# Unit 1: Foundations & Population Ecology

Content Area: **Science**
Course(s):
Time Period: **MP1**
Length: **45 days**
Status: **Published**

## NJSLS - Science

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|---|---|
| HS-LS2-1 | Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. |
| HS-LS2-2 | Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. |
| HS-LS2-6 | Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. |
| HS-LS2-8 | Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. |
| HS-LS4-2 | Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. |
| HS-LS4-4 | Construct an explanation based on evidence for how natural selection leads to adaptation of populations. |
| HS-LS4-5 | Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. |
| HS-ESS2-2 | Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. |
| HS-ESS2-6 | Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. |
| HS-ESS3-1 | Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. |
| HS-ETS1-1 | Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. |

## Science and Engineering Practices

**Using Mathematics and Computational Thinking** — Use mathematical and/or computational representations of phenomena to support explanations and to support and revise explanations based on evidence. *(HS-LS2-1, HS-LS2-2)*

**Constructing Explanations and Designing Solutions** — Construct explanations based on evidence and valid reasoning that account for natural phenomena and patterns. *(HS-LS4-2, HS-LS4-4, HS-ESS3-1)*

**Engaging in Argument from Evidence** — Evaluate the claims, evidence, and reasoning behind currently accepted explanations to determine the merits of arguments. *(HS-LS2-6, HS-LS2-8, HS-LS4-5)*

**Developing and Using Models** — Develop a model based on evidence to illustrate the relationships between systems or components of a system. *(HS-ESS2-6)*

**Analyzing and Interpreting Data** — Analyze data using tools, technologies, and models in order to make valid and reliable scientific claims. *(HS-ESS2-2)*

**Asking Questions and Defining Problems** — Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions. *(HS-ETS1-1)*

**Scientific Knowledge is Open to Revision in Light of New Evidence** — Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. *(HS-LS2-2, HS-LS4-5)*

## Disciplinary Core Ideas

**LS2.A: Interdependent Relationships in Ecosystems** — Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from challenges such as predation, competition, and disease. *(HS-LS2-1, HS-LS2-2)*

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** — A complex set of interactions can keep an ecosystem's numbers and types of organisms relatively constant under stable conditions, but extreme fluctuations in conditions or population size can challenge ecosystem functioning. *(HS-LS2-2, HS-LS2-6)*

**LS2.D: Social Interactions and Group Behavior** — Group behavior has evolved because membership can increase the chances of survival for individuals and their relatives. *(HS-LS2-8)*

**LS4.B: Natural Selection** — Natural selection occurs only if there is variation in the genetic information between organisms in a population and variation in the expression of that genetic information that leads to differences in performance among individuals. *(HS-LS4-2)*

**LS4.C: Adaptation** — Natural selection leads to adaptation — to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. Changes in conditions can affect the distribution of traits in a population and may drive speciation or extinction. *(HS-LS4-4, HS-LS4-5)*

**ESS2.A: Earth Materials and Systems** — Earth's systems are dynamic and interact over a wide range of temporal and spatial scales; a change in one system can create feedbacks that change other systems. *(HS-ESS2-2)*

**ESS2.D: Weather and Climate** — Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen; the carbon cycle moves carbon among the atmosphere, hydrosphere, geosphere, and biosphere. *(HS-ESS2-6)*

**ESS3.A: Natural Resources / ESS3.B: Natural Hazards** — Resource availability, the occurrence of natural hazards, and changes in climate have influenced human activity and continue to shape where and how people live. *(HS-ESS3-1)*

**ETS1.A: Defining and Delimiting Engineering Problems** — Criteria and constraints for a solution to a complex real-world problem should account for societal needs and wants and for relevant scientific, technical, and environmental factors. *(HS-ETS1-1)*

## Crosscutting Concepts

**Scale, Proportion, and Quantity** — The significance of a phenomenon depends on the scale, proportion, and quantity at which it occurs; orders of magnitude relate models at one scale to another. *(HS-LS2-1, HS-LS2-2)*

