Crystal Cove® CONSERVANCY

PROJECT CRYSTAL CODE TEACHER GUIDE

Topic: Decomposition & The Carbon Cycle
Grade Level: 7
Unit Length: Ten sessions

Unit Overview
Middle school scientists investigate how different plant types affect decomposition rate and soil moisture at a restoration site in Moro Canyon. Throughout this unit, they identify how the environment has changed, design a computer model to show how carbon moves through the ecosystem, create a hypothesis, build and program a soil moisture sensor (in an optional extension), record and analyze data, and share their findings back with Crystal Cove State Park.

Essential Questions:
- How has Moro Canyon's landscape changed over time?
- What is the best way to restore Moro Canyon's coastal sage scrub ecosystem?

NGSS Performance Expectations
MS-LS2-3
MS-LS2-4
MS-ESS3-3

NGSS Crosscutting Concept
Systems & System Models

California Computer Science Content Standards
2-DA-09
2-AP-11
2-AP-12
2-AP-13

Welcome to Crystal Cove Conservancy's Project Crystal Code! As you and your students take part in real restoration ecology research at Crystal Cove State Park, you'll help researchers and land managers learn how best to restore degraded habitat in Southern California.

Project Crystal Code is the result of a unique partnership between Crystal Cove Conservancy, UC Irvine's Center for Environmental Biology, UC Irvine's School of Education, Crystal Cove State Park, and local educators. During this multi-week program, middle school scientists are introduced to the concept of ecological restoration and how communities can use technology to protect places like Crystal Cove's Moro Canyon. By engaging in the practices of science, students develop a deep understanding of how environmental systems operate over time. Throughout the program, participants practice skills in computational thinking as they engage in environmental research that can inform land management decisions.

Project Crystal Code involves an integrated curriculum that links classroom learning to a field trip to Crystal Cove State Park. During the 2020-2021 school year, as a result of COVID-19, we have adapted Project Crystal Code so that students can also participate from your schools if field trips are not possible. Video Field Trips and other technology-supported investigations can take the place of in-person visits to the park.

Project Crystal Code is provided free to participating middle school teachers and students. If you would like more information on the program or would like to officially join, please contact Georges Edouard, Crystal Cove Conservancy Education Manager, by emailing ***georges@crystalcove.org***.

Land Acknowledgment

Located on the coast in the area that is today known as Orange County, Crystal Cove State Park is located on the traditional lands and waters of the Acjachemen and Tongva tribal nations. We are deeply indebted to these tribal nations for their continuing role as the caretakers of these lands and waters and as leaders in the fight to ensure that places like Crystal Cove remain protected.

Through our collaborative work, we are together committed to uplifting the voices of everyone dedicated to protecting this important place.

About Crystal Cove State Park

Located on the coast in the area that is today known as Orange County, Crystal Cove State Park is located on the traditional lands and waters of the Acjachemen and Tongva Tribal Nations.

Today, Crystal Cove State Park consists of 3.2 miles of protected coastline, 2,400 acres of backcountry in Moro Canyon, and a 1,150-acre offshore underwater park, designated as the Crystal Cove State Marine Conservation Area in 2012. The park also includes the federally-listed Historic District, which includes an enclave of forty-five vintage coastal cottages originally built as a seaside colony in the 1930s and 1940s and a Japanese language schoolhouse, which was built by Crystal Cove's Japanese American farming community in the early 1930s.

Who We Are

Crystal Cove Conservancy is the nonprofit public benefit partner to Crystal Cove State Park, supporting important preservation, education, and conservation initiatives to cultivate our planet's next generation of environmental stewards ensuring that Crystal Cove, and places like it, live on for generations.

The Conservancy's unique STEM (Science, Technology, Engineering, Mathematics) education programs use community science to immerse students and the public in becoming good stewards of our environment. During our programs, students take part in real scientific investigations, working alongside researchers and land managers to investigate challenges faced by Crystal Cove State Park. Student findings inform real land management decisions, and past student data has even been included in ***academic publications***, furthering our understanding of how best to protect wild places like Crystal Cove State Park.

For questions regarding Project Crystal curriculum, program booking, and logistics, please contact:

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Crystal Cove Conservancy Education Coordinator
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Our Philosophical Approach to Science Learning

Crystal Cove Conservancy's STEM education programs are anchored in the idea of science-as-practice: that the best way to learn science is to do science. All of our programs integrate a three-dimensional approach to learning that aligns with the Next Generation Science Standards.

