.2.6.1.6 Intention to act
1.2.6.2 Minor
1.2.6.2.1 Knowledge of ecology
Appendix C (Continued)

1.2.6.2.2 Androgynty
1.2.6.2.3 Attitudes towards pollution, tech, economics
1.2.6.2.4 Knowledge of consequences
1.2.6.2.5 Commitment to issue resolution
1.2.7 Environmental Literacies
Palmer 1998
1.2.7.1 Education About the Environment (Empirical)
1.2.7.2 Education For the Environment (Ethical)
1.2.7.3 Education In/From the Environment (Aesthetic)
1.2.8 Environmental Literacy
Basile & White 2000

NOTE: Presented as an interdisciplinary context for young children
1.2.8.1 Teaching About the Environment
1.2.8.2 Facilitating Processes
1.2.8.3 Nuturing Respect
1.2.8.4 Modeling Environmental Stewardship
1.2.9 Eco-literacy (highly evolved)
Cutter-Mackenzie & Smith 2003
1.2.9.1 Complex Knowledge
1.2.9.1.1 People / society / systems relations
1.2.9.1.2 Sustainability models & perspectives
1.2.9.1.3 Understanding of env crisis
1.2.9.1.4 Ability to synthesize env information
1.2.9.2 Beliefs
1.2.9.2.1 Cooperative, self-reliant societies
1.2.9.2.2 Intrinsic importance of nature
1.2.9.2.3 Simple living
1.2.9.2.4 Committed, active ecoliterate citizenry
1.2.9.3 Eco Philosophy
1.2.9.3.1 Gaia ecocentric perspective
1.2.10 Critical Ecoliteracy
Kahn 2003
1.2.10.1 Understanding
1.2.10.1.1 How cultures and societies unfold
1.2.10.1.2 How they tend towards sustainability or not
1.2.10.1.3 Transformative energies
1.2.10.1.4 Social/enviro effects of colonialism & imperialism
1.2.10.1.5 Enviro effects of industrial capitalism, science & technology
1.2.10.1.6 Oppression of non-humans
1.2.10.1.7 Evils of ruling class culture
1.2.10.2 Action
1.2.10.2.1 Individual & collection action on these issues
1.2.10.2.2 Engage with sustainable countercultures
1.2.10.2.3 Rescue animals & habitats
1.2.10.2.4 Abolish civic hierarchies
1.2.11 True Environmental Literacy
NEETF 2005, Hungerford & Volk, 1990
1.2.11.1 Ecological Concepts & Interrelationships
1.2.11.2 Environmental Sensitivity
1.2.11.3 In-depth Knowledge of Issues
1.2.11.4 Investigation & Analysis Skills
1.2.11.5 Citizenship Skills to Remediate Issues
1.2.12 Ecological Literacy
Wooltorton 2006
1.2.12.1 Ecological Self
1.2.12.1.1 Interconnectedness
1.2.12.1.2 Care & compassion
1.2.12.1.3 Respect for difference
1.2.12.1.4 Community
1.2.12.2 Sense of Place
1.2.12.2.1 Active citizenship
Appendix C (Continued)

1.2.12.2 Local culture
1.2.12.2.3 Local history
1.2.12.2.4 Local biology
1.2.12.3 Systems Thinking
1.2.12.4 Ecological Paradigm
1.2.12.5 EFS
1.2.12.5.1 Critical literacy
1.2.12.5.2 Social literacy
1.2.12.5.3 Cultural literacy
1.2.12.5.4 Political literacy
1.2.12.6 Reading Nature & Culture
1.2.13 Environmental Literacy
Campaign for Environmental Literacy
2007
1.2.13.1 Awareness
1.2.13.2 Knowledge
1.2.13.3 Attitudes
1.2.13.4 Skills
1.2.13.5 Action
1.2.14 Environmental Literacies
Lencastr & Leal 2007
1.2.14.1 Functional / Cultural / Critical
1.2.14.1.1 Coevolution & change
1.2.14.1.2 Complexity
1.2.14.1.3 Uncertainty
1.2.14.1.4 Risk & precaution
1.2.14.1.5 Diversity
1.2.14.1.6 Sustainability
1.2.14.1.7 Equity
1.2.14.1.8 Controversy
1.2.14.1.9 Deliberation & action
1.2.15 Ecological Literacy
Jordan et al. 2009
1.2.15.1 Ecological Scientific Habits
of Mind
1.2.15.1.1 NOS
1.2.15.1.2 Scale
1.2.15.1.3 Uncertainty
1.2.15.2 Ecological Connectivity & Key Concepts
1.2.15.2.1 Ecology the science
1.2.15.2.2 Species & environment connections
1.2.15.2.3 Biotic & abiotic influences on distribution
1.2.15.2.4 Processes different over space & time
1.2.15.2.5 Models predict and describe Evolutionary framework
1.2.15.2.7 Influence of culture on ecologists
1.2.15.2.8 Eco literacy is connections between people and processes
1.2.15.3 Human Actions - Environmental Linkages
1.2.15.3.1 Understand links
1.2.15.3.2 Economic, social & ethical influences
1.2.15.3.3 Evidence versus values
1.2.15.3.4 Environmental values?
1.2.15.3.5 Behavior?
1.2.16 Environmental Science Literacy
Mohan et al. 2009
1.2.16.1 Practices
1.2.16.1.1 Inquiry
1.2.16.1.2 Scientific Accounts & Application
1.2.16.1.3 Scientific Reasoning / Responsible Citizenship
1.2.16.2 Principles
1.2.16.2.1 Inquiry principles
1.2.16.2.2 Structure of systems
1.2.16.2.3 Constraints on processes
1.2.16.2.4 Change over time
1.2.16.2.5 Citizenship principles
1.2.16.3 Process in Systems
1.2.16.3.1 Earth systems
1.2.16.3.2 Living systems
1.2.16.3.3 Engineered systems
1.2.17 Environmental Literacy
Reynolds et al. 2009
1.2.17.1 Ecosystem Services
1.2.17.2 Ecological Footprint
1.2.17.2.1 Population
1.2.17.2.2 Consumption
1.2.17.3 Sustainability
164
1.2.18 Cumulative Environmental Literacy
Weibacher 2009
1.2.18.1 1. Biodiversity
1.2.18.2 2. Unique adaptations - local species
1.2.18.3 3. Interdependent webs
1.2.18.4 4. Cyclical flow of materials
1.2.18.5 5. Sun is the source
1.2.18.6 6. Nature recycles (people don't always)
1.2.18.7 7. We consume resources to live
1.2.18.8 8. Conservation is wise use of finite resources
1.2.18.9 9. Humans can have a profound effect
1.2.18.10 10. Individuals can have an effect

1.2.18.9 9. Humans can have a profound effect

1.3 Eco & Env Other
1.3.1 Deep Ecology
Devall & Sessions 1985
1.3.1.1 Life has inherent value
1.3.1.2 Diversity has inherent value
1.3.1.3 Humans have no special rights
1.3.1.4 There are too many humans for nature to flourish
1.3.1.5 Human influence on nature is excessive
1.3.1.6 Policies need to change dramatically
1.3.1.7 Ideological change to appreciate life quality
1.3.1.8 There is an obligation to take action

1.3.2 Responsible Environmental Behavior
Hines et al. 1986
1.3.2.1 Intention to Act
1.3.2.1.1 Personality factors
1.3.2.1.1.1 attitudes
1.3.2.1.1.2 locus of control
1.3.2.1.1.3 personal responsibility
1.3.2.1.2 Knowledge of issues
1.3.2.1.3 Action skills
1.3.2.1.4 Knowledge of action strategies
1.3.2.2 Situational Factors
1.3.2.3 Knowledge of consequences
1.3.2.4 Commitment
1.3.3 Empowerment
1.3.3.1 Environmental action skills
1.3.3.2 Locus of control
1.3.3.3 Intention to act
1.3.4 Ecological Thinking
Berkowitz 2000
1.3.4.1 Scientific (evidence-based, critical)
1.3.4.2 Systems and hierarchy
1.3.4.3 Temporal (short-term, historical and evolutionary)
1.3.4.4 Spatial (geographical, place-based and contextual)
1.3.4.5 Trans-disciplinary
1.3.4.6 Ethical
1.3.4.7 Creative
1.3.4.8 Empathic
1.3.5 Ecological Education
Hautecoeur 2002
1.3.5.1 Local and global
1.3.5.2 Lifelong and into next generations
1.3.5.3 Part of civil society
1.3.5.4 Holistic
1.3.5.5 Dynamic
1.3.5.6 Pragmatic
1.3.5.7 Ethical
Appendix C (Continued)

