Raising and Releasing Trout

Sierra Watershed Education Partnerships, CA

Teacher Guide

Raising and Releasing Trout

Sierra Watershed Education Partnerships, CA

Project Synopsis

Students in fourteen elementary, middle school and high school classes in the Tahoe - Truckee area of California raised endangered Lahontan cutthroat trout from eggs to fry. In the process, they observed the trout life cycle and researched the value of this native species in the local ecosystem. The participating classes traveled to cold-water trout streams and released their fry in the spring. Students learned about suitable conditions for trout habitat and monitored the streams into which the fry were released, testing for water quality and temperature.

Adapting the Project for Replication

Trout Unlimited has developed a project model called "Trout in the Classroom" which can be instrumental in setting up a program. See the Resources section for links to information and technical assistance. The Trout Unlimited web site also provides a "crowd-sourced" selection of science and interdisciplinary lessons related to raising trout, reproduced at the end of this lesson plan, with permission.

It is important to establish a relationship with a state fish hatchery that can provide fish eggs. The featured project benefitted greatly from the efforts of a non-profit organization: Sierra Watershed Education Project, that obtained permits for raising endangered species (not always an option in other parts of the country), trained teachers, established protocols, provided equipment to schools, delivered eggs, set up a blog, provided technical assistance, and facilitated field trips for release of fry. For tips on developing a program that is effective and sustainable, please see SWEP's final project grant report, included in the Resources section.

In some parts of the country, "Salmon in the Classroom" programs are sponsored by state Fish and Game or Natural Resources Departments. Sturgeon and bass raising programs are also available in a few warmer states. Conduct an internet search to see if such a program exists in your area.

Correlation to NGSS

3-LS1-1 Growth and Development
MS-LS2-A Interdependent Relationships
MS-LS2-C Ecosystem Dynamics
MS-LS4-C Biodiversity

Supplies and Equipment

Basic Materials

- Chiller
- tank (30-55 gallons)
- table, counter, or stand for the tank
- shade for the eggs
- Fluval 405 canister or Hagen AquaClear filter
- Filter media
- Pea-size Gravel
- Whisper 20 Air Pump
- Sandstone 12" Airstone
- 8' Flexible Airline Tubing
- Check Valve - 1 pk
- Net Breeder -- or homemade basket
- Battery Operated Digital Thermometer
- Floating Thermometer
- 4" Net
- Microbe Lift or other bacteria boost
- Siphon Gravel Cleaner
- 10'-15' Flexible Tubing 5/8"**
- Zinc Plated Clip 1/2" 2 pk**
- Freshwater Master Test Kit

Other Equipment (as needed)

- Turkey baster
- Buckets (2 or more)
- Battery-operated aerator
- Long-handled scrub brush
- Ammonia removal compound
- Tap-water-safe compound
- Clean ice packs, for use in transportation and/or chiller emergencies

Equipment Replaced Yearly

- Filter pads or cartridges
- Airstone and check valve
- Water Quality Test Kit

Procedures

Project Planning

1. Review technical information about the program and determine feasibility
2. Raise funds and establish partnerships, as necessary
3. Obtain supplies and equipment listed
4. Identify a source of fish eggs (state hatchery)
5. Establish timeline for obtaining eggs and releasing fry
6. Select grade-appropriate lessons in science or other subjects, from attached list
7. Set up aquarium and chiller per the directions in the Resources section
8. Arrange for egg delivery

Project Preparation for Students

1. Research fish species being raised and
2. Research habitat necessary for survival

Conducting the Project

3. Feed and care for fish eggs and fry
4. Observe and monitor fry (anatomy, life cycle, behavior, growth, habitat, interrelationships, etc)
5. Design and carry out investigations with fry
6. Test water quality of tank and determine if it meets requirements for trout survival
7. Collect fry survival and growth data to record, analyze and graph
8. Test water quality at proposed release location and deter mine if it meets requirements for trout survival
9. Release fry at a stream that provides suitable habitat in that location and downstream
10. Mark trout stream with artwork or signage, to educate others about importance of keeping water clean

Technology Integration

Technology incorporated in this project includes aquarium chillers and (optional) probes for testing water quality parameters in the classroom aquarium and the stream where fry will be released.

