FUTURELAB+

AG/ENVIRONMENTAL

Plant to Pharmaceutical

Biodiversity on Earth

Developed in partnership with:

Discovery Education and Ignited

In this Lesson Plan:

Print the **Teacher Section** →

Print the **Student Section** →

This document is separated into two sections, For Teachers [T] *and* Student Resources [S]*, which can be printed independently.*

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Cover Image
The Solanaceae plant family is rich in bioactive metabolites and has played an essential role in traditional medicine.

AG/ENVIRONMENTAL / PLANT TO PHARMACEUTICAL

Biodiversity on Earth

ACTIVITY DURATION

Five class sessions
(45 minutes each)

DRIVING QUESTION

How do scientists use mapping tools to investigate the relationships between diverse human stakeholders, their local ecosystems, and potential sources of plant-based medicine?

ESSENTIAL QUESTIONS

How do humans collaborate effectively to conserve biodiversity hotspots as sources of plant-based medicine in the face of habitat destruction and climate change?

How are plants essential for human life?

How does preserving plant biodiversity conserve compounds and genes that may hold the key to treating disease?

OVERVIEW

Plants are and always have been an essential source of medicine and healing for humans. However, many medicinal plants found in unique places on Earth are facing compounding environmental challenges in the 21st century. As the *WHO explains*: "Biological diversity of microorganisms, flora, and fauna provides extensive benefits for biological, health, and pharmacological sciences. Significant medical and pharmacological discoveries are made through greater understanding of the earth's biodiversity, and loss of biodiversity may limit discovery of potential treatments for many diseases and health problems." Ethical collaboration among diverse stakeholder groups—collaboration that considers the needs of humans as well as plants and ecosystems—will be essential to future plant-based drug development opportunities.

In this lesson, students will investigate biodiversity challenges and conservation opportunities in biodiversity hotspots. Students will investigate a particular biodiversity challenge and display their findings using a map. This will allow students to demonstrate awareness of the needs of diverse stakeholder groups, ranging from Indigenous communities to biotechnology researchers.

OBJECTIVES

Students will be able to:

Analyze the role of biodiversity in human health.

Identify factors influencing the local and global distribution of biodiversity and **observe** changes in habitat quality over time.

Apply a model of analysis to a biodiversity hotspot.

Categorize the challenges that exist between different stakeholders in making conservation plans for diverse ecosystems.

Create a visual model of biodiversity resource conflict.

Materials

- **Student Guide**
- **Location of Plants used as Medicine Map**
- **What Does Biodiversity Mean for Human Health? Capture Sheet**
- **Time Lapse Observation and Inference Capture Sheet**
- **Case Study Capture Sheet**
- **Student Hotspot Capture Sheet**
- **Extension Option Capture Sheet: Primary Source Material on Biodiversity Hotspots and Threats**
- **Google My Maps Student Instructions**
- **Computer**
- **Internet access**
- **Google My Maps Presentation Capture Sheet**
- **Gallery Walk Option Student Capture Sheet**

This is an image of a honey bee *(apis mellifera)* on a mint *(menta piperita)* blossom.

Pedagogical Framing

Instructional materials are designed to meet national education and industry standards to focus on in-demand skills needed across the full product development life cycle—from molecule to medicine—which will also expose students and educators to the breadth of education and career pathways across biotechnology.

Through this collection, educators are equipped with strategies to engage students from diverse racial, ethnic, and cultural groups, providing them with quality, equitable, and liberating educational experiences that validate and affirm student identity.

Units are designed to be problem-based and focus on workforce skill development to empower students with the knowledge and tools to be the change in reducing health disparities in communities.

SOCIAL-EMOTIONAL LEARNING

Students will connect emotionally by understanding the relationship between people and their environment, at local and global scales. Students will be encouraged to explore the concept of *biophilia* (a love of nature). Students will be asked to model responsible decision making on various different scales: local, global, short-term, and long-term. Additionally, students will develop social awareness by analyzing the role of local and national governments in conservation, and the conflict that is generated from insufficient regulation of natural resources.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Students will be immersed in real-world case studies that explore how scientists are documenting plant biodiversity and how stakeholders are collaborating around complex global conservation challenges. Additionally, students will meet high expectations by creating a map, similar to maps that scientists would create for their own research.

ADVANCING INCLUSIVE RESEARCH

In this lesson, students explore how biodiversity research is integral to discovering new plant-based medicines. Traditional plant-based medicines are used by 60% of the planet's human inhabitants (WHO, 2015). When the relationship between Indigenous communities and the environment is disrupted, either locally or globally, we see extinction and reduction in habitat for medicinal plants and important ecosystem processes. Still early in the 21st century, we have the opportunity to honor and uphold the relationship between Indigenous communities and environments. In doing so, preserve the genetic and chemical compounds contained within the environments that the Indigenous culture protects.

COMPUTATIONAL THINKING PRACTICES

In this lesson, students will learn by exploring real-world issues while investigating interests and concerns of different stakeholder groups in biodiversity hotspots. Students will develop skills to persevere through open-ended problems while practicing perspective-taking among diverse groups. Computational thinking skills will be developed by gathering and representing data—using digital tools and collaborative technologies—to document biodiversity resource conflicts on a Google My Map. Students will then engage with classmates to share their findings and broaden mutual understanding.

CONNECTION TO THE PRODUCT LIFE CYCLE

In this lesson, students will explore the **discovery** phase of drug development, learning about scientific tools used to document biodiversity. Biodiversity research is foundational to the drug discovery process, as documenting novel plant species is the first step toward identifying plants that might be used as the source of novel medicinal compounds. Given the myriad of threats ecosystems face due to human land use, conservation and collaboration are essential to protecting these vital resources for future generations to discover new plant compounds.

Have you ever wondered…

Where will sources of new medicines be located in the 21st century and beyond?

Conserving biodiversity hotspots is essential to conserving the sources of novel plant compounds for present and future generations. Most of the plant biodiversity that has yet to be described formally by scientists is found in biodiversity hotspots.

How has Indigenous cultural knowledge, through collaboration with western scientists, been foundational to the development of plant-based medicinal compounds?

Indigenous communities have lived with the local environment in different locations on Earth for tens of thousands of years. Thus, each unique Indigenous community has developed deep cultural practices for protecting ecosystems and deriving plant medicine from those ecosystems. Through ethical collaboration, western scientists have learned from this experience to identify and create novel plant-based compounds that can serve as medicines.

MAKE CONNECTIONS!

How does this connect to the larger unit storyline?

The history of medicine and pharmaceuticals is based on what we have learned from the natural world in rich, biodiversity hotspots.

Preserving biodiversity throughout our planet is essential for life on Earth, and is heavily impacted by human activity.

Regions rich in biodiversity present complex challenges among stakeholder groups with regards to accessing natural resources, land use, cultural systems, and environmental protection and conservation.

How does this connect to careers?

Climate scientists use tools from diverse fields (atmospheric science, chemistry, biology, physics, and computer science) to model and make predictions for how the increase in greenhouse gases will impact our planet, now and in the future. Climate scientists might measure carbon cycling in tropical forests, the concentration of CO^2 in the atmosphere, or communicate with stakeholders about the outcomes of various scenarios in terms of a local risk of flooding or forest fires over the next 50 years. Climate scientists often collaborate with policy makers and entrepreneurs to provide data for adaptive decision making.

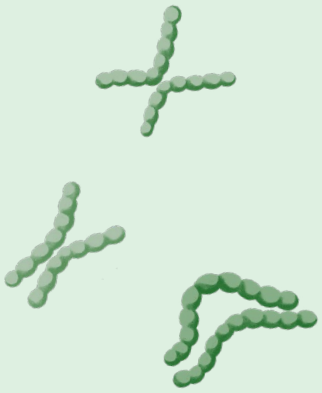
Medical anthropologists are scientists who study disease and illness within biological, cultural, and social contexts. Medical anthropologists examine how the health of humans, other species, and the environment affect each other. They work in hospitals, museums, and government agencies, and develop strong research and analytical skills.

How does this connect to our world?

Understanding the distribution of biodiversity on our planet is essential to understanding the origins of our plant-based medicines.

According to Maori tradition: *When the land is well, the people will be well* (as shared by Indigenous conservationist Rob McGowan).

Reframing the human relationship with the Earth is essential to enhancing access to potential plant-based therapeutics.



Day 1

LEARNING OUTCOMES

Students will be able to:

Define the impact of biodiversity and ecosystem loss on human health.

Identify the levels of biodiversity.

Develop observation and inference skills regarding levels of biodiversity.

Procedure

Teacher Note > *Day 1 and Day 2 are both designed as openers, and can be presented in the order that makes the most sense to you, depending on students' level of familiarity with biodiversity and ecosystem processes. Day 1 explicitly connects to human health, whereas Day 2 focuses on ecosystem-level changes and how biodiversity is impacted by those shifts, and also provides basic instruction on biodiversity and ecosystem function. Both begin by asking students to make observations and inferences from patterns present in visual data.*

Whole Group (15 minutes)

1. To start, project the *Location of Plants used as Medicines Map* and ask students what is highlighted, and what each of these regions may have in common. Explain that these regions are all biodiversity hotspots. A biodiversity hotspot is an area of unique species diversity that is at risk of habitat loss from local human land use challenges.

2. Invite students to view *What Does Biodiversity Mean for Human Health? Capture Sheet*. Ask: Where do you think plant-based medicines come from?

   a. Connect students' thinking about the richness of biodiversity hotspots to the question of where plant-based medicines come from.

   b. The warm up image highlights medicines that have been developed from plant species in these particular regions.

   c. Share with students that in this unit they will focus on identifying plants that can be used in medicines. As a group, they will pitch a drug for a disease target of their choice.

