The Changing Biodiversity of the Brazilian Amazon

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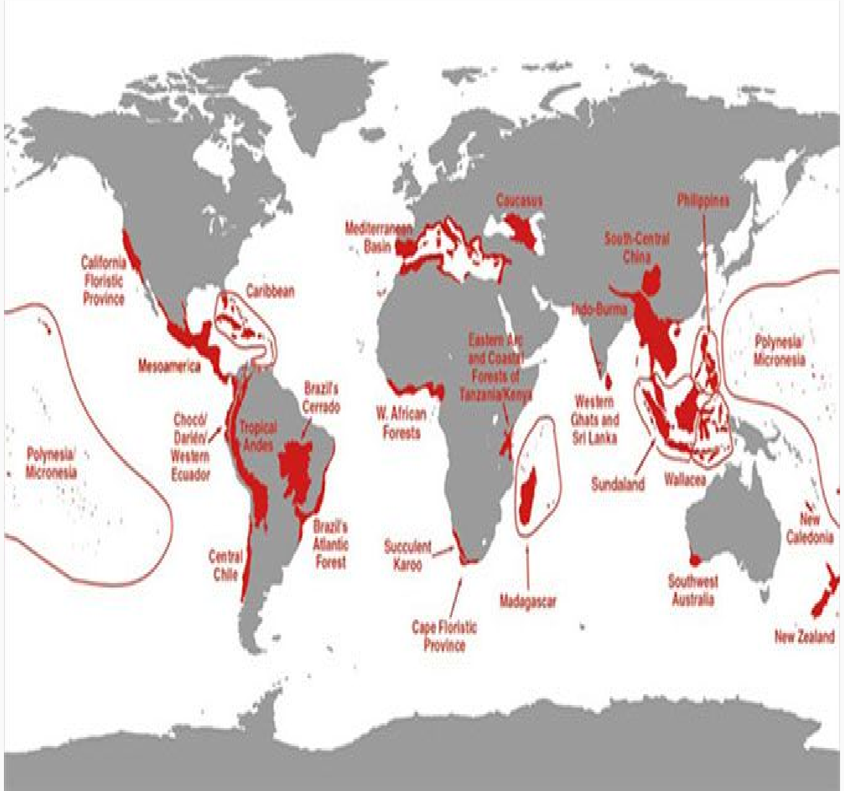
What we are going to cover

- Extent of Biodiversity
- Largest threats to Biodiversity
  -Climate Change, Acid Deposition,etc.

- Deforestation
  -Why?
  - Carbon Storage (as well as other factors)

- Threatened and Endangered Species
  -Adaptations
  -Reasons for endangerment



What is biodiversity??

- “biodiversity refers to the variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it. Biodiversity includes not only species we consider rare, threatened, or endangered, but every living thing—even organisms we still know little about, such as microbes, fungi, and invertebrates.”
  -American Museum of Natural History

Amazon Species

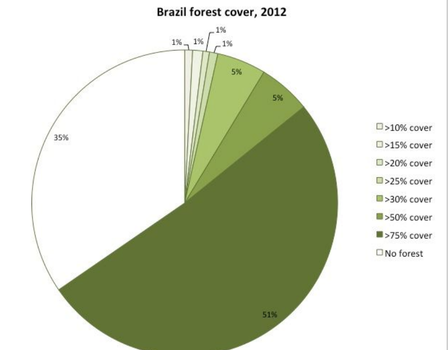
- 40,000 Plant species
- 2.5 million Insects
- 3,000 Fish
- 1,300 Birds
- 427 Mammals
- 378 Reptiles/400 Amphibians

