Environmental Literacy

Scope and Sequence

Providing a systems approach to environmental education in Minnesota

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Foreword

Environmental education has been such a struggle for as long as I have been a part of it, and that has been over thirty years. It was difficult to define, difficult to communicate, difficult to find or write usable curricula, and difficult for educators who were not intuitively interested to perceive any value in it, other than as something nice to do in extra time. We struggled for all those years, groping towards providing a rigor to what was essentially an intuitive conviction that a very important core understanding did exist, something that was not just diluted applied science. We were hovering about the edges of this core for many years, but were never really able to put our fingers on exactly what that was.

We probably should have caught on long ago. The essence lay in the battered, bedraggled (and vastly oversimplified) old phrase "everything is connected." This hoary old phrase had been around as long as I have been in the field. At a day-long meeting of the Minnesota Environmental Education Board in the early 70s, after endless hours trying to decide what the mission of the board was to be, I can remember thinking wearily that of all that was said, if we could just help people understand that interdependency is *the* key concept, I would truly be doing my job. That day, those discussions, and my conviction repeated and repeated over the years like unending groundhog days.

We would say again and again "everything is interconnected," yet go right on teaching as if it weren't, or we would teach in such a way that the lesson was often lost in the methodology and details. We also seemed to have a very narrow concept of what we meant by *everything*. Often, everything didn't seem to include people.

It wasn't until the late 90s, in a fascinating case of convergent idea evolution, that enough people in powerful positions finally buckled down to the real task. That task was to ask, "What is the core of understanding we are seeking that is clearly different from, but would add significant value to, both science and social science? What is it that we are trying to define that would make a difference in how people would understand and treat both our physical and social worlds?"

Within just a few years of each other, a number of groups set out to search for this answer. In all cases, they began to home in on two major ideas: the concept of systems as a way to take apart and study the idea of connectedness and interdependency, and the reality that natural systems and human social systems are constantly and intricately interacting. In fact, separating them as I just have in this sentence into *natural* and *human* is merely a device we use to talk about and analyze them.

I think Dr. Fred Finley, professor at the University of Minnesota and participant in the state's 10 university cooperative environmental education teacher preparation project said it best in the mid-90s when he proposed a goal statement for the project at an initial conference. He said we should take as our focus that "the planet is a set of interacting natural and social systems." This began to light some bulbs in the brainpower that was attending the conference. That teacher preparation project would have been far better conceived and carried out if we had made a better attempt to pounce on that statement and really determine how best to teach it.

This simple statement rang all kinds of familiar bells for me. In the early 1970s when I had been studying anthropology in graduate school at the University of Minnesota, Dr. Luther Gerlach, a professor in the department, had been teaching his students about the importance of understanding systems in order to understand how human social systems worked. Fascinated by the concept of social change, he was interested at the time in social movements in the

United States, one of which was the ecology movement. He was one of the first to analyze the intricacies of interrelationships between how human cultures ordered life, and the natural systems upon which all humans depend for survival. His work and his mentorship became important influences on the direction of the search for a definition of environmental literacy.

That statement of Fred Finley's, summarizing Dr. Gerlach's significant body of work, defined the area of study that is unique to environmental education, and is the core of environmental literacy. It is not just science and not just social science; it is the *interface* between the two that is so crucially important to what happens in both the natural and social worlds. That interface is touched upon by both disciplines, because of its sheer inevitability. It takes a great deal of effort to ignore the importance of the one to the other; (though numerous educators have shown, to our loss, that it can be done). However, this interface is focused on by neither.

At about that same time, two other major state and national projects were coming to the same conclusions. The California Guide for Environmental Literacy Project, initiated within the state's Department of Education, made the assumption that the problems of the world are based in relationships. If that is true, they reasoned, systems thinking can be used to direct attention toward connections and the networks they form. The California committee wrote their guide to environmental literacy to help teachers educate about systems across all disciplines.