**Stability and Change** — Much of science deals with constructing explanations of how things change and how they remain stable; feedbacks can stabilize or destabilize a system. *(HS-LS2-6, HS-ESS2-2)*

**Cause and Effect** — Empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects in populations and communities. *(HS-LS4-2, HS-LS4-4, HS-LS4-5)*

**Systems and System Models** — Models can be used to represent systems and their interactions — such as the flow of matter through Earth's spheres. *(HS-ESS2-6)*

**Influence of Science, Engineering, and Technology on Society and the Natural World** — Modern civilization depends on major technological systems; engineering and policy decisions are shaped by economic, social, and environmental costs, risks, and benefits. *(HS-ESS3-1, HS-ETS1-1)*

## Rationale and Transfer Goals

In this foundational unit, students formulate answers to the question, “What is environmental science, and how do scientists study the interactions between organisms and their environment?” Students first establish the interdisciplinary nature of the field — drawing on the natural sciences, economics, and policy — and the self-correcting process of scientific inquiry. They then model Earth as a set of interconnected systems linked by the cycling of matter and the flow of energy before turning to the ecology of populations and communities: carrying capacity, population growth, natural selection, adaptation, and the interactions that structure communities.

The crosscutting concepts of scale, proportion, and quantity, along with stability and change, serve as organizing ideas throughout. The transfer goal is for students to independently use scientific evidence, quantitative reasoning, and systems thinking to evaluate environmental claims and to weigh the costs and benefits of real-world environmental decisions — beginning with their own ecological footprint and that of their school and community.

## Enduring Understandings

- Environmental science is interdisciplinary; understanding environmental problems requires both scientific evidence and consideration of economics, policy, and ethics.
- Humans alter the environment in ways that affect other humans and other living things. An ecological

footprint allows us to compare which people and which countries place greater demands on the environment by measuring the resources they use (food, energy, land, etc.).
- There are limited resources on Earth. We need to either become sustainable or develop renewable resources so that future generations can also survive.
- Earth functions as a set of interconnected systems (spheres) linked by the cycling of matter and the flow of energy; a change in one system creates feedbacks that affect the others.
- Ecosystems have carrying capacities determined by the availability of resources and by interactions such as competition, predation, and disease.
- Evolution by natural selection explains the diversity of life and how populations change as environmental conditions change.
- Since everyone is connected in nature, we all share responsibility for finding solutions to environmental problems.

## Essential Questions

- What is environmental science, and why does it require both scientific evidence and an understanding of economics, policy, and ethics?
- How do matter and energy move through Earth's interconnected systems?
- What limits the number and types of different organisms that can live in one place?
- How and why do populations change over time, and how does natural selection shape the communities we observe?
- How can measuring our ecological footprint help us make more sustainable choices?

## Content - What will students know?

- The scope and process of environmental science, the steps and self-correcting nature of scientific inquiry, and the distinction between science and the application of science to policy.
- An ecological footprint measures the biologically productive land and water needed to supply the resources a population consumes and to absorb its waste.
- Environmental decisions involve economic costs and benefits and are shaped by United States and international environmental policy.
- Matter is conserved and cycles among Earth's four spheres (atmosphere, hydrosphere, geosphere, biosphere) through biogeochemical cycles, including the carbon, nitrogen, phosphorus, and water cycles.
- Earth's systems interact through feedback loops; a change to one system can create feedbacks that cause changes to other systems.
- Ecosystems have carrying capacities, which are limits to the number of organisms and populations they can support; these limits result from the availability of living and nonliving resources and from predation, competition, and disease.
- Population growth can be described mathematically (exponential versus logistic) and is constrained by density-dependent and density-independent limiting factors.
- Evolution results primarily from overproduction, heritable variation, competition for limited resources, and differential reproductive success.
- Natural selection leads to adaptation; changes in environmental conditions can increase some

populations, drive the emergence of new species, or cause extinction.
- Species interactions (competition, predation, parasitism, mutualism, and commensalism) structure communities, which exhibit stability and respond to disturbance.
- Most scientific knowledge is durable but is, in principle, subject to change based on new evidence or reinterpretation of existing evidence.