1.3.5.8 Seeks justice
1.3.5.9 Artistic
1.3.6 Environmental Learning
Scott & Gough 2003
1.3.6.1 Values
1.3.6.2 Feelings
1.3.6.3 Nature Understanding
1.3.6.4 Nature Skills
1.3.6.5 Conservation Understanding
1.3.6.6 Conservation Behaviors
1.3.6.7 Social Justice
1.3.6.8 Democratic Citizenship Skills
1.3.6.9 Social Change Values
1.3.6.10 Learning about Learning
1.3.7 Political Ecology
Zimmerer & Bassett 2003
1.3.7.1 Social-environmental Interactions
1.3.7.1.1 Ecology
1.3.7.1.2 Physical geography
1.3.7.1.3 Political views of nature
1.3.7.1.4 Cultural views of nature
1.3.7.2 Political Ecology of Scale
1.3.8 Ecological Citizenship
Dobson 2004
1.3.8.1 Ecological Footprint (non-territorial)
1.3.8.2 Duty & Responsibility
1.3.8.3 Virtue
1.3.8.3.1 Justice
1.3.8.3.2 Care & compassion
1.3.8.4 Private & Public
1.3.9 Socio-ecological Perspective
Wenden 2004
1.3.9.1 Values
1.3.9.1.1 Nonviolence
1.3.9.1.2 Social justice
1.3.9.1.3 Ecological sustainability
1.3.9.1.4 Intergenerational equity
1.3.9.1.4.1 conservation of options
1.3.9.1.4.2 conservation of quality
1.3.9.1.4.3 conservation of access
1.3.9.1.5 Civic participation
1.3.9.2.1 Critical reflectiveness
1.3.9.2.1.1 awareness of assumptions & values
1.3.9.2.1.2 alternative values examined & compared
1.3.9.2.1.3 assumptions & related values questioned
1.3.9.2.1.4 new values assessed
1.3.9.2.2 Analytical skills
1.3.9.2.3 Imaging alternative futures
1.3.9.2.4 global ecosystem
1.3.10 Environmental Citizenship
Berkowitz, Ford & Brewer 2005
1.3.10.1 Ecological Literacy
1.3.10.1.1 Key ecological systems
1.3.10.1.1.1 ecological address
1.3.10.1.1.2 ecological interaction web
1.3.10.1.1.3 life support ecosystems
1.3.10.1.1.4 global ecosystem
1.3.10.1.1.5 global & genetic ecosystems
1.3.10.1.2 Ecological thinking
1.3.10.1.2.1 scientific systems
1.3.10.1.2.2 systems
1.3.10.1.2.3 trans-disciplinary
1.3.10.1.2.4 spatial
1.3.10.1.2.5 temporal
1.3.10.1.2.6 quantitative
1.3.10.1.2.7 creative / empathic
1.3.10.1.3 Ecology & society
1.3.10.1.3.1 ecological knowledge construction
1.3.10.1.3.2 influence of society / politics / economics
1.3.10.1.3.3 applying ecological knowledge
1.3.10.2 Civics Literacy
1.3.10.3 Values Awareness
1.3.10.4 Self-efficacy
1.3.10.5 Practical Wisdom
1.3.11 Eco-ethical Consciousness
Martusewicz & Edmundson 2005
1.3.11.1 Diversity
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Appendix C (Continued)

1.3.1.12 Democracy
1.3.1.1.3 Sustainability
1.3.1.1.4 Responsibility
1.3.1.1.5 Connection to Place
1.3.1.1.2 Ecological Thinking / Naturalism
Code 2006
1.3.1.13 Historical Ecology
Crumley 2007
1.3.13.1 Multi-scale Ecology
1.3.13.2 Complex Systems Theory
1.3.13.3 Heterarchical Society
1.3.14 Ecojustice
Center for Ecojustice Education 2008
1.3.14.1 Eliminating the causes of eco-racism
1.3.14.2 Ending North/South exploitation and colonialization
1.3.14.3 Revitalizing the commons
1.3.14.4 Protect prospects of future generations
1.3.14.5 Reduce human threat to natural systems
1.3.15 Integral Ecology
Esbjorn-Hargens & Zimmerman 2009
1.3.15.1 Experiences: Individual Interior (I)
1.3.15.1.1 Somatic
1.3.15.1.2 Psychological
1.3.15.1.3 Aesthetic
1.3.15.1.4 Spiritual
1.3.15.2 Behaviors: Individual Exterior (It)
1.3.15.2.1 Scientific
1.3.15.2.2 Acoustic
1.3.15.2.3 Behavioral
1.3.15.2.4 Medical
1.3.15.2.5 Representational
1.3.15.3 Cultures: Collective Interior (We)
1.3.15.3.1 Cultural
1.3.15.3.2 Linguistic
1.3.15.3.3 Philosophical
1.3.15.3.4 Ethical
1.3.15.3.5 Religious
1.3.15.3.6 Esoteric
1.3.15.4 Systems: Collective Exterior (Its)
1.3.15.4.1 Historical
1.3.15.4.2 Socioeconomical
1.3.15.4.3 Technological
1.3.15.4.4 Evolutionary
1.3.15.4.5 Ecological
1.3.15.4.6 Agricultural
1.3.15.4.7 Geographical
1.3.15.4.8 Complexity
1.3.15.6 Agricultural
1.3.15.7 Geographical
1.3.15.8 Complexity
1.3.16 Ecological Intelligence
Goleman 2009
1.3.16.1 Knowledge
1.3.16.1.1 Ecology
1.3.16.1.2 Connections
1.3.16.1.3 Biogeochemical cycles
1.3.16.1.4 Time / geo scales
1.3.16.1.5 Complexity
1.3.16.2 Intelligent
1.3.16.2.1 Adaptability
1.3.16.2.2 Pattern recognition
1.3.16.2.3 New sensitivities to threats
1.3.16.2.4 Shared / social intelligence
1.3.16.3 Empathy
1.3.16.3.1 Others
1.3.16.3.2 Ecosystems
1.3.16.3.3 Linguistic
1.3.16.3.4 Philosophical
1.3.16.3.5 Religious
1.3.16.3.6 Esoteric
1.3.16.3.7 Cultural
1.3.16.3.8 Linguistic
1.3.16.3.9 Philosophical
1.3.16.3.10 Ethical
1.3.16.4 Socio-economic
1.3.16.4.1 Physical/biological
1.3.16.4.2 Socio-economic
1.3.16.4.3 Human (including spiritual)
1.3.16.4.4 Cultural
1.3.16.4.5 Linguistic
1.3.16.4.6 Philosophical
1.3.16.4.7 Ethical
1.4.1.1 Awareness
1.4.1.2 Attitudes
1.4.1.3 Values
1.4.1.3.1 Consider future generations

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Appendix C (Continued)

1.4.1.4 Skills
1.4.1.4.1 Including political
1.4.1.4.2 Decision making
1.4.1.5 Behavior
1.4.2 Environmental Education for Sustainability

1.4.2.1 Relevance
1.4.2.1.1 Learners lives
1.4.2.1.2 Societies needs
1.4.2.2 Holism
1.4.2.2.1 Scientific
1.4.2.2.2 Aesthetic
1.4.2.2.3 Economic
1.4.2.2.4 Political
1.4.2.2.5 Cultural
1.4.2.2.6 Social
1.4.2.2.7 Historical
1.4.2.2.8 Higher level thinking
1.4.2.3 Values
1.4.2.3.1 Accepting others values
1.4.2.3.2 Responsibility
1.4.2.3.3 Harmony with nature
1.4.2.3.4 Stewardship
1.4.2.3.5 Equality
1.4.2.3.6 Democratic
1.4.2.4 Issues-based
1.4.2.4.1 Identifying
1.4.2.4.2 Investigating
1.4.2.4.3 Solving
1.4.2.4.4 Impact
1.4.2.5 Action-oriented
1.4.2.5.1 Negotiation
1.4.2.5.2 Persuasion
1.4.2.5.3 Consumerism
1.4.2.5.4 Political
1.4.2.5.5 Legal
1.4.2.6 Critical Inquiry
1.4.2.6.1 Critical thinking
1.4.2.6.2 Democratic skills
1.4.2.6.3 Social
1.4.2.7 Futures perspective
1.4.2.7.1 Probable
1.4.2.7.2 Possible

