Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here?

B. B. McBride,[1],† C. A. Brewer,[2] A. R. Berkowitz,[3] and W. T. Borrie[1]

[1]*College of Forestry and Conservation, The University of Montana, Missoula, Montana 59812 USA*
[2]*Division of Biological Sciences, The University of Montana, Missoula, Montana 59812 USA*
[3]*Cary Institute of Ecosystem Studies, Millbrook, New York 12545 USA*

Abstract. Numerous scholars have argued that the terms environmental literacy, ecological literacy, and ecoliteracy have been used in so many different ways and/or are so all-encompassing that they have very little useful meaning. However, despite the seemingly arbitrary and, at times, indiscriminate use of these terms, tremendous efforts have in fact been made to explicitly define and delineate the essential components of environmental literacy, ecological literacy, and ecoliteracy, and to firmly anchor their characterizations in deep theoretical and philosophical foundations. A driving purpose behind these ongoing conversations has been to advance complete, pedagogy-guiding, and broadly applicable frameworks for these ideals, allowing for standards and assessments of educational achievement to be set. In this manuscript, we review a diversity of perspectives related to the often nuanced differences and similarities of these terms. A classification of the numerous proposed frameworks for environmental literacy, ecological literacy, and ecoliteracy (advanced within the fields of environmental education, ecology, and the broader humanities, respectively) is presented, and used to compare and contrast frameworks across multiple dimensions of affect, knowledge, skills, and behavior. This analysis facilitates close examination of where we have been, where we are, and where we might be headed with respect to these vital conversations. This work also offers points of reference for continued critical discourse, and illuminates a diversity of inspiration sources for developing and/or enriching programs aimed at cultivating these types of literacies.

† **E-mail:** brooke.mcbride@umontana.edu

What is Literacy?

Until the late 1800s, the word *literacy* did not exist. In fact, according to the Oxford English Dictionary, the word *literacy* was predated by the word *illiteracy* by several hundred years (Venezky et al. 1987). Although the original term *literacy* referred only to the ability to read and write, its usage has since been extended greatly in scope, beginning during the Industrial Revolution. Emerging in Britain in the late 18th century and then spreading throughout Western Europe and North America, the Industrial Revolution was a period of rapid industrial

growth via the introduction and advancement of machinery, with far-reaching social and economic consequences. During this era, mandatory and widespread elementary public education grew to resemble its present magnitude. Although the precise relationship between industrialization and the rise of public education is difficult to establish, there are nevertheless strong correspondences between the two (Carl 2009). Gains in income and wealth during the industrial age made possible larger public expenditures for the welfare of the general population, in the form of schools and teaching resources. A focus on the three Rs, reading, writing, arithmetic, was seen as essential for preparing a work force that could understand basic instructions, engage in rudimentary written communication, and perform simple office functions, thereby creating the most skilled mass workforce in the world. Additionally, through the cultivation of the western cultural perspective emphasizing rational individuals and egalitarianism, public education promoted a sense of national unity and success (Carl 2009). In the years following the Civil War, the ability to read and write was used to determine whether one had the right to vote. Thus, like other abstract nouns such as *freedom*, *justice*, and *equality*, literacy came to denote a value that was promoted throughout the population of the United States. Government officials, industrial leaders, and educators all began to see illiteracy as a social ill and literacy as something to be advanced for the benefit of society as a whole (Michaels and O'Connor 1990, Carl 2009).

Current dictionaries (e.g., *Merriam Webster*, *Oxford English Dictionary*) generally provide two definitions of literacy: (1) the ability to read and write, and (2) knowledge or capability in a particular field or fields. Today's broader understanding and application of literacy has essentially arisen from the latter interpretation (Roth 1992). Within the field of cognitive science, literacy has been reconceptualized as a tool for knowledge construction (i.e., using reasoning or problem solving to obtain new knowledge) (Michaels and O'Connor 1990). This work set the stage for the extended scope of the term used today. As defined by the United Nations Educational, Scientific, and Cultural Organization (UNESCO Education Sector 2004:13), "[l]iteracy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society".

Clearly, the concept of literacy has evolved considerably from its origin in the ability to read and write. Especially over the last 50 years, expectations for a literate citizenry have been extended to include the ability to understand, make informed decisions, and act with respect to complex topics and issues facing society today. The term literacy also has been extended to refer to such knowledge and capabilities in many different discourses (e.g., computer literacy, mathematics literacy, cultural literacy, arts literacy). Additional notions of literacy that have emerged are environmental literacy, ecological literacy, and ecoliteracy.

ENVIRONMENTAL LITERACY, ECOLOGICAL LITERACY, ECOLITERACY

Numerous scholars have argued that the terms environmental literacy or ecological literacy have been used in so many different ways and/or are so all-encompassing that they have very little useful meaning (e.g., Disinger and Roth 1992, Roth 1992, Stables and Bishop 2001, Payne 2005, 2006). The introduction of the term ecoliteracy has further complicated the conversation. Disinger and Roth (1992) contended that the almost arbitrary application of the term environmental literacy has resulted in nearly as many different perceptions of the term as there are people who use it, and that while various groups often use the term to solidify or demonstrate correctness of either themselves or their clients, they give little or no indication of what they actually mean. Similarly, Stables and Bishop (2001) argued that the meaning of environmental literacy has been greatly muddled as a result of its indiscriminate application. Recently, Payne (2005, 2006) also dismissed the notions of environmental or ecological literacy as vague and messy, arguing instead for a "critical ecological ontology," a curriculum theory focusing on the learner's experience of being in the world. Given the multitude of literacies now being promoted, and the widespread and seemingly arbitrary use of the terms environmental-, ecological-, and eco-literacy in particular, it is easy to see how these authors made these assessments.

Despite the widespread, and at times, indiscriminate, use of these terms, efforts have been made to establish a definition and identify key components of environmental literacy, ecological literacy, and ecoliteracy, and to firmly anchor their characterizations in broad theoretical and philosophical frameworks. A driving purpose behind this work has been to advance complete, pedagogy-guiding, and broadly applicable frameworks allowing for standards and assessments of educational achievement to be set. Widely varying discourses on the nature and essential components of environmental literacy, ecological literacy, and ecoliteracy have arisen primarily within the fields of environmental education, ecology, and the broader humanities, respectively.

The term environmental literacy was first used 45 years ago in an issue of the *Massachusetts Audubon* by Roth (1968) who inquired "How shall we know the environmentally literate citizen?" Since then, the meaning of the term has evolved and been extensively reviewed (e.g., Roth 1992, Simmons 1995, Morrone et al. 2001, Weiser 2001, North American Association for Environmental Education (NAAEE) 2004, O'Brien 2007). The notion of environmental literacy has been and continues to be promoted through creative and intensive discourse from a diversity of perspectives. The most widely accepted meaning of environmental literacy is that it comprises an awareness of and concern about the environment and its associated problems, as well as the knowledge, skills, and motivations to work toward solutions of current problems and the prevention of new ones (NAAEE 2004).

More recently, the term ecological literacy was first publicly used 27 years ago by Risser (1986) in his *Address of the Past President* to the Ecological Society of America. Risser (1986) urged ecologists to ponder, debate, and arrive at consensus as to what comprises basic ecological literacy, adopt a vigorous stance, and embrace their responsibilities as promoters of ecological literacy in their students and the general public. Since then, characterization of ecological literacy within the field of ecology has evolved considerably (Cherrett 1989, Klemow 1991, Odum 1992, Berkowitz 1997, Berkowitz et al. 2005, Jordan et al. 2009, Powers 2010),

focusing on the key ecological knowledge necessary for informed decision-making, acquired through scientific inquiry and systems thinking.

The term ecoliteracy was first published 16 years ago by Capra (1997), who founded the Center for Ecoliteracy, a nonprofit organization dedicated to education for sustainable living (Center for Ecoliteracy 2013*a*). Drawing heavily on the work of Orr (1992), Capra and others in the broader humanities have advanced ecoliteracy, with a focus on the creation of sustainable human communities and society (e.g., Capra 1997, 2002, Cutter-Mackenzie and Smith 2003, Wooltorton 2006, Center for Ecoliteracy 2013*b*).

Despite a shared concern for the environment and recognition of the central role of education in enhancing human-environment relationships, researchers have adopted widely differing discourses on what it mean for a person to be environmentally literate, ecologically literate, or ecoliterate. We approached the multiplicity of theoretical and practical perspectives by developing a classification of the literacy conversation. This involved considering similar propositions within groups (i.e., within the fields of environmental education, ecology, and the humanities), describing each of these groupings and distinguishing it from the others, and highlighting areas of similarity and divergence.

