

Natural Hazards and Disaster



Lab 13: Final Exam Preparation



Final Exam Preparation

Basics:

- Hazard, Disaster, and the links between them
- Probability of hazards; including probability density function
- Risks, risk assessment, risk governance
- Are probabilities of some hazards changing over time and, if so, why?

Four specific examples:

- April 6, 2009 L'Aquila Earthquake (class 5)
- Comparison of Hurricane Katrina and Typhoon Haiyan (class 9)
- The 1974 Super Outbreak of Tornadoes (class 10)
- Holocene and Post-Holocene: Leaving the Safe-Operating Space for Humanity, including modern climate change (classes 11 - 12)

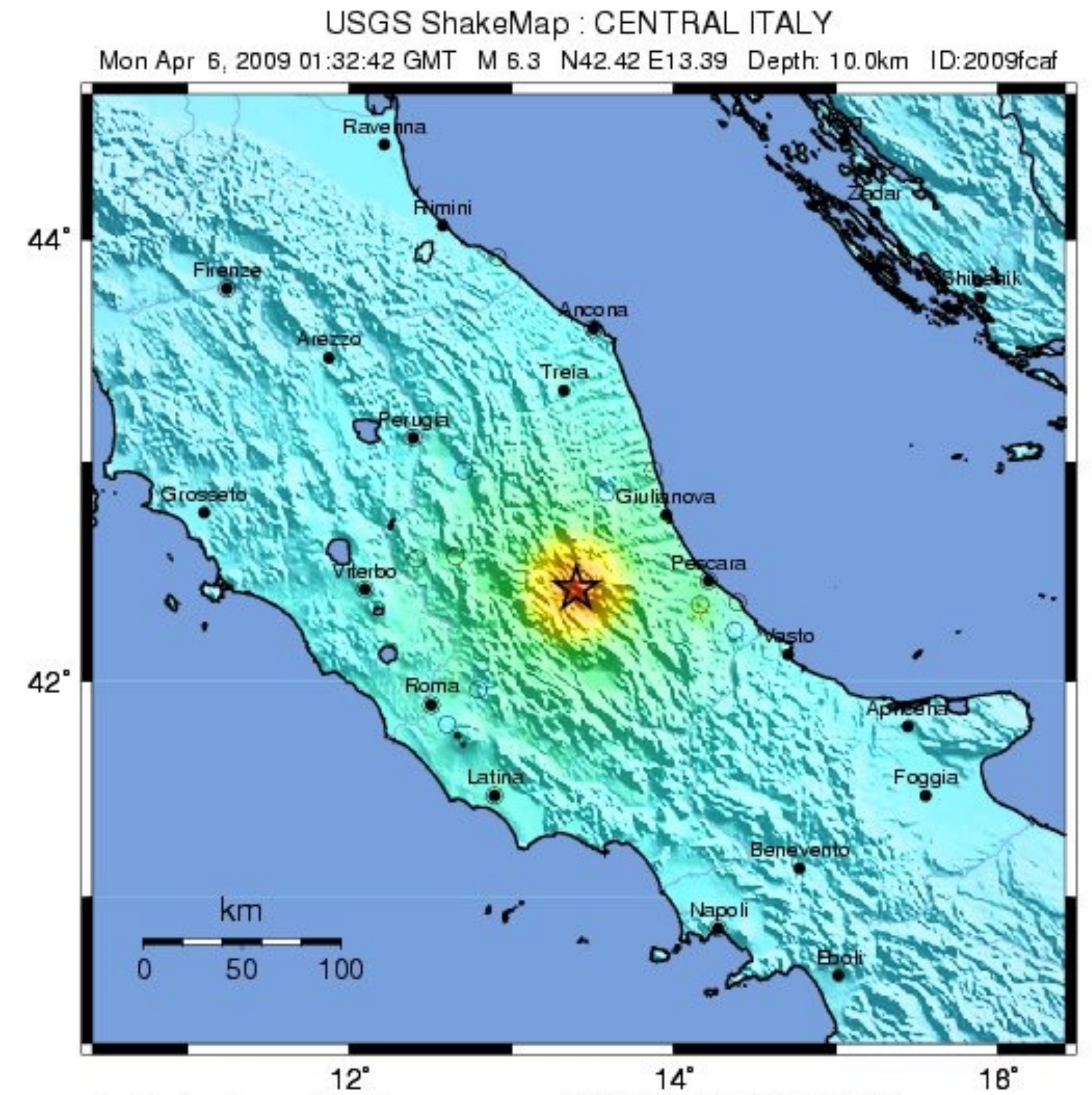
Questions will relate to:

- the hazard (earthquake, hurricane, tornado, climate change, extinction): general description of the type, the specific event;
- the disaster: extent of damage and lives lost;
- cascading impacts, if any;
- the specific reasons for the extent of the disaster (what led to the disaster?);
- particulars of the risk management cycle, in particular: risk assessment prior to the event, early warning; hazard mitigation, if any; impact mitigation, and recovery;

Cases Earthquake

Apr. 6, 2009, L'Aquila M 6.3, I=VIII, Depth 9.5 km
 Deaths 309, Damage \$16 billion

The L'Aquila earthquake occurred in the region of Abruzzo, in central Italy. The epicentre near L'Aquila, the capital of Abruzzo, which together with surrounding villages suffered most damage. There were **several thousand foreshocks** and aftershocks since December 2008, more than thirty of which had magnitude greater than 3.5. 309 people are known to have died, making this the deadliest earthquake to hit Italy since the 1980 Irpinia earthquake.

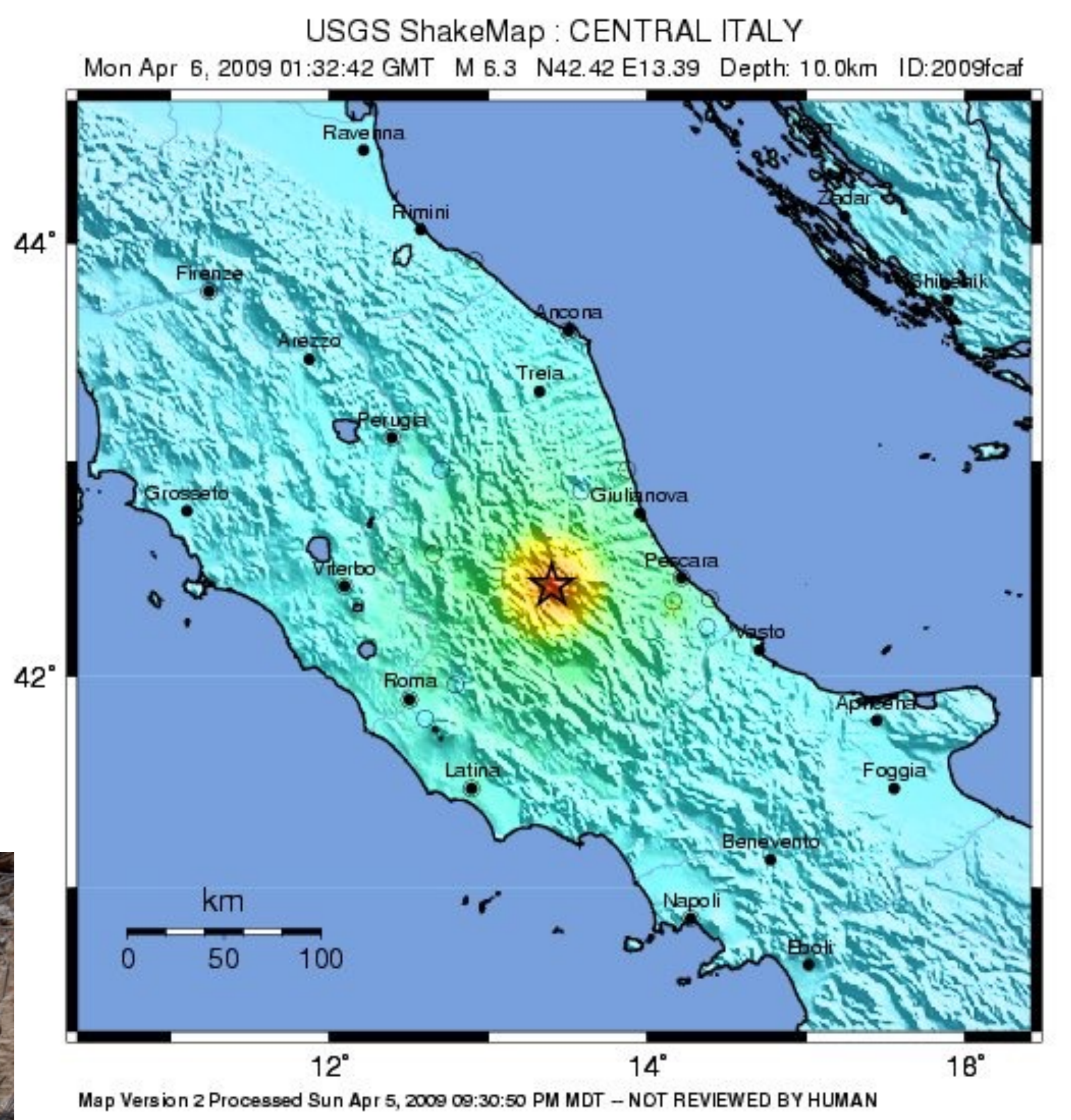


Map Version 2 Processed Sun Apr 5, 2009 09:30:50 PM MDT – NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC. (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL. (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

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Criticism was applied to poor building standards that led to the failure of many modern buildings in a known earthquake zone: an official at Italy's Civil Protection Agency, Franco Barberi, said that "in California, an earthquake like this one would not have killed a single person".



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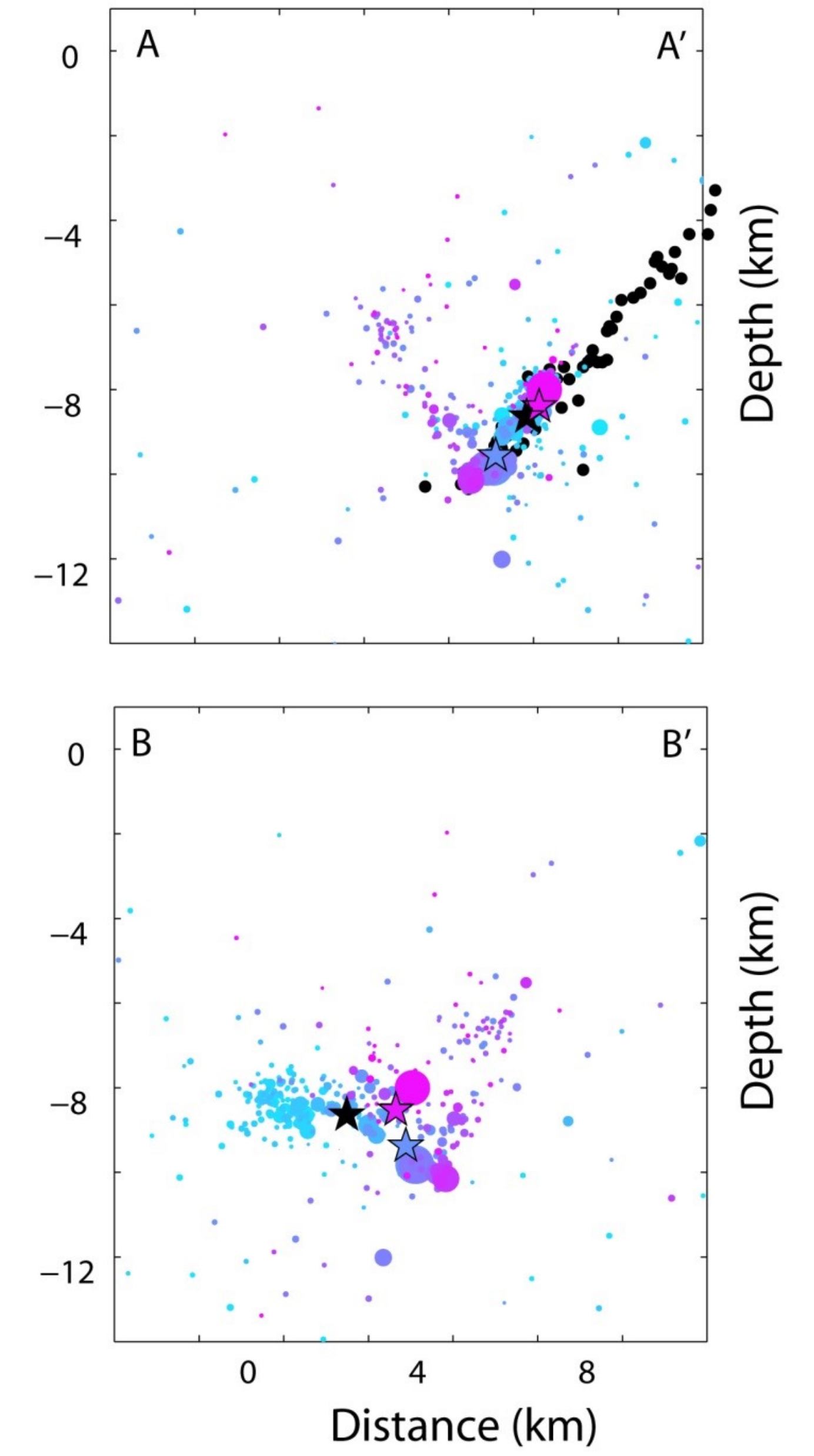
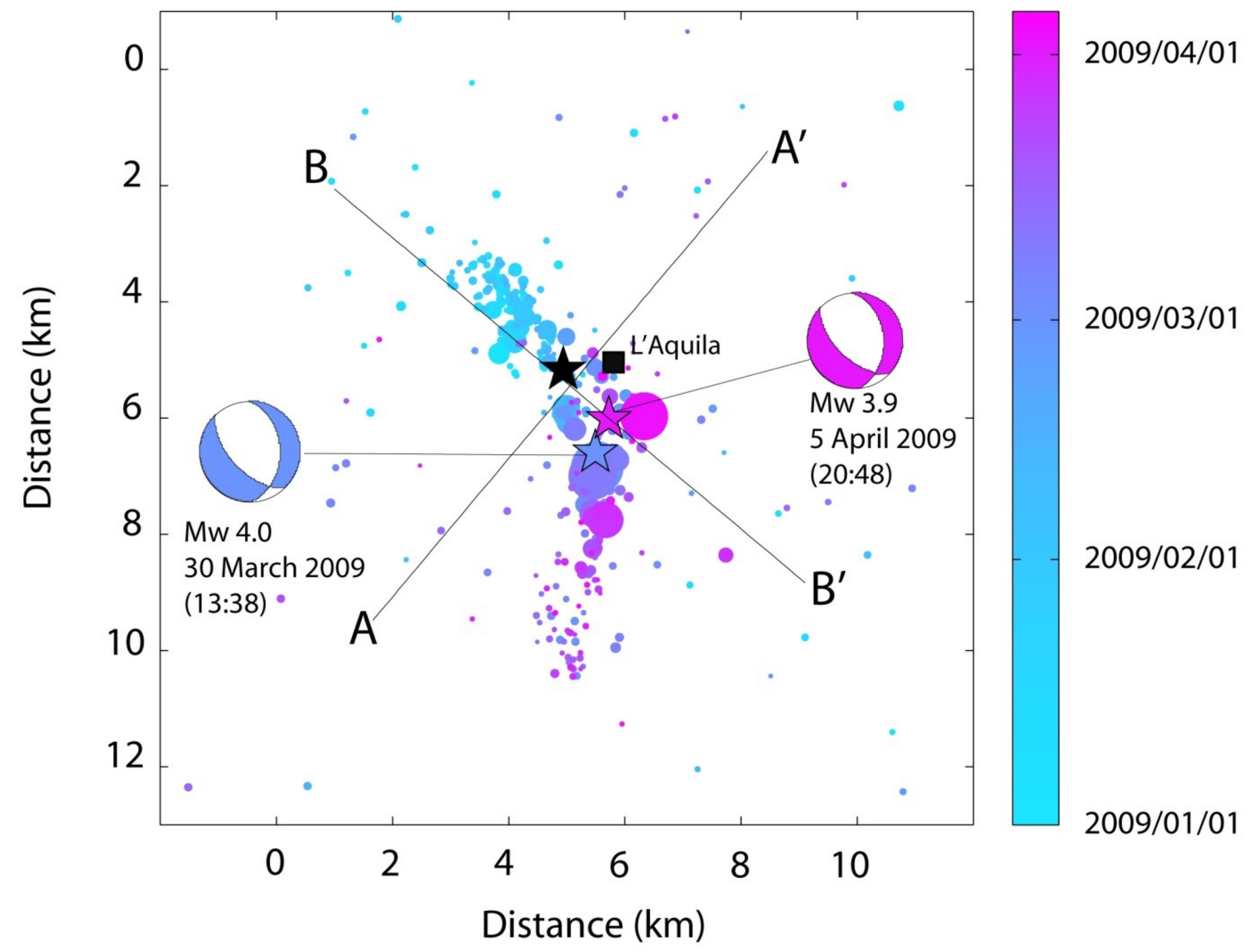
Cases Earthquake



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(Chiaraluce et al., 2011)

Cases Earthquake

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Before the Earthquake:

- The rate of earthquake production increased on March 30th 2009 after a M_L 4.1 earthquake that struck the L'Aquila area
- Preoccupation and panic in population raised
- After a prediction broadcasted by Giuliani, vans mounted with loudspeakers blare warnings to Sulmona residents to flee. Many people do. No earthquake occurs in the prediction window.
- On March 31st the Italian Civil Protection organize in L'Aquila a meeting of the Commissione Grandi Rischi (Major Risks Committee), an expert group that advises the Civil Protection agency on the risks of natural disasters
- Immediately after that meeting, De Bernardinis and Barberi, acting president of the committee, held a press conference in L'Aquila, where De Bernardinis told reporters that **“the scientific community tells us there is no danger, because there is an ongoing discharge of energy. The situation looks favorable”**.

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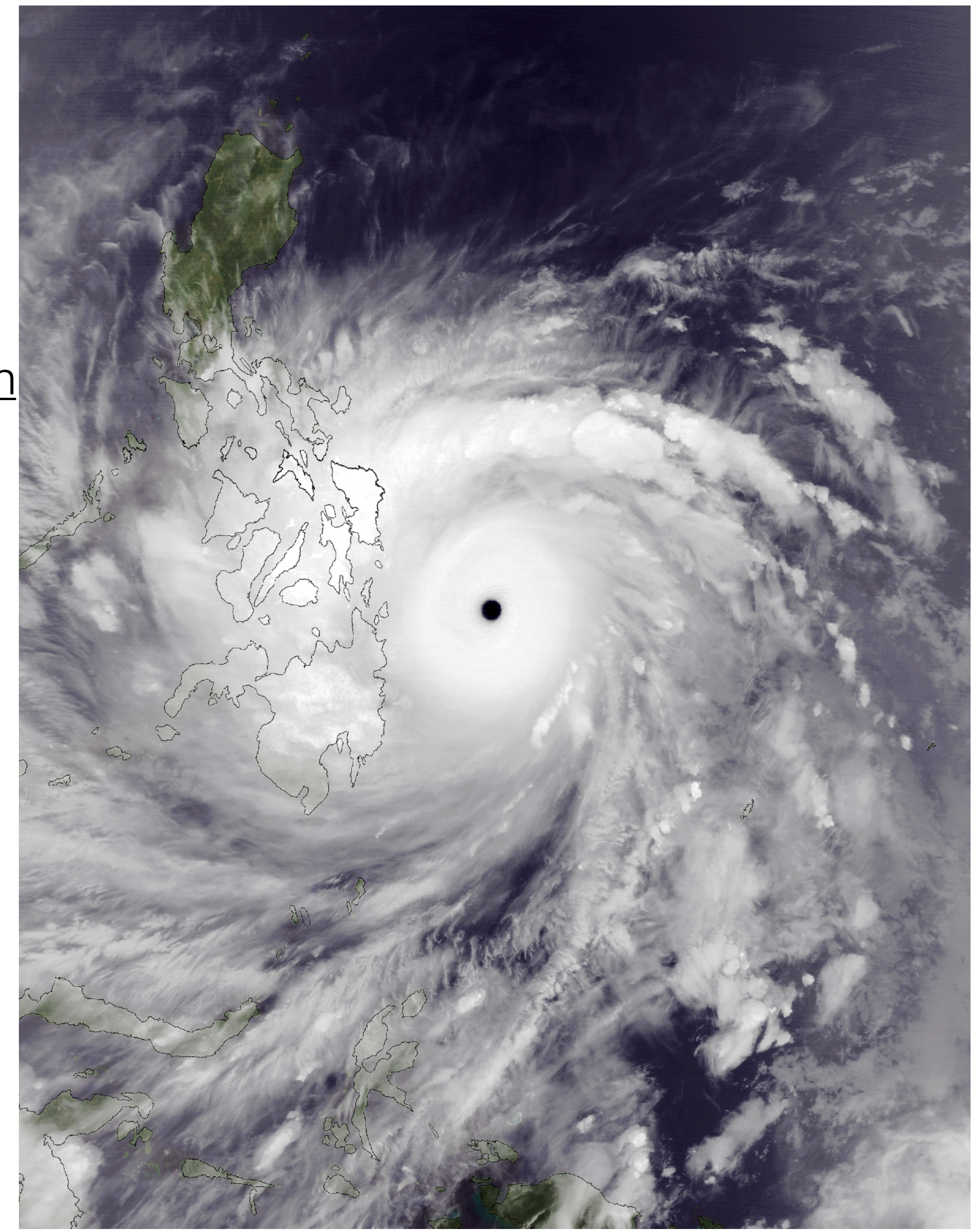
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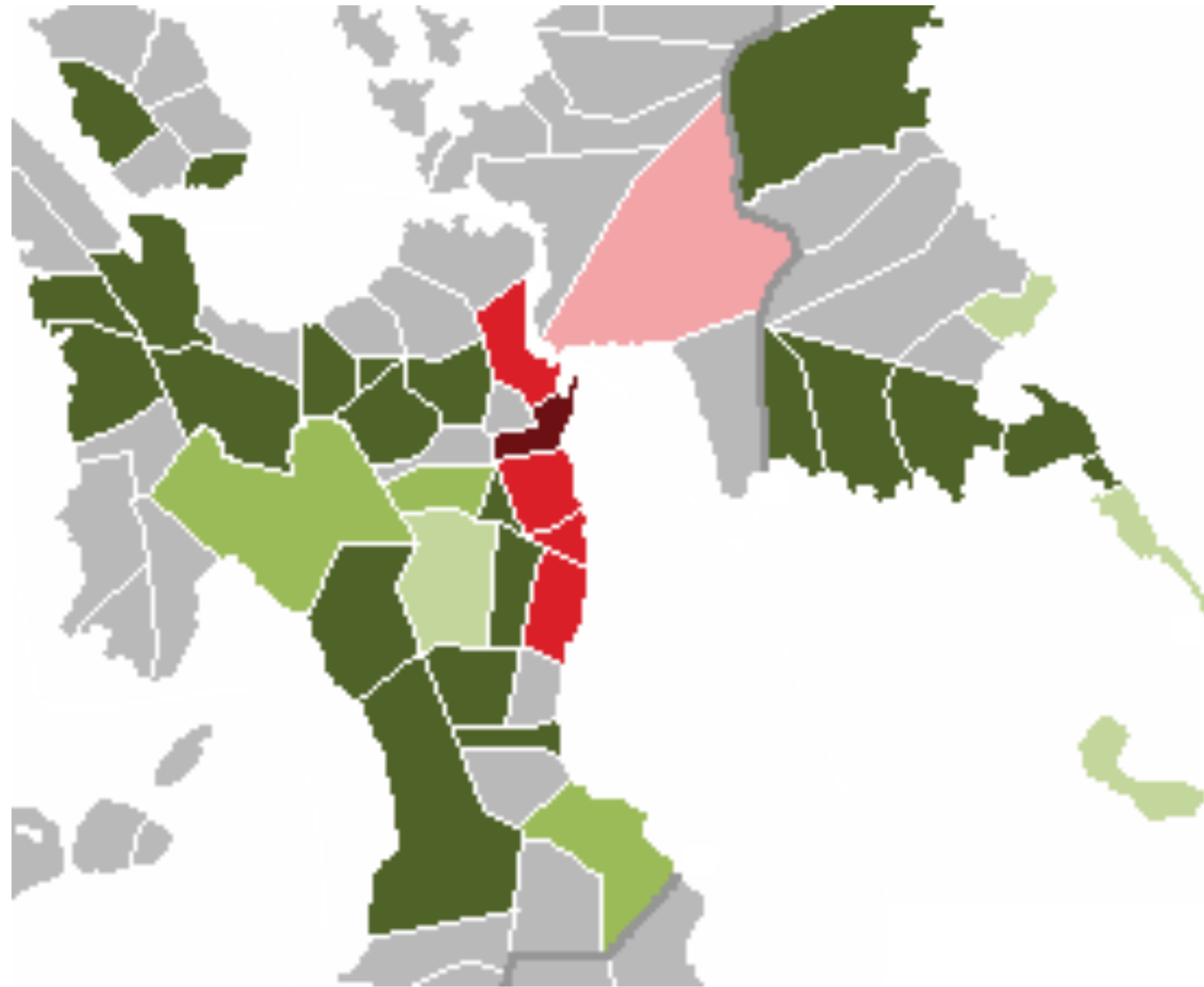
In a subsequent inquiry of the handling of the disaster, seven members of the Italian National Commission for the Forecast and Prevention of Major Risks were accused of giving "inexact, incomplete and contradictory" information about the danger of the tremors prior to the main quake. On 22 October 2012, six scientists and one ex-government official were convicted of multiple manslaughter for downplaying the likelihood of a major earthquake six days before it took place. They were each sentenced to six years' imprisonment. On 10 November 2014, the scientists convicted of manslaughter for failing to predict the deadly earthquake have had the verdict overturned.