Project Partners

Captain Planet Foundation
Sierra Watershed Education Partnerships (SWEP)
California Trout
Trout Unlimited's Trout in the Classroom
Tahoe Environmental Research Center
Lahonton National Fish Hatchery
California Department of Fish and Wildlife
Tahoe Resource Conservation District
Rotary Clubs Truckee
U C Davis /Tahoe Environmental Research Center
Pet Station
Placer County Fish and Game Commission
US Fish and Wildlife Service

This American Land

Greenhouse or indoor location for starting
This American Land is an original conservation newsmagazine series on public television stations nationwide. Opening windows to our country's amazing natural heritage, the show reports engaging stories on America's landscapes, water, and wildlife, taking viewers to the front line of conservation, science and outdoor adventure with stories that inform and entertain.

This American Land is produced by Environmental New Trust (ENT), a non-profit news venture which has produced and distributed hundreds of environmental news stories for an international broadcast and Internet audience since 2004, ENT was founded by award winning television correspondent Gary Strieker, who reported for 20 years with CNN as a bureau chief and international environment correspondent. Gary is the executive producer of *This American Land*.

Native Trout Plant Restoration LITE

The two most expensive elements of a trout raising project are the cost of an aquarium chiller (approximately $650) to keep the fry at temperatures needed for survival, and the cost of transporting of students to a cold-water trout stream for release of the fry. A less expensive, smaller scale option is to adapt a thermoelectric cooler or wine chiller (approx. $150) by removing the shelves and inserting a three gallon aquarium with a light, per these instructions. Alternatively, classes that adopt warm water species, such as bass, can raise eggs and fry in a regular aquarium and release in an appropriate body of water that may be closer to the school. Check with your state Fish and Wildlife or Game and Fish department to see what species of eggs are raised in state hatcheries and may be available for classroom projects.

Debriefing

At the end of this project, students will understand that fish are not randomly distributed around the earth but have adapted over generations, in conjunction with other plants and animals, to be suited to a particular place and its water temperature, nutrients, climate, soils, etc. Human impacts including over-fishing, clearing and development of land, building roads that fragment habitats, removing or introducing species of plants or animals, degrading water quality by disposing of trash or contaminants anywhere in the watershed, warming water, etc., will change the potential of the land to support native plants and animals.

Non-native plants and animals may be present in an ecosystem because they have been introduced by humans, or because abiotic elements have been altered by humans. Non-native species may out-compete native species for limited resources (space, water, food, sunlight) due to lack of predators or other limiting factors they would typically face in their native environment.

Environmental Stewardship and Citizen Science

Environmental stewardship projects, such as native fish restoration, are empowering because they offer students a chance to make a difference by solving real-world problems. This is especially important because research has shown that learning about environmental science in the absence of such opportunities to act, can be overwhelming and affect adult attitudes and behaviors. Stewardship projects also cultivate collaboration, communication and other skills that contribute to employability in STEM fields.

Extensions

Environmental stewardship projects, such as native fish restoration, are empowering because they offer students a chance to make a difference by solving real-world problems. This is especially important because research has shown that learning about environmental science in the absence of such opportunities to act, can be overwhelming and affect adult attitudes and behaviors. Stewardship projects also cultivate collaboration, communication and other skills that contribute to employability in STEM fields.

Links

SWEP Trout in the Classroom Blog for this project:
http://troutintheclassroom.wordpress.com/

SWEP video of egg delivery day for this project
http://www.youtube.com/watch?y=jUQU0ZRENOw

Technical Information, including equipment details, set-up, timeline, trout care, trout feeding, transportation, and year-end
http://www.troutintheclassroom.org/teachers/technical-information

State-Specific Resources for Trout in the Classroom
http://www.troutintheclassroom.org/teachers/state-specific-resources

Trout in the Classroom web site
http://www.troutintheclassroom.org/

Trout in the Classroom Lessons and Science Activities
http://www.troutintheclassroom.org/teachers/lesson-plans/science

Field Guide to Trout and Salmon
http://www.streamexplorers.org/fish-facts/trout-and-salmon-species/brook-trout

The Way of a Trout movie
http://www.lrctu.org/movies/TheWayofaTrout/

Characteristics of a healthy trout stream
http://www.troutintheclassroom.org/teachers/library/dream-stream

Salmon Running the Gauntlet
http://www.pbs.org/wnet/nature/episodes/salmon-running-the-gauntlet/video-full-episode/6620/

Salmon life cycle
http://www.pbs.org/wnet/nature/episodes/salmon-running-the-gauntlet/salmon-lifecycle/6559/