1.4.2.7.3 Local / global
1.4.3 Sustainability Science
1.4.4 Sustainability
1.4.4.1 Respecting life & natural processes
1.4.4.2 Living within limits
1.4.4.3 Valuing the local
1.4.4.4 Accounting for full costs
1.4.4.5 Sharing power
1.4.4.5.1 democracy
1.4.4.5.2 conflict resolution
1.4.4.5.3 Local / global
1.4.4.6 Social
1.4.5 Contextual Sustainability Education
1.4.5.1 Foundations
1.4.5.1.1 Cosmogenesis
1.4.5.1.2 Biocentrism
1.4.5.1.3 Bioregionalism
1.4.5.2 Values
1.4.5.2.1 Ecological sustainability
1.4.5.2.2 Participatory decision making
1.4.5.2.3 Active nonviolence
1.4.5.2.4 Social justice
1.4.6 Sustainability Competencies
1.4.6.1.1 Ecological knowledge
1.4.6.1.1.1 networks
1.4.6.1.1.2 nested systems
1.4.6.1.1.3 cycles
1.4.6.1.1.4 flows
1.4.6.1.1.5 development
1.4.6.1.1.6 dynamic balance
1.4.6.1.2 Ability to think systemically
1.4.6.1.2.1 relationships
1.4.6.1.2.2 connectedness
1.4.6.1.2.3 context
1.4.6.1.3 Ability to think critically, to solve problems creatively, and to
apply environmental ethics to new situations
1.4.6.1.4 Ability to assess the impact of human technologies and actions and to envision the long-term consequences of decisions
1.4.6.2 Heart
1.4.6.2.1 Deeply felt, not just understood, concern for the well-being of the Earth and of all living things
1.4.6.2.2 Empathy and the ability to see from and appreciate multiple perspectives
1.4.6.2.3 Commitment to equity, justice, inclusivity, and respect for all people
1.4.6.2.4 Skills in building, governing, and sustaining communities
1.4.6.3 Hands
1.4.6.3.1 Ability to apply ecological knowledge to the practice of ecological design
1.4.6.3.2 Practical skills to create and use tools, objects, and procedures required by sustainable communities
1.4.6.3.3 Ability to assess and make adjustments to uses of energy and resources
1.4.6.3.4 Capacity to convert convictions into practical and effective action
1.4.6.4 Spirit
1.4.6.4.1 Sense of wonder
1.4.6.4.2 Capacity for reverence
1.4.6.4.3 Deep appreciation of place
1.4.6.4.4 Feeling of kinship with the natural world, and the ability to invoke that feeling in others
1.4.7 Education for Sustainable Development
Sleurs 2008
1.4.7.1 Knowledge
1.4.7.2 Systems Thinking
1.4.7.3 Emotions
1.4.7.4 Values/Ethics
1.4.7.5 Action
1.4.7.6 (orientation - future)
1.4.7.7 (orientation - local/global)
1.4.8 Sustainable Development Learning Outcomes
Svanstrom, Lozano-Garcia & Rowe 2008
1.4.8.1 Systemic / Holistic Thinking Perspectives
1.4.8.2 Integrating Different
1.4.8.3 Skills
1.4.8.3.1 Problem solving
1.4.8.3.2 Critical Thinking
1.4.8.3.3 Creativity
1.4.8.3.4 Self-learning
1.4.8.3.5 Communication
1.4.8.3.6 Teamwork
1.4.8.3.7 Change agent
1.4.8.4 Attitudes & Values
1.4.8.4.1 Ethical
1.4.8.4.2 Economic
1.4.8.4.3 Aesthetic
1.4.8.4.4 Democratic
1.4.9 Sustainable Society Index
van de Kerk & Geurt 2008
1.4.9.1 Personal development
1.4.9.1.1 Healthy life
1.4.9.1.2 Sufficient food
1.4.9.1.3 Sufficient to drink
1.4.9.1.4 Safe sanitation
1.4.9.1.5 Education opportunities
1.4.9.1.6 Gender equality
1.4.9.2 Healthy environment
1.4.9.2.1 Air quality
1.4.9.2.2 Surface water quality
1.4.9.2.3 Land quality
1.4.9.3 Well-balanced society
1.4.9.3.1 Good governance
1.4.9.3.2 Employment
1.4.9.3.3 Population growth
1.4.9.3.4 Income distribution
1.4.9.3.5 Public debt
1.4.9.4 Sustainable use of resources
Appendix C (Continued)

1.4.9.4.1 Waste recycling
1.4.9.4.2 Use of renewable water resources
1.4.9.4.3 Consumption of renewable energy
1.4.9.5 Sustainable world
1.4.9.5.1 Forest area
1.4.9.5.2 Preservation of biodiversity
1.4.9.5.3 Emission of greenhouse gases
1.4.9.5.4 Ecological footprint
1.4.9.5.5 International cooperation
1.4.10 Education for Sustainability (EfS)

The Cloud Institute 2009
1.4.10.1 Core Content
1.4.10.1.1 Cultural preservation & transformation
1.4.10.1.2 Responsible local/global citizenship
1.4.10.1.3 Dynamics of systems & change
1.4.10.1.4 Sustainable economics
1.4.10.1.5 Healthy commons
1.4.10.1.6 Natural laws & ecological principles
1.4.10.1.7 Inventing & affecting the future
1.4.10.1.8 Multiple perspectives
1.4.10.1.9 Sense of place
1.4.10.2 Habits of Mind
1.4.10.2.1 Systems decision making
1.4.10.2.2 Intergenerational responsibility
1.4.10.2.3 Implications & consequences
1.4.10.2.4 Protecting & enhancing the commons
1.4.10.2.5 Awareness of driving forces
1.4.10.2.6 Awareness of strategic responsibility
1.4.10.2.7 Paradigm shifter
1.4.11 Sustainability Literacy

Nolet 2009

1.4.11.1 Stewardship
1.4.11.2 Respect for limits
1.4.11.3 Systems thinking & interdependence
1.4.11.4 Economic restructuring
1.4.11.5 Social justice & fair distribution
1.4.11.6 Intergenerational perspective
1.4.11.7 Nature as model & teacher
1.4.11.8 Global citizenship
1.4.11.9 Importance of local place
1.4.12 Sustainability Curriculum Framework

