A Case for Advancing an Environmental Literacy Plan in Massachusetts

2016

Phase I—A Summary of the Commonwealth's Environment and Education Landscape

Citizens who are literate about the environment are aware of and appreciate the complexities of environmental challenges. They have the knowledge and analytical skills to assess and implement potential solutions. All citizens need foundational knowledge, analytical and communication skills, and ethical viewpoints to guide their choices and behavior. Ultimately, environmentally literate citizens are life-long learners capable of integrating multiple perspectives and skills to understand and act on current environmental issues. It is these environmentally literate citizens that will be able to grapple with the challenges of truly global proportion—climate change and its effects on infrastructure, natural resources and human health, and the reshaping of human's relationship with the resources that have sustained us for hundreds of thousands of years. Implementing an Environmental Literacy Plan for the Commonwealth will enable our citizens to have the knowledge, skills, and resources to shape a more sustainable and prosperous future for our state. This summary provides the foundation for developing an Environmental Literacy Plan.

Phase I—A Summary of the Commonwealth's Environment and Education Landscape

Table of Contents

Acknowledgements

Authors:
Daphne Minner, Ph.D.; Daphne Minner Consulting
Jennifer Klein, M.S.; Lesley University

Project Manager:
Robin Organ, Secretaries Advisory Group on Energy and Environmental Education (SAGEEE)

Funding Support:
Massachusetts Environmental Education Society (MEES)
Mass Audubon
Green Schools

Working Committee Members:
Brock Adler, North American Association for Environmental Education
Adrian Ayson, New England Environmental Education Association
Kim Botelho, Maria Mitchell Association, MEES Board Member
Kay Byram, early childhood educator (retired)
Jennifer Klein, Lesley University
Samuel Koufman, Student liaison, Manchester-Essex Regional School District
Eric Magers, Manchester-Essex Regional School District
Kate Marquis, Department of Conservation and Recreation
Jessica McManus, Mass Audubon
Daphne Minner, Daphne Minner Consulting
Robin Organ, Green Schools
Charles Roth, Earth Lore Associates (deceased)
Kris Scopinich, Mass Audubon
Rebekah Stendahl, New England Aquarium

Suggested citation:
Minner, D. & Klein, J. (2016). *A case for advancing an environmental literacy plan in Massachusetts: Phase I—a summary of the Commonwealth's environment and education landscape*. Report by Massachusetts Environmental Education Society. Retrieved from [website].

Forward

The work of developing the Massachusetts Environmental Literacy Plan (MassELP) is the product of collaboration across sectors with support from state and federal agencies, educational institutions and range of individuals, organizations, and businesses.

Innovation in environmental education has a long history here in the Commonwealth. "Benchmarks to Environmental Literacy" in K-12 education were drafted in 1996, by a wide-ranging group of educators chaired by Charles Roth, then Director of Education at Massachusetts Audubon Society. Trudy Coxe, the Secretary of Environmental Affairs under Governor William Weld at the time took an active role in encouraging the development of the environmental literacy benchmarks. In 2000, funding from the Massachusetts Environmental Trust facilitated the Massachusetts Environmental Education Plan (MEEP), under the leadership of Secretary Robert Durand who served under Governor Paul Cellucci. The drafting the MEEP was led by Dr. Alan Hankin, of Emerson College. This work continued during the administration of Secretary Richard Sullivan and Secretary Maeve Bartlett under Governor Deval Patrick. The new framework is designed to build upon these earlier works and to create an updated Environmental Literacy Plan for Massachusetts.

In 2011 a group of stakeholders from various environmental education organizations came together with a vision to craft a new environmental literacy plan for the Commonwealth of Massachusetts. This group formed the Massachusetts Environmental Literacy Plan steering committee, which worked over five years to develop a vision and framework for environmental literacy in Massachusetts.

In order to achieve this vision, the MassELP steering committee held regular meetings throughout the state to plan for the MassELP drafting and assess existing programs and initiatives that would support a future population of environmentally literate residents of Massachusetts. A valuable aspect of developing the Plan was the community feedback obtained in a 2013 survey of various stakeholder groups across the state. This survey asked questions about the desired role of an Environmental Literacy Plan in the state, the respondents' role in environmental education, and collected examples of best practices across sectors. An additional survey was distributed to youth ages 12-18 who were self-identified as interacting with the environment academically, recreationally, and through volunteer work. The survey results spoke to the need for more stakeholders to have a voice in the development of the MassELP. At the 2014 Massachusetts Environmental Education Society annual conference the MassELP steering committee held a "MassELP Listening Session." This session provided additional breadth and depth for the MassELP development. Finally, in fall 2015, a group of over 50 stakeholders gathered to review the goals of the MassELP and provide initial feedback. The survey results and stakeholder gathering provided content for the writing team as the MassELP was developed.

After 5 years of planning, research, writing, and development, Phase I constructing a summary of environment-related initiatives that provide a necessary framework for the development of an environmental literacy plan has come to fruition. The document that follows is not an implementation plan, rather it is designed to serve as a foundation for advancing environmental literacy in Massachusetts, and will be used to guide environmental literacy in the Commonwealth and inform future work towards implementation of a comprehensive Environmental Literacy Plan.

Executive Summary

Massachusetts is the third most densely populated state in the country[1] with the state capital located on a coastline projected to experience significant effects from the changing climate. The knowledge and commitment needed to address the infrastructure and economic challenges posed by the projected[2] stronger more frequent coastal storms to our region and other current and future environmental problems is complex and urgent. Developing and implementing solutions to these challenges requires a populace that has the skills to identify and understand the complexities of current and future environmental issues. While the residents of Massachusetts are among the most educated in the country, we have struggled to provide a coordinated, comprehensive education for our children about the environmental problems they will be responsible for addressing. It is, accordingly, time for a Massachusetts Environmental Literacy Plan that comprehensively addresses climate, energy, ocean, atmospheric, earth science, sustainability, ecological, and science literacy.

This document represents Phase I of this Plan. It makes the case for the need of a coordinated effort, describes the landscape of stakeholders working on environmental issues and initiatives in the state, and proposes an infrastructure to begin engaging stakeholders in a unified effort. We focus on educational opportunities in this Plan for several reasons. First, without a solid foundation in ecological knowledge and an opportunity to develop critical thinking skills and behavioral action plans, young people will not be able to partake in the economic opportunities of the green economy in the state, have the understanding or desire to engage in the rich civic opportunities of this democratically-vibrant Commonwealth, or feel confident enough to wrestle with the public health and ecological pressures that are present and will continue to mount over the next several decades.

Currently, Massachusetts' PreK-12 students do not have consistent access to high-quality learning experiences to build the environmental literacy needed for understanding complex issues such as climate change and energy use, natural and renewable resource uses, or the contribution sensitive and biologically diverse natural areas make to our quality of life. With the 2016 adoption of revised Massachusetts Science and Technology/Engineering Standards (STE)[3], teachers will review their curriculum to determine the changes necessary to address these revised standards. The standards emphasize providing experiences for students to apply knowledge and practices coherently across time and among disciplines. The natural environment and associated problems provide a rich context to accomplish these educational goals. However, educators need assistance in identifying relevant content and the complexities of environmental issues in order to teach them to their students. *This summary identifies areas within the revised STE where there is clear opportunity to build environmental literacy*[4]. An environmentally literate person—as appropriate for his/her age—can:

1. Understand ecosystems and how they function.
2. Appreciate natural phenomena and biodiversity through observation and direct experiences in natural settings.

---

[1] 2010 U.S Census Data. Retrieved from http://www.census.gov/2010census/data/apportionment-dens-text.php
[2] New England Aquarium. Retrieved from http://www.neaq.org/conservation_and_research/climate_change/climate_change_in_new_england.php#boston
[3] Massachusetts Department of Elementary and Secondary Education. (adopted January 26, 2016). *2016 Massachusetts Science and Technology/Engineering Standards* Retrieved from http://www.doe.mass.edu/stem/review.html
[4] McBride, B.B., Brewer, A.A., Berkowitz, A.R., & Borrie, W.T. (2013). Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here? *Ecosphere 4*(5), article 67, 1-20.

3. Think critically about how human actions affect ecological functioning and subsequent environmental concerns/problems that arise.
4. Participate in action planning for themselves and their community to address environmental issues.

A substantial number of stakeholders in Massachusetts' industries, higher education, and non-formal education are addressing environmental stewardship needs relevant to their organizational missions and foci, however, accessing this expertise is beyond the time constraints of most teachers. *This document contains a comprehensive list of the organizations in Massachusetts working to address environmental issues.* This identification of stakeholders and current resources related to environmental literacy, as well as the gaps and opportunities within the educational systems, will allow Phase II of developing a comprehensive environmental literacy plan to be carried out in subsequent efforts. Phase II would involve the engagement of stakeholders in a coordinated effort to develop the objectives of the environmental literacy plan and implementation strategies to include specific actions, resources, and mechanisms for enacting environmental literacy goals.

What is Environmental Literacy

The Importance of Environmental Literacy

With a global population of more than 7 billion and growing,[5] our planet is closely approaching its carrying capacity. The natural resources we rely on for food production, fresh water, and energy are limited. Growth of the human population also has far reaching costs to the natural world[6,7]. We face catastrophic global environmental problems concerning climate change, biodiversity loss, collapsing marine environments, extreme stressors to sectors of our food systems, and water shortages. With this uncertain future, we must find ways to engage the populace to innovate toward sustainable solutions for the benefit of ecological systems upon which humankind relies. Education is the path to innovation, and choosing effective means for educating young people about these difficult and complex issues is essential. In addition, studies have shown that explicit use of the natural environment and associated challenges can provide an effective educational context for integrating areas of study (such as history, literacy, and mathematics with science), for reducing truancy, and for improving test scores across disciplines[8, 9, 10]. A carefully conceived Environmental Literacy Plan for the Commonwealth can civically engage our residents, improve overall education, and eventually lead to helping us conserve our natural resources and environment. Simply put, Massachusetts needs environmental literacy so our residents can continue to lead the nation in innovative solutions to our collective environmental problems.

Defining Environmental Literacy

Environmental literacy is an essential foundation for vital, prosperous and healthy families and communities, and resilient ecosystems. With the MassELP as a guide, Massachusetts residents will develop an understanding of the interconnected relationships among community, economy and the environment. They will have an appreciation of the impacts that their choices and actions have on others, locally and globally, and on the natural systems that support our lives. Through education, innovation, stewardship, and an environmental ethic, citizens will act to help the state achieve an enduring balance between the needs of society and the natural systems that sustain us. Environmentally literate citizens will create and support an economically thriving and more sustainable Commonwealth.

Environmental literacy is a core goal of environmental education for which both formal and non-formal environmental educators need a solid foundation. When environmental educators discuss the possibility of a global populace that is informed about the natural world and their own connections to it, the concept they most often use is that of environmental literacy. *Environmental literacy uses natural systems or the environment as a learning tool to support learning outcomes across subject areas and teaching philosophies with a goal of providing a person with a knowledge base rooted in ecological systems.*

---

[5] United States Census Bureau. (Dec, 2015). *U.S and world population clocks*. Retrieved from http://www.census.gov/popclock/

[6] Wilson, E. O. (2002). *The future of life*. New York, NY: Random House.

[7] Davies, K. (2010). Sustainable minds. *Alternatives Journal,* 36(5), 8-11.

[8] Otto, S. and Kaiser, F.G. (2014). Ecological behavior across the lifespan: Why environmentalism increases as people grow older. *Journal of Environmental Psychology* (40), 331-338.

[9] Lieberman, G. A. and Hoody, L. (1998). *Closing the achievement gap*. San Diego, CA: State Education and Environment Roundtable.