Our commitment to science-as-practice means that your students will really be helping to advance scientific knowledge as they participate in our STEM education programs. The research that they take part in is real, addressing real questions from scientists and land managers. Every year, we go into our program season unsure of what they'll find. Student data has even been included in scientific journal articles, like ***Dr. Kimball's article*** that was published in *Conservation Science and Practice.*

We also ground our work in sociocultural approaches to learning. We believe that people learn best by engaging in conversation with each other. Explaining reasoning out loud, asking questions of our peers, and responding to critique allows us to develop and test our ideas about how the world works. It also mirrors how professional scientists work by engaging in discussion and challenging ideas together.

Our Approach to Equity & Access

We believe in an assets-based approach to environmental education. The environmental movement has a long history of systematically excluding Black, Indigenous, and People of Color from both the movement itself and from parks and other outdoor spaces. Through programs like Project Crystal Code, we aim to empower youth so that they know that they can make a meaningful contribution to conservation.

We also recognize that all learners are natural scientists who possess an innate curiosity about the world. When students take part in Project Crystal Code, they are not learning to do science from scratch, but are practicing and refining the scientific skills that they already possess. We want to honor the fact that all of our participants have had prior meaningful experiences with nature. Through the Explore at Home extensions, we want to offer opportunities for students to connect learning about the park to their own families, homes, neighborhoods, and communities.

We are deeply committed to improving accessibility to our programs. Videos are close-captioned, and we've provided family-oriented materials in Spanish and English. If you need a different language or other technology to make the program more accessible for your students, please let us know by contacting Georges at ***georges@crystalcove.org***.

Introduction to the Ecological Problem

Southern California's coastal sage scrub (CSS) plant community is an incredibly diverse ecosystem, but it has also been incredibly impacted by development and human activity. As invasive plants such as black mustard dominate its original range, CSS has also come to be threatened by drought and other pressures created by climate change. Today, only 20% of our original coastal sage scrub range remains. Land managers in Crystal Cove State Park aim to take degraded areas of the park that are dominated by black mustard, and turn them back into coastal sage scrub through ecological restoration.

Crystal Cove State Park's Moro Canyon offers an ideal laboratory to study how best to restore coastal sage scrub and help our native CSS ecosystems thrive. During the 2021-2022 school year, our project will investigate how the type of native plant species used in restoration impacts the habitat quality, including the microbial community.

In 2017, Crystal Cove State Park and the Center for Environmental Biology at UC Irvine began restoring a degraded area of the park that was dominated by black mustard back to native coastal sage scrub. As part of the restoration, they set up an experiment to determine if certain mixes of plant species would be more successful than others. To investigate this, they tested different seed mixes in different plots. Each seed mix contained seeds from native plant species with different traits. For Project Crystal Code, our study will compare three of these different treatments: plants with high water use efficiency, plants with low water use efficiency, and unrestored control plots.

To test the impacts of each of these plant types of ecosystem functioning, researchers at the Center for Environmental Biology have collected data on each of the experimental plots to determine which one yielded the most diverse plant community. Now that the seed mixes have had time to grow and establish themselves, we are also interested to know how the plant types affect decomposition and carbon cycling, as well as the amount of water in the soil.

That's where your seventh grade students can help! We need their help to decide the best types of plants to use in future restoration projects by collecting data on decomposition rates and soil moisture in high water use efficiency plots, low water use efficiency plots, and unrestored plots. For Project Crystal Code, we specifically want students to compare the high water use efficiency plants (what we'll call *water-savers*) to the low water use efficiency plants (*water-spenders*) and non-native plants in the unrestored plots. Students will investigate the decomposition rates of the different plant types, the effect of restoration on the decomposition environment, and the effect of the different treatments on soil moisture levels.

Driving Question

How does the type of native plants used in restoration affect decomposition rates and soil moisture?

Testable Research Questions

Research Question (1): Leaf litter decomposition rate. Which type of plants will decompose the quickest and which will decompose the slowest: water-saver plants, water-spender plants, or non-native plants?

Research Question (2): Soil moisture. Where will the soil moisture be highest, and where will it be lowest: in areas with water-saver plants, water-spender plants, or non-native plants?

Research Question (3): Restoration effect on decomposition. Where will leaf litter decompose the quickest and where will it decompose the slowest: in restored or unrestored areas?

Learning Outcomes

During Project Crystal Code, students will be immersed in the practices and processes of scientific research as they take part in an ecological experiment at Crystal Cove State Park. By participating in the full program, they will build a broad understanding of plant ecology, the water cycle, and how professional and community scientists can use science ideas to protect wild places like Crystal Cove State Park.

