

Mangroves

GLOBE		Associated SDG	Type of Activity
Sphere	Protocols		
Atmosphere	Air Temperature. Surface Temperature. Wind Direction and Speed. Precipitation. Relative Humidity	6 (Clean Water and Sanitation) 13 (Climate Action) 14 (Life Below Water) 15 (Life on Land)	Exploratory
Biosphere	Land Cover. Biometry. Phenology		
Pedosphere	Soil Characterization. Fertility. Humidity. pH. Temperature		
Hydrosphere	Water Temperature. pH. Alkalinity. Electrical Conductivity. Transparency. Salinity. Nitrates.		
Bundle	Air quality. Oceans. Rivers and lakes. Water cycle. Water quality. Soils		

Overview

Satellite images and maps are analyzed to determine the impacts of mangrove loss and their replacement by agriculture, aquaculture, urbanization, etc. over the last 20 to 30 years. Cases of mangrove restoration are also analyzed. [Landsat](#) and [Sentinel](#) image series are used to detect changes in land cover and seasonal changes.

Time

3 or 4 classes

Prerequisites

Basic knowledge of ecosystems, meteorology and ICT. Ability to interpret satellite images and maps. Ability to locate points using latitude and longitude.

School level

Upper Elementary, High School and University students

Purpose

To assess the importance and vulnerability of mangrove ecosystems to different natural and anthropogenic impacts

Student Outcomes

- Students will identify the main impacts that cause mangrove loss.
- Students will understand the relevance of mangroves in the fight against climate change.
- Students will analyze changes in mangrove cover through the use of satellite images.
- Students will analyze the impact of human activities and hurricanes on mangrove reduction.
- Students will learn about and analyze cases of mangrove ecosystem restoration

Background

Mangroves are coastal ecosystems, located in tropical and subtropical zones, formed by several species of trees and shrubs that have special salt resistance adaptations (halophytes) to live in saline intertidal environments.

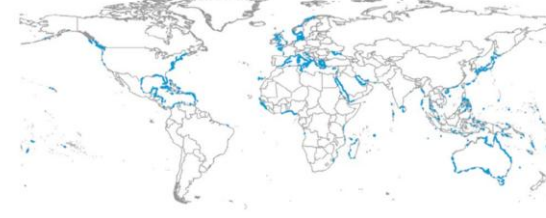
Mangrove forest



Tidal marshes



Seagrass meadows



Source: Macreadie, P. I., Costa, M. D., Atwood, T. B., Friess, D. A., Kelleway, J. J., Kennedy, H., Lovelock, C. E., Serrano, O., & Duarte, C. M. (2021). Blue carbon as a natural climate solution. *Nature Reviews Earth & Environment*, 2(12), 826-839.

Fig. 1. Global Distribution of Blue Carbon Ecosystems (Mangroves, Marshes and Seagrasses)

Mangroves are found on sheltered coasts and estuaries north and south of the Equator between isotherms of 20°C. (Fig. 1) This distribution can be locally extended by warm ocean currents or diminished by cold currents. Mangroves are sensitive to temperatures below 0°C and also suffer from [storm damage](#) (e.g. damage in the [Yucatan Peninsula in 2020](#)). In latitudes with cold temperatures mangroves are often replaced by tidal marshes. Mangroves are widely distributed, but globally they cover less than 1% of the world's tropical forests. Limiting factors in the distribution of mangrove plants are salinity and sediment inundation. To cope with high salinity, mangrove species have a number of mechanisms to remove or exclude salt from their tissues, and some species have developed the ability to actively secrete salt through their leaves. Waterlogged anaerobic soil represents another challenge that mangrove plants have overcome by developing aerial roots to transport oxygen to roots below ground or underwater.

Mangroves are part of the Blue Carbon Ecosystems (BCE), along with tidal marshes and seagrass meadows. This designation is due to their capacity to capture and store carbon.