[10] Ernst, J.A. and Monroe, M. (2004). The effect of environment-based education on students' critical thinking skills and disposition toward critical thinking. *Environmental Education Research*, 10(4), 507-522.

Environmental literacy has been defined in various ways, ranging from the acquisition of ecological knowledge to one's ability to address environmental concerns[11]. Former state-wide director of education for Mass Audubon and pioneer of state-wide environmental literacy plans, Charles Roth[12] states that environmental literacy is the capacity to perceive and interpret the relative health of ecosystems and take appropriate action to maintain and restore the health of those systems. The United Nations Educational, Scientific, and Cultural Organization[13] defines environmental literacy as functional education that provides people with the knowledge, skills, and motives to cope with environmental needs and contribute to sustainable development. The Framework for 21st Century Learning defines an environmentally literate student as one who can demonstrate knowledge of the environment along with societal impacts on the natural world, and can investigate environmental issues and take action on these issues[14]. Similarly, the Campaign for Environmental Literacy defines environmental literacy as the capacity of an individual to act successfully in daily life on a broad understanding of how people and societies relate to each other and to natural systems, and how they might do so sustainably[15]. Finally, the North American Association for Environmental Education (NAAEE) defines an environmentally literate person as someone who, both individually and together with others: makes informed decisions concerning the environment; is willing to act on these decisions to improve the well-being of other individuals, societies, and the global environment; and participates in civic life[16].

Collectively, these definitions outline the importance of acquiring and maintaining ecological knowledge, using that to make informed decisions, and civically engaging in communities for the betterment of both social and natural systems that sustain human life. It is important to focus the work of the MassELP behind one singular definition for a cohesive understanding of environmental literacy in the context of Massachusetts. To that end, the definition below incorporates the work of international constituents since the early inception of environmental education in the 1970's. It includes aspects of literacy important to the scientific community of ecology and science education, as well as the civic and behavioral awareness important to the environmental education and ecojustice communities.

An environmentally literate person—as appropriate for his/her age—can:

1. Understand ecosystems and how they function.
2. Think critically about how human actions affect ecological functioning and subsequent environmental issues/problems that arise.
3. Appreciate natural phenomena and biodiversity through observation and direct experiences in natural settings.
4. Participate in action planning for themselves and their community to address environmental issues.

[11] Daudi, S. S. (2008). Environmental literacy: a system of best-fit for promoting environmental awareness in low literate communities. *Applied Environmental Education & Communication,* 7(3), 76-82. doi: 10.1080/15330150802502155.
[12] Roth, C. (1992). *Environmental literacy: Its roots and directions in the 1990's*. Columbus, OH: Education Development Center.
[13] UNESCO-UNEP. (1976). *The Belgrade Charter*. Connect: UNESCO-UNEP Environmental Education Newsletter, *1*(1), 1-2.
[14] P21. (2015). *Framework for 21st century learning*. Retrieved May 10, 2015, from http://www.p21.org/about-us/p21-framework
[15] Campaign for Environmental Literacy. (2015) *Primer on environmental literacy*. Retrieved from http://www.fundee.org
[16] North American Association for Environmental Education. (2015). *What is environmental education*? Retrieved from http://www.naaee.net/what-is-ee

The Emergence of Environmental Literacy in Massachusetts: A Brief History

Environmental education is one critical tool with which we can achieve our goal for an environmentally literate Commonwealth. The North American Association for Environmental Education describes environmental education[17] as a pedagogy that teaches children and adults how to learn about and investigate their environment and, using that knowledge, how to make intelligent, informed decisions about taking care of it. The Belgrade Charter of 1976[13] defined the goal of environmental education as developing 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.

Environmental education has a long history in Massachusetts, in fact, the concept of environmental literacy was born here more than fourty years ago. A State Plan for Environmental Education was drafted in 1972 by a committee, chaired by then Massachusetts Audubon Society director of education, Charles Roth, with funds from the federal Environmental Education Act[18]. The plan initiated some strong voluntary environmental education efforts, but was not funded and thus never fully implemented. In 1999 an updated environmental education plan[19] was developed based on broad citizen input via working groups across the Commonwealth. Like the first plan the implementation was challenged due to lack of funding and inconsistent leadership. A new Plan must incorporate unaccomplished but important tasks from previous plans plus additional ventures for the next decade and beyond. It should also identify the infrastructure that is needed to support the implementation of this Plan.

Some noteworthy accomplishments since the original drafting of the Massachusetts Environmental Literacy Plan in 1972 include:

- Establishment of the Massachusetts Environmental Education Society and the Secretary's Advisory Group on Energy and Environmental Education (SAGEEE).
- Introduction and establishment of nationally respected and effective programs, such as Project Wet, Project WILD and Project Learning Tree, as part of the education landscape.
- Establishment of a variety of regionally or locally developed programs and projects that have taken hold and which are affecting the education process. Some of these projects originated as part of federal and state environmental protection efforts, such as the Watershed Education Program through the Extension Service, which grew out of the EPA's National Estuary Program efforts. There is also a program at Massachusetts Wildlife that grew out of the University of Michigan's Project GREEN.
- Development of environmental education efforts, such as the Benchmarks on the Way to Environmental Literacy.
- Development of recognition of outstanding school-based environmental education projects through the Executive Office of Environmental Affairs' Environmental Education Awards program, which brings exemplary projects to public attention.
- The founding of the Massachusetts Environmental Education Society (MEES) as the state affiliate organization for the North American Association for Environmental Education in 1990.

[17] North American Association for Environmental Education. (2015). *What is environmental education?* Retrieved from http://www.naaee.net/what-is-ee

[18] Environmental Education Act of 1970 (P.L. 91-516).

[19] Roth, Charles. (1999). *Massachusetts environmental education plan: Education to protect, restore, and preserve our commonwealth*.

- The launching of the MEES sponsored Massachusetts Environmental Education annual conference in 1990 http://massmees.org/annual-conference/ .

What is an Environmental Literacy Plan?

Environmental education in the United States is in the middle of a generational leap forward. Pedagogically, organizationally, and in spirit, the field is bursting with innovation and determination. At the same time, the reality of the alarming state of the environment, combined with limited resources for environmental education, makes it hard to know where to focus efforts or even believe we can ever do enough. Within the changing educational context of the Common Core English Language Arts[20] and Mathematics[21] Standards, Next Generation Science Standards[22], and related local efforts such as the 2016 Massachusetts Science and Technology/Engineering (STE) Standards[3], a national movement has quietly taken hold—nearly every state and the District of Columbia is preparing or revising Environmental Literacy Plans (ELPs)[23] to guide the field of environmental education in the coming years. Overall, Environmental Literacy Plans are frameworks for developing curricula, training teachers, coordinating efforts across many organizations and schools, assessing programs, and a few even detail high school graduation requirements.

An Environmental Literacy Plan provides a unified and collaborative framework for organizations, agencies, schools and individuals to help the general public and students understand, appreciate, and sustain the natural environment. This work was championed by the North American Association for Environmental Education (NAAEE), which provides resources to assist in the drafting of state ELPs.

As of this writing, nation-wide twenty Environmental Literacy Plans have been adopted by the state, ten are awaiting approval, and the remaining states (including Massachusetts) are in various stages of Environmental Literacy Plan development[24]. Of the twenty adopted plans, approximately a third have been enacted into law by state legislatures, a third have been adopted by executive order from their governors, and the remaining were administratively put into place by state departments of education, typically by the instigation of, and cooperation with, environmental education professional associations.

All of the ELPs completed or in drafting phases focus on PreK-12 and higher education, but many also have life-long learning components. In some states the department of education oversees the plans, others have specific subject offices such as science or social studies in charge, and some states have the state college system administer the plan.

In Massachusetts, the institutional home for the MassELP is one of the decisions to be made in the development of the Phase II Implementation Plan, however, options are provided later in this document for consideration.

---

[20] National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards for English language arts and literacy in history/social studies, science, and technical subjects*. Washington, DC: Authors. Retrieved from http://www.corestandards.org/ELA-Literacy/

[21] National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards for mathematics.* Washington, DC: Authors. Retrieved from http://www.corestandards.org/Math/Practice/

[22] NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states*. Retrieved from http://www.nextgenscience.org/next-generation-science-standards

[23] No Child Left Inside Coalition. *Environmental Literacy Plans by state*. Retrieved from http://www.cbf.org/ncli/action/environmental-literacy-plans-by-state#p

[24] North American Association for Environmental Education (2014). *State Environmental Literacy Plans: 2014 status report.* Retrieved from http://www.naaee.net/sites/default/files/programs/SELP/SELP.2.25.15.A.pdf

Why is an Environmental Literacy Plan Needed in Massachusetts?

The section that follows articulates the necessity for an increase in educational attention on environmental literacy in Massachusetts. While the state has several initiatives to address a myriad of environmental issues, the educational training for students is insufficient to prepare our future citizens to understand complex environmental problems and pose new, creative solutions.

Public Health Pressures

Environment related health concerns have long been a topic of study and concern within the public health sector. However, climate changes are expected to increase these pressures by affecting human health in a myriad of ways including heat-related illnesses and death, "respiratory illnesses, exacerbation of allergies and asthma, an increase in vector-borne diseases, and increase in illnesses associated with degraded water quality"[25]. These health challenges are associated with anticipated increases in summer temperatures (hotter and prolonged heat waves, decreased air quality, increased plant pollen production), increased precipitation (runoff releasing toxic chemicals and pathogens into water sources, increased breeding sites for mosquitoes, increase in mold spores), and increases in frequency and intensity of extreme weather[26]. The Governor Patrick Administration made strides to assess the readiness of our local health departments to address these problems in Massachusetts. To date, gradual progress has been made since the release of the findings in 2014 of the statewide survey[27] that recommended providing additional tools for citizens to understand these threats. This limited progress points to an opportunity for the education community to partner with public health to bolster the residents of our state in their understanding of how the environment directly impacts their health and wellbeing. Some of the existing resources and agencies that are working to provide knowledge about environment and health are listed in Appendix A, Table 1.

Ecological Challenges and Opportunities

The natural resources of the state are used in a variety of ways to contribute significantly to our economy through forest products, fisheries, agriculture, and recreation. Forested land provides ecosystem services that include but are not limited to: carbon sequestration, clean air, clean water, wildlife habitat, renewable resources, and recreational opportunities. The annual Gross State Output by the forest products industry is nearly $3 billion while the forest-based recreation economy generates an additional $2.2 billion annually. Massachusetts is 61% forested, and 64% of this land is privately owned with only 20% being state owned, 13% municipally owned, and 3% federally owned[27]. With the majority of Massachusetts forested land being privately owned, it is vital future forest landowners and decision makers understand the importance of the ecosystem services provided by forests. Sustainable forest management is not limited to the management of forests for long-term supply of wood products. The enhancement of wildlife habitat, creation of a diverse forest structure, and increasing recreational opportunities are examples of other forest management objectives. Permanent forest conservation plays an important role in protecting forests and ecosystem benefits for the long term. Forests can be protected permanently through fee purchase by the state or through conservation easements. Protected forests may be managed for wildlife habitat, wood resources,

---

[25] Bureau of Environmental Health Massachusetts Department of Public Health. (April 2014). *Capacity to address the health impacts of climate change in Massachusetts: Findings from a statewide survey of local health departments*. p.2. Retrieved from http://www.mass.gov/eohhs/docs/dph/environmental/exposure/climate-change-report-2014.pdf

[26] Executive Office of Energy and Environmental Affairs & Adaptation Advisory Committee. (2011). *Massachusetts climate change adaptation report*. Retrieved from http://www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf.

[27] North East State Foresters Association. (2015). *The economic importance of Massachusetts' forest based economy 2015*. Retrieved from *http://massforestalliance.org/wp-content/uploads/2015/06/1Economic-Importance-of-Massachusettss-Forest-Based-Economy-5-19-15-Final.pdf*

watershed protection, and many other human needs or ecological processes. This is often referred to as conservation. Permanently protected forests may also be left alone to allow natural processes to take place without human intervention. This is commonly referred to as preservation.