We focused on comparing definitional treatments of environmental, ecological, and ecoliteracy. That is, we focused on contributions that explicitly used one of these terms and attempted to provide or refine a precise definition or framework to describe it. A definition attests to and presents as a description "... a statement of the exact meaning of a word ..." or "... the nature, scope, or meaning of something ...," attributing to a term a commonly understood precise meaning (*Oxford Dictionaries* 2013). Such an approach characterizes a phenomenon as embodying a compendium of key attributes, defined a priori (see Davis and Ruddle 2010). We focused on contributions that took this approach to (re)defining environmental, ecological, or ecoliteracy. As it was impossible to consider all relevant contributions to our collective understanding of human-environment relationships, our focus on definitions and frameworks served to set practical limits on the scope of our study.

In contrast to a definitional approach, a conceptual approach regards phenomena as abstract ideas, whose attributes arise from a particular and identifiable theoretical framework concerning the factors that organize human relationships and affect the human condition (Davis and Ruddle 2010). Stable and Bishop's (2001) and Payne's (2005, 2006) aforementioned critiques of efforts to characterize these types of literacies are based on the argument that these approaches are definitional rather than conceptual/theoretical. Indeed, these are entirely different ways of understanding and explaining phenomena, but they are both valid (Davis and Ruddle 2010). We recognize that innumerable other contributions, on a global scale and throughout history, have directly or indirectly led to broader theoretical conceptualizations related to these types of literacies, often without even naming them as such. However, it was beyond the scope of our study to consider all of these contributions.

In this manuscript, we trace the evolution of the term environmental literacy within the field of environmental education. We also examine the development of the more recent terms ecological literacy and ecoliteracy, and explore how and why they evolved from environmental literacy. We present a classification of the numerous proposed frameworks for environmental literacy, ecological literacy, and ecoliteracy, and compare and contrast these frameworks across multiple dimensions of affect, knowledge, skills, and behavior. This analysis facilitates close examination of where we have been, where we are, and where we might be headed with respect to these vital conversations. This work also offers points of reference for continuing critical discourse and illuminates a diversity of inspiration sources for developing and/or enriching programs aimed at cultivating these types of literacies.

Environmental Literacy

Roth (1992) noted that it was fitting that the term environmental illiteracy predated the term environmental literacy, in the same way that the term illiteracy predated the term literacy. Notably, Roth was referring to his original attempt to define environmental literacy in a 1968 issue of the *Massachusetts Audubon*, written in response to the frequent media references to "environmental illiterates," who were accused of polluting the environment.

The widespread public awareness of and concern about environmental issues at that time is often attributed to the work of the distinguished naturalist and nature writer, Rachel Carson (e.g., Nash 1990, de Steiguer 1997, Rothman 1998). In 1960, Carson published a series of articles in *The New Yorker* concerning the effects of chemical insecticides on the balance of nature, which led to her best-selling publication, *Silent Spring*. Carson (1962) cataloged the impacts of the indiscriminate spraying of DDT in the United States and questioned the logic of releasing large amounts of chemicals into the environment without fully understanding their effects. As part of the legacy of *Silent Spring*, the public began to express their uneasiness, suspicion, and even outright hostility with respect to the nation's unthinking allegiance to progress (Rothman 1998). Environmental illiteracy was no longer acceptable.

It was in this charged atmosphere that Roth (1968) posed the question: "How shall we know the environmentally literate citizen?" Shortly thereafter, the article was reprinted in the *New York Times* (Faust 1969), yet it received relatively little more attention until a year later when the term environmental literacy appeared in several speeches by President Nixon, relating to the passage of the first National Environmental Education Act in 1970 (Roth 1992). As time passed, the term was used more and more frequently within the field of environmental education. Although the first National Environmental Education Act was not signed into law until 1970, environmental education emerged as a distinct field in the mid-1960s (Braus and Disinger 1998). With its primary antecedents in nature study, conservation education, and outdoor education, environmental education arose as a complex and vibrant field of practice and inquiry into the meanings, problems, and potentials of human-environment relationships, and the role of education in this respect.

The rise of the nature study, conservation education, and outdoor education movements largely reflected the socio-political environment of their time (Braus and Disinger 1998). Beginning in the late 1800s, nature study emerged as a

means of providing opportunities for the appreciation and discovery of nature in response to the shift from a mainly agrarian to a more industrial society in which students were no longer spending their childhood in natural settings. In the 1930s, conservation education grew out of concerns about poor natural resource management, as reflected by the Great Dust Bowl, and focused on the importance of conserving soil, water, and other natural resources. In the 1950s, outdoor education emerged out of concern that urban youth were not experiencing direct contact with the outdoor environment; it encouraged the teaching of all subjects outdoors, often using residential camps. By the late 1960s, public awareness of environmental issues had become widespread, and environmental education, with a focus on the social aspects of environmental problems, emerged.

Numerous scholarly reviews have highlighted the fact that, despite a common concern for the environment and human-environment relationships and a shared recognition of the role of education in this respect, the field of environmental education continues to be advanced via widely differing theoretical, pedagogical, and research perspectives (e.g., Robottom and Hart 1993, Disinger 1998, Hart and Nolan 1999, Sauve 1999, Rickinson 2001, Ramsey and Hungerford 2002, Russel and Hart 2003, Disinger 2005, Robottom 2005, Sauvé 2005, Smyth 2006). While originally focused on increasing public awareness of the environmental damage caused by humans, particularly in terms of pollution, environmental education has since evolved into a rich, complex and vast pedagogical landscape, encompassing numerous distinct currents of intervention, each with different objectives, teaching approaches, and strategies (Sauvé 2005).

While developing a consensus set of goals for environmental education continues to be a topic of spirited discourse and debate, many previous and current leaders in the field have identified environmental literacy as the primary goal of environmental education. The goal of environmental literacy was advanced in the *Belgrade Charter* by the United Nations Educational, Scientific, and Cultural Organization and the United Nations Environment Programme (UNESCO-UNEP 1976) and the *Tbilisi Declaration* (UNESCO 1978), which are considered the

official founding documents of the environmental education field. The *Belgrade Charter*, the product of the first international conference on environmental education held in former Yugoslavia in 1975, outlined some of the basic structure and aims of environmental education worldwide, and provided a widely accepted goal statement for environmental education:

"The goal of environmental education is to develop a world population that is aware of and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones (UNESCO 1976: 1).

In 1977, the *Belgrade Charter* was further refined at the Intergovernmental Conference on Environmental Education, held in Tbilisi, Republic of Georgia. The *Tbilisi Declaration* defined three goals as the basis for environmental education (UNESCO 1978: 2): (1) to foster a clear awareness of, and concern about, economic, social, political and ecological interdependence in urban and rural areas; (2) to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment; and (3) to create new patterns of behavior of individuals, groups, and society as a whole towards the environment.

In 1987, ten years after the *Tbilisi Declaration*, an international congress on environmental education was convened in Moscow, USSR, resulting in the *International Strategy for Action on EE and Training for the 1990s*. The action strategy focused on environmental problems and the essential principles of and guidelines for environmental education (UNESCO-UNEP 1988). Soon after, UNESCO-UNEP (1989) published *Environmental Literacy for All*, which positioned environmental literacy as the fundamental goal of environmental education and reviewed the numerous environmental education initiatives that were taking place around the world at that time. Yet, efforts to explicitly define and delineate the essential components of environmental literacy, in the form of frameworks, occurred mainly in the United States.

Identifying the *Belgrade Charter* and the *Tbilisi Declaration* as its guiding documents, The North

American Association for Environmental Education (NAAEE) continues to identify cultivating environmental literacy as the primary goal of environmental education (NAAEE 2004). Like the field of environmental education itself, the term environmental literacy has undergone a lengthy metamorphosis. A driving purpose in the field has been to create a complete and broadly applicable conceptual framework for environmental literacy (i.e., what an environmentally literate person should know and be able to do), allowing for the establishment of guidelines and tools for assessing educational achievement. Since the 1970s, a multitude of new and adapted frameworks, guidelines, and plans for environmental literacy have been put forward by individuals, consortiums, organizations, and states with the primary goal of providing environmental education. Since the 1990s, tremendous efforts have been made across all of these entities to establish a consensus framework to guide educators at the front lines of cultivating environmental literacy in both formal and informal settings (e.g., Simmons 1995, NAAEE 2004).

In 1993, The National Project for Excellence in Environmental Education, sponsored by the NAAEE, was initiated to develop a set of guidelines for high-quality environmental education across the U.S., with the primary purpose of articulating knowledge and skills they viewed as essential for environmental literacy (NAAEE 2004: 1). As part of its goal of reflecting a broadly shared understanding of environmental literacy, NAAEE's *Guidelines for Learning* were developed using the extensive body of existing scholarship in environmental education as its foundation.