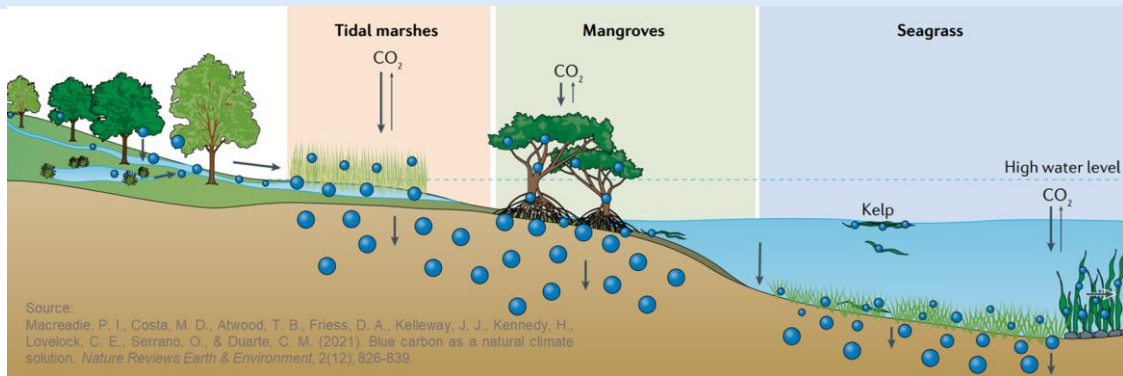


Fig. 2. Comparison of carbon sequestration capacity. Blue carbon ecosystems fix large amounts of indigenous carbon and their position at the land-sea interface allows them to accumulate sediment and allochthonous carbon produced in other ecosystems.

The concept of blue carbon is defined by [UNEP's REDD Programme](#) as the mass of carbon that is stored, sequestered or released from coastal vegetation ecosystems. Mangroves help mitigate climate change because they are very effective carbon sinks for large amounts of carbon (Fig. 2).

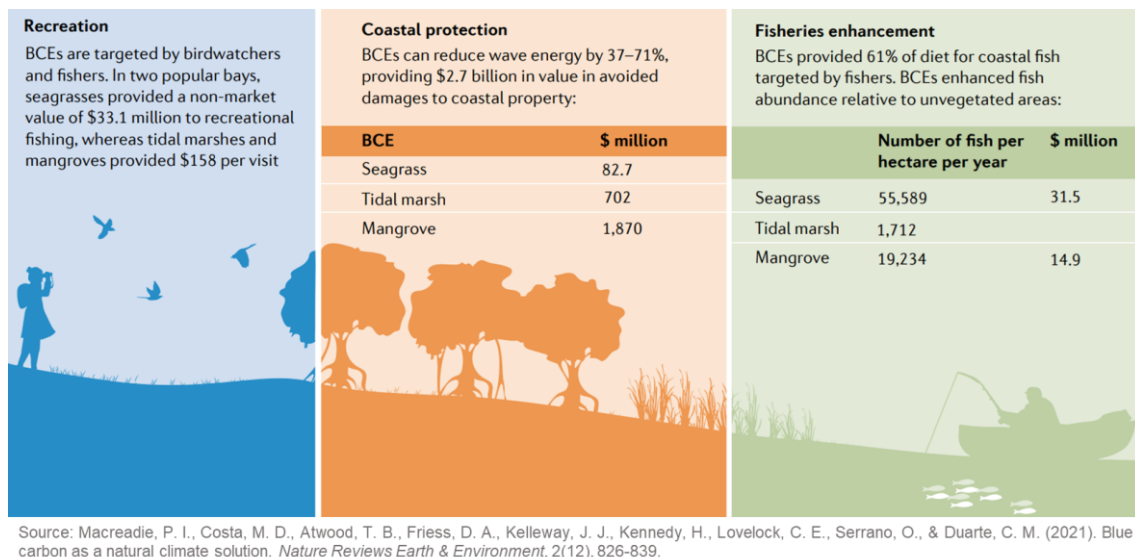
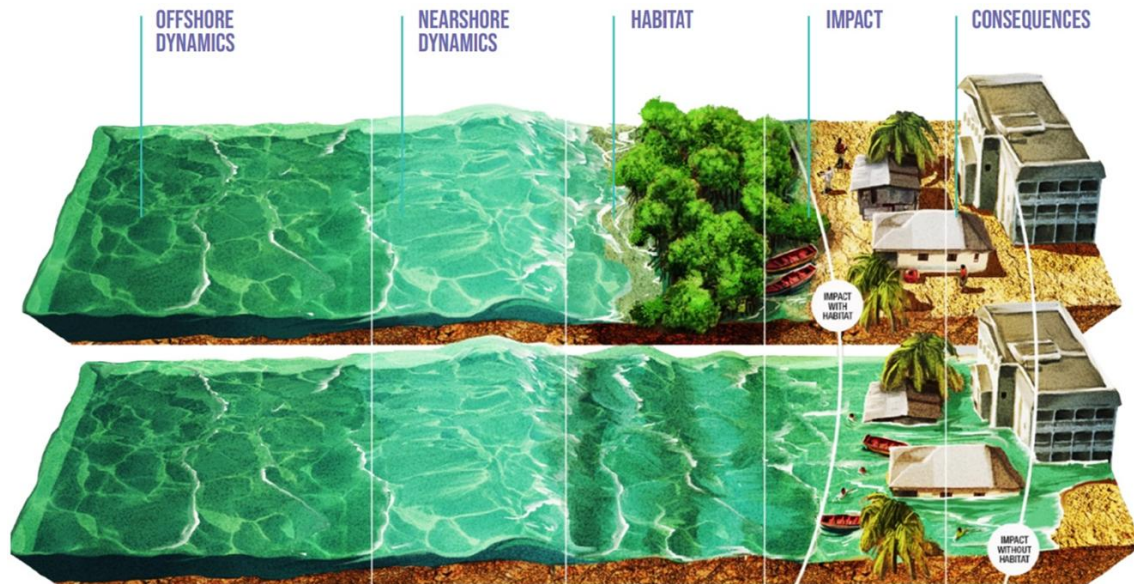


