THE MORPHO INSTITUTE

# TREASURING THE AMAZON

**SUSTAINABILITY & CONSERVATION IN THE AMAZON - RESOURCE GUIDES**

## TEACHER NOTES

Should the Amazon rainforest be seen as a vital biome with globally-significant ecological roles?

Or a bountiful source of resources to be exploited for economic gain?

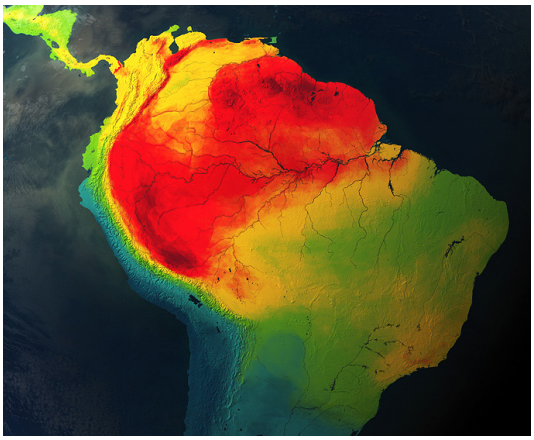
Students discover the exceptionally high biodiversity of the Amazon and the struggle of Indigenous groups to maintain traditional ways of life and protect the rainforests on which their livelihoods depend.

## DISCOVER THE DIVERSITY OF LIFE IN THE AMAZON:

### BIODIVERSITY AND BIOMASS:

Take a look at the ***global biodiversity visualizations*** depicted by Biodiversity Mapping.

Ask students: What do images such as these tell us about the Amazon?



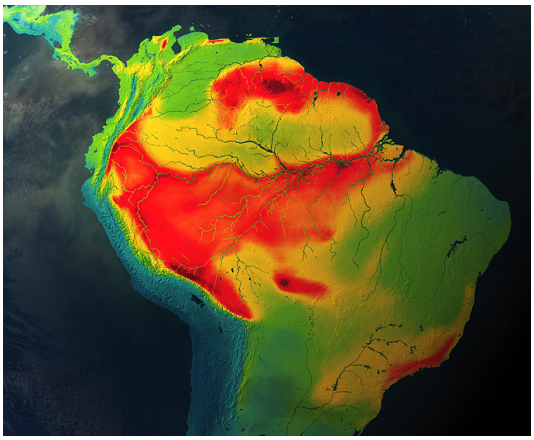


*Image source: https://biodiversitymapping.org/* [1]

Clearly the Amazon rainforest is an area of exceptionally high biodiversity, meaning that it supports many species. It also is quite high in productivity, meaning that it produces a large total biomass per unit area. Why are these metrics important? The Amazon supports many species that are found nowhere else on earth. These provide food, fiber, wood, and medicines. Each species is valuable in its own right, and collectively they build ecosystem stability and resilience and provide ecosystem services of importance throughout the world.

### INDIGENOUS PEOPLE:

Not only is the Amazon a rich ecological biome, it also is home to about 380 indigenous groups who have lived in the rainforest for thousands of years. Some live much as we do, while others rely on the rainforest for their food, shelter, and medicines. Increasingly, these people and resources on which they depend are threatened by external forces beyond their control.

View the documentary film, ***Guardians of the Forest***, for an in-depth view of the Maijuna indigenous people and their ongoing struggle for ecological and cultural survival in the Peruvian Amazon.

Have students read ***The Last Stand of the Amazon.***

[1] These images of mammal and bird species richness come from BiodiversityMapping.org, with species range data by IUCN and BirdLife International.

## CONSIDER THE FATE OF THE AMAZON- OPPOSING WORLDVIEWS:

Have students read ***Amazon's fate hangs on outcome of war between opposing world-views,*** then discuss these opposing points of view:

- The Amazon should be protected intact because its forests and rivers are valuable for their own sake, and for the livelihoods, biodiversity, ecological services and climate change mitigation that they provide.
- Amazon forests and rivers are natural resources to be used for economic gain through activities such as logging, mining, oil and gas extraction, hunting, cattle ranching, and commercial agriculture.

## BACKGROUND INFORMATION ON THE AMAZON

***Protecting What Protects Us: A Network of Conservation Areas in the Amazon***

The Amazon is home to 1/3 of all the world s species, and 1/2 of the world s tropical forests. Known as the world's lungs, it is capable of producing oxygen, of conserving soils and controlling soil erosion, of regulating the climate and the rain cycles, of controlling pests and diseases, and of providing foods that are essential to human beings. But this organ that is so vital for the planet is showing many signs of having fallen ill: as a consequence of climate change, the Amazon is being affected by the rise in the average temperature and by the change in rainfall patterns. This all has an impact on the ecosystems' equilibrium and increases their vulnerability...