Components of environmental literacy

To aid in the development of the NAAEE guidelines, Simmons (1995) conducted a thorough review of the definitions, frameworks and/or models of environmental literacy from 26 relevant sources, including individuals, consortiums, organizations, and state and national guidelines or plans. In that study, Simmons found that, although each framework was based on a different set of assumptions and priorities, the commonalities amongst the plans were considerable. Simmons identified the major components of environmental literacy proposed in each model and designed a draft framework

showing how the different models of environmental literacy were organized around seven major components. These seven major components served as the basis for the structure of NAAEE's *Guidelines for Learning* (NAAEE 2000/2004) and included: (1) affect, (2) ecological knowledge, (3) socio-political knowledge, (4) knowledge of environmental issues, (5) cognitive skills, (6) environmentally responsible behaviors (ERB), and (7) additional determinants of ERB (Simmons 1995, Table 1).

Frameworks for environmental literacy

Since its inception (Roth 1968), the development of the term environmental literacy has been thoroughly reviewed with respect to its multiple and evolving definitions (Roth 1992, Weiser 2001, O'Brien 2007) and its different and/or complementary theoretical frameworks, components, and/or levels (Roth 1992, Simmons 1995, NAAEE 2000/2004, 2011, Morrone et al. 2001, Weiser 2001). A thorough, methodical review of the relevant literature on environmental literacy up to 1995 was conducted by Simmons (1995). Building on Simmons' work (Table 1), we use the 7 components she identified as a basis for comparing the frameworks developed since then (Tables 2 and 3), including by NAAEE (2000/2004, 2011) and others.

From the foundational "spaceship earth" and AKASA models (Stapp and Cox 1974, UNESCO 1978, respectively) to more recent nation-wide assessments (e.g., Coyle 2005, McBeth et al. 2008), frameworks for environmental literacy proposed over the last several decades exhibit a high degree of similarity and congruence with respect to their major components. All frameworks include knowledge of basic ecological concepts, environmental sensitivity or appreciation, awareness of environmental issues and problems, and skills and behaviors to prevent and/or resolve those issues as key attributes of the environmentally literate individual. Environmental problem-solving is a unifying current running throughout these frameworks (Tables 2 and 3), clearly reflecting its roots in the environmental education movement.

As the extent, gravity, and growing acceleration of environmental degradation came to light in the 1960s and 70s and the field of environmental education emerged, the environment was

Table 1. Components of environmental literacy, adapted from Simmons (1995).

Component	Description
Affect	• Environmental sensitivity or appreciation, in terms of responsible attitudes toward pollution, technology, economics, conservation, and environmental action, and a willingness to recognize and choose among differing value perspectives associated with problems and issues. Motivation to actively participate in environmental improvement and protection, desire to clarify one's own values, and confidence to make decisions and judgments about environmental issues according to one's sense of morality.
Ecological knowledge	• An ability to communicate and apply major ecological concepts including those focusing on individuals, species, populations, communities, ecosystems, and biogeochemical cycles. An understanding of energy production and transfer, and the concepts of interdependence, niche, adaptation, succession, homeostasis, limiting factors, and humans as ecological variables. An understanding of how natural systems work, as well as how social systems interface with natural systems.
Socio-political knowledge	• A clear awareness of economic, social, political and ecological interdependence in urban and rural areas; i.e., how human cultural activity influences the environment from an ecological perspective. An understanding of the basic structure and scale of societal systems and of the relationships between beliefs, political structures, and environmental values of various cultures. Geographic understanding at local, regional, and global levels and recognition of patterns of change in society and culture.
Knowledge of environmental issues	• An understanding of various environmentally-related problems and issues and how they are influenced by political, educational, economic, and governmental institutions. Understandings of air quality, water quality and quantity, soil quality and quantity, land use and management for wildlife habitat, and human population, health, and waste.
Cognitive skills	• Identification and definition of environmental problems/issues, and the analysis, synthesis, and evaluation of information about these issues using both primary and secondary sources and one's personal values. Abilities for selecting appropriate action strategies and creating, evaluating, and implementing action plans. Abilities to conduct scientific inquiry and basic risk analysis, think in terms of systems, and to forecast, think ahead, and plan.
Environmentally responsible behaviors (ERB)	• Active participation aimed at problem solving and issues resolution. Action through selected lifestyle activities, including environmentally sound consumer purchasing, using methods for conserving resources; assisting with the enforcement of environmental regulations; using personal and interpersonal means to encourage environmentally sound practices; and supporting environmentally sound policies and legislative initiatives.
Additional determinants of ERB	• A locus of control and assumption of personal responsibility. Locus of control is an individual's perception of his or her ability to bring about change because of his or her behavior; individuals possessing an internal locus of control believe their actions are likely to advance change (see Hines et al. 1986, Newhouse 1990).

considered first and foremost to comprise a set of problems and issues. As reflected in nearly all frameworks, an environmentally literate citizen is an individual who is, most importantly, informed about environmental issues and problems and possesses the attitudes and skills for solving them. While some frameworks prescribe a code of socially desirable attitudes and values, others focus on the construction of one's own values system; in either case, the environmentally literate individual has a well-developed set of environmental values or morals. The individual also takes action in terms of changing his or her own behavior in order to remediate or prevent further environmental problems. The individual is not only able to identify and analyze the values

of protagonists with respect to a given environmental issue, but also is able to clarify his or her own values in connection with action.

By the 1980s, the emphasis on environmental issues resolution as a fundamental component of environmental literacy came into question in the context of more general scientific literacy. *A Nation at Risk* (National Commmission on Excellence in Education 1983) warned of a national education crisis and urged reform of the entire educational system. Dozens of reports over the next few years supported the commission's conclusions, citing American students' low test scores and poor showing in international studies of student achievement, particularly in science. This climate inspired the American Association

Table 2. Frameworks for environmental literacy advanced within the field of environmental education.

Year	Author(s)/ Organization	Description of framework:
1974	Stapp and Cox	The spaceship earth philosophy of EL, divided into knowledge of five basic concepts: (1) ecosystems, (2) populations, (3) economics and technology, (4) environmental decisions, and (5) environmental ethics. In addition, a set of three processes for EL: (1) problem solving skills essential to developing and carrying out action plans; (2) values clarification to help individuals become aware of their personal beliefs, attitudes, values, and behaviors; and (3) community problem solving—application of both problem solving and valuing to an environmental issue that affects an individual directly.
1978	*Tblisi Declaration*, UNESCO	The AKASA model of EL, with five categories of objectives: (1) awareness—awareness and sensitivity to the total environment and its allied problems; (2) knowledge—a variety of experiences in and basic understanding of the environment and its associated problems; (3) attitudes—a set of values and feelings of concern for the environment and the motivation for actively participating in environmental improvement and protection; (4) skills—for identifying and solving environmental problems; and (5) action—active involvement at all levels in working toward the resolution of environmental problems.
1980	Hungerford et al.	Four goal levels for EL: Level I, ecological foundations: understanding of major ecological concepts in areas such as species' interaction and interdependence, energy flow and material cycling, and succession, and abilities to apply that knowledge to the analysis of environmental issues, the selection of appropriate sources of scientific information in order to find solutions for environmental problems, and the prediction of ecological consequences of alternative solutions to environmental problems; Level II, conceptual awareness: understanding of how humans perceive and value the environment and how their behavior effects it, and an ability to identify the cultural implications of a wide variety of environmental issues and their alternative solutions; Level III, investigation and evaluation: abilities to identify and investigate environmental issues using both primary and secondary sources of information, evaluate alternative solutions to those issues, and to identify, clarify, and possibly change personal value positions related to environmental issues and their solutions; and Level IV, issue resolution: competence with a variety of environmental action skills, such as persuasion, political action, legal action, and eco-management.
1990	Ballard and Pandya	Knowledge of three key systems for EL: (1) natural systems—general (environment, earth, biosphere), abiotic components, biotic components, processes, biological systems ; (2) resource systems—natural resources distribution, consumption, management, and conservation, abiotic resources, biotic resources, degradation of resource base; (3) human systems—humans and environment, technological systems, social systems, environmental awareness and protection.
1990	Iozzi et al.	Five taxonomies of educational objectives for EL: (1) cognitive domain—knowledge of basic ecological concepts and an understanding of environmental problems and issues, and skills for selecting, creating, evaluating, and/or implementing action strategies and plans; (2) affective domain—environmental sensitivity or appreciation, responsible attitudes toward environmental issues, values, moral reasoning, and ethics; (3) responsible environmental behavior—active participation aimed at solving problems and resolving issues; (4) locus of control; (5) assumption of personal responsibility—recognition of one's impacts and willingness to fill one's role in helping to resolve environmental issues.
1991	Currciulum Task Group, ASTM	Twelve recommendations for EL: (1) overall environmental awareness and knowledge; (2) understanding of ecology as a critical cornerstone; (3) communication and application of major ecological concepts; (4) communication and application of major social science concepts; (5) understanding of human dependence upon stable and productive ecological and social systems; (6) identification of a wide variety of environmental issues and application of ecological and social science concepts in interpreting these issues; (7) understanding of how human behaviors, beliefs, values, and cultural activities impact the environment; (8) knowledge and application of various issues identification strategies using both primary and secondary sources of information; (9) identification of various alternative solutions to environmental problems and prediction of possible or probable consequences; (10) identification, evaluation, and modification of personal and group values positions and strategies, relative to the environment; (11) demonstration of strategies for the correction of environmental problems; (12) identification of sources of scientific and social scientific information appropriate to the investigation of environmental problems and solutions.