Fig. 3. Co-benefits provided by blue carbon ecosystems. Co-benefits, sometimes called ecosystem services, contribute to the economy and well-being of coastal communities. This example includes Australian dollar (AU\$) values for fisheries, coastal protection, and recreation.

Mangroves contribute to the well-being, food security and protection of coastal communities around the world. (Fig. 3) Mangroves are ecosystems rich in biodiversity because they support complex communities with multiple interactions among the species that inhabit them. (They provide habitat for fish and crustaceans, are a source of food for many species of mammals, birds, insects, etc.).

The United Nations has declared July 26 "[International Mangrove Ecosystem Conservation Day](#)" to highlight the importance and need for mangrove management and restoration, noting that it is a viable and cost-effective way to ensure food security for many coastal communities. Mangroves are a natural coastal defense system against storm surges (tidal waves), tsunamis and sea level rise, control flooding, maintain coastal stability and prevent erosion. (Fig. 4).

Mangrove ecosystems support fisheries, the production of medicines, fibers, wood and fuels. They also filter the water that flows into the oceans and reef systems contributing to improve their quality, help stabilize the climate, among other environmental services. In addition, they have a cultural, recreational and educational component that makes them vital on many levels.



Source: Spalding, M. D. and Leal, M. (editors) (2021) *The State of the World's Mangroves 2021*. Global Mangrove Alliance.

Fig. 4. Mangroves prevent erosion and reduce the force of waves, storm surges and flooding

According to the UNESCO Director-General Audrey Azoulay:

"Mangroves are in danger: it is estimated that more than three-quarters of mangroves in the world are now threatened, and with them all, the fine balances that depend on them. This is why UNESCO is acting to protect them, along with other valuable blue carbon ecosystems, through its geoparks, World Heritage sites and biosphere reserves"

Climate change is affecting mangroves due to the increase of extreme events such as [hurricanes](#), droughts, coastal erosion, sea level rise, increased sediment discharge from large rivers, etc. Human activities (like logging, agriculture, [aquaculture](#), and coastal development) impact mangrove loss through deforestation or pollution. For example, many mangrove areas were converted into [shrimp](#) farms, which impacted water quality and reduced fish breeding habitat, affecting fishing. Shrimp farms can pollute the surrounding environment with excess nutrients, waste and drug residues.

Some mangroves are in [protected areas](#), but because of their importance, [partnerships](#) have been established among technical experts, civil society organizations, governments, local communities, businesses, funding agencies and foundations to accelerate a global, comprehensive and coordinated approach to large-scale mangrove conservation and restoration. Through these partnerships, satellite monitoring and on-the-ground sampling are conducted to know the state of mangroves around the world. As a result of this [monitoring](#), different aspects of mangroves have been mapped. Mangroves have great relevance at local and global scales for decision making. Monitoring the state of mangroves, water, air and soil quality is important to learn more about these ecosystems, detect changes that may affect them and establish restoration programs where necessary.



Source: Spalding, M. D. and Leal, M. (editors) (2021) *The State of the World's Mangroves 2021*. Global Mangrove Alliance.

Fig. 5. Climate change and anthropogenic activities contributing to mangrove loss

Guiding Research Questions

- What is the impact of mangrove loss on ecosystems and people's lives?
- Why have mangroves disappeared in many places?
- What is the relationship between fishing and mangroves?
- In what ways do mangroves protect the coasts?
- How can mangrove areas be restored?
- How can the state of mangroves be monitored?