## Skills - What will students be able to do?

- Use mathematical and computational representations to model carrying capacity and population growth at different scales.
- Compare and contrast the ecological footprints of various countries around the world, and examine the factors that increase or decrease a footprint.
- Graph and interpret population and footprint data, and use orders of magnitude to relate models at one scale to another.
- Construct evidence-based explanations (CER) of how natural selection leads to adaptation of populations.
- Evaluate claims, evidence, and reasoning about ecosystem stability and the effects of changing conditions.
- Develop a quantitative model of the carbon cycle among Earth's spheres.
- Analyze geoscience data to argue how a change in one Earth system produces feedbacks in others.
- Analyze a local or global environmental challenge (e.g., reducing the school's footprint through recycling or composting) to define criteria and constraints for solutions.
- Write an evidence-based argument on an environmental issue and provide structured peer feedback on a classmate's draft.

## Activities - How will we teach the content and skills?

- Launch the unit with the Savvas Unit 1 anchoring phenomenon (“How do ‘dead zones’ affect the environment surrounding them?”) and the Chapter 1 Central Case (“Fixing a Hole in the Sky”) to frame inquiry and surface prior knowledge.
- Structure lessons around authentic questions that relate to students' interests, social and family background, and knowledge of their community.
- Provide multiple means of representation and multiple ways for students to demonstrate understanding, and use varied grouping to encourage collaboration across backgrounds and cultures.
- Use the Savvas “Comparing Ecological Footprints” (Map It) activity and an online footprint calculator; students analyze personal and school footprints and propose reductions (e.g., expanding recycling or starting composting).
- Run Savvas modeling and laboratory activities, including “Using Mark-and-Recapture,” “Yeast Population Growth,” “Simulating Adaptations,” “Successful Succession!,” and “Abiotic and Biotic Factors” (Go Outside).
- Engage students with a variety of Science and Engineering Practices to provide multiple entry points and multiple ways to demonstrate understanding.
- Use a structured discussion protocol (e.g., the “Six Thinking Hats”) to examine a current, controversial

environmental issue from multiple perspectives.

## Evidence/Assessments - How will we know what students have learned?

- **Assessments can be reviewed for each course in[this folder]**

- Formative: footprint data graphs, mark-and-recapture lab analysis, a natural-selection CER explanation, and section exit tickets.
- Summative: Savvas Chapter 1–5 assessments, an argumentative writing piece on a sustainability practice, and a quantitative carbon-cycle model.
- Use mathematical and/or computational representations to support explanations of factors that affect the carrying capacity of ecosystems at different scales.
- Use mathematical representations to support and revise explanations about factors affecting biodiversity and populations across scales.
- Evaluate the claims, evidence, and reasoning that complex interactions maintain relatively consistent numbers and types of organisms under stable conditions, but that changing conditions may result in a new ecosystem.
- Construct explanations of how natural selection leads to adaptation and how changing conditions affect the stability of populations and ecosystems.
- Environmental Benchmark #1 (administered during the last week of MP1; assesses Unit 1 content only).