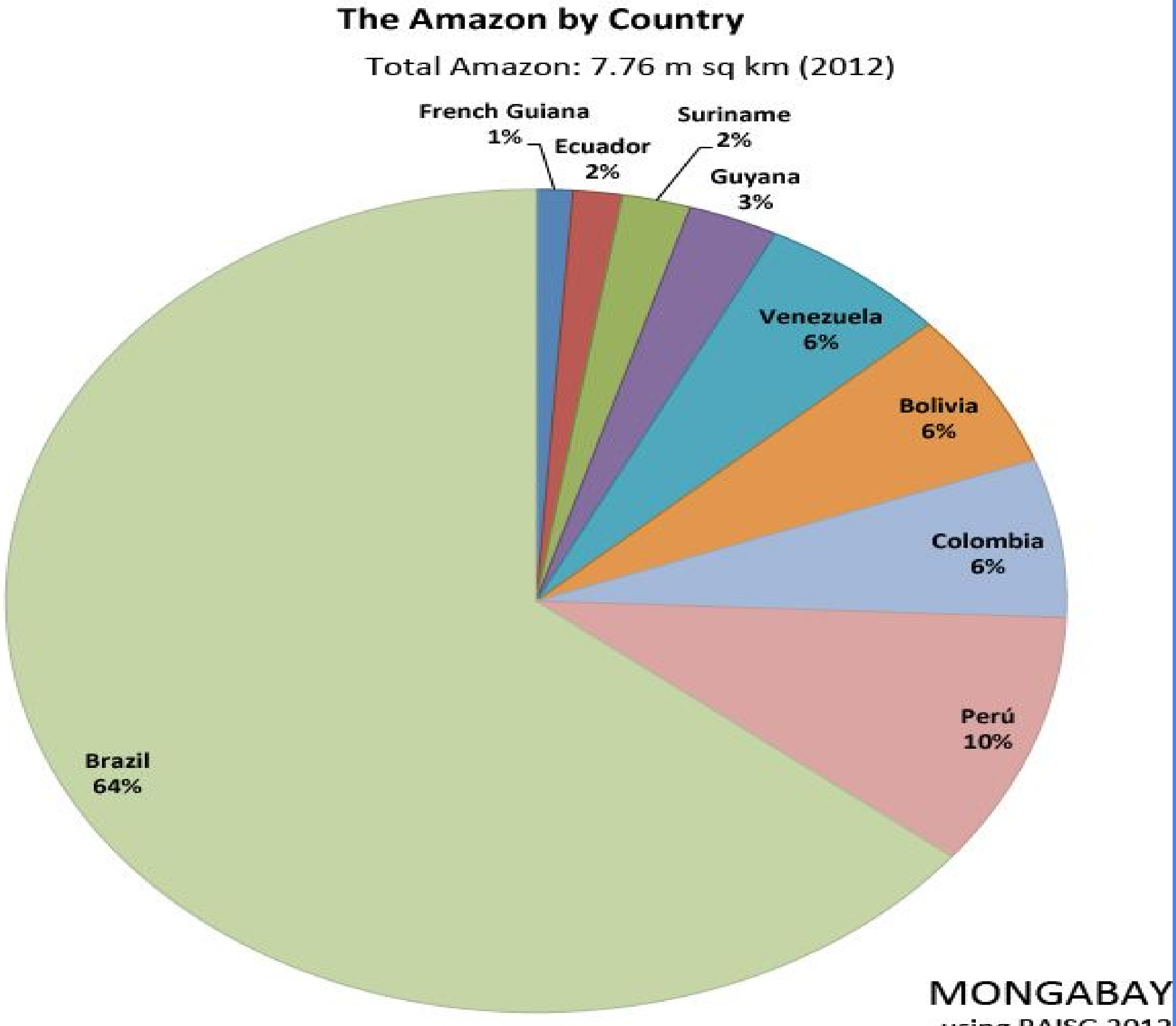
Atlantic Forest Species

- 20,000 Plant Species
- Insects not entirely known (2,120butterflies and 88 tiger beetles described)
- 350 Fish
- 936 Birds
- 264 Mammals
- 311 Reptiles/483 Amphibian

Why so much Biodiversity??

- Large Area
- Geographical isolation (sea level/glacial recession)
- Heterogeneity of biological environment
- Natural Disturbances
- Diversity Refuges (mountainous areas)




The Amazon by Country
Total Amazon: 7.76 m sq km (2012)
French Guiana 1%
Ecuador 2%
Suriname 2%
Guyana 3%
Venezuela 6%
Bolivia 6%
Colombia 6%
Perú 10%
Brazil 64%
MONGABAY

Largest threats

The Amazonian biodiversity is at risk from three significant threats. They go as follows:

- Climate change
- Acid deposition
- Deforestation

The link between climate change and acid deposition (Sanderson et al. 2005)

- "Present and future acid deposition to ecosystems: the effects of climate change"
  - Michael Sanderson, William J. Collins, Colin E. Johnson, and Richard G. Derwent

Table 4
Critical loads for acidic deposition (from Kuylenstierna et al., 2001)

Sensitivity class	Range of critical loads ($meq\,m^{-2}\,yr^{-1}$)	
	Low range	High range
1	0–25	25–50
2	25–50	50–100
3	50–100	100–200
4	100–200	200–400
5	>200	>400

The low range for classes 2–4 increase in line with critical load ranges used in Europe. For the most highly buffered soils (class 5), there is essentially no critical load. The high range of critical loads is simply double the low range, and accounts for the uncertainty in these estimates.

The acid deposition cycle

- Absorbed are **nitrate** ions. emitted as **ammonia** and **nitric oxide**.
- Returns as **nitric acid. Ammonia combines with sulfate ions** in clouds to form **ammonium sulfate**.

Table 1
Reactions of ammonia and sulphur dioxide in the gas and aqueous phases

Gas phase:	
$OH + SO_2 \rightarrow HO \cdot SO_2$ adduct $(+ O_2, H_2O) \rightarrow H_2SO_4(aq)$	(1)
Aqueous phase:	
$NH_3(aq) + H_2O \rightarrow NH_4^+(aq) + OH^-$	(2)
$SO_2(aq) + H_2O \rightarrow HSO_3^-(aq) + H^+$	(3)
$HSO_3^-(aq) + H_2O_2(aq) \rightarrow SO_4^{2-}(aq) + H^+ + H_2O$	(4)
$HSO_3^-(aq) + O_3(aq) \rightarrow SO_4^{2-}(aq) + H^+ + O_2(g)$	(5)
$HSO_3^-(aq) \Leftrightarrow SO_3^{2-}(aq) + H^+$	(6)
$SO_3^{2-}(aq) + O_3(aq) \rightarrow SO_4^{2-}(aq) + O_2(g)$	(7)
$2NH_4^+(aq) + SO_4^{2-}(aq) \rightarrow (NH_4)_2SO_4(s)$	(8)

Sanderson et al.: Methods I

- The research team used four different simulative models to perform their experiment, done over a six-year period.

Table 2
Summary of model simulations

Simulation	Climate	Vegetation	Emissions
A	1990s	1990s	1990s
B	1990s	1990s	2090s
C	2090s	2090s	1990s
D	2090s	2090s	2090s

Sanderson et al.: Methods II

- The team also analyzed their average tropical deposition with that of another six-year European study.
- **1992-1999**

Sanderson et al.: Results I

- The team found that the depositional flux was highest when the 2090s climate, vegetation, and emissions were simulated together.
- The 1990s control had the lowest flux.

Table 2
Summary of model simulations

Simulation	Climate	Vegetation	Emissions
A	1990s	1990s	1990s
B	1990s	1990s	2090s
C	2090s	2090s	1990s
D	2090s	2090s	2090s

Table 3
Summary of 5 year mean nitrogen and sulphur deposition fluxes, and total acid deposition flux to land surfaces only for each simulation (see Table 2)

Flux (Tg N or S yr^{-1})	A	B	C	D
NO emission	58.1	105.3	58.1	105.3
NO_2 deposition	5.2	11.1	4.8	10.0
HNO_3 deposition	51.1	90.8	52.7	93.5
Ammonia emission	53.7	53.7	53.7	53.7
Ammonia deposition	29.0	26.4	27.8	24.9
Ammonium deposition	23.4	26.1	24.3	27.5
SO_2 emission	85.2	156.2	85.2	156.2
Sulphate deposition	34.5	45.4	36.6	49.7
Acid deposition flux to land (10^{15} meq yr^{-1})	3.3	5.4	3.5	5.8

Sanderson et al.: Results II (sulphates)

- In both the global and European studies, sulphate deposition flux decreased.

