Deforestation

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	Agriculture Air quality Water Cycle. Water Quality Soils		

Overview
Satellite images and maps are analyzed to determine deforestation impacts and trends over the last 30 to 40 years. A series of Landsat images are compared to detect changes in land cover, hot spots (which can lead to fires) and seasonal changes. Students analyze cases of deforestation to establish crops (soybeans, palm oil, etc.), cattle raising, mining, urbanization, etc. They also analyze the impact of fires on forests.

Time
4 or 5 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 understand the impact of large-scale deforestation and changes in the interrelationship among the spheres of the Earth System

LEARNING ACTIVITY

Student Outcomes

- Students will identify deforestation patterns associated with different human activities.
- Students will identify the main types of land cover in satellite images.
- Students will analyze land cover changes through the use of satellite images.
- Students will analyze the impact of human activities and fires on land cover.

Background

According to FAO's 2020 assessment, almost one third of the planet's surface is covered by forests. The greatest extension corresponds to tropical forests. Forests have a high biodiversity, many endemic species are specialized in microhabitats within the forest and can only be found in very restricted areas. Their specialization makes them vulnerable to extinction.

Forests provide products for global consumption such as latex, cork, fruits, nuts, wood, fibers, spices, oils, natural resins and medicines, among others. Forests are a huge carbon sink because trees capture CO_2 from the atmosphere, they also absorb and emit water vapor through transpiration and even get to form their own clouds. Forests provide other services to society such as water regulation, soil formation and conservation, biodiversity conservation and climate regulation. They also purify the air, provide food and water, are sources of energy, recreational areas and preserve the cultural identity of the people who live in them, etc. In Latin America, the largest expanse of forests corresponds to the Amazon River basin, which covers about one third of South America, encompassing eight countries.

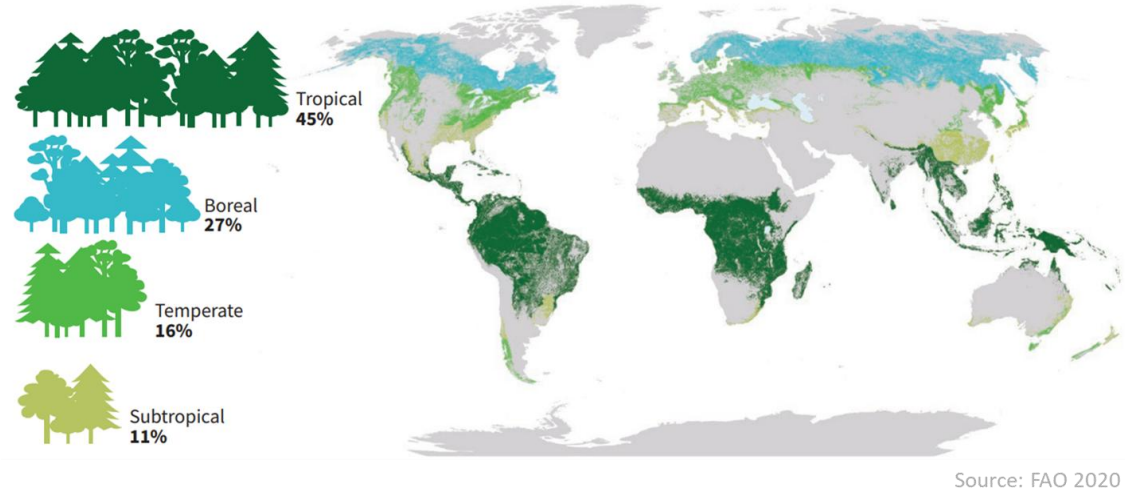
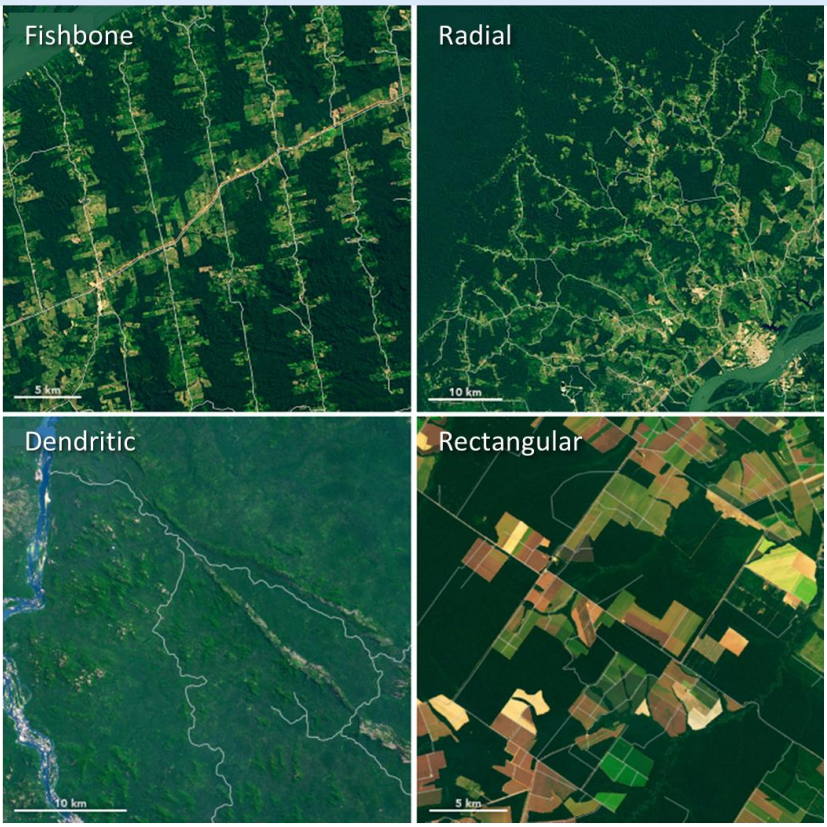


