Conservation Outlook for the Tropics

Describe how we can make priorities for conserving tropical regions

Review some of the most pervasive issues that affect the future of the tropics

What factors do we need to consider when developing conservation strategies?

What makes species more or less extinction prone?

What community level metrics can we use to prioritize regions for conservation?

How do threats to tropical forest systems affect their functionality?

Approaches to understanding biodiversity

Could some populations be 'primed' to face new anthropogenic pressures?

Brown and Brown (1992) suggested that animals of the Atlantic rain forest have existed in small isolated populations historically, so they may be adapted to remain so

Or, perhaps because this rain forest has been subject to high natural disturbances (heavy rains, cold snaps, varying seasonality), it has resulted in the species inhabiting these areas to have adaptive responses to unpredictable events

The Atlantic rain forest is home to some of South America's most endangered species: the maned sloth and golden lion tamarin

Approaches to understanding biodiversity

Susceptibility to extinction clearly varies among species – some species are more extinction-prone, and the loss of some species will have greater impacts on others

1) Characteristics that typify extinction prone species include:

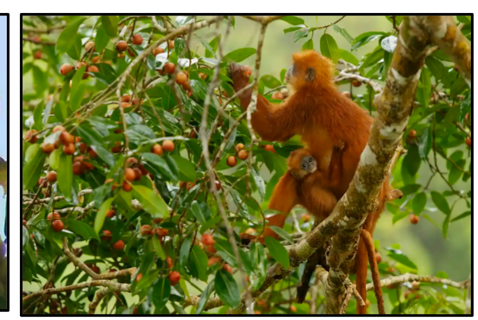
- Species of large body size
- Species near the top of the food web (harpy eagles, jaguars)

(Such species already occur at low densities and require large areas to sustain both individual territories and sufficient populations)

2) Even widespread species with poor dispersal and colonization abilities are extinction prone (e.g., bird species extinctions from BCI)

3) Certain species are essential in maintaining food webs: keystone species
(The loss of fruiting trees like *Ficus* could have disproportionate impacts on other birds and mammal species, compared to the loss of another tree species)

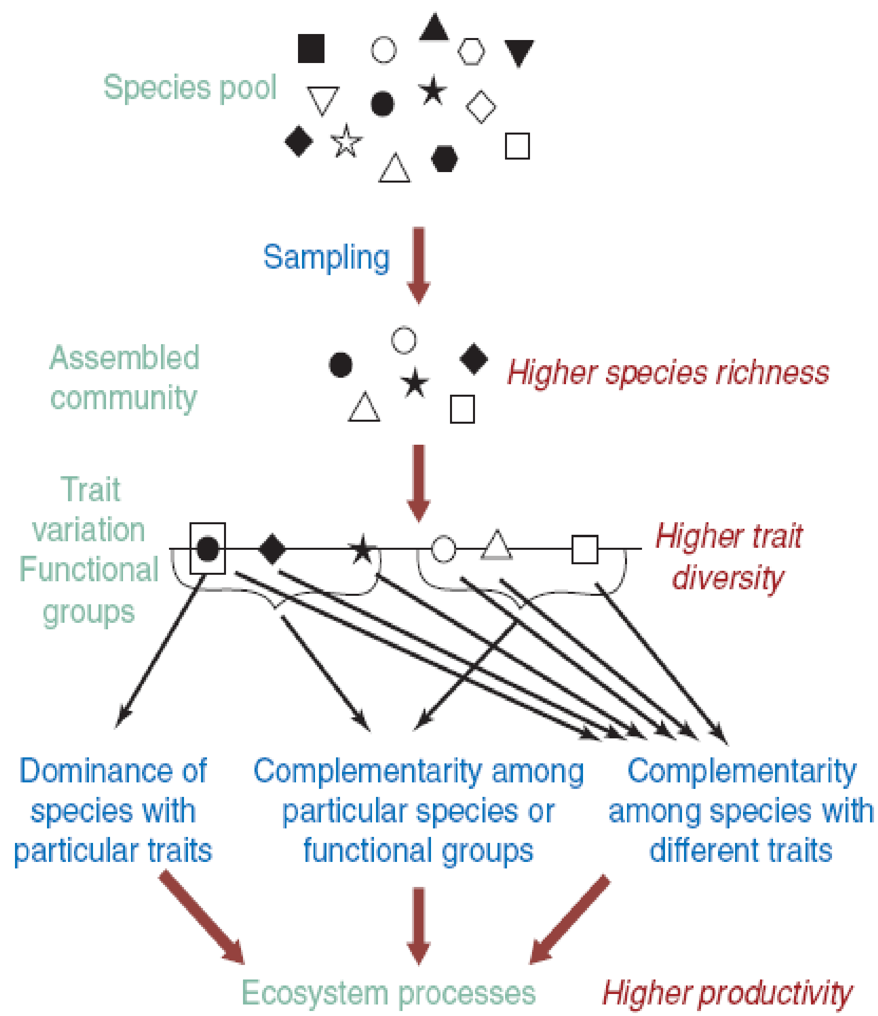


How resistant are high-biodiversity ecosystems to environmental change and species loss?

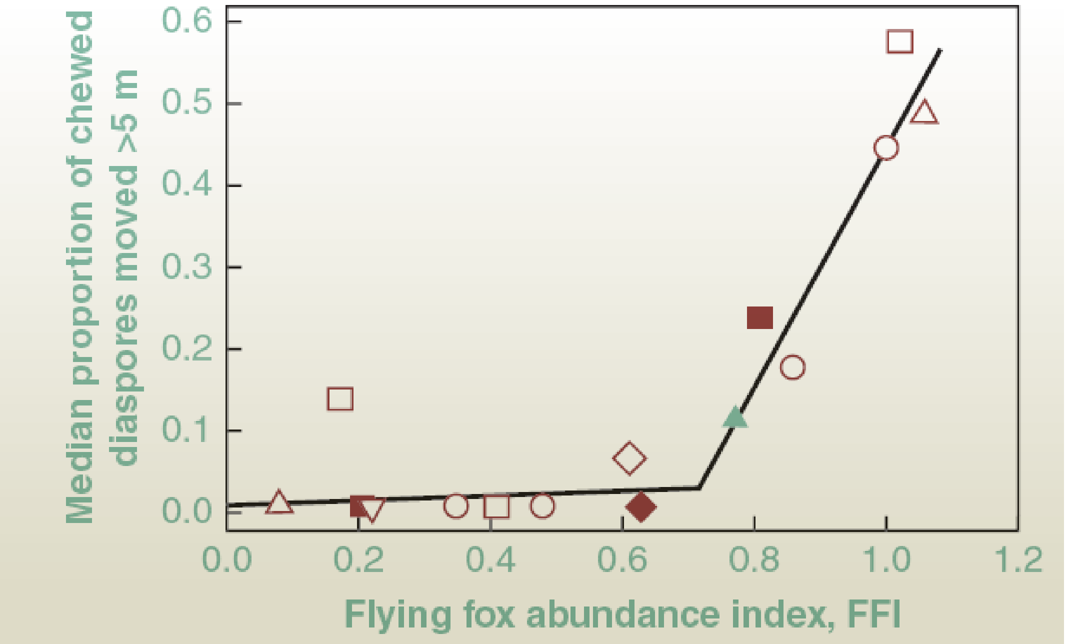
Communities with higher species richness likely show greater phenotypic diversity (higher trait variation and functional groups) but also greater redundancy in traits represented