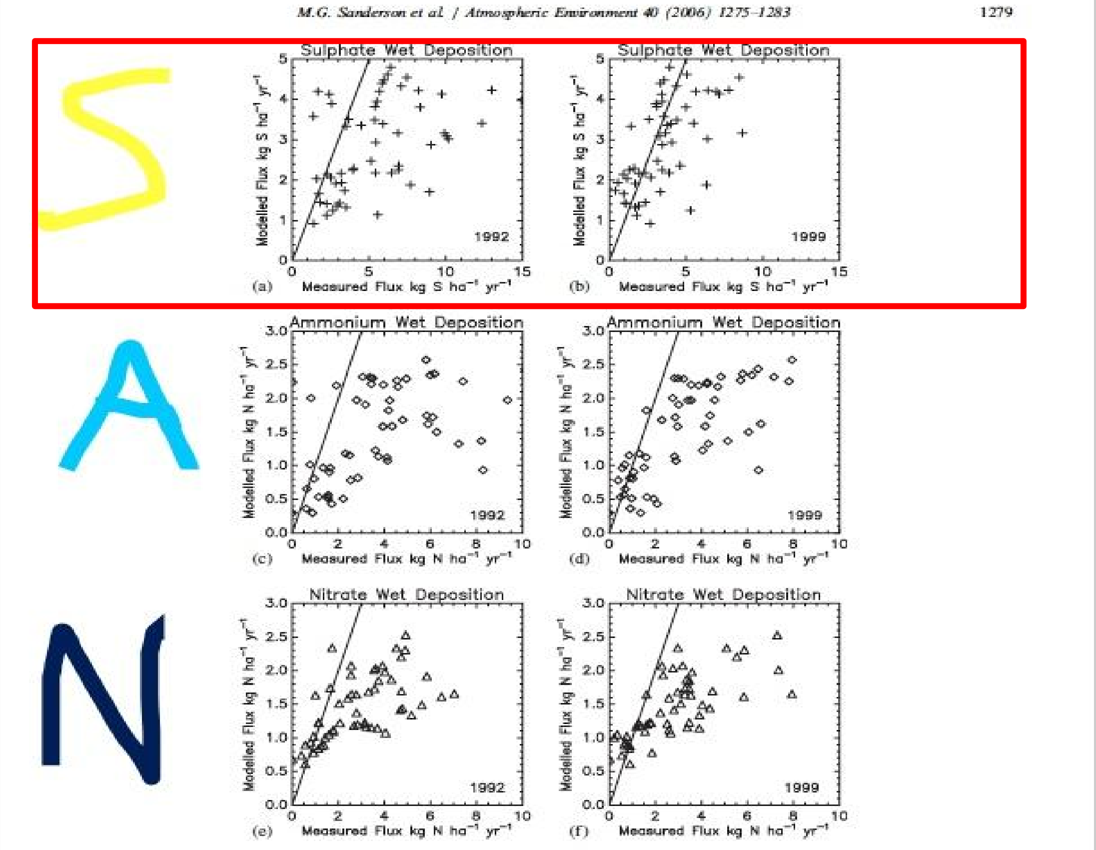
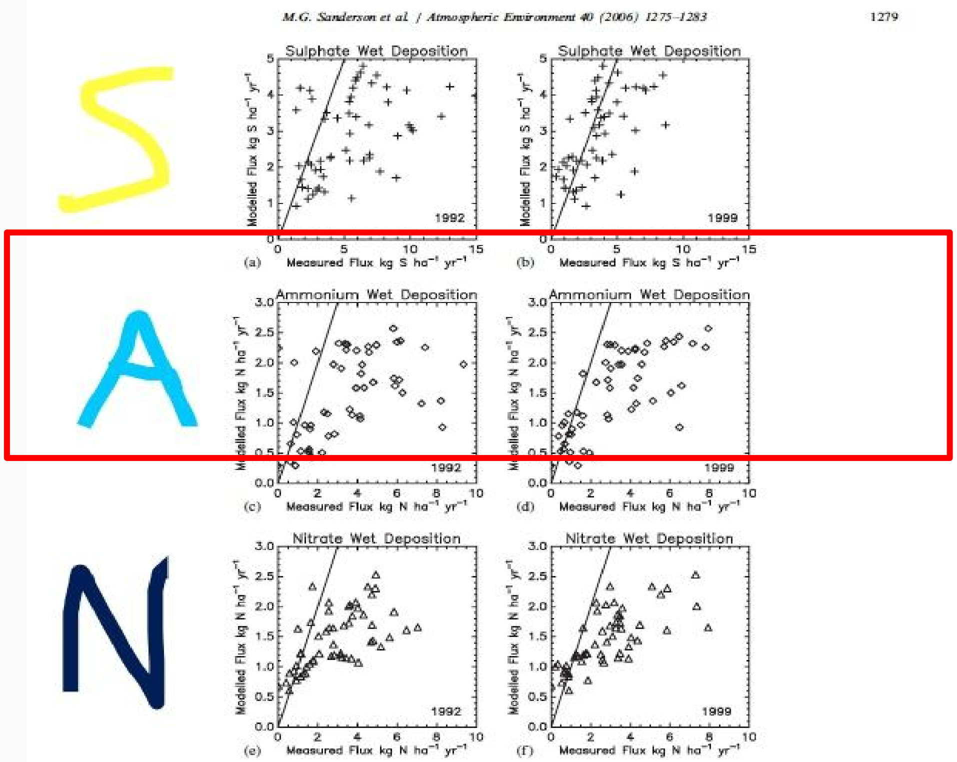


Fig. 1. Comparison of modelled 5 year mean wet deposition fluxes of sulphate, ammonium and nitrate ions with measurements made over Europe as part of the EMEP project. The measurements are described in the EMEP reports by Schaug et al. (1994) and Hjellbrekke (2001). The years on each panel refer to the measurements. The straight line on each panel indicates the position of the 1:1 correlation.