Cases

Typhoon Haiyan was an extremely deadly and intense typhoon, known as Super Typhoon Yolanda in the Philippines. On making landfall, Haiyan devastated portions of Southeast Asia, particularly the Philippines. It is the deadliest Philippine typhoon on record, killing at least 6,300 people in that country alone. In terms of JTWC-estimated 1-minute sustained winds, Haiyan is tied with Meranti for being the strongest landfalling tropical cyclone on record. In January 2014, bodies were still being found.

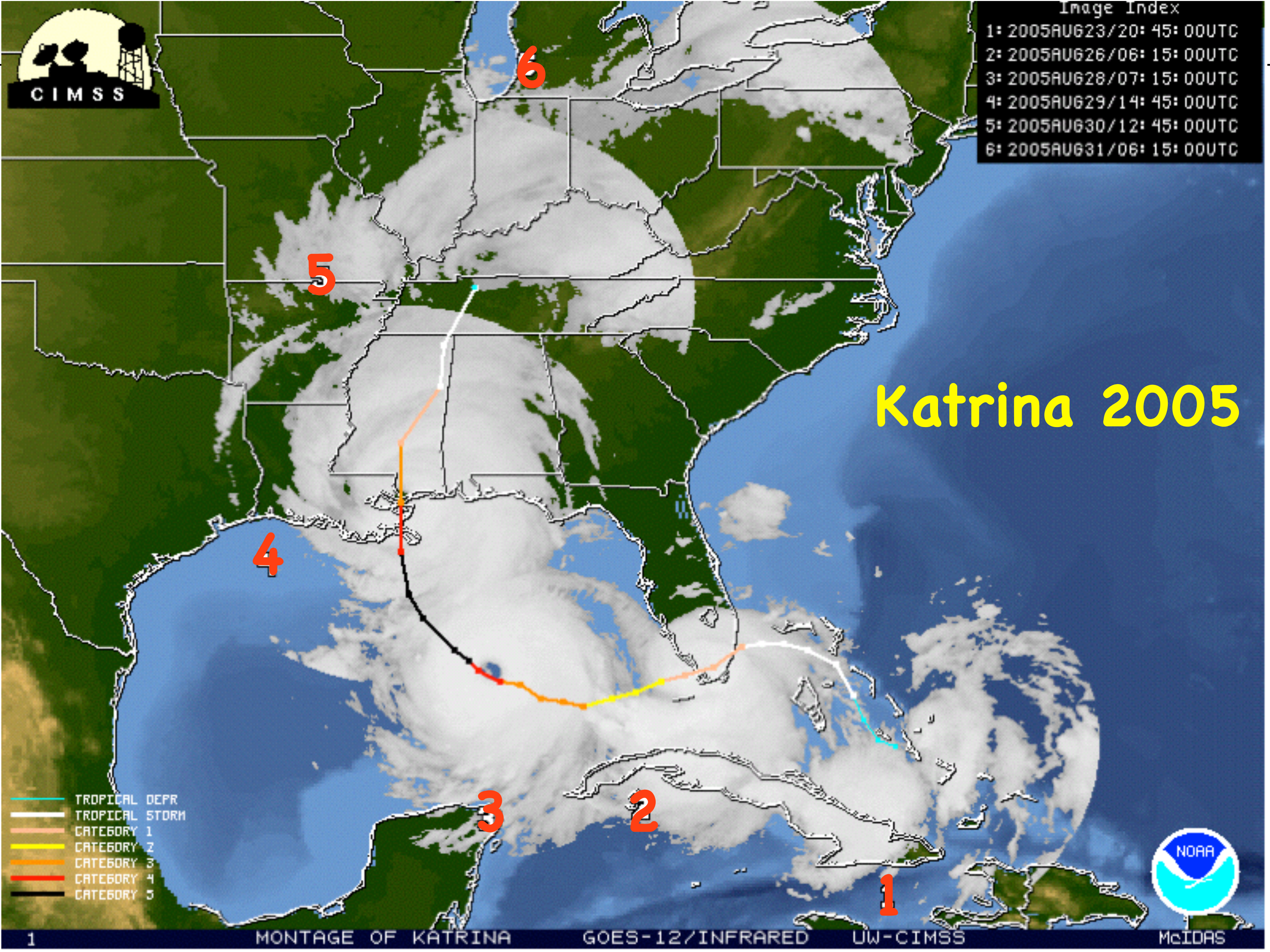
https://en.wikipedia.org/wiki/Typhoon_Haiyan



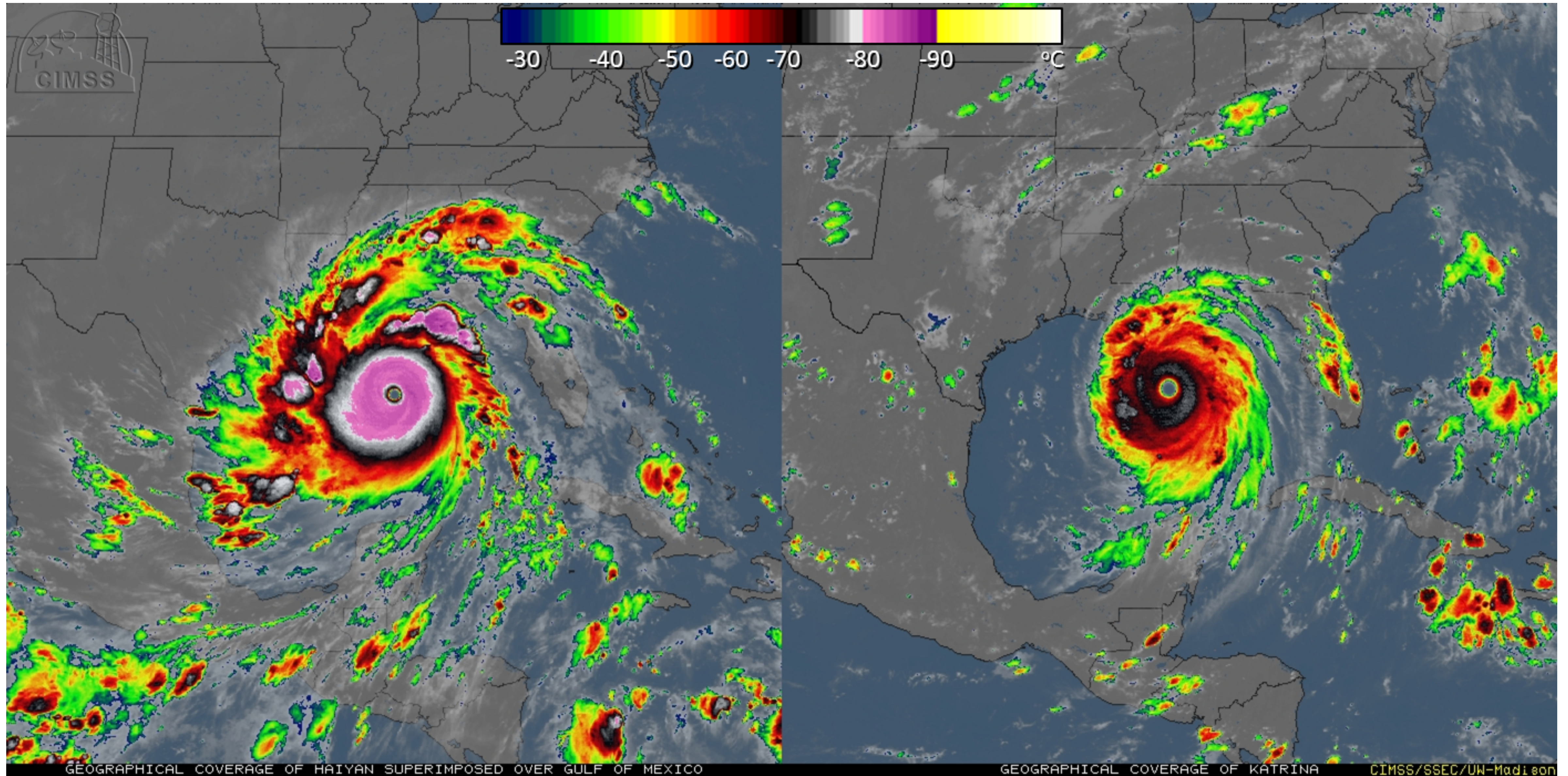


Color coded map of Eastern Visayas showing the number of deaths caused by Typhoon Haiyan. ■ More than 1,000 ■ 500-999

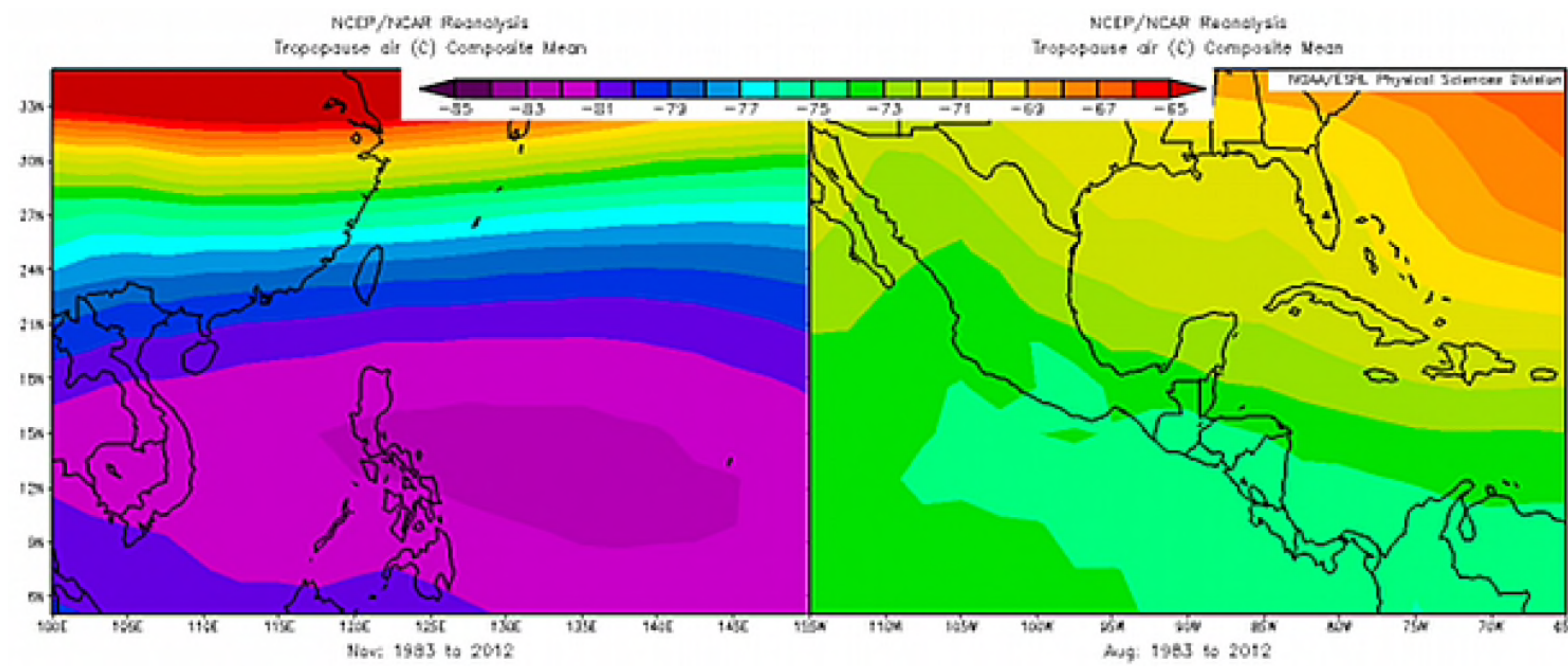
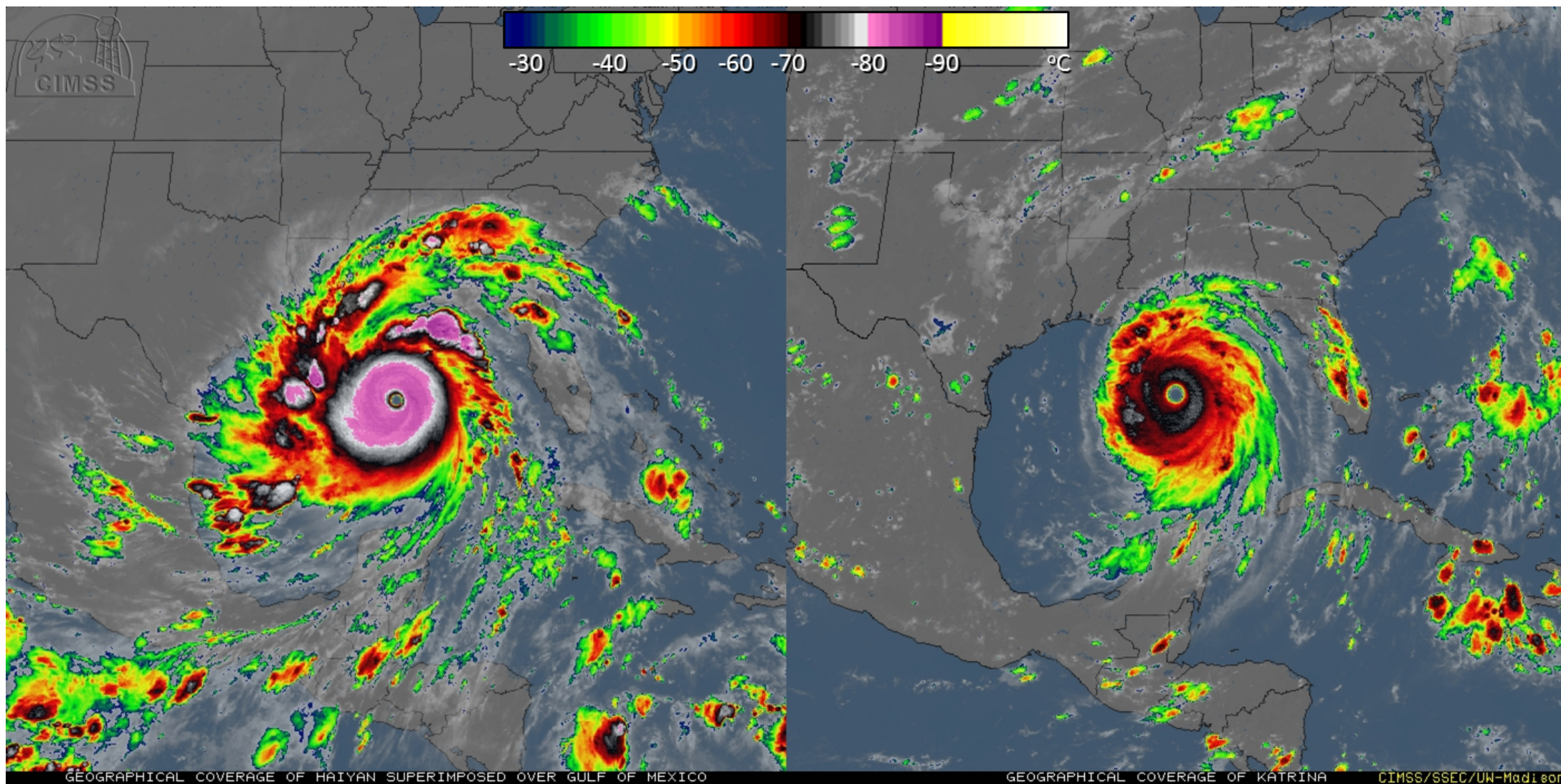
■ 100-499 ■ 50-99 ■ 25-49 ■ 1-24 ■ 0



Comparison of Katrina and Haiyan



Comparison of Katrina and Haiyan



Haiyan (left) was more intense than Katrina (right) at its peak. The ring of clouds over the eyewall is much colder and thicker in Haiyan. While both storms were over very warm water – around 30°C, the tropopause is higher and colder in the western tropical Pacific than it is in the tropical Atlantic, giving storms a decided intensity advantage. The average November tropopause temperature in the West Pacific (corresponding to Haiyan) is about 12°C colder than the average August tropopause temperature in the Gulf of Mexico (corresponding to Katrina).