Offers complementarity among species and possible redundancy in maintaining ecosystem processes



How resistant are high-biodiversity ecosystems to environmental change and species loss?

Some relationships, however, depend upon critical numbers of participants



Flying fox bats (Megachiroptera) are essential seed dispersers in the Paleotropics. But one study showed that the efficacy of bats as dispersers depended on their population density. If numbers dropped below a critical number, seed dispersal was severely reduced.

High aggression in dense groups that aggregate in fruiting trees causes more bats to ingest fruit and fly away, enhancing successful seed dispersal.

Monitoring top carnivores

In some cases, we can monitor some populations, particularly those of top carnivores, with the use of camera traps, which are increasingly deployed to survey mammal populations

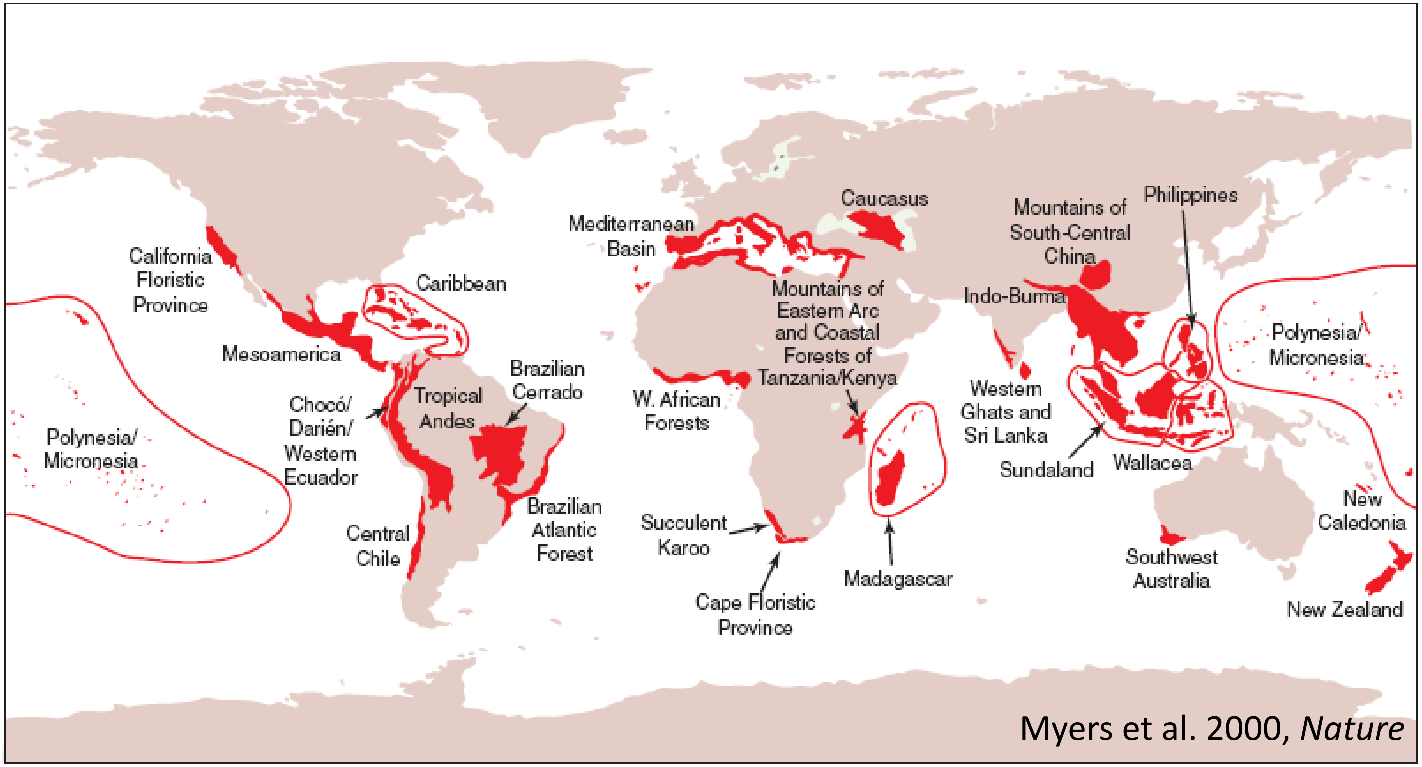
Jaguars, which are important top predators in tropical forests, are notoriously difficult to monitor, but in the forests around Gallon Jug, western Belize, camera traps established that densities were 11.8 individuals / 100 square kilometers (the highest density reported anywhere in the Neotropics)

Spotting patterns lets researchers keep track of different individuals captured in photos across camera traps

Hotspots: biodiversity and endemism

Focusing on biodiversity hotspots has been a strategy to target areas where we can preserve the most species – defined by species richness, endemism as well as anthropogenic activity

