

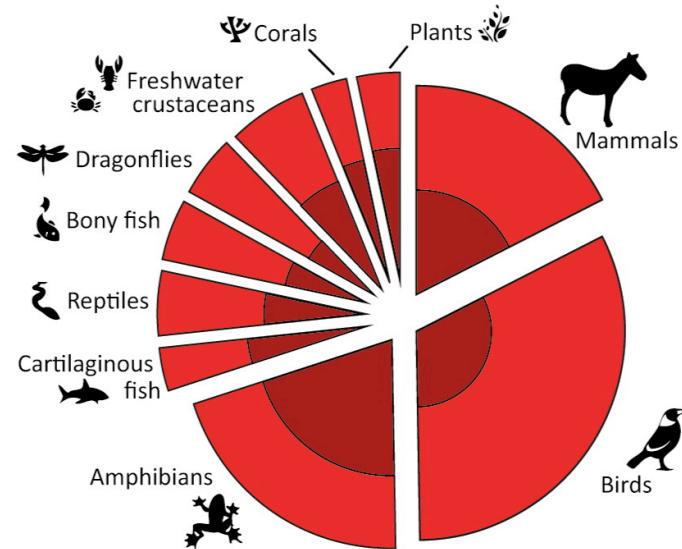
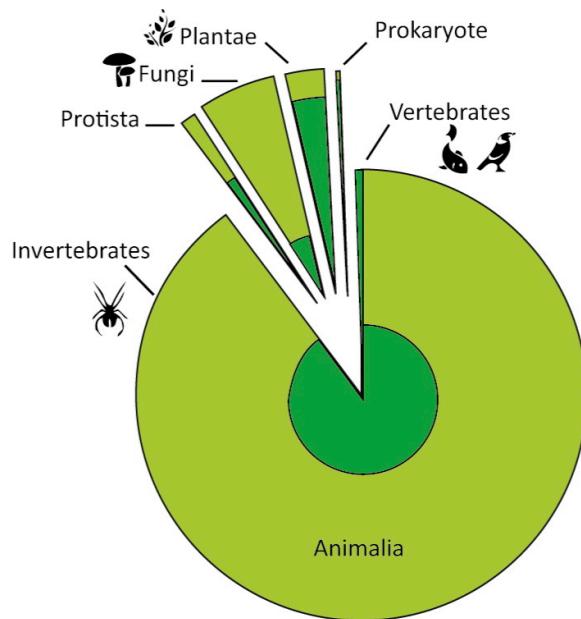
# PoE lecture 3: Biodiversity change

Isla Myers-Smith  
Crew Building, School of GeoSciences

# How many species are there on Earth?

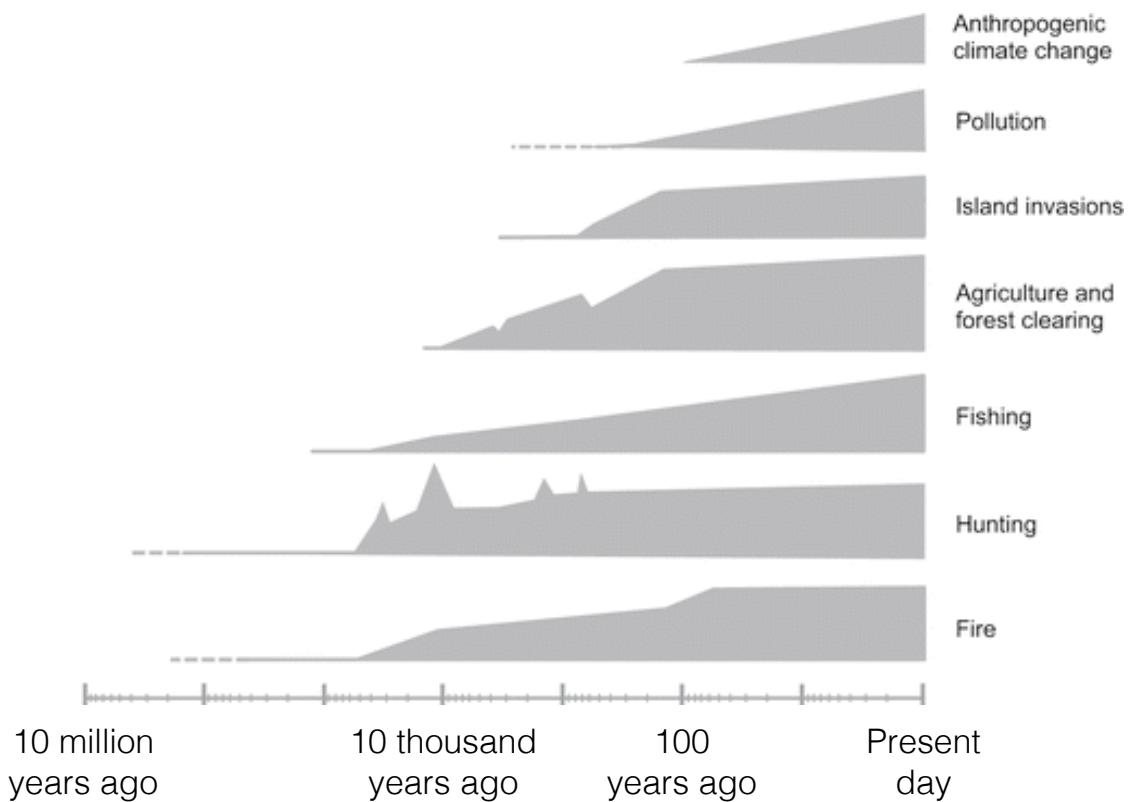
~ 1.5 million species have been named

Estimates of total # range from 3-30 million



Pereira et al. Annu. Rev. Environ. Resour. 2012

# Historic human impact



Pereira et al. Annu. Rev. Environ. Resour. 2012

# Biotic Homogenization



What does this all mean for biodiversity change over time?



# What is biodiversity?



# Biodiversity

“The variety of life, including variation among genes, species and functional traits.” - Wikipedia

# Biodiversity

“The variety of life, including variation among genes, species and functional traits.” - Wikipedia

Often measured as:

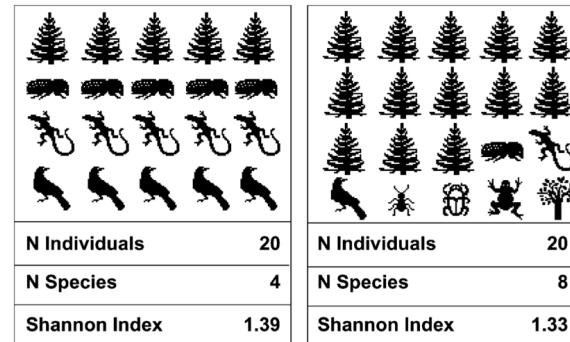
Richness - a measure of the number of unique life forms

Evenness - a measure of the equitability among life forms

Heterogeneity - the dissimilarity among life forms



Arctic Tundra



Coastal Rain Forest

# Biodiversity

A narrower (and more scientifically useful) definition of biodiversity:

The numbers and relative equitability of different biological variants found in a given place and time.



Arctic Tundra

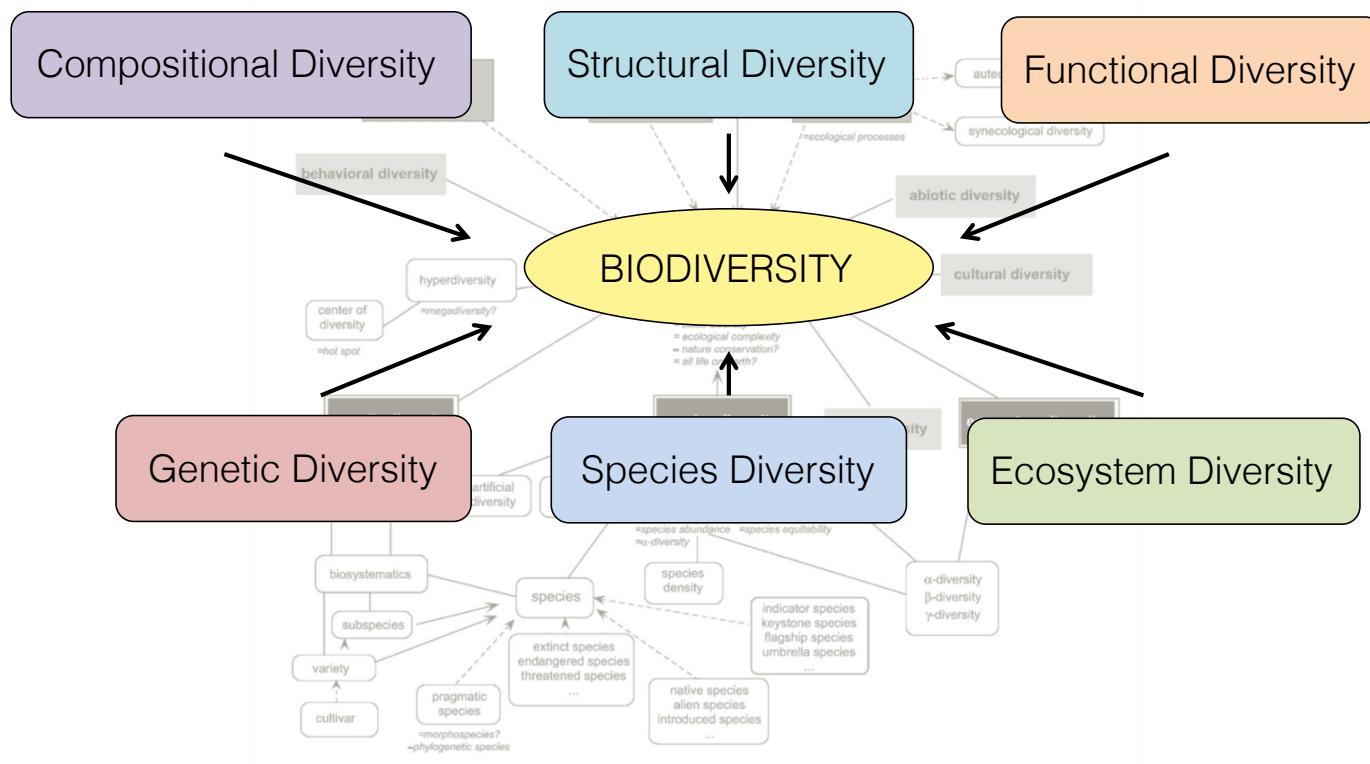


Coastal Rain Forest

# What is biodiversity?

- Genetic diversity: amount of genetic variation within a species
- Species diversity: number of species within a region
- Ecosystem diversity:
  - variation among ecosystems, communities, landscapes
  - Variation within ecosystems