While this project was in its final stages, representatives from the Departments of Education from 12 states were meeting, supported by the Pew Charitable Trusts, to discover how best to enhance environmental education in those states. That group was the State Education and Environment Roundtable (SEER) headed by Dr. Jerry Lieberman. One of its proposed projects was to develop an assessment for environmental literacy that could be used nationwide to discover just how environmentally literate our students were and what was the size of the education job yet to be done. In order to develop an assessment, it's necessary to know exactly what is to be assessed. SEER chose a committee, of which I was a member, to meet five or six times over a six-month period, to define that core of knowledge that would be necessary for an environmentally literate student to know and be able to do. After those grueling meetings, the bare essence of the core this committee defined was the same as Dr. Fred Finley's statement.

In Minnesota, meantime, the state Department of Children, Families and Learning (DCFL) had taken up with gusto the national challenge to create sets of educational standards for students. The Minnesota Environmental Education Advisory Board persuaded the state department to include a standard on environmental systems. The essence of the standard (and, coincidentally, another written quite apart by the committee working on resource management) turned out, again, to be based on the goal of teaching the interaction of natural and social systems.

This convergence by such separate but highly credible groups on the core knowledge necessary for environmental literacy was, for me, momentous. Just being able to define where we needed to go with our educational task caused me to breathe a great sigh of relief. It was like breaking the surface of the water after a long, deep, dark dive. Now, not only did we know where we wanted to go, but we had questions to ask that would tell us if learners had arrived there. That is, could they tell us and demonstrate that they knew how systems worked, and how natural and social systems interacted? And could they use that knowledge to make informed decisions? We had a way to assess environmental literacy.

But up above the water surface, standing on the shore, was another question the size of an elephant. If that's where we wanted learners to go, how were we going to help them get there?

SEER and DCFL agreed that we needed to build a series of connected learning steps from kindergarten, or even prekindergarten to adulthood. Since Minnesota needed to do this for all of its education standards, SEER decided to support Minnesota's effort, and, if it was a good one, to use it nationwide.

Over the following five years, the two organizations, ably supported by the Minnesota Office of Environmental Assistance, did develop that sequence of steps in such a way that at each grade level the progress toward the goal could be measured. Many teachers, DCFL staff, and environmental education resource people spent countless grueling hours working towards this sequence.

Early in the sequence development work, Ed Hessler, from DCFL, brought about a major breakthrough in the effort. Clearly, what a student was capable of learning and understanding about systems at each separate level had to be the basis for each of the steps. Employing a child development specialist to work with the committees would have been very expensive monetarily, but even more so in time. We all groaned at the thought because we had spent so much time already, and were impatient to have the thing done and in play.

Wonderfully, Ed discovered that most of this work had already been done. The American Association for the Advancement of Science (AAAS) had already published such a sequence of steps for learning about systems in general. AAAS's *Benchmarks for Science Literacy* give us a thorough analysis of systems and their characteristics; they also provide a sequence for teaching systems to students and adults.

The task of the committees then became one of adapting the more general systems grade level learnings (now called benchmarks, implying their use as measuring devices) to be more specific to social and natural systems and their interactions. One of their major tasks within this was to identify the major concepts and ideas necessary for learners to master in order to reach the goal of environmental literacy as we have defined it.

The results of the hours of work, communications and miscommunications, abraded egos, long phone calls, passionate e-mails, people entering and leaving the project, grinding teeth, and moments of sheer gratitude, relief and satisfaction are in this publication. I fervently hope it will take away some of the frustration and feelings of being lost in a black hole many environmental educators endure, and leave you with a clear sense of purpose and task. If it does, please take a moment to think kind thoughts about the many people who were a part of it. I can only mention some of the very key ones; Dr. Luther Gerlach, whose research and writings were basic to our current definition of environmental literacy, and who mentored the environmental education community in Minnesota; Kathleen Lundgren with the Department of Children, Families and Learning; Dr. Jerry Lieberman with the State Education and Environment Roundtable; Mike Naylon who worked with me throughout the project; Bill Linder-Scholer with Science and Math in Minnesota (SciMathMN), and Annette Drewes and Denise Stromme who have taken on the task of publishing this *Environmental Literacy Scope and Sequence* and all of its supporting materials.

Pam Landers

Pam Landers has worked in environmental education for over 30 years. She is the former Executive Director of the GreenPrint Council. She also served as Formal Environmental Education Coordinator for the Minnesota Environmental Education Advisory Board and as Project Manager of the Minnesota Teacher Preparation Project. In 1996, she won the North American Association for Environmental Education award for "Outstanding Service to Environmental Education by an Individual at the Local Level."