Sanderson et al.: Results III (ammonium)

- Ammonium deposition in both study areas decreased.
- This is a tentative estimation because extraneous factors were not considered.



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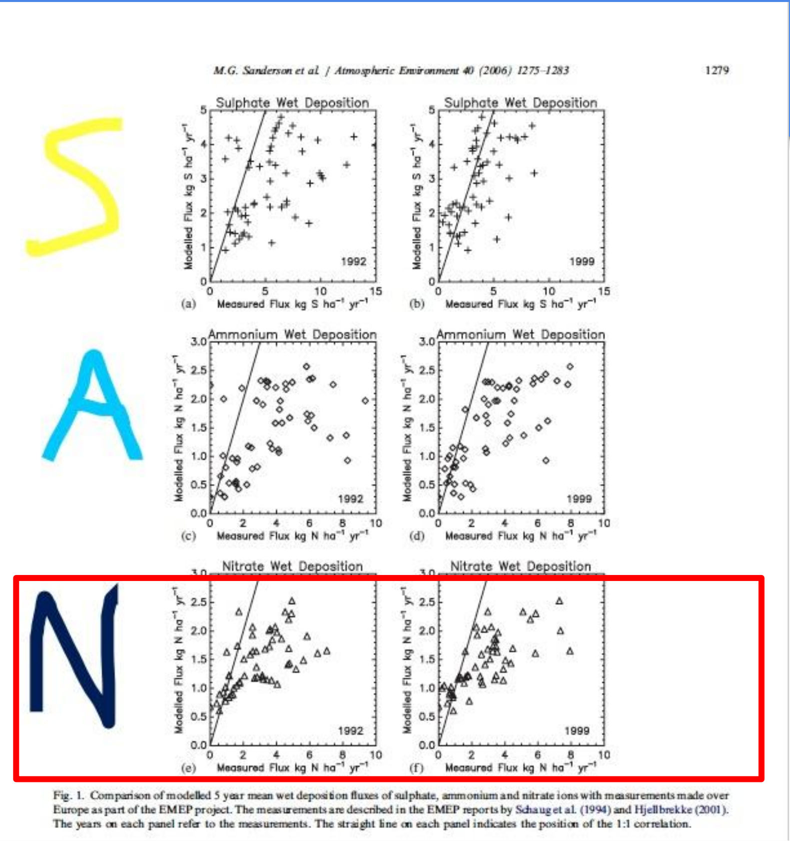
Sanderson et al.: Results IV (nitrogen)

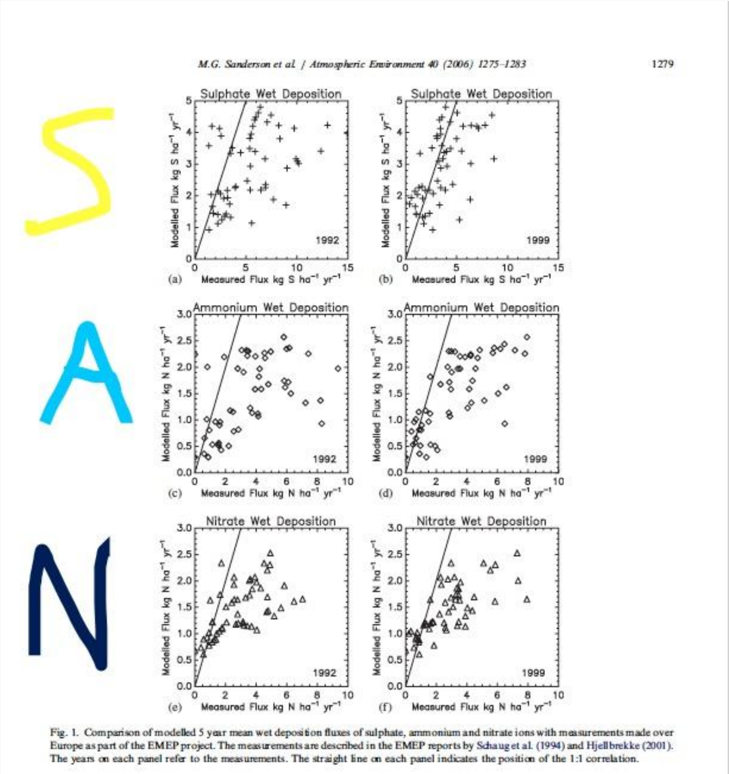
- Nitrate deposition flux also decreased in both study areas.

- This is also a tentative estimation because of extraneous variables.



Sanderson et al. V: Conclusion

- The study concluded that effects of a warming climate would worsen acidification by
  - Increasing conversion from nitric acid to nitrous oxide.
  - Increasing conversion of ammonia into ammonium sulfate.
- **Loss in productivity and biodiversity.**



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Species of Concern: Hoatzin

- The hoatzin (*Opisthocomus hoazin*) thrives in swamps rich in legumes plants.

- The increased acidity would kill some of the species of legumes.

- “The Globalization of N deposition: Ecosystem Consequences in Tropical Environments”

- Pamela A. Matson, William H. McDowell, Alan R. Townsend, and Peter M. Vitousek investigated the changes in nitrogen deposition in tropical environments induced by climate change.

Matson et al. I

- Matson et al. relied on analyses of anthropogenic alterations in the environment alongside with analyses of nitrogen fixation in both **temperate and tropical forests.**
- In both locations, **agriculture and industry** are the major sources for anthropogenic nitrogen.