3. As a class, use the *Ecosystem services video* from the California Academy of Sciences to explore the idea of *direct services* (start video at two minutes and 23 seconds). Ask students to listen for and provide examples of direct services that ecosystems provide humans.

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Day 1

Continued

Procedure

4 Central claim: *Medicine comes from studying organisms in their environment.* (1:54) Pause the video when this sentence is displayed to allow students to capture this claim. Examples of additional direct services mentioned in the video include:

- Food
- Medicine
- Clothing
- Housing
- Transportation

Teacher Note > *If time allows, watch Ecosystem services (9:02) and compare and contrast direct services, indirect services, and ethical and aesthetic values. Note that indirect services are influenced by multiple factors, and students should be encouraged to consider multiple perspectives, needs, and concerns of all stakeholder groups when evaluating values and actions. For example, in the video, the presence of mangroves in an ecosystem is given a higher value than the use of the ecosystem by shrimp farmers. But this perspective does not acknowledge the potentially limited incomes of individuals in this area and the lack of alternative income sources.*

INDUSTRY AND CAREER CONNECTION

Medical anthropologists study how human diseases interact with other social, biological, economic, and environmental perspectives. Students will be exploring this career when they read the included WHO article about Biodiversity and Health.

Small Group (20 minutes)

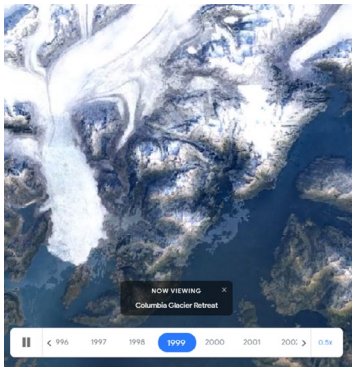
Have students read the WHO article *Biodiversity and Health* and complete the notes scaffold in mini-jigsaw format. All students should read the first four paragraphs, and then divide the remaining sections (health research and medicine, nutrition, infectious disease, climate change and health, and threats) to summarize and share with the rest of the group to complete the information map. All students should individually complete and reflect on key facts to share with the class.

Whole Group (10 minutes)

1 Ask each student to share their reflection of which of the WHO key facts on biodiversity impacts is most important to them.

2 Preview Day 2 activities for students by connecting the WHO key facts to the activity that students will do with Google Earth Time Lapse. Many of the ecosystem changes discussed in the WHO article can be observed from satellite imagery.

Teacher Note > *The Student Guide is designed to support students in the final assessment in Week 9 and in their Unit Project (Lessons 6–9). A unique version is provided for each lesson. As an exit ticket (if time permits) or as homework, students should add to their Student Guide by completing the first question for Lesson 1.*



Day 2

LEARNING OUTCOMES

Students will be able to:

Observe large-scale impacts on ecosystems.

Make connections between climate change, biodiversity loss, and carbon cycling.

INDUSTRY AND CAREER CONNECTION

Climate scientists study how humans affect the climate, and in turn, how climate change impacts environments at large and small scales, and impacts all facets of Earth's systems, including the biosphere, hydrosphere, cryosphere, geosphere, and atmosphere.

Procedure

Whole Group (5 minutes)

1 This lesson focuses on introducing habitat change on Earth. Students will use *Google Earth Time Lapse* that allows them to explore change over time at a particular location on Earth, using satellite images that are stitched together forming a time lapse.

2 To start, model the observation/inference process for students, using the time lapse of the Alaskan Glacier Clip and the think-pair-share protocol.

Small Group (15 minutes)

Students will use the *Time Lapse Observation and Inference Capture Sheet* to document observations and inferences at a location of their group's choosing. We suggest that student groups sign up on the board for a particular location of interest (either listed or of their own choosing) or use the categories on the capture sheet to focus on a particular impact or shift.

Whole Group (15 minutes)

Ask groups to share their observations and inferences. The changes observed in today's activity are dynamic, and are directly related to a shift in ecosystems due to climate change, habitat destruction, and other threats. Using the observations and inferences as a basis, introduce the idea of biodiversity and the levels at which biodiversity is observed and studied (satellite imagery vs specific field sites).

Individual Work (10 minutes)

1 Introduce the *Lungs of the Planet* reading on the *Case Study Capture Sheet*. Invite students to explore forest biodiversity and climate science through a specific field location in the Amazon rainforest. The interactive article provides an example of how scientists analyze a field site prior to on-site research. The articles and video sources provided give students an opportunity to observe scientists collecting data on photosynthesis, respiration, and carbon cycling, from the individual leaf level to the landscape level.

2 Students can complete the assignment individually, or complete the *Case Study Capture Sheet* in pairs, with different questions assigned to each partner.

Day 3

LEARNING OUTCOMES

Students will be able to:

Explore biodiversity hotspots.

Map the structure of key ecosystems that are sources of current medicines and that may hold future medicines that are as of yet unknown to science.

Procedure

Teacher Note > *This case study provides one example of collaboration between an Indigenous community (the Maori of New Zealand) and western scientists.*

Whole Group (10 minutes)

1 Review the Lungs of the Planet reading assignment and answer any questions students may have from looking at collaboration challenges and the scientific process in the Amazon River Basin.

2 Show an image of a New Zealand kauri forest. The kauri tree is a *keystone species*: a species whose role in the ecosystem has a direct impact on many other species and whose absence impacts ecosystem stability and the ecosystem's resilience or function. Let students know that they will be exploring how scientists, farmers, Indigenous Maori people, local governments, and other stakeholders collaborate around conservation and commerce needs surrounding the kauri tree.

Small Group (35 minutes)

In small groups of three or four, students will read *The Swamp Sentinels*, and use a Google mapping tool to connect data about local human populations, biodiversity, and conservation strategies necessary in the region. (*Google MyMap example*) Students will work in groups to complete the *Student Hotspot Capture Sheet* as they analyze the reading and interactive visuals linked within that capture sheet.

Teacher Note > *As an optional extension for student groups, allow them to identify which biodiversity hotspot they'd like to study from the list on the Extension Option Capture Sheet: Primary Source Material on Biodiversity Hotspots and Threats. They will document the stakeholders and the threats specific to that location (e.g., forestry, agriculture, urbanization, overharvesting, pollution) using primary literature, guided by the Extension Capture Sheet. This option requires student independence and collaboration with group members to read and find information in professional-level texts. Provide guidance on specific reading strategies, including skimming and using Ctrl+F to locate key search terms and using Google to further investigate the meaning of science vocabulary.*

Teacher Note > *As an exit ticket (if time permits) or as homework, students should add to their Student Guide by completing the second and third questions for Lesson 1.*

Day 4

Procedure

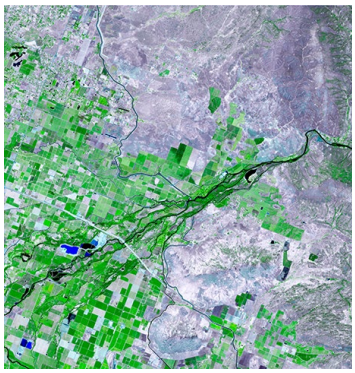
LEARNING OUTCOMES

Students will be able to:

Visually communicate findings about biodiversity, conservation, and human impacts. (Google Maps)

Demonstrate spatial reasoning (perceive objects in 3D and form conclusions).

Collaborate to create visual communication for peers.



Whole Group (5 minutes)

1 Use of Google My Maps allows students to mimic careers that work with Geographic Information System (GIS)—a commonly used spatial analysis and mapping software—without the years of training needed to be proficient with GIS. Many careers in this field communicate "stories" based on data analyses and spatial reasoning.

2 Demonstrate where the tutorial and *Example Map* can be found in the *Google My Maps Student Instructions*. Describe the decisions students need to make about key concepts from their Day 3 research. These decisions will help them to communicate the following in their maps: land use, resource use, and stakeholder collaboration challenges in New Zealand's kauri forests. Students can insert videos, photos, draw shapes, indicate ranges of specific species, and alter the base map to communicate different facets of their research about plant biodiversity.

Small Group (35 minutes)

Groups will create their story using *Google My Maps Presentation Capture Sheet*. If groups have not finalized their maps during the class period, ask them to do so as homework prior to the presentation or gallery walk showcase on Day 5.

Teacher Note > *As a possible extension to add context to the story they are presenting, students can choose to explore their biodiversity hotspot using the Google Earth Time Engine to look at change over time (using the location search bar to look at satellite imagery), or iNaturalist to explore human observations of biodiversity (using the Explore function).*

Day 5

LEARNING OUTCOMES

Students will be able to:

Share visual communication with peers.

Observe peers' visual communication to gain a broader perspective.

Procedure

Whole Group (45 minutes)

1 Each group should be given two to three minutes to present their findings. They should project their map and share a summary of their analysis of collaboration challenges surrounding the kauri tree (or their biodiversity hotspot of choice).

a. During the presentations, the audience should look for differences in how data are displayed, features are emphasized, and perspectives are prioritized, and make notes on their Day 5 worksheet.

2 As an alternative to presentations, arrange to have a Gallery Walk, where one group member from each group shares the group's map while other students observe other groups' maps, capturing findings on their *Gallery Walk Option Student Capture Sheet*.