Second Nature 2009

1.4.12.1 Scale
1.4.12.1.1 Time
1.4.12.1.2 Geographic
1.4.12.2 Connections to Natural World
1.4.12.2.1 Part of nature
1.4.12.2.2 Effects on health
1.4.12.2.3 Population, consumption, technology, carrying capacity
1.4.12.3 Ethics & Values
1.4.12.3.1 Equity, justice, culture, development
1.4.12.3.2 Wellbeing, change, growth
1.4.12.3.3 Individual & community improvement
1.4.12.3.4 Decision making
1.4.12.3.4.1 precautionary principle
1.4.12.3.4.2 scientific uncertainty
1.4.12.4 Natural Systems
1.4.12.4.1 Natural laws
1.4.12.4.2 Interdependence & holism
1.4.12.4.3 Ecosystems as communities
1.4.12.4.4 Partnerships, cooperation, competition
1.4.12.5 Technology & Economics
1.4.12.5.1 Technology, science, institutions
1.4.12.5.2 Energy & natural resources
1.4.12.5.3 Pollution & waste
1.4.12.5.4 Environmental design
1.4.12.5.5 Remediation & preservation of biodiversity
1.4.12.6 Motivating Sustainable Behavior
1.4.12.6.1 Social, legal, government
1.4.12.6.2 Population, culture, equity
1.4.12.6.3 Micro & macro economics
1.4.12.6.4 Spirituality & cultural beliefs
1.4.12.7 Sustainability Pedagogies
1.4.12.7.1 Service learning
1.4.12.7.2 Real world, hidden curriculum
1.4.12.7.3 Interdisciplinary, systems thinking
1.4.12.7.4 Green research
1.4.13 5 Dimensions of Sustainability
Seghezzo 2009
1.4.13.1 Place
1.4.13.1.1 Intra-generational justice
1.4.13.2 Permanence
1.4.13.2.1 Inter-generational justice
1.4.13.3 Persons
1.4.13.3.1 Identity
1.4.13.3.2 Happiness
1.4.14 Sustainability Literacy
Stibbe 2010
1.4.14.1 Ecocriticism
1.4.14.2 Optimization
1.4.14.3 Grounded economic awareness
1.4.14.4 Advertising awareness
1.4.14.5 Transition skills
1.4.14.6 Commons thinking
1.4.14.7 Effortless action
1.4.14.8 Permaculture design
1.4.14.9 Community gardening
1.4.14.10 Ecological intelligence
1.4.14.11 Systems thinking
1.4.14.12 Gaia awareness
1.4.14.13 Futures thinking
1.4.14.14 Values reflection & the Earth Charter
1.4.14.15 Social conscious
1.4.14.16 New media literacy
1.4.14.17 Cultural literacy
1.4.14.18 Carbon capability
1.4.14.19 Greening business
1.4.14.20 Materials awareness
1.4.14.21 Appropriate technology & design
1.4.14.22 Technology appraisal
1.4.14.23 Complexity, systems thinking & practice
1.4.14.24 Coping with complexity
1.4.14.25 Emotional wellbeing
1.4.14.26 Experiencing meaning without consuming
1.4.14.27 Being-in-the-world
1.4.14.28 Beauty as a way of knowing
1.4.15 ESD Learning Outcomes
Learning for a Sustainable Future n.d.
1.4.15.1 Knowledge
1.4.15.1.1 Earth as a finite system and the elements that constitute the planetary environment
1.4.15.1.2 resources , especially soil, water, minerals, etc., and their distribution and role in supporting living organisms
1.4.15.1.3 nature of ecosystems and biomes; their health, interdependence within the biosphere
1.4.15.1.4 dependence of humans on the resources of the environment for life and sustenance
1.4.15.1.5 sustainable relationship of native societies to the environment
1.4.15.1.6 implications of the distributions of resources in determining the nature of societies and the rate and character of economic development
1.4.15.1.7 impacts of human societies including nomadic, hunter gatherer, agricultural, industrial and post industrial
Appendix C (Continued)

1.4.15.1.8 role and impacts of science and technology in the development of societies
1.4.15.1.9 Philosophies and economical patterns & their different impacts on the environment, societies and cultures
1.4.15.1.10 urbanization and implications of de-ruralization
1.4.15.1.11 interconnectedness of present world political, economic, environmental and social issues
1.4.15.1.12 aspects of perspectives and philosophies concerning the ecological and human environments; for example, the interconnectedness of matter, energy and human awareness
1.4.15.1.13 international and national efforts to find sustainability strategies & solutions to common global issues
1.4.15.1.14 implications of the political, economic and socio-cultural changes needed for a more sustainable future
1.4.15.1.15 processes of planning, policy-making and action for sustainability by governments, businesses, non-governmental organizations and public
1.4.15.2 Skills
1.4.15.2.1 frame appropriate questions to guide relevant study and research
1.4.15.2.2 apply definitions of fundamental concepts to local, national and global experiences
1.4.15.2.3 use a range of resources and technologies in addressing questions
1.4.15.2.4 assess the nature of bias and evaluate different points of view
1.4.15.2.5 develop hypotheses based on balanced information, critical analysis and careful synthesis
1.4.15.2.6 test hypotheses against new information and personal experience and beliefs
1.4.15.2.7 communicate information and viewpoints effectively
1.4.15.2.8 cooperative strategies to change relationships between ecological preservation and economic development
1.4.15.2.9 work toward negotiated consensus and cooperative resolution of conflict
1.4.15.3 Values
1.4.15.3.1 appreciation of the resilience, fragility and beauty of nature
1.4.15.3.2 interdependence and equal importance of all life forms
1.4.15.3.3 appreciation of the dependence of human life on the resources of a finite planet
1.4.15.3.4 appreciation of the role of human ingenuity and creativity in ensuring survival and sustainable progress
1.4.15.3.5 appreciation of the power of humans to modify the environment
1.4.15.3.6 self-worth and rootedness in one's own culture and community
1.4.15.3.7 respect for other cultures and recognition of the interdependence of the human community
1.4.15.3.8 global perspective and loyalty to the world community
1.4.15.3.9 concern for disparities and injustices, commitment to human rights, peaceful resolution of conflict
1.4.15.3.10 appreciation of sustainability challenges
1.4.15.3.11 sense of balance in deciding among conflicting priorities
1.4.15.3.12 personal acceptance of a sustainable lifestyle and a commitment to participation in change
Appendix C (Continued)

1.4.15.3.13 realistic appreciation of the urgency and complexity of the challenges
1.4.15.3.14 sense of hope and a positive personal and social perspective on the future
1.4.15.3.15 appreciation of the importance and worth of individual responsibility and action
1.5 Other definitions
1.5.1 Biological Literacy
Uno & Bybee 1994
1.5.1.1 NOS
1.5.1.1.1 Characteristics
1.5.1.1.2 Processes
1.5.1.1.3 Values
1.5.1.2 Biological Principles
1.5.1.3 Human impact
1.5.1.4 History of bio
1.5.1.5 Values
1.5.1.5.1 Questioning is essential
1.5.1.5.2 Verified data is important
1.5.1.5.3 Biodiversity
1.5.1.5.4 Cultural diversity
1.5.1.5.5 Impact on society
1.5.1.5.6 Importance to individual
1.5.1.6 Skills
1.5.1.6.1 Creative thinking
1.5.1.6.2 Critical thinking
1.5.1.6.3 Evaluate information
1.5.1.6.4 Decision making
1.5.1.6.5 Problem solving
1.5.2 Koyukon Ideology
Nelson 1983
1.5.2.1 Natural & Spiritual Worlds are Inseparable
1.5.2.2 Distant Time Origins
1.5.2.2.1 World creation & transfiguration
1.5.2.2.2 Characteristics from transfiguration
1.5.2.2.3 Relatedness
1.5.2.2.4 Humans & animals less distinct
1.5.2.2.5 DT characteristics relevant today
1.5.2.2.6 DT stories beget present day rules
1.5.2.3 Spiritual Power in Natural Entities
1.5.2.3.1 All animals, some plants & features
1.5.2.3.2 Differing amounts of power correlate to economic value
1.5.2.3.3 Power doesn't always random is rare
1.5.2.3.4 Power is often vague
1.5.2.3.5 Earth itself a source of power
1.5.2.3.6 Spirits influence events -
1.5.2.4 Spiritual Interchange Affects Human Behavior
1.5.2.4.1 Spiritual respect-based rules for behavior
1.5.2.4.1.1 respectful speaking about
1.5.2.4.1.2 respectful speaking to
1.5.2.4.1.3 respectful use of names
1.5.2.4.1.4 avoid live capture or captivity
1.5.2.4.1.5 humane treatment
1.5.2.4.1.6 avoid waste
1.5.2.4.1.7 respectful use
1.5.2.4.1.8 respect for physical world & dangerous
1.5.2.4.2 Powerful spirits are sensitive
1.5.2.4.3 Physical environment is spiritual & aware
1.5.2.4.4 Spirit remains sensitive for a time after death
1.5.2.4.5 Bad behavior punished by bad luck illness or death
1.5.2.4.6 Men & women have different effects on spiritual interactions
1.5.2.4.7 Age effects spiritual interactions
1.5.2.4.8 Rules are dynamic and responsive
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Appendix C (Continued)