Tornadoes: Cases

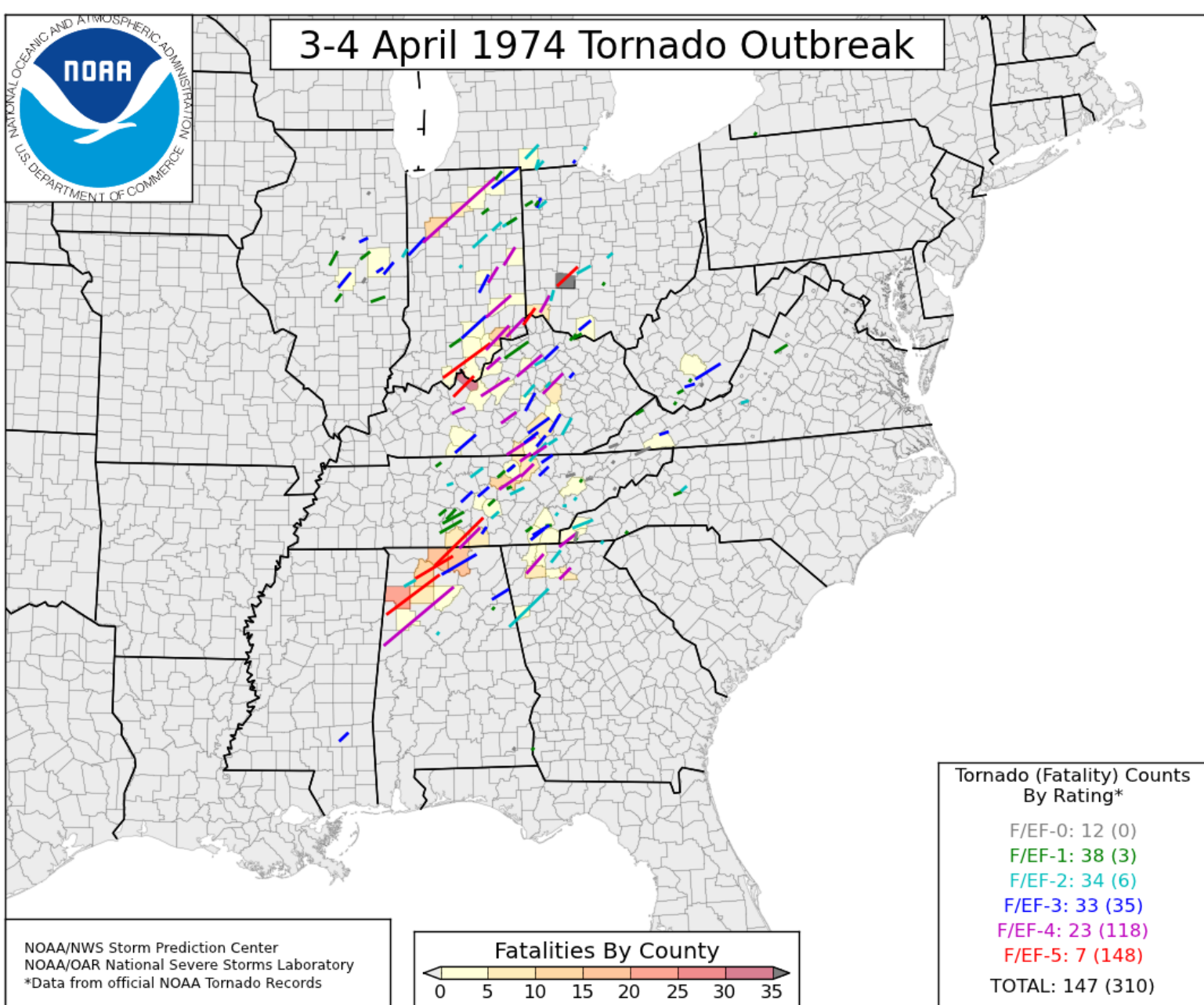
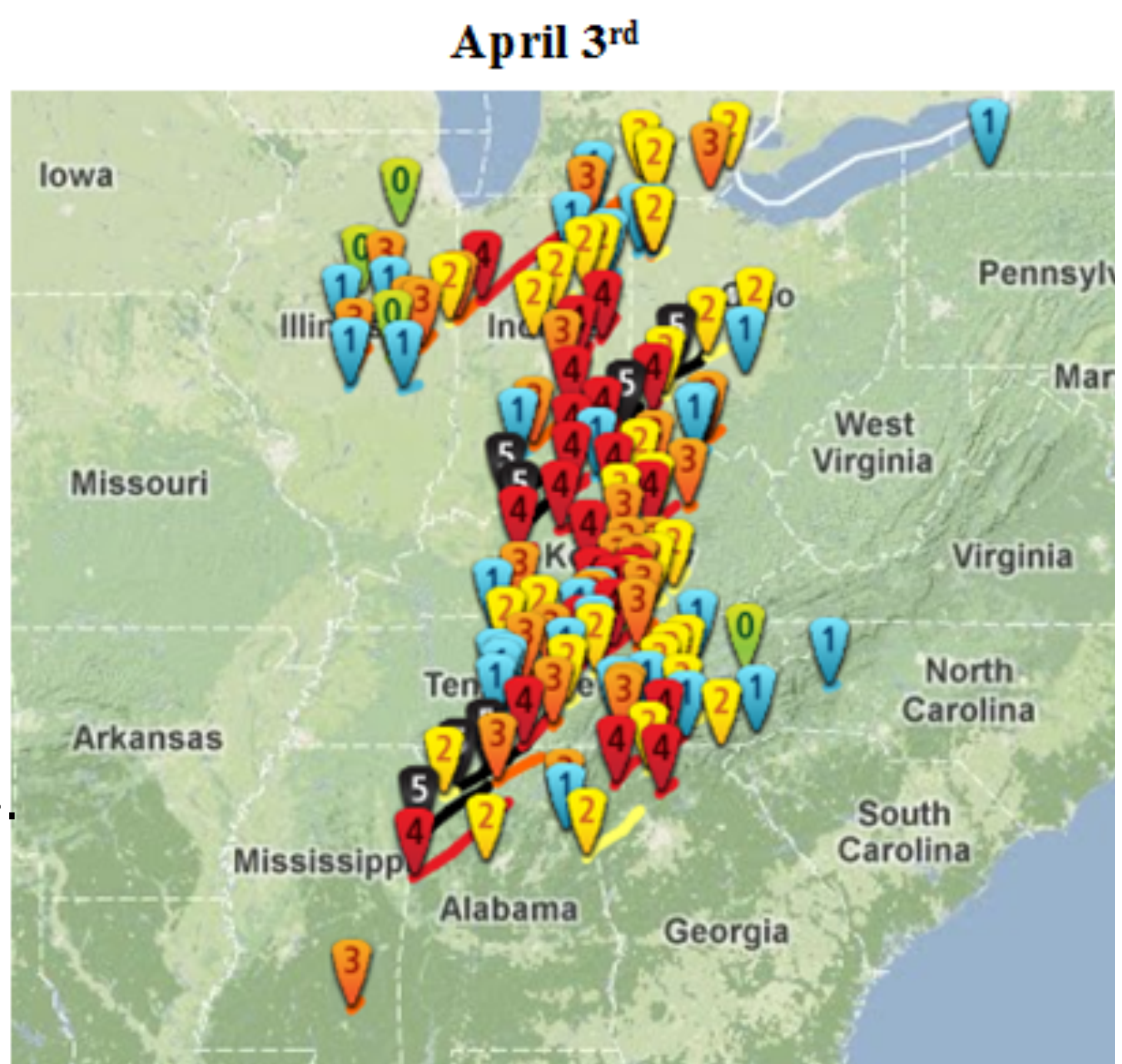
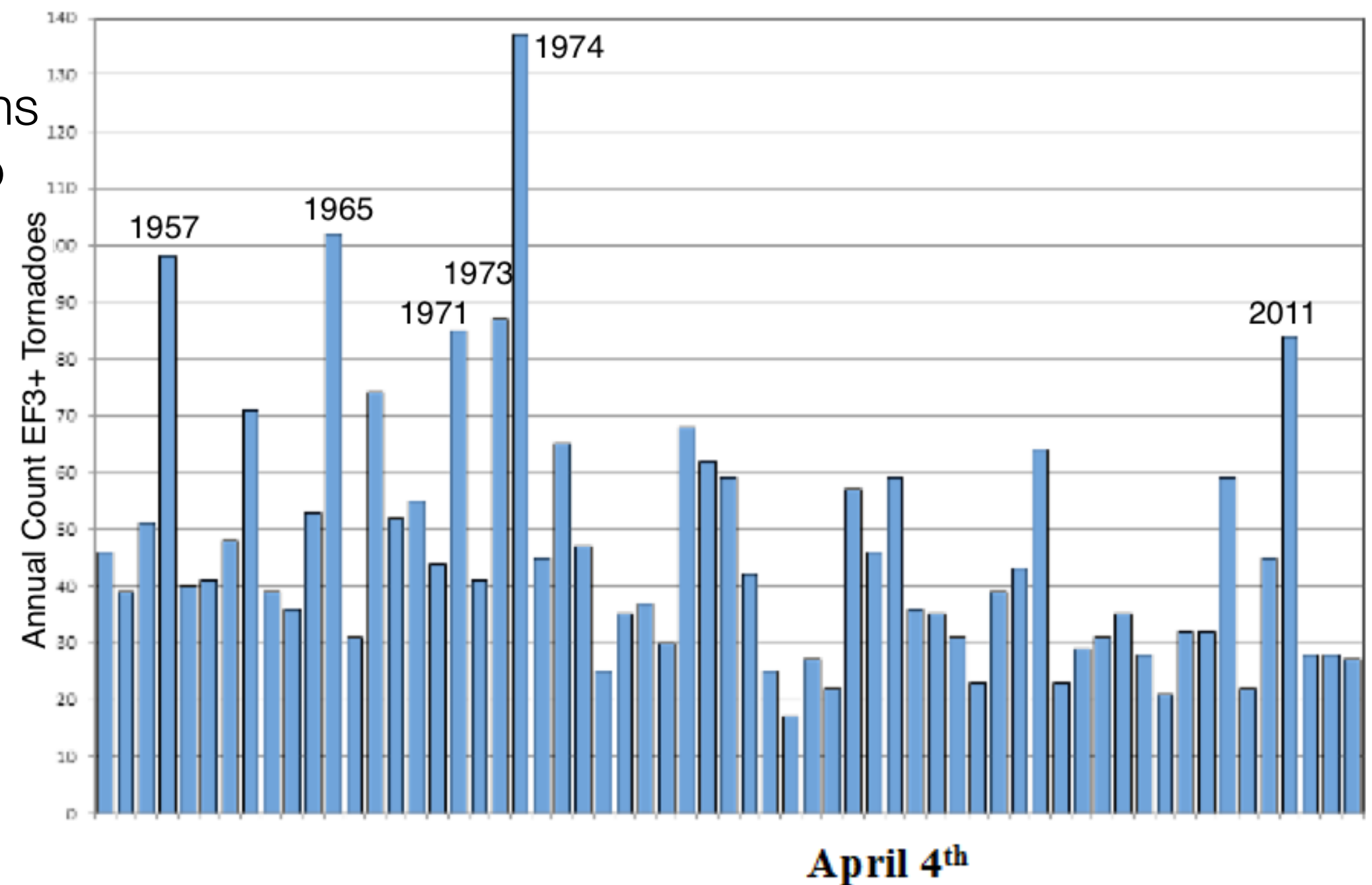
The 1974 Super Outbreak

A Super Outbreak is one in which there is an exceptional number of tornadoes in one day.

Although the April 2011 Super Outbreak now holds the record for the most tornadoes generated in a 24-hour period, a Super Outbreak in 1974 still holds the record for the total number of EF3 and higher-rated tornadoes, and April 3, 1974 holds the record for the number of severe EF4 and EF5 tornadoes in one 18-hour period. Of the 148 tornadoes that occurred across 13 states on April 3 and 4, 1974, on a path covering 4,000 km from Alabama to the Great Lakes region, 23 were EF4 and 7 were EF5 tornadoes. By the time the storm system had dissipated, almost 5,500 people had been injured and 330 killed, with northern Alabama suffering the worst number of fatalities. An excellent summary of the 1974 Super Outbreak is available at https://en.wikipedia.org/wiki/1974_Super_Outbreak.

Tornado touchdowns in the eastern U.S.A. on April 3, 1974. Left: Number/color indicates EF rating. Right: Tornado tracks for April 3 and 4, 1974: blue = EF3; magenta = EF4; red = EF5.

Annual count of EF3 and higher tornado touchdowns in the U.S.A. from 1954 to 2014.

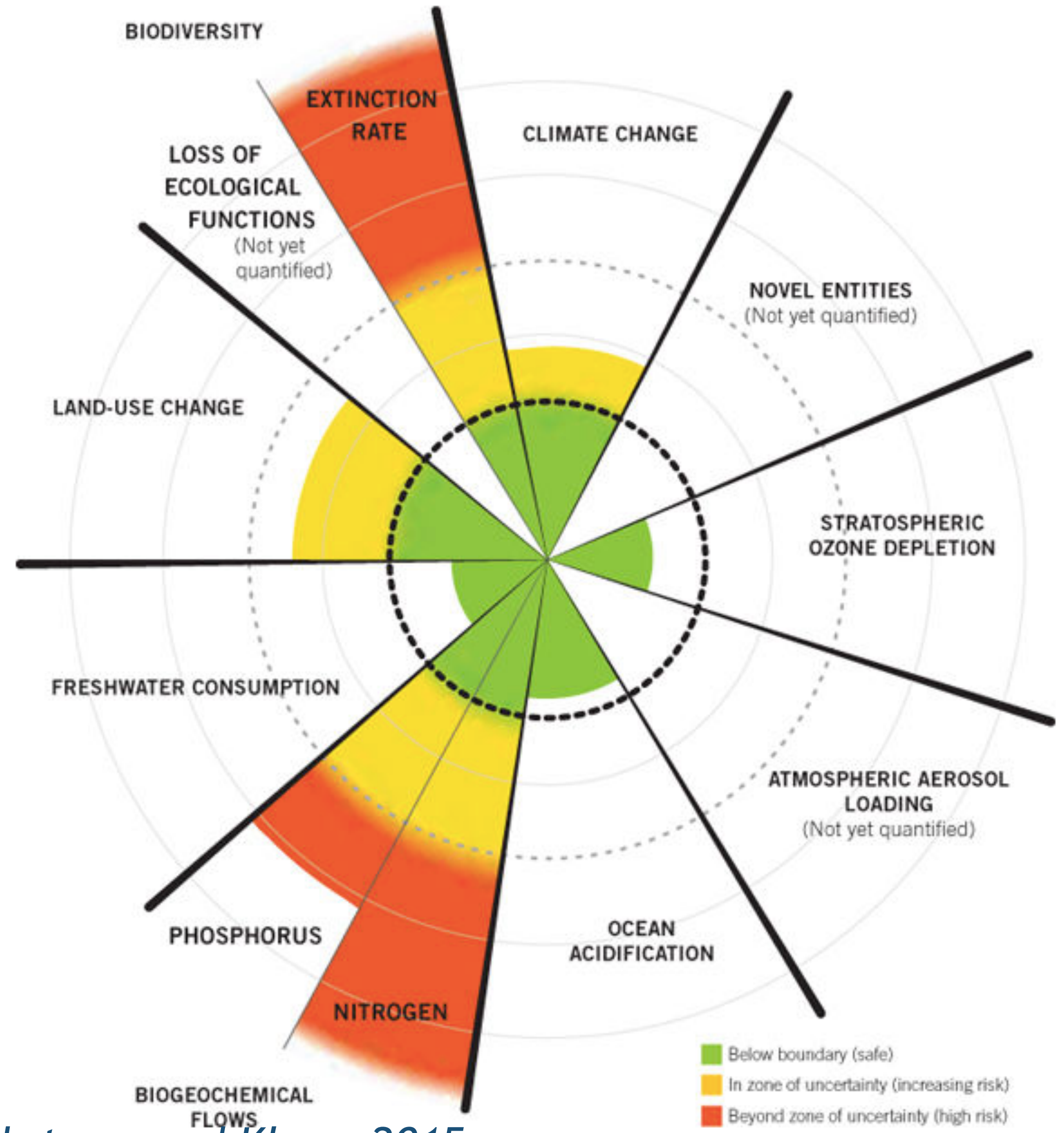


The Diagnosis: Leaving the “Safe Operating Space”

Impacts on the Earth’s Life-Support System

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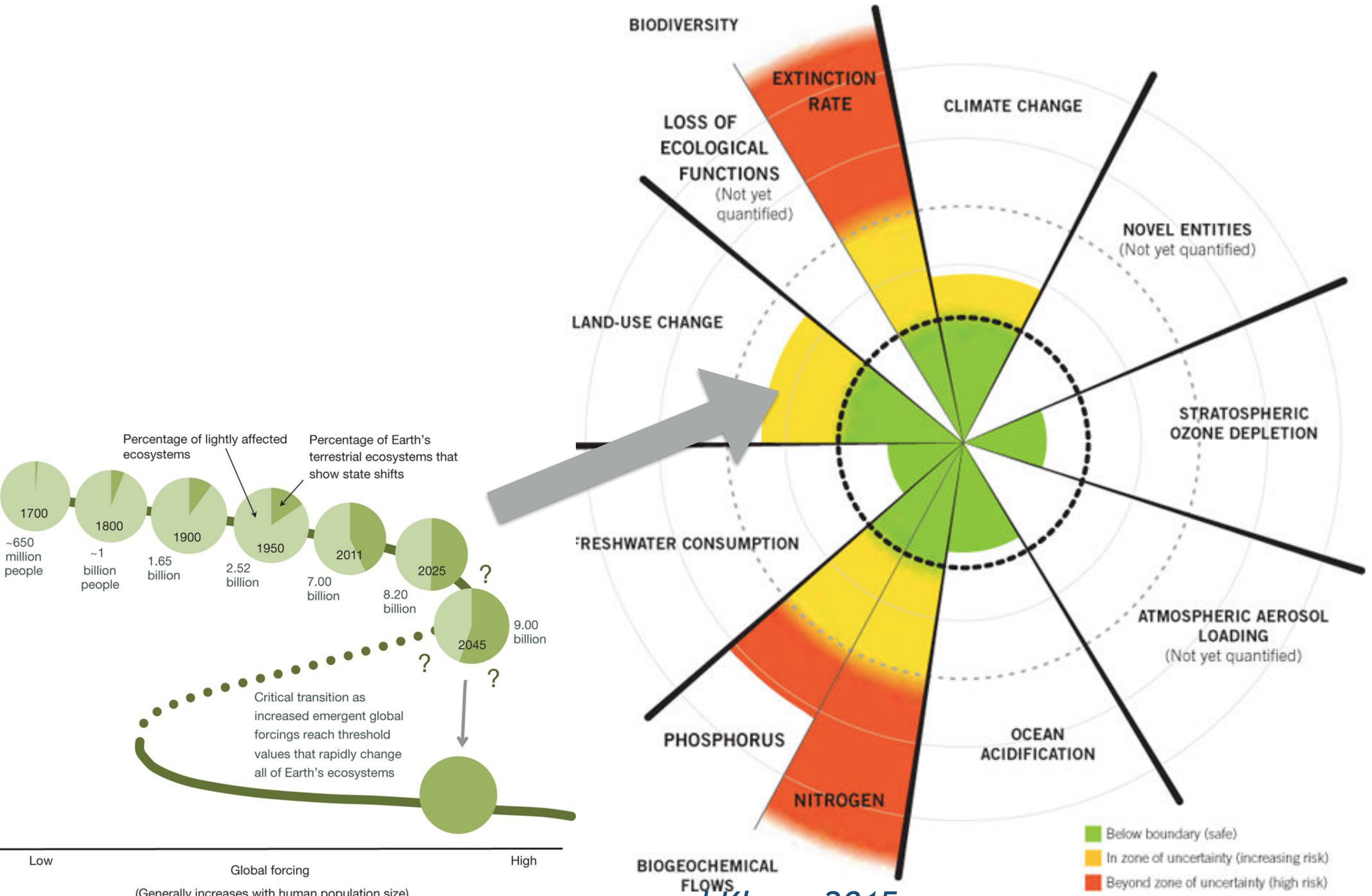
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Rockstrom and Klum, 2015