Fig. 1. Global forest area by climate zones, 2020. Source: FAO 2020

In the last 20 years, satellites have shown forest cover change and rapid decline in some places. In addition to the species that are lost when a sector of the forest is deforested, the remaining forest fragments are increasingly vulnerable. When a forest becomes fragmented, the edges begin to change rapidly due to exposure to increased solar radiation, winds, etc.



Source: NASA Earth Observatory (2022)

Fig 2 Deforestation patterns observed in the Amazon basin

Human activity is responsible for the generation of major impacts on forests. From the analysis of satellite images, different patterns of deforestation have been detected: 1) *Fishbone*: from the construction of roads the deforestation process began, set up in a perpendicular direction, to establish crops and form later urbanizations. E.g. Rondonia in Brazil. 2) Radial: In some sectors deforestation began by starting from a center and extending radially. E.g. Santa Cruz de la Sierra, Bolivia. 3) *Ramified*: A large-scale, rapid deforestation was started to replace it with pastures that provide food for cattle. E.g. São Félix do Xingu, Brazil. 4) *Rectangular*: deforestation occurs through burning to establish crops, such as soybeans. E.g. Salta, Argentina. In recent years, soybean cultivation has spread throughout most of the tropical and temperate zones of Latin America, causing deforestation in many places. Another similar case occurs with palm oil plantations. E.g. Yurimaguas, Peru. Small-scale gold mining produces another type of deforestation, leaving a *pattern of water-filled prospecting pits* where mercury is used to amalgamate with gold. E.g. Madre de Dios, Peru.

Another type of disturbance caused by deforestation is fire. In dry periods, fires cause major changes in forest cover spreading smoke to almost the entire continent, for example, the number of hot spots increased in the Caribbean region in early 2020 and in South America from August 2020. Combined images of the hot spots and smoke generated by the 2019 fires that some days darkened the sky in the city of São Paulo, Brazil, can be seen in Worldview. Similar events occurred in Corrientes, Argentina. The 2020 drought affected the flows of the Paraná River creating large fires in this river delta vegetation. Forest modification has environmental, economic, social and political implications on a local, regional and global scale.