# Biodiversity



Duelli and Obrist AE&E 2003

# What is biodiversity?

Taxa:

Kingdoms



↓  
Genera

↓  
Species

Scale:

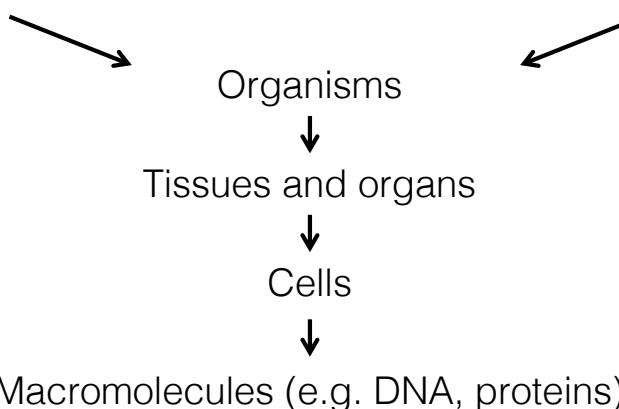
Ecosystem



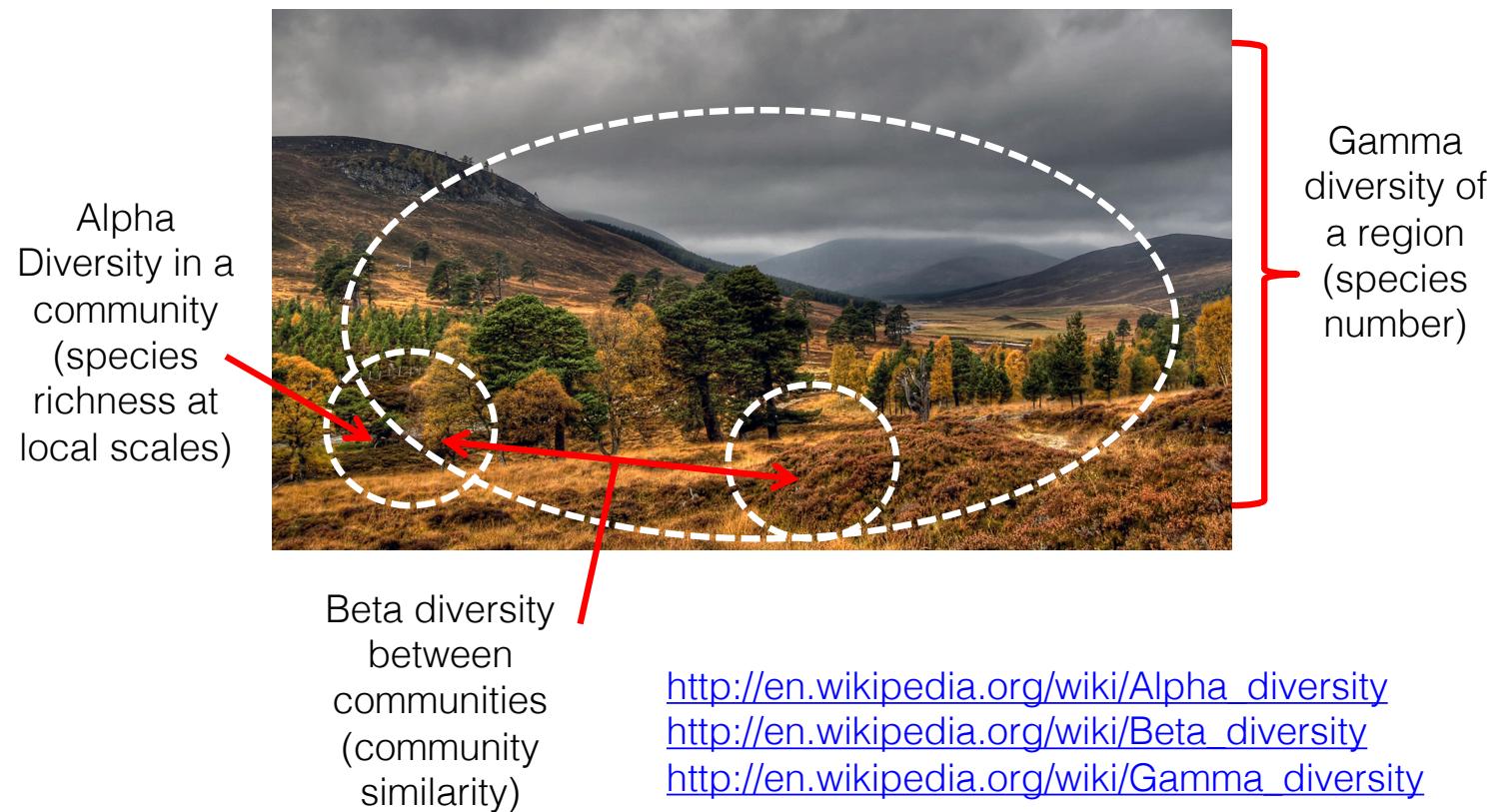
Communities



Populations



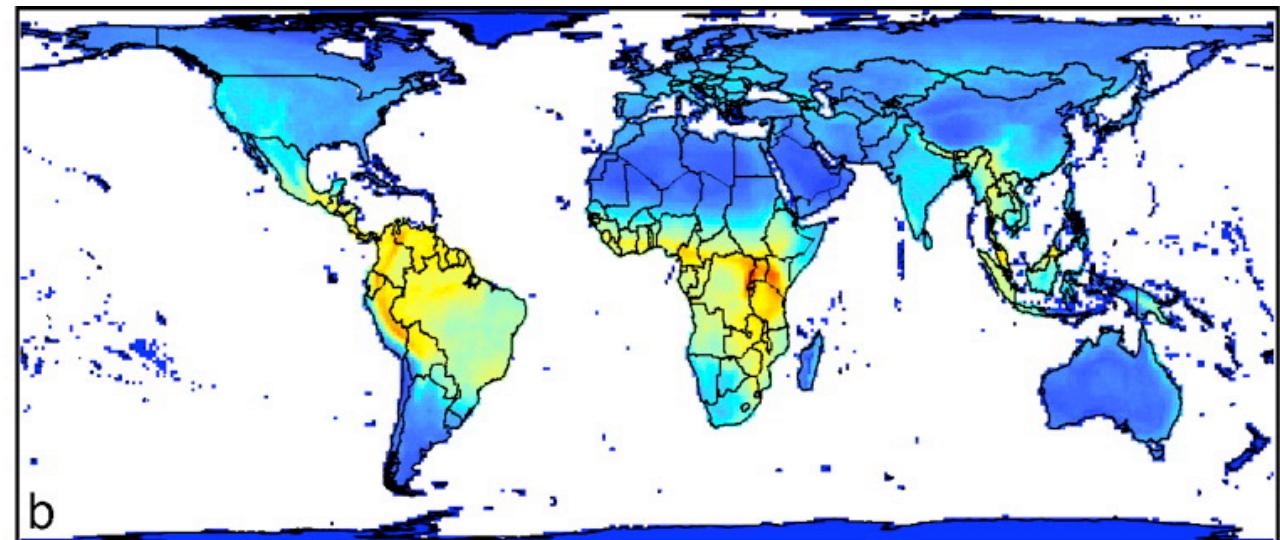
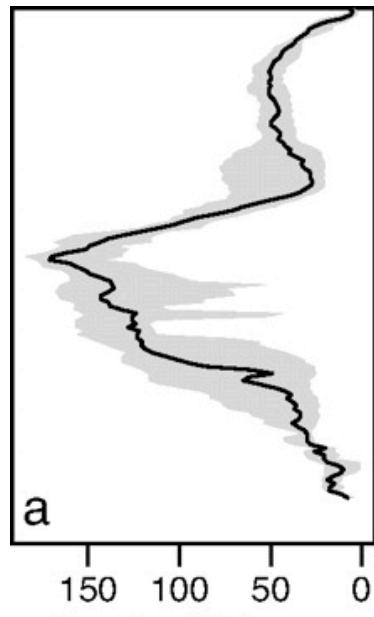
# What are the biodiversity metrics across scales?



# How does biodiversity change across geographic gradients?



# Biodiversity Gradients



The Latitudinal geographic gradient in biodiversity for mammals

Davies et al. PNAS 2008

# Why do we care about biodiversity?



## How do you value biodiversity?

- a) Just because (inherent value)
- b) Because of the goods or services it provides
- c) Because it is beautiful/cool/fun (instrumental value)
- d) I don't especially value biodiversity