Teacher Note > *The Gallery Walk Option Student Capture Sheet should not be used as an assessment. The Google My Map is the assessment. This capture sheet is an opportunity to support student-to-student communication in the classroom.*

3 Following presentations, have a class discussion around observed differences, and create a list of:

- Specific examples of unique biodiversity
- Stakeholders at particular field sites
- Specific threats at specific field sites
- Any conservation success stories

4 Wrap up the week by introducing that next week, students will be focusing on ethical collaboration in biodiversity research and pharmaceutical research.

Teacher Note > *As an exit ticket (if time permits) or as homework, students should add to their Student Guide by completing the final question for Lesson 1.*

National Standards

Next Generation Science Standards

LS2.A: Interdependent Relationships in Ecosystems
Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
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. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. 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.

LS4.D: Biodiversity and Humans
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 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.

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National Standards

Next Generation Science Standards

Continued

ESS3.D: Global Climate Change
Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Science and Engineering Practices

Analyzing and Interpreting Data
Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Obtaining, Evaluating, and Communicating Information
Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Career and Technical Education (CTE)

A2.4
Understand the critical need for ethical policies and procedures for institutions engaged in biotechnology research and product development.

A5.1
Use the Internet and World Wide Web to collect and share scientific information.

A5.3
Compile labs (results, tables, graphs) in a legal scientific notebook and/or an Internet site or Web page.

A7.1
Identify agencies at the local, state, and federal levels.

5.3
Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment.

5.4
Interpret information and draw conclusions, based on the best analysis, to make informed decisions

What Does Biodiversity Mean for Human Health?
Capture Sheet

ANSWER KEY **Do not share with students**

Directions
During the Ecosystem Services video from the California Academy of Sciences, listen for and provide examples of direct services that ecosystems provide humans.

1. What is the meaning of direct service?

Things we get directly from biodiversity include food, clothing, housing, transportation, many medicines and medical supplies, and sometimes energy. These are derived directly from various ecosystems.

2. Where does medicine come from?

Almost all medicines developed have come from studying the way organisms live in their environment, how they interact, and the chemicals that they use during those interactions.

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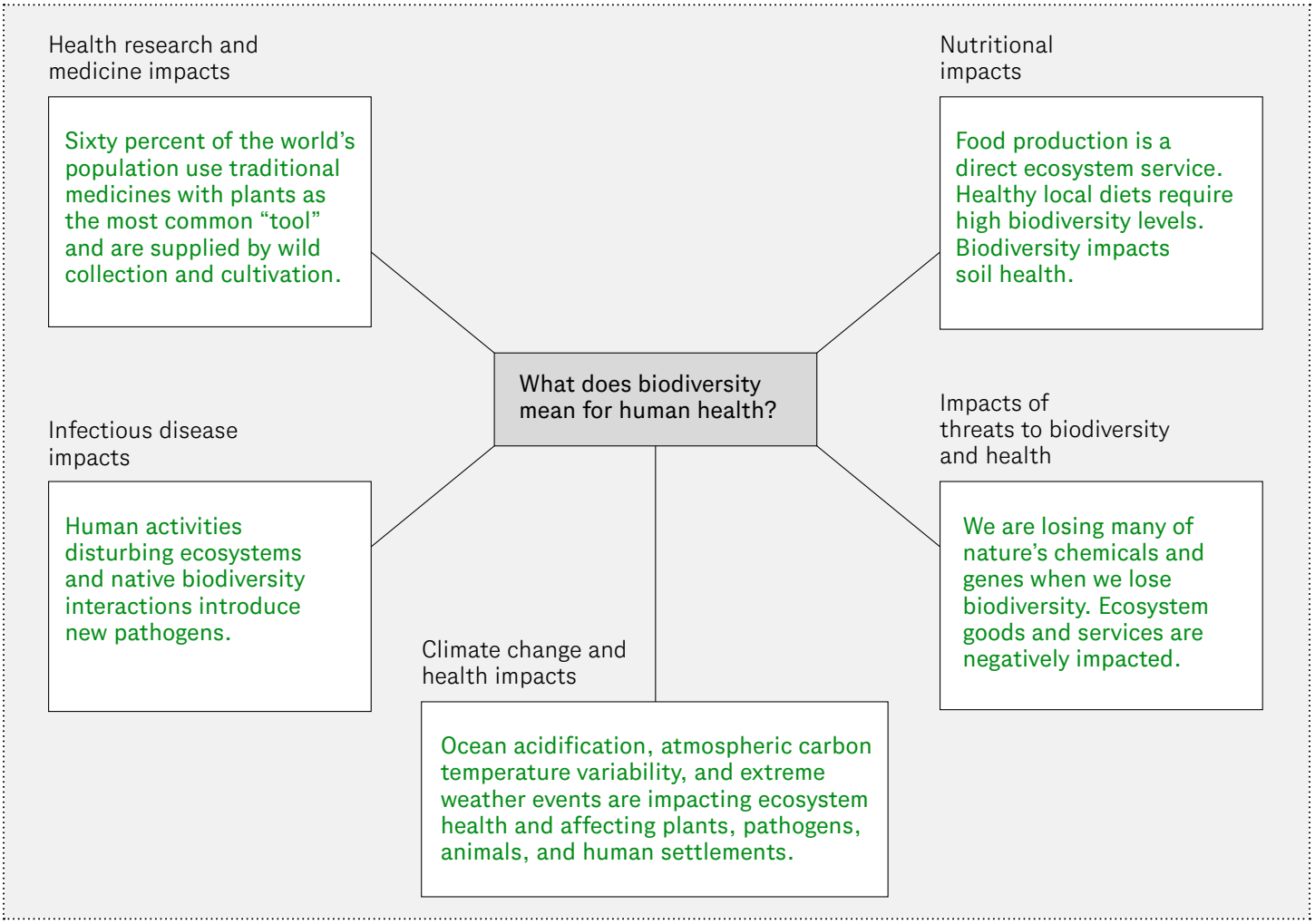
What Does Biodiversity Mean for Human Health?
Capture Sheet

ANSWER KEY **Do not share with students**

Continued

3. Read the first four paragraphs of the article *Biodiversity and Health* from the WHO. As a group, divide the remaining sections (health research and medicine, nutrition, infectious disease, climate change and health, and threats) and answer one section to share with your group.

Biodiversity's Impact on Human Health



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What Does Biodiversity Mean for Human Health?
Capture Sheet

ANSWER KEY **Do not share with students**

Continued

4. Which of the key facts listed in the *Biodiversity and Health*, WHO article seems most important to you and why?

Responses will vary.

Below is an example of a student answer:
Biodiversity is essential to life on Earth.
This is important to me because I care about the future of our planet.

Time Lapse Observation and Inference Capture Sheet

ANSWER KEY **Do not share with students**

Directions

Use Google Earth Time Lapse to explore change in satellite images over time at a particular location on Earth. You will use this sheet to document observations and inferences at a location of your choice.

1. Using *Google Earth Engine Time Lapse*, select an option from the list below. Please circle what you chose.

	Topic	Location
a	Infrastructure growth	Teles Pires River, Brazil
b	Urban growth	Naypyitaw, Myanmar
c	Urban growth	Las Vegas, Nevada
d	Deforestation	Toliara and Saint Augustin, Madagascar
e	Deforestation	Nuflo de Chavez, Bolivia
f	Coastal Expansion	Dubai, United Arab Emirates
	You may also examine other locations that you are interested in. Optionally, list these below.	
g		
h		
i		
j		

Vocabulary

Observation	Quantitative or qualitative information obtained using your senses
Inference	A logical explanation or interpretation based on your observations

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Time Lapse Observation and Inference Capture Sheet

ANSWER KEY **Do not share with students**

Continued

2. Watch the time lapse a few times to get a sense of how the location has changed. Be sure to note the time frame in which these changes occurred (see scale along the bottom of the images). Record your observations in the table below with your partner or group.

   Infer how the observed changes may impact:

Biodiversity	
Climate Change	Sea level riser Loss of ice or snow pack Change in precipitation (increase or decrease)
Human populations	Roads Edges of urban areas Types of buildings Other impacts on neighboring natural areas
Natural resources	Habitat shifts Water body shifts Tree cover or ice cover changes

Below is an example of a student answer.

Location	Time Frame	Observations	Inferences
Columbia glacier retreat	1984–2020	Less ice, more brown and green surface areas	A warmer climate causing the ice to melt

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Time Lapse Observation and Inference Capture Sheet

ANSWER KEY **Do not share with students**

Continued

3. What is biodiversity?

Bio: Life

Diversity: Different forms

4. What are the different levels of biodiversity?

Genetic: All different forms of all different genes in genomes from all living things on Earth.

Species: All different Archaea, Eukaryota, and Bacteria on the planet; this is the form of biodiversity that is most often focused on.

Ecosystem: This captures all the different biomes and microclimates, and the study of interactions between species and between species and abiotic (nonliving) components of a given ecosystem.

5. What level of biodiversity are you observing through the Google Earth Time Lapse tool?

Ecosystem; you cannot directly see the impact on individual organisms, but can make inferences about the impact on particular species. It is not possible to observe genetic shifts using this tool.

Case Study Capture Sheet

ANSWER KEY **Do not share with students**

Directions

Working in pairs or groups of three, read The Lungs of the Planet and watch Checking the Rainforest's Vital Signs. Then answer the following questions.

Sample responses provided here represent all possible answers. Students may submit one or two of these ideas.

1. Describe some of the working conditions and challenges that face Scott Saleska as he conducts research in the Amazon rainforest.

   What characteristics must a scientist possess or develop to persist with challenging conditions?

   Who else is on his team? (Four people are mentioned in the article.)