Forests play a critical role in carbon sequestration, which directly relates to one of our most pressing environmental issues, climate change. Carbon sequestration is one of these important natural processes that directly relates to one of our most pressing environmental issues, climate change. As a forest grows, through the process of photosynthesis atmospheric carbon dioxide is taken in by trees and the carbon is sequestered in the wood of the tree while oxygen is released back to the atmosphere. Consequently, as forests increase in volume and accumulate carbon mass they provide a positive benefit in the greenhouse gas equation. In Massachusetts, carbon in the above-ground portion of trees one-inch diameter or more increased more than 7% between 2007 and 2013 according to the USDA Forest Service, Forest Inventory and Analysis[29]. Forests managed for human or biological needs plays various roles in carbon sequestration. When trees are used for building material, carbon is stored for a very long time while a new forest grows. Processing a tree into dimensional lumber also uses less energy than the equivalent volume of concrete or steel, creating a carbon offset. Management techniques can focus on carbon storage by growing trees for a long time before harvesting them or leaving trees behind after a harvest to continue to grow and sequester carbon. Unmanaged forests (preserved forests) continually store carbon, releasing carbon as individual trees die and decay.

Forests are one of the natural resources that we rely on for our state economy, but others include ocean fisheries and farm land. Ocean fisheries are a significant contributor to the state's economy. According to the latest report on fisheries economics[28], Massachusetts ranks second nationally in the number of jobs impacted by the seafood industry (107,000 jobs) and third in the highest sales generated ($8.5 billion). The Massachusetts Ocean Management Plan[29] updated in 2015 articulates how the state will provide protection and sustainable use of state ocean waters, protect critical marine habitat and important water-dependent uses, and set standards for new ocean-based development. However, few outside the fishing industry are aware of the economics or the large scale impacts the changing climate will have on this vital industry.

Agriculture is another substantial industry in Massachusetts that is directly impacted by environmental issues.

> *The Massachusetts food system employs 426,000 people, or 1 of every 10 jobs in the state, and accounts for 4.5 percent of all economic activity. In 2012, there were over 41,000 farms and food businesses in Massachusetts, and the Commonwealth ranks sixth in the U.S. for the total number of "community supported agriculture," or CSA, farms[30].*

The Massachusetts Food Policy Council recently released a *Massachusetts Local Food Action Plan*[31] which is the first food system plan since 1974. There are several aspects of this plan designed to address challenges in the

---

[28] National Marine Fisheries Service. (2014). *Fisheries economics of the United States, 2012*. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-137, 175p. Retrieved from https://www.st.nmfs.noaa.gov/st5/publication/index.html

[29] Executive Office of Energy and Environmental Affairs, Office of Coastal Zone Management (January 6, 2015). Retrieved from http://www.mass.gov/eea/waste-mgnt-recycling/coasts-and-oceans/mass-ocean-plan/2015-final-ocean-plan.html

[30] Massachusetts Executive Office of Energy and Environmental Affairs. (2015). *Baker-Polito administration announces final Massachusetts food system plan.* Press release retrieved from http://www.mass.gov/eea/pr-2015/massachusetts-food-system-plan-announced.html

[31] Massachusetts Food Policy Council. (December 4, 2015). *Massachusetts local food action plan*. Retrieved from http://www.mapc.org/sites/default/files/MLFAPSummary.pdf

entire food system in Massachusetts. Education of producers, processors, and consumers is one of the key goals of the plan.

> *The plan calls for a system that clearly informs consumers about the implications of their food purchases, and reinforces the connections between those purchases and the growth of the State's economy, viability of our farms, fisheries, and other food businesses, and preservation of the open working landscapes that so many Massachusetts residents value* (p. 15, Introduction).

Climate change and sea level rise will affect the city of Boston and eastern half of the state of Massachusetts in a profound way. Being a coastal state, there are huge implications for health, welfare, building, economy, and natural resources (fisheries, estuarine habitats). The science of climate change is little contested in the state, but large-scale efforts to make changes to our infrastructure or social structure to meet these challenges has lagged. While a number of the state initiatives and plans highlighted here address environmental concerns, many residents are unaware of them. See Appendix A, Table 2 for a full listing. The MassELP will provide a mechanism for bridging the different industries and sectors of our economy and translating technical documents into citizen-friendly versions that can be easily understood and will build our citizens' environmental literacy.

Civic Initiatives

There are numerous examples of vibrant civic engagement in the State. There is a growing recognition of the connection between civic engagement and knowledge of, and action towards environmental issues. Examples range from the development of town conservation commissions, to the growth of community gardens and neighborhood associations.

The North American Association for Environmental Education has recently prioritized civic and community environmental education engagement through the development of *Community Environmental Education Guidelines*[32]. Others in academic communities[33] have begun to embrace the idea of Civic Ecology[34] where residents can civically engage in their communities to reclaim and restore natural systems.

In 2014 an Executive Order[35] requiring Secretariats to take action in promoting environmental justice was signed by Governor Patrick. The Executive Order requires new environmental justice strategies that promote positive impacts in environmental justice communities and focus on several environmental justice initiatives ranging from public health to community and civic engagement.

In 2014 the Massachusetts Board of Higher Education released the *Preparing Citizens Report on Civic Learning and Engagement*[36] highlighting the importance of civic learning and engagement for our young adults. In 2015 the Massachusetts Service Alliance oversaw 23 AmeriCorps programs aimed at providing young adults opportunities to give back to and engage communities in issues related to environmental and social well-being. See Appendix A, Table 3 for additional organizational information. As of December 2015 thirteen

---

[32] Towards Community Engagement blog. Retrieved from https://naaee.org/eepro/blog/towards-community-engagement
[33] Cornell University Civic Ecology Lab. http://civicecology.org/
[34] Krasny, M.E. and Tidball, K.G. 2012. Civic ecology: a pathway for earth stewardship in cities. *Frontiers in Ecology and the Environment,* (10), 267–273. Retrieved from http://dx.doi.org/10.1890/110230
[35] Patrick, D. (n.d.) Executive Order on Environmental Justice No.552. Retrieved from http://www.mass.gov/courts/docs/lawlib/eo500-599/eo552.pdf
[36] Study Group on Civic Learning and Engagement for the Massachusetts Board of Higher Education. March, 2014. *Preparing citizens: Report on civic learning and engagement.* Retrieved from http://www.mass.edu/preparingcitizensreport/2014-03PreparingCitizensReportOnCivicLearningAndEngagement.pdf

communities in Massachusetts have officially become "Transition Town" communities—communities seeking to mitigate the global crises by engaging their communities in home-grown, citizen-led education, action, and multi-stakeholder planning to increase local self-reliance and resilience.

Citizen Science opportunities throughout Massachusetts and beyond[37] encourage interested citizens to contribute to scientific studies by conducting regular natural history observations and recording events of interest. Some projects focus on rare species of reptiles or birds, others on when plants first bloom or leaf out. These kinds of direct natural history opportunities are one of the best examples of civic engagement that can lead to better environmental literacy. However, it is not currently possible to find out about civic activities in one centralized location, making it difficult for anyone to happen upon a group that might be of interest.

Economic Opportunities

In 2014, Massachusetts was ranked fifth in the nation for sustainable building design, construction and transformation[38]. We are also a leader in energy efficiency with clean energy yielding significant economic benefits through a 47 % growth in jobs since 2010. Massachusetts is a clean-energy leader, ranking second behind California of the top 15 clean-energy states[39]. Within the Massachusetts Department of Energy Resources there are numerous initiatives for encouraging: renewable resources, energy efficiency, green communities, green businesses, and alternative transportation. However, for a green economy to continue to grow here in Massachusetts, students need to graduate with an understanding of the complexities of the issues related to both the economics and natural resources of these new business opportunities. The success of these businesses also relies heavily on an environmentally literate citizenry to provide the customer base for this burgeoning sector of our state economy. Unfortunately, there is little specifically addressing these technologies in the Massachusetts' Science Technology/Engineering standards[3]. When these energy and human social interfaces are touched on it is obliquely, leaving much up to the knowledge and interest of individual teachers to make the connections between basic science concepts and their application to green technologies and businesses.

Business leaders in the state recognize this knowledge gap[40] and are working with many different types of colleagues to enact a STEM (Science, Technology, Engineering, Mathematics) Agenda for Massachusetts[41, 42] via the STEM Advisory Council that was established by executive order of Governor Patrick and continues under Governor Baker. See Appendix A, Table 4 for additional organization information.

---

[37] Friends of the Assabet River National Wildlife Refuge. http://www.farnwr.org/volunteer1.html

[38] Massachusetts Executive Office of Energy and Environmental Affairs. *Massachusetts ranks 5th in nation for LEED certified buildings.* Press Release retrieved February 11, 2015 from http://www.mass.gov/eea/pr-2015/ranks-5th-in-nation-for-leed-certified-buildings.html

[39] Clean Edge, Inc. 2010. *A future of innovation and growth: Advancing Massachusetts' clean-energy leadership.* Retrieved from http://images.masscec.com/uploads/attachments/Create%20Basic%20page/A_Future_of_Innovation_and_Growth_Advancing_Massachusetts'_Clean-Energy_Leadership.pdf

[40] Massachusetts Department of Higher Education. (October 2014). *Degrees of urgency: Why Massachusetts needs more college graduates now.* Retrieved from https://www.tbf.org/~/media/TBFOrg/Files/Reports/2014%20Vision%20Project-%20Degrees%20of%20Urgency.pdf

[41] Massachusetts Business Organizations. (2009). *Tapping MA potential: The MA employers' STEM agenda.* Retrieved from https://maroundtable.com/doc_reports/0906_TAP_Report.pdf

[42] Governor's STEM Advisory Council (November, 13, 2013). *A foundation for the future: Massachusetts' plan for excellence in STEM education: Version 2.0 expanding the pipeline for all.* Retrieved from http://www.mass.edu/stem/documents/2013-11MassachusettsSTEMPlan2.0.pdf

The themes around which the STEM Plan 2.0[43] is built are: (1) reducing gaps in achievement, interest, and skills; (2) creating and maintaining a skilled STEM educator workforce; (3) exploring diverse and innovative instructional strategies to promote the teaching and learning of STEM; and (4) increasing the scale of programs across the Commonwealth. There are five goals articulated in that plan:

> *1. Increase student interest in STEM areas. 2. Increase student achievement among all PreK–12 students in order to prepare graduates to be civically and college and/or career ready. 3. Increase the percentage of skilled educators who teach PreK–16 STEM. 4. Increase the percent of students completing postsecondary degrees or certificates in STEM subjects. 5. STEM degrees and certificate attainment will be aligned with corresponding opportunity in STEM-related fields to match the state's workforce needs for a STEM talent pipeline. p.4*

Version 2.0 builds on Version 1.0, which focused on[43] establishing an organizational structure of several State government departments, business partners, and educational units. Regional STEM Networks were developed to represent community interests (including non-formal educators) into the effort.

> *The Regional STEM Networks bring together public and private K-12 schools and districts, public and private higher education institutions, business and industry, regional employment/workforce investment boards and non-profit organizations around STEM to address local education and workforce needs. Each network is managed by an executive director and housed in either an institution of higher education or a regional employment board. As a regional system, managed by the Department of Higher Education under the direction of the Governor's STEM Advisory Council, the networks play a key function in implementing the goals of STEM Plan 2.0 by coordinating and promoting collaborations of STEM programs, projects and partners. The networks regularly communicate information about funding opportunities, events, announcements, and training sessions. Funding for the networks comes from the STEM Pipeline Fund.*[44]

There are currently nine regional networks with varying degrees of resources and programming options provided on their websites. This network provides an existing community of educators to which additional programming and resources developed with a specific focus on environmental literacy can be distributed. There is currently not a great deal of overlap between environmental education and STEM education in terms of professional communities. However, for the green economy to truly flourish and ensure a pipeline of interested, prepared environmentally literate students and workers, these educational communities need to come together to embrace common goals and consistent strategies.