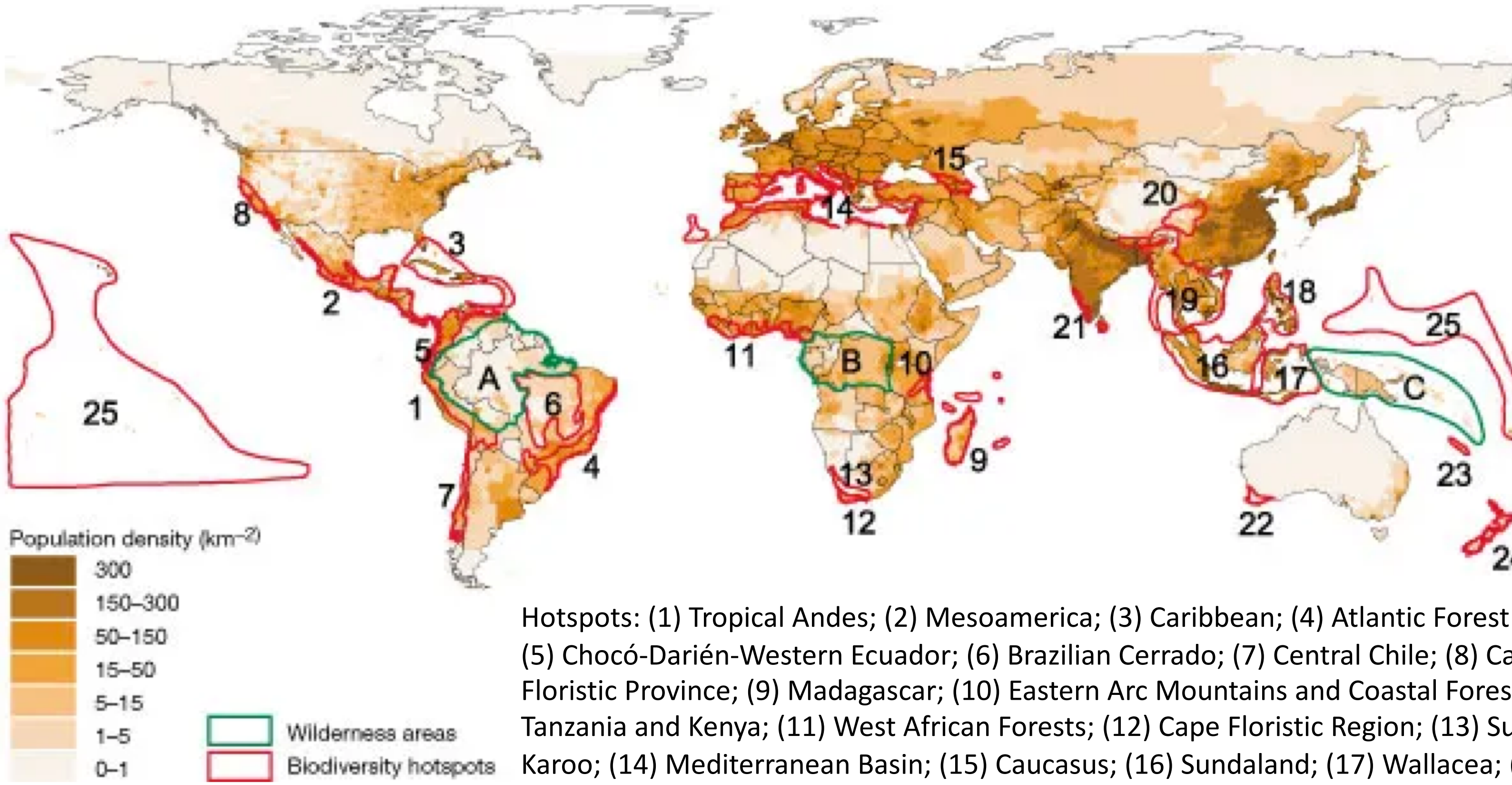
A hotspot should 1) contain a biota that can be considered as a biogeographic unit; 2) must include 0.5% of the world's plant species as endemics and 3) must have lost 70% of its primary vegetation



Myers et al. 2000, *Nature*

Hotspots: biodiversity and endemism

It is also important to consider how these biodiversity hotspots intersect with human population density and growth. In 1995, 20% of the world population was living within these hotspots (occupying 12% of Earth's terrestrial surface)