   The videos *Blood, Sweat, and Snakes* and *When the Rainforest Canopy is Your Office* supplement the text in the article to answer this question.

- Largest aqueous artery on the planet, providing one-fifth of all the freshwater that flows into oceans
- Seasonality: dry season and wet season; high temperature, humidity, and precipitation
- Extreme weather conditions such as monsoons and El Niño Southern Oscillation (ENSO)-related weather events
- Tree fall; erosion caused by extreme precipitation
- Wildlife such as jaguars, pit vipers, black scorpions, wolf spiders, white-kneed tarantulas, and Brazilian giant centipedes
- Limited communication (i.e., cell service, internet) and limited infrastructure
- A field scientist must be versatile and multifaceted, having the traits of endurance, resourcefulness, patience, and capacity to transform data into insightful analysis.
- Saleska's team includes Klebar Silva Campos, a local with a Master's degree in environmental science; Jose Mauro S. Moura, a professor of biogeochemistry at UFOPA; Deliane Penha, a PhD student at UFOPA; and Neill Prohaska, a 36-year-old PhD candidate in Saleska's lab at the University of Arizona.

2. What is Scott Saleska studying? How is it connected to research by Joseph Fourier, John Tyndall, and Charles Keeling?

- How climate impacts the rainforest and how rainforest impacts the climate
- His primary aim is to assess the impact of climate change on the Amazon's respiratory state.
- Saleska's work measures water loss and carbon uptake of individual leaves during photosynthesis by cross-referencing on-the-ground measurements of leaf production against satellite imagery.
- The research questions he aims to answer are: Which factors control carbon dioxide and water vapor fluxes, or exchanges, between the forest and the atmosphere during "normal" seasonal dry periods and during extreme drought periods of El Niño years? How will climate changes affect the 5.4-million-square-kilometer Amazon rainforest's ability to absorb atmospheric carbon? And how will feedback from these changes alter environmental systems and patterns around the world?
- Saleska's work is connected to the research of Fourier, Tyndall, and Keeling, as they've all investigated the effect of human activities on the global climate. Keeling constructed long-term data sets in the 1950s on Hawaii's big island to show rising levels of atmospheric carbon dioxide. Keeling's work showed seasonal shifts in atmospheric carbon dioxide, which decreases in the Northern Hemispheric spring from increased photosynthesis. Keeling's most significant work is what is known as the "Keeling curve," which plots atmospheric carbon dioxide levels in parts per million (ppm) over time.

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Case Study Capture Sheet

ANSWER KEY **Do not share with students**

Continued

3. Describe the methods and variables involved in Scott's research. As an alternative, draw the experimental design.

   What is a flux tower?

   What other measurements does the team take?

— A flux tower is loaded with multiple sensors designed to track changes in CO_2 and water vapor from the forest floor to above the forest canopy. These sensors measure CO_2 and H_2O concentrations eight times per second at multiple heights along the tower. They also monitor daily and seasonal fluctuations.

— Surrounding the flux tower, the team has devices to measure soil moisture content and tree-mounted solar devices to measure light quality.

— In addition, they measure water vapor exchanges in leaves using a leaf porometer.

— Prohaska takes hyperspectral camera images that measure the changing quantity of leaves over time.

4. Using the graph in *Catching the Rainforest's Breath*, explain what Dr. Saleska means when he says that the forest breathes.

— When Dr. Saleska says that the forest breathes, he means that trees inhale carbon dioxide and exhale oxygen through photosynthesis. Trees do not only exhale, or produce, oxygen but also produce carbon dioxide when they decompose and metabolize. Scientists have long wondered if the Amazon is currently inhaling more carbon dioxide during photosynthesis than it exhales (through decomposition and respiration).

— The top graph charts the amount of carbon dioxide taken in by the forest during photosynthesis. The sensors on the flux tower record carbon released during respiration and tree-death events, and carbon absorbed during photosynthesis.

— The bottom graph charts the monthly rainfall and intensity of drought.

— Scientists found that photosynthesis rates are highest during the dry season.

— In late 2009 and early 2010, the highest value of photosynthetic carbon uptake coincided with the most severe drought.

— Measurements from the flux tower indicated that trees in the Tapajós forest were actively growing new leaves in the dry season, increasing the rate of photosynthesis. In broad-leaf, evergreen, tropical forests, light was more important than rainfall because of its role, a substrate, in photosynthesis.

Continues next page >

Case Study Capture Sheet

ANSWER KEY **Do not share with students**

Continued

5. What was surprising to your group as you explored these resources? Or, what questions do you still have?

— What other data can be collected from satellites or computer models?

— What other measurements or methodologies could be used to support the findings of Saleska's work?

— How do the findings of Saleska's work compare to other biomes, such as the Pacific temperate rainforest?

6. If your group has additional time, or you want to learn about other threats to Tapajós National Forest, review *In a drier Amazon, small farmers and researchers work together to reduce fire damage*.

What are your reactions to the information in this piece?
What conflicts do you see between different stakeholders?

— Fire management practices have disproportionately affected Indigenous populations who have been using controlled fires in agriculture, with sustainability in mind, to fertilize crop pastures. I was also fascinated by the classification of fires by fire-mapping tools to show that deforestation has had the biggest impact on the frequency and intensity of forest fires in the Amazon.

— There is a conflict between the Indigenous people, the government and scientists. Indigenous community members rely on burning techniques to open up small farming plots because other methods, like agroforestry and the use of tractors, are not accessible without external aid and expertise. Scientists would argue that destruction of the forest by burning negatively impacts the climate despite being a technique used by the Indigenous community for centuries.

— However, burning techniques used by Indigenous community members for small rural farming are used in a rotational system to allow the forest to regenerate and preserve biodiversity. Fires used to clear livestock pasture or clear away vegetation after forest clearing tend to be more problematic and burn uncontrollably more often, destroying vast swaths of the rainforest.

— There is another conflict between Indigenous people and the local government. Fire stewardship is a multifaceted challenge to regulate because of cultural and economic values. Additionally, the use of fire in subsistence agriculture has not been as problematic as deforestation fires and wildfires. The challenges of regulating fire stewardship involve understanding what is burning, which factors influence the extent and spreading of a forest fire, and how a forest fire can become more flammable.

Student Hotspot Capture Sheet

ANSWER KEY — **Do not share with students**

Directions

The source you are about to read is technical and challenging. The task is not to read every word, but to examine the document to identify populations in biodiversity hotspots experiencing threat or loss, key groups of human stakeholders involved, and issues with land use and natural resources. You can skim, focus on particular sections of high relevance, or use other reading strategies to accomplish the task in the time allotted.

Use this document to capture bullet-pointed summary information about your biodiversity hotspot location.

Students may provide one or two of the listed stakeholder options, rather than all of the ideas provided.

Title of your assigned source	Swamp Sentinels
What are some biodiversity populations noted in your source? Which populations are experiencing threat or loss? Remember HIPPO (Habitat loss, Invasive species, Pollution, overPopulation, Overharvesting).	Kauri forests in northern New Zealand are listed as threatened by the Department of Conservation. Live kauri can no longer be cut on public lands. Swamp kauri, which have been buried in peat bogs for hundreds of years, were sought after, resulting in the draining of endangered wetlands to access the buried trees.
Who are the key human stakeholder groups noted in your source? Describe their roles or differing perspectives.	**Māori communities:** The kauri tree is sacred to the Māori. Kauri trees are used for cultural ceremonies and community purposes, including giving away pieces to form relationships and alliances with others. Māori are most likely interested in preserving the kauri and its environment. **Local Farmers:** Kauri is very valuable. Historically, outsiders came to New Zealand looking for the kauri trees and paid farmers for kauri (kauri was selling for up to $200 per square foot). Local farmers are most likely interested in fair compensation, and regulating access to farmlands and land use. **Developers:** Developers come across buried kauri during construction and utility projects. In the article, their interests included both development of their projects and coordination with community wishes regarding kauri logs. **Scientists:** Because kauri are very old trees, scientists find samples that northern hemisphere glacial ice sheets tended to destroy. These samples provide climate and atmospheric information that is often hard to obtain. Multiple long-lived kauri can be used to create tree ring sequences (forming a chronology) to reveal larger climate patterns. Kauri data have helped create new timelines for other events such as rapidly rising sea levels, volcanic eruptions, and human paleontological and archaeological events. Scientists are most likely interested in having access to kauri samples for long-term studies. **Lumber Exporters:** Historically, people sought to exploit the kauri for the resin produced by the tree to use in varnishes, jewelry, and other products. When the value of kauri as an exotic wood increased, lumber exporters were more interested in gaining access to deposits of buried Kauri trees to export for high prices than protecting ecosystems or compensating locals.

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Student Hotspot Capture Sheet

ANSWER KEY **Do not share with students**

Continued

What are some natural resources involved in any conflicts noted in your source? Again, remember HIPPO.	The draining of endangered wetlands to access buried kauri contributed to habitat loss and destruction—currently only 8% of wetlands remain intact. Live kauri forests are dwindling due to overharvesting, regulation was needed to ban the cutting of live kauri on public lands. Live kauri are also threatened by a deadly fungus-like pathogen, a potential invasive species. To the Māori, the kauri trees are a natural resource in the context of being a sacred, living member of their community with spiritual significance.
If your source is citing the work of others, are the references credible? What do you think the author's motivation could be for creating the document? Do they have a target audience? What is their angle?	The author is a New Zealand resident who wrote the content for the California Academy of Sciences. The author notes a particular interest in how humans and plants interact. It is possible the author's target audience includes others who are interested in the role of an organism, like the kauri tree, in its ecosystem, as well as how it "records" the world around them over time. The author's angle seems to include pointing out the different types of value and essential roles a species has in its environment over time, and the need to preserve those species.