Introduction

Why should we want to be environmentally literate?

Throughout every day, all of us in all our roles are making decisions that affect the environment we depend on. A county commissioner has to decide whether to grant a building permit. A business person chooses which supplies to buy or what kind of vehicle fleet to build. A homeowner ponders whether to install central air conditioning. A family mulls over whether to move to the edge of town and create a long commute or live downtown where both employed people can walk to work. A voter is in a quandary about whether to give her support to a candidate who has strong, well-articulated opinions on environmental issues, but is less interested or concerned about good education.

Each of these decisions, when taken by millions of people, will and do create major changes in environmental systems. Each of these decisions is also intertwined with myriad personal and social considerations that might override what little each knows about the environmental impacts they are creating. Yet in the long run, we know that just these kinds of decisions are changing both the physical and social world and each of our own little pieces of it. Would we change our decisions if we had full knowledge of how what we do affects our own futures? Maybe—and maybe not; but without that knowledge, we are shortchanging ourselves by unwittingly creating changes we might not have chosen, had we known.

If we are environmentally literate about our own choices, we travel with eyes wide open into our futures. We are far better prepared for any unwelcome consequences that we endure because we valued the trade-off more, and we are better prepared to live within the physical and social boundaries we know are there.

If this is something we want, why are we not more environmentally literate right now?

Often it takes a long time to build knowledge. The environmental education (EE) community has been struggling with defining what we need to know and be able to do for some time, both as individuals living our lives and as educators working with students of all ages. Often our subject matter has been too narrow, focused only on material that is really primarily science. Since environmental education is not a discipline, whether it is taught at all often depends on the teacher's or organization's interest. We have made no concentrated efforts to carry the education through in a connected way from lower to upper grades, so understanding is piecemeal at best. Moreover, we haven't done a good job of defining

Minnesota Statute §115A.073 outlines the state's environmental education goals and plan as follows: **"Pupils and citizens should be able to apply informed decision-making processes to maintain a sustainable lifestyle.**

In order to do so, citizens should:

1. understand ecological systems;
2. understand the cause and effect relationship between human attitudes and behavior and the environment;
3. be able to evaluate alternative responses to environmental issues before deciding on alternative courses of action; and
4. understand the effects of multiple uses of the environment."

exactly what core of knowledge is absolutely necessary in order to make those informed decisions for which we are striving. That results in very fuzzy ideas of what is really important to know. This lack of clarification has resulted in many environmental educators focusing on nature study, ecology, or environmental issues.

So what do we need to do to build environmental literacy?

The problems we have created in the world today will not be solved by the same level of thinking that created them.
—Albert Einstein

We need to tackle the problems:

- by identifying what we need to know and what we need to be able to do to make informed environmental decisions—*the scope*
- by creating a step-by-step guide from prekindergarten through adult ages to achieve the scope—*the sequence*
- by finding a way to measure whether the guide works

We hope the *Environmental Literacy Scope and Sequence* is a step in that direction. It defines what students should know and be able to do to be environmentally literate. It is a guide for building a curriculum from prekindergarten to adult levels that should enable the learner who has mastered it to make informed environmental decisions. It can be used for curriculum development and adaptation by educators in schools, environmental learning centers, higher education institutions, agencies, and nonprofit organizations. Furthermore, the Scope and Sequence gives us a way to measure how well students are doing in achieving environmental literacy.

Defining the core knowledge

Environmental educators are finally coming to some consensus about what people need to know and be able to do. The National Environmental Education Advisory Council of the U.S. EPA (Environmental Protection Agency) defines environmental education as:

> *The interdisciplinary process of developing a citizenry that is knowledgeable about the total environment in its natural and built aspects and has the capacity and commitment to insure environmental quality by engaging in inquiry, problem solving, decision-making and action.*

A GreenPrint for Minnesota: State Plan for Environmental Education, (*GreenPrint),* defines the mission of environmental education to:

> *Develop a population that has the knowledge, skills, attitudes, motivation and commitment to work individually and collectively toward sustaining a healthy environment..*[1]

[1] *A GreenPrint for Minnesota: State Plan for Environmental Education.* Minnesota Environmental Education Advisory Board. St. Paul. 1993, revised edition 2000.