By the end of the program, your students will be able to…	*You can assess this using…*
1. *Participate* productively in scientific practices and the discourse of science.	Observations of student discussions throughout the program
2. *Compare* coastal sage scrub plant community landscape to a degraded landscape, and reflect on what might have caused these changes.	Observations of student discussions and field notebooks in Session 1
3. *Construct* a computer model of a coastal sage scrub plant community that shows conditional relationships between components.	Student models, created in Session 3
4. *Use* their model to make hypotheses about the effects of changing environmental conditions on the decomposition rate and soil moisture in different plant communities.	Hypotheses in Session 4
5. *Reflect* on why scientists must test their models by designing an experiment and collecting data.	Observations of student discussions and field notebooks in Session 4
6. *Use* ideas about electronics and circuits to design a soil moisture sensor.	Soil moisture sensor schematics submitted in Session 7
7. *Use* ideas about variables and conditional relationships to create block-based code for a soil moisture sensor.	Soil moisture sensor code submitted in Session 7
8. *Represent* their data in different types of graphs.	Graphs in Session 9 and final presentations in Session 10
9. *Construct* evidence-based explanations about the effects of using different plant types on soil moisture and decomposition.	Graphs in Session 9 and final presentations in Session 10
10. *Communicate* findings of the investigation with their teachers, parents, and environmental researchers using appropriate representations of data.	Final presentations in Session 10
11. *Reflect* on how individual communities can use science ideas to protect places like Crystal Cove State Park.	Field notebooks in session 10

Next Generation Science Standards Alignment

The Project Crystal program is aligned with the three-dimensional approach of the Next Generation Science Standards. As students engage in community science research that focuses on a specific disciplinary core idea, they utilize science practices to plan and carry out investigations. Our programs frame science investigation through the crosscutting concept lens of Systems & Systems Models, challenging students to think about the visible and invisible interactions that affect environmental systems at Crystal Cove State Park.

By taking part in the six modules, students will be able to demonstrate understanding in the following areas:

Performance Expectations

- *MS-LS2-3:* Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- *MS-LS2-4:* Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- *MS-ESS3-3:* Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Science Practices

1. Asking questions
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Crosscutting Concept

- Systems and System Models

Computer Science Content Standards Links

One of the unique facets of the Project Crystal Code program is its integration of computational thinking. Throughout the program, students use conditional statements and variables as they build a computer model, explore block-based coding, and build and code an environmental sensor to measure soil moisture.

When our partner UC Irvine learning scientists assessed Project Crystal Code in the past, they found that the inclusion of these computational thinking pieces helped to shape how students talk about interactions within the Moro Canyon ecosystem. Ultimately, students who participated in the full program (including all of the computational thinking elements) developed a better understanding of the environmental system as a whole. Although these aspects may seem different than a typical science program, we highly encourage you to include them in your classroom.

By taking part in the full program, students will be able to demonstrate understanding in the following areas under California's Computer Science Content Standards:

Data and Analysis

- ***2-DA-09:*** Refine computational models based on data that students have generated.

Algorithm and Programming

- ***2-AP-11:*** Create clearly named variables that represent different data types and perform operations on their values.

- ***2-AP-12:*** Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals.

- ***2-AP-13:*** Decompose problems and subproblems into parks to facilitate the design, implementation, and review of programs.

Session Overview

Project Crystal Code is divided into 10 connected sessions. Each session runs between 45-60 minutes each.

Session	Overview	Length
1 *Welcome to Moro Canyon!*	In this initial session, students are introduced to the Project Crystal Code program. After learning about the project, they are divided into research teams and start their field notebooks. They then take a virtual hike through Moro Canyon to explore its coastal sage scrub ecosystem.	45-60 minutes
2 *Asking Questions*	Student research teams meet Kristin Barbour, the UC Irvine graduate student that they will be working with through the program, and are introduced to this year's experiment involving decomposition.	45-60 minutes
3 *Designing a Model*	Research teams create a model that shows how different factors and processes might impact the decomposition rates in The Bowl Experiment in Crystal Cove State Park's Moro Canyon.	Two sessions of 45-60 minutes
4 *Making a Hypothesis*	Students use their models to make a hypothesis, determine what evidence they need to collect, and design an experiment to answer their research questions.	45-60 minutes
5 *Building Circuits (optional)*	Students are introduced to the idea of building a soil moisture sensor to collect data. They take part in an online simulation to explore how circuits work, and then apply their understanding of circuits to design a schematic for a soil moisture sensor.	45-60 minutes
6 *Learning to Code (optional)*	Students are introduced to block-based coding on the MakeCode website. As they begin learning to code, they develop the skills they'll need to code a soil moisture meter.	Two sessions of 45-60 minutes
7 *Building & Coding a Soil Moisture Meter (optional)*	Students synthesize what they've learned so far as they finalize their schematic and create blockcode for a soil moisture meter.	45-60 minutes
8 *Collecting Data*	Students help record data as they explore the Project Crystal Code research site virtually.	45-60 minutes
9 *Analyzing Data*	As student research teams analyze their data, they create graphs, and validate their models.	45-60 minutes
10 *Sharing Our Findings (optional)*	Student research teams develop a recommendation to share with Crystal Cove State Park, and then design a presentation to share their findings.	Two sessions of 45-60 minutes