Extension Option Capture Sheet

ANSWER KEY — **Do not share with students**

Directions

The source you are about to read is technical and challenging. The task is not to read every word, but to examine the document to identify biodiversity populations experiencing threat or loss, key groups of human stakeholders involved, and issues with land use and natural resources. You can skim, focus on particular sections of high relevance, or use other reading strategies to accomplish the task in the time allotted.

Use this document to capture bullet-pointed summary information about your biodiversity hotspot location.

Answers represent the collaboration of 3–4 students and will include a subset of those provided below.

Title of your assigned source	Indonesia: Threats to the Country's Biodiversity	
What are some biodiversity populations noted in your source? Which populations are experiencing threat or loss? Remember HIPPO (Habitat loss, Invasive species, Pollution, overPopulation, Overharvesting).	— Indonesia is home to one of the most diverse groups of terrestrial and marine species with a high level of endemism. — Coral reefs are a highly structured ecosystem that supports an array of plants and animals. — 480 species of corals. — Molluscs such as nudibranchs and sea stars. — Other coral species threatened are *Leptoria phrygia*, *Porites spp.*, *Pocillopora damicornis*, *Seriatopora hystrix*, and *Montipora spp.* — 1650, species of fish, including parrotfish and butterflyfish. — Chronic disturbance threatens coral reef populations — from both climate change and ENSO (El Niño Southern Oscillation) events.	— Eighty five percent of Indonesia's reefs are threatened with more than 50% highly threatened. — The human activities that directly affect the health of coastal environments and coral reefs are coral mining, dredging and resort construction, industrial and agricultural pollution, oil spills, and fishing. — Natural causes of marine degradation are biotic erosion and climate factors such as warming events. — Terrestrial threats to biodiversity are logging, forest fires, and deforestation. — Population growth, changes in land-use, and ENSO events have increased the probability of catastrophic fires. — Indonesia has the highest rate of deforestation in the world at 1.6% annually. An estimated 75% of original forests and 42% of biodiversity will be lost by 2100.
Who are the key human stakeholder groups noted in your source? Describe their roles or differing perspectives.	— Indonesia is the fourth most populous country in the world with an average population density of 134 people per square kilometer, although the population is not evenly distributed. — Java and Bali are both overpopulated. To alleviate overpopulation of these areas, Indonesia has relocated more than 3.6 million people to outer islands. This, however, caused the loss of more than 3.7 million hectares of Indonesia's forests. — Human stakeholder groups are coral miners, resorts, industrial and agricultural industries, and fishermen.	— Coral mining removes live coral from the reef for construction, lime production, jewelry, souvenirs, aquarium trade, and medicinal use. — Industrial pollution introduces heavy metals and other toxic compounds to coral reefs, reducing growth of symbiotic algae and causing coral reef mortality. — Coastal communities in Indonesia rely heavily on fishing. The following fishing methods all contribute to loss of coral reefs: hook and line, portable fish traps and gill nets, spear-fishing, blast fishing, cyanide fishing, and muro-ami.

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Extension Option Capture Sheet

ANSWER KEY **Do not share with students**

Continued

What are some natural resources involved in any conflicts noted in your source? Again, remember HIPPO.	— Indonesia's forests continue to be threatened by Indonesian transmigration to alleviate overpopulation of islands like Bali and Java, where there is an average density of 940 people per square kilometer. — The rapid rate of industrialization in Indonesia poses a serious threat to its natural environment. — The impacts of humans on the Indonesian environment are complex and often poorly understood. Compared to other tropical regions, Indonesia receives less scientific attention. — An estimated 51,000 square kilometers of coral reef protect Indonesia's shore from erosion by reducing wave energy and shielding coasts from storms. Indonesia's coral reefs have been severely degraded by human activities. — Human industries like oil and gas production, transportation, and tourism represent a significant portion of Indonesia GDP, yet negatively impact the health of coastal environments and coral reefs.	— Tourism has negatively impacted coral reefs through the construction of hotels using mined coral. Resort construction sand is often mined from adjacent reefs and used to fortify beaches. Reefs are also being dredged to create navigational channels for boats. — Indonesia supports one of the world's largest fisheries, yet methods like blast fishing, cyanide poisoning, and muro-ami fishing are contributing the greatest amount of destruction to the marine environment. — Terrestrial resources are being threatened by logging practices and causing adverse effects, changing forest microclimate and fuel load. — Agricultural practices have created vast areas of impoverished grassland. Invasive species such as *Imperata cylindrica* and *Saccharum spontaneum* have moved in and are costly to remove.
If your source is citing the work of others, are the references credible? What do you think the author's motivation could be for creating the document? Do they have a target audience? What is their angle?	— The sources are credible with properly cited references and case study data, such as Ongkosongo (1986) and Hungspreugs (1988) to show severe water contamination from industrial and agricultural pollution. (Ideally, more recent publications could be cited as well.) — The author's motivation for this article is to raise awareness of the developing threats of biodiversity loss in Indonesia.	— The target audience is more general, as opposed to a focused group of people. By including more general information about the geographic region and specific case study data, this article effectively informs the reader of the Indonesian marine and terrestrial environments.

Google My Maps Presentation Capture Sheet

ANSWER KEY **Do not share with students**

Directions
During class presentations of the Google My Maps compare and contrast your map interpretation with those of other groups.

1. Notice and briefly record:
    a. Similarities in ideas about identified stakeholder groups, their role in the story, and what their interests and perspective might be.
    b. Differences in ideas about identified stakeholder groups. This would be the same as the elements identified under "similarities in ideas." The roles and interests wouldn't change.

Student answers will vary. The example provided below is written for the Ngawha region of northern New Zealand.

Stakeholder Group	Similarities in thinking about stakeholder role and perspective	Differences in thinking about stakeholder role and perspective
Māori communities	Tree is sacred, has community uses, and should be protected.	Answers will vary based on students' individual observations.
Local Farmers	See value in the kauri tree, hope to be fairly compensated, and able to use their land as desired.	Answers will vary.
Scientists	The historic and prehistoric data provided by kauri trees is very valuable.	Answers will vary.
Developers	Interested in being able to develop their projects but also coordinate with community wishes regarding kauri logs.	Answers will vary.
Lumber exporters	High value on kauri wood caused questionable means to get deposits of buried kauri trees to export for high prices; ecosystem damage and fair compensation for locals was not a priority.	Answers will vary.

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Google My Maps Presentation Capture Sheet

ANSWER KEY **Do not share with students**

Continued

2. Summarize the challenges facing the conservation efforts for kauri trees and the wetland ecosystem they define, using the different perspectives you have outlined above.

The kauri tree has a long history of being a sacred species to Māori communities who wish to protect it, as well as buried kauri logs and the ecosystems they are found in. This can cause challenges for local farmers and developers who want access to their own land or land being used for development, but also wish to work with Māori communities who have traditional and ceremonial connections to the logs. Everyone would like to be fairly compensated (financially or in the form of having the kauri logs for traditional uses). Due to the high value of the trees, foreign interest has caused damage to local environments (wetlands, for example) and the diverse organisms who live there, and conflict among individuals with different perspectives on the value and use of the kauri trees. When individuals see the value of the kauri tree in different ways (spiritual, biological, economical), conflict occurs.

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Student Resources

Location of Plants used as Medicines Map

This map highlights medicines that have been developed from plant species in these particular regions.

1	2	3	4	5
				
Sangre de Grado or dragon's blood, source of crofelemer, is used to treat GI discomfort for HIV-AIDS patients. Many Indigenous communities in the Amazon region, including the Yurilama of Peru, extract the sap to treat various conditions.	Wild Yam, source of diosgenin used in steroids, is used by many Indigenous North Americans for pain relief. Additional uses include treatments for asthma, arthritis, and eczema.	Pacific Yew Tree, source of Taxol, is used in cancer treatment. Many Indigenous North Americans in the Pacific Northwest use tinctures and teas to treat various ailments.	Madagascar periwinkle is a source of a medicine used in cancer and diabetes treatment by communities in parts of Africa, Asia, and Europe.	Manuka Tree, source of tea tree oil with antimicrobial properties, is utilized by the Maori people of New Zealand.

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What Does Biodiversity Mean for Human Health?
Capture Sheet

Directions

During the Ecosystem Services video from the California Academy of Sciences, listen for and provide examples of direct services that ecosystems provide humans.