These two definitions agree fairly well. Each includes the concept that there is a core of knowledge that is important to master in order to become environmentally literate. Though this consensus is spreading, until a few years ago no one had really come to grips with identifying what that core knowledge consisted of.

So what is this core knowledge?

One of the major agreements among environmental educators is that science may be the basis on which the core knowledge is built, but it is *more* than science. If that is true, then what is the environmental educator's perspective that is different from but builds on and adds to the knowledge gained by studying science and social science?

In the 1990s, several thoughtful groups of people spent a great deal of effort on this question. These included representatives of 10 Minnesota universities involved in the Environmental Education Teacher Preparation Project; representatives of 12 state departments of education in the Pew Charitable Trust's State Education and Environment Roundtable; and several committees working to define the Minnesota Environmental Systems graduation standard.

These three groups independently came to this definition:

> *The Earth is a set of interacting natural and social systems. An environmentally literate person must understand the relationship of the parts of a system and the interdependence of human and environmental systems.*[2] *The content of environmental education is the exploration of the relationships between social and natural systems.*[3]

This is the ***scope*** for environmental literacy, the vision of what students should have achieved at the end of their entire learning experience.

What is new about this core knowledge definition?

There are two important new elements in this definition: 1) the idea of the importance of learning how systems work, and 2) the recognition that the study of the interaction between natural and social systems is crucial to understanding what is happening in the world.

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[2] North American Association for Environmental Education (NAAEE). *Guidelines for Excellence in Environmental Education.* (Draft.)

[3] Lieberman, Gerald A. and Linda L. Hoody. 1997. *Putting the Pieces Together: Improving Student Learning with the Environment as an Integrating Context.* State Education and Environment Roundtable. Pew Charitable Trusts. Lieberman, Gerald A. and Linda L. Hoody. 1998. Closing the Achievement Gap. Using the Environment as an Integrating Context for Learning. State Education and Environment Roundtable. Pew Charitable Trusts. Science Wizards, Poway, CA.

Why systems?

Traditional environmental education accepted as a basic concept that everything was connected. This was the underlying idea behind most environmental education efforts. However, we never really examined that whole idea in terms of what it meant, exactly, and how it should be taught clearly and understandably. The concept of system allows us to explore what that interconnectedness is and how it works.

A system is a collection of interrelated parts consisting of objects, materials, phenomena, processes, ideas, principles, rules, organizations or people that interact to form a distinguishable whole. It consists of parts that work together in ways that cannot be understood only by studying the parts alone. Systems are characterized by what arises from the interactions of the parts; and these interactions are often as much a part of the study as the parts themselves.[4]

Using this systems school of thought, the Minnesota Scope and Sequence Development Team created the *Environmental Literacy Scope and Sequence*. The team was made up of experienced practicing environmental education professionals and representatives of preK through adult education, state agencies, higher education, and environmental learning centers. Because the Scope and Sequence is based on both state and national standards, it enables environmental education deliverers to build, adapt or integrate curriculum and assessments that are most appropriate for their particular grade level or audience. The *Environmental Literacy Scope and Sequence* is designed to help create opportunities for mainstreaming environmental education in a way that has not been possible before.

System is an idea that helps us think about parts and wholes. It draws attention to the interactions of the parts of something with one another and the relation of the parts to the whole. The idea also emphasizes effects—what influences the behavior of something and what, in turn, that thing accomplished.

—AAAS

[4] American Association for the Advancement of Science. 1993. *Benchmarks for Science Literacy.* Oxford University Press. New York.

Environmental Literacy Scope and Sequence

According to the environmental education goals and plan outlined by the Minnesota Legislature (Minn. Stat. §115A.073), "pupils and citizens should be able to apply informed decision-making processes to maintain a sustainable lifestyle. In order to do so, citizens should:

1. understand ecological systems;
2. understand the cause and effect relationship between human attitudes and behavior and the environment;
3. be able to evaluate alternative responses to environmental issues before deciding on alternative courses of action; and
4. understand the effects of multiple uses of the environment."