Basic Session Structure

Each session within Project Crystal Code is broken down into four sections. These sections align with the five elements of the BSCS 5E Instructional Model (although we use slightly different names).

Launch *(or Engage)*

At the start of every session, a short video introduces students to the day's driving question and invites them to share their initial ideas.

Explore

Next, students take part in short investigations related to the module's driving question. These investigations are designed to be flexible, and can take place during scheduled class time or independently outside of class.

Share *(or Explain & Expand)*

Students come back together to share their observations and discuss their ideas with their peers. These discussions may take place in student research teams or as a whole class. In the ***Session 1 slideshow***, we've included slides with suggested science discussion norms, sentence starters, and suggested questions to get you started! You can adapt these for your class.

Reflect *(or Evaluate)*

At the end of each session, students watch a video prompt and reflect on what they've learned so far in their field notebook.

Student Assessments

Crystal Cove Conservancy has pre- and post-assessments to help us evaluate the program's effectiveness, measure its impact on students, and report back on student learning outcome to our funders.

Before you start the Project Crystal Code program, please ask students to complete the pre-program assessment. After completing your last session of the program, please have them fill out the post-program assessment. You can assure students that their responses to these two assessments will not be graded or scored -- they're simply to help us assess the program itself.

Student Pre-Program Assessment
Student Post-Program Assessment

Technological Platforms

Throughout Project Crystal Code, we use a few different technological platforms to support student learning.

Sharing Information

Most of the program's presentations are hosted on ***Google Slides***, with videos embedded from our ***Crystal Cove Conservancy Education Youtube*** account. Due to school permissions, you will likely need to make a copy of each Google Slides presentation on your school Google account so that students can access it.

Exploring Places Virtually

Thinglink is an easy-to-use platform that allows organizations to create interactive photo maps that users can click on and explore -- including 360-degree photos. During Project Crystal Code, students will use Thinglink ***to take a virtual hike*** through Moro Canyon in ***Session 1***. They can then visit another Thinglink later in ***Session 8*** if you are not able to complete in-person field trips to virtually collect data. (You will not need to know how to use it, other than demonstrating how to access virtual explorations and click through it!)

Creating Models

You can choose between two different options for students to use when they create a model in ***Session 3***. The ***Session 3*** lesson guide has more specific information on the advantages and disadvantages of the two platforms.

- ***Padlet*** is a collaboration platform similar to an online bulletin board, which will let multiple students collaborate and build a model at the same time. Free accounts (which students can sign up for) can create up to three Padlet boards. Pro accounts, which let a user create unlimited boards, start at $8/month. If you don't have access to Padlet but prefer a collaborative option for modeling, you might consider using ***Google Jamboard*** or another ***online collaborative whiteboard*** instead.

- ***SageModeler*** is a free, online modeling tool that can be used to build computer simulations of systems. Although it is challenging to collaborate on SageModeler because only one person can manipulate the model, this platform will also allow students to easily define computational relationships between different factors in their models and simulate how environmental change will affect them.

Building and Coding Sensors

During *Sessions 5-7*, students learn to build and code an electronic sensor to measure soil moisture data. This is an optional part of the program.

- ***Micro:bit*** is a type of micro-computer similar to an Arduino or Raspberry Pi, which was built specifically for education by the British Broadcasting Corporation and Microsoft. It uses a block-based coding system, which can be accessed for free on ***Microsoft's MakeCode website***.

  Micro:bit kits cost about $20 each, but students can practice writing code online without one. If you are interested in including the micro:bit lessons in your classroom, Crystal Cove Conservancy also has classroom sets of micro:bits that are available for loan. Please contact ***georges@crystalcove.org*** with any questions!

- ***PhET Circuit Construction Kit*** In *Session 5*, students also explore how to apply ideas about circuits to build a soil moisture sensor. For virtual learning, we recommend using the interactive circuit simulation from ***PhET***, which allows students to experiment with connecting wires and batteries to build circuits. This simulation is available for free on PhET's website.