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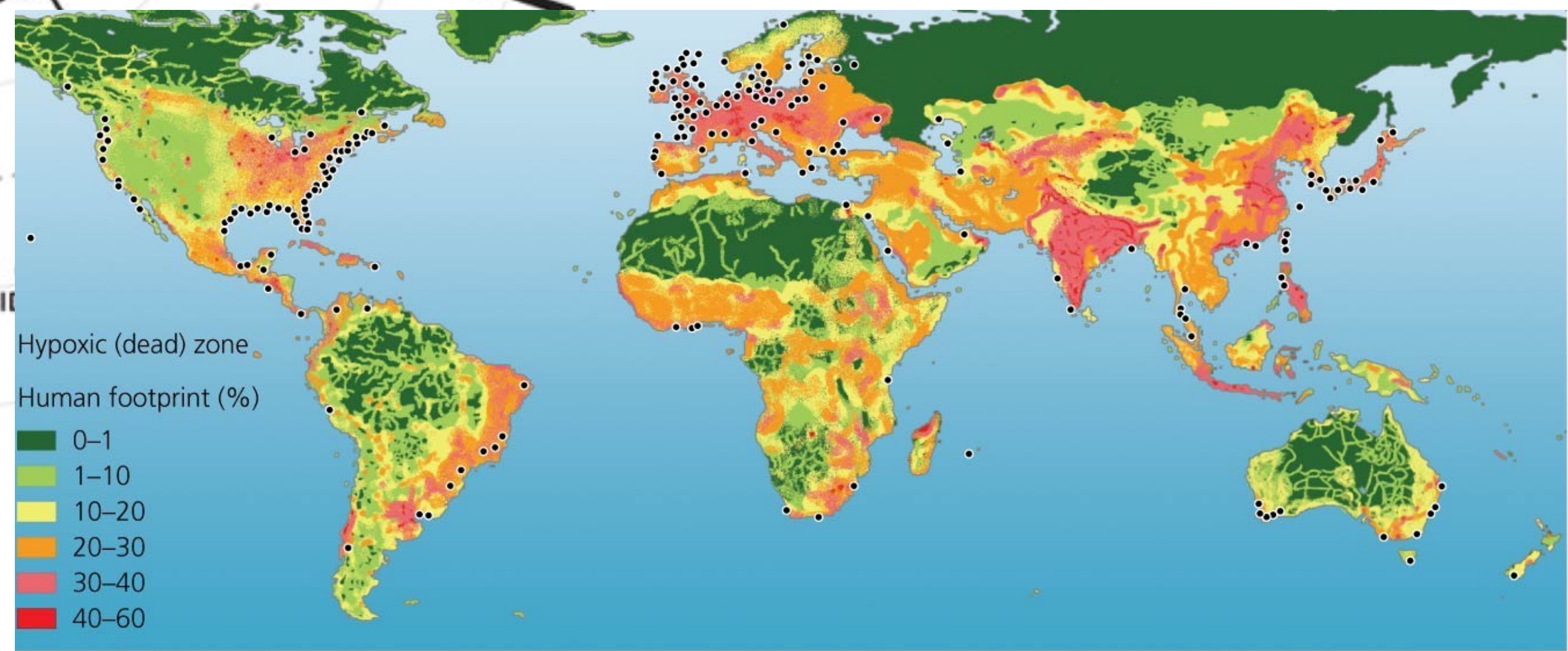
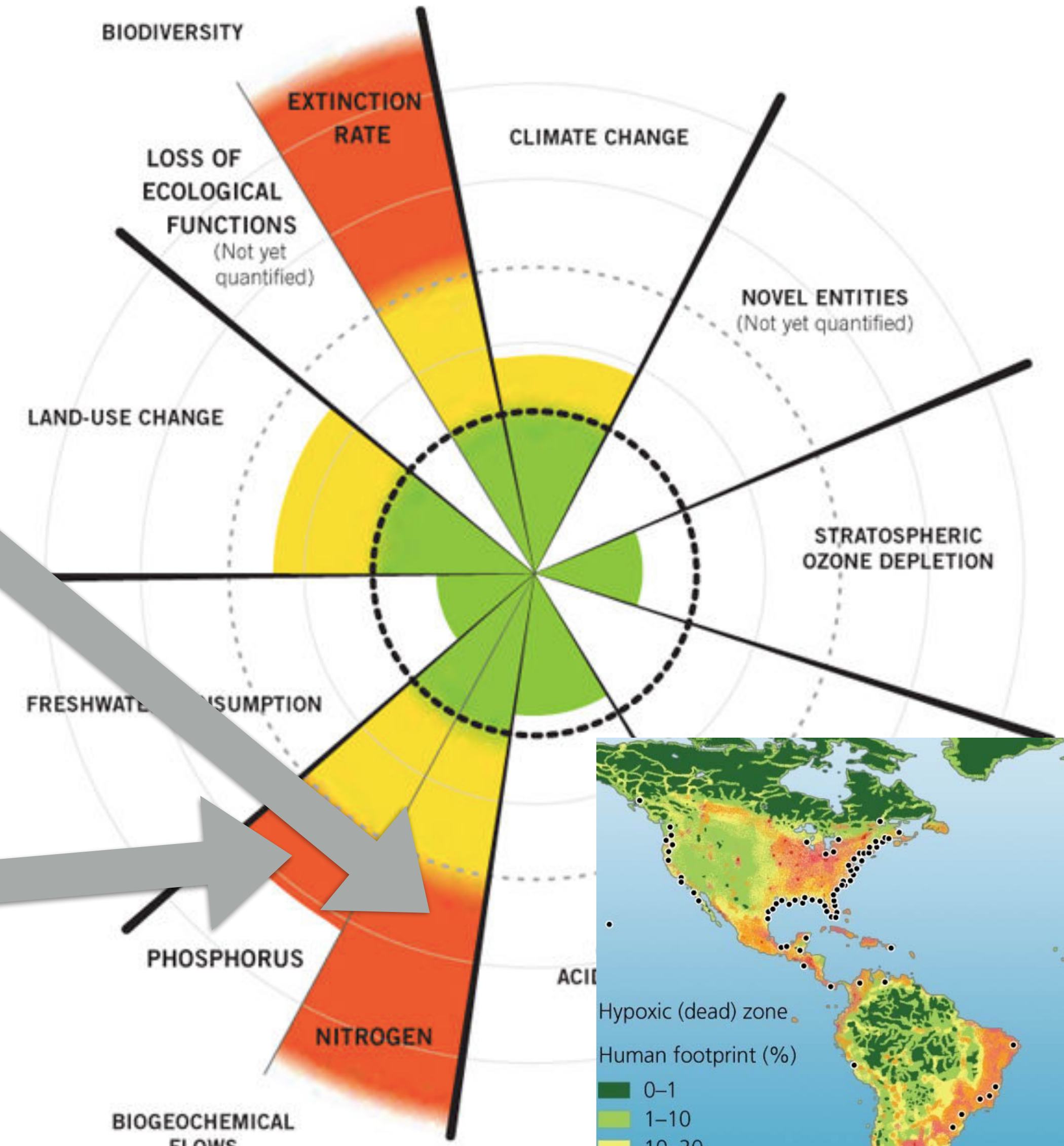
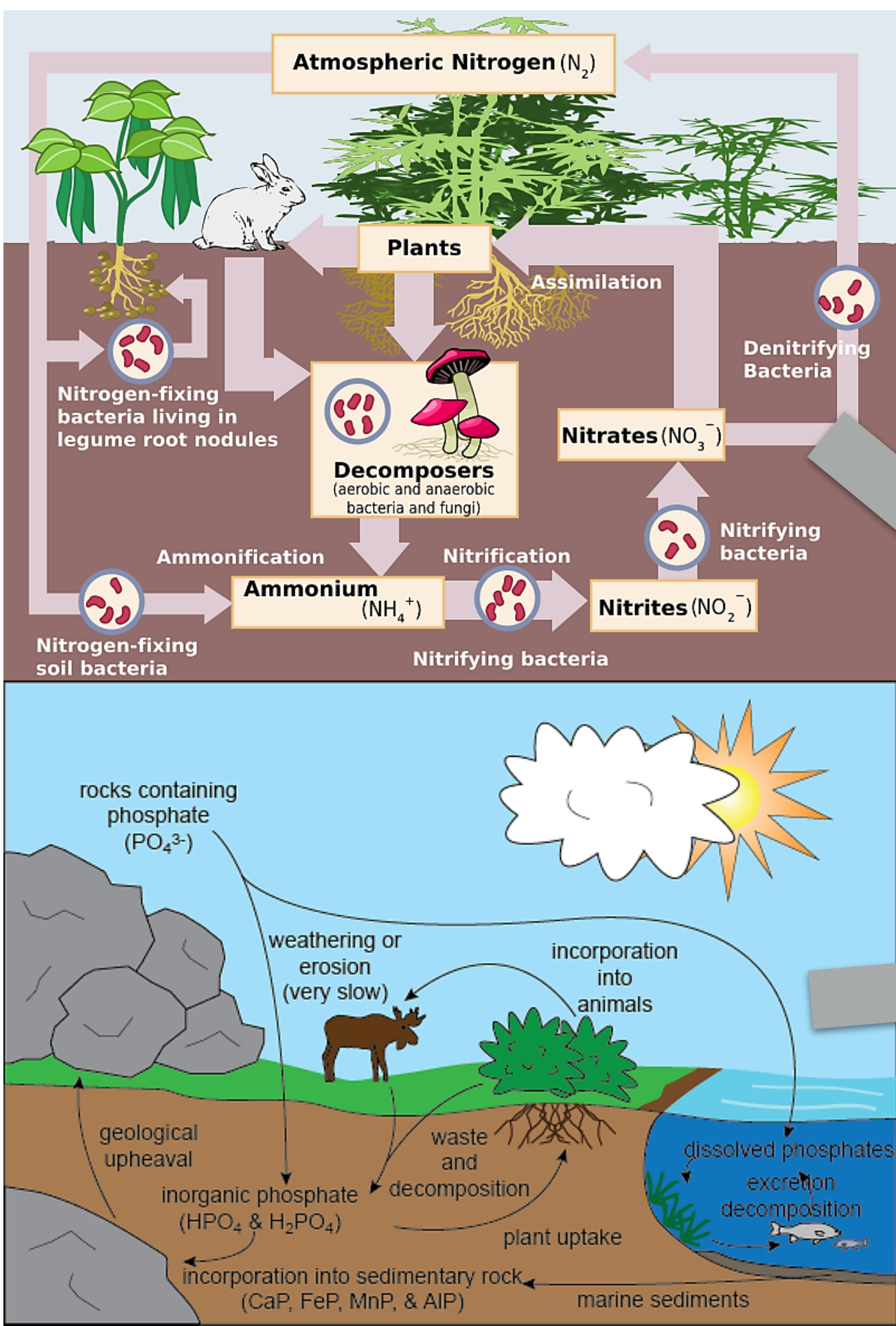
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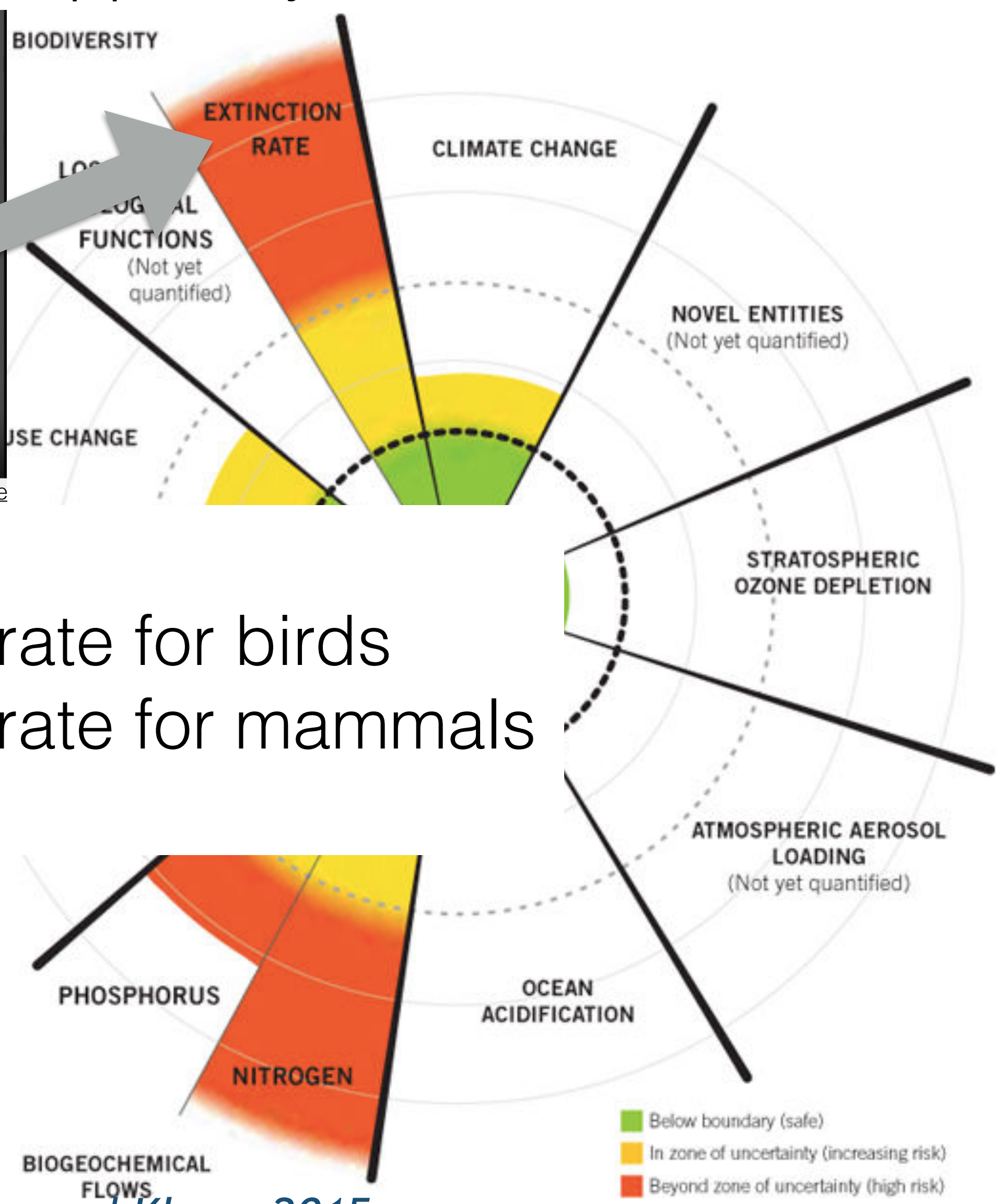
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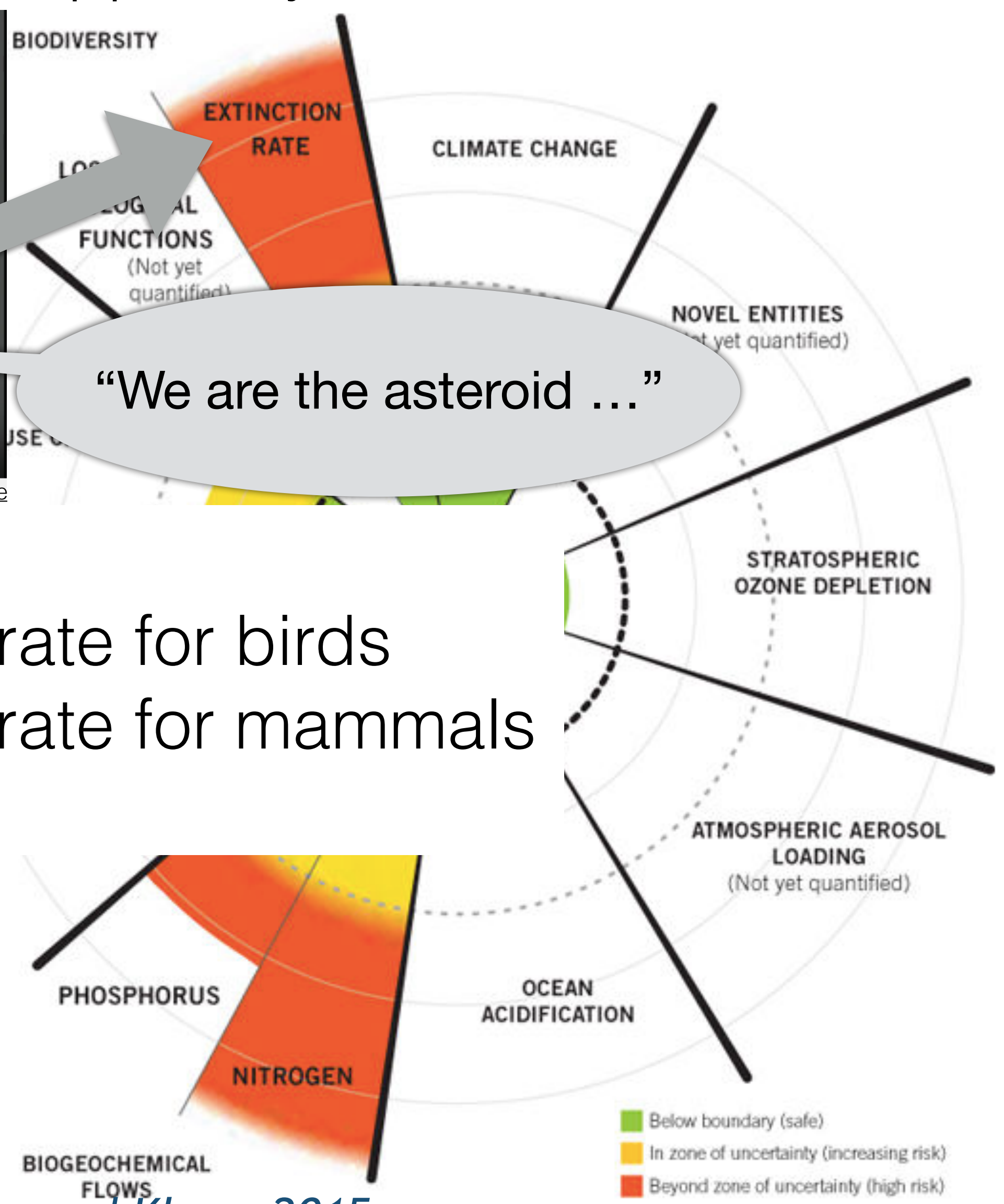


Current extinction rates:
300 times background rate for birds
80,000 times background rate for mammals

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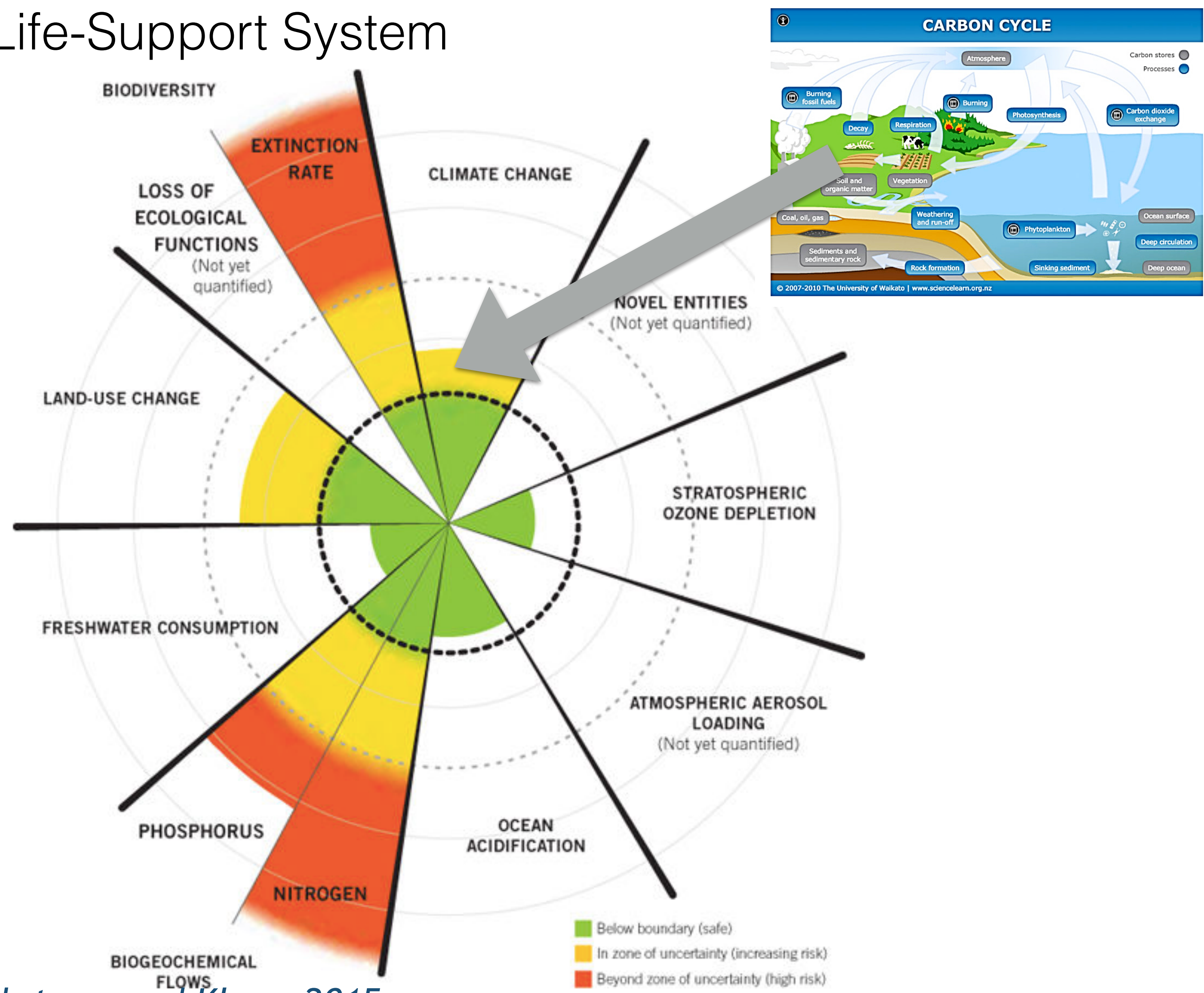
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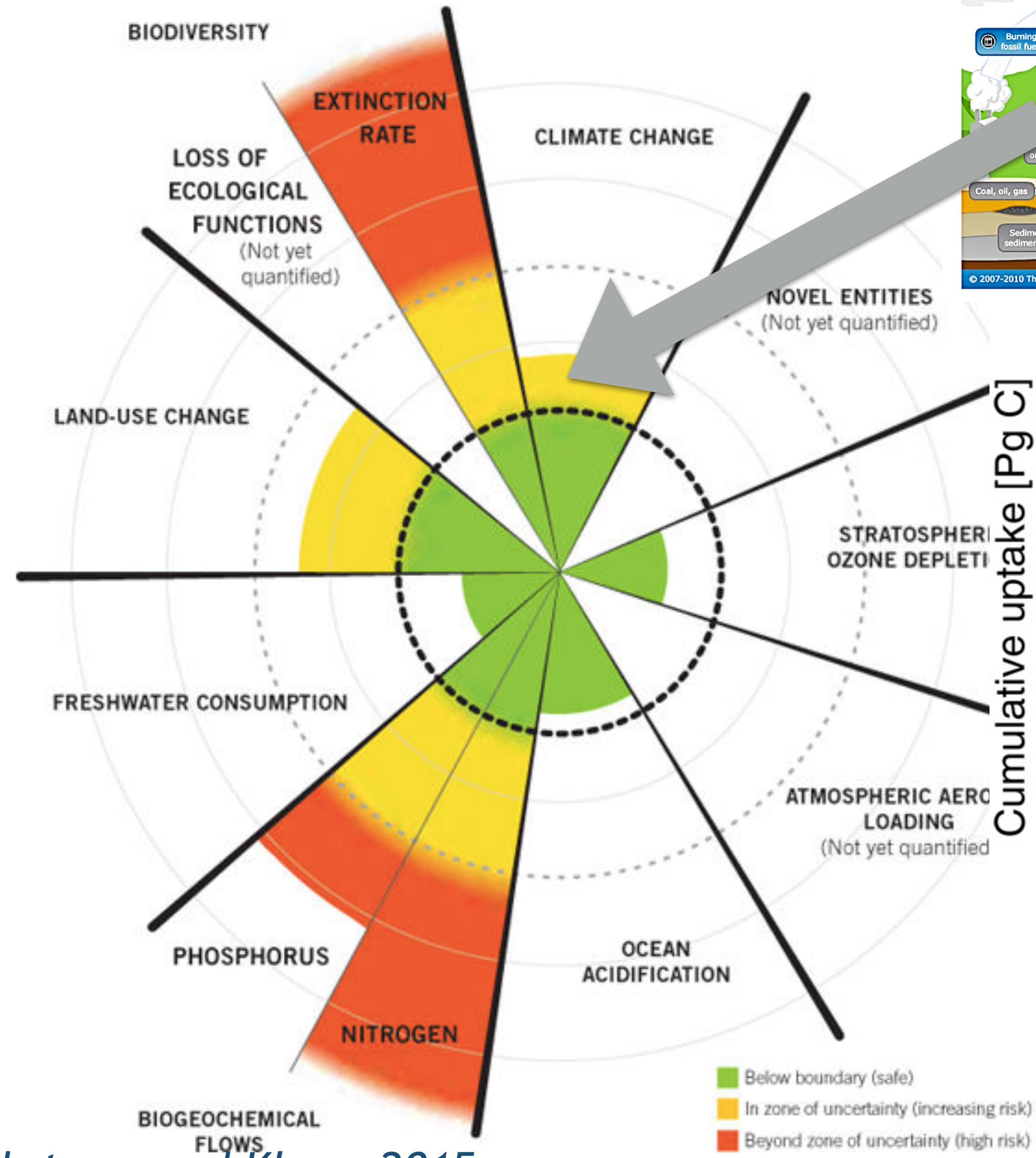
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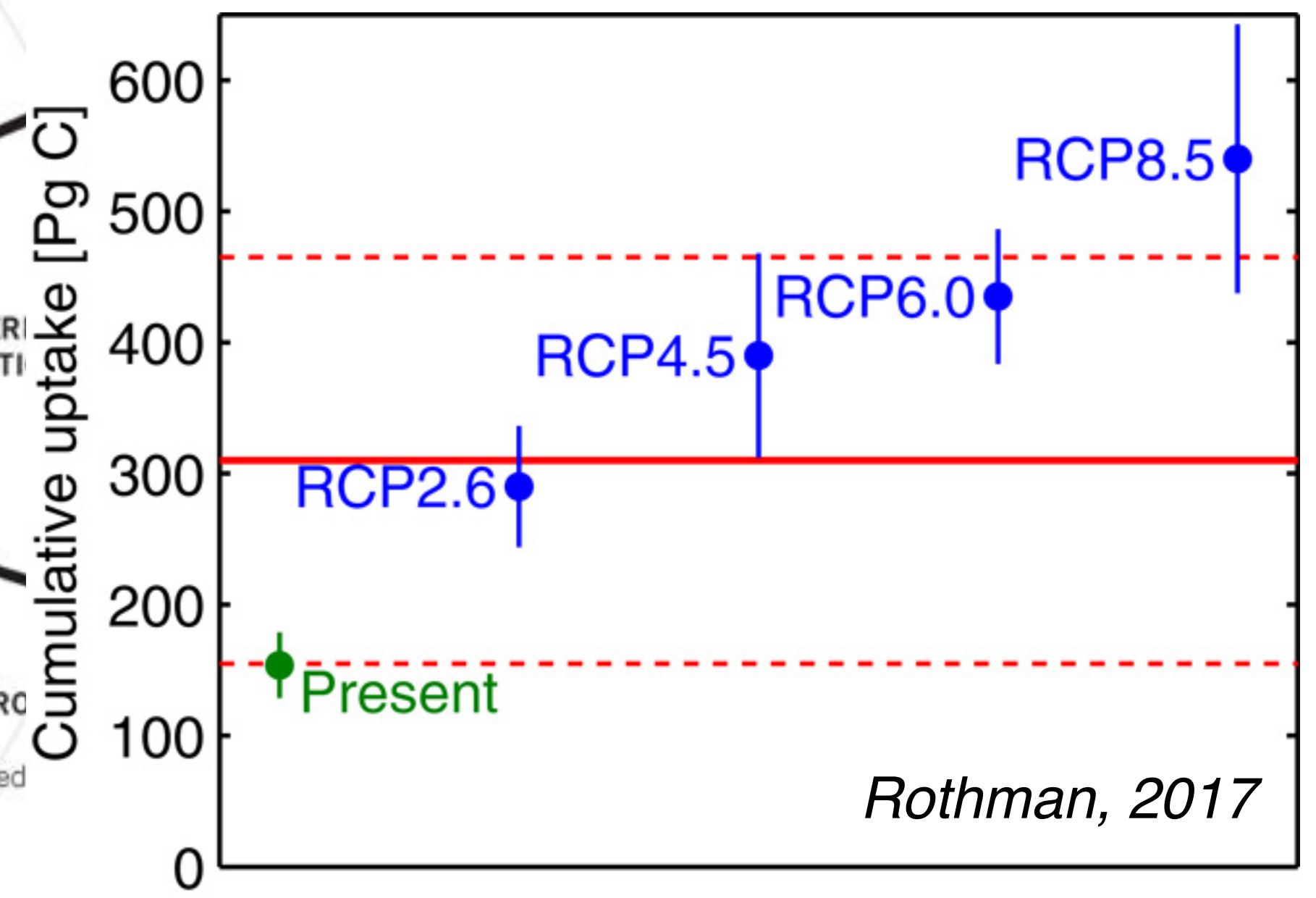
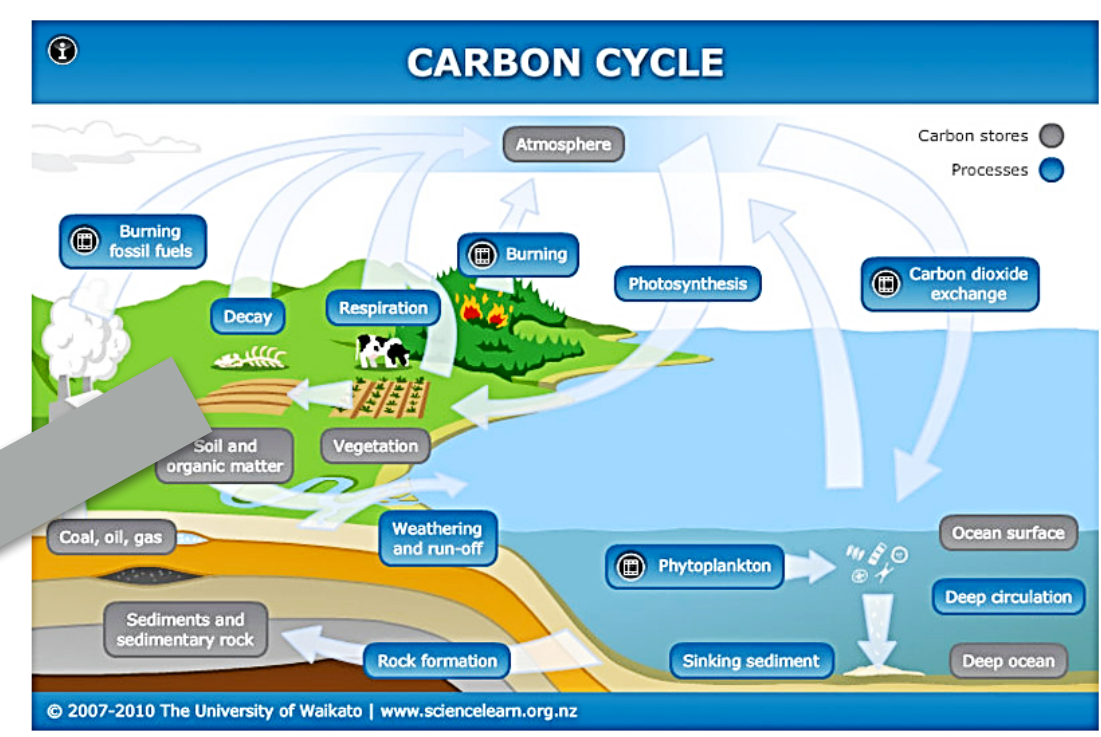
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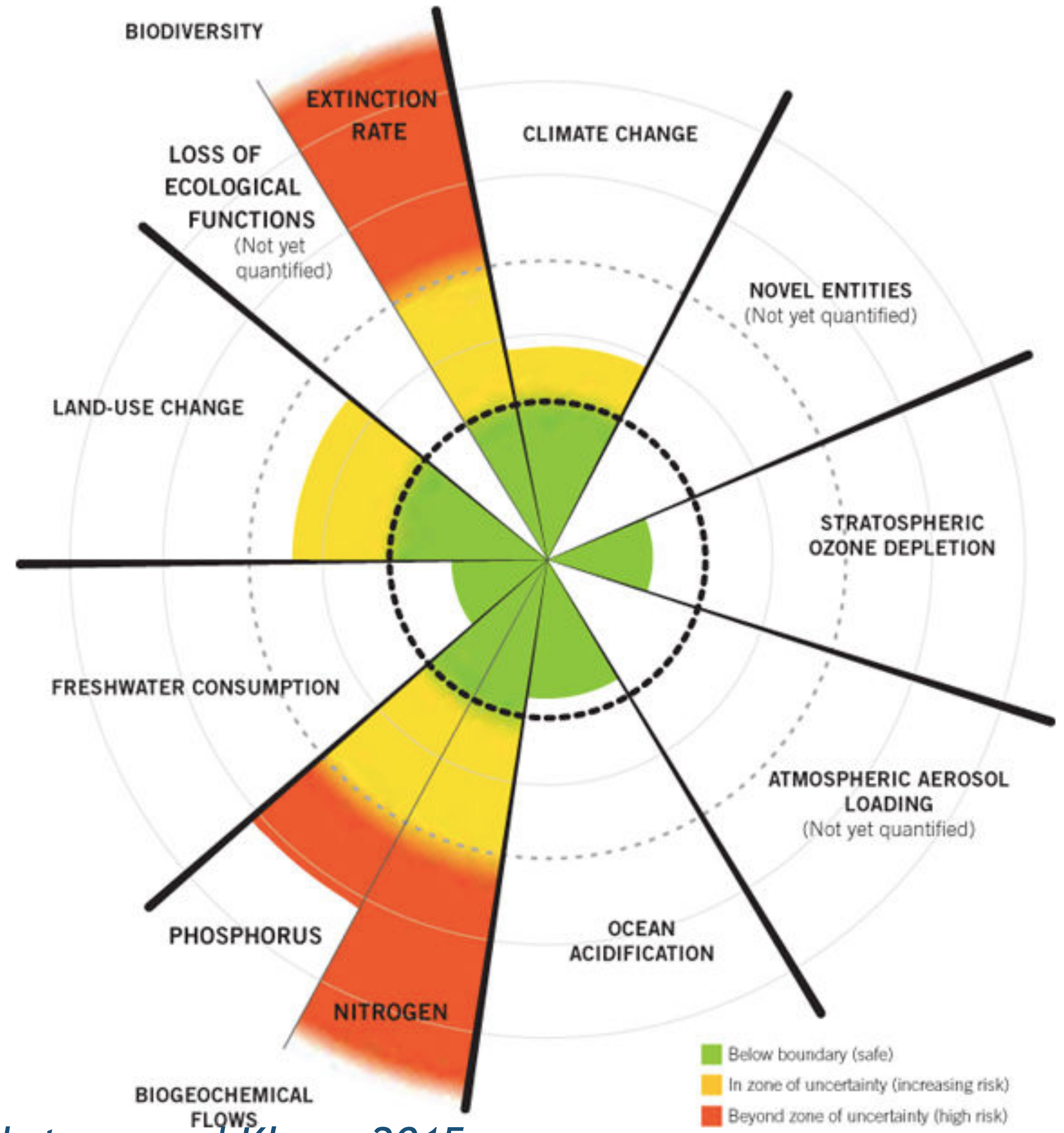
Rockstrom and Klum, 2015