Table 2. Continued.

Year	Author(s)/ Organization	Description of framework:
1991	Marcinkowski	Nine items comprising EL: (1) awareness and sensitivity toward the environment; (2) attitude of respect for the natural environment and of concern for the nature of magnitude of human impacts on it; (3) knowledge and understanding of how natural systems work, as well as of how social systems interface with natural systems; (4) understanding of the various environmentally related problems and issues across multiple scales, local to global; (5) skills required to analyze, synthesize, and evaluate information about environmental problems using primary and secondary sources and to evaluate a select problem on the basis of evidence and personal values; (6) sense of personal investment in, responsibility for, and motivation to work individually and collectively toward the resolution of environmental problems; (7) knowledge of strategies available for use in remediating environmental problems; (8) skills required to develop, implement and evaluate single strategies, and composite plans for remediating environmental problems; and (9) active involvement at all levels in working toward the resolution of environmental problems.
1992	Roth	Three levels of EL, nominal, functional, and operational: (1) a nominally environmentally literate person is able to recognize and provide rough working definitions of many of the basic terms used in communicating about the environment, and is developing awareness, sensitivity, and an attitude of respect and concern for natural systems; (2) a functionally environmentally literate individual has a broader understanding of the interactions between natural systems and human social systems and is aware and concerned about negative interactions between those systems; he or she has developed the skills to analyze, synthesize, and evaluate information about environmental issues, and evidences a personal investment and motivation to work toward remediation; (3) an operationally environmentally literate person has moved beyond functional literacy in both the breadth and depth of his or her understandings and skills. The individual demonstrates a strong, ongoing sense of investment in and responsibility for preventing or remediating environmental degradation, and routinely advocates action positions and takes action that work to sustain or enhance a healthy environment.
1992/1997	Wisconsin Center for Environmental Education	Four general EL outcomes: (1) cognitive—knowledge of ecological principles (individuals, populations, and communities, change and limiting factors, energy flow, biogeochemical cycling, ecosystems and biodiversity), knowledge of environmental problems and issues, knowledge of issue investigation strategies, knowledge of appropriate action strategies for prevention or resolution of environmental issues; (2) affective—environmental sensitivity and awareness, positive attitudes and values for the prevention and remediation of environmental issues; (3) determinants of ERB—locus of control, assumption of personal responsibility; and (4) ERB—ecomanagement, economic action, persuasion, political action, legal action.
1993/2006	Project Learning Tree	Five goals for EL: (1) awareness, appreciation, skills, and commitment to address environmental issues; (2) application of scientific processes and higher order thinking skills to resolve environmental problems; (3) appreciation and tolerance of diverse viewpoints on environmental issues, attitudes and actions based on analysis and evaluation of the available information; (4) creativity, originality, and flexibility to resolve environmental problems and issues; (5) inspiration and empowerment to become responsible, productive, and participatory members of society. Four basic concepts: diversity, systems, structure and scale, and patterns of change in the environment, resource management and technologies, societies, and cultures.
1994	Hungerford et al., EL Consortium	Four categories of objectives for EL: (1) cognitive dimensions—knowledge of ecological and socio-political foundations, knowledge of and ability to evaluate environmental issues, apply action strategies, and develop and evaluate appropriate action plans; (2) affective dimensions—empathic, appreciative, and caring attitudes toward the environment and willingness to work toward prevention and/or remediation of issues; (3) additional determinants of ERB—locus of control and assumption of personal responsibility; (4) personal and/or group involvement in ERB—ecomanagement, economic/consumer action, persuasion, political action, legal action.
2000/2004	NAAEE	Four strands of EL: (1) questioning, analysis, and interpretation skills—familiarity with inquiry, mastery of fundamental skills for gathering and organizing information, ability to interpret and synthesize information to develop and communicate explanations; (2) knowledge of environmental processes and systems—the Earth as a physical system, the living environment, humans and their societies, environment and society; (3) skills for understanding and addressing environmental issues—skills for analyzing and investigating environmental issues, decision-making and citizenship skills; (4) personal and civic responsibility—willingness and ability to act on one's own conclusions about what should be done to ensure environmental quality, understanding of what can be done individually and in groups to make a difference.

Table 2. Continued.

Year	Author(s)/ Organization	Description of framework:
2003	NSTA	Nine declarations for EL: (1) observation, investigation, experimentation, and innovation; (2) scientific literacy; (3) appreciation for and knowledge of range of environmental issues, perspectives, and positions; (4) critical thinking skills; (5) awareness and understanding of global environmental issues, potential solutions, and ways to prevent environmental crises; (6) balance of environmental, economic, and social perspectives; (7) use of appropriate technologies to advance EL; (8) EL fostered through both formal and informal learning experiences; (9) EL encouraged through collaborations among formal and informal learning environments.
2005	Coyle	Three levels of EL: (1) environmental awareness—simple familiarity with an environmental subject with little real understanding of its deeper causes and implications; (2) personal conduct knowledge—willingness to go a step further to take personal action and make connections between an environmental issue and one's individual conduct; (3) true literacy—understanding of principles underlying an environmental issue, skills needed to investigate it, and understanding of how to apply that information.
2008	McBeth et al.	Four components of EL: (1) foundational ecological knowledge; (2) environmental affect—verbal commitment, environmental sensitivity, environmental feeling; (3) cognitive skills—issue identification, issue analysis, action planning; (4) behavior—actual commitment, i.e., pro-environmental behavior.
2011	NAAEE	Four components of EL: (1) contexts—awareness of local, regional, or global situations that involve the environment; (2) competencies—abilities to identify and analyze environmental issues, evaluate potential solutions to environmental issues, and propose and justify actions to address environmental issues; (3) environmental knowledge—knowledge of physical ecological system, environmental issues, socio-political systems, strategies for addressing environmental issues; (4) dispositions toward the environment—interest, sensitivity, locus of control, responsibility, intention to act.

Notes: Framework terminology reflects authors' usage. Frameworks are arranged in chronological order based on initial publication date to reflect progression within the field. Abbreviations are: ASTM, American Society for Testing and Materials; NSTA, National Science Teachers Association; NAAEE, North American Association for Environmental Education; EL, environmental literacy; ERB, environmentally responsible behaviors; UNESCO, United Nations Educational, Scientific, and Cultural Organization.

for the Advancement of Science (AAAS) to place science literacy at the top of its priority list with *Project 2061*, a long-term science, mathematics, and technology K–12 education reform initiative (AAAS 1989). The widespread apprehension about scientific literacy was reflected in the discourse about environmental literacy. The Independent Commission on Environmental Education (ICEE) raised concerns about much of the content of K–12 environmental education materials, suggesting that the field was geared more toward advocacy than education (ICEE 1997, see also Hug 1997). The commission argued that environmental educators should be more focused on building environmental science knowledge than changing behaviors. Other environmental education scholars also began to express dissatisfaction with the focus on environmental attitudes and issues resolution, and supported a more scientific approach to environmental literacy (e.g., Zimmerman 1995, Golley 1998).

It was during this period of pronounced enthusiasm for an emphasis on science in environmental education and environmental literacy that ecological scientists became involved. In 1986, Paul Risser, in his *Address of the Past President* to the Ecological Society of America, initiated a dialogue with his fellow ecologists when he decried the lack of scientific literacy in the American public and identified the need for ecology-based literacy in particular, which he termed ecological literacy (Risser 1986), thereby triggering the discussion within the field of ecology (see *Ecological Literacy* below).

At about the same time, the concept of environmental literacy evolved in yet a third direction, with the 1992 publication of *Ecological Literacy: Education and the Transition to a Postmodern World* by David Orr. Using the terms environmental literacy and ecological literacy interchangeably (an ambiguity noted by Quammen 1994), Orr advanced a vision of literacy that was distinct from the ongoing conversation

Table 3. Comparison of environmental literacy frameworks advanced within the field of environmental education.