## Spiraling for Mastery

*Because this is the opening unit of the course, the spiral focus draws on prior-grade (middle school) NGSS foundations rather than a previous high-school unit.*

| Content or Skill for This Unit | Spiral Focus from Prior Grade / Knowledge | Instructional Activity |
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| Carrying capacity and the limits on population size (HS-LS2-1). | MS-LS2-1: effects of resource availability on organisms and populations in an ecosystem. | Savvas Ch. 4 “Using Mark-and-Recapture” modeling; revisit middle-school resource-limit graphs, then extend to quantitative carrying-capacity models. |
| Cycling of matter through Earth's spheres; the carbon cycle (HS-ESS2-6). | MS-LS2-3 and MS-ESS2-4: matter cycling and energy flow within ecosystems and the hydrosphere. | Savvas Ch. 3 quantitative carbon-cycle model; compare to the matter-flow food-web models built in middle school. |
| Natural selection and adaptation of populations (HS-LS4-2, HS-LS4-4). | MS-LS4-4 and MS-LS4-6: natural selection and the basis of adaptation over generations. | Savvas Ch. 5 “Simulating Adaptations”; build from prior variation/selection reasoning to evidence-based CER explanations. |
| The ecological footprint and human impact on the environment (HS-ESS3-1). | MS-ESS3-3 and MS-ESS3-4: human impact on the environment and the role of per-capita consumption. | Savvas Ch. 1 “Comparing Ecological Footprints” (Map It) and online footprint calculator; extend qualitative MS reasoning to cross-country quantitative comparison. |

## Key Resources

Primary text and platform: Savvas Environmental Science (Withgott & Laposata), print and online course — Unit 1 (Introduction) and Unit 2 (Ecology), Chapters 1–5. Resources below replace the legacy Holt Environmental Science materials used in the prior curriculum.

- Central Cases: “Fixing a Hole in the Sky” (Ch. 1), “Cleaning the Tides of San Diego and Tijuana” (Ch. 2), “The Gulf of Mexico's Dead Zone” (Ch. 3), “Finding Gold in a Costa Rican Cloud Forest” (Ch. 4), “Black and White, and Spread All Over” (Ch. 5).
- Science Behind the Stories: “The Lesson of Easter Island” (Ch. 1), “The Cloudless Forest” (Ch. 4), “A Broken Mutualism?” (Ch. 5).
- Labs, Real Data, and Modeling: “Comparing Ecological Footprints” (Map It), “Measure for Measure” (Go Outside), “Cost-Benefit Analysis” (Quick Lab), “Finite Resources” and “Using Mark-and-Recapture” (Modeling), “Yeast Population Growth” (Scientific Method), “Simulating Adaptations” (Modeling), “Successful Succession!” (Quick Lab), and “Abiotic and Biotic Factors” (Go Outside).
- Savvas online course: investigative-phenomenon videos, interactive simulations, and the Unit 1 Anchoring Phenomenon Project.
- Supplemental: an online ecological-footprint calculator (e.g., Global Footprint Network) for the footprint activity.

## Career Readiness, Life Literacies, & Key Skills

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| 9.4.12.CT.3 | Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice). |
| 9.4.12.GCA.1 | Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3). |
| 9.4.12.IML.2 | Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources. |
| 9.4.12.IML.3 | Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8). |
| 9.4.12.IML.4 | Assess and critique the appropriateness and impact of existing data visualizations for an intended audience (e.g., S-ID.B.6b, HS-LS2-4). |
| 9.4.12.IML.7 | Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4). |

## Interdisciplinary Connections/Companion Standards

| Standard | Companion Standard Description |
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| RST.11-12.1 | Cite specific textual evidence to support analysis of science and technical texts, attending to |

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| | important distinctions and gaps or inconsistencies in the account. |
| RST.11-12.7 | Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, charts) to address an environmental question or problem. |
| WHST.11-12.1 | Write arguments focused on discipline-specific content (e.g., a persuasive piece on reducing the school's ecological footprint). |
| WHST.11-12.7 | Conduct short and sustained research projects to answer a question or solve a problem, synthesizing multiple sources on an environmental topic. |
| HSN-Q.A.1 | Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in footprint and population data. |
| HSS-ID.B.6 | Represent data on two quantitative variables on a scatter plot and describe how the variables are related (e.g., population vs. time; footprint vs. GDP). |