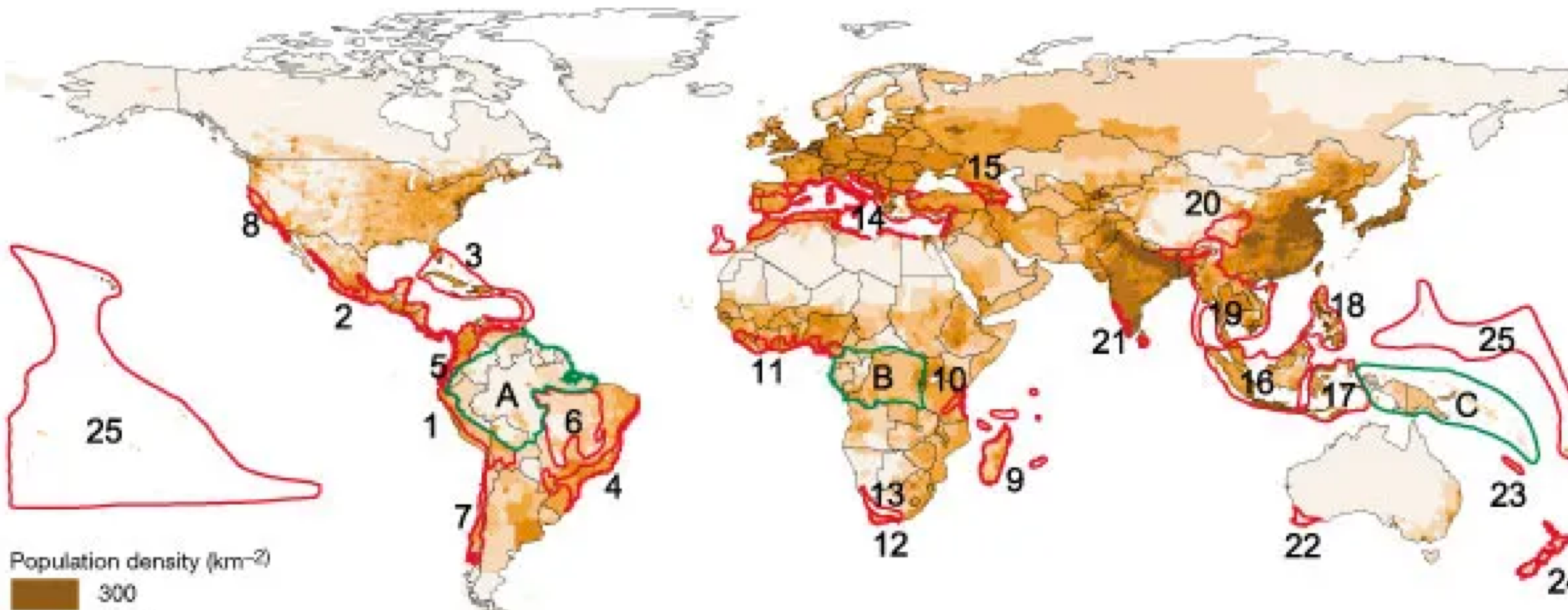


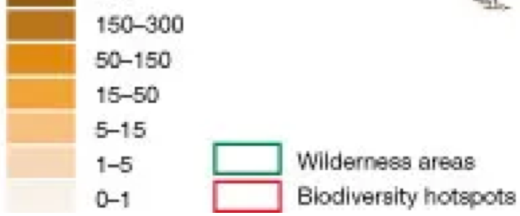
Hotspots: (1) Tropical Andes; (2) Mesoamerica; (3) Caribbean; (4) Atlantic Forest Region; (5) Chocó-Darién-Western Ecuador; (6) Brazilian Cerrado; (7) Central Chile; (8) California Floristic Province; (9) Madagascar; (10) Eastern Arc Mountains and Coastal Forests of Tanzania and Kenya; (11) West African Forests; (12) Cape Floristic Region; (13) Succulent Karoo; (14) Mediterranean Basin; (15) Caucasus; (16) Sundaland; (17) Wallacea; (18) Philippines; (19) Indo-Burma; (20) Mountains of South-Central China; (21) Western Ghats and Sri Lanka; (22) Southwest Australia; (23) New Caledonia; (24) New Zealand; and (25) Polynesia and Micronesia. Major tropical wilderness areas: (A) Upper Amazonia and Guyana Shield; (B) Congo River Basin; and (C) New Guinea and Melanesian Islands.

Cincotta et al. 2000, *Nature*

Hotspots: biodiversity and endemism

Population growth rate in the hotspots (1995–2000) is 1.8% / yr, substantially higher than the population growth rate of the world as a whole (1.3% / yr) and above that of the developing countries (1.6% / yr)





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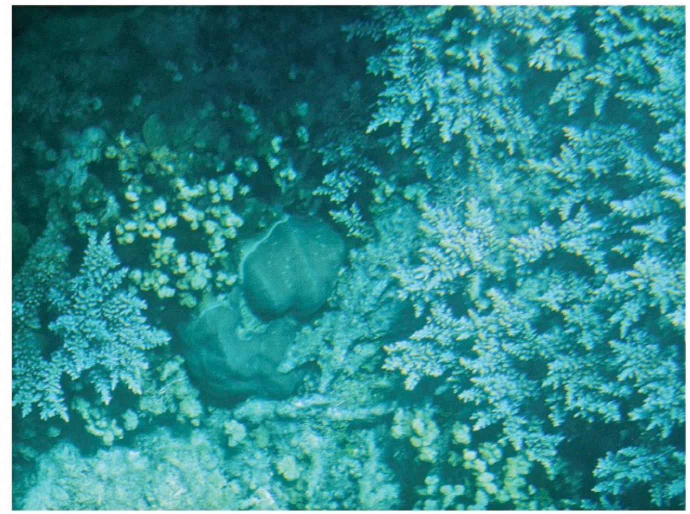
Cincotta et al. 2000, *Nature*

Hotspots: biodiversity and endemism

How do other ecosystem qualities weigh in?

Places like Madagascar meet all criteria – high species richness, many endemic species due to its long isolation from Africa, under great threat from expanding human population.



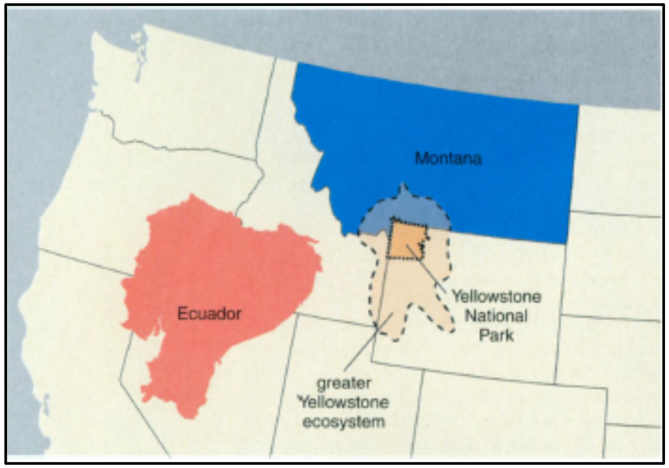
Coral reefs are uniquely threatened systems which harbor -- but they contain no vascular plants (missed by many initial hotspot analyses!)

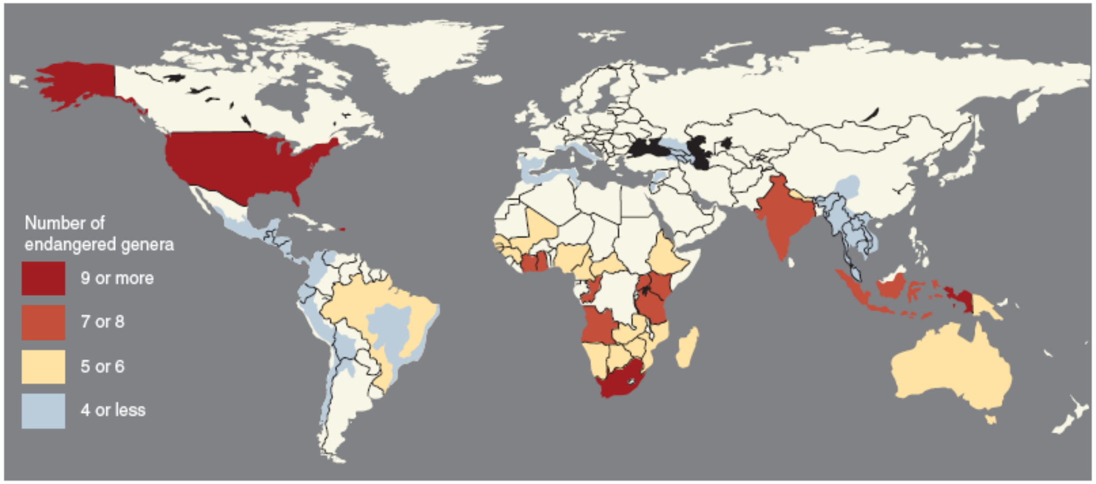
Hotspots: biodiversity and endemism

What are we missing by focusing on hotspots?

We could be ignoring the needs of large carnivores that live nowhere else, important migratory corridors or low diversity systems that provide important ecosystem services (e.g., salt marshes)

Focusing on endangered bird and mammal genera by nation would shift the conservation priorities substantially from the Myers et al. framework





Kareiva & Marvier 2003, American Naturalist

Conservation: our concepts and threats

Between 39 – 50 % of Earth's land surface has been transformed or degraded by humans (Uriarte et al. 2009)

Why does this loss or alteration of habitats matter? Two concepts are useful to understand this problem:

1) Loss of species richness (aka the biodiversity crisis)
2) Loss of ecosystem services

In conservation, we need to evaluate the collective impacts of habitat alterations (e.g., replacement of an area of forest with a soybean monoculture), by understanding, or at least approximating the importance of those myriad interactions and webs among organisms and their various ecological functions (mineral recycling and carbon storage).