Raising Bass
http://www.bassresource.com/fish_biology/smallmouth-fry.htm

Small Fry to Go Program
http://www.smallfrytogo.net/

Source of Fish Posters
http://www.nature-discovery.com/page_1_34/trout-salmon-char-of-north-america-i-fish-poster

Free Fish Identification and Record Weight Poster
http://www.anglingtrust.net/news.asp?section=29&from=2012/01/01&to=2013/01/01&itemid=1446

Chiller Options
from Trout Unlimited

You will need a chiller to keep the tank's water temperature at about 50° Fahrenheit. Most chillers are only designed to chill aquarium water to around 60°-70° Fahrenheit. Therefore, for our program, we must purchase chillers that are rated for a larger size tank--for example, for a 55-gallon TIC tank, we purchase at least 1/4 horsepower chillers which are technically designed for 100-125 gallon tanks. Some classes prefer to purchase 1/3 horsepower chillers, just to increase longevity by decreasing wear. By using a more powerful chiller, we decrease our chances of burning our chiller out after only a year or two.

Here are the most popular chiller options:

1. **AquaEuro**

2. **Glacier** —the original TIC chiller, a drop-in.
Glacier Corporation Chiller - Ph# (714) 557-2826 1/6 Horsepower -1 year warranty – Immersed Coil Type (Cooling coil is placed in water)– While this unit is very durable and has been the standard in the past, the chillers below are now generally preferred. No tubing or pump needed for the chiller. A pump will be needed for the UV sterilizer—use what is recommended for the UV flow rate.

3. **TradeWind** --a reliable, well-priced alternative
Many TIC programs have been having great luck with chillers (a variety of styles and sizes) from TradeWind Chillers.

Notes about the pump:
Once you have selected a chiller, that will determine which size pump you use. Each flow-through chiller requires a certain range of gallons or water per hour. Please ask your chiller source the recommended pump capacity and power for the chiller you chose.

Life & Learning

COURTESY ASHLEY PHILLIPS

Truckee High School's River Ecology students release Lahontan cutthroat trout fingerlings with their second-grade "Trout Buddies" from Glenshire Elementary.

Sierra Watershed Education Partnerships to be featured on PBS

Special to the Sun

Sierra Watershed Education Partnerships (SWEP) would like to thank the community for another successful school year. This spring, a producer and film crew from PBS's "This American Land" came to the Tahoe-Truckee region to film two of SWEP's most successful programs, the Envirolution Club's Trashion Show and the Trout in the Classroom (TIC) fish release.

The TIC program is a conservation-oriented, environmental education program that connects students to their local watershed. Throughout the spring students monitor and care for Lahontan cutthroat trout eggs, raising them from egg to fry, and eventually release them into an approved nearby stream or lake. Through this project students learn about native species, habitats, water quality and develop a conservation ethic. Thanks to the Captain Planet Foundation and the Placer County Fish and Game Commission for their support of the 2013 TIC program.

For more details on SWEP, and other SWEP programs visit www.4swep.org. Also, be sure to tune into PBS this fall to view SWEP and our local students in action. Exact airing time will be posted on the website.

COURTESY ASHLEY PHILLIPS

Dr. Leri, TTUSD superintendent, releases a LCT fingerling under the watchful eyes of Kings Beach Elementary students.

Captain Planet Foundation
Final Grant Report

Introduction

An important goal of the Captain Planet Foundation (CPF) is to collect and disseminate information about the "best practices" in environment-based education. This information is vital so CPF can help other schools and organizations learn from the experience of CPF's grantees. CPF has recently begun to develop a database of effective program designs and instructional materials.

We understand that projects often do not follow the predicted course but knowledge of your experiences and lessons learned are valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions—remember that all experiences both positive and negative are valuable, as they help us all to learn.

Reporting Requirements[1]

CPF requires all grant recipients to complete a CPF Final Grant Report using this form. This report must be submitted within 30 days of the end of the grant period as specified in the signed Grant Agreement.

In addition to the CPF Final Grant Report, your school/organization has agreed to submit, as part of this final report, photographs and/or other "artifacts" of the project, such as brochures or student-developed websites.

Please attach Videos, Photographs and/or other "artifacts". If you have items you cannot attach to this document, you may mail them to:

Captain Planet Foundation, Inc.
133 Luckie Street, 2nd Floor
Atlanta, GA 30303

Please contact us if you have any questions about this report.