Educational Opportunities

The national rollout of the Next Generation Science Standards[22] (NGSS), and companion Massachusetts STE Standards[3] revision, have shifted the education landscape toward (1) more explicit integration of key concepts across grade levels and (2) the application of those concepts through scientific and engineering practices to understand everyday issues. On December 9, 2015 congress passed a new K-12 education law that empowers schools, promises more flexibility for states, and reduces the reliance on high-stakes testing in public schools while maintaining strong oversight of student achievement. Included in the *Every Student*

[43] Governor's STEM Advisory Council (September, 28, 2010). *A foundation for the future: Massachusetts' plan for excellence in STEM education: Version 1.0 building the pipeline of STEM professionals to fuel Massachusetts' innovation economy.* http://www.mass.edu/stem/documents/MA_STEM_Plan_Final_9_28_10.pdf

[44] The STEM Nexus website. http://www.mass.edu/stem/getinvolved/pipelinenetworks.asp.

Succeeds Act (ESSA)[45], a bipartisan bill that replaces the *No Child Left Behind Act*, is a key provision co-authored by U.S. Senator Jack Reed (D-RI) and Congressman John Sarbanes (D-MD) that aims to strengthen environmental education programs in schools across the country. The *Every Student Succeeds Act* will allow school districts to use federal funds for environmental education into their curriculum and out-of-school programs to ensure a well-rounded education. It is, then, an opportune time to systematically integrate aspects of environmental education into both the formal and non-formal educational landscape of Massachusetts to explicitly foster the development of an environmentally literate citizenry. See Appendix A, Table 5 for additional information on educational stakeholders in the State and resources available.

Working Towards Environmental Literacy in Massachusetts

Components of Environmental Literacy

The North American Association for Environmental Education's (NAAEE) *Excellence in Environmental Education Guidelines for Learning* (Pre K-12)[46] serves as the national reference for environmental education. These guidelines are organized into four strands that represent different aspects of environmental education leading to environmental literacy. The four strands are: questioning, analysis, and interpretation skills; knowledge of environmental processes and systems; skills for understanding and addressing environmental issues; and personal and civic responsibility. While NAAEE's guidelines are useful, they are not articulated at a standards-approach level of specificity, thus they remain rather broad and less useful for comparison to our State Frameworks. A number of organizations and scholars have continued to refine these general guidelines, most notably by adapting them for specific environmental topics such as *sustainability literacy*[47], *ecological literacy*[48], *earth science literacy*[49], *energy literacy*[50], *climate literacy*[51], *science literacy*[52], *atmospheric literacy*[53], *and ocean literacy*[54]. When taken as a collective, the components of environmental literacy that are consistent across environmental areas emerge, and are reflected in Figure A below.

[45] United States Congress. *The every student succeeds act* (S.1177). Retrieved from https://www.gpo.gov/fdsys/pkg/BILLS-114s1177enr/pdf/BILLS-114s1177enr.pdf

[46] North American Association for Environmental Education. (2010). *Excellence in environmental education: Guidelines for excellence*. NAAEE Publications: Washington D.C.

[47] Murray, P., Brown, N., & Murray, S. (n.d.) Deconstructing sustainability literacy: The cornerstone of education for sustainability? The role of values. *The International Journal of Environmental, Cultural, Economic and Social Sustainability*, (2)7, 83-92. Retrieved from http://ijs.cgpublisher.com/product/pub.41/prod.2

[48] Center for Ecoliteracy website: http://www.ecoliteracy.org/resources

[49] Earth Science Literacy Initiative (n.d.) *Earth Science Literacy Principles.* Retrieved from http://www.earthscienceliteracy.org/

[50] U.S. Department of Energy (n.d.) *Energy Literacy: Essential principles and fundamental concepts for energy education.* Retrieved from http://energy.gov/sites/prod/files/2014/09/f18/Energy_Literacy_Low_Res_3.0.pdf

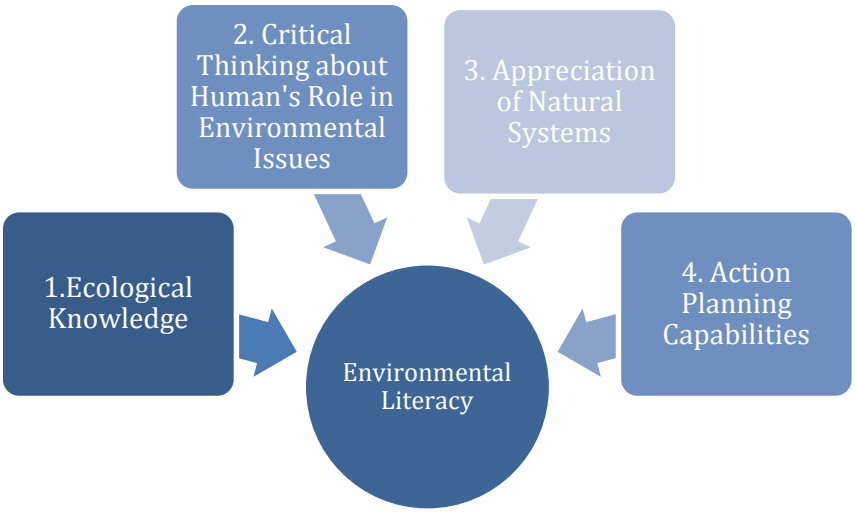
[51] U.S. Global Change Research Program (March 2009). *Climate Literacy: The essential principles of climate science.* Retrieved from http://cpo.noaa.gov/sites/cpo/Documents/pdf/ClimateLiteracyPoster-8_5x11_Final4-11.pdf

[52] American Association for the Advancement of Science (2009). *Benchmarks for Science Literacy.* Retrieved from http://www.project2061.org/publications/bsl/online/index.php

[53] University Corporation for Atmospheric Research (2007). *Essential principles and fundamental concepts for atmospheric science literacy.* Retrieved from http://eo.ucar.edu/asl/

[54] National Oceanic and Atmospheric Administration's Office of Education and the National Marine Sanctuary Foundation. *Ocean Literacy: The essential principles and fundamental concepts of ocean sciences for learners of all ages (Version 2: March 2013).* Retrieved from http://www.coexploration.org/oceanliteracy/documents/OceanLitChart.pdf

Figure A. Environmental Literacy Components



For an individual to become environmentally literate, he or she needs opportunities to experience natural systems in order to develop an emotional connection, appreciation, and motivation to protect them. An individual needs to obtain objective knowledge about ecology, how human social systems work, and the contributing factors to pressing environmental issues[55]:

- Climate change (implications for precipitation, coastlines, disease vectors)
- Pollution (waste quality, pesticide dependence, air quality, clean energy development)
- Natural resource depletion (water shortages, collapse of fisheries, spills of mining waste, desertification)
- Habitat and biodiversity loss in various kinds of ecosystems (forests, oceans, grasslands, fresh water)
- Human population growth (pressures on natural systems, sustainable communities)

Individuals need the opportunity to develop skills of action planning for themselves and their community to address environmental issues. These skills include weighing evidence, consideration of multiple perspectives, and making a decision with concrete steps for enacting that decision. The components identified in Figure A, can also guide the kind of educational experiences Massachusetts residents should have to become more environmentally literate and actively engaged in solutions to environmental challenges.

Identifying Gaps in our Current Education Standards

When the 2016 adopted STE standards[3] were reviewed for this summary (by the authors), gaps in the opportunities for students to develop environmental literacy emerged. Appendix B lists the standards (PreK-12 by conceptual area) that can be met through instruction about environmental issues. In the last column of each table is noted the Environmental Literacy Goals (from Figure A) that could also be addressed by a student meeting this standard. There are twelve standards that meet more than one goal (see Appendix B). There are 264 standards listed, and of those, 122 (46%) meet at least one environmental literacy (EL) goal. When each goal is considered separately, a more concerning picture emerges. Of the 122 standards that meet at least one EL goal:

[55] Natural Resources Defense Council website: http://www.nrdc.org/issues/

- 87 (71%) meet goal 1—E*cological systems knowledge*
- 27 (22%) meet goal 2—*Critical thinking about human's role in environmental issues*
- 6 (5%) meet goal 3—*Appreciation of natural systems through direct observation and experience*
- 14 (11%) meet goal 4—*Action planning capabilities*

This indicates a heavy reliance on knowledge building (goal 1), and nearly none on developing an affectively positive association with natural systems (goal 3). Even if a student meets all 122 standards over the course of her formal education, she will graduate having had little opportunity to exercise her ecological knowledge through critically grappling with human's role in creating, exacerbating, or solving environmental issues (goal 2), or developing new or better solutions for themselves or their communities (goal 4).

Table 16 in Appendix B displays the percentage of standards by conceptual area and grade level that address at least one Environmental Literacy Goal. From this analysis we can see that within the Earth and Space Science conceptual area, 93% of the standards address at least one environmental literacy goal, and in the Life Science area 72% of the standards address an EL goal. However, in Physical Science it is only 3% (all related to energy) of the standards and in Technology/Engineering it is 28% of the standards that address an environmental literacy goal. This is particularly concerning because many of the potential solutions to our environmental crises depend on the kind of innovation that will require the application of physical science through technology and engineering to solve. Students often struggle with the abstract nature of physics concepts and the indirect causality that is frequently at play in many physical phenomena. For this reason, using environmental issues to explore the application of physics concepts may make this subject area more meaningful to students and perhaps spark their interest in STEM career options.

Bridging these gaps in our current standards pose an opportunity to be met by other types of educators. Non-formal educators and stakeholders already play a critical role in the development of an environmentally literate populace in concert with more active partnerships with formal educators. Non-formal environmental education can take place in zoos, museums, aquariums, nature centers, community centers, and via businesses. Non-formal partners may serve as providers of programing to young people (both in and out of school) and/or providers of professional development for formal educators. Non-formal educators are passionate about their work and knowledgeable about environmental content, however, it is critical that non-formal educators unite behind the goals and objectives of the MassELP so that all educators may advance with shared goals and objectives.

Before non-formal partners engage with young people or formal educators it is critical that they themselves have a solid foundation in the principles of environmental literacy. They should not only have a robust understanding of what it means to be environmentally literate, but they must also reflect on their own level of environmental literacy. Non-formal educators should enhance their own understanding of environmental literacy through on-going professional development.

Non-formal educators have the opportunity to provide content directly to many audiences, but to do this well, the providers need to be knowledgeable about not only the content, but also pedagogies that are effective in non-formal learning arenas. Environmental pedagogical practices that non-formal educators should be well-versed in include, but are not limited to: inquiry-based teaching and learning, place-based education, youth development, systems thinking, citizen science, experiential learning, and outdoor education.

An environmentally literate non-formal educator should work diligently to become active participants in community outreach. Through deeply understanding environmental content educators should then explore ways in which content knowledge can be used to aid their audiences in civic engagement. Non-formal educators must approach their practice through a systems thinking lens and look for creative ways to make environmental issues applicable to the cities and neighborhoods where young people live.

The other kind of intervention that non-formal educators can engage in is professional development. With a comprehensive understanding of environmental pedagogies, practices, and content non-formal educators are well positioned to serve as professional development providers for educators in formal settings. This can come in the form of providing in-service professional development for formal educators, hosting workshops at non-formal sites, and/or partnering with fellow community-based organizations and businesses for collaborative professional development.