Ecosystem services of tropical habitats

Coastal mangroves significantly dampen the effects of tsunamis and hurricanes and also aid in fertilizing coastal fisheries

What costs do we pay to replace those services when they are gone?

Ecosystems provide essential functions without costs to humans (though costs become apparent when our activities disrupt those services)

- Moderating weather extremes and impacts
- Dispersing seeds
- Mitigating flood and droughts
- Cycling and moving nutrients
- Erosion protection
- Maintaining biodiversity
- Soil preservation and renewal of fertility
- Climate stabilization
- Air and water purification
- Regulate disease-carrying organisms
- Pollination of crops and natural vegetation

(compiled by Ecological Society of America)

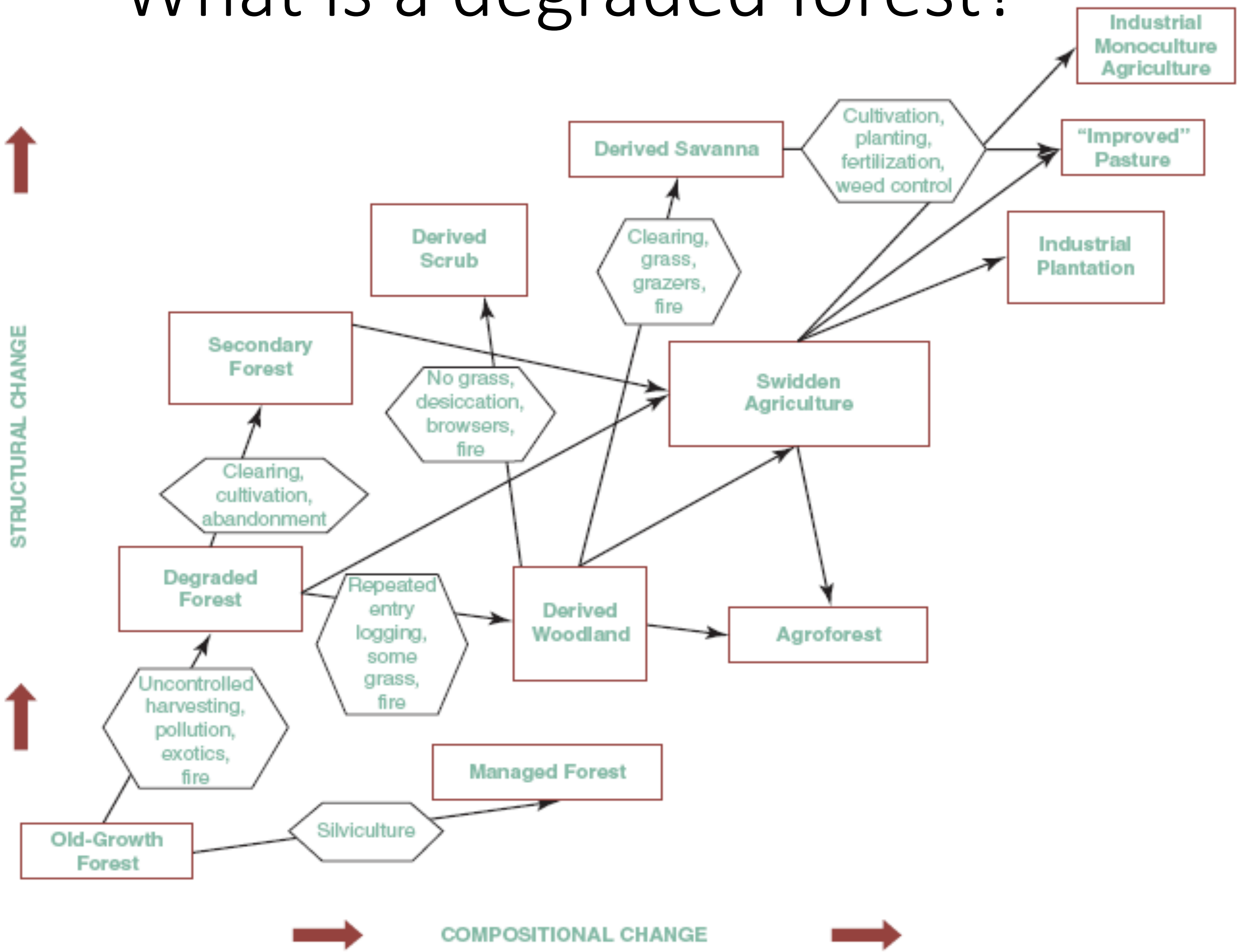
Threats to tropical forests

This road through a forest in Tanzania is a popular resting site for baboons, but roads have significant impacts on biodiversity, not only posing dispersal barriers, but acting as conduits of infiltration and facilitating other forms of degradation

Perhaps the greatest threat is the loss of forest itself (in process of deforestation, degradation and fragmentation)

- Logging, agriculture and mineral prospecting degrade the structure of forests
- Bushmeat extraction is a pressure that leaves forests intact, but removes essential players
- Climate change is altering forest dynamics, biotic interactions, carbon sequestration and recycling of nutrients
- Subsequent affects include those from invasive species and emerging pathogens

What is a degraded forest?