Year	Author(s)/Organization(s)	Affect	Knowledge Ecological	Knowledge Socio-political	Knowledge Environmental issues	Skills	ERB	Additional determinants of ERB
1974	Stapp and Cox	✓	✓	✓	✓	✓	✓	
1977	*Tblisi Declaration*, UNESCO	✓	✓	✓	✓	✓	✓	✓
1980	Hungerford et al.	✓	✓	✓	✓	✓	✓	
1990	Ballard and Pandya	✓	✓	✓			✓	
1990	Iozzi et al.	✓	✓		✓	✓	✓	✓
1990	Curriculum Task Group, ASTM	✓	✓	✓	✓	✓	✓	
1991	Marcinkowski	✓	✓	✓	✓	✓	✓	✓
1992/1997	Wisconsin Center for EE	✓	✓		✓	✓	✓	✓
1992	Roth	✓	✓	✓	✓	✓	✓	✓
1993/2006	Project Learning Tree	✓	✓	✓	✓	✓	✓	✓
1994	Hungerford et al., EL Consortium	✓	✓	✓	✓	✓	✓	✓
2000/2004	NAAEE	✓	✓	✓	✓	✓	✓	✓
2003	NSTA	✓	✓	✓	✓	✓		
2005	Coyle	✓	✓	✓	✓		✓	
2008	McBeth et al.	✓	✓	✓	✓	✓	✓	✓
2011	NAAEE	✓	✓	✓	✓	✓	✓	✓

Note: Abbreviations are: ASTM, American Society for Testing and Materials; NSTA, National Science Teachers Association; NAAEE, North American Association for Environmental Education; EE, environmental education; EL, environmental literacy; ERB, environmentally responsible behaviors; UNESCO, United Nations Educational, Scientific, and Cultural Organization.

within environmental education and from the newly-seeded discussion within ecology. Orr (1992) argued that the ecological crisis was in every way a crisis of education, and that ecological literacy required a transformatory reconstruction of the industrial Western education system to focus on the creation of sustainable human communities and society. Orr's work directly inspired the movement for ecoliteracy, arising from the broader humanities (see *Ecoliteracy* below).

ECOLOGICAL LITERACY

In addition to the heightened concern in the 1980s over the lack of science literacy in general, numerous studies began to elucidate students' widely held misconceptions about fundamental ecological concepts (reviewed by Munson 1994), and other studies suggested that people held a number of errant views related to ecology, such as equating ecology with environmentalism (e.g., Krebs 1999). Recognizing that ecologists could offer tremendous insights into the key ideas in their field, how these ideas are linked, and how they can be thought about and translated for different audiences, numerous ecologists heeded the call to weigh in on the content and pedagogy of a framework for ecological literacy.

Frameworks for ecological literacy

Several frameworks addressing ecological literacy were developed beginning in the early 1990s (Klemow 1991, Odum 1992, Berkowitz 1997, Berkowitz et al. 2005, Jordan et al. 2009, Powers 2010). Cherrett (1989), while not aiming to define ecological literacy per se, surveyed the British Ecological Society for what they considered the most important ecological concepts for people to understand, resulting in a list of 20 most frequently mentioned ecological concepts. Acknowledging that the entire discipline of ecology could not be taught to everyone, these frameworks considered a shorter list of key knowledge and skills a person should have and be able to apply to be considered ecologically literate, while balancing brevity with comprehensiveness, assuring practicality while aiming to be inspirational, and being synthetic and novel while sufficiently reflecting current vernacular (Table 4).

Similar to environmental literacy, conversations related to ecological literacy and ecology education were undoubtedly occurring on an international scale. However, with the exception of Cherrett's (1989) work, efforts to define and delineate the essential components of ecological literacy in the form of frameworks were advanced mainly in the United States, in the publications of the Ecological Society of America.

Table 4. Frameworks for ecological literacy advanced within the field of ecology.

Year	Author(s)	Description of framework:
1986	Risser	Four notions for EL:(1) multimedia transport of materials—e.g., sources and sinks, biomagnifications, chemical transformations; (2) clarification of the "everything is connected to everything" concept—understanding specific instances of connections and the relative strength of interactions; (3) ecology-culture interactions—economics, management of natural resources, relationships between ecology and cultural heritage; (4) familiar ecological field observations based on a specific, local spot—a concrete example of ecological concepts, a site for action and for furthering understanding and appreciation of other spots.
1989	Cherrett	Top 20 ecological concepts, in rank order: (1) the ecosystem, (2) succession, (3) energy flow, (4) conservation of resources, (5) competition, (6) niche, (7) materials cycling, (8) the community; (9) life history strategies, (10) ecosystem fragility, (11) food webs, (12) ecological adaptation, (13) environmental heterogeneity, (14) species diversity, (15) density dependent regulation, (16) limiting factors, (17) carrying capacity, (18) maximum sustainable yield, (19) population cycles, (20) predator-prey interactions.
1991	Klemow	Eleven basic ecological concepts for EL: (1) nature of ecological science, (2) influences of physical and biological factors on organisms, (3) species distribution, (4) populations, (5) communities, (6) organismal interactions, (7) ecosystem concept, (8) energy flow through ecosystems, (9) nutrient cycling in ecosystems, (10) constant change in ecosystems, (11) human impacts on ecosystems.
1992	Odum	Twenty "great ideas" in ecology: (1) an ecosystem is thermodynamically open and far from equilibrium; (2) the source-sink concept; (3) species interactions are constrained by slower interactions that characterize larger systems; (4) first signs of environmental stress usually occur at the population level, affecting especially sensitive species; (5) feedback in an ecosystem is internal and has no fixed goal; (6) natural selection may occur at more than one level; (7) there are two kinds of natural selection: organism vs. organism, which leads to competition, and organism vs. environment, which leads to mutualism; (8) competition may lead to diversity rather than extinction; (9) evolution of mutualism increases when resources become scarce; (10) indirect effects may be as important as direct interactions in a food web and may contribute to network mutualism; (11) organisms have not only adapted to physical conditions but have modified the environment in ways that have proven beneficial to life in general; (12) heterotrophs may control energy flow in food webs; (13) an expanded approach to biodiversity should include genetic and landscape diversity, not just species diversity; (14) autogenic ecological succession is a two phase-process—earlier stages tend to be stochastic whereas later stages are more self-organized; (15) carrying capacity is a two-dimensional concept involving number of users and intensity of per capita use; (16) input management is the only way to deal with nonpoint pollution; (17) energy expenditure is always required to produce or maintain an energy flow or material cycle; (18) there is an urgent need to bridge the gaps between human-made and natural life support goods and services; (19) transition costs are always associated with major changes in nature and in human affairs; (20) a parasite-host model for man and the biosphere is a basis for going from dominionship to stewardship.
1997	Berkowitz	Four organizing themes for EL: (1) knowledge of human and natural systems (the nature of scientific understanding, basic insights about the functioning of natural systems, earth's physical systems, species assemblages and interactions, ecosystems, ecosystem function, human dependence on the environment, humans as an ecological variable, understanding of a range of environmental issues, what shapes individual and group behavior toward the environment, human cultural activities and their environmental influence, how governments make and enforce environmental laws, awareness of inequity); (2) inquiry skills; (3) skills for decision and action; (4) personal responsibility.
2005	Berkowitz et al.	Three overlapping components of EL: (1) knowledge of five key ecological systems (one's ecological neighborhood, ecological basis of human existence, ecology of systems that sustain humans, human impacts on globe as an ecosystem, genetic/evolutionary systems and how humans affect them), (2) ecological thinking toolkit (scientific thinking, systems thinking, trans-disciplinary thinking, temporal thinking, spatial thinking, quantitative thinking, creative and empathic thinking) (3) understanding of the nature of ecological science and its interface with society.
2009	Jordan et al.	Three overlapping components of EL: (1) ecological connectivity and key concepts (ecology is a science, functional connections within species and between species and the environment, biotic and abiotic factors interact to influence species distributions, ecological processes operate to different extents when studied at different spatial and temporal scales, ecological models are used as descriptors and predictors of ecological processes, evolutionary theory is a framework for understanding ecological connections, ecologists may interpret ecological processes within the context of their own cultural background, ecological literacy allows people to understand connections between themselves and ecological processes and can help them make informed decisions about environmental issues; (2) ecological scientific habits of mind (modeling, dealing with environmental uncertainty, understanding issues of scale); (3) human actions-environmental linkages (links between human actions and their subsequent effects on ecosystems).
2010	Powers	Five key concepts for EL: (1) trade-offs; (2) succession; (3) population dynamics; (4) element cycles; (5) global ecology (human impacts).

Notes: Terminology reflects authors' usage. Frameworks are presented in chronological order based on initial publication date to reflect progression within the field. The abbreviation "EL" stands for "ecological literacy."

Table 5. Comparison of ecological literacy frameworks advanced within the field of ecology.

Year	Author(s)	Affect	Knowledge			Cognitive skills	ERB	Additional determinants of ERB
			Ecological	Socio-political	Environmental issues			
1986	Risser		√	√				
1989	Cherrett		√	√				
1991	Klemow		√		√			
1992	Odum		√	√	√			
1997	Berkowitz*		√	√		√		√
2005	Berkowitz et al.*		√	√	√	√		
2009	Jordan et al.		√	√		√		
2010	Powers		√		√			

Notes: Authors marked with an asterisk suggest that ecological literacy is a subset of environmental literacy. The abbreviation "ERB" stands for "environmentally responsible behaviors."