Next Steps for Phase II: Implementation

This document is the first step towards addressing environmental literacy in an explicit way in Massachusetts. It identifies why environmental literacy is important to many of the existing economic and civic initiatives currently ongoing in the Commonwealth. It identifies who are the current stakeholders working in various ways on environmental issues (Appendix A). It identifies where in the current educational standards there are areas of clear connection to building environmental literacy and where there needs to be augmentation by teachers supported by non-formal educators (Appendix B).

The next steps are to take the information compiled here to begin in earnest a coordinated multi-stakeholder effort around the construct of Environmental Literacy as defined in this document.

Identifying an Organizational Home for MassELP

Since this effort has thus far been spearheaded by the Secretaries Advisory Group for Energy and Environmental Education (SAGEEE), which cannot by its structure lead Phase II and ongoing management of this effort, a new organizational home needs to be appointed. There are several options for groups that could serve this role:

- Massachusetts Environmental Education Society (MEES)—the state affiliate for the North American Association for Environmental Education. This is a volunteer organization with staffing and funding associated constraints that would need to be considered.
- Massachusetts Audubon Society—a state-wide non-profit education and conservation organization with a strong network of educators and communication avenues. Some funding may be available initially, but a long-term strategy would be needed.
- A Program within the Executive Office of Energy and Environmental Affairs
- Department of Elementary and Secondary Education—STEM unit
- An Institution of Higher Education

The organizational home of the MassELP, will need to have capacity to host a paid, dedicated staff to collaborate with an appointed task force of stakeholders and coordinate a cooperative approach to design and implement an implementation plan for environmental literacy. The organizational home will also need the capacity to host a dedicated website and social media platform which can reflect a multi-stakeholder effort. The MassELP should have its own branding to reflect the multiple stakeholders that will be contributing to this effort and should not become subsumed under an existing organization to avoid

undermining the interest of other stakeholders in contributing to the effort. An organizational home is needed to oversee and keep vibrant the MassELP effort over time. This will require some level of funding from a source yet to be identified. With the passage of the *Every Student Succeeds Act*, there may be funds that Massachusetts could direct to support the development of the MassELP Implementation Plan (Phase II) and establishment of an organizational home. There may also be other state funding and/or Massachusetts foundations willing to contribute to the effort if it is undertaken by a 501(c)(3) status institution. This organizational home would be responsible for demonstrating accountability for meeting the goals of the MassELP.

Engaging Stakeholders

Regardless of the final institutional home for the MassELP effort, there must be a sense of legitimacy bestowed upon it from an agent of the State government, either Secretaries or the Governor. Since the intent of the MassELP is to have a state-wide reach with multi-stakeholder investment, this show of support is essential for it to have any traction and staying power, unlike the previous efforts noted earlier in this document. After the release of this Phase I Summary document at the MEES conference in March 2016, this governmental support will be sought to enable the institutional home of the MassELP to reach out to those agencies and organizations identified in this document to begin the process of Phase II.

As with any long-term effort, maintaining engagement of participants is an ongoing effort. The best way to encourage engagement is through hosting collaborative learning opportunities, offering resources and related news on a regular basis. Some of the educators that should be included in providing these resources and professional development resources are:

1. District-level curriculum coordinators to leverage existing programs
2. Higher education community doing curriculum development and pre-service training
3. Non-formal education community providing content and professional development

The Appendix A of this summary provides a starting point for developing a network through a community engagement/stakeholder meetings and a dedicated website. The next step would be in Phase II to determine the framework for community engagement meetings and corresponding layout of the website, how information from each sector (health, environmental resources, civic, economic, and education) of stakeholders will be represented and updated. Some suggested resources that should be initially developed for the website include:

For educators:

- Professional development offerings for current and pre-service educators around the principles of environmental education and environmental literacy – what it is and what it looks like in practice is crucial.
- Environmental Science curriculum designed with crosswalks to other State science and Common Core Standards so that educators can create more productive and meaningful instructional time.

For civic and environmental health groups:

- A framework for understanding our natural resources and connected systems.
- A platform for service-based initiatives.

For businesses and resource agencies:

- Success stories of businesses that support environmental literacy efforts.
- Highlight legislation and regulations that have particular bearing on environmental issues.
- Tracking community actions and trends across the state related to the environment.

One current example of an effective collaborative effort that could serve as a model for the MassELP is the The New England Ocean Science Education Collaborative (NEOSEC) http://www.neosec.dreamhosters.com/about/. This collaborative leverages and strengthens the region's extraordinary ocean science and educational assets to advance understanding of the vital connections between people and the ocean. To support this mission, member institutions:

- Expand their collective capacity to bring ocean science to the public by working together and learning from each other.
- Create and deliver programs to diverse audiences by working in partnership with people and organizations who share our mission.
- Create and disseminate materials and programs that enable people of all ages, from diverse backgrounds and experience, to learn about the ocean
- Model innovative and effective methods for integrating ocean sciences and scientists into education and outreach efforts.

NEOSEC taps into the wealth of ocean resources in the region. The diversity represented by NEOSEC of professional expertise (from aquarists to institutional Vice Presidents), resources (animals, boats, visitor centers, and libraries), locations (urban to rural, sandy, rocky, and marshy coastlands), and audiences (from pre-school to adult learners, both formal and informal) facilitates strong connections between New England scientists and educators, linking research and practice to create powerful and effective educational programs and materials. Critical to their success is the partnerships between organizations, scientists, and educators who, with the member organizations, deliver programs to diverse audiences.

Developing an Implementation Plan with Actionable Items over 5-Year Timeframe

The main body of work for Phase II will be to develop a substantive implementation plan with input from the stakeholder groups identified in this document. There are a couple of examples of existing implementation plans from other states that can be used as guides:

California State Superintendent of Public Instruction Tom Torlakson's statewide Environmental Literacy Task Force (2015). *A blueprint for environmental literacy: Educating every California student in, about, and for the environment* Retrieved from file:///C:/Users/Daphne%20Minner/Documents/MASSELP/State%20ELPs/CA20environliteracyblueprint.pdf

Maryland State Department of Education (June 2010). *Environmental education in Maryland public schools: The development and implementation of Maryland's environmental education program.* Retrieved from file:///C:/Users/Daphne%20Minner/Documents/MASSELP/State%20ELPs/MD%20Environmental-Ed_Guide_FINAL.pdf

APPENDIX A: Environmental Literacy Related Resources

Table 1. Public Health Organizations and Resources

Public Health Resources	Mission and Website
Executive Offices of Health and Human Development	The Bureau of Environmental Health (BEH) has a broad mission of protecting the public health from a variety of environmental exposures. http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/ Key Report: 2014 Report on Capacity to Address the Health Impacts of Climate Change in Massachusetts: Findings from a statewide survey of local health departments. http://www.mass.gov/eohhs/docs/dph/environmental/exposure/climate-change-report-2014.pdf
Harvard T.H. Chan School of Public Health	Center for Health and the Global Environment. The mission is to help people understand that our health, and that of our children, depends of the health of the environment, and that we must do everything we can to protect it. The Center was hounded in 1996 to study and promote a wider understanding of the human health consequences of global environmental change. http://www.chgeharvard.org/resources The Center is an official Collaborating Center of the U.N. Environmental Programme. http://www.unep.org/
National Environmental Education Foundation (NEEF)	The National Environmental Education Act of 1990 established the National Environmental Education and Training Foundation, operating as the National Environmental Education Foundation (NEEF), as an independent non-profit organization complementary to the US Environmental Protection Agency (EPA), extending its ability to foster environmental education for all ages and in all segments of the American public. They have initiatives for health, nature, weather and climate. http://www.neefusa.org/

Table 2. Ecological Organizations and Resources

Ecological Resources	Mission and Website
MA Department of Conservation and Recreation (DCR)	DCR strives to protect, preserve, manage and enhance the natural and cultural resources of the Commonwealth in order to promote healthy, livable and sustainable communities, and to connect people to these resources through recreation and education. This agency offers training for teachers in Project Wet, Project Wild, and Project Learning Tree. www.mass.gov/eea/agencies/dcr
MA Department of Fish and Game (DFG)	DFG is charged with stewardship of the Commonwealth's marine and freshwater fisheries, wildlife species, plants and natural communities, and wildlife dependent recreation. Specific Divisions include: Division of Fisheries and Wildlife; Division of Ecological Restoration; Office of Fishing and Boating Access; Division of Marine Fisheries; Land Protection Program. www.mass.gov/eea/agencies/dfg/about *Climate Action Tool.* With this tool, you can: access information on climate change impacts and vulnerability of species and habitats, and explore adaptation strategies and actions to help maintain healthy, resilient natural communities based on your location and interests. Initial development of the tool is focused on fish and wildlife species, forests and forestry practices, landscape connectivity (with a focus on climate related impacts on roads and culverts), land protection, and conservation planning. http://climateactiontool.org/content/about-us
MA Department of Agricultural Resources (DAR)	DAR works to provide a safe, local supply of high quality foods and to strengthen the economic viability of Massachusetts agriculture. DAR promotes the environmental sustainability of the agricultural industry by preserving significant farmland resources and supporting agriculture as an important part of the Commonwealth's economy. Agricultural Preservation Restriction Program is of particular interest for environmental literacy action planning. www.mass.gov/eea/agencies/agr

Ecological Resources	Mission and Website
MA Department of Environmental Protection (DEP)	DEP is responsible for ensuring clean air and water, the safe management of toxics and hazards, the recycling of solid and hazardous wastes, the timely cleanup of hazardous waste sites and spills, and the preservation of wetlands and coastal resources. http://www.mass.gov/eea/agencies/massdep/about/ Clean Energy Results Program http://www.mass.gov/eea/agencies/massdep/climate-energy/energy/ Climate Action http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ Wind Turbines http://www.mass.gov/eea/agencies/massdep/climate-energy/energy/wind-turbines/
MA Office of Coastal Zone Management (CZM)	CZM's mission is to balance the impact of human activities with the protection of coastal and marine resources through planning, public involvement, education, research, and sound resource management. To achieve these goals, as well as to meet the needs of municipal officials, property owners, educators, and others in the coastal community. http://www.mass.gov/eea/agencies/czm/ MA Bays National Estuary Program (MassBays) http://www.mass.gov/eea/agencies/mass-bays-program/about-us/ Buzzards Bay National Estuary Program http://www.mass.gov/eea/agencies/czm/national-estuary-programs/buzzards-bay/
Massachusetts Watershed Coalition (MWC)	The mission is to protect and restore watershed ecosystems to sustain healthy rivers, streams, lakes, water supplies, terrestrial and aquatic habitats. www.commonwaters.org
Massachusetts Land Trust Coalition (MLTC)	The Coalition is an association of land trusts founded to provide a forum for the exchange of ideas and information, to increase the effectiveness of Massachusetts land trusts in working with the state legislature and environmental agencies, and to promote high professional standards. www.massland.org
Trustees of Reservations	The Trustees preserve, for public use and enjoyment, properties of exceptional scenic, historic, and ecological value in Massachusetts. www.thetrustees.org
Mass Audubon	The role of Mass Audubon is to serve as a leader and catalyst for conservation, by acting directly to protect the nature of Massachusetts and by stimulating individual and institutional action through conservation, education, and advocacy. They offer hundreds of education programs throughout Massachusetts. http://www.massaudubon.org/ Citizen Science opportunities http://www.massaudubon.org/get-involved/citizen-science