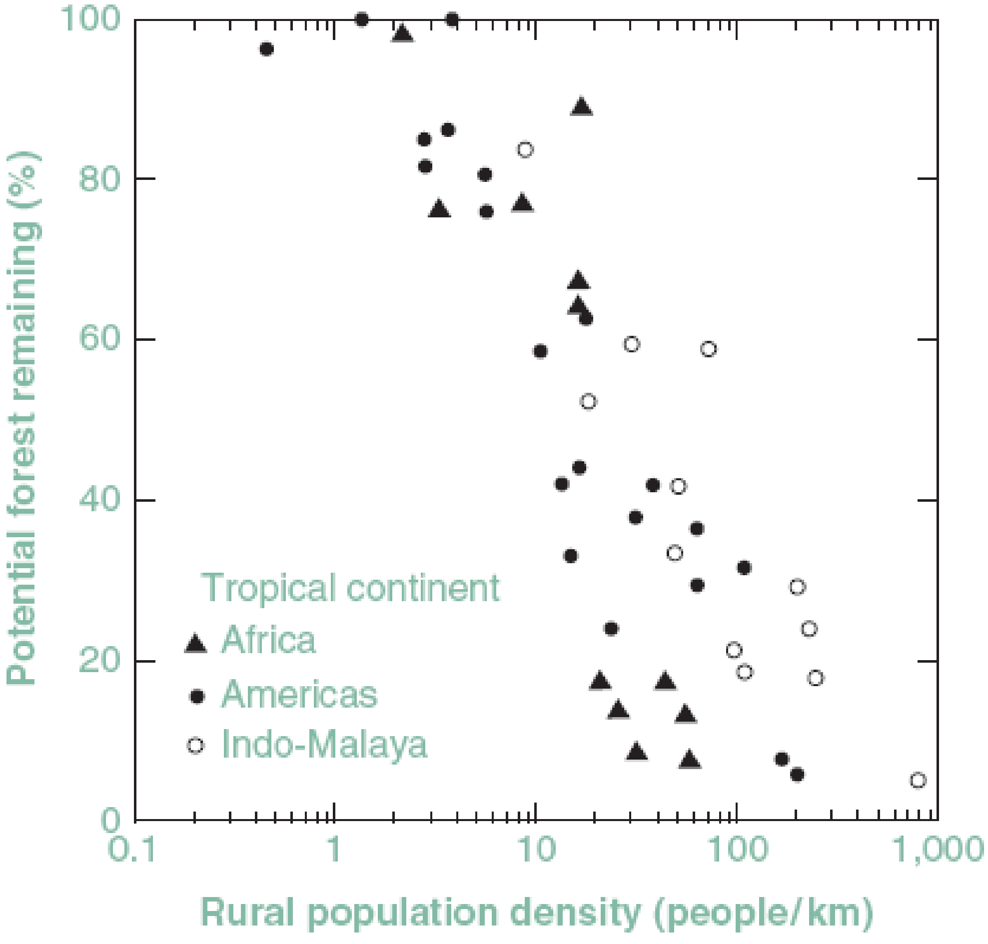
Ecological state changes starting from a reference condition (e.g., old-growth forest)
This doesn't show all possible transitions (or back transitions and restoration activities) – principle drivers shown in hexagons

Threats to tropical forests

Deforestation is closely linked with growth of human population

Satellite observations from the UN Food and Agriculture Organization indicate that tropical deforestation occurs first in dry and open forests (easier for humans to access)

But rates of deforestation throughout the tropics are difficult to obtain – satellite imagery has become a method of choice for estimating deforestation, since it allows large-scale perspectives over time



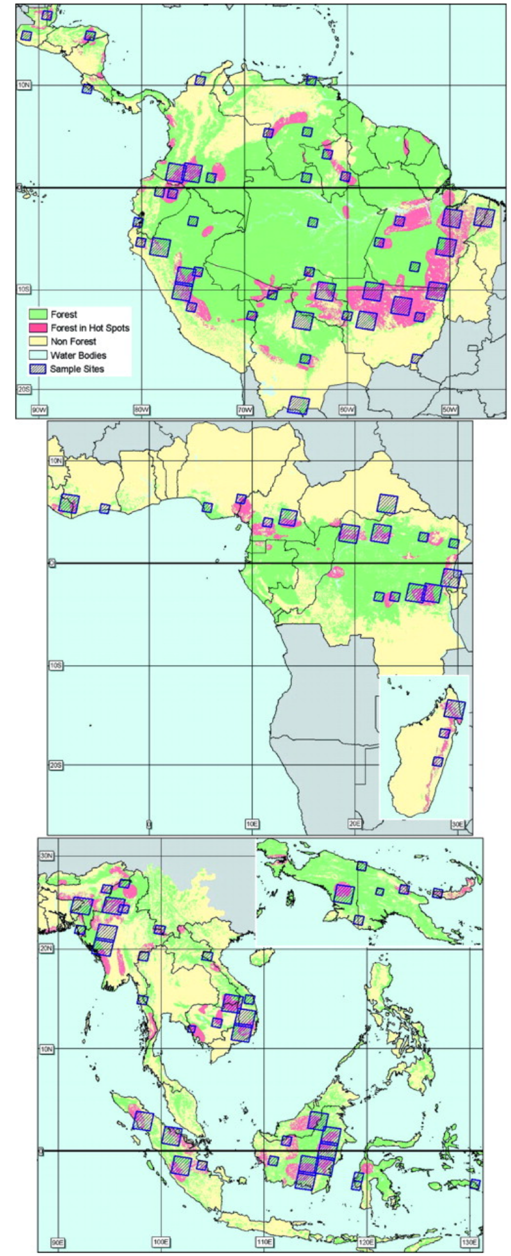
Threats to tropical forests

Achard et al 2002 used 30 m resolution satellite imagery to estimate forest loss between 1990 and 1997 in the tropics globally

Found that greatest forest loss has been occurring in Southeast Asia, with rates half as high in Latin America and Africa

Challenges exist in accounting for dynamic aspects of forests – areas may undergo secondary succession and regrowth following logging or other uses

	Latin America	Africa	Southeast Asia	Global
Total study area	1155	337	446	1937
Forest cover in 1990	669 ± 57	198 ± 13	283 ± 31	1150 ± 54
Forest cover in 1997	653 ± 56	193 ± 13	270 ± 30	1116 ± 53
Annual deforested area	2.5 ± 1.4	0.85 ± 0.30	2.5 ± 0.8	5.8 ± 1.4
Rate	0.38%	0.43%	0.91%	0.52%
Annual regrowth area	0.28 ± 0.22	0.14 ± 0.11	0.53 ± 0.25	1.0 ± 0.32
Rate	0.04%	0.07%	0.19%	0.08%
Annual net cover change	−2.2 ± 1.2	−0.71 ± 0.31	−2.0 ± 0.8	−4.9 ± 1.3
Rate	0.33%	0.36%	0.71%	0.43%
Annual degraded area	0.83 ± 0.67	0.39 ± 0.19	1.1 ± 0.44	2.3 ± 0.71
Rate	0.13%	0.21%	0.42%	0.20%



Threats to tropical forests: Logging

Logging practices in the tropics differ substantially from temperate zone logging, where forests can be managed and regrowth is rapid (pine forest plantations)

In the tropics, if valuable trees are removed individually and are found far apart (tropical species are usually locally uncommon), so logging roads are pervasive and penetrate forests

Moving logs out of forest damages structure of forest (skid trails) and logging roads allow hunters to reach areas that would otherwise be difficult to access