There is tremendous variation in the proposed number of "most important" items for ecological literacy, ranging from four to twenty. Frameworks for ecological literacy reviewed here emphasize, often in explicit detail, the ecological knowledge component (Tables 4 and 5). While earlier frameworks define ecological literacy with respect to its essential knowledge components only, more recent frameworks also emphasize cognitive skills, particularly scientific inquiry and ecological thinking. Also, all frameworks incorporate an understanding of ecological-cultural interactions in terms of human dependence on and/or integration with ecological systems, with the exception of Klemow's (1991) and Powers' (2010) frameworks, which consider humans solely in terms of their impacts.

In contrast with frameworks for environmental literacy, which mainly focus on the environment as a series of issues to be resolved through values and action, frameworks for ecological literacy emphasize that knowledge about the environment is necessary for informed decision-making. As emphasized in more recent ecological literacy frameworks, this knowledge is acquired through the scientific method of systematic observation, measurement, and experimentation, and the formulation, testing, and modification of hypotheses. An ecologically literate individual understands environmental realities by specifically identifying their cause and effect relationships. Recent ecological literacy frameworks also emphasize systems thinking, which involves identifying the various biophysical and social components in a given environmental context and distinguishing their interrelations, allowing

for the construction of a "big picture" view. As such, the ecologically literate individual has a clear perception and understanding of a system's dynamics and ruptures, as well as its past and alternate future trajectories. He or she understands the complexity of studied objects and phenomena, allowing for more enlightened decision-making.

When considered collectively, frameworks for ecological literacy do espouse a view that is quite different from environmental literacy. Yet, there is obvious, significant overlap between the two perspectives. In particular, frameworks proposed by Berkowitz (1997) and Berkowitz et al. (2005) show a high degree of overlap with environmental literacy (Tables 5 and 3, respectively). These efforts did not conflate the two terms; rather, they represent an original explicit attempt to distinguish between them. In particular, Berkowitz et al. (2005) attempted to bridge the gap between these research areas in ecology and environmental education by suggesting that ecological literacy is a subset of environmental literacy; that is, environmental literacy is essentially an amalgam of ecological literacy and civics literacy. The results of the classification approach we used support their proposition that ecological literacy may be a subset of environment literacy (Tables 5 and 3, respectively).

ECOLITERACY

At about the same time that ecological literacy took root in ecology, another conceptual understanding took root in the broader humanities, with Orr's (1992) distinctly different description

of ecological literacy. Orr (1992) advanced an idea of literacy that placed emphasis on the creation of sustainable human communities and called for a fundamental reconstruction of the entire educational system.

The ideology of sustainable development, central to Orr's (1992) conceptualization of environmental/ecological literacy, gained popularity during the mid-1980s, with the convening of the World Commission on Environment and Development (WCED) in 1983 to address growing concerns about the accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development. The WCED (renamed the Brundtland Commission) report, *Our Common Future*, was the first genuinely comprehensive survey of the planet's health, detailing the problems of atmospheric pollution, desertification, and poverty. The report proposed the concept of sustainable development, defined as "…development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). This report laid the groundwork for Chapter 36 of *Agenda 21*, which recommended reorienting education toward sustainable development (UNESCO 1992). Following these recommendations, UNESCO replaced its International Environmental Education Program (1975–1995) with *Educating for a Sustainable Future* (UNESCO 1997). As such, the ideology of sustainable development gradually penetrated the environmental education movement and has since asserted itself as a dominant perspective, and even as an educational field in its own right (i.e., education for sustainable development; reviewed by Bonnett 2002, Gonzalez-Gaudiano 2006, Stevenson 2006).

Soon after and drawing heavily on Orr's (1992) work, Capra (1997) coined the term ecoliteracy, defined as an understanding of the principles of the organization of ecosystems and the application of those principles for creating sustainable human communities and societies. (see also Cutter-Mackenzie and Smith 2003, Wooltorton 2006). The idea of using resources in such a way as to ensure future availability was an essential element of ecoliteracy. And, while the term ecoliteracy was not used explicitly, other frameworks identifying sustainability as the preferred

outcome of the promotion of literacy have been advanced by Thomashow (1995), Jardine (2000), Bowers (2001), Woolpert (2004), and Stone and Barlow (2005).

Frameworks for ecoliteracy

Frameworks for ecoliteracy exhibit a high degree of similarity with frameworks for environmental literacy, in that both sets include similar affective, knowledge, cognitive skills, and behavioral components (Tables 6, 7, and 3, respectively). However, what most differentiates ecoliteracy from environmental literacy is the clear emphasis on sustainability, and the introduction of spiritual, holistic components, expressed in terms of "celebration of Creation" (Orr 1992), "spirit" and "reverence for the Earth" (Capra 1997, 2002, Center for Ecoliteracy 2013b), and "expansion of the soul" (Wooltorton 2006) (Table 6). An ecoliterate person is prepared to be an effective member of sustainable society, with well-rounded abilities of head, heart, hands, and spirit, comprising an organic understanding of the world and participatory action within and with the environment.

CONCLUSION

In this study, we classified the numerous proposed frameworks for environmental literacy, ecological literacy, and ecoliteracy (as advanced within the fields of environmental education, ecology, and the broader humanities, respectively) and compared and contrasted these frameworks across multiple dimensions of affect, knowledge, skills, and behavior. While neither exhaustive nor intended as a rigid categorization, this analysis may be useful in that it allows for easier examination of the multiplicity and diversity of uses of these characterizations. In addition to describing the overall discourse, this work may provide avenues for deeper exploration and critical analysis of each strand of discussion (Table 8). It may also offer reference points and/or sources of inspiration for planning educational strategies, and may assist educators in situating, analyzing, and/or enriching their own theoretical choices and practices. Additionally, this examination of the present range of the environmental-, ecological-, and ecoliteracy landscape may inspire and inform the development of new contribu-

Table 6. Frameworks for ecoliteracy.

Year	Author(s)/ Organization	Description of framework
1992	Orr	The basis of ecological literacy: knowledge, caring, and practical competence. A broad understanding of how people and societies relate to each other and natural systems, and how to do so sustainably. The ability to answer "What then?" questions, requiring the comprehension of the interrelatedness of life grounded in the study of natural history, ecology, and thermodynamics. An understanding of the speed of the environmental crisis upon us. A comprehension of the idea of controlling nature and the ways in which people and whole societies have become so destructive. Broad familiarity with the development of ecological consciousness. Participation in sustainability: prudence, stewardship, and celebration of Creation.
1997/2002/2013*b*	Capra, Center for Ecoliteracy	Four sets of competencies for ecoliteracy: (1) head/cognitive—approach issues from a systems perspective, understand fundamental ecological principles (networks, nested systems, cycles, flows, development, dynamic balance), think critically, assess impacts and ethical effects of human actions, envision long-term consequences of decisions; (2) heart/emotional—feel concern, empathy, and respect for other people and living things, appreciate multiple perspectives, commit to equity and justice for all people; (3) hands/active—create and use tools and procedures required by sustainable communities, turn convictions into practical and effective action, assess and adjust uses of energy and resources; (4) spirit/connectional—experience wonder and awe toward nature, feel reverence for the Earth and all living things, feel a strong bond with and deep appreciation of place, feel kinship with the natural world and invoke that feeling in others.
2003	Cutter-Mackenzie and Smith	Four levels of ecoliteracy: (1) eco-illiteracy—little understanding and many misconceptions about environmental issues; (2) nominal ecoliteracy—recognition and use of some basic terms used in communicating about the environment, beginning to identify environmental problems and issues surrounding proposed solutions; (3) functional/operational ecoliteracy—understanding of organization and function of environmental systems and interaction with human systems, knowledge and skills; (4) highly evolved ecoliteracy—thorough understanding of how people and societies relate to each other and natural systems, and how to do so sustainably, thorough understanding of the environmental crisis, understanding of models of sustainability, able to synthesize environmental information and act in a way that leads to environmental sustainability.
2006	Wooltorton	Six elements of ecoliteracy: (1) ecological self—a sense of interconnectedness with the cycle of life on the basis of care and compassion, expansiveness of the soul and respect for others on the basis of respect for difference; (2) sense of place and active citizenship—engagement in local culture, history, and organic community together with the ecosystem; (3) systems thinking and relationship—a sense of relationality, connectedness, and context; (4) the ecological paradigm—study of the whole, relationships, and networks, a focus on contextual knowledge, consideration of quality, attention to processes, study of patterns; (5) pedagogy of education for sustainability—an experiential, participatory and multidisciplinary approach, focusing on the learning process; (6) reading the world of nature and culture—engagement with nature as early in life as possible with ecoliteracy as first literacy.

Note: Terminology reflects authors' usage.

Table 7. Comparison of ecoliteracy frameworks.