1.5.2.4.9 Rules are contingent on belief
1.5.2.4.10 Trapping & hunting devices are spiritually connected
1.5.2.4.11 Spiritual characteristics can be contagious
1.5.2.4.11.1 slowness & heaviness
1.5.2.4.11.2 other taboos
1.5.2.4.11.3 behavioral traits
1.5.2.4.11.4 positive traits
1.5.2.4.11.5 proximity effects
1.5.2.4.12 Food influences
1.5.2.4.13 Natural entities can forecast events
1.5.2.4.14 Animal intrusions dangerous
1.5.2.4.15 Natural entities can be propitiated
1.5.2.4.16 Shamanistic practice influences spirit powers
1.5.2.4.17 Hostile forces dominate interchange
1.5.3 Permaculture Principles Holmgren 2002
1.5.3.1 Observe & interact
1.5.3.2 Catch & store energy
1.5.3.3 Obtain a yield
1.5.3.4 Apply self-regulation & accept feedback
1.5.3.5 Use & value renewable resources/services
1.5.3.6 Produce no waste
1.5.3.7 Design from patterns to details
1.5.3.8 Integrate don't segregate
1.5.3.9 Use small slow solutions
1.5.3.10 Use & value diversity
1.5.3.11 Use edges value marginal
1.5.3.12 Creatively use & respond to change
1.5.4 Pluralistic Views of Nature Lijmbach et al. 2002
1.5.4.1 Sociological
1.5.4.1.1 Nature as resource
1.5.4.1.2 Nature as Arcadia
1.5.4.1.3 Nature as social construction
1.5.4.1.4 Nature as lifeworld
1.5.4.2 Philosophical
1.5.4.2.1 Instrumental-intrinsic dualism
1.5.4.2.2 Philosophical pluralism
1.5.4.2.3 Social pluralism
1.5.4.3 Educational
1.5.4.3.1 Emancipatory
1.5.4.3.2 Consciousness of needs
1.5.4.3.3 Respect for life
1.5.4.3.4 Biocratic participation
1.5.4.3.5 Integrity of natural systems
1.5.4.4 Political and social participation
1.5.4.5 Culture of democracy
1.5.4.6 Cultures of sustainability
1.5.5 Integral Peace Education Brenes-Castro 2004
1.5.5.1 Peace with Self
1.5.5.1.1 Peace of mind
1.5.5.1.1.1 self appreciation
1.5.5.1.1.2 self realization
1.5.5.1.1.3 autonomy
1.5.5.1.2 Peace of heart
1.5.5.1.2.1 harmony
1.5.5.1.2.2 love and compassion
1.5.5.1.2.3 tolerance
1.5.5.1.3 Peace with body
1.5.5.1.3.1 psychosomatic harmony
1.5.5.1.3.2 consciousness of needs
1.5.5.1.3.3 right use of satisfiers
1.5.5.2 Peace with Nature
1.5.5.2.1 Ecological consciousness
1.5.5.2.1.1 identity with the cosmos
1.5.5.2.1.2 evolutionary potential
1.5.5.2.1.3 respect for life
1.5.5.2.2 Biological diversity
1.5.5.2.2.1 biocratic participation
1.5.5.2.2.2 protection
1.5.5.2.3 Peace with Others
1.5.5.2.3.1 Culture of democracy
1.5.5.2.3.2 sustainable resources
1.5.5.2.3.3 ecological security
1.5.5.3 Peace with Others
1.5.5.3.1 Culture of democracy
1.5.5.3.1.1 critical participation
1.5.5.3.1.2 responsibility
1.5.5.3.1.3 solidarity
1.5.5.3.2 Political and social participation
1.5.5.3.3 Peace with Each Other
1.5.5.3.3.1 respect for life
1.5.5.3.3.2 respect for each other
1.5.5.3.4 Peace with Self
1.5.5.3.4.1 self appreciation
1.5.5.3.4.2 self realization
1.5.5.3.4.3 autonomy
1.5.5.3.5 Peace with Others
1.5.5.3.5.1 respect for life
1.5.5.3.5.2 respect for each other
1.5.5.3.5.3 respect for others
Appendix C (Continued)

1.5.5.3.2.1 democratic participation
1.5.5.3.2.2 promotion of common good
1.5.5.3.2.3 peaceful conflict resolution
1.5.5.3.3 Health for all
1.5.5.3.3.1 generosity
1.5.5.3.3.2 being, the guide for having and doing
1.5.5.3.3.3 economic security
1.5.6 Consciousness of Interdependence
   Daloz 2004
1.5.6.1 Sense of planet's fragility
1.5.6.2 Awareness of life's intrinsic interdependence
1.5.6.3 Being in and of the world (Dance of Nature)
   1.5.6.3.1 systems awareness
   1.5.6.3.2 sense of place
   1.5.6.3.3 constructed self / participatory reality
   1.5.6.3.4 dialectical-paradoxical thought (openness to opposing views)
   1.5.6.3.5 power of not knowing; cusp of mystery
1.5.7 Critical Pedagogy of Place
   Furman & Gruenwald 2004
1.5.7.1 Natural History
1.5.7.2 Cultural Journalism
1.5.7.3 Action Research
1.5.8 Place-Based Education
   Sobel 2004

NOTE: calls it less contentious then environmental education or ecological literacy
1.5.8.1 Sustainability
1.5.8.2 Systems thinking
1.5.8.3 Scale (here & now to far and past)
1.5.8.4 Educational diversity
1.5.9 Wellbeing Manifesto
   Australia Institute 2005
1.5.9.1 Provide fulfilling work
1.5.9.2 Reclaim our time
1.5.9.3 Protect the environment
1.5.9.4 Rethink education
1.5.9.5 Invest in early childhood
1.5.9.6 Discourage materialism / responsible advertising
1.5.9.7 Build communities & relationships
1.5.9.8 A fairer society
1.5.9.9 Measure what matters
1.5.10 Global Issues
   Facing the Future 2005
1.5.10.1 Population & carrying capacity
1.5.10.2 Essential human needs
1.5.10.2.1 food
1.5.10.2.2 water
1.5.10.2.3 energy
1.5.10.3 Environment
   1.5.10.3.1 biodiversity & forests
   1.5.10.3.2 air
   1.5.10.3.3 oceans
   1.5.10.3.4 environmental justice
1.5.10.4 Quality of life
   1.5.10.4.1 culture
1.5.10.5 Building sustainability
   1.5.10.5.1 governance
   1.5.10.5.2 economic development
   1.5.10.5.3 peace
1.5.11 Sense of Place
   Ardoin 2006
   1.5.11.1 Biophysical
   1.5.11.2 Sociocultural
1.5.11.3 Personal / Psychological
   1.5.11.3.1 Place identity
1.5.11.3.2 Place dependence
1.5.11.3.3 Place attachment
1.5.11.4 Political / Economic
1.5.12 Global Citizenship
Appendix C (Continued)

Oxfam GB 2006
1.5.12.1 Knowledge & Understanding
1.5.12.1.1 Social justice & equity
1.5.12.1.2 Diversity
1.5.12.1.3 Globalization & interdependence
1.5.12.1.4 Sustainable development
1.5.12.1.5 Peace & conflict
1.5.12.2 Skills
1.5.12.2.1 Critical thinking
1.5.12.2.2 Ability to argue effectively
1.5.12.2.3 Ability to challenge injustice & inequalities
1.5.12.2.4 Respect for people and things
1.5.12.2.5 Cooperation & conflict resolution
1.5.12.3 Values & Attitudes
1.5.12.3.1 Sense of identity & self-esteem
1.5.12.3.2 Empathy
1.5.12.3.3 Commitment to social justice & equity
1.5.12.3.4 Value & respect for diversity
1.5.12.3.5 Concern for environment & commitment to sustainable development
1.5.12.3.6 Belief that people can make a difference
1.5.13 Nature of Science
Lederman 2007
1.5.13.1 Observations v. inferences
1.5.13.2 Laws v. theories
1.5.13.3 Natural world
1.5.13.4 Subjective & theory laden
1.5.13.5 Sociocultural context
1.5.13.6 Tentative but durable
1.5.14 Gestaltungskompetenz
Transfer-21 2007
1.5.14.1 Gather knowledge (open minded)
1.5.14.2 Forward looking / acting
1.5.14.3 Interdisciplinary
1.5.14.4 Plan / act autonomously
1.5.14.5 Plan / act with others
1.5.14.6 Participate in decision making
1.5.14.7 Motivate oneself to action
1.5.14.8 Motivate others to action
1.5.14.9 Reflect on principles
1.5.14.10 Empathy & solidarity for the disadvantaged
1.5.15 The Transition Movement
Hopkins 2008
1.5.15.1 Visioning
1.5.15.2 Inclusion
1.5.15.3 Awareness-raising
1.5.15.4 Resilience
1.5.15.5 Psychological Insights
1.5.15.6 Credible & Appropriate Solutions
Charles 2009
1.5.16 Natural Guides
1.5.16.1 Diversity
1.5.16.2 Niche
1.5.16.3 Cooperation
1.5.16.4 Self-regulation
1.5.16.5 Optimization
1.5.16.6 Connectedness
1.5.16.7 Community
1.5.17 Bioregionalism
Hathaway & Boff 2009
1.5.17.1 Sustainability
1.5.17.2 Economic justice & equity
1.5.17.3 Biological & cultural diversity
1.5.17.4 Rootedness in place
1.5.17.5 Self-reliance & openness
1.5.17.6 Democracy, participation & subsidiarity
1.5.17.7 Cooperative self-organization
1.5.17.8 Sharing of knowledge & wisdom
1.5.17.9 Responsibility & rights
1.5.17.10 Balance
1.5.18 Steady State Economy
CASSE 2010
1.5.18.1 Sustainable Scale
Appendix C (Continued)