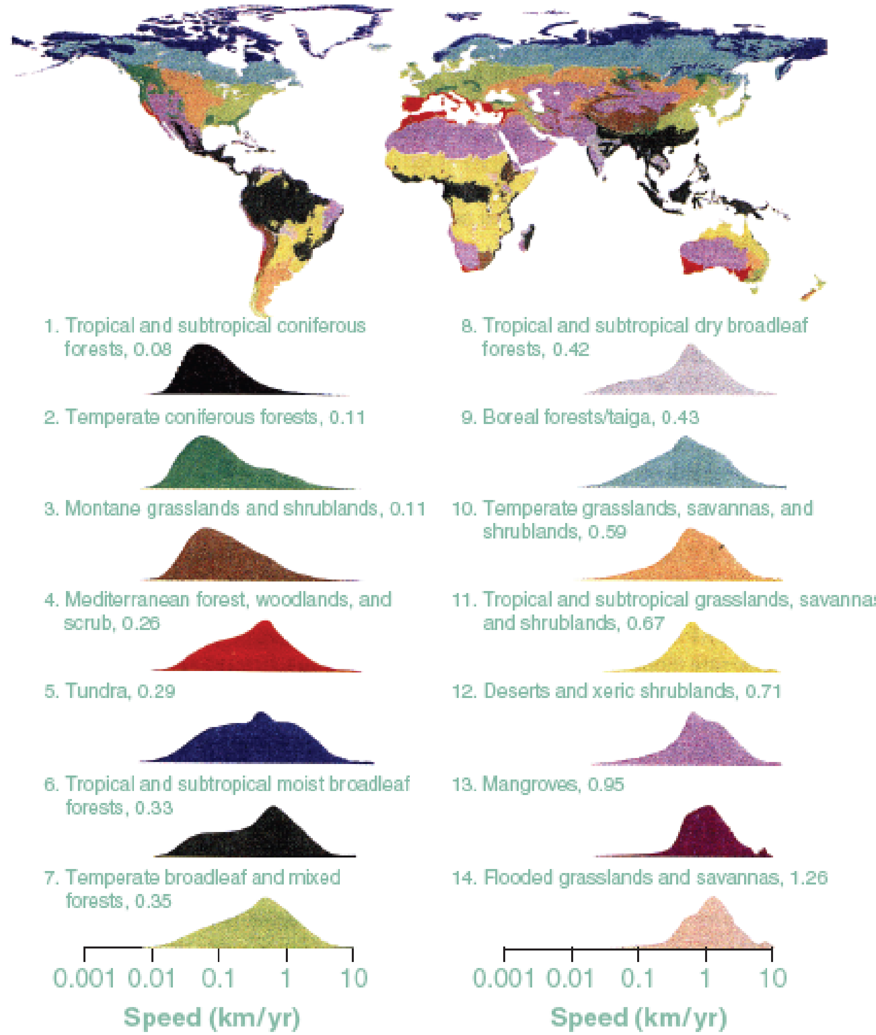
Satellite imagery shows extent of forest loss in Gunung Palung National Park and surrounding areas outside the park, Borneo

Threats to tropical forests: Climate change

Terrestrial areas in the tropics have become a major source of added greenhouse gases due to deforestation, when forests cleared and burned release CO2

Species ranges shifts in relation to changing temperatures can occur at different rates:

- Depends on velocity of change in a system (figure shows high variation)
- Depends on species dispersal capacity to keep up
- Species with different rates of movement will result in reshuffled communities
- Species also have different sensitivities to changing temperatures

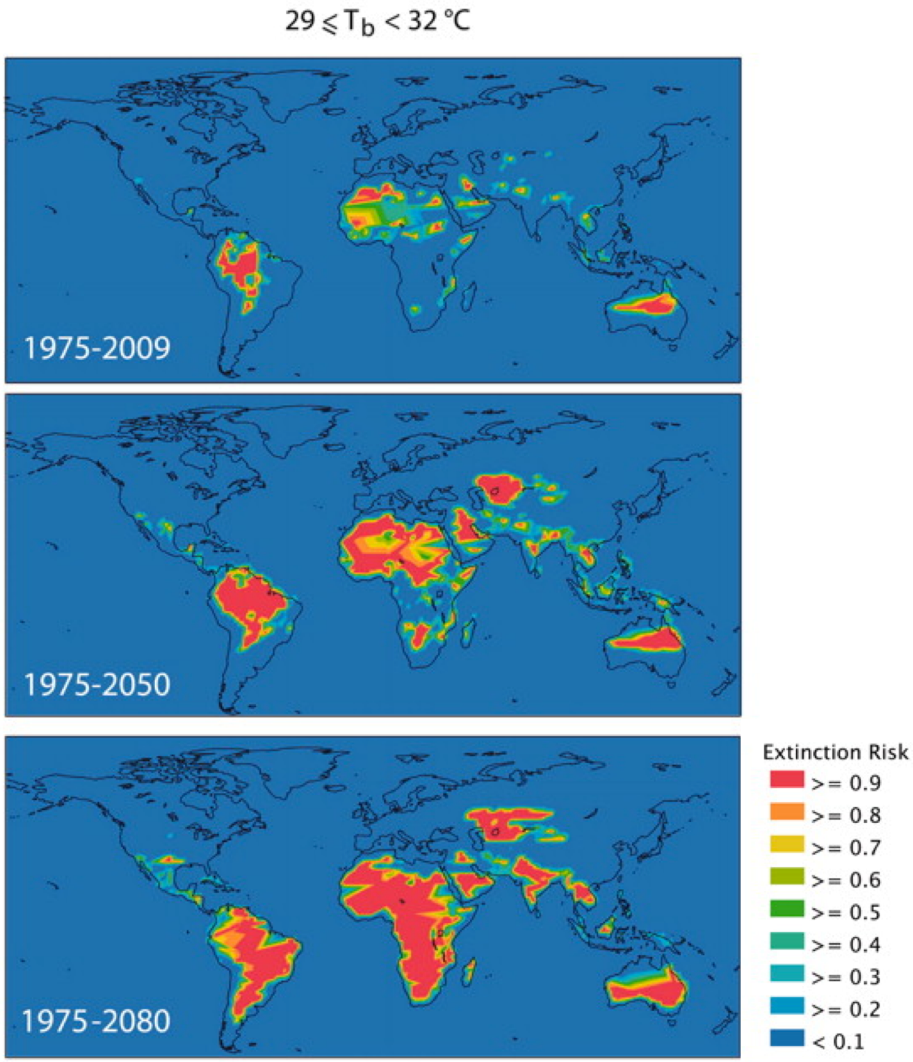


Estimated rate of temperature change in each major biome – shows velocity of temperature change

Threats to tropical forests: Climate change

Species ranges shifts in relation to changing temperatures can occur at different rates:

