Lindenwold Public Schools

Environmental Science Unit 2: Populations and Biodiversity

25 instructional days

Content Standards

HS-ESS3-3. Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* [Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

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.

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Science and Engineering Practices

Using Mathematics and Computational Thinking

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3)
- Create or revise a simulation of a phenomenon, designed device, process, or system. (HS-LS4-6)
- Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)

Constructing Explanations and Designing Solutions

- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7, HS-ETS1-2)
- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)

Asking Questions and Defining Problems

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

LS4.C: Adaptation

- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-5),(HS-LS4-6)

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS-LS2-7)

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)

Crosscutting Concepts

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3)
- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-7)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-6)

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)

Rationale and Transfer Goals :

All populations are affected by several factors: birth and death rate, immigration and emigration, reproductive potential of the female, limiting factors in the environment (such as space or availability of food) and density dependent (disease) factors and independent factors (like a hurricane). Human populations are affected by these things as well. In addition, human populations are affected by social factors, such as wealth distribution, literacy and social structure. The study of human populations in particular is called demography. Students will look at various demographic information for different countries to draw conclusions about population growth. The last section in the unit is on biodiversity and endangered species. This correlates with the other sections on population growth, because there is a direct link to increasing human population and decreasing biodiversity in the world today. Students should see that as human populations continue to grow at an exponential rate, and use up finite resources, this leaves less for other populations. Having high biodiversity is a sign of a healthy environment. There will be a focus on endangered species, and some of the laws that have been put in place to help save them.

Enduring Understandings:

- All populations follow patterns and are limited or influenced by factors in the environment.
- Population growth can be graphed, and can be exponential or logistic.
- Human populations are affected by the same factors that affect other populations, in addition to social and economic influences.
- Human population growth in particular has an impact on other populations of organisms, as we use up more resources.
- As our population continues to increase, biodiversity continues to decrease.
- Decreased biodiversity is a sign of an unhealthy environment.
- As other populations decrease, some may reach the point where they are endangered.
- Endangered species have protection under federal law. We believe the # of endangered species today is at a critically high number.

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Essential Questions:

- How might we change habits if we replaced the word “environment” with the word “life support system”?
- Does reducing human impacts on our global life support system require social engineering or mechanical engineering?
- Is the damage done to the global life support system permanent?

Content/Objectives		Instructional Actions	
Content ***What students will know***	**Skills** ***What students will be able to do***	**Activities/Strategies** ***How we teach content and skills***	**Evidence (Assessments)** ***How we know students have learned***
• The sustainability of human societies and the biodiversity that supports them require responsible management of natural resources. • Change and rates of change can be quantified and modeled over very short or very long periods. • Some system changes are irreversible. • Modern civilization depends on major technological systems. • New technologies can have deep impacts on society and the environment including	• Have an understanding of how a complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. • Explore human dependence on Earth's resources and the nature and effects of human interactions with their environment. • Know that the sustainability of human societies and the biodiversity that supports them require responsible	• Structure lessons around questions that are authentic, relate to students’ interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar	• Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. • Quantify and model change and rates of change in the relationships among management of natural resources, the sustainability of human populations, and biodiversity. • Design, evaluate, and refine a solution for reducing the impacts of

some that are not anticipated. ● Scientific knowledge is a result of human endeavors imagination and creativity. ● Anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. ● Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). ● Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having	management of natural resources. ● Synthesize information from multiple sources and evaluate claims about the impacts of human activity on biodiversity based on analysis of evidence. ● Create a computational simulation or mathematical model illustrating the relationships among management of natural resources, the sustainability of human populations, and biodiversity. ● Symbolically and quantitatively represent natural resource management, sustainability of human populations, and biodiversity. ● Map relationships discovered, considering limitations on	backgrounds (e.g. conversations via digital tools such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understanding. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or	human activities on the environment and biodiversity based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ● Construct explanations for how the environment and biodiversity change and stay the same when affected by human activity. ● Evaluate a solution for reducing the impacts of human activities on the environment and biodiversity based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ● Analyze costs and benefits of a solution for reducing the impacts of human activities on the environment and

adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. ● Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. ● Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. ● Much of science deals with constructing explanations of how things change and how they remain stable. ● When evaluating solutions, it is important to take into account a range of	measurement when reporting quantities or data. ● Understand that sustaining biodiversity is critical to maintaining functional ecosystems. ● Collect data on growth patterns (exponential, logistic) and carrying capacity using bacterial populations in a petri dish, status of local fish and mollusk populations in Narragansett Bay, erosion of eelgrass beds, or continued Quonset Point dredging. ● Use data to make informed decisions about how environmental issues affect their communities politically, economically, and ecologically. ● Connect scientific knowledge to human endeavors, imagination, and creativity using conceptual simulations	solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities.	biodiversity based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ● Create or revise a simulation based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations to test a solution to mitigate adverse impacts of human activity on biodiversity. ● Use empirical evidence to make claims about the impacts of human activity on biodiversity. ● Break down the criteria for the design of a simulation to test a solution for mitigating adverse impacts of human activity on biodiversity into simpler ones that can be