Year	Author(s)	Affect	Knowledge			Cognitive skills	ERB	Additional determinants of ERB
			Ecological	Socio-political	Environmental issues			
1992	Orr	√	√	√	√	√	√	
1997/2002/2013*b*	Capra, CfE	√	√	√	√	√	√	
2003	C.M. and S.	√	√	√	√	√	√	
2006	Wooltorton	√	√	√	√	√	√	

Note: Abbreviations are CfE, Center for Ecoliteracy; C.M. and S., Cutter-Mackenzie and Smith; ERB, environmentally responsible behaviors.

Table 8. Characterizations of environmental literacy, ecological literacy, and ecoliteracy, including questions for further discussion.

General conceptions of environment	Dominant educational objectives	Primary pedagogical approaches	Examples of strategies	Questions for further discussion
Environmental literacy • Problem • Field of values	• Develop problem-solving skills, from diagnosis to action. • Develop a system of ethics. • Adopt environmentally responsible behaviors.	• Cognitive • Pragmatic • Affective/ Moral	• Case study, issue analysis, problem-solving project. • Analysis and clarification of values, criticism of social values.	Must environmental literacy be fundamentally oriented toward problem solving? What is the range of environmental values appropriate for environmental literacy, and who should determine them? How can we recognize that environmentally literate individuals may reasonably disagree with respect to issues requiring significant trade-offs?
Ecological literacy • Object of study • System	• Acquire knowledge of ecological concepts and principles. • Develop skills related to the scientific method: observation and experimentation. • Develop systems thinking: analysis and synthesis. • Understand environmental realities in view of informed decision-making.	• Cognitive • Experiential	• Observation, demonstration, experimentation, research activity. • Case study, environmental system analysis, construction of ecosystem models.	Is the scientific method a necessary and sufficient way to understand environmental realities, or is it imposing a quest for *the* right answer? In practical terms, is ecological literacy different than environmental literacy-perhaps a subset as Berkowitz et al. (2005) suggest? If so, can a person be considered ecologically literate without being environmentally literate, or vice versa?
Ecoliteracy • Shared resource for sustainable living • Gaia	• Promote and contribute to economic development that addresses social equity and ecological sustainability. • Develop the many dimensions of one's being in interaction with all aspects of the environment. • Develop an organic understanding of the world and participatory action in and with the environment.	• Cognitive • Pragmatic • Holistic • Intuitive/ Creative	• Case study, social marketing, sustainable consumption activities, sustainable living management project. • Immersion, visualization, creative workshops.	Precisely what is the ecoliterate individual striving to sustain under the aegis of sustainable development, at what level, and over what spatial and temporal scales? How is the ecoliterate person to judge which actions will positively contribute to sustainable development (see also Bonnett 2002)? What roles might intuition, creativity, and spirituality play in enhancing ecoliteracy? Alternately, what are the pitfalls that may be associated with a spiritual approach?

tions. Future efforts to conceptualize a complete, broadly applicable, and pedagogy-guiding framework for any of these literacies, and to operationalize them in terms of standards and assessments of educational achievement, should continue to build upon the tremendous existing foundation of scholarship and should aim to represent, collectively, the prodigious expertise both within and related to the field.

LITERATURE CITED

American Association for the Advancement of Science (AAAS). 1989. Science for all Americans. Oxford University Press, New York, New York, USA.

Ballard, M. and M. Pandya. 1990. Essential learnings in environmental education. North American Association for Environmental Education, Troy, Ohio, USA.

Berkowitz, A. R. 1997. Defining environmental literacy: a call for action. Bulletin of the Ecological Society of America 78:170–172.

Berkowitz, A. R., M. E. Ford, and C. A. Brewer. 2005. A framework for integrating ecological literacy, civics literacy, and environmental citizenship in environmental education. Pages 227–265 in E. A. Johnson and M. J. Mappin, editors. Environmental education or advocacy: perspectives of ecology and education in environmental education. Cambridge University Press, New York, New York, USA.

Bonnett, M. 2002. Education for sustainability as a frame of mind. Environmental Education Research 8:9–20.

Bowers, C. A. 2001. Educating for eco-justice and community. The University of Georgia Press, Athens, Georgia, USA.

Braus, J., and J. F. Disinger. 1998. Educational roots of environmental education in the United States and their relationship to its current status. Pages 9–19 in M. Archie, editor. Environmental education in the United States—past, present, and future. North American Association for Environmental Education, Troy, Ohio, USA.

Capra, F. 1997. The web of life: a new scientific understanding of living systems. Anchor Books, New York, New York, USA.

Capra, F. 2002. The hidden connections: a science for sustainable living. Anchor Books, New York, New York, USA.

Carl, J. 2009. Industrialization and public education: social cohesion and structural stratification. Pages 503–518 in R. Cowen and A. M. Kazamias, editors. International handbook of comparative education. Volume 22. Springer, New York, New York, USA.

Carson, R. 1962. Silent spring. Houghton-Mifflin, New York, New York, USA.

Center for Ecoliteracy. 2013a. What we do. Center for Ecoliteracy, Berkeley, California, USA. http://www.ecoliteracy.org/about-us/what-we-do

Center for Ecoliteracy. 2013b. Discover: competencies. Center for Ecoliteracy, Berkeley, California, USA. http://www.ecoliteracy.org/taxonomy/term/84

Cherrett, J. M. 1989. Key concepts: the results to a survey of our members opinions. Pages 6–7 in J. M. Cherrett, editor. Ecological concepts. Blackwell, London, UK.

Coyle, K. 2005. Environmental literacy in the U.S.: what ten years of NEETF/Roper research and related studies say about environmental literacy in the United States. National Environmental Education and Training Foundation (NEETF), Washington, D.C., USA.

Curriculum Task Group, American Society for Testing and Materials (ASTM). 1991. Environmental education curriculum standards. ASTM, Philadelphia, Pennsylvania, USA.

Cutter-Mackenzie, A. and R. Smith. 2003. Ecological literacy: the 'missing paradigm' in environmental education (part one). Environmental Education Research 9:497–524.

Davis, A. and K. Ruddle. 2010. Constructing confidence: rational skepticism and systematic enquiry in local ecological knowledge research. Ecological Applications 20:880–894.

de Steiguer, J. E. 1997. The age of environmentalism. McGraw-Hill, New York, New York, USA.

Disinger, J. F. 1998. An epilogue: environmental education's definitional problem: 1997 update. Pages 29–31 in H. R. Hungerford, W. J. Bluhm, T. L. Volk, and J. M. Ramsey, editors. Essential readings in environmental education. Stipes, Champaign, Illinois, USA.

Disinger, J. F. 2005. Tensions in environmental education: yesterday, today, and tomorrow. Pages 1–12 in: H. Hungerford, W. Bluhm, T. Volk, and J. Ramsey, editors. Essential readings in environmental education. Third edition. Stipes, Champaign, Illinois, USA.

Disinger, J. F., and C. E. Roth. 1992. Environmental literacy. ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio, USA.

Faust, J. L. 1969. About environmental literacy. New York Times April 13:39.

Golley, F. B. 1998. A primer for environmental literacy. Yale University Press, New Haven, Connecticut, USA.

Gonzàlez-Gaudiano, E. J. 2006. Environmental education: a field in tension or in transition? Envrionmental Education Research 12:3–4.

Hart, P., and K. Nolan. 1999. A critical analysis of research in environmental education. Studies in Science Education 34:1–69.

Hines, J., H. Hungerford, and A. Tomera. 1986. Analysis and synthesis of research on responsible environmental behavior: a meta-analysis. Journal of Environmental Education 18:1–8.

Hug, J. 1997. Two hats. In J. L. Aldrich, A.-M. Blackburn, and A. A. George, editors. The report of the North American regional seminar on environmental education for the real world. SMEAC Information Resource Center, Columbus, Ohio, USA.

Hungerford, H. R., R. B. Peyton, and R. J. Wilke. 1980.

Goals for curriculum development in environmental education. Journal of Environmental Education 11:42–47.

Hungerford, H. R., T. Volk, R. Wilke, R. Champeau, T. Marcikowski, T. May, W. Bluhm, and R. McKeown—Ice (Environmental Literacy Consortium). 1994. Environmental literacy framework. Environmental Education Literacy Consortium. Southern Illinois University, Carbondale, Illinois, USA.

Independent Commission on Environmental Education (ICEE). 1997. Are we building environmental literacy? ICEE, Washington, D.C., USA.

Iozzi, L., D. Laveault, and T. Marcinkowski. 1990. Assessment of learning outcomes in environmental education. UNESCO, Paris, France.

Jardine, D. 2000. Unable to return to the gods that made them. Pages 267–278 in D. W. Jardine, S. Friesen, and P. Clifford, editors. Curriculum in abundance. L. Ehrlbaum Associates, Washington, D.C., USA.

Jordan, R., F. Singer, J. Vaughan, and A. Berkowitz. 2009. What should every citizen know about ecology? Frontiers in Ecology and the Environment 7:495–500.