Surveys in the 1990s indicate that while teachers are improving their knowledge of environmental education content and methodology and their confidence in using these, they are still far from feeling comfortable integrating environmental education into the curriculum. The problem, however, was that there was no standards-based model of environmental literacy that described and ordered the sequence of knowledge and skills people must acquire to be environmentally literate. The *Environmental Literacy Scope and Sequence* can serve as an approach to focus the efforts of teachers and deliverers of environmental education to unify their many independent efforts.

The Scope and Sequence makes it possible for all its deliverers, no matter how diverse, to maximize their ability to contribute to student achievement in environmental education. In addition, a curriculum based on the Scope and Sequence is able to:

- Build on what the grade level or audience has learned before.
- Contribute to what that audience will learn later.
- Enable teachers and other environmental education deliverers to create coordinated programs that allow students to have a seamless learning experience as they:
    - Move up the grade levels.
    - Participate in out-of-classroom programs conducted in the community or at day visit and residential sites.
    - Apply more precise assessments.
    - Progress through an articulated series of developmentally appropriate concepts and skills that lead, measurably, to their becoming environmentally literate and enabled citizens.

Scope: *The vision of what the students should have achieved at the end of their entire school experience.*

Sequence: *A series of age-appropriate achievements that students succeed at during their school experience in order to master the Scope.*

The *Environmental Literacy Scope and Sequence* consists of:

1. Environmental Literacy Benchmarks

The Benchmarks help define the scope of knowledge students need to understand in order to become environmentally literate. These benchmarks are sequenced so that new knowledge is constructed on prior knowledge. Successful environmental education programs will build upon these benchmarks, utilizing the social and natural systems identified in their communities.

2. Key Systems Concepts and Supporting Concepts

Key Systems Concepts and Supporting Concepts of natural and social systems. The five Key Systems concepts, which assist in understanding the application of each Benchmark to environmental lessons are to be used as a guide to formulate questions about the social and natural systems being examined. The Supporting Concepts provide further detail and clarification for the Key Systems Concepts.

These two pieces together provide the framework for developing successful environmental education in working towards environmentally literate individuals and societies.

Key Systems Concepts

- *parts and objects*
- *interactions and relationships*
- *subsystems*
- *inputs and outputs*
- *change over time*

Environmental Literacy Benchmarks

The Environmental Literacy Benchmarks define the scope of knowledge students should understand, at the end of each level, in order to become environmentally literate. These Benchmarks are sequenced so that new knowledge is constructed on prior knowledge. Successful EE programs will build upon these Benchmarks, using them to organize instruction and learning experiences for preK to adult audiences.

Grades preK - 2

- Social systems and natural systems are made of parts.
- Social systems and natural systems may not continue to function if some of their parts are missing.
- When the parts of social systems and natural systems are put together, they can do things they couldn't do by themselves.

Grades 3 - 5

- In social and natural systems that consist of many parts, the parts usually influence one another.
- Social and natural systems may not function as well if parts are missing, damaged, mismatched or misconnected.

Grades 6 - 8

- Social and natural systems can include processes as well as things.
- The output from a social or natural system can become the input to other parts of social and natural systems.
- Social and natural systems are connected to each other and to other larger or smaller systems.

Grades 9 – 12 (adult)

- The interaction of social and natural systems can create properties that are different from either individual system.
- Interaction between social and natural systems is defined by their boundaries, relation to other systems, and expected inputs and outputs.
- Feedback of output from some parts of a managed social or natural system can be used to bring it closer to desired results.
- It is not always possible to predict accurately the result of changing some part or connection between social and natural systems

Key Systems Concepts and Supporting Concepts

Achieving the Benchmarks will require that students, be they age four or forty, understand the five Key Systems Concepts and their Supporting Concepts. These Key Systems Concepts, *parts and objects, interactions and relationships, subsystems, inputs and outputs, and change over time*, derived from the Environmental Literacy Benchmarks, are to be used as a guide to formulate questions about the social and natural systems being examined. The Supporting Concepts help clarify the application of each Benchmark to environmental lessons examining the interaction between social and natural systems.