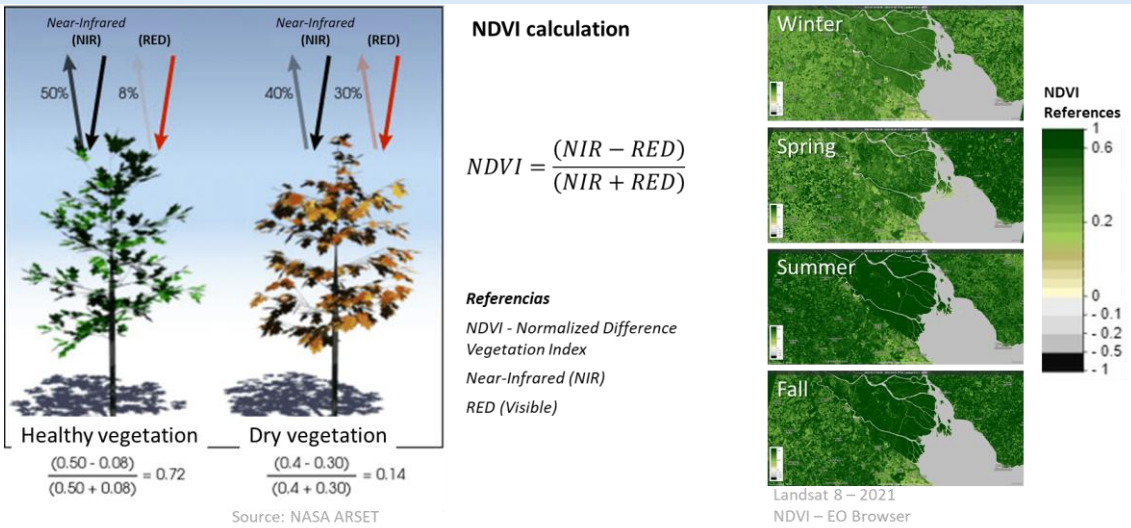


Fig. 3. Calculation and NDVI processed satellite images of the Paraná River Delta

Changes in forest cover are easily detected by looking at a satellite image, but more detail can be analyzed by applying indices. The Normalized Difference Vegetation Index (NDVI) is the most commonly used, but there are several similar indices. The NDVI allows estimating the quantity, quality and development of vegetation based on the measurement of the radiation intensity of some bands of the electromagnetic spectrum that vegetation emits or reflects. The bands vary according to the type of satellite, but some imagers automatically generate the indices. High NDVI values indicate healthy vegetation, low values indicate that the vegetation is drying out (may be due to water stress, disease, fire, etc.).

Knowing and monitoring land cover change is the first step in understanding and designing mitigation measures to prevent impacts.

Guiding Research Questions

- What is the impact of deforestation on ecosystems and people's lives?
- What human activities impact large-scale deforestation?
- How do fires impact deforestation? How far does smoke from fires spread and how does it impact other ecosystems and nearby cities?
- How can deforestation and fires be monitored?
- How does NDVI vary in forest patches and other areas (crops, urbanization, etc.) during different seasons of the year?
- How does land cover change in the short and long term?

Scientific Concepts

- Ecosystems
- Deforestation
- Land cover
- Crops
- Electromagnetic spectrum
- Satellite Images - Spectral Bands - NDVI Index

Materials and tools

1. ArcGIS StoryMaps https://storymaps.arcgis.com
2. Esri Living Atlas – Land Cover Explorer https://livingatlas.arcgis.com/landcoverexplorer
3. Satellite images of:

Case 1. Rondônia, Brazil:

- Google Map - Location
- Google Earth (Sequence 1985 to 2022)
- GFW tree cover loss (2001 to 2021)
- Wordview (1984 and 2022 comparison)
- Copernicus Browser - NDVI (seasonal changes): Spring, Summer, Autumn, Winter
- GFW fire alerts (3-month periods)
- NASA FIRMS - fire alerts (hot spots)
- Wordview (Smoke and heat sources) 9 Aug. 2021

Case 2. Santa Cruz de la Sierra, Bolivia:

- Google Map - Location
- Google Earth (Sequence 1985 to 2022)
- GFW tree cover loss (2001 to 2021)
- Wordview (comparison 1986 and 2021)
- Copernicus Browser - NDVI (seasonal changes): Spring, Summer, Autumn, Winter
- GFW fire alerts (3-month periods)
- NASA FIRMS - fire alerts (hot spots)
- Wordview (Smoke and heat sources) 26 Sep. 2021

Case 3. São Félix do Xingu, Brazil:

- Google Map - Location
- Google Earth (Sequence 1985 to 2022)
- GFW tree cover loss (2001 to 2021)
- Wordview (1984 and 2022 comparison)
- Copernicus Browser - NDVI (seasonal changes): Spring, Summer, Autumn, Winter
- GFW fire alerts (3-month periods)
- NASA FIRMS - fire alerts (hot spots)
- Wordview (Smoke and heat sources) 23 Aug. 2022

Case 4. Salta, Argentina:

- Google Map - Location
- Google Earth (Sequence 1985 to 2022)
- GFW tree cover loss (2001 to 2021)
- Wordview (comparison 1986 and 2022)