Ecological Resources	Mission and Website
New England Wild Flower Society (NEWFS)	The mission is to conserve and promote the region's native plants to ensure healthy, biologically diverse landscapes. They have one of the largest programs in native plant education in the country and offer hundreds of programs for children and adults throughout New England. They offer certificate programs in Field Botany and Native Horticulture and Design. http://newfs.org/
National Park Service	The National Park Service preserves the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations. The Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world. http://www.nps.gov/state/ma/index.htm
The Nature Conservancy	The mission is to conserve the lands and waters on which all life depends. http://www.nature.org/
U.S. Fish and Wildlife Service	The objectives of the Service are (1) to assist in the development and application of an environmental stewardship ethic for our society, based on ecological principles, scientific knowledge of fish and wildlife, and a sense of moral responsibility; (2) guide the conservation, development, and management of the Nation's fish and wildlife resources; and (3) administer a national program to provide the public opportunities to understand, appreciate, and wisely use fish and wildlife resources. The Service is a Bureau within the Department of the Interior. Northeast Region http://www.fws.gov/northeast/

Table 3. Civic Organizations and Resources

Civic Engagement Resources	Mission and Website
Transitions United States	The transition movement is comprised of vibrant, grassroots community initiatives that seek to build community resilience in the face of such challenges as peak oil, climate change and the economic crisis. As of January 2016, there are thirteen official Transition Towns in Massachusetts. http://transitionus.org/
Massachusetts Service Alliance (MSA)	Established in 1991, the MSA serves as the state commission on community service and volunteerism. Its mission is to catalyze the innovation and growth of service and volunteerism by creating partnerships that maximize resources, expertise, capacity and impact. http://www.mass-service.org/
Massachusetts Association of Conservation Commissions (MACC)	Massachusetts invented the municipal Conservation Commission in 1957. The duties and responsibilities of a Conservation Commission are spelled out in the Conservation Commission Act. The Conservation Commission is the official agency specifically charged with the protection of a community's natural resources. The Commission also advises other municipal officials and boards on conservation issues that relate to their areas of responsibility. Commissions are the local environmental agencies responsible for protecting the land, water and biological resources of their communities. MACC supports the work of the town Commissions, and participates in professional education and advocacy activities. https://www.maccweb.org/
The Garden Club of America (GCA)	The purpose is to stimulate knowledge and love of gardening, to share the advantages of association by means of educational meetings, conferences, correspondence and publications, and to restore, improve and protect the quality of the environment through educational programs and action in the fields of conservation and civic improvement. The club was founded in 1913 and there are 12 clubs in Massachusetts https://www.gcamerica.org/
Massachusetts Horticultural Society	The Society was founded in 1829, and is dedicated to encouraging the science and practice of horticulture and developing the public's enjoyment, appreciation and understanding of plants and the environment. They offer a Master Gardener Certificate Program. www.masshort.org
The Stewardship Network New England	This is a clearinghouse for citizen science projects throughout New England. http://newengland.stewardshipnetwork.org/
The Union of Concerned Scientists (UCS)	The UCS puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with citizens across the country, they combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe and sustainable future. The key areas of interest include: clean energy, clean vehicles, food and agriculture, global warming, nuclear power and nuclear weapons. http://www.ucsusa.org/

Civic Engagement Resources	Mission and Website
Environment Massachusetts Research & Policy Center, Inc.	They are dedicated to protecting our air, water and open spaces. They investigate problems, craft solutions, educate the public and decision-makers, and help the public make their voices heard in local, state and national debates over the quality of our environment and our lives. http://www.environmentmassachusettscenter.org/
Environmental League of Massachusetts (ELM)	ELM is dedicated to protecting the health of our environment and citizenry by safeguarding the land, water and air of our Commonwealth. ELM is focused on environmental advocacy and strengthening the voice and effectiveness of the environmental community. ELM advocates for strong environmental laws and regulations of a broad range of environmental issues, voices the concerns of citizens, ensures that laws are properly implemented and enforced, and educates the public. http://www.environmentalleague.org/
Massachusetts 4-H Youth Development Clubs (4-H)	Massachusetts 4-H is a youth development program open to all young people ages 5 through 18 throughout the Commonwealth. It is part of a nationwide system connected to each land-grant institution of higher education and as such, has access to a wealth of resources and curriculum. In Massachusetts, 4-H is based at the University of Massachusetts Amherst and has offices in seven regions of the state. Based on the Eight Essential Elements of Positive Youth Development, 4-H helps young people learn life skills under the guidance of trained, screened volunteers in non-formal educational settings such as clubs, camps and afterschool programs. These Essential Elements can also be viewed as the Five "C's" – Competence, Confidence, Connection, Character and Caring. When young people work on these characteristics they demonstrate a Sixth "C": Contribution to self, family, community and the institutions of a civil society. They have a science, engineering and technology program area. https://mass4h.org
Natural Resources Defense Council (NRDC)	NRDC is an environmental action group, combining grassroots efforts of members with the expertise of nearly 500 lawyers, scientists and other professionals. They work to safeguard the earth—its people, its plants and animals and the natural systems on which all life depends. http://www.nrdc.org
Mass Audubon	Listed on Table 2.

Table 4. Economic Organizations and Resources

Economic Resources	Mission and Website
Massachusetts Department of Energy Resources (DOER)	DOER is committed to creating a greener energy future for the Commonwealth. This includes: achieving all cost-effective energy efficiencies; maximizing development of greener energy resources; creating and leading implementation of energy strategies to assure reliable supplies at reasonable cost, supporting clean technology companies and spurring employment in the clean energy industry. http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/agencies-and-divisions/doer/
Massachusetts Department of Public Utilities (DPU)	DPU is responsible for the structure and control of energy provision in the Commonwealth; monitoring service quality; regulating safety in the transportation and gas pipeline areas; and for the siting of energy facilities. The mission of the Department is to ensure that utility consumers are provided with the most reliable service at the lowest possible cost; to protect the public safety from transportation and gas pipeline related accidents; to oversee the energy facilities siting process; and to ensure that ratepayers' rights are protected. http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/agencies-and-divisions/dpu/
Massachusetts Life Sciences Center (MLSC)	The Center is an investment agency that supports life sciences innovation, research, development and commercialization. MLSC is charged with implementing a 10-year, $1 billion, state-funded investment initiative to create jobs and support advances that improve health and well-being. http://www.masslifesciences.com/
Massachusetts Business Roundtable (MBR)	MBR is a public policy organization comprised of Chief Executive Officers and Senior Executives from some of the state's largest employers. MBR's mission is to strengthen the state's economic vitality, with the goal of making Massachusetts a highly-desirable place to do business. To achieve this mission and goal, MBR engages with both public and private leaders to provide the strategic thinking of its members to develop and influence public policy that will strengthen the long-term health of the Massachusetts economy. http://www.maroundtable.com/mission.html The Education and Workforce Development Task Force STEM focus area: http://www.maroundtable.com/focus_educ.html
U.S. Green Building Council (USGBC)	This organization is probably best known for their green building certification program—LEED. Their mission is to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthier, and prosperous environment that improves the quality of life. http://www.usgbc.org/about

Economic Resources	Mission and Website
Center for Green Schools at U.S. Green Building Council	The mission is to create green schools for everyone within this generation, and as such the Center works directly with teachers, students, administrators, elected officials and communities to create programs, resources and partnerships that transform all schools into healthy learning environments. This is an opportunity to educate a new generation of leaders, including sustainability natives, capable of driving global market transformation. http://www.centerforgreenschools.org/about The Center for Green Schools (2014). *National Action Plan for Educating for Sustainability*. http://www.centerforgreenschools.org/sites/default/files/resource-files/National-Action-Plan-Educating-Sustainability.pdf
Green Schools	This is a Massachusetts-based organization for innovative environmental education, e-STEM education, leadership, and action. It provides a number of environmental programs and resources to best develop the next generation of GREEN students and schools http://projectgreenschools.org/
The Massachusetts Clean Energy Center (MassCEC)	This is a publicly-funded agency dedicated to accelerating the success of clean energy technologies, companies and projects in Massachusetts—while creating high-quality jobs and long-term economic growth for the people of Massachusetts. http://www.masscec.com/
U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy	This education portal has a range of resources for educators including specific information and links to the Seven Essential Principles of Energy. http://energy.gov/eere/education/education-homepage
Governor's STEM Advisory Council	Created by Gov. Patrick Executive Order. The Council serves as the central coordinating entity to bring together all of the participants and parties from state agencies, the legislature, and members of the public and private sectors involved with STEM planning and programming. Meetings are quarterly and are open to the public. http://www.mass.edu/stem/home/council.asp

Table 5. Education Organizations and Resources

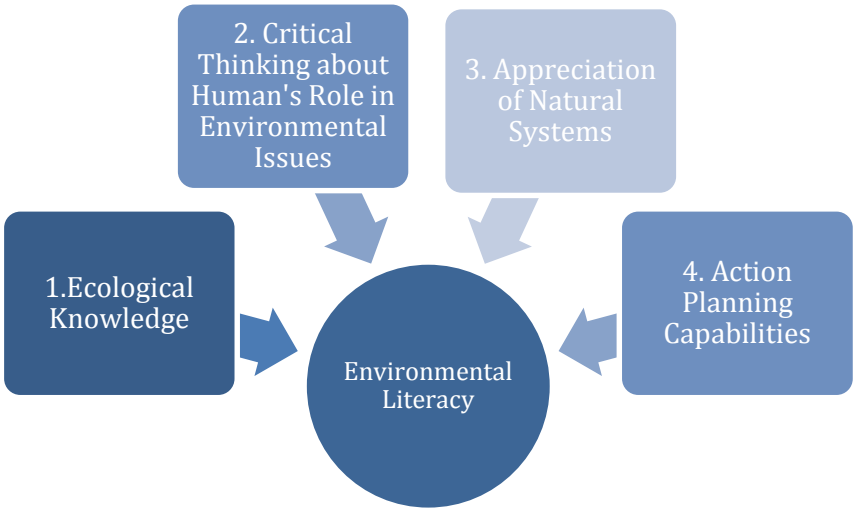
Education Resources	Mission and Website
Massachusetts Department of Elementary and Secondary Education (DESE)	Science, Technology, Engineering, and Mathematics Program Area. http://www.doe.mass.edu/stem/
Massachusetts Association of Science Teachers (MAST)	MAST is a professional organization dedicated to improving science education at all levels. It is the state chapter of the National Science Teachers Association (NSTA) and acts as Massachusetts's teachers' representative on national and state policies concerning science education. http://www.massscienceteach.org
Museum Institute for Teaching Science (MITS)	MITS provides inquiry-based, hands-on science, engineering, technology and math professional development for K-12 teachers and informal educators. http://mits.org/
Museum of Science	The Museum's mission is to play a leading role in transforming the nation's relationship with science and technology. www.mos.org
Woods Hole Oceanographic Institute	The Institute is dedicated to research and education to advance understanding of the ocean and its interaction with the Earth system, and to communicating this understanding for the benefit of society. https://www.whoi.edu/main/k-12
New England Aquarium	The Aquarium is a global leader in ocean exploration and marine conservation. They combine education, entertainment and action to address the most challenging problems facing the ocean. They have a wide variety of educational programs and conservation initiatives for children and adults. www.neaq.org
Zoo New England	The mission is to inspire people to protect and sustain the natural world for future generations by creating fun and engaging experiences that integrate wildlife and conservation programs, research, and education. www.zoonewengland.org
Harvard Museum of Natural History	The museum's mission is to enhance public understanding and appreciation of the natural world and the human place in it. They have self-guided museum visits, K-12 classes taught by museum educators, kids' classes and family programs, adult classes, afterschool programs and resources for teachers. www.hmnh.harvard.edu
Ecotarium	The mission is to inspire passion for science and nature with a focus on hands-on exploration and discovery. This museum has indoor exhibits as well as outdoor grounds for exploration. www.ecotarium.org