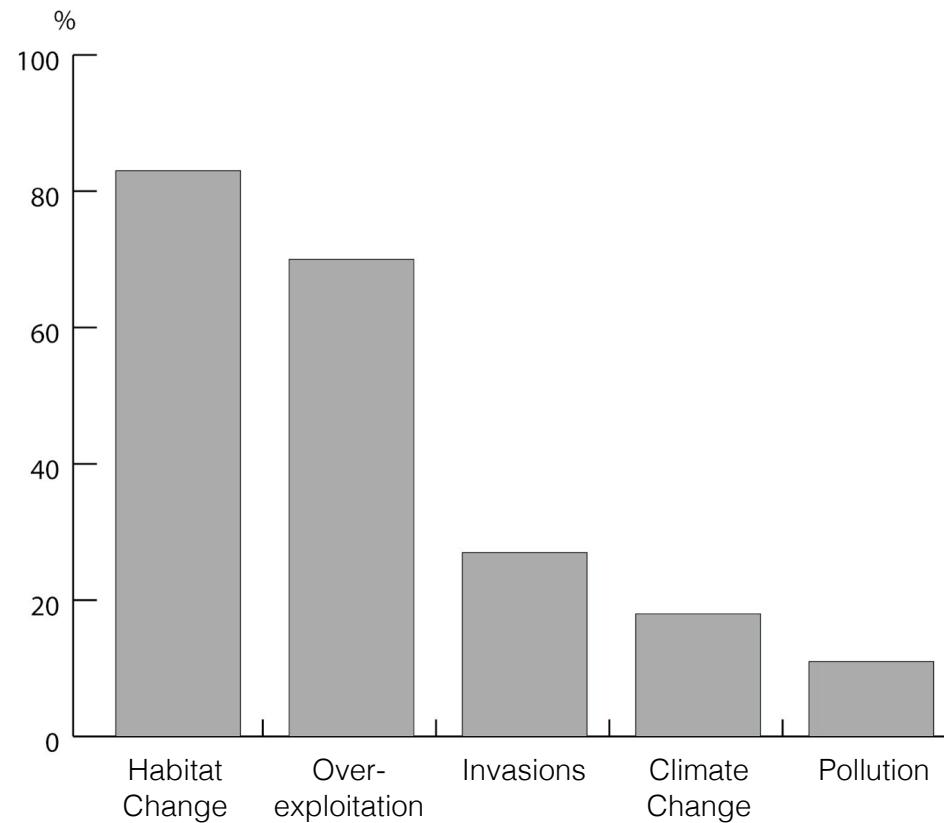
# The value of biodiversity

- Goods (food, fiber, medicine)
- Services (water/air purification, flood control, pollination, etc.)
- Informational (scientific)
- Psychological (nature appreciation, cultural)
- Intrinsic (each species is inherently valuable)

What are the biggest threats to biodiversity?



# What are the biggest threats to biodiversity?



Pereira et al. Annu. Rev. Environ. Resour. 2012

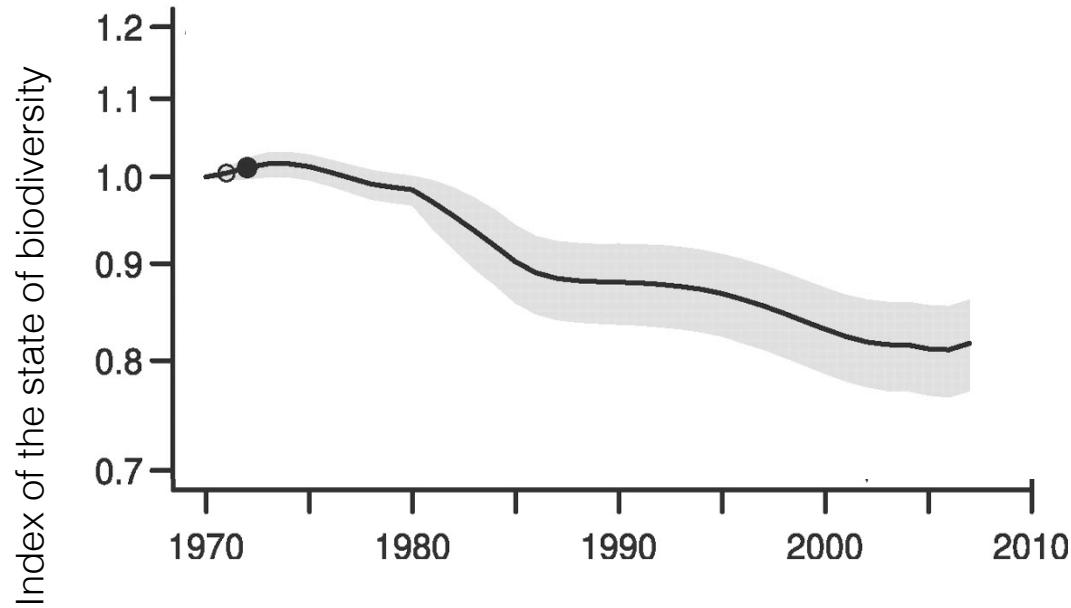
# Habitat Conversion



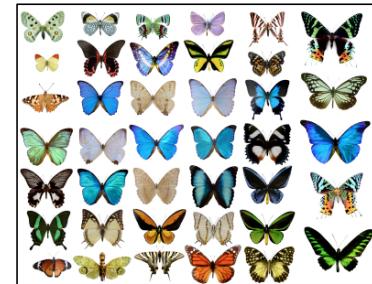
Hansen et al. Science 2013

# Exploitation

“The state of biodiversity based on nine indicators of species’ population trends, habitat extent and condition, and community composition”



Black rhino



Butchart et al. Science 2010

# Is biodiversity declining?

## Biodiversity loss and its impact on humanity

Bradley J. Cardinale, J. Emmett Duffy, Andrew Gonzalez, David U. Hooper, Charles

A global synthesis reveals biodiversity loss as a major driver of ecosystem change

David U. Hooper, E. Carol Adair, Bradley J. Cardinale, Jarrett E. K. Byrnes, Bruce A.

## Improving estimates of biodiversity loss

Chase D. Mendenhall\*, Gretchen C. Daily, Paul R. Ehrlich

*Center for Conservation Biology, Department of Biology, Stanford University, Stanford, CA 94305-5020, USA*

## Despite Progress, Biodiversity Declines

Erik Stokstad

## Global Biodiversity: Indicators of Recent Declines

Stuart H. M. Butchart<sup>1,2,\*</sup>, Matt Walpole<sup>1</sup>, Ben Collen<sup>3</sup>, Arco van Strien<sup>4</sup>, Jörn P. W. Scharlemann<sup>1</sup>,

## Species Coextinctions and the Biodiversity Crisis

Lian Pin Koh<sup>1,\*†</sup>, Robert R. Dunn<sup>2,\*‡</sup>, Navjot S. Sodhi<sup>1,§</sup>, Robert K. Colwell<sup>3</sup>, Heather C. Proctor<sup>4</sup>,  
Vincent S. Smith<sup>5,¶</sup>

## Biodiversity: Species loss revisited

Carsten Rahbek & Robert K. Colwell

## Impacts of Biodiversity Loss Escalate Through Time as Redundancy Fades

Peter B. Reich<sup>1,2</sup>, David Tilman<sup>3,4</sup>, Forest Isbell<sup>3</sup>, Kevin Mueller<sup>3</sup>, Sarah E. Hobbie<sup>3</sup>, Dan F. B. Flynn<sup>5</sup>,

## Climate Change, Keystone Predation, and Biodiversity Loss

Christopher D. G. Harley

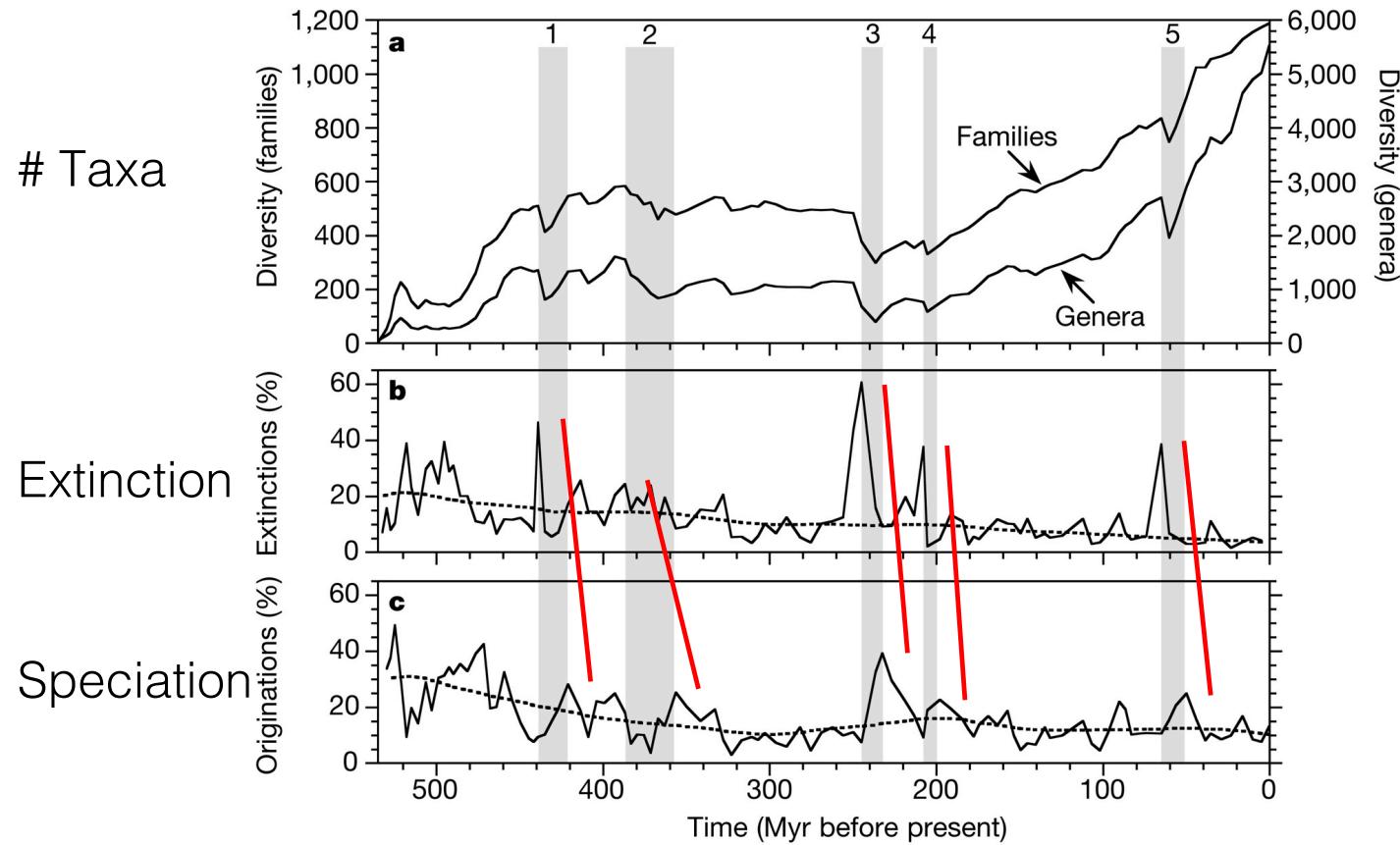
## Consequences of biodiversity loss for litter decomposition across biomes

I. Tanya Handa, Rien Aerts, Frank Berendse, Matty P. Berg, Andreas Bruder, Olaf

How has biodiversity changed in the past?