Scientific Concepts

- Ecosystems
- Deforestation
- Land cover
- Agriculture
- Aquaculture
- Electromagnetic spectrum
- Satellite images - False color images

Materials and Tools

1. ArcGIS StoryMaps <https://storymaps.arcgis.com/>
2. Satellite images of:

Case 1. Impact of aquaculture on mangroves:

- Google Map - [Location](#)
- Google Earth (Sequence [1985 to 2020](#))
- Wordview ([comparison](#) 1986 and 2022)
- Copernicus Browser - False color (seasonal changes): [March](#) - [July](#)
- Global Intertidal Change - ([changes in the mangrove](#)) Activate different layers, top right

Case 2. Impact of hurricanes in 2020:

- Google Map - [Location](#)
- Google Earth (Sequence [1985 to 2020](#))
- Wordview ([comparison](#) 1986 and 2021)
- Copernicus Browser - Changes due to hurricanes. False color ([before](#) – [after](#)) - NDVI ([before](#) – [after](#)). See *explanation of NDVI in Deforestation activity*.
- Trajectory of hurricanes [Delta](#) and [Zeta](#)
- Global Intertidal Change - ([changes in the mangrove](#)). Activate different layers, top right

Case 3. Changes in the mangroves of The Esmeraldas River Estuary Mangrove Wildlife Refuge.

- Google Map - [Location](#)
- Google Earth (Sequence [1985 to 2020](#))
- Wordview ([comparison](#) 2000 and 2022)
- Copernicus Browser - False color (seasonal changes): [January](#) - [April](#)
- Global Intertidal Change - ([changes in the mangrove](#)). Activate different layers, top right

Case 4. Changes in The Gulf of Nicoya Mangroves with rehabilitation programs.

- Google Map - [Location](#)
- Google Earth (Sequence [1985 to 2020](#))
- Wordview ([comparison](#) 1986 and 2022)
- Copernicus Browser - False color (seasonal changes): [March](#) - [June](#)
- Global Intertidal Change - ([changes in the mangrove](#)) Activate different layers, top right)
- Story Map: 1) [Land use](#), 2) [Rehabilitation](#)

Protected Planet ([Map of protected areas](#))

World Natural Heritage ([State of conservation](#))

What and how to do it

- Beginning

Watch the videos: [International Mangrove Ecosystem Conservation Day](#) and [Protecting Mangroves](#). Then ask your students to make a list of the most important items about mangroves.

- Development

1. Read the introduction to the activity and show your students the global maps of [mangrove distribution](#), [protected areas](#), [World Natural Heritage](#) areas and compare the state of protection of mangroves in different regions of Latin America and the Caribbean.

Divide the class into student groups and assign one case study to each group. Tell your students:

- a. Look at the current satellite image on Google Map. What do you see in that image (mangroves, cities, shrimp ponds, crops, roads, rivers, forest, etc.)?
 - b. Open the Google Earth sequence and note the changes in each year. Note the changes: What happened to the mangroves, did they remain intact, did they shrink, did they grow, were they replaced by aquaculture (shrimp farming), agriculture, growth of cities, or coastal development of tourism infrastructure, etc.?
 - c. Compare the two Landsat images (old and current). Record the observed changes.
 - d. Compare EO Browser Sentinel images and record seasonal changes.
 - e. Check Global Intertidal Change to see if the mangrove site you are analyzing has remained intact, grown or lost mangrove areas.
 - f. Note: for case 4 look at the Story Maps describing soil use and ecosystem rehabilitation.
2. Ask your students to develop a presentation on the case study. They can make a story with maps (using ArcGIS StoryMaps), or a presentation with slides.
 3. Bring all the groups together and ask them to explain the cases they analyzed and compare the similarities among such cases.
 4. Discuss the threats to mangroves and the state of protection and conservation in different locations. Explore the [map of restoration areas](#) and activate the different layers such as population density, droughts, etc. Which would be the best sites to restore? On what criteria do you base your decision?
 5. If you live near mangrove areas, you can use the same tools to analyze their condition and changes in recent years. You can also visit the site and take land cover and tree height measurements to characterize the mangrove. Atmosphere, pedosphere and hydrology measurements will help to understand the role of mangroves in the ecosystem (with respect to air quality, water quality, soil type and the biodiversity supporting the mangrove).