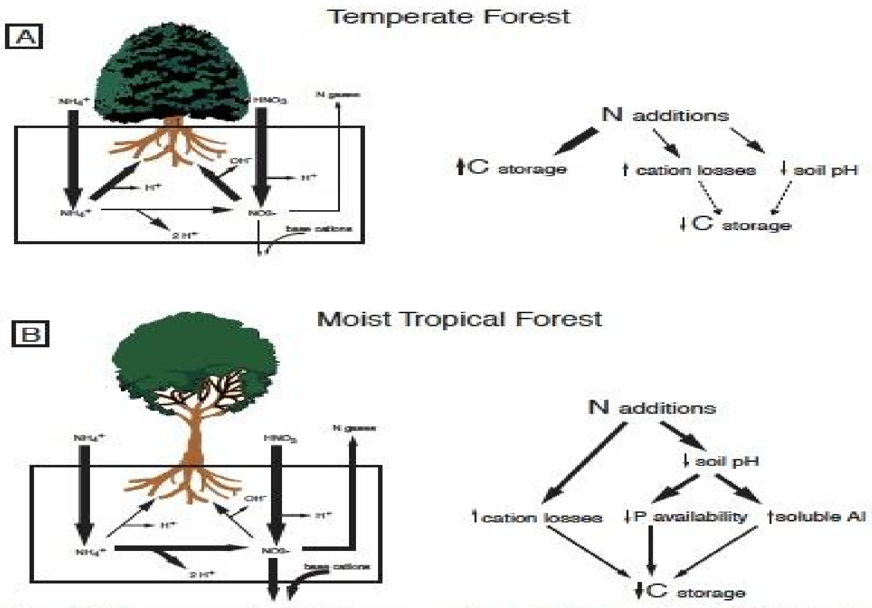


Figure 1. Diagram comparing initial responses of temperate (A) vs moist tropical (B) forests to elevated inputs of atmospheric nitrogen. The figure assumes that plant growth and carbon storage in the majority of temperate forests are initially limited by N supply, and that N functions in relative excess in the majority of lowland moist tropical forests. The thickness of the arrows represents the relative magnitude of fluxes of N in the diagrams on the left, and the relative magnitude of the effects of those fluxes in the summary flow charts on the right. Thus, in (A), we contend that most of the N additions will be retained in the system and initially lead to C storage, whereas in (B), we argue that most of the additional N inputs will be lost from the system, and that the consequences of increased nitrification rates and N losses will be losses of base cations and decreases in soil pH, which may in turn lead to decreases in C storage in moist tropical forests.

Matson et al. II (temperate forests)

- **In temperate forests, anthropogenic nitrogen usually leads to the following:**
  - **Initial increase in botanical productivity (b/c of the excess nitrogen)**
  - **Nitrogenous thresholds are reached**
  - **Ecosystem loses it's ability to retain Nitrogen**

Matson et al. III (tropical forests)

- Matson et al. predicted that because tropical forests are different from temperate forests, the tropical forests would
  - [Direct effect] Retain much less nitrogen than the temperate forests
  - [Indirect effects] And increase the severity of
    - Soil acidification
    - Base cation depletion
    - Distribution of aluminum ions

Matson et al. IV

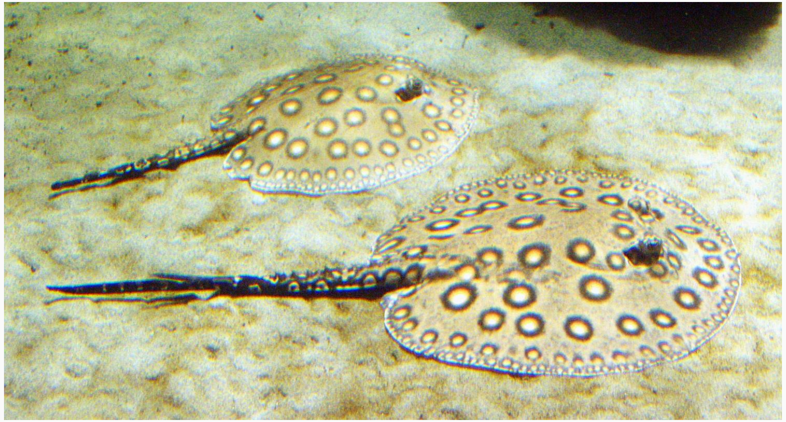
- The movement of aluminum ions is a serious threat to biodiversity because:
    - Aluminum leaching occurs more intensely in a downstream direction, which means the ions would affect many different species.

Matson et al. V

- Aquatic ecosystems are especially at risk to increased Al ion movement.
  - This would lead to aluminum poisoning of fish and other creatures in the aquatic trophic system.

Species of Concern: Ocellate River Stingray

- The ocellate river stingray (*Potamotrygon motoro*) is the only entirely freshwater stingray in the Amazon.
- It is especially vulnerable to aluminum ion accumulation because of its habitat and lifestyle.