- Species also have different sensitivities to changing temperatures
- Tropical ectotherms have narrow tolerances and live close to thermal maxima and will experience greater extinction risks



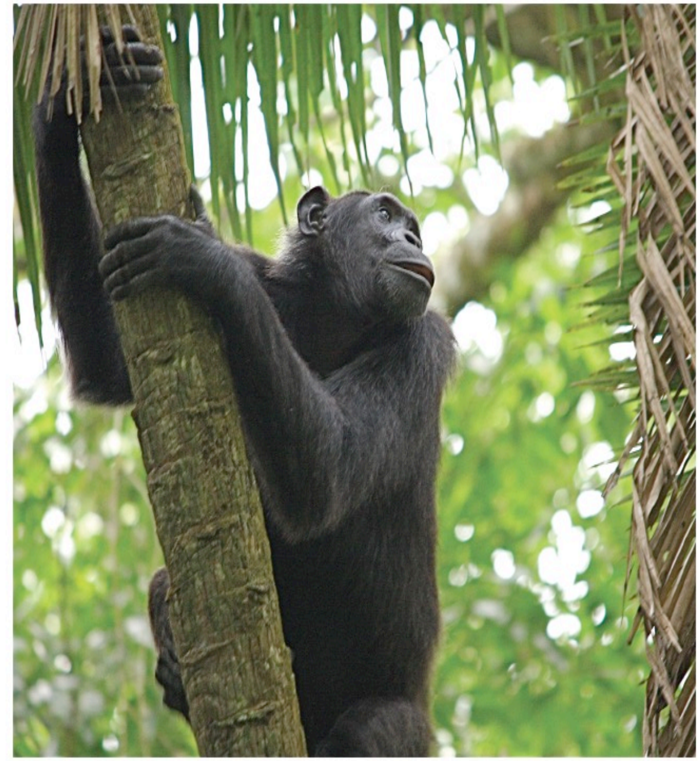
Sinervo et al. 2010, *Science*

Threats to tropical forests: Emerging Pathogens

HIV and Ebola are examples of the potential for animal viruses to mutate and infect humans

Hypothesized that bushmeat hunters butchering chimpanzees in the forest were exposed through cuts in the skin to SIV (simian virus), which mutated to HIV

Chimpanzees have challenges with their own emerging viruses like SIVcpz, which causes simian immunodeficiency disease



Anopheles mosquitoes, vectors for malaria, survive best in deforested areas – the risk of malaria increased in Amazonia significantly during the 1980’s which was linked to changes in forest cover. Studies have found increased biting rates of *Anopheles* and deforestation.

Foley et al. 2007, *Frontiers in Ecology and Environment*

Threats to tropical forests: Bushmeat

Bushmeat extraction is enhanced by roads that increase access to forest

Bushmeat trade is also driven by international markets (in July 2010, 5 tons of bushmeat passed through the Paris airport weekly)

In some places, like Ghana, fishing is preferred to bushmeat, but pressures shift to bushmeat extraction when fishing is poor

Hunting pressures affect ecological patterns, like the effect of species on seed shadows:

- Lower tree species richness on hunted sites
- Reduced seed predation for plants with large seeds
- Alters species composition for seedling and sapling layers

Restoration and Rehabilitation of Tropical Forests

To what degree are conservation goals, focused on biodiversity preservation, compatible with activities such as human subsistence farming?

REDD: reducing emissions from deforestation and degradation

PES: payments for ecosystem services

EEFD: ecological-economic farm diversification

With REDD, economic policies are created to add high financial value for carbon that remains stored in forests

Developed nations are expected to fund REDD initiatives, but developing nations will need to build their economic stability to where they will have less impact on forest systems

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PES has broader goals, not only on the reduction of carbon emissions, but other ecosystem services

Places economic values on services and creates an economic market or subsidy to reward people for conserving those services – difficulty in quantifying value of services (how much is a watershed worth?)

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EEFD focuses on active reforestation of degraded land using native species, and requires diversification in land use, combining limited logging with agriculture and restoration (diversification hedges against market flux)

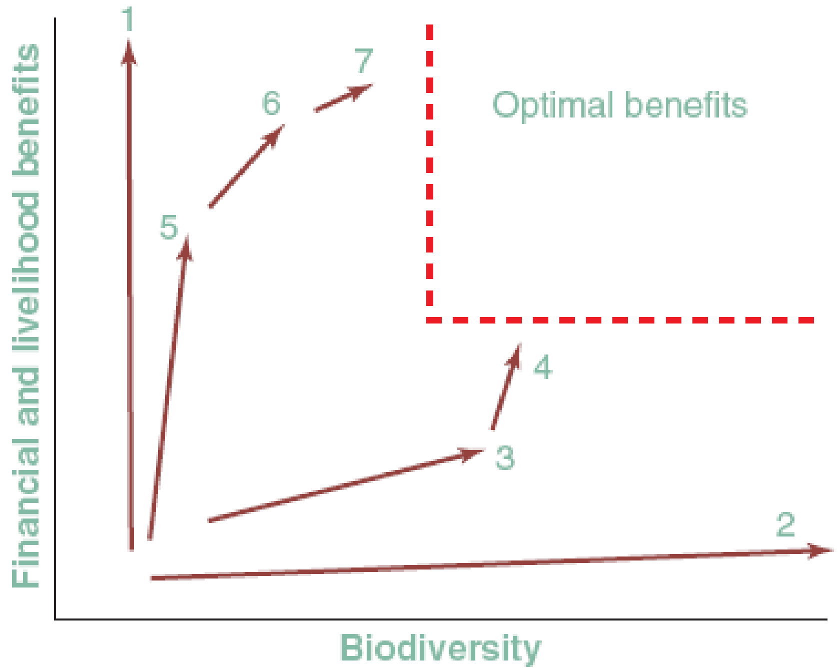
Restoration and Rehabilitation of Tropical Forests

How to restore degraded tropical forests areas to ensure that conservation goals are met…

1) Expand the number of protected areas to hopefully protect biodiversity
2) Improve agriculture techniques and minimize degradation
3) Employ active reforestation and restoration

Restoration planting – planting rapidly growing successional species can shade out invasive weeds and grasses and reduce fire hazards (attempting to mimic mid-succession

Plantation establishment -- usually happens as a monoculture, but nice examples of *Inga* canopy over shade grown coffee might encourage more biodiversity



Some keys to studying ecology (and the tropics)

As scientists, we find ourselves on the front lines of trying to understand how systems work…to hold true to this, we must:

- Stay curious – never stop asking questions!
- Be creative – never be convinced that answers do not exist
- Embrace the complexity of our planet – don't shy away because it's complicated
- "Work the problem"