constraints—including costs, safety, reliability, and aesthetics—and to consider social, cultural, and environmental impacts. ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. ● New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of cost and benefits is critical. ● Changes in the physical environment, whether naturally occurring or human induced, have contributed to the expansion of some	that illustrate relationships such as those between the management of natural resources in local New England fisheries or the lobster-harvesting industry, the needs of the human population, and the effect on marine diversity. ● Use data collected to model changes in marine animal populations to better understand the relationship between management of natural resources, biodiversity, and the sustainability of human populations. ● Investigate and research major contributions of scientists and engineers who have developed technologies to produce less pollution and waste in order to prevent ecosystem degradation.		approached systematically based on consideration of tradeoffs. ● Design a solution for a proposed problem related to threatened or endangered species or to genetic variation of organisms for multiple species. ● Analyze costs and benefits of a solution to mitigate adverse impacts of human activity on biodiversity. ● Environmental Benchmark #3

species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. ● Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. ● Thus sustaining biodiversity so that ecosystems' functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining	● Synthesize information from multiple sources to construct explanations and verify claims about how the environment and biodiversity change and stay the same when affected by human activity. ● Designing and evaluating a solution for a proposed problem related to threatened or endangered species or to genetic variation of organisms for multiple species. ● Determine long- and short-terms goals of a potential solution, while considering that new technologies can have deep impacts on society and the environment, including some that were not anticipated. ● Use empirical evidence of decreasing bird populations to		

biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. ● Both physical models and computers can be used in various ways to aid the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test ways of solving a problem or to see which one is most	differentiate between specific causes and effects. ● Use physical models and computer simulations to aid in the engineering process, test potential solutions, and refine designs. ● Consider the cost, benefits, and risks of systems created by engineers. ● Analyze data for positive and negative feedback within natural systems to predict if there would be stabilization or destabilization of greenhouse gas concentrations.		

efficient or economical, and in making a persuasive presentation to a client about how a given design will meet his or her needs. ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. ● New technologies can have deep impacts on society and the environment, including some that were not anticipated. ● Analysis of costs and benefits is a critical aspect of decisions about technology.			
Spiraling for Mastery			

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Content or Skill for this Unit	Spiral Focus from Previous Unit	Instructional Activity
*The sustainability of human societies and the biodiversity that supports them require responsible management of natural resources. *Changes in the physical environment, whether naturally occurring or human induced, have contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. *When evaluating solutions, it is important to take into account a range of constraints—including costs, safety, reliability, and aesthetics—and to consider social, cultural, and environmental impacts.	*Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. *In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. *Growth of organisms and population increases are limited by access to resources. *Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations or organisms. Mutually beneficial interactions, in contrast, may become	Resources from the Holt Environmental Science Text *Using the Figure: Age-Structure Diagrams *MathPractice: Extending the Equation for Population Change *Interpreting Statistics: Historical Correlation *Career: Statistician *Graphic Organizer: Spider Map *Case Study: Thailand's Population Challenges *Interpreting Statistics: Declining Fertility Rate *Map Skills: Population Density *Student Opportunities: Controlling Invasive Species *MathPractice: Estimating Species Loss *Case Study: A Genetic Gold Rush *MathPractice: Measuring Risk

*Thus sustaining biodiversity so that ecosystems' functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. *Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).	so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. *Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. *Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	
Key resources:		

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Cost-Benefit Analysis Primer: Students read this explanation about how cost-benefit analysis is derived and applied in order to apply this model to design solutions related to human sustainability. Students then read the application of CBA to water sanitation.

Carbon Stabilization Wedge: Students play this game in order to evaluate competing design solutions for developing, managing, and utilizing energy resources based on cost-benefit ratios.

One For All: A Natural Resources Game: Identify a strategy that would produce a sustainable use of resources in a simulation game. Draw parallels between the chips used in the game and renewable resources upon which people depend. Draw parallels between the actions of participants in the game and the actions of people or governments in real-world situations.

Building Biodiversity and the PREDICTS project and GLOBIO project: Students explore this website to develop an understanding of how computational models of the impacts on biodiversity are created. Next, they explore Conservation Maps for a global perspective of land use and conservation efforts.

Rainforest carbon cycling and biodiversity: Students apply this model to simulate how atmospheric CO2 concentrations, which influence global climate

21st Century Life & Careers:

9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs.

9.2.12.CAP.3: Investigate how continuing education contributes to one's career and personal growth.

9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.

Career Readiness, Life Literacies, & Key Skills:

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.CT.4: Participate in online strategy and planning sessions for course-based, school-based, or other projects and determine the strategies that contribute to effective outcomes.

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.

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.

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.

9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.

9.4.12.IML.5: Evaluate, synthesize, and apply information on climate change from various sources appropriately.

9.4.12.IML.6: Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity.

9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.

Interdisciplinary Connections/Companion Standards:

NJSLS Mathematics

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 formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-7)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-LS2-7)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-7)

NJSLS ELA

RST.9-10.8 Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-7)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-7)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-7)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS4-6)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7), (HS-LS4-6)

Companion Standards for ELA in Science and Technical Subjects: Reading

RST.9-10.8. Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem

Companion Standards for ELA in Science and Technical Subjects: Writing

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating an understanding of the subject under investigation.