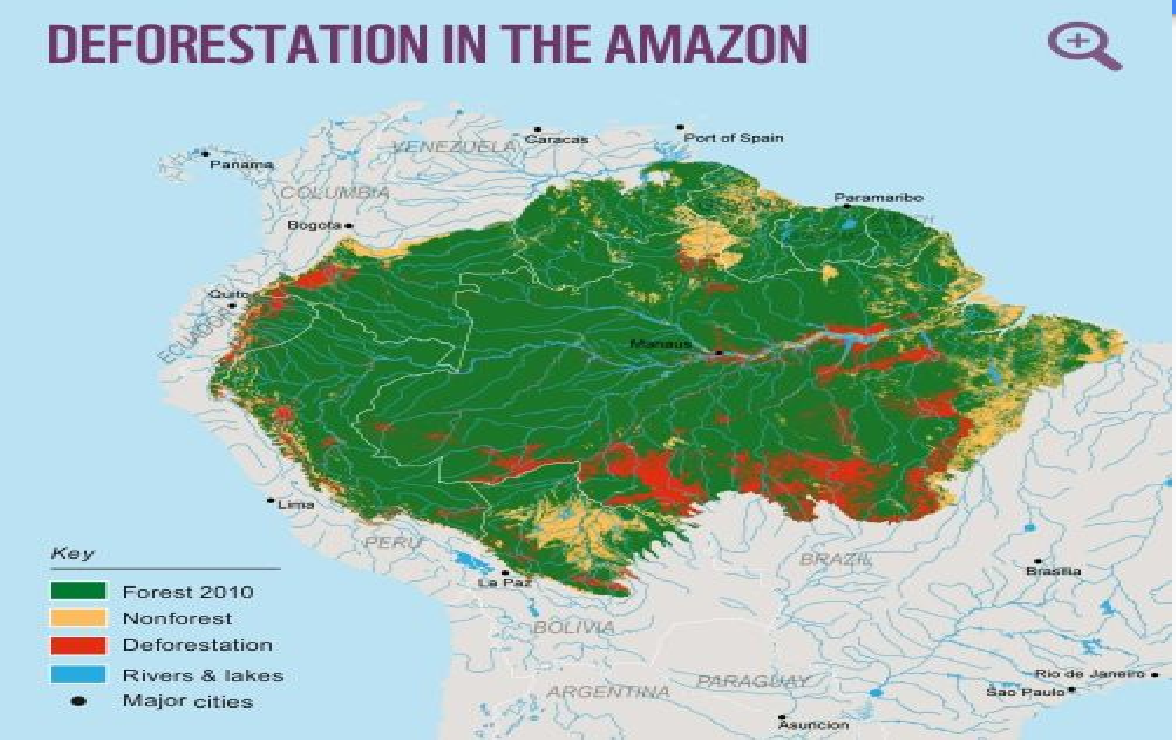


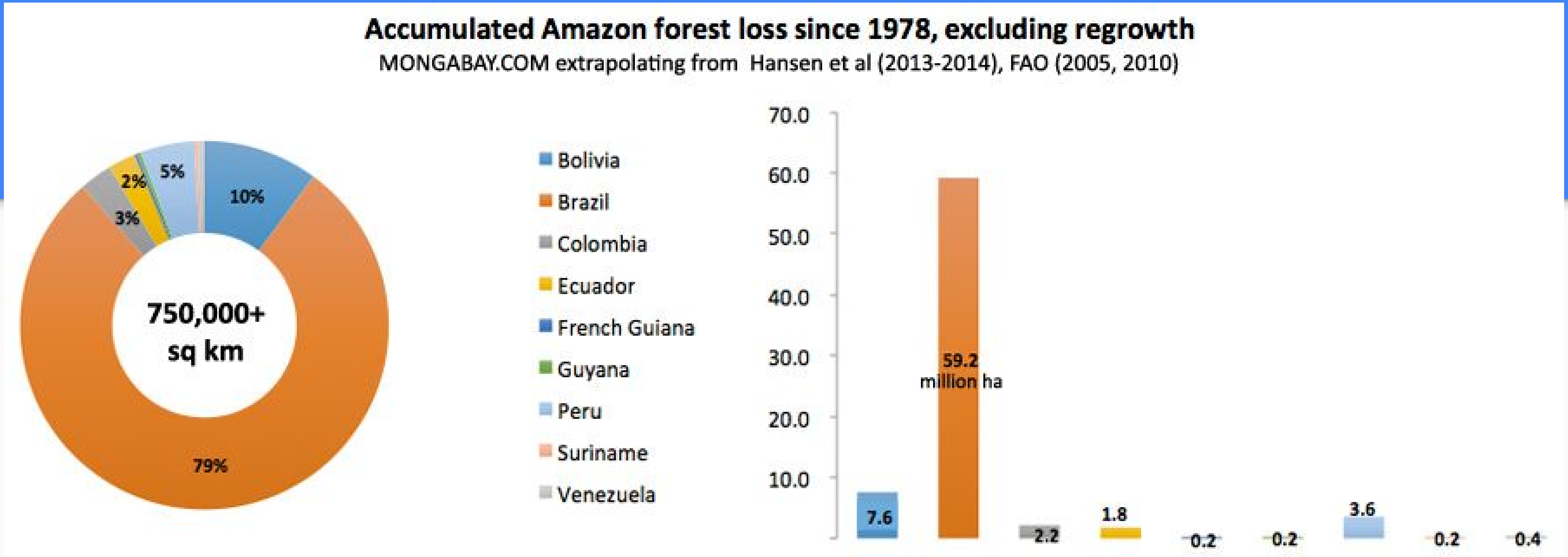
Species of Interest: Tambaqui

- Interestingly, the tambaqui (*Colossoma macropomum*) has been shown to be very resistance to low pHs (as low as 3.0).
- Additionally, the fish eat seeds of hardy trees (such as rubber trees).