Rothman, 2017

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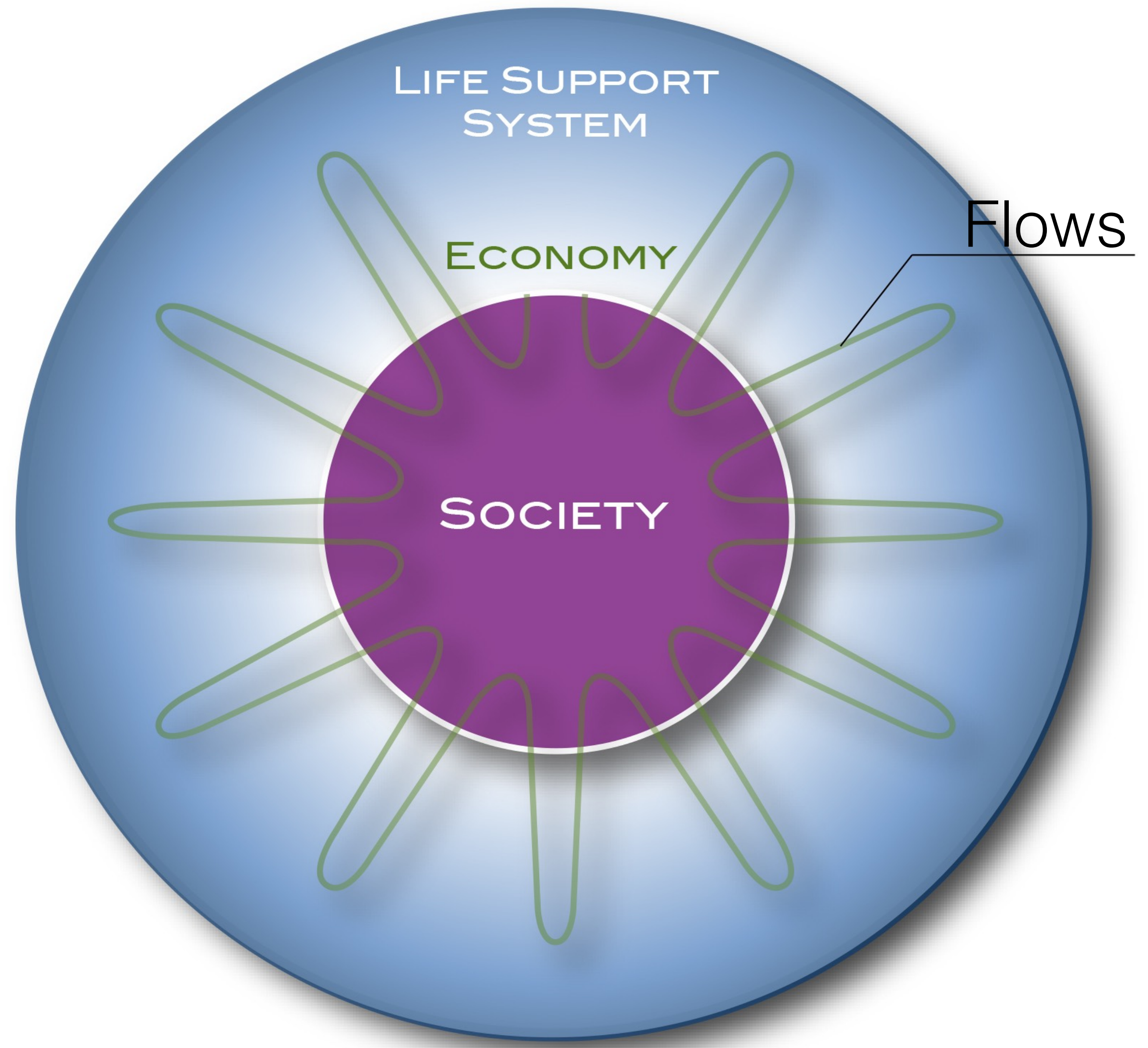


Rockstrom and Klum, 2015

Modern climate change is a symptom, not the cause, not the “sickness.”

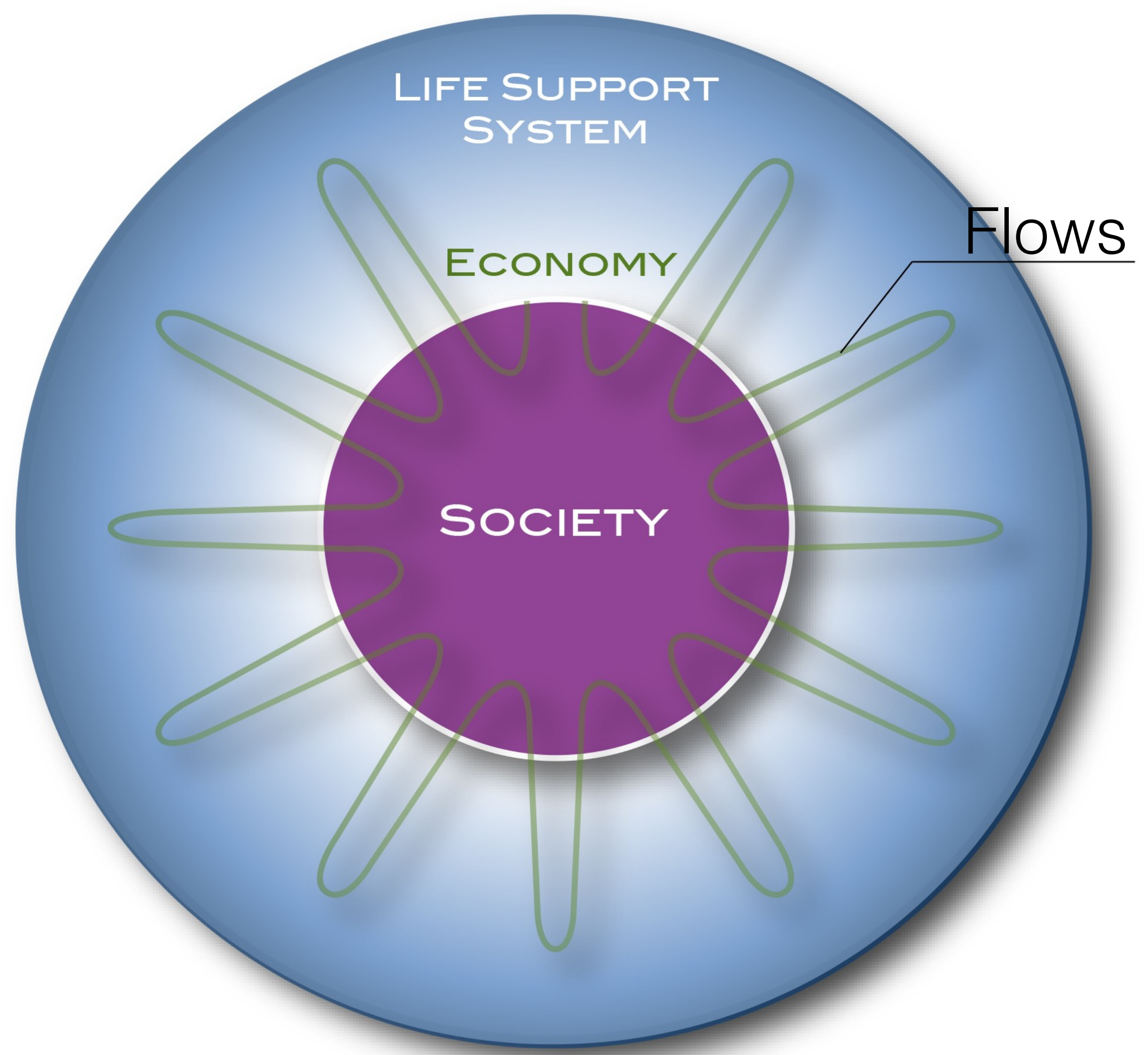
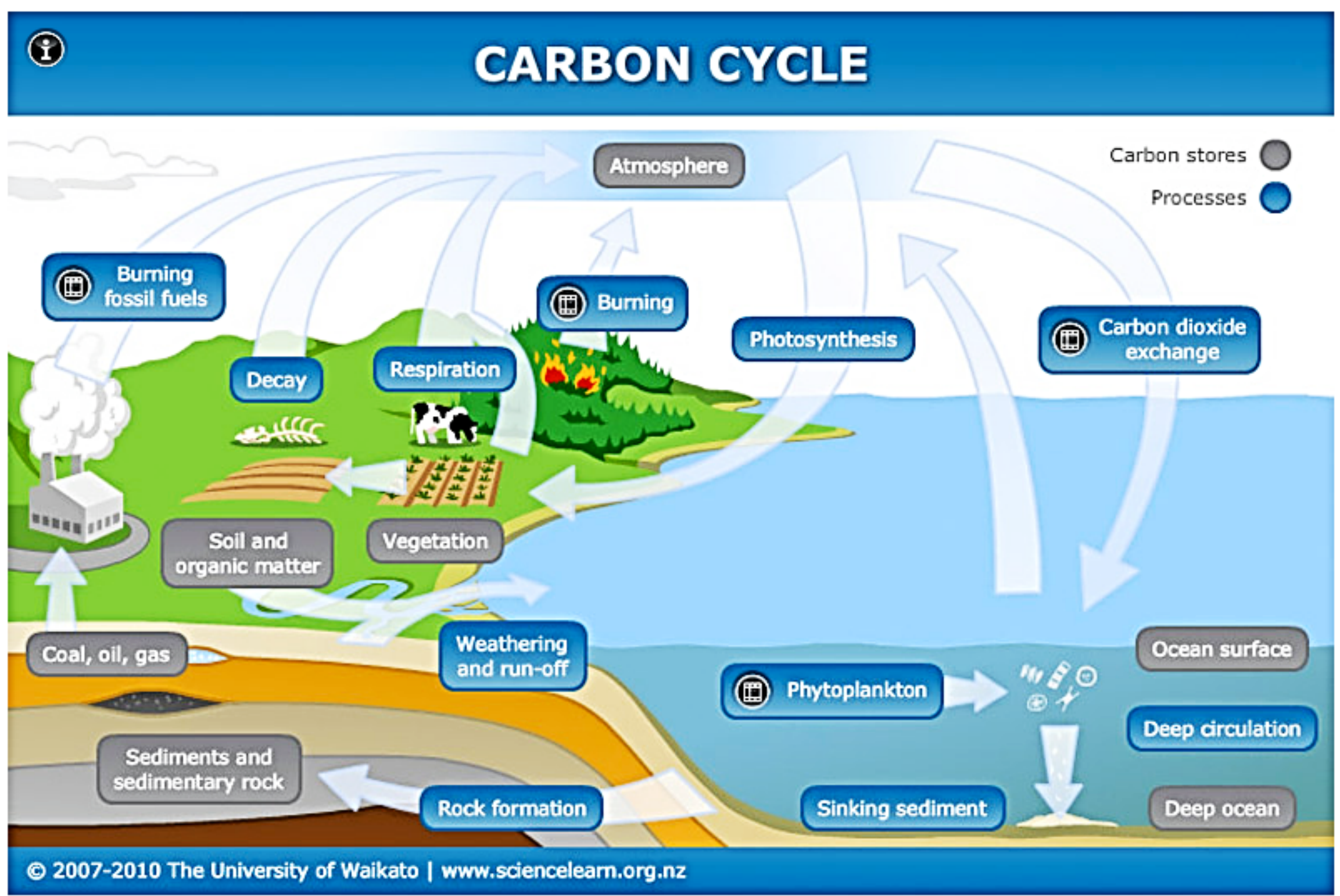
Prognosis: Journey into the Unknown