# Global Diversity of Marine Fossils

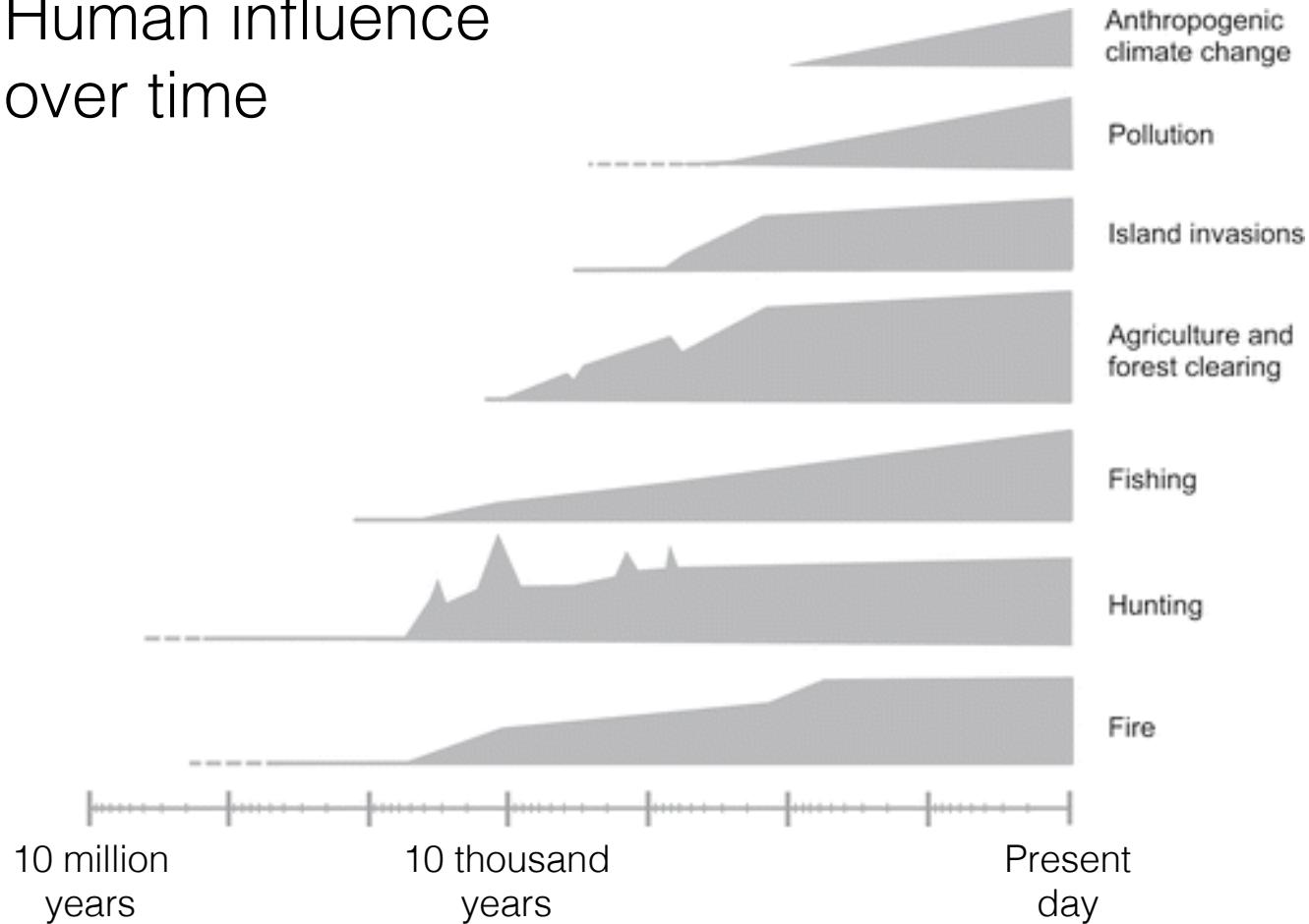


Kirchner & Wiel Nature 2000

How have humans influenced biodiversity in the past?



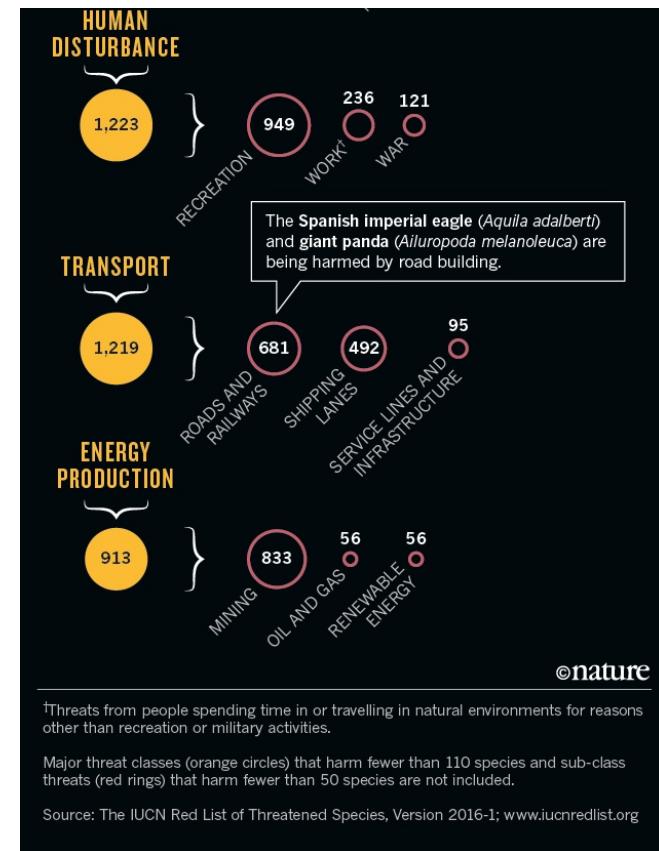
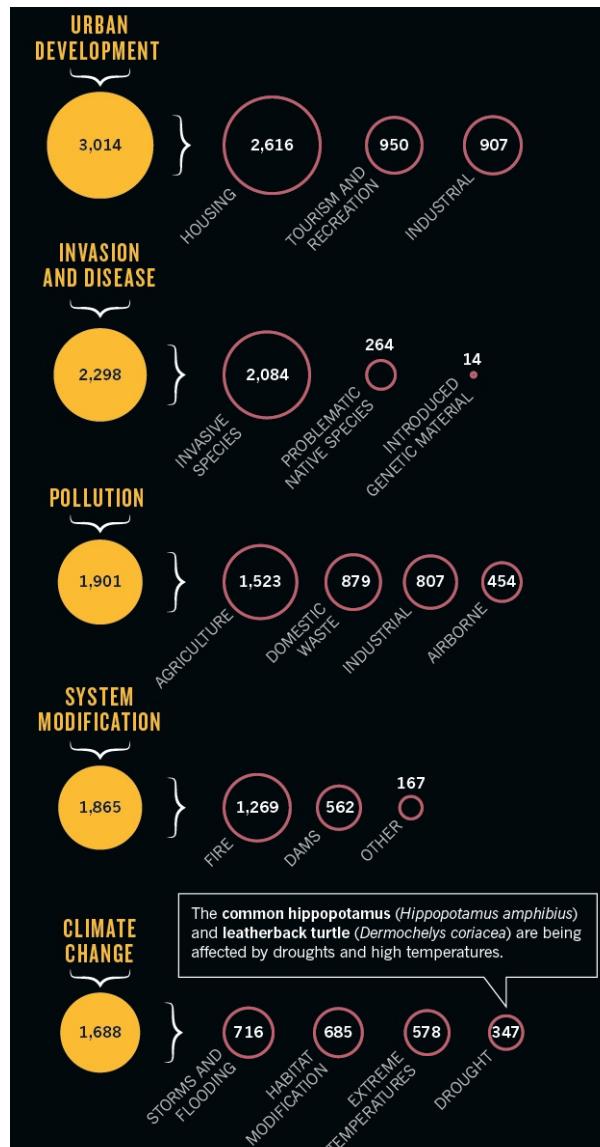
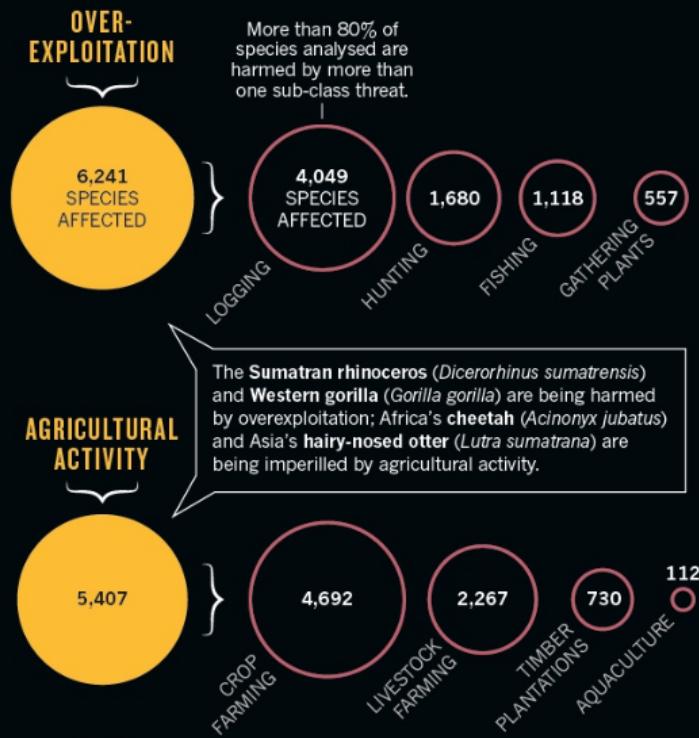
## Human influence over time



Pereira et al. Annu. Rev. Environ. Resour. 2012

# BIG KILLERS

Overexploitation and agriculture are the most prevalent threats facing the 8,688 threatened or near-threatened species from comprehensively assessed species groups on the IUCN Red List.