Education Resources	Mission and Website
Hitchcock Center for the Environment	The Center fosters awareness and understanding of the environment through programs with a particular focus on children. The educational framework centers on five fundamentals: understanding principles of ecology; valuing place; promoting resilience; demonstrating sustainability in the built environment; and educating for active citizenship. www.hitchcockcenter.org
City Sprouts	CitySprouts introduces school gardens as a core element of children's public education. They partner with public schools to ensure that hands-on learning, environmental stewardship and the experience of growing and eating healthy food becomes a part of every child's life. www.citysprouts.org
The UMass Center for Agriculture, Food and the Environment	The Center creates programs of integrated research and educational outreach that address public priorities and concerns. The programs advance environmental quality, agricultural sustainability and the viability of food systems, from production to consumption. https://ag.umass.edu
Mass Audubon	Listed on Table 2
Green Schools	Listed on Table 5
New England Wildflower Society (NEWFS)	Listed on Table 2
U.S. Global Change Research Program (USGCRP)	This program was established to assist the Nation and world to understand, assess, predict, and respond to human-induced and natural processes of global change. The mission is to build a knowledge base that informs human responses to climate and global change through coordinated and integrated Federal programs of research, education, communication, and decision support. There are thirteen Federal agencies contributing to this effort. http://www.globalchange.gov Report: *National Climate Assessment (May 2014).* http://nca2014.globalchange.gov/
American Association for the Advancement of Science (AAAS)	In addition to publishing Science, AAAS fulfills its mission to advance science and serve society through initiatives in science policy; diplomacy; education and career support; and public engagement with science. www.aaas.org Report: *Communicating and learning about global climate change: an abbreviated guide for teaching climate change.* http://www.project2061.org/publications/guides/climate.pdf
Massachusetts Environmental Education Society (MEES)	MEES is dedicated to the promotion, preservation, and improvement of environmental education in the state and region. It provides tools for environmental educators, including an annual conference in March. http://massmees.org

Education Resources	Mission and Website
EE Capacity	The Expanding Capacity in Environmental Education Project provides opportunities for professionals and volunteers to build and expand the critical role environmental education plays in fostering healthy environments and communities. They provide a number of resources for climate change education. http://www.eecapacity.net/climate-change-ee-project-based-online-learning-community-alliance.html
Program in Education, Afterschool & Resiliency (PEAR)	PEAR's mission is to create and foster school and afterschool setting in which all young people can be successful. They provide resources and tools for informal science educational settings. http://www.pearweb.org
The Maria Mitchell Association	The Association provides scientific resources and educational programs that use Nantucket Island as a natural laboratory for studying science and the environment, and maintains research and representative collections of Nantucket's biodiversity. http://www.mariamitchell.org
Climate Literacy & Energy Awareness Network (CLEAN)	This organization has a collection of resources on teaching climate and energy science. www.cleanet.org

APPENDIX B: Massachusetts STE Standards Related to Environmental Literacy Goals

Figure A. Environmental Literacy Goals for Massachusetts



The numbers below are used in the following tables to indicate which Environmental Literacy. Goal* can be met by students meeting a given standard.

1. Understand ecosystems and how they function.
2. Think critically about how human actions effect ecological functioning and subsequent environmental issues/problems that arise.
3. Appreciate natural phenomena and biodiversity through observation and direct experiences in natural settings.
4. Participate in action planning for themselves and their community to address environmental issues.

Table 6. Earth's Systems PreK-12 Standards

Standard Number	Earth's Systems Standards	Env. Lit. goal*
PreK-ESS2-1(MA)	Raise questions and engage in discussions about how different types of local environments (including water) provide homes for different kinds of living things.	1
PreK-ESS2-2(MA)	Observe and classify non-living materials, natural and human made, in their local environment.	1
PreK-ESS2-3(MA)	Explore and describe different places water is found in the local environment.	1
PreK-ESS2-4(MA)	Use simple instruments to collect and record data on elements of daily weather, including sun or clouds, wind, snow or rain, and higher or lower temperature.	1
PreK-ESS2-5(MA)	Describe how local weather changes from day to day and over the seasons and recognize patterns in those changes.	1
PreK-ESS2-6(MA)	Provide examples of the impact of weather on living things.	1
K-ESS2-1	Use and share quantitative observations of local weather conditions to describe patterns over time.	1
K-ESS2-2	Construct an argument supported by evidence for how plants and animals (including humans) can change the environment.	1,2
2-ESS2-1	Investigate and compare the effectiveness of multiple solutions designed to slow or prevent wind or water from changing the shape of the land.	2
2-ESS2-2	Map the shapes and types of landforms and bodies of water in an area.	1
2-ESS2-3	Use examples obtained from informational sources to explain that water is found in the ocean, rivers and streams, lakes and ponds, and may be solid or liquid.	1
2-ESS2-4(MA)	Observe how blowing wind and flowing water can move Earth materials from one place to another and change the shape of a landform.	1
3-ESS2-1	Use graphs and tables of local weather data to describe and predict typical weather during a particular season in an area.	1
3-ESS2-2	Obtain and summarize information about the climate of different regions of the world to illustrate that typical weather conditions over a year vary by region.	1
4-ESS2-1	Make observations and collect data to provide evidence that rocks, soils, and sediments are broken into smaller pieces through mechanical weathering and moved around through erosion by water, ice, wind, and vegetation.	1,3
4-ESS2-2	Analyze and interpret maps of Earth's mountain ranges, deep ocean trenches, volcanoes, and earthquake epicenters to describe patterns of these features and their locations relative to boundaries between continents and oceans.	1

Standard Number	Earth's Systems Standards	Env. Lit. goal*
5-ESS2-1	Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.	1
5-ESS2-2	Describe and graph the relative amounts of salt water in the ocean; fresh water in lakes, rivers, and ground water; and fresh water frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth's biosphere.	1
6.MS-ESS2-3	Analyze and interpret maps showing the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence that Earth's plates have moved great distances, collided, and spread apart.	1
7.MS-ESS2-4	Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in Earth's hydrosphere.	1
8.MS-ESS2-1	Use a model to illustrate that energy from the Earth's interior drives convection which cycles Earth's crust leading to melting, crystallization, weathering, and deformation of large rock formations, including generation of ocean sea floor at ridges, submergence of ocean sea floor at trenches, mountain building, and active volcanic chains.	1
8.MS-ESS2-5	Interpret basic weather data to identify patterns in air mass interactions and the relationship of those patterns to local weather.	1
8.MS-ESS2-6	Describe how interactions involving the ocean affect weather and climate on a regional scale, including the influence of the ocean temperature as mediated by energy input from the sun and energy loss due to evaporation or redistribution via ocean currents.	1
HS-ESS2-2	Analyze geoscience data to make the claim that one change to Earth's hydrosphere can create feedbacks that cause changes to other Earth systems.	1
HS-ESS2-4	Use a model to describe how variations in the flow of energy into and out of Earth's systems over different time scales result in changes in climate. Analyze and interpret data to explain that long-term changes in Earth's tilt and orbit result in cycles of climate change such as Ice Ages.	1
HS-ESS2-5	Describe how the chemical and physical properties of water are important in mechanical and chemical mechanisms that affect Earth materials and surface processes.	1
HS-ESS2-6	Use a model to describe cycling of carbon through the ocean, atmosphere, soil, and biosphere and how increases in carbon dioxide concentrations due to human activity has resulted in gradual atmospheric and climate changes.	1,2

Table 7. Earth and Human Activity PreK-12 Standards

Standard Number	Earth and Human Activity Standards	Env. Lit. goal*
PreK-ESS3-1(MA).	Engage in discussion and raise questions using examples about local resources (including soil and water) humans use to meet their needs.	2
PreK-ESS3-2(MA).	Observe and discuss the impact of people's activities on the local environment.	2
K-ESS3-3	Communicate solutions to reduce the amount of natural resources individuals use.	4
3-ESS3-1	Evaluate the merit of a design solution that reduces the damage caused by weather.	2
4-ESS3-1	Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not.	2
4-ESS3-2	Evaluate different solutions to reduce the impacts of a natural event such as an earthquake, blizzard, or flood on humans.	2,4
5-ESS3-1	Obtain and combine information about ways communities reduce the impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process.	2
5-ESS3-2(MA)	Test a simple system designed to filter particulates out of water and propose one change to the design to improve it.	4
7.MS-ESS3-2	Obtain and communicate information on how data from past geologic events are analyzed for patterns and used to forecast the location and likelihood of future catastrophic events.	1
7.MS-ESS3-4	Construct an argument supported by evidence that human activities and technologies can mitigate the impact of increases in human population and per capita consumption of natural resources on the environment.	2
8.MA-ESS3-1	Analyze and interpret data to explain that the Earth's minerals and fossil fuel resources are unevenly distributed as a result of geologic processes.	1
8.MS-ESS3-5	Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.	2
HS-ESS3-1	Construct an explanation based on evidence for how the availability of key natural resources and changes due to variations in climate have influenced human activity.	2
HS-ESS3-2	Evaluate competing design solutions for minimizing impacts of developing and using energy and mineral resources, and conserving and recycling those resources, based on economic, social, and environmental cost-benefit ratios.	2,4
HS-ESS3-3	Illustrate relationships among management of natural resources, the sustainability of human populations, and biodiversity.	2
HS-ESS3-5	Analyze results from global climate models to describe how forecasts are made of the current rate of global or regional climate change and associated future impacts to Earth systems.	1

Table 8. From Molecules to Organisms: Structures and Processes PreK-12 Standards

Standard Number	From Molecules to Organisms: Structures and Processes Standards	Env. Lit. goal*
K-LS1-1	Observe and communicate that animals (including humans) and plants need food, water, and air to survive. Animals get food from plants or other animals. Plants make their own food and need light to live and grow.	1
K-LS1-2 (MA)	Recognize that all plants and animals grow and change over time.	1
1-LS1-1	Use evidence to explain that (a) different animals use their body parts and senses in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air, and (b) plants have roots, stems, leaves, flowers and fruits that are used to take in water, air, and other nutrients, and produce food for the plant.	1
1-LS1-2	Obtain information to compare ways in which the behavior of different animal parents and their offspring help the offspring to survive.	1
3-LS1-1	Use simple graphical representations to show that species have unique and diverse life cycles. Describe that all organisms have birth, growth, reproduction, and death in common but there are a variety of ways in which these happen.	1
4-LS1-1	Construct an argument that animals and plants have internal and external structures that support their survival, growth, behavior, and reproduction.	1
5-LS1-1	Ask testable questions about the process by which plants use of air, water, and energy from sunlight to produce sugars and plant materials needed for growth and reproduction.	1
6.MS-LS1-1	Provide evidence that organisms (unicellular and multicellular) are made of cells.	1
6.MS-LS1-2	Develop and use a model to describe how parts of cells contribute to the cellular functions of obtaining food, water, and other nutrients from its environment, disposing of wastes, and producing energy for cellular processes.	1
7.MS-LS1-4	Construct an explanation based on evidence for how characteristic animal behaviors and specialized plant structures increase the probability of successful reproduction of animals and plants.	1
8.MS-LS1-5	Construct an argument based on evidence for how environmental and genetic factors influence the growth of organisms.	1
HS-LS1-2	Develop and use a model to illustrate the key functions of animal body systems, including (a) food digestion, nutrient uptake, and transport through the body, (b) exchange of oxygen and carbon dioxide, (c) removal of wastes, and (d) regulation of body processes.	1
HS-LS1-3	Provide evidence that homeostasis maintains internal body conditions through both body-wide feedback mechanisms and small-scale cellular processes.	1

Table 9. Energy PreK-12 Standards

Standard Number	Energy Standards	Env. Lit. goal*
K-PS3-1	Make observations to determine that sunlight warms materials on Earth's surface.	1
5-PS3-1	Use a model to describe that the food animals digest (a) contains energy that was once energy from the Sun, and (b) provides energy and materials for life processes, including body repair, growth, motion, body warmth, and reproduction.	1
HS-PS3-3	Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy.	4
HS-ETS4-1(MA)	Research and describe various ways that humans use energy and power systems to harness resources to accomplish tasks effectively and efficiently.	2