Deforestation in the Amazon

- Since 1970, there has been significant cutting of trees and clearing of land



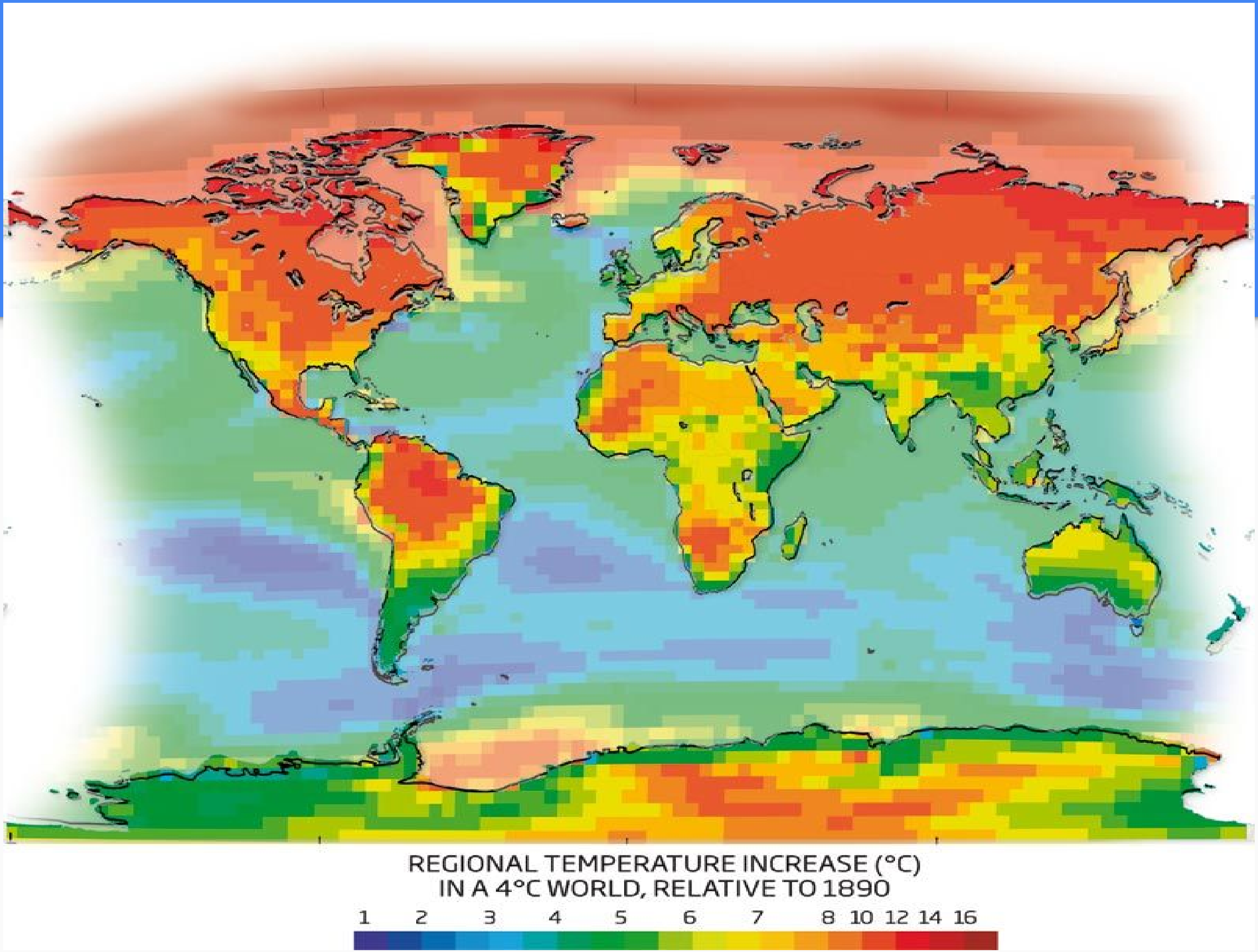

Accumulated Amazon forest loss since 1978, excluding regrowth
MONGABAY.COM extrapolating from Hansen et al (2013-2014), FAO (2005, 2010)
750,000+
sq km
10%
79%
3%
2%
5%
Bolivia
Brazil
Colombia
Ecuador
French Guiana
Guyana
Peru
Suriname
Venezuela
70.0
60.0
50.0
40.0
30.0
20.0
10.0
7.6
59.2
million ha
2.2
1.8
0.2
0.2
3.6
0.2
0.4

Why??

- Large Scale Agriculture
- Cattle-Ranching
- Logging
- Possible Palm Oil Plantations
- Soy Farms
- Mineral Digging
- Towns
- Colonization

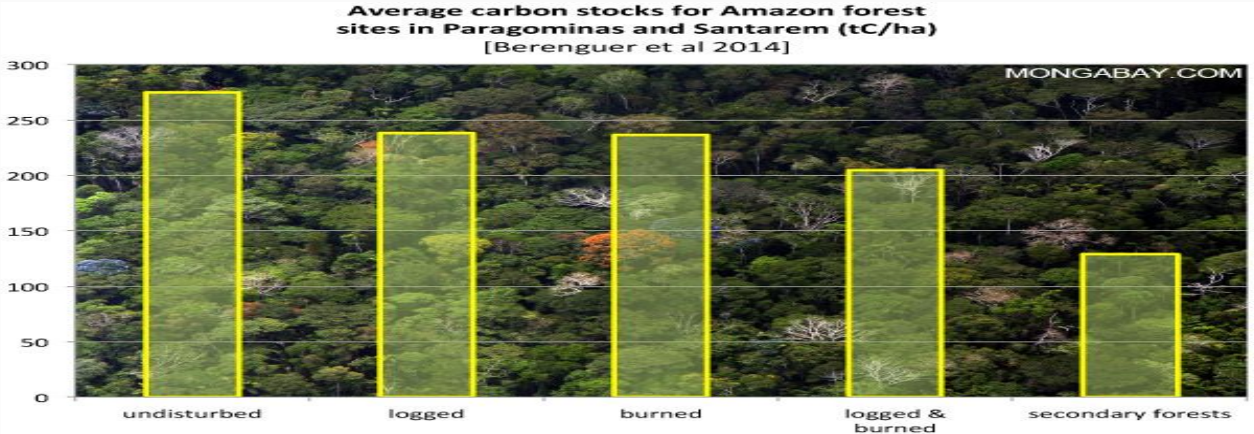
Global Drivers of Amazonian Climate Change

- There has been a drying trend in northern Amazonia since the mid-1970s (right around the time deforestation started).
- temperatures are projected to rise 3.3°C this century
- Removal of 30 to 40% of the forest could push much of Amazonia into a permanently drier climate regime
- Because trees absorb and store greenhouse gases, with the extreme loss of tree's, more of these greenhouse gases are staying in the atmosphere, which can cause the temperature in the rain forest to increase.


