Sustainability and Conservation in the Amazon

Investigating Ecosystem Services
Teacher Notes

Opener:

- Introduce the concept of Ecosystem Services with this 2-page overview by the Ecological Society of America: *https://www.esa.org/esa/wp-content/uploads/2012/12/ecosystemservices.pdf*

Explore the role of the Amazon rainforest in providing ecosystem services:

- Show this 5-minute National Geographic video, ***Amazon Deforestation and Climate Change****:* *https://www.nationalgeographic.org/media/amazon-deforestation-and-climate-change/* *and/or,*
- Have students read ***Why are Rainforests so Important?*** (provided as a Student Reading, condensed from this post by Jon Foley*: https://www.calacademy.org/blogs/from-our-director/guardians-of-biodiversity-stewards-of-our-climate)*
- Discuss questions such as these:
  - How could deforestation cause the Amazon to become a desert? (Even if the trees are cut, wouldn't the area still get a huge amount of rainfall?)
  - How does eating beef in other parts of the world affect the Amazon?
  - How does the Amazon rainforest affect the climate in other parts of the world?
  - What role does the Amazon play in the global carbon cycle?
  - What does the scientist in the video mean by "Plan B"? What ideas do you have for actions that would be included in Plan B?
- Consider implementing this National Geographic lesson: ***Local and Global Effects of Deforestation in the Amazon Rain Forest*** – students identify areas of deforestation on a map of the Amazon, consider the role of the rainforest in maintaining water and nutrient cycles, and construct a scientific argument for the effects of deforestation on these cycles and on rainforest organisms: *https://www.nationalgeographic.org/activity/local-and-global-effects-deforestation-amazon-rain-forest/*

DRAFT FOR REVIEW: Please send feedback or questions to Dr. Nancy Trautmann (nmt2@cornell.edu)

Calculate ecological benefits provided by trees in your community:

- Using the USDA Forest Service's ***i-Tree*** online software, quantify the amounts and dollar values of the carbon, air pollution, and hydrologic benefits provided by trees based on the tree cover in a region you have selected: *https://www.itreetools.org/*
  and/or,
- Use the ***Tree Benefit Calculator*** to estimate the environmental and economic value provided by individual trees: *http://www.treebenefits.com/calculator/*

Background Information on Ecosystem Services Provided by the Amazon

ARTICLES

Indigenous forests could be a key to averting climate catastrophe
https://news.mongabay.com/2017/11/indigenous-forests-could-be-a-key-to-averting-climate-catastrophe/
by S. Branford and M. Torres. Mongabay, 11/06/2017.

- A new study finds the world's tropical forests may no longer be carbon sinks, with a net loss of 425 million tons of carbon from 2003 to 2014. Also, 1.1 billion metric tons of carbon is emitted globally from forested areas and land use annually — 4.4 billion metric tons are absorbed by standing forests on managed lands, but 5.5 billion metric tons are released via deforestation and degradation.
- As a result, curbing deforestation and degradation is now seen by scientists as a vital strategy for nations to meet the carbon reduction goals set in Paris in 2015, and of averting a catastrophic 2-degree Celsius rise in temperatures by the end of the century.
- Other new research finds that indigenous and traditional community management of forests could offer a key to curbing emissions, and give the world time to transition to a green energy economy. In a separate study, Amazon deforestation rates were found to be five times greater outside indigenous territories and conservation units than inside.
- "We are a proven solution to the long-term protection of forests, whose survival is vital for reaching our [planetary] climate change goals," said an envoy of a global indigenous delegation in attendance at COP23 in Bonn, Germany. The delegation wants the world's nations to protect indigenous forests from an invasion by global extraction industries.

Observations of increased tropical rainfall preceded by air passage over forests
http://www.nature.com/nature/journal/v489/n7415/full/nature11390.html
by D.V. Spracklen, S.R. Arnold, & C.M. Taylor. 2012. Nature 489, 282–285.

Editorial Summary: This global observational analysis demonstrates that forests exert a strong control on rainfall hundreds of kilometers downwind through a water-cycle feedback. When precipitation occurs, some of the water returns to the atmosphere through transpiration and evaporation. In the tropics, this process has long been thought to be an important part of the overall precipitation budget. But most evidence has come from modelling studies, which remain inconclusive. Spracklen and colleagues use remote sensing and atmospheric back-trajectory modelling to show that air passage over dense forests produces about twice as much rain as passage over sparse vegetation. They estimate a 1221% reduction in seasonal precipitation if Amazon deforestation continues at the current rate, and conclude that efforts to curb deforestation are vital if drastic impacts on regional rainfall are to be avoided.

Mammal diversity influences the carbon cycle through trophic interactions in the Amazon
https://www.nature.com/articles/s41559-017-0334-0

by M. Sobral, K.M. Silvius, H. Overman, L.F.B. Oliveira, T.K. Raab, & J.M.V. Fragoso. 2017. Nature Ecology & Evolution 1, 1670–1676.