Protected areas are considered to be one of the best strategies to conserve biological diversity. They can serve as important reservoirs of natural capital. A global network of protected areas - where human activities are managed so as to preserve the structure and function of the full range of ecosystems - is one of the best ways to continue to obtain benefits for present and future generations, with the ultimate objective of achieving a significant reduction in the rate of biodiversity loss.

***Amazon Deforestation and Climate Change***

The Amazon rainforest absorbs one-fourth of the CO2 absorbed by all the land on Earth. The amount absorbed today, however, is 30% less than it was in the 1990s because of deforestation. A major motive for deforestation is cattle ranching. China, the United States, and other countries have created a consumer demand for beef, so clearing land for cattle ranching can be profitable — even if it's illegal. The demand for pastureland, as well as cropland for food such as soybeans, makes it difficult to protect forest resources.

***Forest Carbon in Amazonia: The Unrecognized Contributions of Indigenous Territories and Protected Natural Areas***

55% of the carbon stored above ground in the Amazon is located in indigenous territories and protected lands. Sequestration of this carbon is critical to the stability of the global climate as well as to the livelihoods of indigenous peoples and the health of the ecosystems they inhabit. However, nearly 20% of tropical forests across Amazonia are at risk from legal and illegal logging, construction of new roads and

dams, and the expansion of commercial agriculture, mining, and petroleum industries. These pressures are exacerbated because governments have failed to recognize or enforce indigenous land rights.

***Ask an Amazon Expert: Why We Can't Afford to Lose the Rain Forest***

The Amazon basically makes half of its own rainfall. Moisture comes in off the Atlantic Ocean, falls as rain in the Amazon forest, and about three-quarters of it evaporates back into the atmosphere. This then gets carried west and most of it turns into rain again closer to the Andes, where it falls and feeds the Amazon river system. This system holds about 20% of the world's river water, which is huge. What isn't rained out of the Andes disperses north and south, with the southern portion being really important for agriculture in Brazil and Argentina. So, São Paulo's current drought — possibly the worst in its history — is happening partly because the region is getting less rainfall from the Amazon.

It's estimated that 20% of the Amazon rain forest has disappeared during the past 50 years. Deforestation due to agriculture, urbanization, and illegal logging is not only threatening the millions of unique plant and animal species native to the Amazon River region, it's affecting humans worldwide. Whether it's extreme drought in São Paulo, the multibillion-dollar illegal wildlife trade, or the catastrophic impacts of climate change, threats to the Amazon are having a very tangible ripple effect around the globe.

***Trees in the Amazon Make Their Own Rain***

Previous research showed early accumulation of moisture in the atmosphere over the Amazon, but scientists weren't sure why. "All you can see is the water vapor, but you don't know where it comes from," says Rong Fu, a climate scientist at the University of California, Los Angeles. Satellite data showed that the increase coincided with a "greening" of the rainforest, or an increase in fresh leaves, leading researchers to suspect the moisture might be water vapor released during photosynthesis. In a process called transpiration, plants release water vapor from small pores on the underside of their leaves.

Fu thought it was possible that plants were releasing enough moisture to build low-level clouds over the Amazon. But she needed to explicitly connect the moisture to the tropical forest. So Fu and her colleagues observed water vapor over the Amazon with NASA's Aura satellite, a spacecraft dedicated to studying the chemistry of Earth's atmosphere. Moisture that evaporates from the ocean tends to be lighter than water vapor released into the atmosphere by plants. That's because during evaporation, water molecules containing deuterium, a heavy isotope of hydrogen made of one proton and one neutron, get left behind in the ocean. By contrast, in transpiration, plants simply suck water out of the soil and push it into the air without changing its isotopic composition.

Aura found that the early moisture accumulating over the rainforest was high in deuterium — "too high to be explained by water vapor from the ocean," Fu says. What's more, the deuterium content was highest at the end of the Amazon's dry season, during the "greening" period when photosynthesis was strongest.

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The tree-induced rain clouds could have other domino effects on the weather. As those clouds release rain, they warm the atmosphere, causing air to rise and triggering circulation. Fu and colleagues believe that this circulation is large enough that it triggers the shift in wind patterns that will bring in more moisture from the ocean, they report in the Proceedings of the National Academy of Sciences.