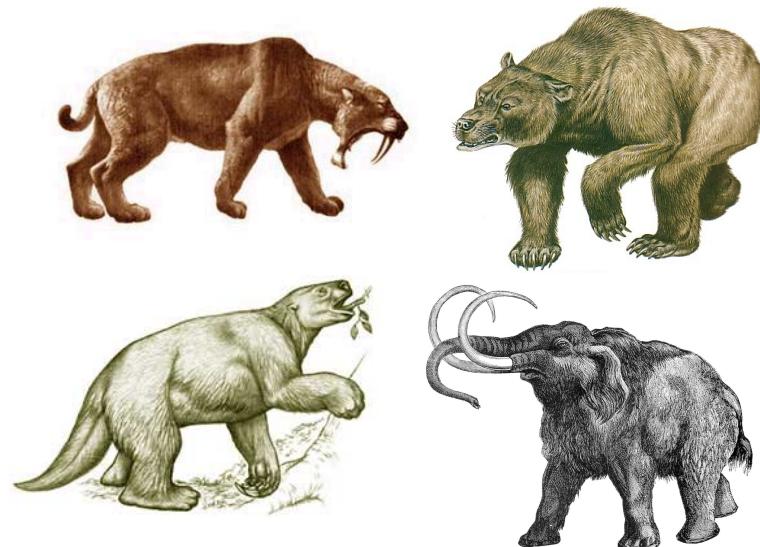
Maxwell et al. *Nature* 2016

Have humans caused extinctions in the past?



# Extinction of Pleistocene megafauna

Overkill hypothesis: naïve prey with a new, efficient predator



- Starting ~11-12,000 years ago, rapid extinction of mammals in the Americas
- Highly size biased (>50kg herbivores + dependent carnivores)
- Extinction wave north to south

# Are we in a new mass extinction?

Past:

Estimated from fossil record:

~1 species / million species / year

Contemporary:

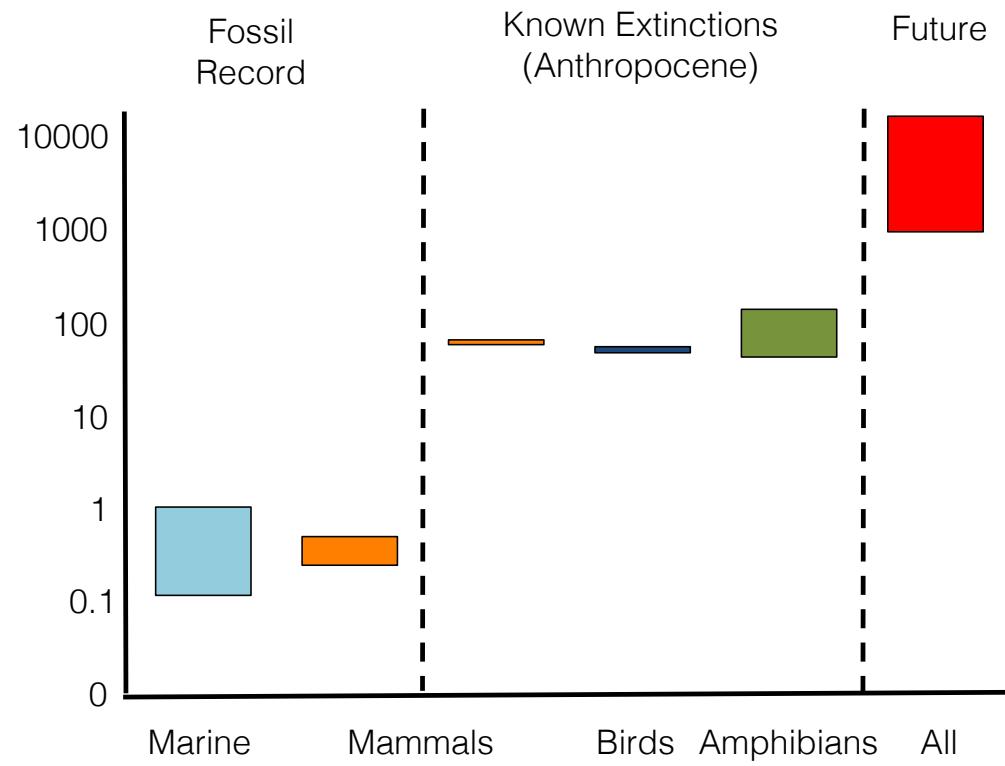
Example: Birds since 1500

25-100 species / million species / year

On par with some mass extinctions

Pimm et al. PNAS 2000

# Are we in a new mass extinction?

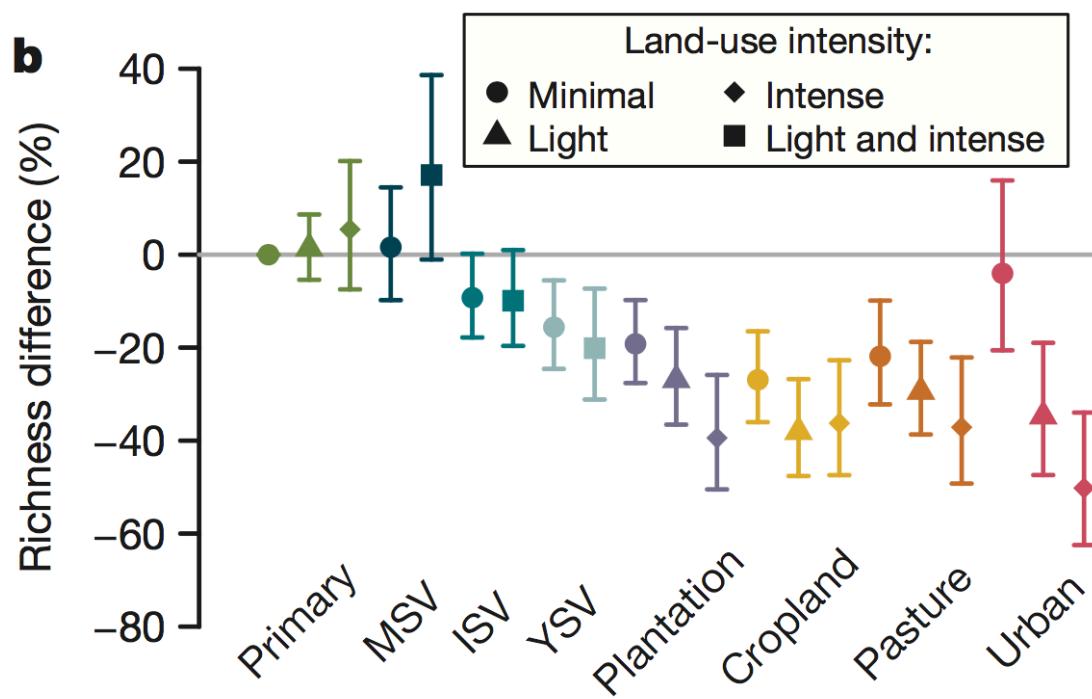


Pereira et al. Science 2010, Millennium Ecosystem Assessment

Where is biodiversity decreasing?



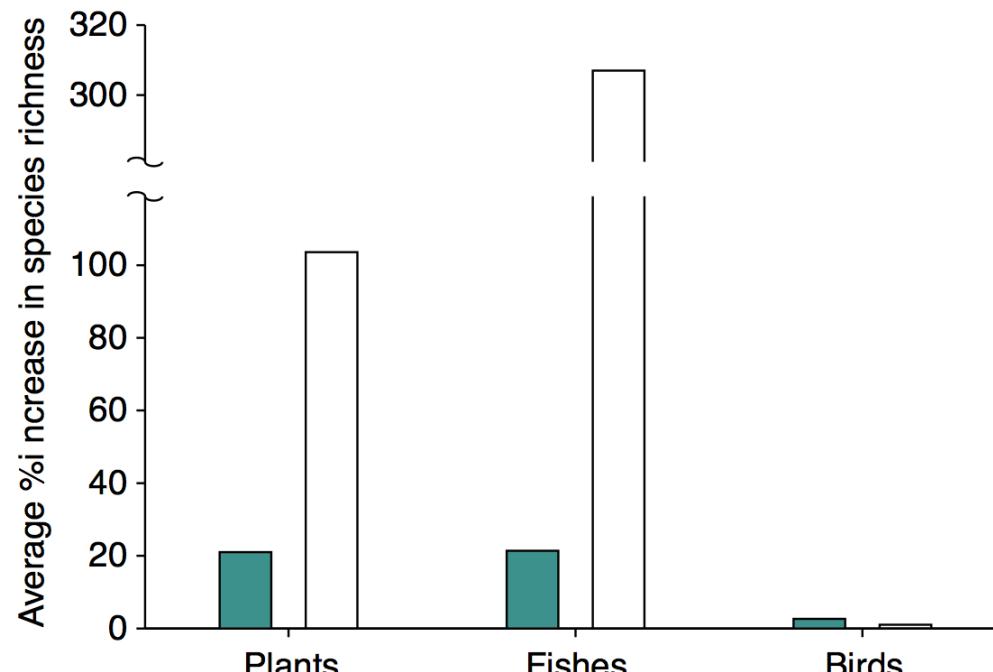
More diversity loss with more intense landuse change



Where is biodiversity increasing?



# Biotic homogenization... at regional scales



Species richness changes on oceanic islands (white) and continental regions (green).

Sax & Gaines TREE 2003

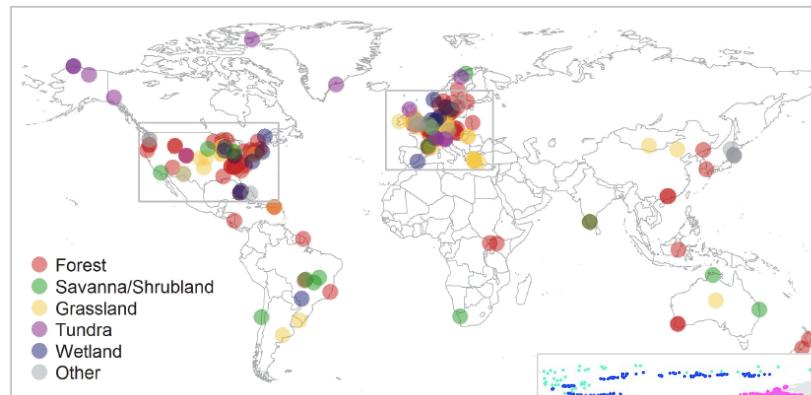
How is species richness changing at the local scale?