1. What is the meaning of direct service?

2. Where does medicine come from?

Continues next page >

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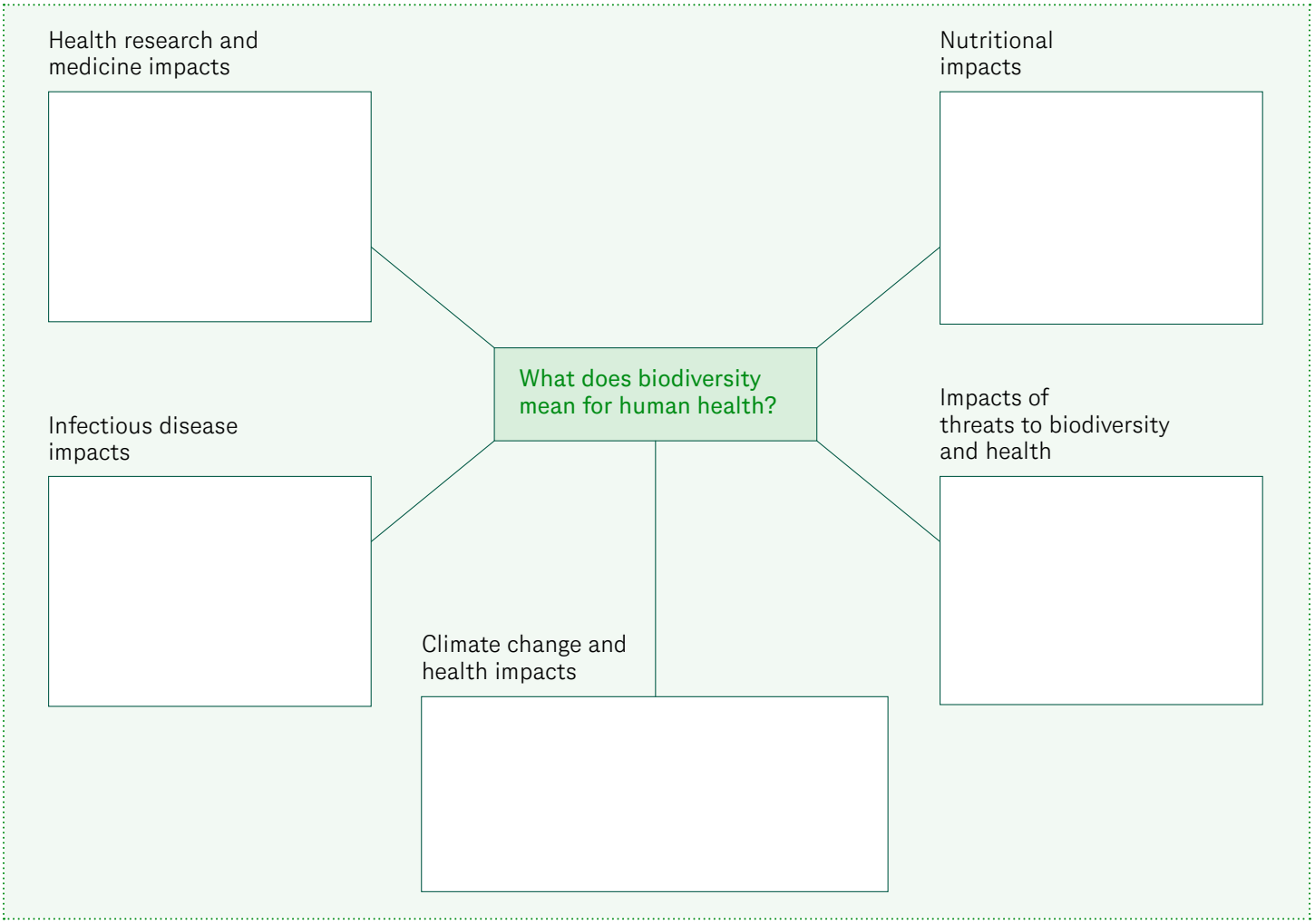
What Does Biodiversity Mean for Human Health? Capture Sheet

Continued

3. Read the first four paragraphs of the article *Biodiversity and Health* from the WHO. As a group, divide the remaining sections (health research and medicine, nutrition, infectious disease, climate change and health, and threats) and answer one section to share with your group.

Biodiversity's Impact on Human Health



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What Does Biodiversity Mean for Human Health?
Capture Sheet

Continued

4. Which of the key facts listed in the *Biodiversity and Health* WHO article seems most important to you and why?

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Time Lapse Observation and Inference Capture Sheet

Directions

Use Google Earth Time Lapse to explore change in satellite images over time at a particular location on Earth. You will use this sheet to document observations and inferences at a location of your choice.

1. Using *Google Earth Engine Time Lapse*, select an option from the list below. Please circle what you chose.

	Topic	Location
a	Infrastructure growth	Teles Pires River, Brazil
b	Urban growth	Naypyitaw, Myanmar
c	Urban growth	Las Vegas, Nevada
d	Deforestation	Toliara and Saint Augustin, Madagascar
e	Deforestation	Nuflo de Chavez, Bolivia
f	Coastal Expansion	Dubai, United Arab Emirates
	You may also examine other locations that you are interested in. Optionally, list these below.	
g		
h		
i		
j		

Vocabulary

Observation	Quantitative or qualitative information obtained using your senses
Inference	A logical explanation or interpretation based on your observations

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Time Lapse Observation and Inference Capture Sheet

Continued

2. Watch the time lapse of the location you selected on the previous page a few times to get a sense of how the location has changed. Be sure to note the time frame in which these changes occurred (see scale along the bottom of the images). Record your observations in the table below with your partner or group.

   Infer how the observed changes may impact:

Biodiversity	
Climate Change	Sea level rise Loss of ice or snow pack Change in precipitation (increase or decrease)
Human populations	Roads Edges of urban areas Types of buildings Other impacts on neighboring natural areas
Natural resources	Habitat shifts Water body shifts Tree cover or ice cover changes

Location	Time Frame	Observations	Inferences

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Time Lapse Observation and Inference Capture Sheet

Continued

3. What is biodiversity?

4. What are the different levels of biodiversity?

5. What level of biodiversity are you observing through the Google Earth Time Lapse tool?

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Case Study Capture Sheet

Directions

Working in pairs or groups of three, read The Lungs of the Planet and watch Checking the Rainforest's Vital Signs. Then answer the following questions.

1. Describe some of the working conditions and challenges that face Scott Saleska as he conducts research in the Amazon rainforest.

   What characteristics must a scientist possess or develop to persist with challenging conditions?

   Who else is on his team? (Four people are mentioned in the article.)

   The videos *Blood, Sweat, and Snakes* and *When the Rainforest Canopy is Your Office* supplement the text in the article to answer this question.

2. What is Scott Saleska studying? How is it connected to research by Joseph Fourier, John Tyndall, and Charles Keeling?

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Case Study Capture Sheet

Continued

3. Describe the methods and variables involved in Scott's research. As an alternative, draw the experimental design.

   What is a flux tower?

   What other measurements does the team take?

4. Using the graph in *Catching the Rainforest's Breath*, explain what Dr. Saleska means when he says that the forest breathes.

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Case Study Capture Sheet

Continued

5. What was surprising to your group as you explored these resources? Or, what questions do you still have?

6. If your group has additional time, or you want to learn about other threats to Tapajós National Forest, review *In a drier Amazon, small farmers and researchers work together to reduce fire damage*.

   What are your reactions to the information in this piece?
   What conflicts do you see between different stakeholders?

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Student Hotspot Capture Sheet

Directions

The source you are about to read is technical and challenging. The task is not to read every word, but to examine the document to identify populations in biodiversity hotspots experiencing threat or loss, key groups of human stakeholders involved, and issues with land use and natural resources. You can skim, focus on particular sections of high relevance, or use other reading strategies to accomplish the task in the time allotted.

Use this document to capture bullet-pointed summary information about your biodiversity hotspot location.

Title of your assigned source	
What are some biodiversity populations noted in your source? Which populations are experiencing threat or loss? Remember HIPPO (Habitat loss, Invasive species, Pollution, overPopulation, Overharvesting).	
Who are the key human stakeholder groups noted in your source? Describe their roles or differing perspectives.	

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Student Hotspot Capture Sheet

Continued

What are some natural resources involved in any conflicts noted in your source? Again, remember HIPPO.	
If your source is citing the work of others, are the references credible? What do you think the author's motivation could be for creating the document? Do they have a target audience? What is their angle?	

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Extension Option Capture Sheet

Directions

The source you are about to read is technical and challenging. The task is not to read every word, but to examine the document to identify biodiversity populations experiencing threat or loss, key groups of human stakeholders involved, and issues with land use and natural resources. You can skim, focus on particular sections of high relevance, or use other reading strategies to accomplish the task in the time allotted.

Use this document to capture bullet-pointed summary information about your biodiversity hotspot location.

Title of your assigned source	
What are some biodiversity populations noted in your source? Which populations are experiencing threat or loss? Remember HIPPO (Habitat loss, Invasive species, Pollution, overPopulation, Overharvesting).	
Who are the key human stakeholder groups noted in your source? Describe their roles or differing perspectives.	

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Extension Option Capture Sheet

Continued

What are some natural resources involved in any conflicts noted in your source? Again, remember HIPPO.	
If your source is citing the work of others, are the references credible? What do you think the author's motivation could be for creating the document? Do they have a target audience? What is their angle?	

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Extension Option Capture Sheet

Primary Source Material on Biodiversity Hotspots and Threats

Directions

As a group, use one of the primary source links below to complete the assignment.