1.5.18.1.1 Resource capacity
1.5.18.1.2 Waste capacity
1.5.18.2 Fair Distribution
1.5.18.2.1 Equal opportunities
1.5.18.2.2 Limits to inequality
1.5.18.3 Efficient Allocation
1.5.18.4 High Quality of Life
1.5.18.4.1 Health
1.5.18.4.2 Wellbeing
1.5.18.4.3 Secure employment
1.5.18.4.4 Leisure time
1.5.18.4.5 Strong communities
1.5.18.4.6 Economic stability
1.5.19 Green Belt Movement Values
Maathai 2010
1.5.19.1 Love for the Environment
1.5.19.1.1 Positive actions
1.5.19.1.2 Tangible appreciation
1.5.19.2 Gratitude & Respect for Earth's Resources
1.5.19.2.1 Reduce, reuse recycle
1.5.19.2.2 No waste
1.5.19.3 Self-empowerment and Betterment
1.5.19.3.1 Self-reliance
1.5.19.3.2 Self-efficacy
1.5.19.4 Service & Volunteerism
1.5.19.4.1 Work for common good
1.5.19.4.2 Other species as well
1.6 Government
1.6.1 Tbilisi Declaration
UNESCO 1978

NOTE: Categories of environmental education objectives; "to help social groups and individuals..."
1.6.1.1 Awareness
1.6.1.2 Knowledge
1.6.1.3 Attitudes
1.6.1.4 Skills
1.6.1.5 Participation
1.6.2 Earth Charter
Earth Charter Initiative 2000
1.6.2.1 I. Respect & Care for the Community of Life
1.6.2.1.1 1. Respect Earth and life in all its diversity
1.6.2.1.2 2. Care for the community of life with understanding, compassion, and love
1.6.2.1.3 3. Build democratic societies that are just, participatory, sustainable, and peaceful
1.6.2.1.4 4. Secure Earth's bounty and beauty for present and future generations
1.6.2.2 II. Ecological Integrity
1.6.2.2.1 5. Protect and restore the integrity of Earth's ecological systems, with special concern for biological diversity and the natural processes that sustain life
1.6.2.2.2 6. Prevent harm as the best method of environmental protection and, when knowledge is limited, apply a precautionary approach
1.6.2.2.3 7. Adopt patterns of production, consumption, and reproduction that safeguard Earth's regenerative capacities, human rights, and community well-being
1.6.2.3 III. Social & Economic Justice
1.6.2.3.1 8. Advance the study of ecological sustainability and promote the open exchange and wide application of the knowledge acquired
1.6.2.3.2 9. Eradicate poverty as an ethical, social, and environmental imperative
1.6.2.3.3 10. Ensure that economic activities and institutions at all levels promote human development in an equitable and sustainable manner
1.6.2.3.4 11. Affirm gender equality and equity as prerequisites to sustainable development and ensure
universal access to education, health care, and economic opportunity
1.6.2.3.5 12. Uphold the right of all, without discrimination, to a natural and social environment supportive of human dignity, bodily health, and spiritual well-being, with special attention to the rights of indigenous peoples and minorities
1.6.2.4 IV. Democracy, Nonviolence & Peace
1.6.2.4.1 13. Strengthen democratic institutions at all levels, and provide transparency and accountability in governance, inclusive participation in decision making, and access to justice
1.6.2.4.2 14. Integrate into formal education and life-long learning the knowledge, values, and skills needed for a sustainable way of life
1.6.2.4.3 15. Treat all living beings with respect and consideration
1.6.2.4.4 16. Promote a culture of tolerance, nonviolence, and peace
1.7 Education
1.7.1 Bloom's Taxonomy
Bloom & Krathwohl 1956
1.7.1.1 Knowledge
1.7.1.1.1 draw
1.7.1.1.2 identify
1.7.1.1.3 label
1.7.1.1.4 list
1.7.1.1.5 locate
1.7.1.1.6 name
1.7.1.1.7 outline
1.7.1.1.8 recite
1.7.1.1.9 record
1.7.1.1.10 repeat
1.7.1.1.11 select
1.7.1.1.12 state
1.7.1.1.13 write
1.7.1.2 Comprehension
1.7.1.2.1 explain
1.7.1.2.2 relate
1.7.1.2.3 describe
1.7.1.2.4 paraphrase
1.7.1.2.5 confirm
1.7.1.2.6 convert
1.7.1.2.7 match
1.7.1.2.8 infer
1.7.1.2.9 discuss
1.7.1.2.10 estimate
1.7.1.2.11 predict
1.7.1.3 Application
1.7.1.3.1 apply
1.7.1.3.2 build
1.7.1.3.3 construct
1.7.1.3.4 modify
1.7.1.3.5 produce
1.7.1.3.6 report
1.7.1.3.7 sketch
1.7.1.3.8 solve
1.7.1.4 Analysis
1.7.1.4.1 analyze
1.7.1.4.2 categorize
1.7.1.4.3 compare
1.7.1.4.4 debate
1.7.1.4.5 differentiate
1.7.1.4.6 examine
1.7.1.4.7 investigate
1.7.1.4.8 sort
1.7.1.5 Synthesis
1.7.1.5.1 combine
1.7.1.5.2 compose
1.7.1.5.3 design
1.7.1.5.4 devise
1.7.1.5.5 formulate
1.7.1.5.6 generate
1.7.1.5.7 hypothesize
1.7.1.5.8 invent
1.7.1.5.9 originate
1.7.1.5.10 plan
1.7.1.5.11 revise
1.7.1.6 Evaluation
1.7.1.6.1 appraise
1.7.1.6.2 assess
1.7.1.6.3 conclude
1.7.1.6.4 criticize
Appendix C (Continued)

1.7.1.6.5 critique
1.7.1.6.6 judge
1.7.1.6.7 justify
1.7.1.6.8 solve
1.7.2 Science Education for Citizenship
Ratcliffe & Grace 2003
1.7.2.1 Conceptual knowledge
1.7.2.1.1 scientific endeavour
1.7.2.1.1.1 ideas / theories / models
1.7.2.1.1.2 systemic data collection
1.7.2.1.1.3 reporting of findings
1.7.2.1.1.4 peer review
1.7.2.1.2 probability & risk
1.7.2.1.3 issue scope
1.7.2.1.3.1 personal
1.7.2.1.3.2 local
1.7.2.1.3.3 national
1.7.2.1.3.4 global
1.7.2.1.3.5 political
1.7.2.1.3.6 societal
1.7.2.1.4 underpinning science concepts
1.7.2.1.5 environmental sustainability
1.7.2.2 Procedural knowledge
1.7.2.2.1 opinion forming & decision making
1.7.2.2.1.1 incomplete evidence
1.7.2.2.1.2 biased evidence
1.7.2.2.2 evaluating evidence
1.7.2.2.3 ethical reasoning
1.7.2.2.4 clarifying personal values & responsibilities
1.7.2.3 Attitudes & beliefs
1.7.2.3.1 clarifying personal values & responsibilities
1.7.3 Conceptual Clusters
Newell et al. 2005
1.7.3.1 Organization & scale
1.7.3.2 Controlling models
1.7.3.3 Dynamics & system
1.7.3.4 Management & policy
1.7.3.5 Adaptation & learning
1.7.3.6 History
1.7.4 Improving Environmental Education
Blumstein & Saylan 2007
1.7.4.1 Programs that can be evaluated
1.7.4.2 Target consumption patterns
1.7.4.3 Teach phase shifts
1.7.4.4 World view / respect for cultures
1.7.5 Earth System Science
Hoffman & Barstow 2007
1.7.5.1 Earth as a Dynamic System
1.7.5.2 Space-Age Perspectives
1.7.5.3 Twenty-First Century Technology
1.7.5.4 Inquiry-Based Approaches
1.7.5.5 Ocean Literacy
1.7.5.6 Atmosphere, Weather, Climate
1.7.5.7 Environmental Literacy
1.7.6 Educational Levels
Marzano & Kendall 2007
1.7.6.1 Self-system
1.7.6.1.1 Overall Motivation
1.7.6.1.1.1 Importance
1.7.6.1.1.2 Efficacy
1.7.6.1.1.3 Emotional Response
1.7.6.1.2 Metacognitive System
1.7.6.1.2.1 Specifying Goals
1.7.6.1.2.2 Process Monitoring
1.7.6.1.2.3 Monitoring Accuracy
1.7.6.2 Knowledge Utilization
1.7.6.3.1 Decision Making
1.7.6.3.2 Problem Solving
1.7.6.3.3 Experimenting
1.7.6.3.4 Investigating
1.7.6.4 Analysis
1.7.6.4.1 Matching
1.7.6.4.2 Classifying
1.7.6.4.3 Analyzing Errors
1.7.6.4.4 Generalizing
1.7.6.5 Comprehension
Appendix C (Continued)