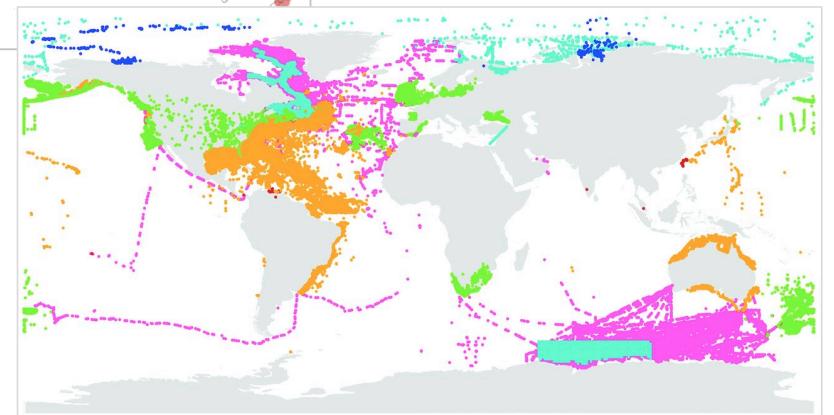
# How is species richness changing at the local scale?



1999

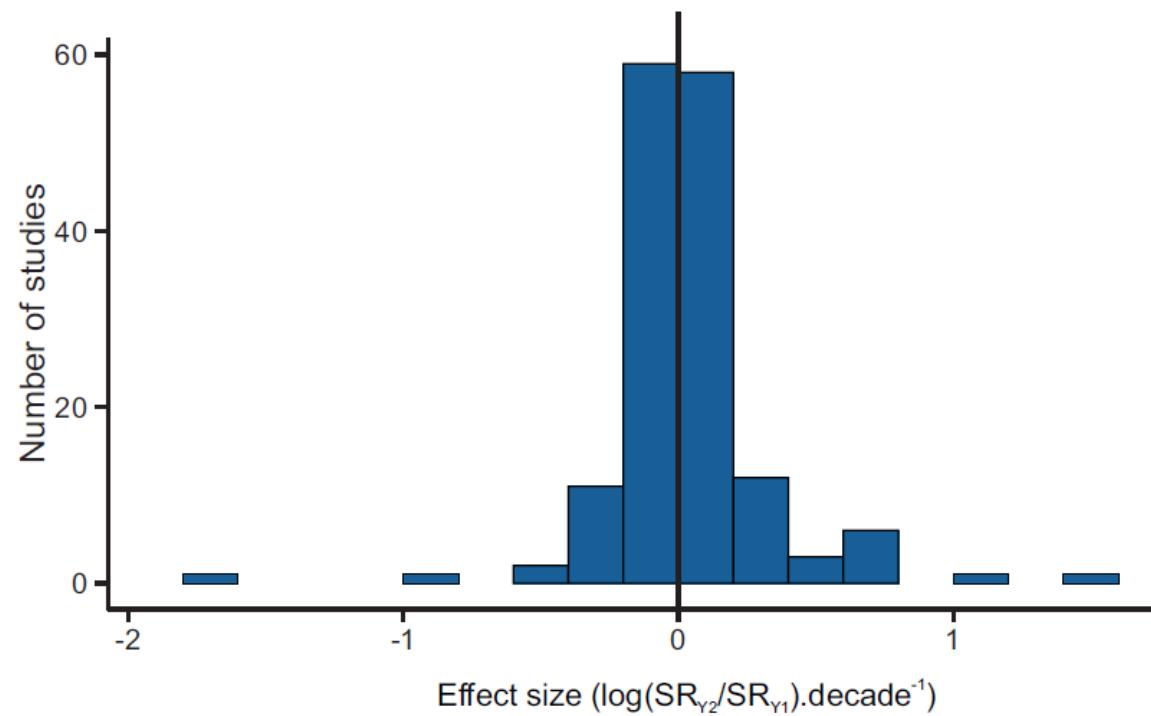


2013



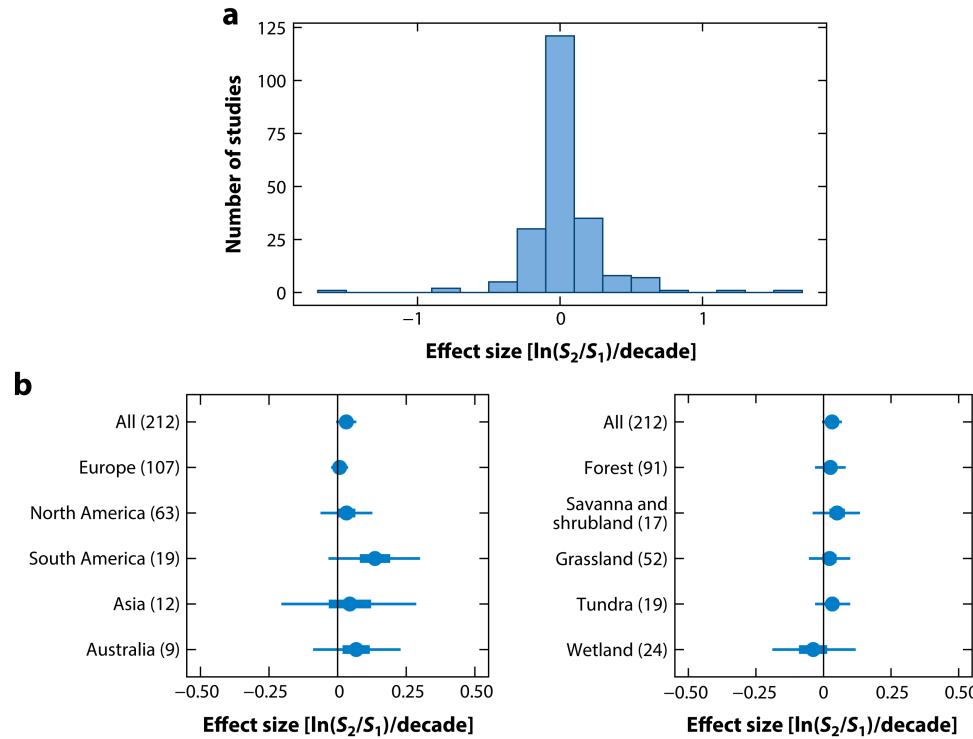
Vellend et al. PNAS 2013, Dornelas et al. Science 2014

No net change in species richness... at the local scale?



Vellend et al. PNAS 2013

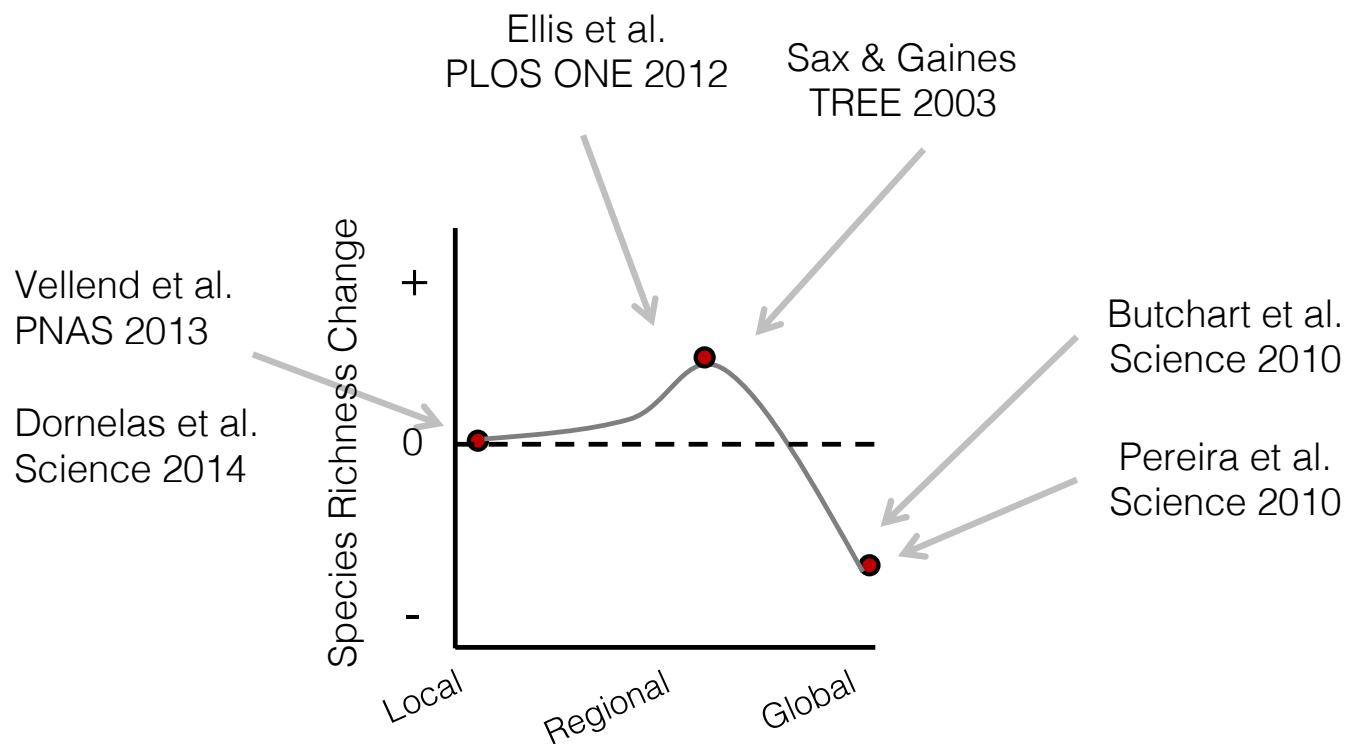
# No net change in species richness... at the local scale?