Abstract: Biodiversity affects many ecosystem functions and services, including carbon cycling and retention. While it is known that the efficiency of carbon capture and biomass production by ecological communities increases with species diversity, the role of vertebrate animals in the carbon cycle remains undocumented. Here, we use an extensive dataset collected in a high-diversity Amazonian system to parse out the relationship between animal and plant species richness, feeding interactions, tree biomass and carbon concentrations in soil. Mammal and tree species richness is positively related to tree biomass and carbon concentration in soil—and the relationship is mediated by organic remains produced by vertebrate feeding events. Our research advances knowledge of the links between biodiversity and carbon cycling and storage, supporting the view that whole community complexity—including vertebrate richness and trophic interactions—drives ecosystem function in tropical systems. Securing animal and plant diversity while protecting landscape integrity will contribute to soil nutrient content and carbon retention in the biosphere.

Planetary health: protecting human health on a rapidly changing planet

https://www-sciencedirect-com.proxy.library.cornell.edu/journal/the-lancet

by S.S. Myers, MD. 2017. The Lancet. DOI: http://dx.doi.org/10.1016/S0140-6736(17)32846-5.

Summary: The impact of human activities on our planet's natural systems has been intensifying rapidly in the past several decades, leading to disruption and transformation of most natural systems. These disruptions in the atmosphere, oceans, and across the terrestrial land surface are not only driving species to extinction, they pose serious threats to human health and wellbeing. Characterizing and addressing these threats requires a paradigm shift. In a lecture delivered to the Academy of Medical Sciences on Nov 13, 2017, I describe the scale of human impacts on natural systems and the extensive associated health effects across nearly every dimension of human health. I highlight several overarching themes that emerge from planetary health and suggest advances in the way we train, reward, promote, and fund the generation of health scientists who will be tasked with breaking out of their disciplinary silos to address this urgent constellation of health threats. I propose that protecting the health of future generations requires taking better care of Earth's natural systems.

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

http://www.tandfonline.com/doi/abs/10.1080/17583004.2014.990680

by W. Walker, A. Baccini, S. Schwartzman, S. Ríos, M.A. Oliveira-Miranda, C. Augusto, M.R. Ruiz, C.S. Arrasco, B. Ricardo, R. Smith, C. Meyer, J.C. Jintiach & E.V. Campos. 2014. Carbon Management 5, 479-485.

Summary by EDF: Summary: Protecting the vast amount of carbon stored above ground in the forests of indigenous and protected lands – totaling 55% of the Amazon – is critical to the stability of the global climate as well as to the cultural identity of forest-dwelling peoples and the health of the ecosystems they inhabit. Yet the authors also find that 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, pressures which are exacerbated in many countries because governments have failed to recognize or enforce indigenous land rights.

Abstract of the article: Carbon sequestration is a widely acknowledged and increasingly valued function of tropical forest ecosystems; however, until recently, the information needed to assess the carbon storage capacity of Amazonian indigenous territories (ITs) and protected natural areas (PNAs) in a global context remained either lacking or out of reach. Here, as part of a novel north–south collaboration among Amazonian indigenous and non-governmental organization (NGO) networks, scientists and policy experts, we show that the nine-nation network of nearly 3000 ITs and PNAs stores more carbon above ground than all of the Democratic Republic of the Congo and Indonesia combined, and, despite the ostensibly secure status of these cornerstones of Amazon conservation, a conservative risk assessment considering only ongoing and planned development projects puts nearly 20% of this carbon at risk, encompassing an area of tropical forest larger than that found in Colombia, Ecuador and Peru combined. International recognition of and renewed investment in these globally vital landscapes are therefore critical to ensuring their continued contribution to maintaining cultural identity, ecosystem integrity and climate stability.

BOOKS

Kosloff, N. 2010. ***No Rain in the Amazon: How South America's Climate Change Affects the Entire Planet***. St. Martin's Press.

Acting as the planet's air conditioner, the rainforest sucks up millions of tons of greenhouse gases and stores them safely out of the atmosphere. South America's deforestation threatens to unleash a kind of "carbon bomb" that will add to our already deteriorating climate difficulties. As he travels across Peru and Brazil, recognized South America expert Nikolas Kozloff talks to locals, scientists and activists about the rainforest and what should be done to avert its collapse. Drawing on his expertise of South American politics, Kozloff argues that cooperation between the world's countries is essential in turning back the tide of climate change and that the fate of the planet depends on our response to environmental problems within the southern hemisphere.

Bush, M., Flenley, J., & W. Gosling (Eds.). 2011. ***Tropical Rainforest Responses to Climatic Change***, 2nd Ed. Springer.