Location	Primary Source Link	Summary
South Ecuador	*Deforestation and Forest Fragmentation in South Ecuador since the 1970s—Losing a Hotspot of Biodiversity* *Deforestation in protected areas in the Amazon: a threat to biodiversity* *Land occupations and deforestation in the Brazilian Amazon*	Deforestation and habitat fragmentation are serious threats to the biodiversity of Southern Ecuador. Since 2000, the rate of habitat destruction has increased greatly due to creation of infrastructure projects (such as roads), manipulating land for farming and urban use, as well as illegal logging. This transformation of land has been identified using satellite images, aerial photographs, and spatial analysis. The loss of habitat has serious implications for endemic (native) species, causes an increase in carbon dioxide, and increases the pH of the soil. These primary sources further explain the current state of the land in Southern Ecuador, the methods and details of the data collected, and possible solutions for the future.
Caribbean	*Plant Conservation in the Caribbean Island Biodiversity Hotspot* *Climate change and biodiversity conservation in the Caribbean Islands* *Integrating Habitat Status, Human Population Pressure, and Protection Status into Biodiversity Conservation Priority Setting*	The Caribbean islands encompass more than 7,000 islands and are considered a biodiversity hotspot. The plants and animals within these islands and cays are not only valuable to the ecology of the area, but also valuable to the economical and cultural health of the area. In order for this area to be conserved, all stakeholders must work together to establish protected areas and priorities for conservation. Additionally, there needs to be more data collected about the native plants in the area in order to properly manage the diversity. In these primary sources, the authors discuss the specific ways climate change has impacted the region (such as increases in sea surface and air temperature), possible solutions to mitigate impact, recommendations for plant conservation, and the importance of including both biological and social aspects of conservation planning.
Madagascar	*Rain, forests and farmers: Evidence of drought induced deforestation in Madagascar and its consequences for biodiversity conservation* *Modeling impacts of climate change on the potential distribution of six endemic baobab species in Madagascar* *The biodiversity of Madagascar: one of the world's hottest hotspots on its way out; Biodiversity hotspots for conservation priorities; Fifty years of deforestation and forest fragmentation in Madagascar*	Madagascar is the fourth largest island in the world and considered a biodiversity hotspot. A variety of biomes can be found on this island and with that, a variety of endemic plants and animals. Deforestation caused by climate change and cropland expansion have severely fragmented the habitats of Madagascar. The evidence for this has been clearly captured using remote sensing data and aerial photography. Additionally, scientists have conducted studies using focus species (such as the baobab plant/tree) to predict future changes. These primary sources further explain the changes that have taken place over time (beginning in the 1600s), the impact of drought on deforestation, the predicted habitat changes for baobabs, and how statistics can be used to make decisions about future conservation efforts.

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Extension Option Capture Sheet

Primary Source Material on Biodiversity Hotspots and Threats

Continued

Location	Primary Source Link	Summary
South Africa	*Predicting the Landscape—Scale Distribution of Alien Plants and Their Threat to Plant Diversity* *Current and future threats to plant biodiversity on the Cape Peninsula, South Africa*	The Cape Peninsula in South Africa is an important area rich in biodiversity. However, this biodiversity has been in steady decline since 1692 when Europeans settled in the area. While many factors have influenced the loss of native species, the introduction of non-native (alien) species has caused a serious threat to the area. This threat was determined by using logistic regression models and the presence of plants in the taxa Proteaceae (this plant is found throughout the region and is a useful indicator species). These primary sources discuss how to manage the invasive species and minimize further damage to the area through a plan that involves multiple steps and stakeholders.
California	*Grazing for Biodiversity in Californian Mediterranean Grasslands* *Biodiversity is critical to future health of California's ecology and economy* *Restoration management for spatially and temporally complex Californian grassland*	California has always supported a wide variety of plants and animals. Throughout time (dating back to the Pleistocene Epoch) there have been periods of ice caps and varied sea levels that have impacted the region. Today, the biodiversity of the area is threatened and further destruction of the space will have economic and environmental consequences. The grasslands of California, which hold up to 40 percent of the native plant species, is an area that would benefit greatly from a restoration plan. These primary sources discuss the history of non-native species, the benefits of preserving the space, and specific solutions to restore the biodiversity of California and prevent further degradation.
New Zealand	*Intensification of New Zealand agriculture: Implications for biodiversity* *Climate-Change Effects on Alpine Plant Biodiversity: A New Zealand Perspective on Quantifying the Threat*	New Zealand is a unique area of biodiversity because of its topography and the geographic isolation of the island. While this isolation has produced an interesting landscape, it also means organisms are particularly vulnerable to climate change (example, they don't have an accessible "escape route"). There is a need for increased monitoring of the threats of biodiversity in order to understand the scope of the problem. In these primary sources, the methods of how this data was collected is explored. For example, species-area relationships were used as well as long-term transdisciplinary research. Additionally, these sources offer solutions for mitigation or reversal of climate change (which can result in a loss of more than 200 plant species).
The Andes	*Climate Change and Biodiversity in the Tropical Andes* *Conservation gaps and priorities in the Tropical Andes biodiversity hotspot: Implications for the expansion of protected areas* *Eucalyptus and alder field margins differ in their impact on ecosystem services and biodiversity within cropping fields of the Peruvian Andes*	The Andes is an area of rich and important biodiversity and although much of the Tropical Andes is protected, there are many gaps in protection that, if not resolved, can have a negative impact on the area. For example, 90 percent of endemic vertebrate species have not met the conservation targets, putting the populations of these organisms in danger. The deep canyons and isolated valleys of the Andes are situated between the lowlands of the Amazon and the arid Sechura Desert which make for a complex and interconnected ecosystem. In these primary sources, the relationship between the physical geography and ecosystems is examined, conservation gaps are explored, and the biodiversity and ecosystem services were examined around the margins of woody fields.

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Extension Option Capture Sheet

Primary Source Material on Biodiversity Hotspots and Threats

Continued

Location	Primary Source Link	Summary
Melanesia	*Biodiversity conservation in tropical forest landscapes of Oceania* *Chapter 4—Biodiversity of Polynesian Islands: Distribution and Threat from Climate Change* *Ecosystem profile: East Melanesian islands biodiversity hotspot*	Not only is Melanesia an area of biodiversity and has a high ecological value, much of the economy of the area (fishing and tourism) is also dependent on biodiversity. In addition to having more than 3,000 endemic vascular plants, this area also contains the "coral triangle" which supports 36 percent of the world's coral reef fish species. This area (both land and marine) is particularly sensitive to climate change and other human-related activities. Human activities such as mining, population increase, and commercial logging will have devastating effects on the area if they are not managed. And while the population of the area is increasing, this region has a relatively small contribution of greenhouse gas emission and is disproportionately impacted by the effects of climate change. In these primary sources, the Melanesian ecosystem is thoroughly discussed, the projected impact of climate change, and possible solutions are discussed.
The Himalayas	*Hazards in the Himalayas* *Effects of ecotourism on forest loss in the Himalayan biodiversity hotspot based on counterfactual analyses* *Sustainable utilization and conservation of plant biodiversity in montane ecosystems: the western Himalayas as a case study*	The Himalayan mountains, which cover about one-fifth of the Earth's land surface, are an important area of biodiversity which provide a variety of ecosystem services for the population of humans who have settled in the area (in the lowlands). While there are many individuals working toward preserving the organisms in the area, much of this work is not collaborative and, therefore, the preservation is not as effective as it could be. Maintaining the biodiversity (specifically shrubby vegetation) of the area is crucial to preventing erosion and avalanches. In these primary sources, different methodologies and conservation strategies are discussed, the current hazards of the area (such as glacier retreat from current warming), and the effect of ecotourism on the area are discussed and analyzed.
Brazil Atlantic Forest	*Deforestation causes different subregional effects on the Amazon bioclimatic equilibrium* *Defining endemism levels for biodiversity conservation: Tree species in the Atlantic Forest hotspot* *Biodiversity and threats in non-protected areas: A multidisciplinary and multi-taxa approach focused on the Atlantic Forest* *Experiences from the Brazilian Atlantic Forest: ecological findings and conservation initiatives*	The Brazilian Atlantic Forest has a rich history of biodiversity and ecological services. These services are vast and include food (such as passion flowers and legumes), water for electricity and drinking, and raw fibers for building. There are many areas in Brazil that are non-protected areas (NPAs) and have been damaged by anthropic activities, traces of pesticides and pharmaceuticals. It is important to accurately quantify endemic species in order to provide the correct protection for the area. In these primary sources, conceptual models of the changing landscape are introduced, the current state of the NPAs, how best to qualify and preserve endemic species, and how the landscape of the Brazil Atlantic Forest landscape could be altered by climate change resulting in a savanna-like environment.

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Extension Option Capture Sheet

Primary Source Material on Biodiversity Hotspots and Threats

Continued

Location	Primary Source Link	Summary
The Philippines	*The rate, extent and spatial predictors of forest loss (2000–2012) in the terrestrial protected areas of the Philippines* *Biodiversity State and Trends in Southeast Asia* *Understanding the drivers of Southeast Asian biodiversity loss*	The biodiversity in the Philippines is vast and without proper protection; 74 percent of Southeast Asia's forests will be destroyed by 2100. The threats of biodiversity are many and include mining (this threat is often overlooked in the area), hydropower dam construction, building roads that fragment the landscape, invasive species, and exploitation of species for traditional medicine. Not only are Southeast Asia's forests an important area of biodiversity, the area also supports a terrestrial carbon sink. In these primary sources, the drivers of biodiversity loss are investigated and explained, logistic regressions are used to predict future forest loss, and the current state of the issue and solutions for the future are discussed.
The Mediterranean	*The Mediterranean: a biodiversity hotspot under threat* *Threats and biodiversity in the mediterranean biome* *Future Trends of Mediterranean Biodiversity*	The Mediterranean Sea and the Mediterranean biome hold an enormous amount of biodiversity. This area supports 25,000 native species with more than 50 percent being endemic. The threats to the area include urbanization, pollution, increase in coastal development, invasive species, and wildfires. Because the Mediterranean biome is found in a variety of places around the world (from Australia to Chile and Baja California to Southern California), main threats vary. For example, agriculture is a major threat in Australia but not in Baja California and California where population growth threatens the area. In these primary sources, the current threats of the area are identified and analyzed, the future threats are explored (separated by natural anthropogenic events), and a detailed look at the area and organisms around the Mediterranean Sea are identified and explained.