1.7.6.5.1 Integrating
1.7.6.5.2 Symbolizing
1.7.6.6 Retrieval
1.7.7 Educational Domains
Marzano & Kendall 2007
(see:) 1.7.7.1 Psychomotor Procedures
1.7.7.1.1 Processes
1.7.7.1.1.1 complex combination procedures
1.7.7.1.2 Skills
1.7.7.1.2.1 simple combination procedures
1.7.7.1.2.2 foundational procedures
1.7.7.2 Mental Procedures
1.7.7.2.1 Processes
1.7.7.2.1.1 macroprocedures
1.7.7.2.2 Skills
1.7.7.2.2.1 tactics
1.7.7.2.2.2 algorithms
1.7.7.2.2.3 single rules
1.7.7.3 Information
1.7.7.3.1 Details
1.7.7.3.1.1 vocabulary terms
1.7.7.3.1.2 facts
1.7.7.3.1.3 time sequences
1.7.7.3.2 Organizing Ideas
1.7.7.3.2.1 Generalizations
1.7.7.3.2.1.1 persons
1.7.7.3.2.1.2 places
1.7.7.3.2.1.3 living & nonliving things
1.7.7.3.2.1.4 events
1.7.7.3.2.1.5 abstractions
1.7.7.3.2.2 Principles
1.7.7.3.2.2.1 cause-effect
1.7.7.3.2.2.2 correlational
1.7.8 Environmental Education
Strategies
Monroe, Andrews & Biedenweg 2007
1.7.8.1 Convey Information
1.7.8.1.1 Issues
1.7.8.2 Build Understanding
1.7.8.2.1 Values
1.7.8.2.2 Sense of place
1.7.8.2.3 Concern
1.7.8.2.4 Concepts
1.7.8.3 Improve Skills
1.7.8.4 Enable Sustainable Actions
1.7.8.4.1 Creative problem solving
1.7.8.4.2 Monitoring
1.7.9 PISA 2006 Science Framework
OECD 2007
1.7.9.1 Context
1.7.9.1.1 Life situations involving science & tech
1.7.9.2 Competencies
1.7.9.2.1 Identify scientific issues
1.7.9.2.2 Explain phenomena scientifically
1.7.9.3 Knowledge
1.7.9.3.1 Knowledge of science
1.7.9.3.2 Knowledge about science
1.7.9.4 Attitude
1.7.9.4.1 Interest in science
1.7.9.4.2 Support for scientific enquiry
1.7.9.4.3 Responsibility
1.7.9.5 Habits of Mind
Costa & Kallick 2009
1.7.10 Persisting
1.7.10.1 Listening with understanding & empathy
1.7.10.2 Thinking communicating with clarity & precision
1.7.10.3 Managing impulsivity
1.7.10.4 Gathering data through all senses
1.7.10.5 Creating, imaging & innovation
1.7.10.6 Striving for accuracy
1.7.10.7 Thinking flexibly
1.7.10.8 Responding with wonderment & awe
1.7.10.9 Metacognition
1.7.10.10 Taking responsible risks
1.7.10.11 Striving for accuracy
1.7.10.12 Finding humor
1.7.10.13 Questioning & posing problems
1.7.10.14 Thinking interdependently
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<td>1.7.10.15 Applying past knowledge to new situations</td>
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<td>1.7.10.16 Remaining open to continuous learning</td>
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<td>1.7.11 Global Competence</td>
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<td>EdSteps 2009</td>
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<td>1.7.11.1 Investigate the World</td>
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<td>1.7.11.4 Take Action</td>
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<td>1.7.12 Sustainable Schooling Guiding Principles</td>
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<td>Stone &amp; Center for Ecoliteracy, 2009</td>
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<td>1.7.12.1 Nature is Our Teacher</td>
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<td>1.7.12.1.1 Ecological literacy</td>
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<td>1.7.13 21st Century Skills</td>
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<td>Hilton 2010</td>
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<td>1.7.13.1 Adaptability</td>
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<td>1.7.13.1.1 Uncertainty / change</td>
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<td>1.7.13.3 Non-routine Problem Solving Skills</td>
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<tr>
<td>1.7.13.3.1 Narrow information for problem diagnosis</td>
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<td>1.7.13.3.2 Reflect on strategy success and change if appropriate</td>
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1.8.1.7 Production, Distribution & Consumption
1.8.1.8 Science, Technology & Society
1.8.1.9 Global Connections
1.8.1.10 Civic Ideals & Practices
1.8.2 National Science Education Standards
National Research Council 1995
1.8.2.1 Unifying Concepts and Processes
1.8.2.1.1 Systems, order & organization
1.8.2.1.2 Evidence, models & explanation
1.8.2.1.3 Change, constancy & measurement
1.8.2.1.4 Evolution & equilibrium
1.8.2.1.5 Form & function
1.8.2.2 Science as Inquiry
1.8.2.2.1 Abilities
1.8.2.2.2 Understandings
1.8.2.3 Physical Science
1.8.2.3.1 Structure of atoms
1.8.2.3.2 Structure & properties of matter
1.8.2.3.3 Chemical reactions
1.8.2.3.4 Motions & forces
1.8.2.3.5 Conservation of energy & increase in disorder
1.8.2.3.6 Interactions of energy & matter
1.8.2.4 Earth & Space Science
1.8.2.4.1 Energy in the earth system
1.8.2.4.2 Geochemical cycles
1.8.2.4.3 Origin and evolution of the earth system
1.8.2.4.4 Origin and evolution of the universe
1.8.2.5 Science & Technology
1.8.2.5.1 Abilities of technological design
1.8.2.5.2 Understandings about science & technology
1.8.2.6 Life Science
1.8.2.6.1 The cell
1.8.2.6.2 Molecular basis of heredity
1.8.2.6.3 Biological evolution
1.8.2.6.4 Interdependence of organisms
1.8.2.6.5 Matter, energy & organization in living systems
1.8.2.6.6 Behavior of organisms
1.8.2.7 Personal & Social Perspectives
1.8.2.7.1 Personal & community health
1.8.2.7.2 Population growth
1.8.2.7.3 Natural resources
1.8.2.7.4 Environmental quality
1.8.2.7.5 Natural & human-induced hazards
1.8.2.7.6 Science & tech in local, national & global challenges
1.8.2.8 History & Nature of Science
1.8.2.8.1 Science as a human endeavor
1.8.2.8.2 Nature of scientific knowledge
1.8.2.8.3 Historical perspectives
1.8.3 Guidelines for Excellence
NAAEE 2004
1.8.3.1 Questioning, Analysis & Interpretation Skills
1.8.3.1.1 Questioning
1.8.3.1.2 Designing investigations
1.8.3.1.3 Collecting information
1.8.3.1.4 Evaluating accuracy & reliability
1.8.3.1.5 Organizing information
1.8.3.1.6 Working with models & simulations
1.8.3.1.7 Drawing conclusions & developing explanations
1.8.3.2 Knowledge of Environmental Processes & Systems
1.8.3.2.1 The Earth as a Physical System
1.8.3.2.1.1 Processes that shape the earth
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1.8.3.2.1.2 Changes in matter
1.8.3.2.1.3 Energy
1.8.3.2.2 The Living Environment
1.8.3.2.2.1 Organisms, populations & communities
1.8.3.2.2.2 Heredity & evolution
1.8.3.2.2.3 Systems & connections
1.8.3.2.2.4 Flow of matter and energy
1.8.3.2.3 Humans & Their Societies
1.8.3.2.3.1 Individuals and groups
1.8.3.2.3.2 Culture
1.8.3.2.3.3 Political and economic systems
1.8.3.2.3.4 Global connections
1.8.3.2.3.5 Change & conflict
1.8.3.2.4 Environment & Society
1.8.3.2.4.1 Human/environment interaction
1.8.3.2.4.2 Places
1.8.3.2.4.3 Resources
1.8.3.2.4.4 Technology
1.8.3.2.4.5 Environmental issues
1.8.3.3 Skills for Understanding & Addressing Environmental Issues
1.8.3.3.1 Skills for Analyzing and Investigating Environmental Issues
1.8.3.3.1.1 Identifying & investigating issues
1.8.3.3.1.2 Sorting out consequences of issues
1.8.3.3.1.3 Alternative solutions
1.8.3.3.1.4 Flexibility, creativity, openness
1.8.3.3.2 Decision-Making and Citizenship Skills
1.8.3.3.2.1 Forming & evaluating personal views
1.8.3.3.2.2 Evaluating need for citizen action
1.8.3.3.2.3 Planning & taking action
1.8.3.3.2.4 Evaluating results of action
1.8.3.4 Personal & Civic Responsibility
1.8.3.4.1 Understanding societal values & principles
1.8.3.4.2 Recognizing citizen's rights & responsibilities
1.8.3.4.3 Recognizing efficacy
1.8.3.4.4 Accepting personal responsibility
1.8.4 Standards for EE in the Curriculum
1.8.4.1 Community
1.8.4.1.1 Engage with local environment
1.8.4.1.2 Explore & appreciate outdoors
1.8.4.1.3 Connect to local & global environments
1.8.4.1.4 Demonstrate environmental stewardship
1.8.4.2 Knowledge
1.8.4.2.1 Human & natural systems
1.8.4.2.2 Types of interactions
1.8.4.2.3 Sustainability
1.8.4.3 Perspectives
1.8.4.4 Action
1.8.5 Project 2061 Benchmarks
AAAS 2009
1.8.5.1 Nature of Science
1.8.5.1.1 The scientific worldview
1.8.5.1.2 Scientific inquiry
1.8.5.1.3 The scientific enterprise
1.8.5.2 Nature of Mathematics
1.8.5.2.1 Patterns & relationships
1.8.5.2.2 Math, science & technology
1.8.5.2.3 Mathematical inquiry
1.8.5.3 Nature of Technology
1.8.5.3.1 Technology & science
1.8.5.3.2 Design & systems
1.8.5.3.3 Issues in technology
1.8.5.4 Physical Setting
1.8.5.4.1 The universe
1.8.5.4.2 The Earth
1.8.5.4.3 Processes that shape the Earth
Appendix C (Continued)