Physiology of the Life-Support System: Flow



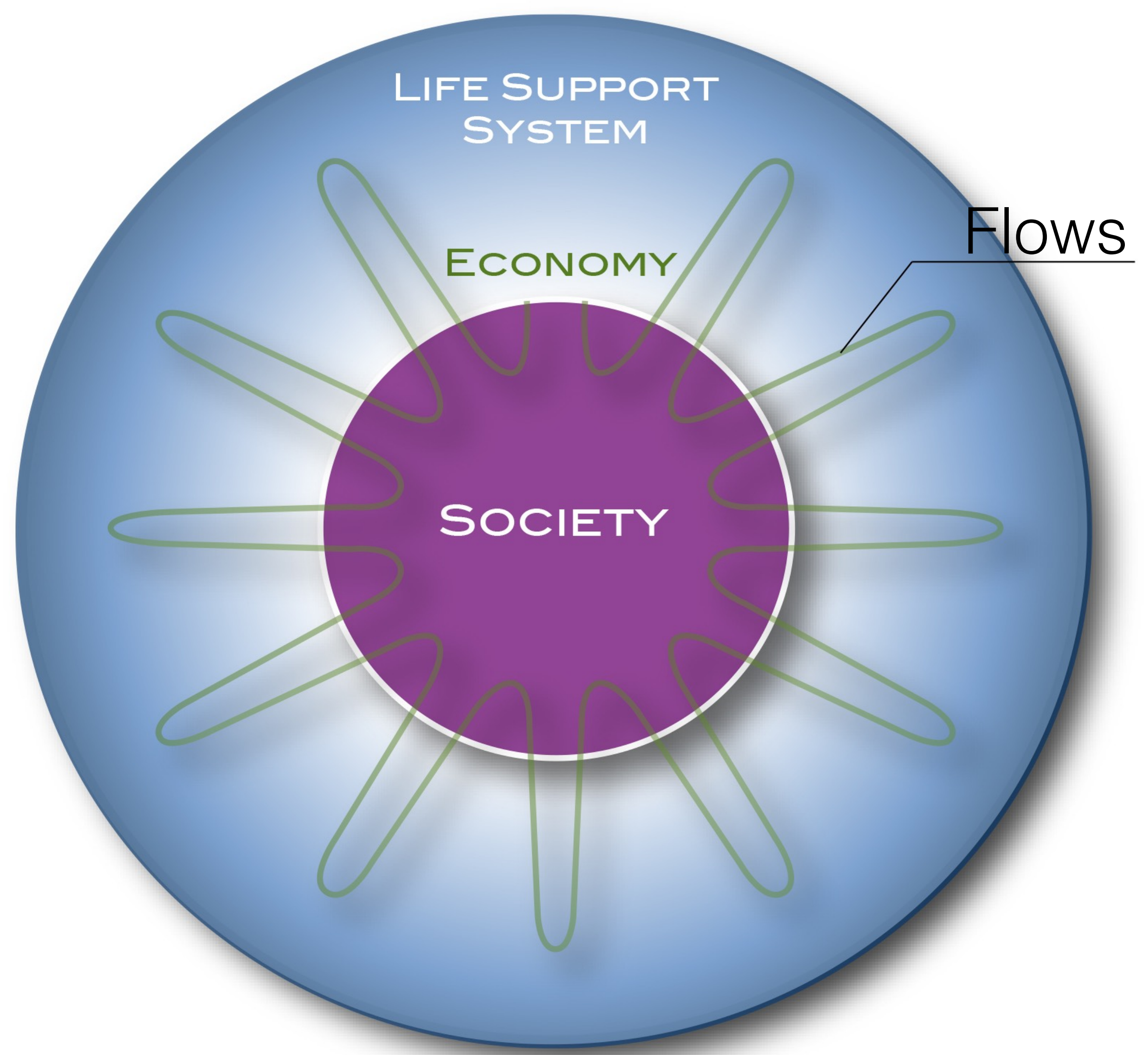
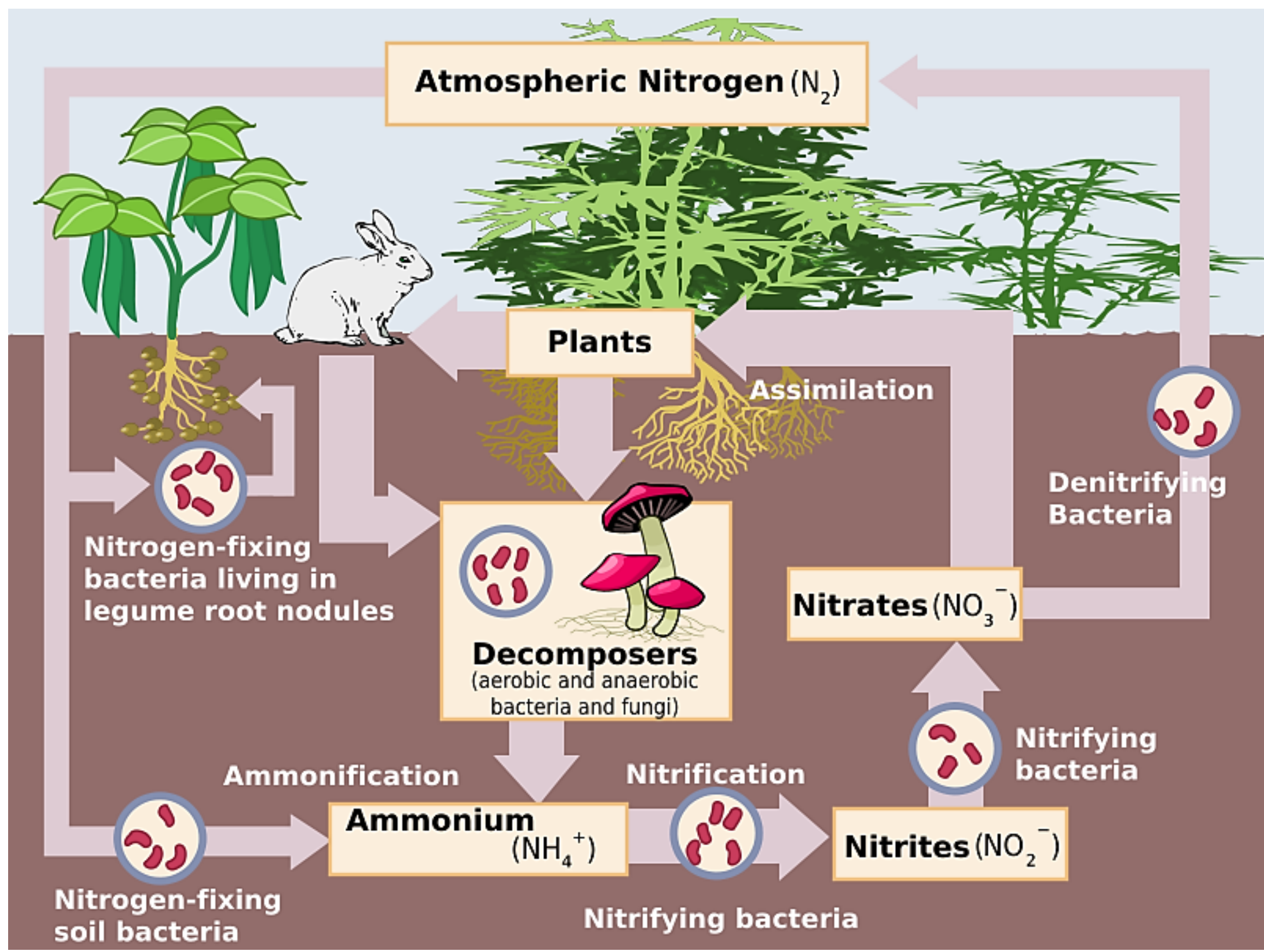
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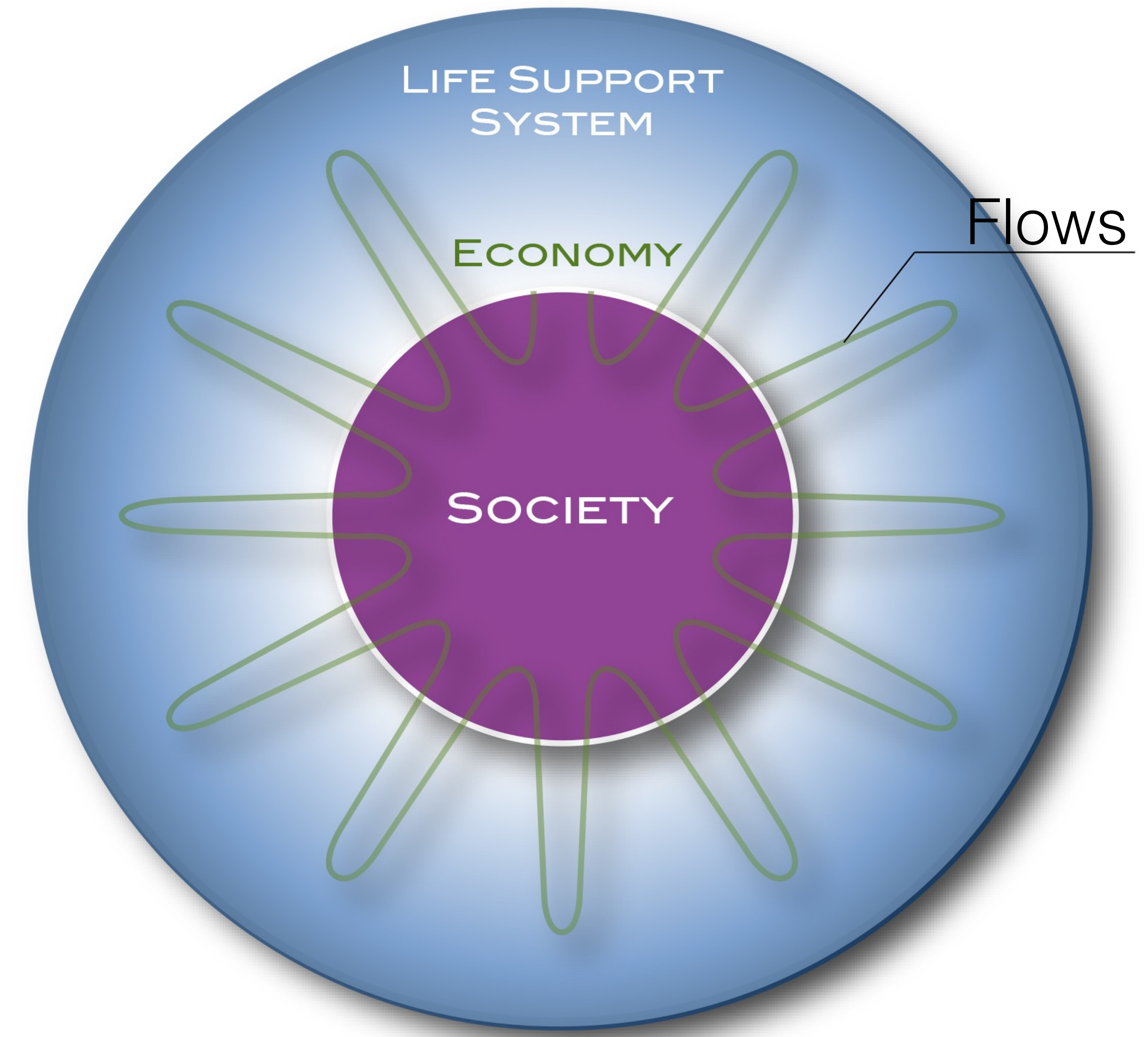
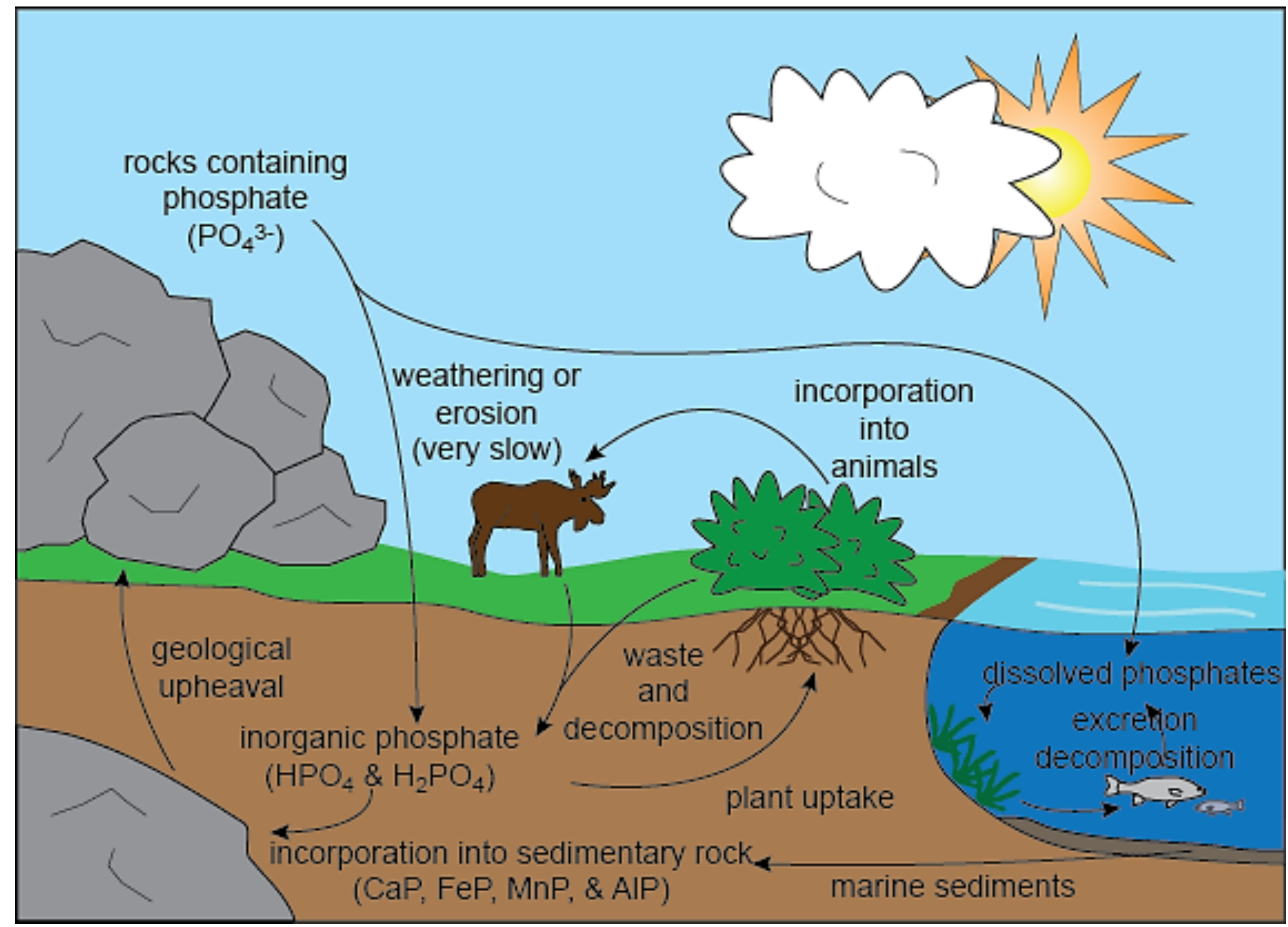
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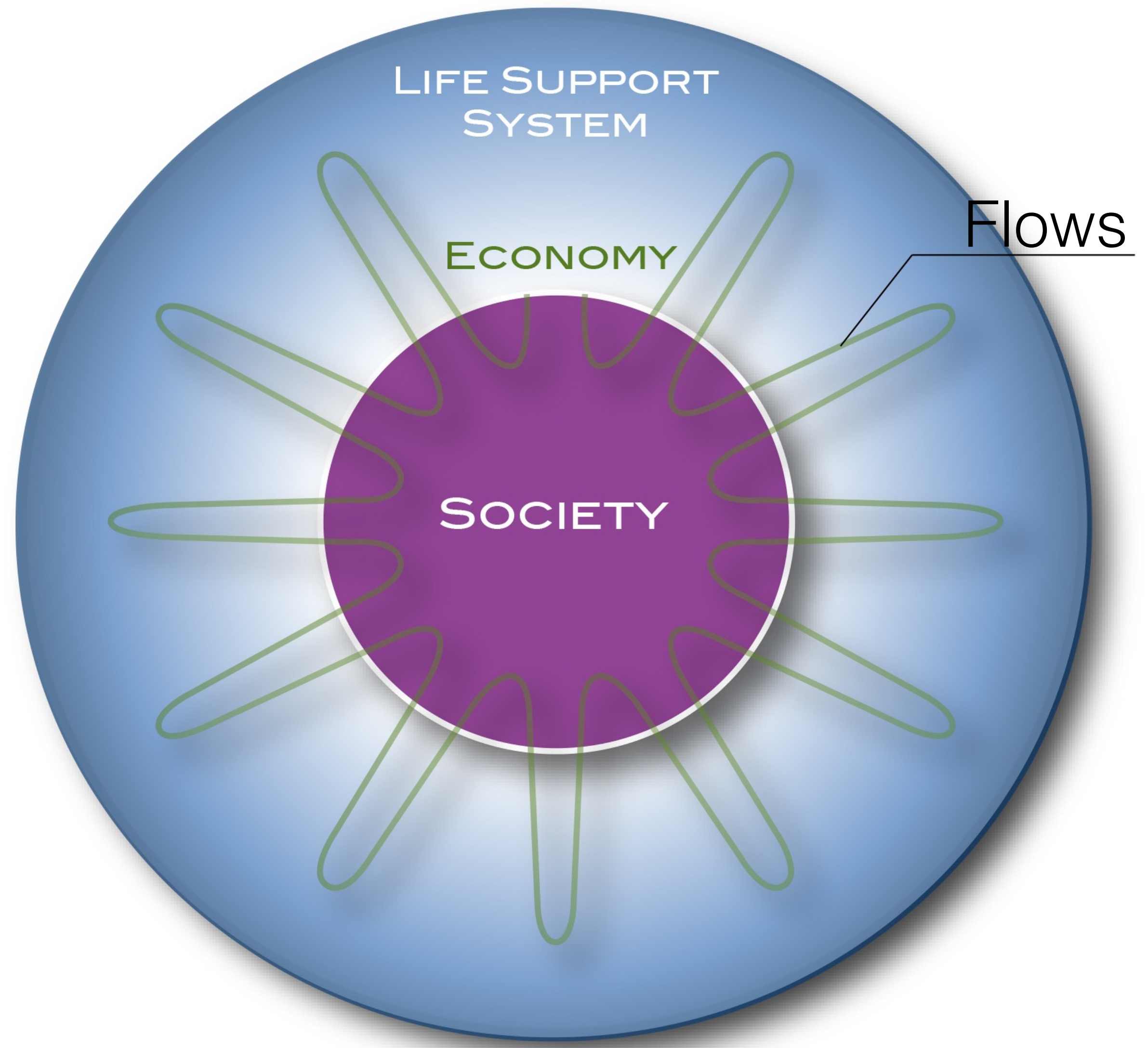
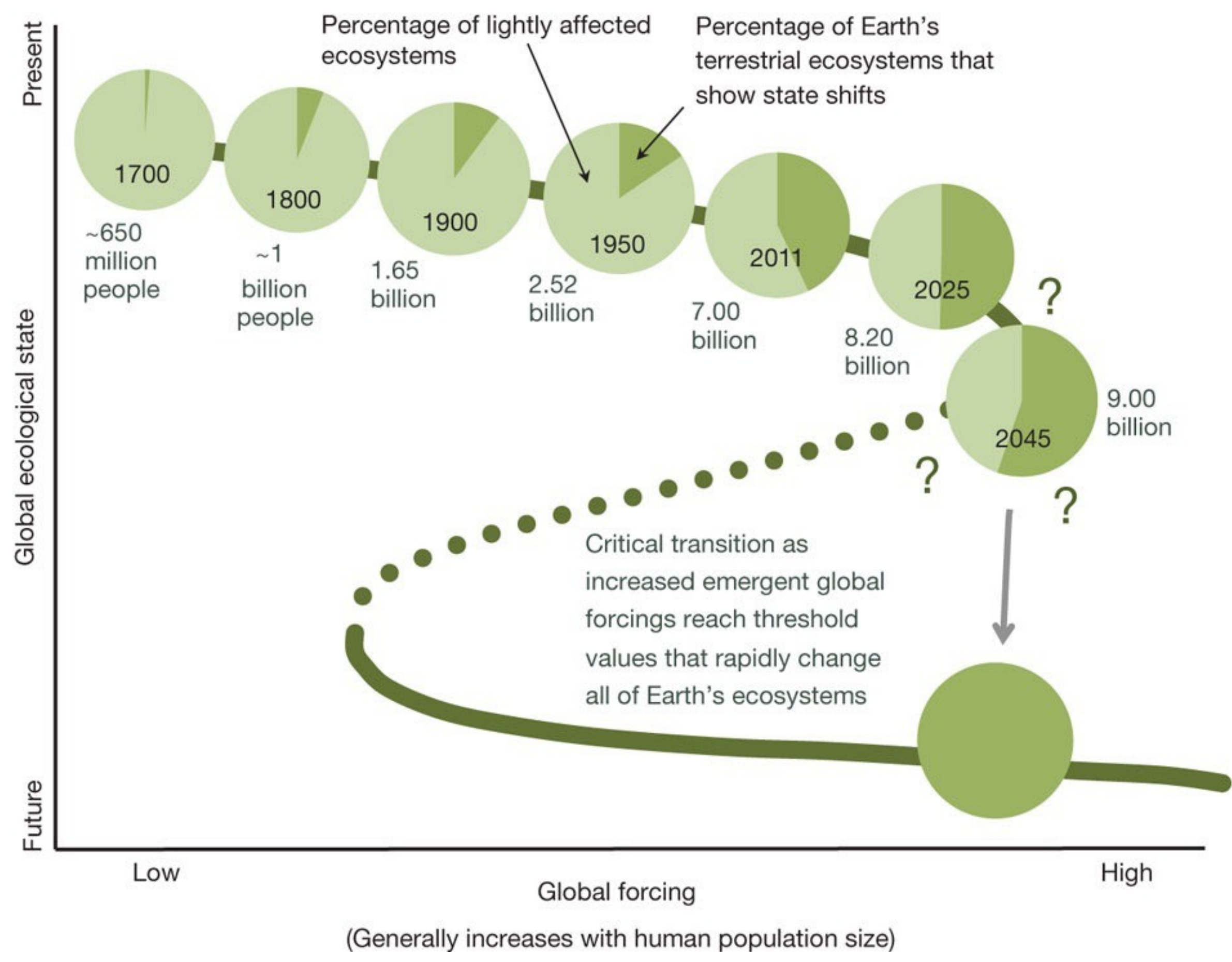
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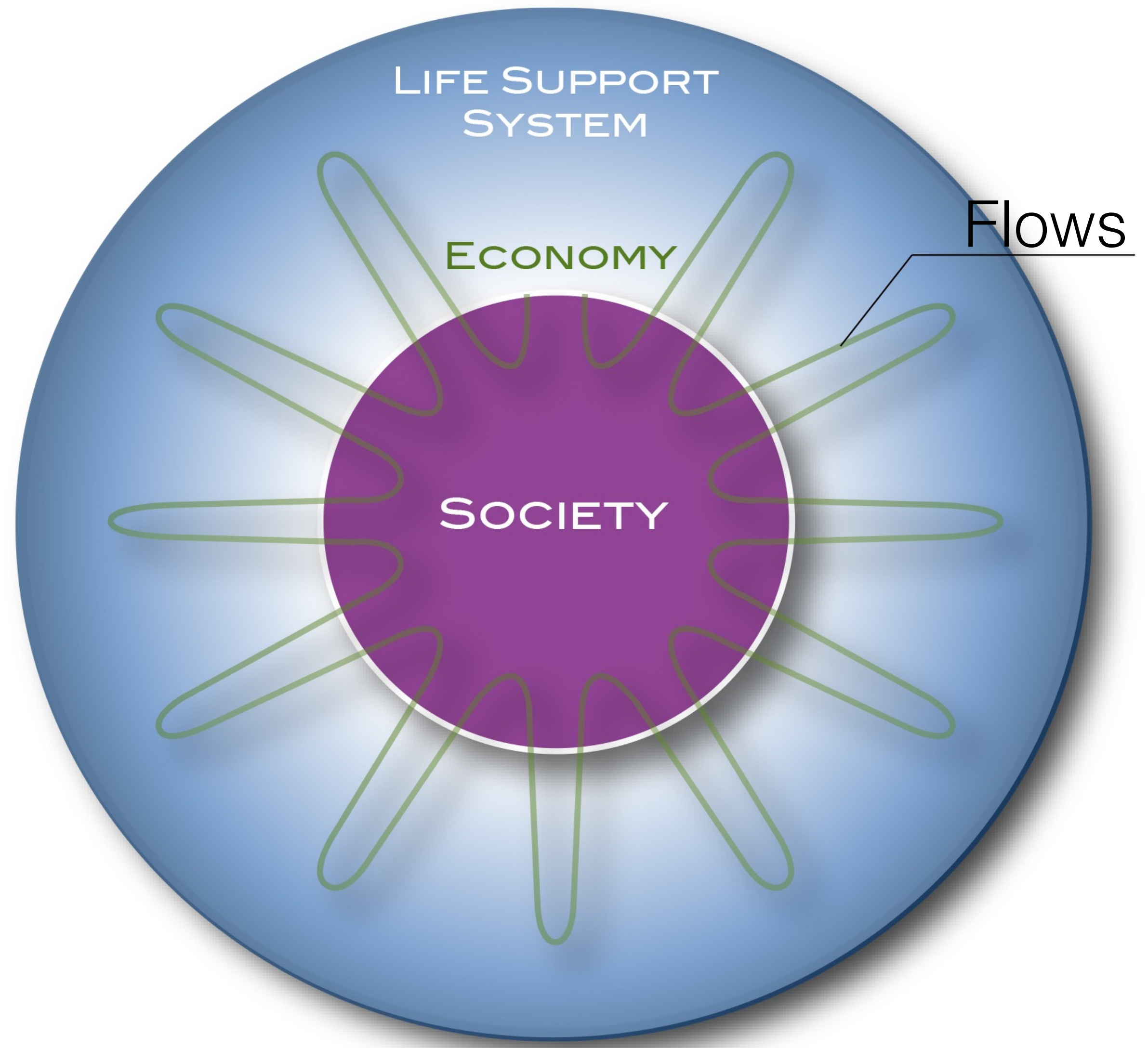
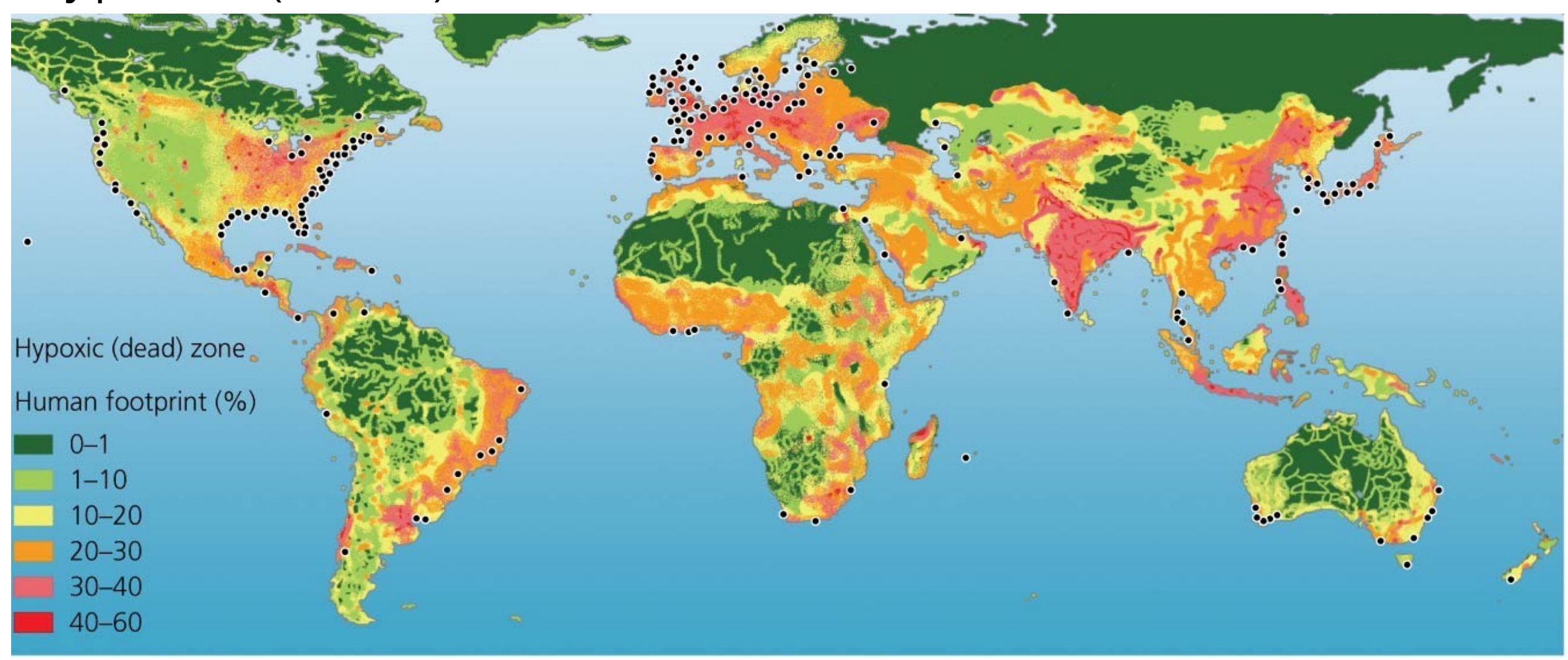
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Hypoxic (dead) zones