Kathy Lively
Programs & Grants Manager
kathy@captainplanetfdn.org
(404) 522-4159

Certification

I certify that the information in this report is true and correct to the best of my knowledge. I also affirm that CPF is licensed to use the enclosed photographs and other "artifacts" for educational purposes on CPF's website, reports, and newsletters, as well as allow them to be shared with other grantees. We have obtained written permission for CPF to use these materials for the purposes listed above.

Signature: Ashley Phillips Printed Name: Ashley Phillips

Title: Project Director Date submitted: July 5, 2013

Name of School/Organization Sierra Watershed Education Partnership

Address: PO Box 1602

City: Tahoe City State: California Zip: 96145

General Project Information

Name of project: Trout in the Classroom

Date project activity started: March 2013

Amount awarded by Captain Planet Foundation: $650

Amount of grant funds expended: $ $650

Number of individuals who benefitted from this project:

# of students/youth: 1,996 students Grade/age range: K-12

# of teachers: 14 teachers

# of Community Members/Parents: 1000

Others: 400 Description: Partners and teachers from neighboring communities of Galena and South Lake Tahoe.

Please use as much space as you need to provide complete answers that may benefit others interested in implementing a similar project.

1. Describe the greatest educational achievements of the project. (Include data you collected related to state/district education standards or the other content and skills that are the focus of student learning.)

The Trout in the Classroom project is an environmental education program for K-12 students that engages students in true interdisciplinary learning. Each teacher who facilitates the TIC program is encouraged to customize the program to fit his or her particular curricular needs. Therefore, each classroom and program is unique. Concepts and state educational standards in math, science, language arts, social studies, fine arts, and physical education can all be addressed through the TIC project. The teachers that SWEP supports with the TIC project love the hands-on, real world experience that this project emphasizes, and the ability to cross curricular boundaries with science, art, math, and environmental learning.

2. Describe challenges and/or obstacles related to the educational activities undertaken during the project. How were these handled? What are some of the lessons learned from facing these challenges/obstacles?

There is no one way to implement the Trout in the Classroom project, and no particular curriculum that is prescribed. This is one on the great benefits to this project, but it can also be daunting to teachers who are new to the project. Some of our teachers easily incorporate language arts learning with the TIC, while others focus on science standards, and still others emphasize fine art expression. One of the challenges is for teachers to develop their own unique way of implementing the project and connecting their students' learning.

To support teachers who are new to the TIC project, SWEP provides an annual training. During the training teachers are given a variety of cross-curricular resources to utilize in their classroom. We also have veteran TIC teachers to give an overview of how they implement the TIC project with their students during the training. This year, we also developed an online community for TIC teachers so that resources, ideas, and support could be shared. The training and the online support have helped to alleviate some of the initial challenges and concerns as new teachers take on this project.

3. Describe the greatest environmental achievements of the project. (Include data you collected related to the environmental benefits, such as the amount of habitat restored, materials recycled, waste removed, gardens planted, etc.)

The greatest environmental achievement of the TIC project is the development of the conservation and stewardship ethic among the student and community participants. In the process of raising Lahonton Cutthroat Trout from eggs to fry, participants become connected to their environment. This connection leads to action. In the words of conservationist: Baba Dioum, "In the end, we only conserve what we love. We only love what we understand. We only understand what we are taught." Through the TIC project participants learn about the threatened native trout species in their watershed, and through this experience participants are inspired to become stewards of the environment.

4. Describe the challenges/obstacles related to the environmental activities undertaken during the project. How were these handled? What are some of the lessons learned from facing these obstacles?

This year, SWEP delivered over 1,600 Lahonton Cutthroat Trout eggs to 14 classrooms in the North Tahoe-Truckee region, with the goal of having 95% of these eggs survive and be released as fry into approved nearby streams, rivers and lakes with-in the Lake Tahoe Basin watershed. Through the TIC program, SWEP along with TIC participants, hope to aid the Lahonton National Fish Hatchery in their restoration efforts of the threatened Lahonton Cutthroat Trout.

One challenge we have experienced this year, as well as in past years, is a lower survival rate than our goal states. Some of mortality is normal, and what the hatchery expects. However, we feel one way we can improve the survival rate is to develop a newer version of the "tank set-up and maintenance" instructions with more updated information and techniques. We are currently working with a local aquarist to develop this new set of standards, and hope to have all teachers trained and implementing these practices by next spring.
Another way we plan to increase the success of the tank is to begin to require that all teachers attend teacher training workshop annually. In the past few years we have only required that new teachers participate in the training, and recommend that our veteran TIC teachers attend. We have found that while some veteran TIC attend, many do not. Mandatory participation would benefit the project by providing all participants with the most current informationand techniques, would help with the permitting process, and would help us have all teachers who are participating with communication

5. Describe the involvement of students/youth in the project and the benefits they received from their hands-on learning opportunities. (Include data collected related to student involvement in project activities and the effectiveness of hands-on learning during the project.)