Analyzing Data

You can choose between two different options for students to use when they analyze data in *Session 9*. Again, the *Session 9* lesson guide has more specific information on the advantages and disadvantages of the two types of platforms.

- ***SageModeler*** has the ability to create graphs and display data using visualizations that are deliberately designed to help students think about data distribution and outliers. This can help students to build a conceptual understanding of ideas like statistical significance. It is also easy to use, which makes it ideal for younger students. However, it is challenging to collaborate on SageModeler because only one person at a time can manipulate it, and it is not a platform that would be used by practicing researchers.

- ***Google Sheets*** is a more traditional data analysis platform that is very similar to Microsoft Excel. It allows students greater freedom in creating graphs and performing calculations, and it can also be accessed collaboratively, with multiple students working on the same document in real time. However, using Google Sheets requires students to be more attentive to the step-by-step process involved in creating graphs and performing calculations, which can detract from conceptual understanding.

If you prefer another platform that serves a similar purpose, please feel free to substitute it in. If you or your students have any trouble accessing the slideshows or videos, please contact Georges at ***georges@crystalcove.org***!

Decisions to Make

Before beginning Project Crystal Code, it will be helpful to think through how you want to integrate and support a few key aspects of the program. Below, you'll find more information on four key decisions that you may want to make.

Supporting Collaboration

We often learn science best by engaging in discussions and collaboration, but COVID-19 restrictions and time limitations make it challenging to support collaboration. As a result, it's worth thinking ahead about ways that you can intentionally support student collaboration.

We recommend dividing students into research teams early in Session 1. Students will continue to work in these same teams throughout the program. If you are teaching in a fully online or hybrid environment, you might consider dividing into small discussion groups on Zoom or giving students options to meet in their research teams independently.

Integrating Field Notebooks

Throughout Project Crystal Code, students are encouraged to use field notebooks to make observations, respond to questions, and reflect on their own thinking. This is intended as a teaching tool to support metacognition. Before beginning the program, we recommend thinking through the logistics of the field notebooks.

- ***What kind of journal do you want students to use?*** If you want to give students an opportunity to get off of their computers, you may ask them to use a physical field notebook, like a notebook, notepad, or paper stapled together. Individual Google Docs work for a digital option, which may be easier to review and assess.

- ***How much scaffolding do you want to give students?*** There is benefit to letting students use a free-form notebook, since it will force them to think through how to structure their thinking. However, some students may need more support which can come from pre-designed pages. If you would like to provide students with more scaffolding, we have provided scaffolded field notebook pages for each lesson.

- ***How will you assess the science journals?*** Consider whether you want to collect the physical field notebooks, or if it's better to ask students to share photos of their entries so that you can assess their learning.

Building & Coding Sensors

Sessions 5-7 of Project Crystal Code challenge students to design, build, and code a sensor that can measure the amount of moisture in the soil. Although these sessions are optional, they are beneficial because they introduce students to block-based coding and computational thinking concepts in a project-based format.

If you'd like to include the Building & Coding Sensors sessions in your classroom, you can choose from two options:

- ***For an entirely virtual experience,*** students can code the sensors on the MakeCode website. Students will be able to participate in all of the activities, but will not be able to test or use their sensors in person.

- ***For an in-person experience,*** you can have students use micro:bit kits in your classroom. These kits are available from a wide variety of retailers and sell for approximately $20. You will also need to purchase other limited supplies (such as nails). A full list of supplies is included in ***Session 7***.

Crystal Cove Conservancy does have some micro:bit kits available to lend out to teachers. If you would like to borrow a set of our kits, please reach out to Georges by emailing ***georges@crystalcove.org***.

Assessing Student Work

Assessment can be challenging during COVID restrictions, so it is worth thinking ahead about how you will monitor and assess student learning. In the module lesson guides, we've identified learning outcomes for each module, along with suggestions for assessments.

- ***For formative assessments,*** you can observe student field notebooks and other student-created work, monitor students during discussions, and have students share their personal reflection at the end of each session.

- ***For summative assessments,*** you might decide to use our pre- and post-program learning assessments or grade research teams' final presentation that you can grade with a rubric.

Explore at Home Extensions

In addition to the main learning sequence within Project Crystal Code program, we also offer a series of extensions that can be used to get students off the computer and investigating plants in and around their home.

Although these investigations were developed as part of our fifth grade program, Project Crystal, they can easily be adapted for middle school students as well.

Visit our website to learn more about the Explore at Home Extensions!
https://crystalcove.org/education/school-programs/explore-at-home-investigations/