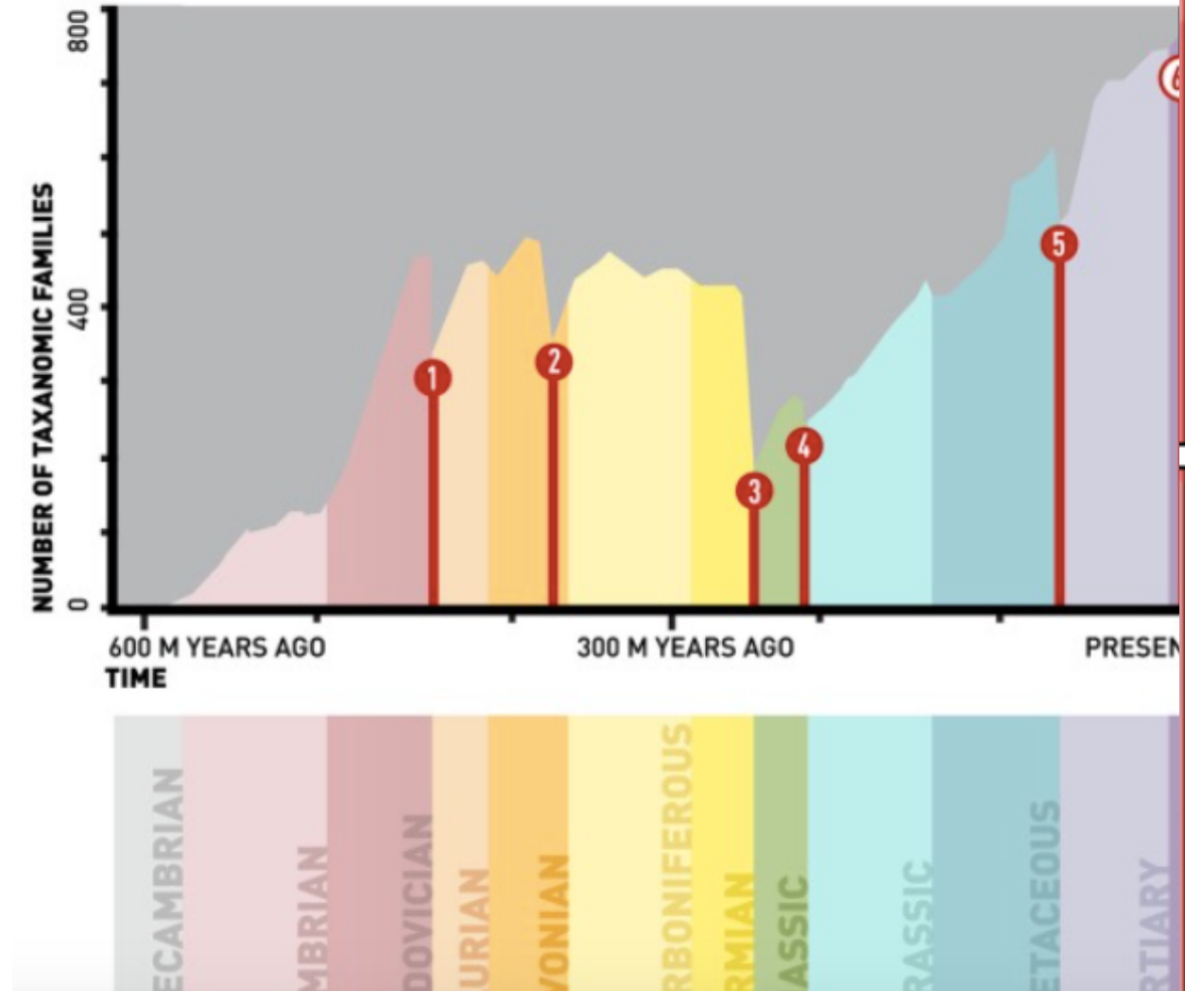


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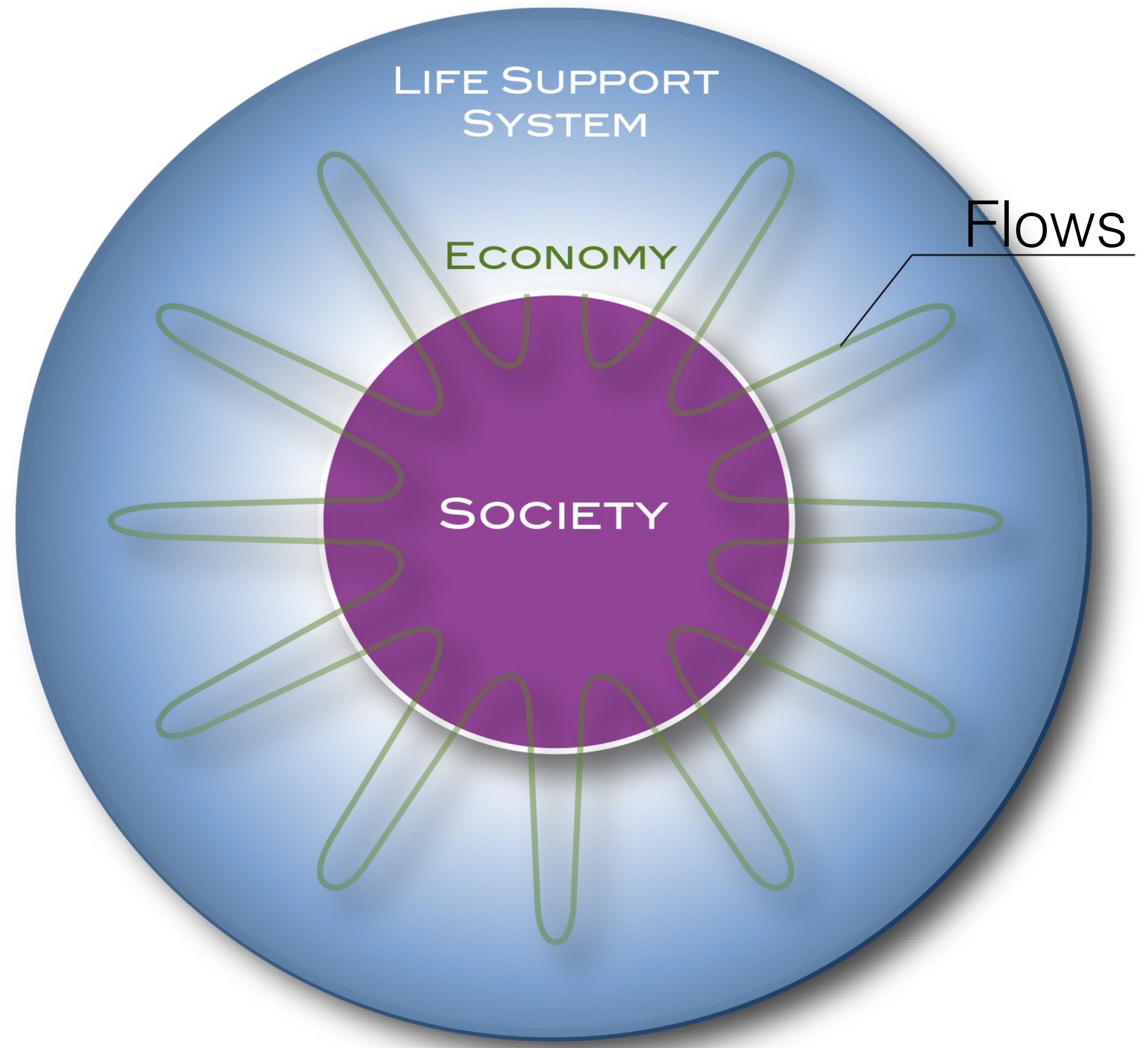
DEEP DIVE: MASS EXTINCTIONS

BY JULIE ROSSMAN & CLARE SMITH MARASH

World Science Festival
worldsciencefestival.com



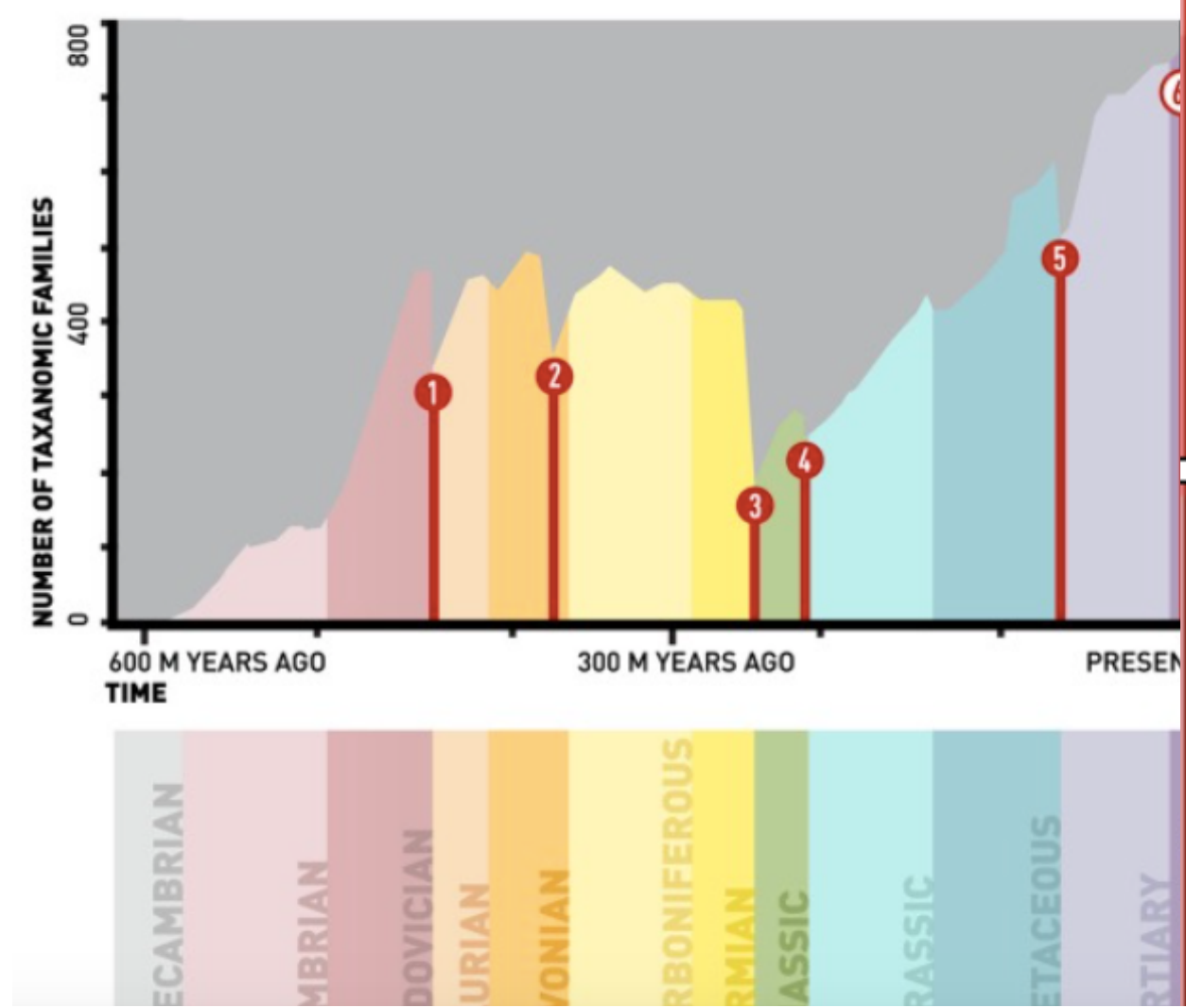
END ORDOVICIAN	<p>1</p> <p>85% of living organisms lost</p> <p>WHAT HAPPENED: Glaciation followed by a rebound of a greenhouse climate.</p> <p>HARD-HIT GROUPS: TRILOBITES, BRACHIOPODS, BRIGIDIAKS, ECHINODERMS, GRAPTOLITES</p>
LATE DEVONIAN	<p>2</p> <p>70% of all marine species lost</p> <p>WHAT HAPPENED: Lack of oxygen in the oceans, rising sea levels, and global cooling.</p> <p>HARD-HIT GROUPS: REEF ENVIRONMENTS, OSTRACODERMS & PLACODERMS, STROMATOPORIDS, RUGOSA & TABULATA, TRILOBITES (SHARK)</p>
END PERMIAN (THE GREAT DYING)	<p>3</p> <p>96% of all species lost</p> <p>WHAT HAPPENED: Extremely dry, hot conditions led to animal and plant decline, and a large volcanic eruption pushed carbon dioxide into the atmosphere, raising temperatures and lowering oxygen in the ocean. It took 10-20 million years for life to recover its diversity after this event.</p> <p>HARD-HIT GROUPS: TRILOBITES (TETRAPOD), EURYPTERIDS, FOSSILING FORAMINIFERA, ACANTHODIANS, MONURA AND OTHER INSECTS</p>
END TRIASSIC	<p>4</p> <p>76% of all species lost</p> <p>WHAT HAPPENED: Extreme volcanic activity, which would eventually break apart the supercontinent of Pangaea, raised global temperatures and acidified the ocean. There is still a great deal of controversy surrounding the main cause of extinction during this period.</p> <p>HARD-HIT GROUPS: THERIAZODON & OTHER MAMMALS LIKE BEUTLERIA, MASTODONTOSAURUS & OTHER SAUROSAURIA, BRACHIOPODS, AMMONITES, CONODONTS</p>
END CRETACEOUS	<p>5</p> <p>70% of all species lost</p> <p>WHAT HAPPENED: After millions of years of animal and plant decline due to dropping sea levels and intensifying volcanic activity, which caused acid rain and cooling temperatures, a gigantic asteroid struck Earth, causing further devastation.</p> <p>HARD-HIT GROUPS: DINOSAURS, PTEROSAURS, MAMMALS, PLESIOSAURS, RODENTIA & OTHER MAMMALS</p>



Prognosis: Journey into the Unknown

DEEP DIVE: MASS EXTINCTIONS

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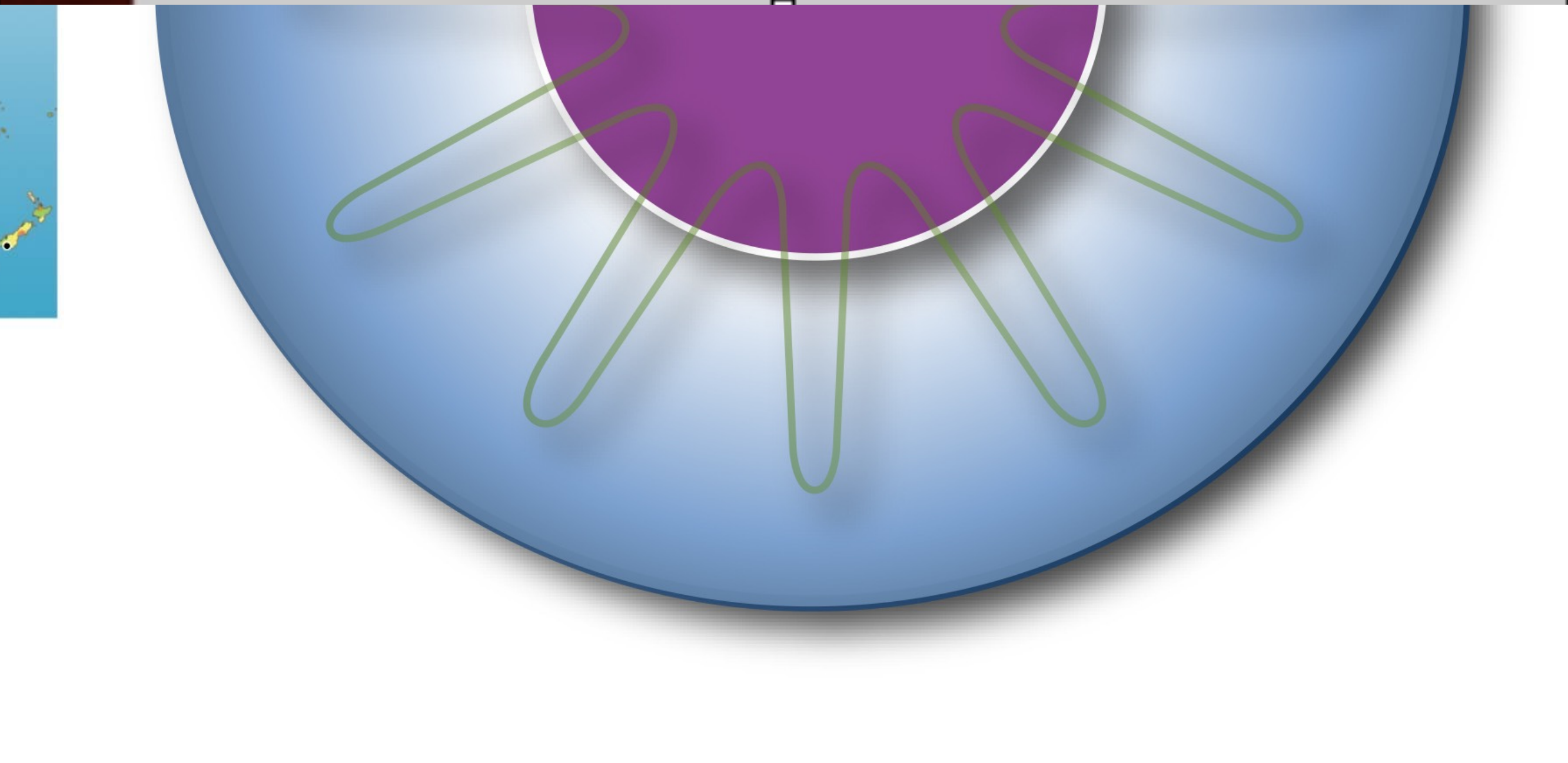
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WHAT HAPPENED:	Glaciation followed by a rebound of a greenhouse climate.	
HARD-HIT GROUPS:	TRILOBITES BRACHIOPODS BRYozoans ECHINODERMS GRAPTOLITES	
2	LATE DEVONIAN	70% of all marine species lost
WHAT HAPPENED:	Lack of oxygen in the oceans, rising sea levels, and global cooling.	
HARD-HIT GROUPS:	REEF ENVIRONMENTS OSTRACODS & PLACODERMS STROMATOLITES RUGOSA & TABULATA TRILOBITES (SHARK)	
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WHAT HAPPENED:	Extremely dry, hot conditions led to animal and plant decline, and a large volcanic eruption pushed carbon dioxide into the atmosphere, raising temperatures and lowering oxygen in the ocean. It took 10-20 million years for life to recover its diversity after this event.	
HARD-HIT GROUPS:	TRILOBITES EURYPTERIDS FOSSILING FORAMINIFERA ACANTHODIANS MONURA AND OTHER INSECTS	
4	END TRIASSIC	76% of all species lost
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HARD-HIT GROUPS:	TRINACRODON MASTODONSAURUS BRACHIOPODS AMMONITES CONODONTS & OTHER MARINE LIFE REPTILES & OTHER AMPHIBIANS	
5	END CRETACEOUS	70% of all species lost
WHAT HAPPENED:	After millions of years of animal and plant decline due to dropping sea levels and intensifying volcanic activity, which caused acid rain and cooling temperatures, a gigantic asteroid struck Earth, causing further devastation.	
HARD-HIT GROUPS:	DINOSAURS PTEROSAURS MARSUPIALS PLESIOSAURS RODENTIA & OTHER MAMMALS	

6? **??%** of all species lost

WHAT'S HAPPENING: Some scientists think the sixth major extinction event started 10,000 years ago when humankind began to dominate the Earth, with extinctions tied to a wide array of causes including hunting, habitat destruction, pollution, and global climate change.