REGIONAL TEMPERATURE INCREASE (°C)
IN A 4°C WORLD, RELATIVE TO 1890
1 2 3 4 5 6 7 8 10 12 14 16

Carbon Storage

- Amazonian forests have a substantial influence on regional and global climates.
- They store 120 ± 30 Pg C in biomass carbon of which 0.5 Pg C year−1 (0.3 to 1.1) were released through deforestation in the 1990s.



Other effects of forest loss

Loss of forest also results in

(i) decreased cloudiness and increased insolation,

(ii) increased land surface reflectance, approximately offsetting the cloud

effect

(iii) changes in the aerosol loading of the atmosphere

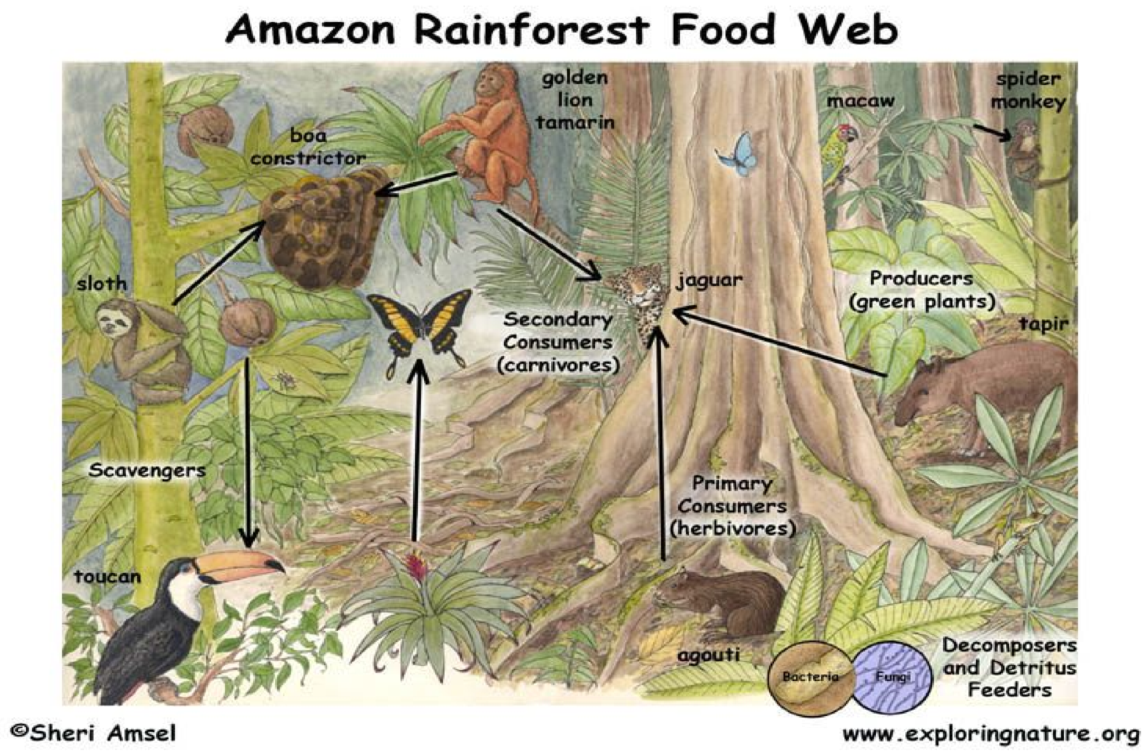
Cont.

- The interaction between global climate change and regional deforestation may make Amazonian forests vulnerable to large-scale degradation.

- Ironically, it is also this linkage between the global (carbon sequestering) ecosystem service

Other threats to Biodiversity in the Amazon

- Introduction of Exotic Species
- Poaching
- Lack of Regional Planning
  (Lack of Enforcement)


Amazon Rainforest Food Web
golden lion tamarin
macaw
spider monkey
boa constrictor
sloth
jaguar
Producers (green plants)
tapir
Secondary Consumers (carnivores)
Scavengers
Primary Consumers (herbivores)
toucan
agouti
Bacteria
Fungi
Decomposers and Detritus Feeders
©Sheri Amsel
www.exploringnature.org

Species of concern

Jaguar (*Panthera onca*)

Near-Threatened

-Apex predators of the Amazon

-Encroach on cattle ranches

-Killed out of fear for lives and livestock

-Very few attacks on humans (rarity)

Species of Concern

Harpy Eagle (*Harpia harpyja*)
Near Threatened

- Apex Predators of the Amazon
- Threatened primarily by deforestation and shooting

Species of Concern

Golden Lion Tamarin (*Leontopithecus rosalia*)

Endangered

- Omnivores of the coastal Atlantic forests
- Primary threats are logging and deforestation
- Important in seed-dispersal of many plant species.

Species of Concern: Secondary consumers I

- Tayra (*Eira barbara*):
  - Least Concern
- Threats
  - Habitat destruction

Species of Concern: Secondary consumers II

- Smooth-fronted caiman (*Paleosuchus trigonatus*):
  - Least Concern
- Threats:
  - Water pollution, especially from gold mining.

Species of Concern: Secondary Consumers III

- Margay: (*Leopardus wiedii*)
  - Near Threatened
- Threats:
  - Excessive hunting
  - Habitat destruction

Species of Concern: Primary Consumers I

- Capybara (*Hydrochoerus hydrochoeris*)
- Threats: Habitat destruction and poaching

Species of Concern: Primary consumers II

- White-cheeked spider monkey

  (*Ateles marginatus*)

- Threats:
  - Habitat destruction, especially from deforestation

Species of Concern: Primary consumers III

- Tapir species (two species, *Tapirus* spp.)
  - South American (*T. terrestris*)
  - Kabomani (*T. kabomani*)
- Threats:
  - Habitat destruction
  - Remoteness of habitat

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