Table 10. Earth's Place in the Universe PreK-12 Standards

Standard Number	Earth's Place in the Universe Standards	Env. Lit Goal*
PreK-ESS1-1(MA)	Demonstrate awareness that the moon can be seen in the daytime and at night, and of the different apparent shapes of the moon over a month.	1
PreK-ESS1-2(MA)	Observe and use evidence to describe that the Sun is in different places in the sky during the day.	1
1-ESS1-1	Use observations of the sun, moon, and stars to describe that each appears to rise in one part of the sky, appears to move across the sky, and appears to set.	3
1-ESS1-2	Analyze provided data to identify relationships among seasonal patterns of change, including relative sunrise and sunset time changes, seasonal temperature and rainfall or snowfall patterns, and seasonal changes to the environment.	1
4-ESS1-1	Use evidence from a given landscape that includes simple landforms and rock layers to support a claim about the role of erosion or deposition in the formation of the landscape over long periods of time.	1
5-ESS1-1	Use observations, first-hand and from various media, to argue that the Sun is a star that appears larger and brighter than other stars because it is closer to the Earth.	1,3
5-ESS1-2	Use a model to communicate Earth's relationship to the Sun, Moon, and other stars that explain (a) why people on Earth experience day and night, (b) patterns in daily changes in length and direction of shadows over a day, and (c) changes in the apparent position of the Sun, Moon, and stars at different times during a day, over a month, and over a year.	1
6.MS-ESS1-1a	Develop and use a model of the Earth-Sun-Moon system to explain the causes of lunar phases and eclipses of the Sun and Moon.	1
6.MS-ESS1-4	Analyze and interpret rock layers and index fossils to determine the relative ages of rock formations that result from processes occurring over long periods of time.	1
6.MS-ESS1-5(MA)	Use graphical displays to illustrate that the Earth and its solar system are one of many in the Milky Way galaxy, which is one of billions of galaxies in the universe.	1
8.MS-ESS1-1b	Develop and use a model of the Earth-Sun system to explain the cyclical pattern of seasons, which includes the Earth's tilt and differential intensity of sunlight on different areas of Earth across the year.	1
8.MS-ESS1-2	Explain the role of gravity in ocean tides, the orbital motions of planets, their moons, and asteroids in the solar system.	1
HS-ESS1-1	Use informational text to explain that the life span of the Sun over approximately 10 billion years is a function of nuclear fusion in its core. Communicate that stars, through nuclear fusion over their life cycle, produce elements from helium to iron and release energy that eventually reaches Earth in the form of radiation.	1

Standard Number	Earth's Place in the Universe Standards	Env. Lit Goal*
HS-ESS1-5	Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor.	1

Table 11. Heredity: Inheritance and Variation of Traits PreK-12 Standards

Standard Number	Heredity: Inheritance and Variation of Traits Standards	Env. Lit. goal*
1-LS3-1	Use information from observations (first-hand and from media) to identify similarities and differences among individual plants or animals of the same kind.	3
3-LS3-1	Provide evidence, including through the analysis of data, that plants and animals have traits inherited from parents and that variation of these traits exist in a group of similar organisms.	1
3-LS3-2	Distinguish between inherited characteristics and those characteristics that result from a direct interaction with the environment. Give examples of characteristics of living organisms that are influenced by both inheritance and the environment.	1
8.MS-LS3-1	Develop and use a model to describe that structural changes to genes (mutations) may or may not result in changes to proteins, and if there are changes to proteins there may be harmful, beneficial, or neutral changes to traits.	1
8.MS-LS3-2	Construct an argument based on evidence for how asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. Compare and contrast advantages and disadvantages of asexual and sexual reproduction.	1
HS-LS3-4	Use scientific information to illustrate that genetic traits of individuals, and the presence of specific alleles in a population, are due to interactions of genetic factors with environmental factors.	1,2

Table 12. Ecosystems: Interactions, Energy, and Dynamics PreK-12 Standards

Standard Number	Ecosystems: Interactions, Energy, and Dynamics Standards	Env. Lit. goal*
PreK-LS2-2(MA).	Using evidence from the local environment explain how familiar plants and animals meet their needs where they live.	1
PreK-LS2-3(MA).	Give examples from the local environment of how animals and plants are dependent on one another to meet their basic needs.	1
2-LS2-3 (MA)	Develop and use models to compare how plants and animals depend on their surroundings and other living things to meet their needs in the places they live.	1
5-LS2-1	Develop a model to describe the movement of matter among producers, consumers, decomposers, and the air and soil in the environment (a) show that plants produce sugars and plant materials, (b) show that animals can eat plants and/or other animals for food, and (c) show that some organisms, including fungi and bacteria, break down dead organisms and recycle some materials back to the air and soil.	1
5-LS2-2 (MA)	Compare at least two designs for a composter to determine which is most likely to encourage decomposition of materials.	2
7.MS-LS2-1	Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth of organisms and the size of populations in an ecosystem.	1
7.MS-LS2-2	Describe how relationships among and between organisms in an ecosystem can be competitive, predatory, parasitic, and mutually beneficial and that these interactions are found across multiple ecosystems.	1
7.MS-LS2-3	Develop a model to describe that matter and energy cycle among living and nonliving parts of an ecosystem and that both matter and energy are conserved through these processes.	1
7.MS-LS2-4	Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations.	1,2
7.MS-LS2-5	Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.	2,4
7.MS-LS2-6(MA)	Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use.	2
HS-LS2-1	Analyze data sets to support explanations that biotic and abiotic factors affect ecosystem carrying capacity.	1
HS-LS2-2	Use mathematical representations to support explanations that biotic and abiotic factors affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem.	1
HS-LS2-4	Use a mathematical model to describe the transfer of energy from one trophic level to another. Explain how the inefficiency of energy transfer between trophic levels affects the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment.	1

Standard Number	Ecosystems: Interactions, Energy, and Dynamics Standards	Env. Lit. goal*
HS-LS2-5	Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere.	1
HS-LS2-6	Analyze data to show ecosystems tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur but that extreme fluctuations in conditions may result in a new ecosystem. Construct an argument with evidence that ecosystems with greater biodiversity tend to have greater resistance to change and resilience.	1
HS-LS2-7	Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.	2,4

Table 13. Engineering Design PreK-12 Standards

Standard Number	Engineering Design Standards	Env. Lit. goal*
6.MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution. Include potential impacts on people and the natural environment that may limit possible solutions.	2
6.MS-ETS1-5(MA)	Create visual representations of solutions to a design problem. Accurately interpret and apply scale and proportion to visual representations.	4
6.MS-ETS1-6(MA)	Communicate a design solution to an intended user, including design features and limitations of the solution.	4
HS-ETS1-1	Analyze a major global challenge to specify a design problem that can be improved. Determine necessary qualitative and quantitative criteria and constraints for solutions, including any requirements set by society	2
HS-ETS1-2	Break a complex real-world problem into smaller, more manageable problems that each can be solved using scientific and engineering principles.	4
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, aesthetics, and maintenance, as well as social, cultural, and environmental impacts.	4
HS-ETS1-4	Use a computer simulation to model the impact of a proposed solution to a complex real-world problem that has numerous criteria and constraints on the interactions within and between systems relevant to the problem.	4
HS-ETS1-5(MA)	Plan a prototype or design solution using orthographic projections and isometric drawings, using proper scales and proportions.	4
HS-ETS1-6(MA)	Document and present solutions that include specifications, performance results, successes and remaining issues, and limitations.	4

Table 14. Technological Systems PreK-12 Standards

Standard Number	Technological Systems Standards	Env. Lit. Goal*
7.MS-ETS3-3(MA)	Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.	2
7.MS-ETS3-4(MA)	Show how the components of a structural system work together to serve a structural function. Provide examples of physical structures and relate their design to their intended use.	2
HS-ETS3-5(MA)	Analyze how the design of a building is influenced by thermal conditions such as wind, solar angle, and temperature. Give examples of how conduction, convection, and radiation are considered in the selection of materials for buildings and in the design of a heating system.	2

Table 15. Biological Evolution: Unity and Diversity PreK-12 Standards

Standard Number	Biological Evolution: Unity and Diversity Standards	Env. Lit. goal*
2-LS4-1	Use texts, media, or local environments to observe and compare (a) different kinds of living things in an area, and (b) differences in the kinds of living things living in different types of areas.	1,3
3-LS4-1	Use fossils to describe types of organisms and their environments that existed long ago and compare those to living organisms and their environments. Recognize that most kinds of plants and animals that once lived on Earth are no longer found anywhere.	1,3
3-LS4-2	Use evidence to construct an explanation for how the variations in characteristics among individuals within the same species may provide advantages to these individuals in their survival and reproduction.	1
3-LS4-3	Construct an argument with evidence that in a particular environment some organisms can survive well, some survive less well, and some cannot survive.	1
3-LS4-4	Analyze and interpret data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.	1
3-LS4-5(MA)	Provide evidence to support a claim that the survival of a population is dependent upon reproduction.	1
6.MS-LS4-1	Analyze and interpret evidence from the fossil record to describe organisms and their environment, extinctions, and changes to life forms throughout the history of the Earth.	1
6.MS-LS4-2	Construct an argument using anatomical structures to support evolutionary relationships among and between fossil organisms and modern organisms.	1
8.MS-LS4-4	Use a model to describe the process of natural selection, in which genetic variations of some traits in a population increase some individuals' likelihood of surviving and reproducing in a changing environment. Provide evidence that natural selection occurs over many generations.	1
8.MS-LS4-5	Synthesize and communicate information about artificial selection, or the ways in which humans have changed the inheritance of desired traits in organisms.	2
HS-LS4-2	Construct an explanation based on evidence that Darwin's theory of evolution by natural selection occurs in a population when the following conditions are met: (a) more offspring are produced than can be supported by the environment, (b) there is heritable variation among individuals, and (c) some of these variations lead to differential fitness among individuals as some individuals are better able to compete for limited resources than others.	1
HS-LS4-4	Research and communicate information about key features of viruses and bacteria to explain their ability to adapt and reproduce in a wide variety of environments.	1
HS-LS4-5	Evaluate models that demonstrates how changes in an environment may result in the evolution of a population of a given species, the emergence of new species over generations, or the extinction of other species due to the processes of genetic drift, gene flow, mutation, and natural selection.	1

Table 16. Percentage of Standards by Conceptual Area and Grade Level that address at least one Environmental Literacy Goal

Standards' Conceptual Areas	INDIVIDUAL GRADE LEVELS										HIGH SCHOOL				
	PK	K	1	2	3	4	5	6	7	8	Earth & Space Science	Biology	Chemistry	Intro Physics	Technology Engineering
Earth and Space Science:															
Earth's Place in the Universe	100	*	100			100	100	100		100	67				
Earth's Systems	100	100		100	100	100	100	100	50	100	80				
Earth and Human Activity	100	50			100	100	100		100	100	100				
Life Science:															
From Molecules to Organisms	0	100	100		100	100	100	67	100	50		29			
Heredity			100		100					50		25			
Ecosystems	66			100			100		100			100			
Variation of Traits	0														
Biological Evolution				100	100			100		100		75			
Physical Science:															
Matter and Its Interactions	0	0		0			0	0		0			0	0	
Motion and Stability	0	0			0		0	0	0	0			0	0	
Waves and their applications in technologies for information transfer	0		0			0		0						0	
Energy		50		0		0	100		0				0	20	
Technology/ Engineering:															
Engineering Design			0	0	0	0		100	0						100
Technological Systems							0		40						17
Materials, Tools, and Manufacturing								0		0					0
Energy and Power Technologies															20

*Highlighted cells indicate no standards in a given Conceptual Area for that grade level