This year SWEP directly supported 14 teachers in our region in implementing the Trout in the Classroom project, reaching nearly 2,000 students directly. Through the TIC project, these students benefited from the first hand experience raising and releasing Lahonton Cutthroat Trout. During this project students learned in an experiential way about native species, life cycles, endangered species, habitat and environmental issues in their local region, and more. This service project allows students to learn actively, and participate locally to preserve and protect native species.

6. Describe the challenges/obstacles related to the involvement of students/youth in the project. How were these handled? What are some of the lessons learned from facing these obstacles?

In our region, our local school district recently allocated funding to directly support science education. As a result, many school sites were able to hire a science coordinator/educator. One benefit this provided the TIC project was that many of the new science coordinators hosted the TIC tank in their classrooms. This allowed all students within the school access to the tank to observe and participate in the TIC program. The down side of this model of implementation was that individual students were only interacting with the tank and TIC project once a week during their science lesson time. Our observation has been that the program has more of an impact on students when it is implemented within the individual classrooms, so that students are interacting with the tank, and involved in the TIC program daily for the duration of the 6-8 week project. We have also found that the teacher training and resources that are available are really geared towards

implementation of the TIC project on an individual classroom model versus the whole school model.

As we move forward with this project in coming years, we hope to increase the number of teachers participating on an individual classroom basis, while also developing a model for implementing the TIC program on a whole school level. To accomplish this goal we plan to assisting teachers with obtaining the resources to purchase individual tanks and supplies necessary to participate. We also plan to enhance our teacher training program to provide more information and materials for the teacher implementing on an individual basis, as well as those implementing with the whole school model.

7. List the names of the community organizations you partnered with and describe how they helped with the project activities (Please add rows if needed).

Name of organization	How they helped implement the project
Tahoe Environmental Research Center	☒ Co-directed the annual teacher training workshop ☒ Provided venue for the teacher training workshop ☒ Assisited with egg pick-up at the Lahonton National Fish Hatchery ☒ Provided additional support and resources to teacher participants
Lahonton National Fish Hatchery	☒ Provided "Lahonton Cutthroat Trout" (LCT) presentation at teacher training workshop ☒ Provided 2,300 LCT eggs to be deliver to participating classrooms in Truckee-North Tahoe Region ☒ Provided additional support and recources to teacher participants
California Department of Fish and Wildlife	☒ Provided "Fish Biology & State Regulations", and "Raising Trout? Connecting Students" presentation at the teacher training workshop. ☒ Assisted with state permitting and regulatory process ☒ Provided additional curriculum and classroom resources to teacher participants
Pet Station	☒ Provided "Tank Set-up" presentation at the teacher training workshop ☒ Provided additional tank set-up and maintenance support to teacher participants
Trout Unlimited	☒ Assisted on fish release day as guest expert on LCT
Placer County Fish and Game Commission	☒ Provided additional financial support

8. What are your plans for the future of this project? If this project was a part of a larger program, explain how this grant has helped you sustain this project for the future.

SWEP has been involved in the TIC program in the Tahoe-Truckee region for several years, slowly developing a small basis of teachers who implement this project with their students annually. This year, SWEP was able to grow the program to support 14 teacher directly, and over 30 teachers indirectly. We continue to develop our local community partnerships as a way of enhancing and enriching this project, and were fortunate to receive national recognition for our work with this project through the PBS program "This American Land", airing this fall. As we move forward, we plan to involve more teachers and classrooms locally, so that all students in the Tahoe Truckee Unified School District benefit from this place-based, hands-on learning opportunity that connects students to their local watershed.

9. What, if any, advice would you give another school/organization trying to replicate your project?

The Trout in the Classroom project is hugely beneficial to students, teachers, and the environment. However, the time necessary to understand and obtain the required permits, set-up and maintain a tank, and gather background information and curricular resources to implement this project can be overwhelming and prohibitive to teachers interested in implementing this project on their own. We find that our support role, as coordinators of the Trout in the Classroom project, makes this project accessible to teachers, and is crucial to its success.