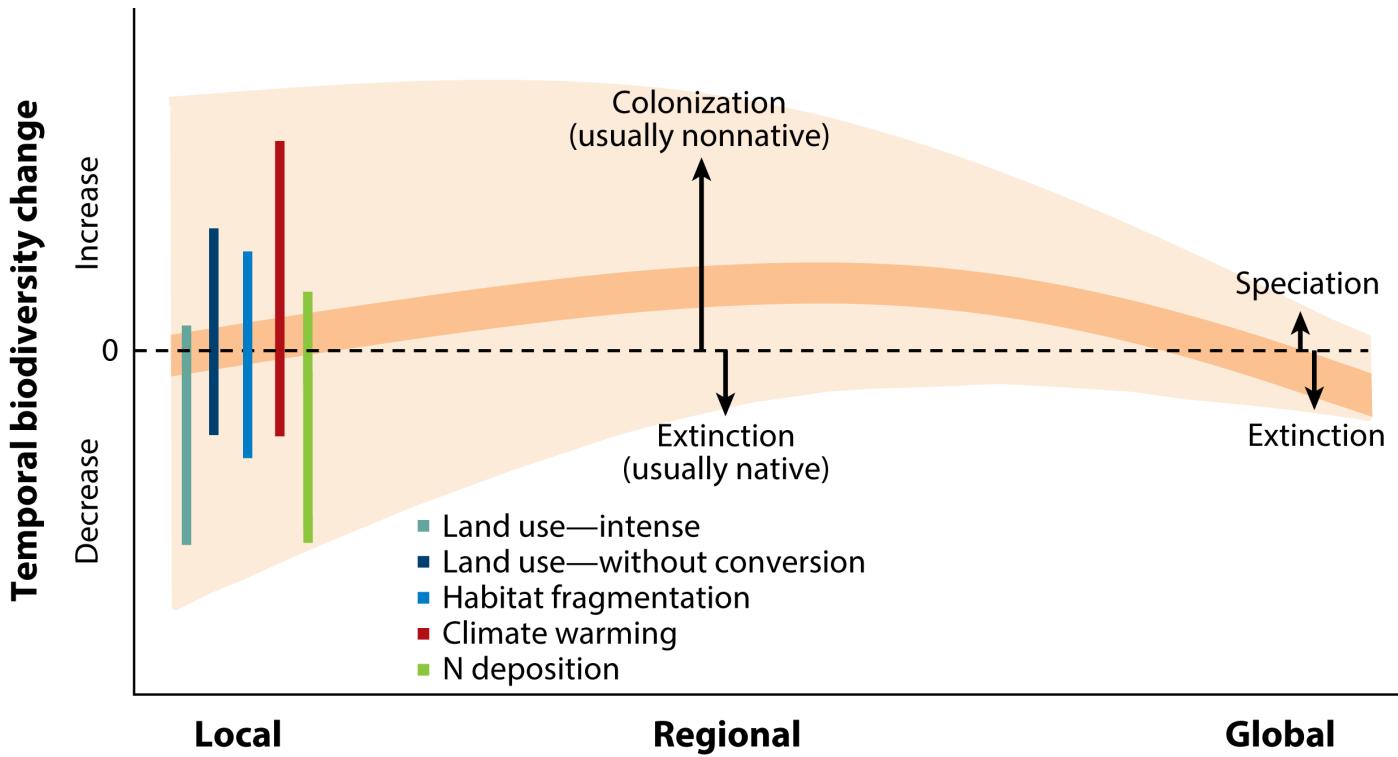


 Vellend M, et al. 2017.  
Annu. Rev. Plant Biol. 68:563–86

Vellend et al. ARPB 2017

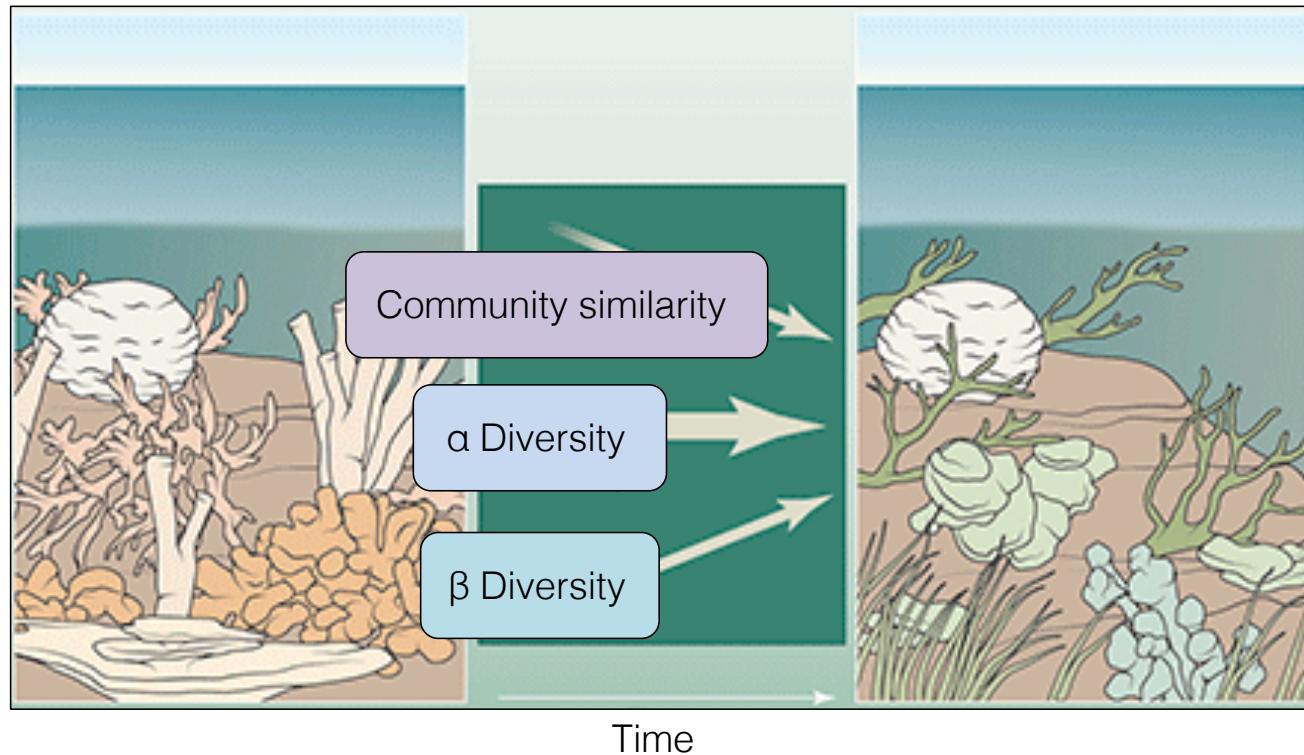
# Across scales





**A** Vellend M, et al. 2017.  
**R** Annu. Rev. Plant Biol. 68:563–86

# Across metrics



Pandolfi & Lovelock Science 2014

# How will biodiversity change in the future?

The screenshot shows the IPBES website's navigation bar with links for About IPBES, Work Programme, Resources, Get Involved, and Meetings and documents. Below the navigation is a breadcrumb trail: Home > About IPBES. The main content area features a large image of a dense tropical forest with the text "IPBES at a Glance". Below the image is a bulleted list of facts about IPBES.

About IPBES    Work Programme    Resources    Get Involved    Meetings and documents

Home > About IPBES

## About IPBES

### IPBES at a Glance

- Established in 2012 in Panama by over 100 governments as a mechanism to provide scientific information in response to requests from policy makers
- Current membership includes 125 governments
- Placed under the auspices of UNEP, FAO, UNDP, and UNESCO, and administered by UNEP

<http://www.ipbes.net/>

# What is Conservation Science?



# What is Conservation Science?

Conservation Science: “Conservation science improves human well-being through the management of the environment, with strategies to jointly maximize benefits to people and to biodiversity using both natural and social sciences and the dynamics of coupled human–natural systems.”

The image shows a screenshot of a web page from BioScience. At the top, there is a navigation bar with the word 'Articles' followed by a horizontal bar. Below this, the main title 'What Is Conservation Science?' is displayed in a large, bold, black font. Underneath the title, the authors' names, 'PETER KAREIVA AND MICHELLE MARVIER', are listed in a smaller, black font. At the bottom of the visible portion of the page, there is a brief abstract or introduction in a smaller, italicized font.