- Copernicus Browser - NDVI (seasonal changes): Spring, Summer, Autumn, Winter
- GFW fire alerts (3-month periods)
- NASA FIRMS - fire alerts (hot spots)
- Wordview (Smoke and heat sources) 21 Aug. 2022

Case 5. Yurimaguas, Peru:

- Google Map - Location
- Google Earth (Sequence 1985 to 2022)
- GFW tree cover loss (2001 to 2021)
- Wordview (comparison 1985 and 2022)
- Copernicus Browser - NDVI (seasonal changes): Spring, Summer, Autumn, Winter
- GFW fire alerts (3-month periods)
- NASA FIRMS - fire alerts (hot spots)
- Wordview (Smoke and heat sources) 15 Sep. 2016

Case 6. Madre de Dios, Peru

- Google Map - Location
- Google Earth (Sequence 1985 to 2022)
- GFW tree cover loss (2001 to 2021)
- Wordview (comparison 1986 and 2022)
- Copernicus Browser - NDVI (seasonal changes): Spring, Summer, Autumn, Winter
- GFW fire alerts (3-month periods)
- NASA FIRMS - fire alerts (hot spots)
- Wordview (Smoke and heat sources) 22 Aug. 2022

Case 7. Paraná River Delta, Argentina - Fires:

- Google Map - Location
- Google Earth (Sequence 1985 to 2022)
- GFW tree cover loss (2001 to 2021)
- Wordview (comparison 1986 and 2021)
- Copernicus Browser - NDVI (seasonal changes): Spring, Summer, Autumn, Winter
- GFW fire alerts (3-month periods)
- NASA FIRMS - fire alerts (hot spots 30 Dec. 2021)
- Wordview (Smoke and heat sources) 19 Aug. 2022

What and how to do it

- ***Beginning***

  Show your students the GFW map of forest loss in Latin America and the Caribbean.

Show the changes from 2001 to 2021 (by clicking on the years in the legend on the left of the screen).

Ask your students to note the years of greatest forest loss. They can zoom in on the map to see some sites in more detail.

Ask your students to suggest hypotheses about possible causes of deforestation.

- ***Development***

1. Ask your students to read the introduction to this activity and make a concept map with the information.
2. 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 (cities, forest, plantations, roads, rivers, lakes, etc.)? What type of cover do they correspond to (Urban, Suburban, Roads, Forest, Grasslands, Crops, Bare Soil, Water, etc.)?
    b. Refer to the Copernicus Global Land Cover to characterize the land cover type. Are there any changes between 2015 and 2019 for the analyzed region?
    c. Open the Google Earth sequence and observe the changes in each year. Note the changes. What pattern of deforestation do you observe for that location?
    d. Analyze the same in the GFW (Global Forest Watch) sequence. In which years did the most deforestation occur? What do you suppose was the cause (establishing areas for agriculture and urbanization, cattle raising, gold prospecting, fires, etc.)?
    e. Compare Landsat images (old and current). Record the observed changes.
    f. What seasonal changes are observed in EO Browser images processed with the NDVI index? Consider crops and forest patches.
    g. Consult fire occurrences in GFW, NASA FIRMS and Wordview. Has the area under analysis had fire alerts? Do they intensify at any time of the year? What is the fire trend at this site? Has it suffered large fires at any given time? Is it affected by smoke from nearby fires?
3. 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.
4. Bring all the groups together and ask them to explain the cases they analyzed and compare the similarities among such cases.
5. Complete the conceptual map with the impacts observed in each case and their ecological effects.
6. If there are forests in your area, you can use the same tools to analyze their condition and changes over the last few years. You can get more information and statistics from GFW (Global Forest Watch) and supplement it with field measurements.

- ***Closing***

Due to the relevance of this problem, it is important to develop outreach activities. Students can develop a story with maps (Story Map), a video, or flyers to post on social networks summarizing the analyzed cases 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 forest cover loss? GFW has information on primary forest cover loss and gain.

Where can I look up fires? - NASA Firms - GFW Fires - Worldview

Suggested resources for further information.

As an extension of this activity, students can consult satellite images from different dates and locations to explore other sites where large-scale deforestation has occurred. Worldview and Google Earth store images dating back to the 1980s. In addition, Global Forest Watch collects a wealth of information on forests and the problems of deforestation, fires, plantations, etc. that can be used to supplement research.

Other Resources:

Tutorials for: Worldview, Story Map, Copernicus Browser

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