SWEP makes this project accessible to teachers by weaving together a backbone of local experts that include: fish experts, state wildlife regulatory agencies, nearby fish hatchery, and local aquarists. Through these partnerships we are able to provide an annual teacher training workshop that provides teachers access to regional experts and agencies, as well as the background information and curricular resources to implement this project. SWEP researches and manages the required permitting that allows teachers to raise and release trout following state regulations. We also pick-up and deliver the trout eggs to the participating classrooms, eliminating another time consuming step for our busy teachers. Throughout the project SWEP is on-hand to provide teachers support, whether it be trouble shooting problems that arise with their tank, or providing classroom support and assistance.

This project thrives on successful partnerships. It is essential, that teachers or schools interested in participating in the Trout in the Classroom project establish a local coordinator that can provide the support system to make this project possible.

Financial Information

Please copy the two left-hand columns from your proposal and add the information for the expenditures column from your records.

Items ***Our grant proposal was incomplete. Please see narrative below.	Funds Requested from CPF	Actual Amount Expended	Difference, if any (Funds Requested – Funds Expended)
TOTALS			

Financial Information

Our initial grant proposal did not include a project budget. SWEP requested a $500 grant donation from the Captain Planet Foundation, and was fortunate to receive a $650 grant donation. Initially, we anticipated using these grant funds to purchase additional supplies to complete the materials needed for an entire tank set-up for a teacher new to the Trout in the Classroom project. However, our partners at the Tahoe Environmental Research Center received a generous grant from Trout Unlimited

that provided the materials for four complete tank set-ups for local teachers who were interested in implementing the TIC project. The Trout Unlimited grant met the need for supplies in our region, and allowed SWEP to use the Captain Planet Foundation grant donation to support our growing network of Trout in the Classroom participants.

To support these teachers, SWEP enhanced the teacher training workshop by including presentations from our regional experts. This year, the California Department of Fish and Wildlife attended our teacher training workshop and shared two informative presentations: " Fish Biology and State Regulations" and "Raising Your Fish/ Connecting Your Students". We also had our local pet store owner and aquarist, demonstrate and discuss tank set-up and maintenance for the first time at this year's training. These new guest experts, as well as others provided an excellent foundation for teachers to begin the project. Many teacher's said that the guest experts were the highlight of the training.

Another way that SWEP was able to provide additional support to TIC teachers this year, was by creating an online community with a Trout in the Classroom blog. This resource was one that allowed teachers to ask and answer questions, and share observations and resources with one another. The blog also allowed SWEP to share informative videos, resources and other incites from our regional experts. SWEP managed the blog throughout the project, posting information and resources, and responding to others' posts.

SWEP also supported TIC participants this year, by providing on-site, classroom assistance and on-call availability. As concerns arose, particularly as teachers were initially setting up tanks, we were able to address and assist, so that all tanks were ready when the eggs were delivered. Throughout the project, SWEP staff communicated regularly with TIC participants to ensure project success.

SWEP is grateful to the Captain Planet Foundation for their support of this project. The grant funds donated allowed us the opportunity to strengthen our support to the TIC participants, grow the number of participants in the project, and increase the overall success of the project. This year, we were able to develop new partnerships that will enhance this project in coming years, create an online community to support our TIC participants, and enhance our overall support throughout the project.

Next Generation Science Standards for Native Trout Restoration Project

Third Grade

3-**LS1.B: Growth and Development of Organisms**

- Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1)

Students who demonstrate understanding can:

3-LS1-1. **Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.** [Clarification Statement: Changes organisms go through during their life form a pattern.] [*Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.*]

Middle School

MS-LS2.A: Interdependent Relationships in Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)
- 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. (MS-LS2-1)
- Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become 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. (MS-LS2-2)

MS-LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- 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. (MS-LS2-4)
- 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. (MS-LS2-5)

MS-LS4.D: Biodiversity and Humans

- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.*(secondary to MS-LS2-5)*

Students who demonstrate understanding can:

MS-LS2-1. **Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

MS-LS2-2. **Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.**[Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]

MS-LS2-4. **Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about

High School

- 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)
- Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5)

LS4.D: Biodiversity and Humans

- 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 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. (HS-LS4-6) *(Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)*

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. *(secondary to HS-LS4-6)*
- 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.*(secondary to HS-LS4-6)*

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.** [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in 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 designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

Photos

Photos

Photos

Photos

Photos