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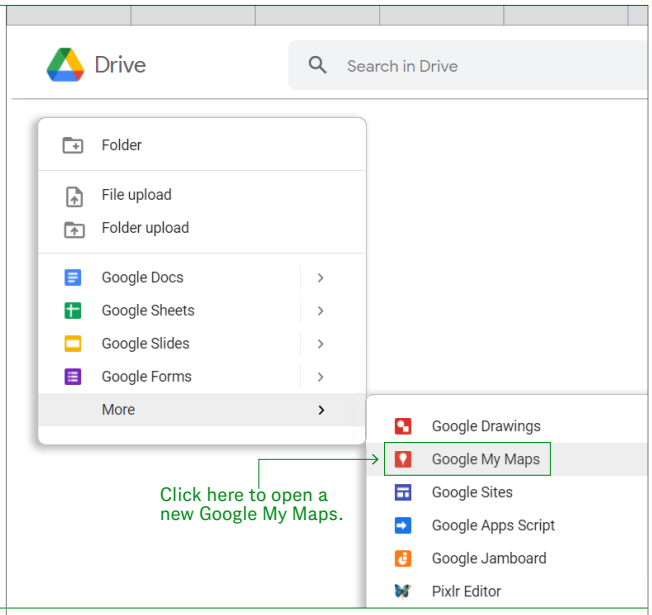
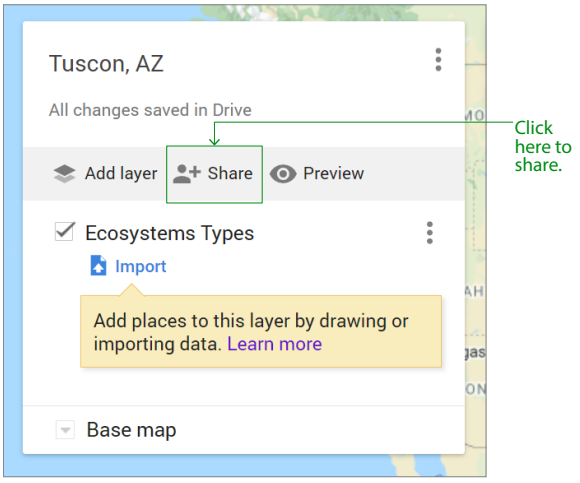
Google My Maps Student Instructions

Directions
Follow the step-by-step instructions below to learn how to use Google My Maps.

1	Go to Google Drive. Select 'More' from the drop-down menu to find Google My Maps. Click on Google My Maps to create a new map. **Note** > *Only 1 person per team needs to do this step.*	
2	Share the file with your team members using their gmail addresses. Make sure you give them *edit access*.	

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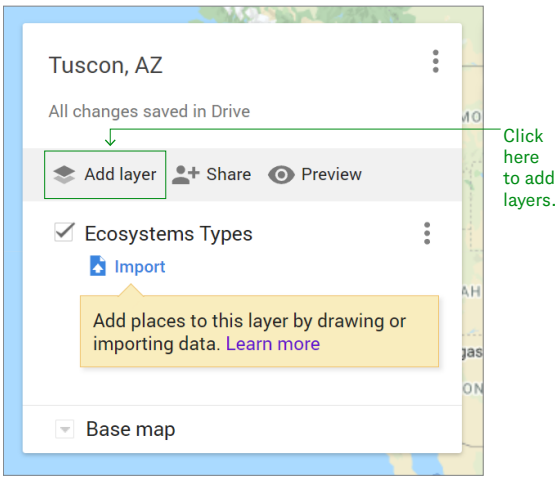
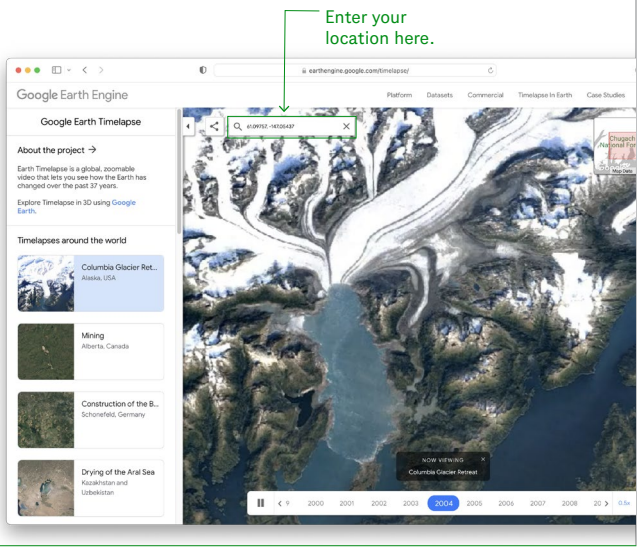
Google My Maps Student Instructions

Continued

3	Next, add the necessary layers to your map by clicking "Add layer." Be sure to give each layer a useful category name. *Some layers to consider include: ecosystem type, human land uses (mining, roads, urban areas, farming, forestry, other), specific plant and animal biodiversity highlights, and Indigenous land use information (if known). There are certainly other categories to consider and you can be creative in how you decide to divide up your information.*	
4	You can change the "Base Map." Use Search to find your hotspot and investigate specific ecosystem human impacts and threats over time. Other options include: Terrain (to see the topography) or Satellite (to see photographs), *Google Earth Engine* (to go back in time).	

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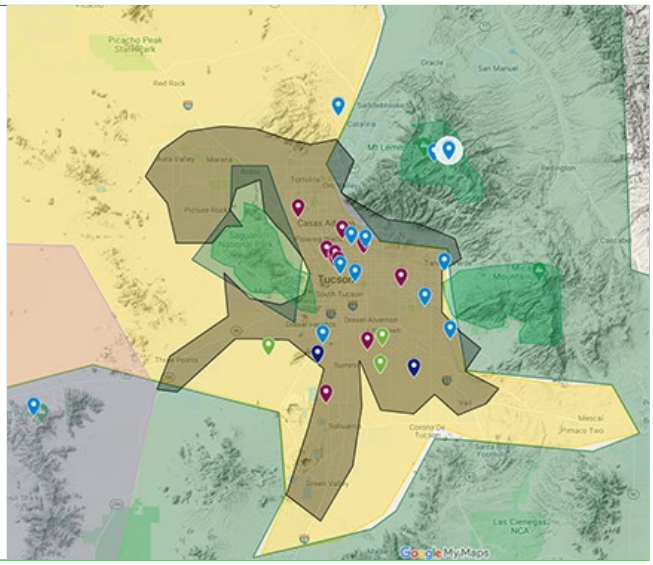
Google My Maps Student Instructions

Continued

6 The *Example map: Tucson, AZ* shows what you might include for your hotspot.

This example includes plants and animals, locations of agriculture and mining industries, and national parks and forests, among other items of interest.

Note > *your map may have different elements or foci based on the source you analyzed on Day 3.*



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Google My Maps Tools

Directions
Use the tools described below to enhance your map.

Tools 1–4 are located below the search button.

1	This tool adds a specific location marker to a layer of your map.	
2	This tool adds a free form shape to highlight a specific feature such as habitat type, land use, or other area-covering features.	
3	This tool adds a road, bike, or walking route to a map (probably not necessary for this project).	
4	This tool creates a measurement (either linear or area) of any feature of the map.	

Open the location marker tool (1) to find tools 5–7.

5	This tool changes the color of your point of interest or area drawing. A shared color can be used to indicate similarities across different points (i.e., blue for mammals, green for plants).	
6	This tool lets you edit the title and detail text for your point of interest or area drawing.	
7	This tool lets you add photos from your device or from a Google Image Search.	

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Google My Maps Presentation Capture Sheet

Directions
During class presentations of the Google My Maps compare and contrast your map interpretation with those of other groups.

1. Notice and briefly record:
    a. Similarities in ideas about identified stakeholder groups, their role in the story, and what their interests and perspective might be.
    b. Differences in ideas about identified stakeholder groups. This would be the same as the elements identified under "similarities in ideas." The roles and interests wouldn't change.

Stakeholder Group	Similarities in thinking about stakeholder role and perspective	Differences in thinking about stakeholder role and perspective

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Google My Maps Presentation Capture Sheet

Continued

2. Summarize the challenges facing the conservation efforts using the different perspectives you have outlined above.

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Gallery Walk Option Student Capture Sheet

Directions
Optionally, provide feedback to other groups about their map using this sheet.

Location Name	*Group Members*

Why is this location a biodiversity hotspot?

Human threats		
Unique species and ecosystem level biodiversity		
What stakeholders are present in this biodiversity hotspot?		
What natural resources are present in this biodiversity hotspot?		

What conservation priorities or strategies are in use (or should be in use) to preserve biodiversity?

Any remaining questions?

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Rubric for Biodiversity Stakeholders Map

Analyzing and Interpreting Data

Observable Features of the Student Journal	Meets Expectations 8–10 points	Progressing 5–7 points	No attempt 0 points
Research			
a. Students categorize stakeholder positions and ecological evidence.			
b. Students use *Google My Maps* to explore evidence of ecosystem-level biodiversity.			
Prototype Model			
a. Students create a *Google My Map*, clearly illustrating ecosystem types and stakeholder land uses.			
Gallery Walk			
a. Students clearly communicate how human stakeholders are collaborating around ecological resources.			
b. Students clearly define threats to ecological resources and biodiversity.			
c. Student presentation is clearly tied to the evidence presented in *Google My Maps* artifact.			
Final Score			
Grade			