This book looks at how tropical rain forest ecology is altered by climate change. A major theme of the book is the interaction between humans, climate and forest ecology. The authors, all foremost experts in their fields, explore the long term occupation of tropical systems, the influence of fire and the future climatic effects of deforestation, together with anthropogenic emissions. Incorporating modelling of past and future systems paves the way for a discussion of conservation from a climatic perspective, rather than the usual plea to stop logging.

Investigating Ecosystem Services – Student Reading

Why are Rainforests so Important?[1]

First of all, **tropical rainforests house the richest collection of plant and animal species on the planet** and include some of the most important "hotspots" of biological diversity worldwide. In fact, scientists estimate that more than 50% of all of Earth's terrestrial species are found in tropical forests. In order to preserve the world's biological diversity for future generations, it is therefore *essential* to protect tropical rainforests.

Furthermore, **tropical forests are *crucial* parts of Earth's global environmental system**, and help drive our planet's climate, water cycle, and carbon cycle. In fact, tropical forests perform roughly 25% of the world's land-based photosynthesis, and they contain roughly 40% of all Earth's terrestrial biomass—which is currently locking enormous amounts of carbon (in plant biomass) away from the atmosphere. That's why tropical deforestation is such a problem. **Logging and burning these forests releases tremendous amounts of carbon dioxide to the atmosphere**, adding to the emissions from burning fossil fuels, greatly accelerating global warming.

But maintaining healthy rainforests does much more than simply avoiding deforestation-based emissions. **Intact rainforests are also a large, active *sink* of atmospheric carbon dioxide**—helping to partially offset humanity's greenhouse gas emissions. Trees in our tropical rainforests, along with other forests around the globe, actively remove CO2 from the atmosphere, storing it in plant biomass and soils. In fact, it is estimated that forests around the world help remove about 30-40% of our greenhouse gas emissions, greatly slowing the rate of climate change we would have experienced otherwise. But this biological "brake" on climate change is only going to continue as long as we maintain healthy forests.

This is why **I believe that protecting tropical rainforests is one of the most important things we can do to combat climate change**. Slowing and ultimately ceasing global deforestation, which has been responsible for 10-15% of global CO2 emissions since the 1990s, eliminates an important source of greenhouse gasses. (In fact, tropical deforestation releases nearly as much CO2 as *all* of the world's electricity production, or all of the world's transportation.) Moreover, protecting intact forests helps maintain an important carbon sink, which offsets a major share of our current greenhouse gas emissions. **More than any single action we can take, stopping deforestation and protecting our remaining tropical rainforests is one of the best things we can do to stabilize our climate**.

In addition to their role in keeping carbon out of the atmosphere and slowing global warming, tropical forests also play an important *physical* role in the Earth's climate system, acting as giant,

[1] Condensed from *Guardians of Biodiversity, Stewards of our Climate*, by Jon Foley (February 19, 2016. California Academy of Sciences): https://www.calacademy.org/blogs/from-our-director/guardians-of-biodiversity-stewards-of-our-climate

living pumps of water and energy into the atmosphere, helping to fuel atmospheric circulation patterns and key aspects of our climate.

In addition to their role in harboring biodiversity and regulating our climate system, **we are now beginning to recognize many other important "ecosystem goods and services" provided by intact tropical forests**. Healthy tropical forests deliver many benefits to society, first by providing essential goods—including food, feed, fiber, forest products, freshwater, hydroelectric power, minerals, pharmaceuticals, and many other natural resources. Healthy forests also help regulate crucial environmental systems that strongly affect people, such as the presence of pollinators, seed dispersers, pest predators, and other beneficial animals; the flow of water in rivers and wetlands, with impacts on fisheries, flooding, and hydroelectricity generation; the pumping of energy and water into the atmosphere, which affects atmospheric circulation and climate worldwide; the uptake, storage, and release of atmospheric carbon dioxide, which affects the future path of global warming; and the mitigation of disease by affecting the ecology of disease organisms, hosts, and vectors.

In short, we now see that **healthy rainforests are *crucial* to humanity**, and provide countless goods and services to the world—even to people far away from the tropics. In fact, we are now slowly recognizing that, on the whole, forests are far more valuable to society when they are intact than when they are clear-cut. The instrumental role tropical forests play in the larger Earth system make them **perhaps the most important ecosystems on our planet**—affecting environments, natural resources, and people worldwide.

Unfortunately, rainforests—and their associated species, environmental systems, and ecological services—are increasingly threatened. Already, large areas of forest have been lost to deforestation—largely for commodity agriculture, timber harvesting, and mining operations. In addition, the increasing impacts of climate change will have profound impacts on tropical forests, with some modeling studies suggesting that forests could reach a "tipping point" where might they "flip" into degraded savannas.

Today, we desperately **need to improve our understanding of the environmental and societal value of tropical rainforests and share this knowledge with decision-makers and the larger public** as quickly as possible. Without a concerted effort to explore and understand tropical forests, we risk vastly undervaluing, and eventually losing, the myriad benefits they provide the world.