1.8.5.4.4 The structure of matter
1.8.5.4.5 Energy transformations
1.8.5.4.6 Motion
1.8.5.4.7 Forces of nature
1.8.5.5 Living Environment
1.8.5.5.1 Diversity of life
1.8.5.5.2 Heredity
1.8.5.5.3 Cells
1.8.5.5.4 Interdependence of life
1.8.5.5.5 Flow of matter & energy
1.8.5.6 Human Organism
1.8.5.6.1 Human identity
1.8.5.6.2 Human development
1.8.5.6.3 Basic functions
1.8.5.6.4 Learning
1.8.5.6.5 Physical health
1.8.5.6.6 Mental health
1.8.5.6.7 Human Society
1.8.5.7.1 Cultural effects on behavior
1.8.5.7.2 Group behavior
1.8.5.7.3 Social change
1.8.5.7.4 Social trade-offs
1.8.5.7.5 Political & economic systems
1.8.5.7.6 Social conflict
1.8.5.7.7 Global interdependence
1.8.5.8 Designed World
1.8.5.8.1 Agriculture
1.8.5.8.2 Materials & manufacturing
1.8.5.8.3 Energy sources & use
1.8.5.8.4 Communication
1.8.5.8.5 Information processing
1.8.5.8.6 Health technology
1.8.5.9 Mathematical World
1.8.5.9.1 Numbers
1.8.5.9.2 Symbolic relationships
1.8.5.9.3 Shapes
1.8.5.9.4 Uncertainty
1.8.5.9.5 Reasoning
1.8.5.10 Historical Perspectives
1.8.5.10.1 Displacing the Earth from the center of the universe
1.8.5.10.2 Uniting the heavens & earth
1.8.5.10.3 Relating matter & energy and time & space
1.8.5.10.4 Extending time
1.8.5.10.5 Moving the continents
1.8.5.10.6 Understanding fire
1.8.5.10.7 Splitting the atom
1.8.5.10.8 Explaining the diversity of life
1.8.5.10.9 Discovering germs
1.8.5.10.10 Harnessing power
1.8.5.11 Common Themes
1.8.5.11.1 Systems
1.8.5.11.2 Models
1.8.5.11.3 Constancy & change
1.8.5.11.4 Scale
1.8.5.11.5 Values & attitudes
1.8.5.11.6 Computation & estimation
1.8.5.11.7 Manipulation & observation
1.8.5.11.8 Communication skills
1.8.5.11.9 Critical-response skills
1.8.5.11.10 Earth Science Literacy Principles
1.8.6 Earth Science Literacy Initiative 2009
1.8.6.1 Repeatable observations & testable ideas
1.8.6.2 Age of the earth
1.8.6.3 Earth systems
1.8.6.4 Continuous change
1.8.6.5 Water & oceans
1.8.6.6 Life evolution & interaction
1.8.6.7 People depend on resources
1.8.6.8 Natural hazards
1.8.6.9 Human induced change
1.8.6.10 National EfS K-12 Standards
1.8.7 USPESD 2009
1.8.7.1 Intergenerational Responsibility
1.8.7.1.1 Intergenerational equity
1.8.7.2 Interconnectedness
1.8.7.2.1 Systems thinking
1.8.7.2.2 Cradle to cradle design
1.8.7.3 Ecological Systems
1.8.7.3.1 Respect for limits
1.8.7.3.2 Respect for nature
Appendix C (Continued)

1.8.7.3 Biomimicry
1.8.7.4 Tragedy of the commons
1.8.7.5 Environmental justice
1.8.7.6 Urban design / land management
1.8.7.7 Natural capital
1.8.7.4 Economics Systems
1.8.7.1 Poverty
1.8.7.2 Ecosystem services
1.8.7.3 Alternative indicators & indexes of progress
1.8.7.4 Globalization
1.8.7.5 True or full cost accounting
1.8.7.6 Triple bottom line
1.8.7.7 Micro credit
1.8.7.8 Social & Cultural Systems
1.8.7.9 Human rights
1.8.7.10 Peace & conflict
1.8.7.11 Multilateral organizations
1.8.7.12 International summits, conferences, conventions, and treaties
1.8.7.13 Global health
1.8.7.14 Appropriate technology
1.8.7.15 Governance
1.8.7.16 Personal Action
1.8.7.17 Personal responsibility
1.8.7.18 Accountability
1.8.7.19 Lifelong learning & action
1.8.7.20 Personal change skills & strategies
1.8.7.21 Collective Action
1.8.7.22 Local to global responsibility
1.8.7.23 Community based and societal decision making
1.8.7.3 Public discourse & policy
1.8.7.4 Organizational and societal change skills & strategies
1.8.8 AP Environmental Science
The College Board 2010
1.8.8.1 Earth systems & resources
1.8.8.2 Living world
1.8.8.3 Population
1.8.8.4 Land & water use
1.8.8.5 Energy resources & consumption
1.8.8.6 Pollution
1.8.8.7 Global change
1.8.8.8 Science process
1.8.8.9 Earth as interconnected system
1.8.8.10 Humans alter natural systems
1.8.8.11 Cultural & social context
1.8.8.12 Conservation balanced w development
1.8.8.13 Common resource management
1.8.9 Ocean Literacy
Ocean Literacy Network 2010
1.8.9.1 One big ocean
1.8.9.2 Ocean shapes Earth features
1.8.9.3 Ocean influences weather & climate
1.8.9.4 Ocean makes earth habitable
1.8.9.5 Ocean supports biodiversity
1.8.9.6 Ocean & humans interconnected
1.8.9.7 Ocean largely unexplored