- **Closing**

Due to the relevance of this problem, it is important to develop outreach activities. Students can elaborate a story with maps ([Story Map](#)), a video, or flyers to post on social networks summarizing the cases they analyzed and highlighting the importance of their conservation.

Frequently Asked Questions

Where can I find satellite images? - Worldview - EO Browser - Google Earth - Google Map

Where do I find information on the status of mangroves? Global Mangrove Alliance - Global Mangrove Watch - Save Our Mangroves Now!

Suggested resources for further information

As an activity extension, more variables can be analyzed by making comparisons in the information of the different maps listed in the resources. You can also consult satellite

images from different dates and locations. Worldview and Google Earth store imagery from the 1980s. The mappings listed in the resources gather information on mangroves.

Other Resources:

- Global Mangrove Alliance <https://www.mangrovealliance.org>
- Mangrove Science <https://mangrovescience.org>
- Protected Planet (Map of protected areas on the planet) <https://www.protectedplanet.net/en>
- World Natural Heritage <https://worldheritageoutlook.iucn.org/es>
- Save Our Mangroves Now! (Mangrove restoration projects and educational resources) <https://www.mangrovealliance.org/save-our-mangroves-now>
- UNESCO - International Day for the Conservation of the Mangrove Ecosystem. July 26. <https://www.unesco.org/es/days/mangrove-ecosystem-conservation>

Tutorials of: [Worldview](#), [Copernicus Browser](#), [Story Map](#)

Mangrove mapping

1. Mangrove Distribution. Global Distribution of Mangroves <https://data.unep-wcmc.org/datasets/4>
2. Mangrove height and biomass. Global Mangrove Height & Biomass Explorer. Earth Engine Apps <https://bit.ly/3yATbMF> (Select layers from menu)
3. Global Mangrove Loss Drivers. Global Mangrove Loss Drivers. <https://bit.ly/3yGSykm> (Some cases. Select layers from menu)
4. Mangrove dataset. Mangrove Dataset Selector <https://bit.ly/3D8jVa1> (Select layers from menu)
5. Comparison of Mangrove Extent. Comparison of Mangrove Extent. <https://bit.ly/3MzN9S1> (Select layers from menu)
6. Global Mangrove Watch. Global Mangrove Watch (1996 - 2020). <https://data.unep-wcmc.org/datasets/45>
7. Global Mangrove Watch (Mangrove information and maps of the world's mangroves) <https://bit.ly/3CUD5jw> (Select from the menu below)
8. Map of mangrove restoration projects. Mangrove Restoration <https://maps.oceanwealth.org/#/mangrove>
9. Map of mangrove restoration, adaptation, livelihood, research, policy, climate projects. Global Mangrove Alliance - Initiatives <https://www.mangrovealliance.org/initiatives>
10. Global Intertidal Change - Global Intertidal Change <https://www.globalintertidalchange.org>

Videos

UNDP PANAMA (2018) *Protection of Mangroves*. Youtube:
<https://youtu.be/Z4jiJLaVQIQ>

UNESCO (2019) International Day for the Conservation of the Mangrove Ecosystem.

Youtube: <https://youtu.be/DHwIVzSYTL8>

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NASA Earth Observatory (2006) *Shrimp Farming in Honduras*. <https://go.nasa.gov/3SVVvpX>

NASA Earth Observatory (2012) *Tiny Shrimp, Big Changes*. <https://go.nasa.gov/3MxtK4c>

NASA Earth Observatory (2014) *Notes from the Field Mangroves, Mud, and More*. <https://go.nasa.gov/3eleZoF>

NASA Earth Observatory (2020) *2020 Hurricanes Damage Vulnerable Mangroves*. <https://go.nasa.gov/3g2VaCX>

NASA Earth Observatory (2021) *A Closer View of 2020 Hurricane Damage*. <https://go.nasa.gov/3TjtVT4>

NASA Earth Observatory (2021) *Shrimp Farms Spread in Sinaloa*. <https://go.nasa.gov/3Cqk1rH>

NASA Goddard (2021) *NASA Finds Cause of Florida Mangrove Forests Die-off*. Youtube: <https://youtu.be/M0tYfMjxeAM>

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UNESCO (2022) *International Day for the Conservation of the Mangrove Ecosystem*. July 26th. UNESCO. UNESCO International Days. <https://www.unesco.org/es/days/mangrove-ecosystem-conservation>

WWF (2022) *Incredible mangroves. Discover these forest wonders from around the world*. World Wildlife Fund. <https://wwf.to/3seVJMV>