Klemow, K. M. 1991. Basic ecological literacy: a first cut. Ecological Society of America Education Section Newsletter 2:4–5.

Krebs, R. E. 1999. Scientific development and misconceptions throughout the ages. Greenwood, Westport, Connecticut, USA.

Marcinkowski, T. 1991. The relationship between environmental literacy and responsible environmental behavior in environmental education. In M. Maldague, editor. Methods and techniques for evaluating environmental education. UNESCO, Paris, France.

McBeth, B., H. Hungerford, T. Marcinkowski, T. Volk, and R. Meyers. 2008. National environmental literacy assessment project: year 1, national baseline study of middle grades students—final research report. Environmental Protection Agency, Washington, D.C., USA. http://www2.epa.gov/sites/production/files/documents/masternela_year1report_081208_.pdf

Michaels, S., and M. C. O'Connor. 1990. Literacy as reasoning within multiple discourses: implications for policy and educational reform. Education Development Corporation Literacies Institute, Newton, Massachusetts, USA.

Morrone, M. K., K. Mancl, and K. Carr. 2001. Development of a metric to test group differences in ecological knowledge as one component of environmental literacy. Journal of Environmental Education 32:33–42.

Munson, B. H. 1994. Ecological misconceptions. Journal of Environmental Education 24:30–34.

Nash, R. F. 1990. American environmentalism: readings in conservation history. McGraw-Hill, New York, New York, USA.

National Commission on Excellence in Education. 1983. A nation at risk: the imperative for educational reform. US Department of Education, Washington, D.C., USA.

National Science Teachers Association (NSTA). 2003. NSTA position statement on environmental education. NSTA, Arlington, Virginia, USA. http://www.nsta.org/about/positions/environmental.aspx

Newhouse, N. 1990. Implications of attitude and behavior research for environmental conservation. Journal of Environmental Education 22:26–32.

North American Association for Environmental Education (NAAEE). 2000/2004. Excellence in environmental education: guidelines for learning (K–12). NAAEE, Washington, D.C., USA.

North American Association for Environmental Education (NAAEE). 2011. Developing a framework for assessing environmental literacy. North American Association for Environmental Education, Washington, D.C., USA. http://www.naaee.net/sites/default/files/framework/DevFramewkAssessEnvLitOnlineEd.pdf

O'Brien, S. R. M. 2007. Indications of environmental literacy: using a new survey instrument to measure awareness, knowledge, and attitudes of university-aged students. Dissertation 1446054. Iowa State University, Ames, Iowa, USA. Proquest UMI Dissertations Publishing.

Odum, E. P. 1992. Great ideas in ecology for the 1990s. BioScience 42:542–545.

Orr, D. W. 1992. Ecological literacy: education and transition to a postmodern world. SUNY Press, Albany, New York, USA.

Oxford Dictionaries. 2013. Definition of definition. http://oxforddictionaries.com/definition/english/definition?q=definition

Payne, P. 2005. Lifeworld and textualism: reassembling the research/ed and 'others.' Environmental Education Research 11:413–431.

Payne, P. 2006. The technics of environmental education. Environmental Education Research 12:487–502.

Powers, J. 2010. Building a lasting foundation in ecological literacy in undergraduate, non-majors courses. Nature Education Knowledge 4:53.

Project Learning Tree. 1993/2006. Project Learning Tree's conceptual framework. American Forest Foundation, Washington, D.C., USA.

Quammen, D. 1994. E is for ecosystem: ecological literacy in the wonder years. Outside 19:35–42.

Ramsey, J. and H. R. Hungerford. 2002. Perspectives on environmental education in the United States. Pages 147–160 in T. Dietz and P. C. Stern, editors. New tools for environmental protection: education,

information, and voluntary measure. National Academy Press, Washington, D.C., USA.

Rickinson, M. 2001. Learners and learning in environmental education: a critical review of the evidence. Environmental Education Research 7:207–320.

Risser, P. G. 1986. Ecological literacy. Bulletin of the Ecological Society of America 67:264–270.

Robottom, I. 2005. Critical environmental education research: re-engaging the debate. Canadian Journal of Environmental Education 10:62–78.

Robottom, I. and P. Hart. 1993. Research in environmental education: engaging the debate. Deakin University Press, Geelong, Victoria, Australia.

Roth, C. E. 1968. On the road to conservation. Massachusetts Audubon 38–41.

Roth, C. E. 1992. Environmental literacy: it's roots, evolution, and direction in the 1990s. ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio, USA.

Rothman, H. K. 1998. The greening of a nation? Environmentalism in the United States since 1945. Harcourt Brace, Orlando, Florida, USA.

Russell, C., and P. Hart. 2003. Exploring new genres of inquiry in environmental education research. Canadian Journal of Environmental Education 8:5–8.

Sauvé, L. 1999. Environmental education between modernity and postmodernity: searching for an integrating educational framework. Canadian Journal of Environmental Education 4:9–35.

Sauvé, L. 2005. Currents in environmental education: mapping a complex and evolving pedagogical field. Canadian Journal of Environmental Education 10:11–37.

Simmons, D. 1995. Papers on the development of environmental education. North American Association for Environmental Education, Troy, Ohio, USA.

Smyth, J. C. 2006. Environment and education: a view of a changing scene. Environmental Education Research 12:247–264.

Stables, A., and K. Bishop. 2001. Weak and strong conceptions of environmental literacy: implications for environmental education. Environmental Education Research 7:89–97.

Stapp, W. B., and D. A. Cox. 1974. Environmental education model. In W. B. Stapp and D. A. Cox, editors. Environmental education activities manual. Thomson-Shore, Dexter, Michigan, USA.

Stevenson, R. B. 2006. Tensions and transitions in policy discourse: recontextualizing a decontextualized EE/ESD debate. Environmental Education Research 12:277–290.

Stone, M. K., and Z. Barlow, editors. 2005. Ecological literacy: education our children for a sustainable world. Sierra Club Books and University of California Press, San Francisco, California, USA.

Thomashow, M. 1995. Ecological identity: becoming a reflective environmentalist. MIT Press, Cambridge, Massachusetts, USA.

United Nations Educational, Scientific, and Cultural Organization (UNESCO). 1992. Chapter 36 of Agenda 21: promoting education, public awareness, and training. UNESCO, Paris, France. http://www.unesco.org/education/educprog/wche/principal/ag-21-e.html

UNESCO. 1997. Educating for a sustainable future: a transdisciplinary vision for concerted action. Report of the International Conference: Education and Public Awareness for Sustainability. UNESCO, Paris, France. http://unesdoc.unesco.org/images/0011/001106/110686eo.pdf

UNESCO Education Sector. 2004. The plurality of literacy and its implications for policies and programs: position paper. UNESCO, Paris, France. http://unesdoc.unesco.org/images/0013/001362/136246e.pdf

United Nations Educational, Scientific, and Cultural Organization and United Nations Environment Programme (UNESCO-UNEP). 1976. The Belgrade Charter. Connect: UNESCO-UNEP Environmental Education Newsletter 1:1–2.

UNESCO-UNEP. 1978. The Tbilisi Declaration. Connect: UNESCO-UNEP Environmental Education Newsletter 3:1–8.

UNESCO-UNEP. 1988. International strategy for action in the field of environmental education and training for the 1990s. http://unesdoc.unesco.org/images/0008/000805/080583eo.pdf

UNESCO-UNEP. 1989. Environmental literacy for all. Connect: UNESCO-UNEP Environmental Education Newsletter XIV(2):1–8. http://unesdoc.unesco.org/images/0015/001535/153577eo.pdf

Venezsky, R. L., C. F. Kaestle, and A. M. Sum. 1987. The subtle danger: reflections on the literacy abilities of America's young adults. Center for the Assessment of Educational Progress, Princeton, New Jersey, USA.

Weiser, B. G. 2001. The Envirothon and its effects on students' environmental literacy. Dissertation 3027890. University of Houston, Houston, Texas, USA. Proquest UMI Dissertations Publishing.

Wisconsin Center for Environmental Education. 1992/1997. Environmental education in Wisconsin: are we walking the talk? Wisconsin Center for Environmental Education, Stevens Point, Wisconsin, USA.

Woolpert, S. 2004. Seeing with new eyes: "ecological thinking" as a bridge between scientific and religious perspectives on the environment. International Journal of the Humanities 2:4–30.

Wooltorton, S. 2006. Ecological literacy "basic" for a sustainable future. In Proceedings of the Social Educator's Association of Australia (SEEAA) national biennial conference. Brisbane, Australia.

January 11–13, 2006. http://www.afssse.asn.au/seaa/conf2006/wooltorton_s.pdf

World Commission on Environment and Education (WCED). 1987. Our common future: report of the World Commission on Environment and Educa-tion. Oxford University Press, Oxford, UK.

Zimmerman, L. K. 1995. Science, nonscience and nonsense: approaching environmental literacy. Johns Hopkins University Press, Baltimore, Maryland, USA.