Articles

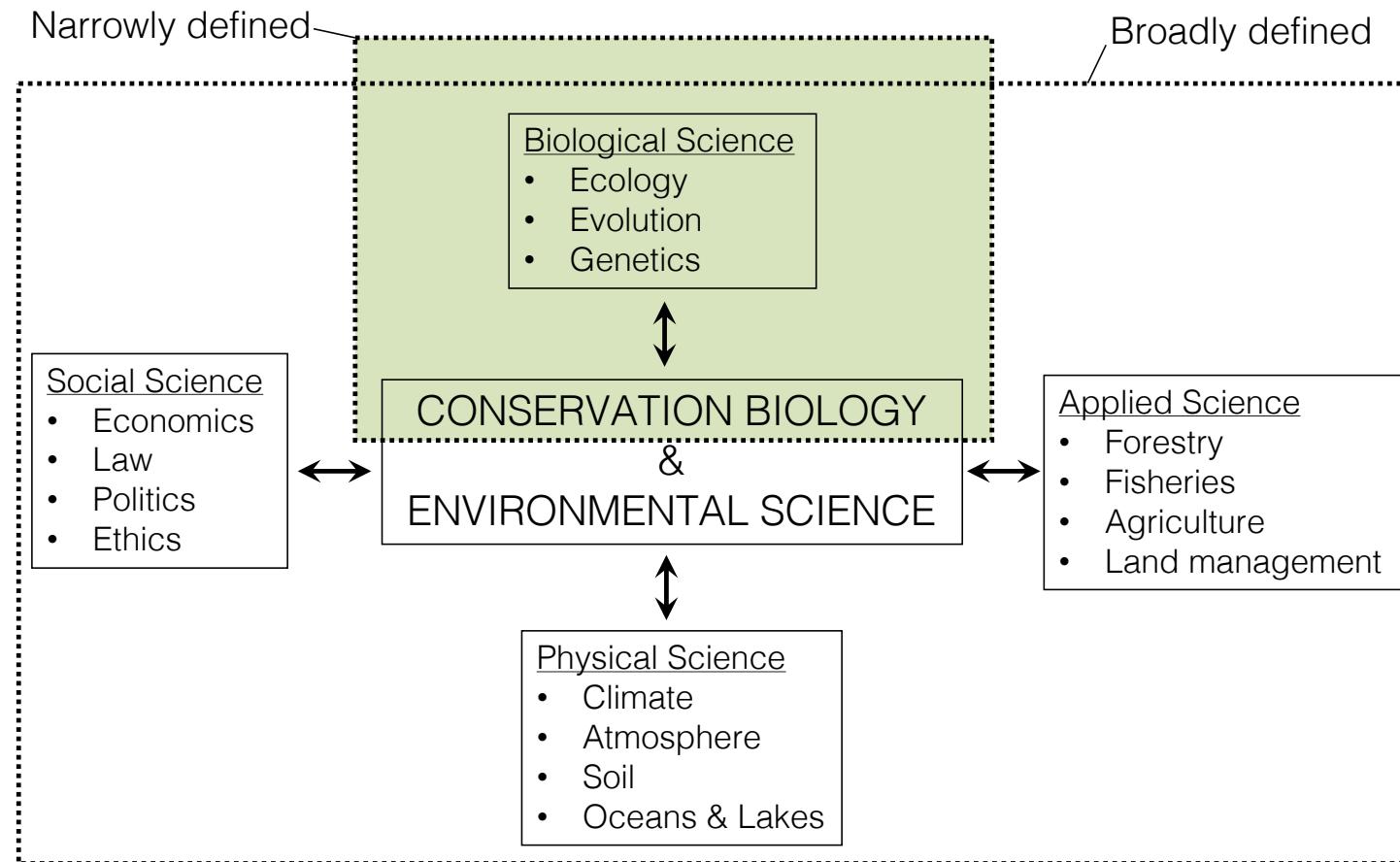
## What Is Conservation Science?

PETER KAREIVA AND MICHELLE MARVIER

*In 1985, Michael Soulé asked, “What is conservation biology?” We revisit this question more than 25 years later and offer a revised set of core principles in light of the changed global context for conservation. Most notably, scientists now widely acknowledge that we live in a world*

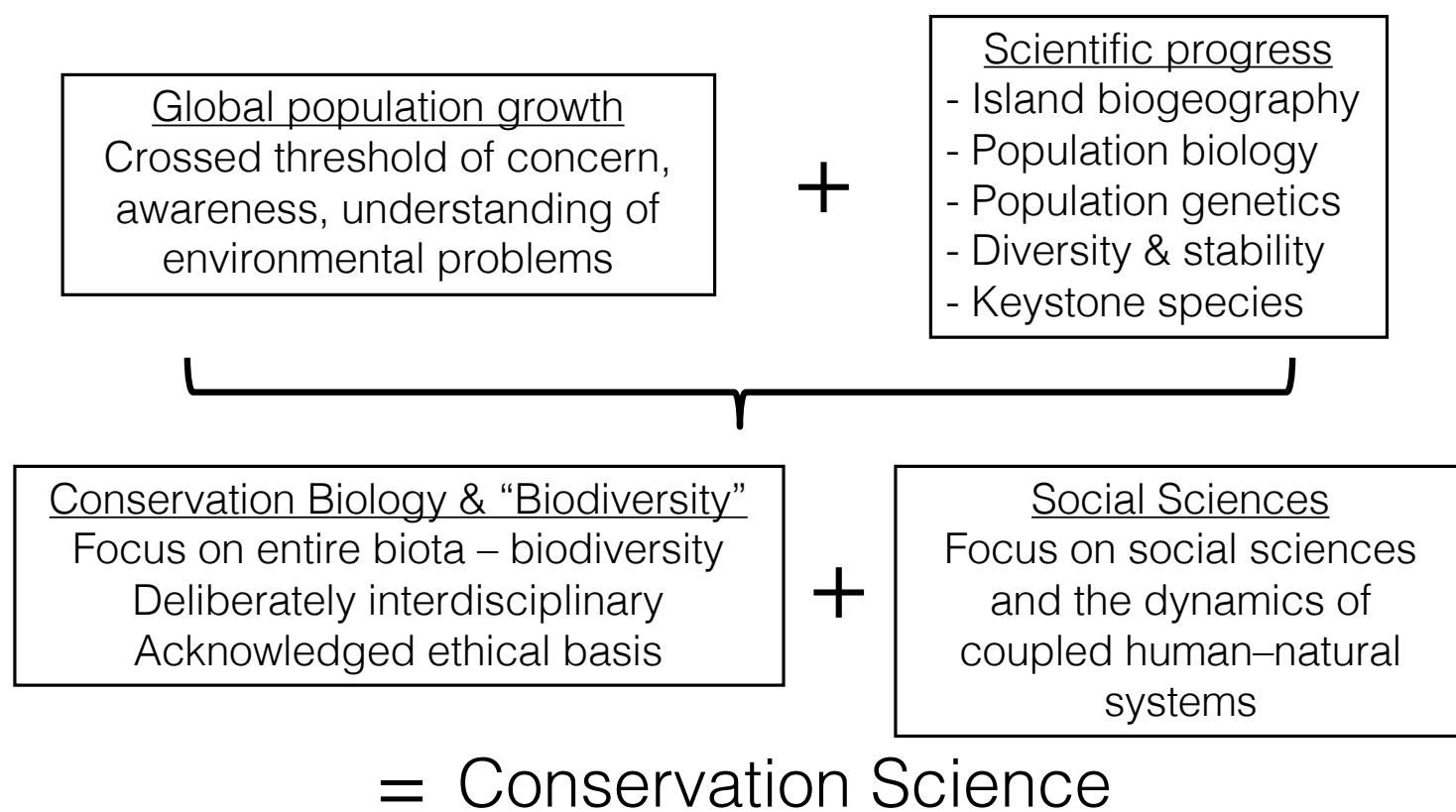
Kareiva and Marvier BioScience 2012

# Conservation science in the context of other disciplines



see Conservation Biology, June 2006

# The “recent” emergence of conservation science

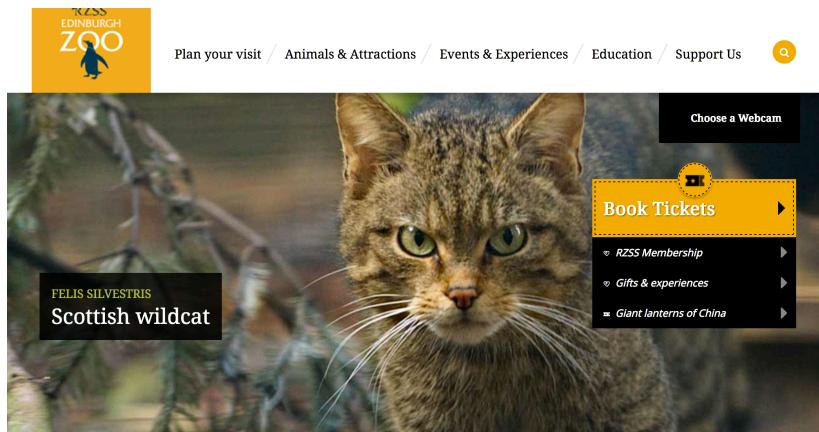


# How can we conserve biodiversity?

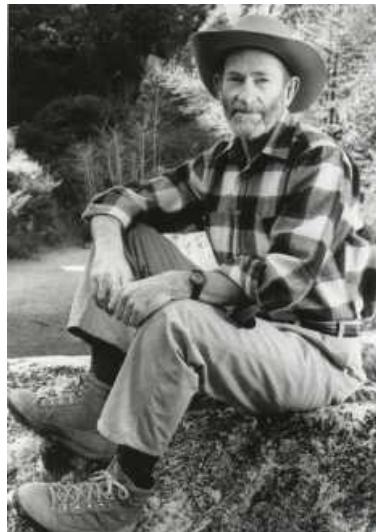


# How can we conserve biodiversity?

- Habitat preservation / restoration
- Zoos and captive breeding
- Predator control / eradication
- Biological control
- Financial compensation for loss of livelihoods



1960s - 1980s:  
Fundamental biologists become  
conservation biologists...



Michael Soulé



Jane Goodall



E. O. Wilson



David Suzuki

Conservation Biology as a “crisis discipline”

# E. O. Wilson

*“The worst thing that can happen during the 1980's is not energy depletion, economic collapse, limited nuclear war, or conquest by a totalitarian government. As terrible as these catastrophes would be for us, they can be repaired within a few generations. The one process in the 1980's that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly that our descendants are least likely to forgive us.”*

From E.O. Wilson (1985, from The biological diversity crisis: a challenge to science. Issues Science Technology 2: 20-25.)



E. O. Wilson

Do you agree with this statement?  
Is it still true now?

How do you view the future of the environment?

- a) Optimistically
- b) Pessimistically
- c) Neither
- d) I don't care

# Extra Reading

Chapin III, F. Stuart, et al. "Consequences of changing biodiversity." *Nature* 405.6783 (2000): 234-242.

Pereira, H. M., et al. 2012. Global biodiversity change: the bad, the good, and the unknown. *Annual Review of Environment and Resources*. 37: 25-50.

Butchart, Stuart HM, et al. 2010. Global biodiversity: indicators of recent declines." *Science* 328.5982: 1164-1168.

Dornelas, Maria, et al. 2014. Assemblage Time Series Reveal Biodiversity Change but Not Systematic Loss. *Science* 344.6181 (2014): 296-299.

Vellend, Mark, et al. 2013. Global meta-analysis reveals no net change in local-scale plant biodiversity over time. *Proceedings of the National Academy of Sciences* 110.48: 19456-19459.

Sax, Dov F., and Steven D. Gaines. 2003. Species diversity: from global decreases to local increases. *Trends in Ecology & Evolution* 18.11 (2003): 561-566.

Living Planet Report. 2014. WWF.

[http://wwf.panda.org/about\\_our\\_earth/all\\_publications/living\\_planet\\_report/](http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/)