Parts and objects	Interactions and relationships	Subsystems	Inputs and outputs	Change over time
Abiotic factors Biotic factors Group Ideas and concepts Individual Member Properties Similarities and differences	Cause and effect Change and constancy Chaos Communication Cycles Ecosystem Feedback Formal and nonformal Function Ideal and real Migration Patterns Predation Population Probability Reciprocity Structure Synergy Trophic level	Biome Boundary Communication Community Economics Ecosystem Family and kinship Habitat Language Niche Politics Religion Scale Stratification	Artifact Communication Energy and energy flow Innovation and invention Instruction Products Resources Technology Waste	Accumulation Climate Cycles Diversity Evolution Extinction Geomorphism Ideas and concepts Innovation and invention Knowledge Migration Mutation Population Probability Rate Redundancy Scale Species Threshold

Concepts in natural and social systems

The following table highlights the five Key Systems Concepts and their Supporting Concepts, based upon whether they are commonly used with social systems and/or natural systems.

Concepts most commonly used with natural systems	Concepts shared by both natural and social systems	Concepts most commonly used with social systems
	Parts and objects	
	abiotic factors, biotic factors, individuals properties, similarities & differences	group ideas and concepts, member
	Interactions and relationships	
trophic level	cause and effect, change and constancy chaos, communication, cycles, ecosystem, feedback function, migration, patterns, predation population, probability, reciprocity, structure, synergy	ideal and real formal and nonformal
	Subsystems	
biome, ecosystem habitat, niche	boundary, communication community, population, scale	economics, family and kinship language, religion, stratification politics
	Inputs and outputs	
	communication, energy and energy flow products, resources, waste	artifact, innovation/invention instruction, technology
	Change over time	
	accumulation, climate, cycles, diversity, evolution, extinction geomorphism, migration, mutation, population probability, rate, scale, species, threshold	ideas and concepts knowledge, innovation/invention

Environmental Literacy Benchmarks and Concepts by grade level

Arranged by grade level, these tables highlight the Key Systems Concepts and Supporting Concepts that underlie the appropriate Benchmarks, by providing real world examples of social and natural systems and their interactions. These examples are provided for reference and are meant to provide more insight into possible areas of research for students.

Environmental Literacy Benchmarks	Key Systems Concepts and Supporting Concepts	Examples of natural and social systems and their interactions
Grades preK – 2 **Social systems and natural systems are made of parts.** **Social systems and natural systems may not continue to function if some of their parts are missing.** **When the parts of social systems and natural systems are put together, they can do things they couldn't do by themselves.**	**Parts and objects** individuals, groups, ideas and concepts, biotic factors, abiotic factors, similarities and differences, properties **Interactions and relationships** structure, function **(See individual concept sheets.)**	**Single system examples** • If bees were removed from an ecosystem, all the flowering plants that depend on them for pollination (the bees' **function** within this system) are affected. • Objects in natural systems have observable **properties**, e.g. size, weight, color, shape or existence in different states. • **Similarities and differences** of the properties of the parts of natural systems form the basis of the taxonomic system of classification used to characterize species and their relationships to other groups of organisms. • Family is a social system that we are all aware of. For younger students, identifying the members of the family, and the roles they play help them to see **similarities and differences** in a personal way. **Interactions** • **Individual** humans make decisions that are often very dependent on the social systems of which they are a part, like family. These decisions affect other **individuals** in the system. • **Groups** utilize the environment for air, water, food, energy, space and a place to put their wastes. • Humans can make changes in the **biotic factors** influencing a garden, influencing the plants that grow there. • Fishermen use their knowledge of light, temperature and oxygen preferences (**abiotic factors**) of fish to locate them for angling.