Scientists have studied the connection between trees and rain in the Amazon before. A 2012 study found that plants help "seed" the atmosphere for rain by releasing tiny salt particles. But the new study strongly supports the idea that plants play an important role in triggering the rainy season, says Scott Saleska, an ecologist at the University of Arizona in Tucson, who was not involved with the work. The deuterium provides a clear "fingerprint" for what plants contribute to the process, he says.

The findings also address a long-standing debate about the role plants play in weather, says Saleska, suggesting that they are more than just "passive recipients," and that they instead can play an active role in regulating rainfall. If that's true in the Amazon, Saleska says, climate scientists will need to take into account practices like deforestation when predicting regional changes in weather patterns. And curbing deforestation will be an important step for people to take in preventing drought.

***Amazon Seeds Its Own Rain***

The Amazon rainforest makes its own rain. That's the conclusion of a new study, which finds that microscopic bits of potassium-rich salt spewed skyward by trees and fungi may be seeding much of the region's precipitation. Because aerosols also scatter light back into space, they can cool Earth's surface as well.

Unless temperatures are extremely cold, raindrops don't just form in thin air; molecules of water vapor must actually aggregate around a tiny core. Those seeds can either be particles such as mineral dust, soot, salt spray from the ocean — even airborne bacteria — or droplets such as the sulfur dioxide spewed by volcanoes. Scientists previously knew that the organic-rich particles of haze floating above the Amazon Basin acted as the seeds for much of the rainfall there, but what had served to trigger the growth of those particles—known scientifically as secondary organic aerosols — was a big mystery, says Christopher Pöhlker, an atmospheric chemist at the Max Planck Institute for Chemistry in Mainz, Germany.

Now, field studies by Pöhlker and his colleagues hint that the forest itself is the ultimate source of its own precipitation. The team's detailed analyses of tiny aerosols slurped from the air above the rainforest during the rainy season at a remote site 150 kilometers northwest of Manaus, Brazil, revealed that a tiny chunk of potassium-rich salt lies at the core of most of the particles. For aerosols measuring about 0.15 micrometers across, the salty core accounted for as much as 20% of the particle's weight; in larger aerosols, the fraction of weight due to the core was much smaller. Together, these trends suggest that the bits of salt act as the seeds upon which the organic-rich haze particles grow, the researchers report online today in *Science.*

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Although scientists have identified several sources of airborne salt bits, a number of them are unlikely in this case, Pöhlker says. For one thing, potassium-rich particles often show up in smoke from wildfires or fires used to clear land, but the team's samples didn't include soot particles typically found in such smoke, and satellite images didn't discern any fires upwind of the site where the aerosols were collected. Second, the potassium-rich bits probably didn't come from salt spray above the Atlantic, which is located about 1000 kilometers upwind of the study site. Also, Pöhlker notes, the cores had a chemical composition distinctly different from sea salt.

Evidence suggests the salty cores of the aerosols originated in the forest itself. Previous studies have shown that plants and fungi release salts into the air, Pöhlker says. In particular, when fungi expel spores into the air, they also spew droplets that contain carbohydrates and potassium and chloride ions. Besides the aerosols, the air samples that the team collected over the Amazon also included large numbers of fungal spores.

Pöhlker and his colleagues "have found a new significant source for primary aerosol particles, which will enhance cloud droplet concentration," says Markku Kulmala, an atmospheric scientist at University of Helsinki. "The connection between biogenic particle emissions and cloud properties in the tropical rainforest ecosystem appears even stronger and more direct than previously assumed."

Because tropical rainforests have a large influence on atmospheric chemistry, the biological activity and diversity of the ecosystem's particle-emitting organisms have played an important role in past climate and will likely do so in the future, Kulmala says. The findings may also help explain how secondary organic aerosols form in other parts of the world, although in many of those regions the cores of those particles are presumed to be dust, soot, or manmade pollutants.

***Intact forests crucial to Amazon ecosystem resilience, stable climate***

- Three recent South American studies emphasize the importance of intact forests to healthy habitat and a stable climate — both locally, and at a great distance.
- The first study found that forest integrity is crucial for habitat stability and resilience. Degradation makes it harder for Brazil's Caatinga forest to recover from intensifying drought due to climate change. Protected forests are more resilient against drought.
- Another study showed that intense land use change in central Brazil and northern Argentina has resulted in the dry season becoming warmer across South America, with changes in Amazon plant productivity 500 kilometers from the disturbed area.
- A third study's modelling found that major future deforestation anywhere in the Amazon will dramatically reduce rainfall in the Amazon's southwest — accounting for about 25 percent of the Amazon basin — and the La Plata basin.