Environmental Literacy Benchmarks	Key Systems Concepts and Supporting Concepts	Examples of natural and social systems and their interactions
Grades **3 – 5** **In social and natural systems that consist of many parts, the parts usually influence one another.** **Social and natural systems may not function as well if parts are missing, damaged, mismatched or misconnected.**	**Parts and objects** similarities and differences **Interactions and relationships** structure, function, patterns, trophic level, cycles, change and constancy, migration, predation, feedback, communication **(See individual concept sheets.)**	**Single system examples** • The **structure** of an ecosystem is based on its interacting biotic and abiotic parts. Producer, consumer, and decomposer are dependent upon green plants that, in turn, are dependent upon certain abiotic factors. Changes in an ecosystem's structure influences its other parts. • Wildlife species will **migrate,** adapt or die if their existing habitat no longer meets their survival needs. • Humans **migrate** in response to population pressure, e.g. settlement of the New World and the Irish response to the potato famine. Humans **migrate** in response to cultural pressures such as war or persecution. Humans **migrate** in the desire to better their lives or obtain advantages for themselves and their children. • Bats vocalize ultrasonic sound waves that bounce off objects and return to the bats' ears. This **feedback** is used by bats to locate food and navigate in their environment. • Social structure is any reoccurring **pattern** of social behavior. Individuals create and participate in a variety of social structures such as family, education, government, and religion. **Interactions** • **Cycles** in natural systems affect the activities of social systems. The seasons are **cycles**. During winter, shipping on Lake Superior stops until the ice breaks up in the spring • People can **change** the composition of plants and animals in an area by changing the biotic or abiotic factors (e.g. overgrazing, building dams, irrigation • **Communication** occurs between people and natural systems. Animals, plants, and the overall environment cannot **communicate** the way humans do, so people have to pay close attention in order to discover what the natural systems need. By monitoring the types of aquatic insects in a stream, a biologist learns about water quality. Some species will be absent in polluted water.

<table>
<tr><th>Environmental Literacy Benchmarks</th><th>Key Systems Concepts and Supporting Concepts</th><th>Examples of natural and social systems and their interactions</th></tr>
<tr><td>Grades
6 – 8

Social and natural systems can include processes as well as things.

The output from a social or natural system can become the input to other parts of social and natural systems.

Social and natural systems are connected to each other and to other larger or smaller systems.</td><td>Interactions and relationships
population, structure, function, change & constancy, cycles, ideal and real, formal and nonformal, trophic level, feedback, reciprocity, predation, migration, communication

Subsystems
habitat, biome, boundary, scale, family and kinship, stratification, politics, economic, religion, language, niche, communities

Inputs and outputs
artifact, waste, technology, instruction

Change over time
diversity, rate, ideas and concepts, geomorphism, accumulation, threshold, mutation, evolution, extinction, knowledge, innovation and invention, species (group)

(See individual concept sheets.)</td><td>Artifacts produced by societies can have profound effects on both social and natural systems. The invention of agriculture and agricultural tools enabled human populations to spread over a wide territory, to live in stable, permanent communities and to produce enough surplus to support a more complex way of life, including cities. At the same time, it allowed humans to change the landscape in major ways, turning natural ecosystems into human-managed systems. Some waste artifacts created by social systems can disrupt the normal function of natural systems, i.e. chlorofluorocarbon waste from refrigeration and air conditioners get into the atmosphere and reduce the amount of ozone that protects us from ultraviolet radiation.
Changes in natural system boundaries can affect social systems. If the earth's atmosphere is indeed warming, climatological boundaries to snowfall will have a major effect on the recreational patterns of people in Minnesota, and therefore on the economy in the areas of the state dependent on heavy snowfall to bring in tourists such as snowmobilers and skiers.
The consumption lifestyle of a population is important to understand. How much food and water does one person need vs. how much water does one person use? Can the earth provide for all of us if the population keeps growing? If it cannot, who will be provided for and who will not?
Social systems are influenced by the biomes in which they are located. Biomes influence the economic systems of the humans that inhabit them; people who live near forests are often part of the wood industries; people who live in the Red River Valley of Minnesota are agricultural, growing sugar beets, wheat and sunflowers—crops that can thrive in a dryer prairie area.
Sportsmen's groups (informal) lobbied their legislators (law making formal) to have a national tax on the sale of sporting goods (Pittman Robertson Act) to generate money for fish and wildlife habitat management that would supplement federal budget allocations for this purpose.
Urban sprawl, energy production and agriculture needed to produce food and fiber required by human communities have impacts on natural systems. All of the aforementioned require space and reduce the capacity of an area to support the plants and animals that occupied the former habitat.</td></tr>
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Environmental Literacy Benchmarks	Key Systems Concepts and Supporting Concepts	Examples of natural and social systems and their interactions
Grades **9 – 12 (adult)** **The interaction of social and natural systems can create properties that are different from either individual system.** **Interaction between social and natural systems is defined by their boundaries, relation to other systems, and expected inputs and outputs.** **Feedback of output from some parts of a managed social or natural system can be used to bring it closer to desired results.** **It is not always possible to predict accurately the result of changing some part or connection between social and natural systems.**	**Parts and objects (all)** individual, biotic factors, abiotic factors, similarities and differences, properties, member, ideas and concepts, group **Interaction and relationships (all)** trophic level, structure, function, ideal and real, change and constancy, patterns, cycles, feedback, migration, predation, population, reciprocity, communication, synergy, cause and effect, probability, chaos, ecosystem, formal and nonformal **Subsystems (all)** habitat, biome, ecosystem, boundary, scale, community, politics, population, religion, language, family and kinship, stratifcation, economics, niche, communication **Inputs and outputs (all)** energy and energy flow, resources, products, communication, technology, waste, innovation/invention, artifact, instruction **Change over time (all)** climate, geomorphism, probability, diversity, species, evolution, cycles, scale, rate, accumulation, threshold, migration, population, mutation, extinction, ideas and concepts, knowledge, innovation/invention **(See individual concept sheets.)**	• Sparrows and starlings were introduced to this country as biological control agents as people in Europe had observed that they were competitors. However, they expanded into new habitats in America, displacing native species through competition for food, shelter, and places to raise their young. In the example above, the social system predicted how the natural system would **probably** respond, but other variables in the natural system were not thoroughly understood. • Natural systems are affected by the demands of social systems for **energy**. Electrical generating plants often use water from rivers or lakes to cool equipment. The waste heat from the plant is transferred to the water that is returned to the aquatic ecosystem from which it was drawn. Under some conditions, the increase in temperature of the water in the natural ecosystem can have a negative effect on the organisms living there. • The actions of a social system can result in creating **chaos** in natural systems, other social systems, and its own social system. The practice of cities dumping raw sewage into river systems reduced the dissolved oxygen content of the water below four parts per million. This threw the aquatic system into chaos, killing all species that could not survive at that level of oxygen. • Conservation groups use the knowledge about the **synergistic** relationship between bacteria and ruminants and introduce deer herds to certain foods prior to starvation periods in winter. This helps guarantee that adequate populations of bacteria are present in the deer's stomachs when their normal diet needs to be supplemented. • Conservation is a major enterprise in Minnesota. Multiple agencies have been created and citizen groups have been formed that have overlapping (**redundant**) or shared environmental concerns. Reduction of the activities of some agencies working on soil conservation does not mean that soil conservation efforts will end. • Synthetic chemicals invented by social technologies are not always recyclable by natural processes nor in a timely fashion. Many of these compounds (**products**) are harmful to the environment and people.

Teaching the Key Systems Concepts from the tables above can be summarized as follows:

In grades preK-5

Students should be introduced to examples of natural and social systems, and learn to identify the different *parts and objects* of these systems. Discussion of how one part affects another encourages students to explore *interactions and relationships* between the parts of a natural or social system. Experiences should include a variety of systems, and involve questions on how well a system works or doesn't work, when parts are missing or broken. The focus in the elementary grades should be on **single** systems and their parts and relationships.

In grades 6-12 (adult)

Students should begin to look at *interactions and relationships* between **multiple** systems. In their study of natural and social systems, students should begin manipulating and observing systems to identify *subsystems*, the relationship of *inputs and outputs* to systems function, and learn to recognize how systems *change over time*. Observing how an aquarium or garden changes over time, and how it is affected by changing its parts or inputs, is one such example. In the higher grades, students should be able to apply systems thinking to many diverse interactions between natural and social systems.

Concept reference pages

This section provides an easy-to-use reference for each of the 64 Concepts involved in a systems-based approach to environmental lessons and environmental issues. Concepts are listed in alphabetical order.

Individual Concept reference pages include:

- a definition of the Concept
- a statement of student understanding of the Concept
- a brief discussion of the basic ideas of the Concept

In addition, the Concept's application to natural systems and social systems is described and examples are provided of the interaction between natural and social systems.