HARD-HIT GROUPS: WOOLY MAMMOTH DODO PASSENGER PIGEON GOLDEN TOAD & OTHER AMPHIBIANS GREAT AUK

HOLOCENE (PROPOSED)

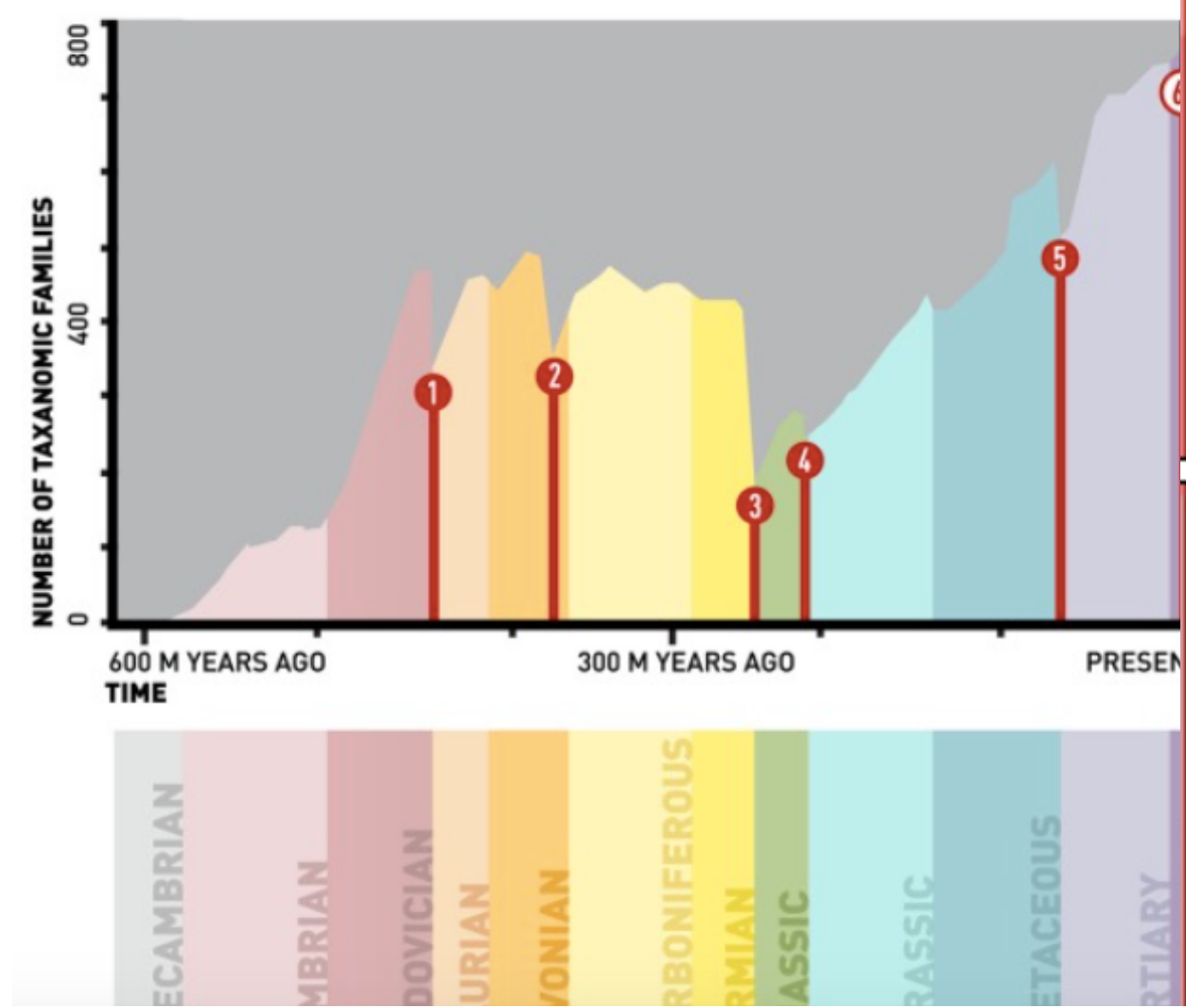


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1	2	3	4	5
END ORDOVICIAN	LATE DEVONIAN	END PERMIAN (The Great Dying)	END TRIASSIC	END CRETACEOUS
<p>85% of living organisms lost</p> <p>WHAT HAPPENED: Glaciation followed by a rebound of a greenhouse climate.</p> <p>HARD-HIT GROUPS: TRILOBITES, BRACHIOPODS, BRIDGIANS, ECHINODERMS, GRAPTOLITES</p>	<p>70% of all marine species lost</p> <p>WHAT HAPPENED: Lack of oxygen in the oceans, rising sea levels, and global cooling.</p> <p>HARD-HIT GROUPS: REEF ENVIRONMENTS, OSTRACODS & PLACODS, STROMATOLITES, RUGOSA & TABULATA, TRILOBITES</p>	<p>96% of all species lost</p> <p>WHAT HAPPENED: Extremely dry, hot conditions led to animal and plant decline, and a large volcanic eruption pushed carbon dioxide into the atmosphere, raising temperatures and lowering oxygen in the ocean. It took 10-20 million years for life to recover its diversity after this event.</p> <p>HARD-HIT GROUPS: TRILOBITES, EURYPTERIDS, FOSILING FORAMINIFERA, ACANTHODIANS, MONURA AND OTHER INSECTS</p>	<p>76% of all species lost</p> <p>WHAT HAPPENED: Extreme volcanic activity, which would eventually break apart the supercontinent of Pangaea, raised global temperatures and acidified the ocean. There is still a great deal of controversy surrounding the main cause of extinction during this period.</p> <p>HARD-HIT GROUPS: TRINACRIDON & OTHER MARINE LIFE REPTILES & OTHER AMPHIBIANS, MASTODONSAURUS & OTHER AMPHIBIANS, BRACHIOPODS, AMMONITES, CONODONTS</p>	<p>70% of all species lost</p> <p>WHAT HAPPENED: After millions of years of animal and plant decline due to dropping sea levels and intensifying volcanic activity, which caused acid rain and cooling temperatures, a gigantic asteroid struck Earth, causing further devastation.</p> <p>HARD-HIT GROUPS: DINOSAURS, PTEROSAURS, MISAURS, PLESOSAURS, RODENTIA & OTHER MAMMALS</p>

6? % of all species lost

WHAT'S HAPPENING: 10,000 years ago when humankind began to dominate the Earth, with extinctions tied to a wide array of causes including hunting, habitat destruction, pollution, and global climate change.

Living Planet Report 2016

Risk and resilience in a new era

WWF - LIVING PLANET REPORT 2016

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Logos: WWF, ZSL (Let's Move for Wildlife), Global Freshwater Network

Science & Environment

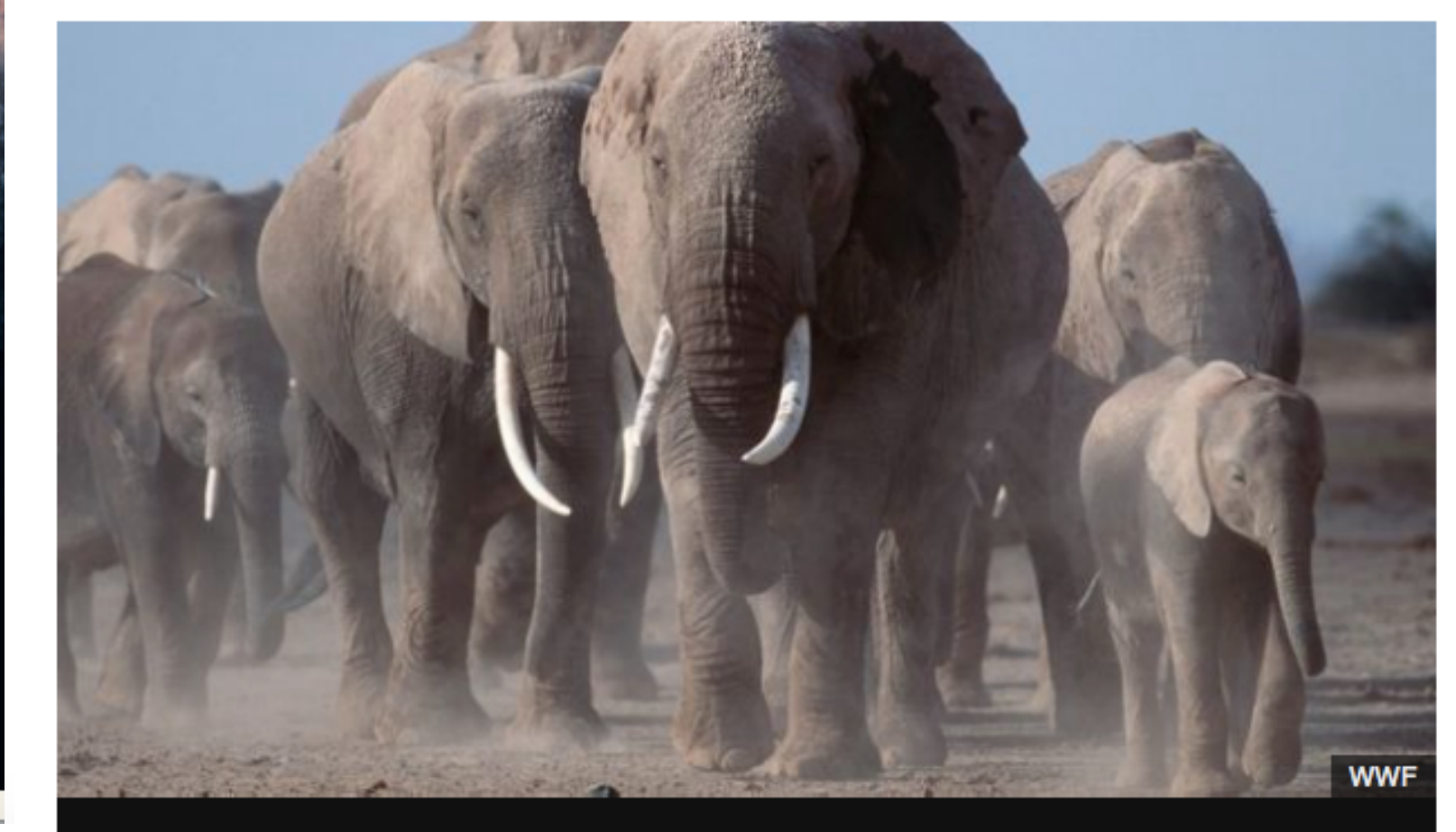
World wildlife 'falls by 58% in 40 years'

By Rebecca Morelle
Science Correspondent, BBC News

27 October 2016 | Science & Environment

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"We do see particularly strong declines in the freshwater environment - for freshwater species alone, the decline stands at 81% since 1970. This is related to the way water is used and taken out of fresh water systems, and also the fragmentation of freshwater systems through dam building, for example."

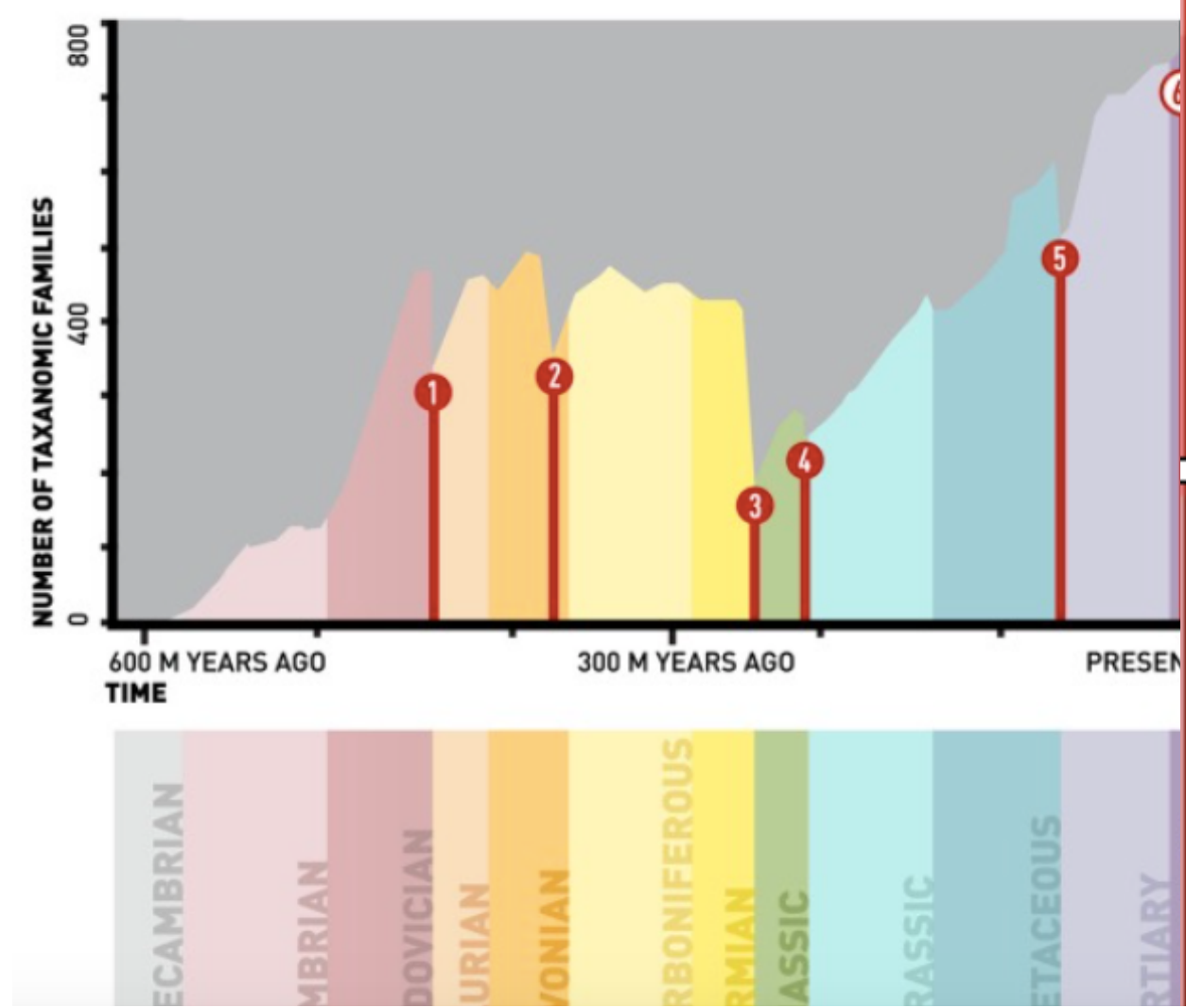


Prognosis: Journey into the Unknown

DEEP DIVE: MASS EXTINCTIONS

BY JULIE ROSSMAN & CLARE SMITH MARASH

World Science Festival
worldsciencefestival.com



Event	Percentage of Species Lost	Hard-Hit Groups
End Ordovician	85% of living organisms lost	Trilobites, Brachiopods, Bryozoans, Echinoderms, Graptolites
Late Devonian	70% of all marine species lost	Reef environments, Ostracoderms & Placoderms, Stromatopores, Rugosa & Tabulata, Trilobites
End Permian (The Great Dying)	96% of all species lost	Trilobites, Eurypterids, Fossiliferous Foraminifera, Acanthodians, Monura and other insects
End Triassic	76% of all species lost	Therapsids, Mastodons/Gaurs, Brachiopods, Ammonites, Conodonts
End Cretaceous	70% of all species lost	Dinosaurs, Pterosaurs, Mosasaurs, Plesiosaurs, Rudistid & other mollusks

6? % of all species lost

WHAT'S HAPPENING: Some scientists think the sixth major extinction event started 10,000 years ago when humankind began to dominate the Earth, with extinctions tied to a wide array of causes including hunting, habitat destruction, pollution, and global climate change.

Living Planet Report 2016

Risk and resilience in a new era

WWF - LIVING PLANET REPORT 2016

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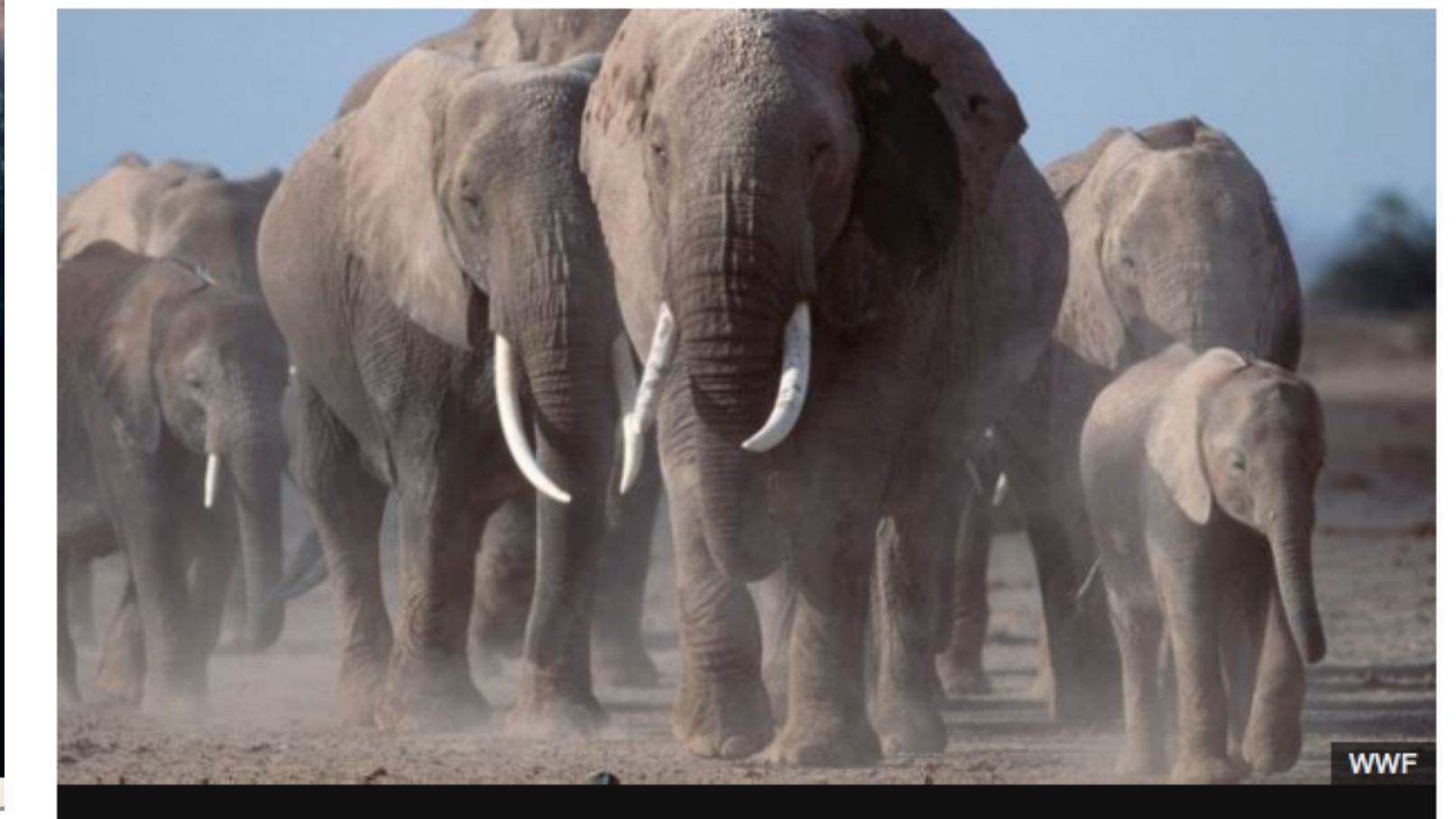
World wildlife 'fallen 81% since 1970'

By Rebecca Morelle, Science Correspondent, BBC

27 October 2016 | Science & Environment

Freshwater: 81% since 1970

"We do see particularly strong declines in freshwater species alone, the decline stands at 81% since 1970. This is related to the way water is used and taken out of fresh water systems, and also the fragmentation of freshwater systems through dam building, for example."

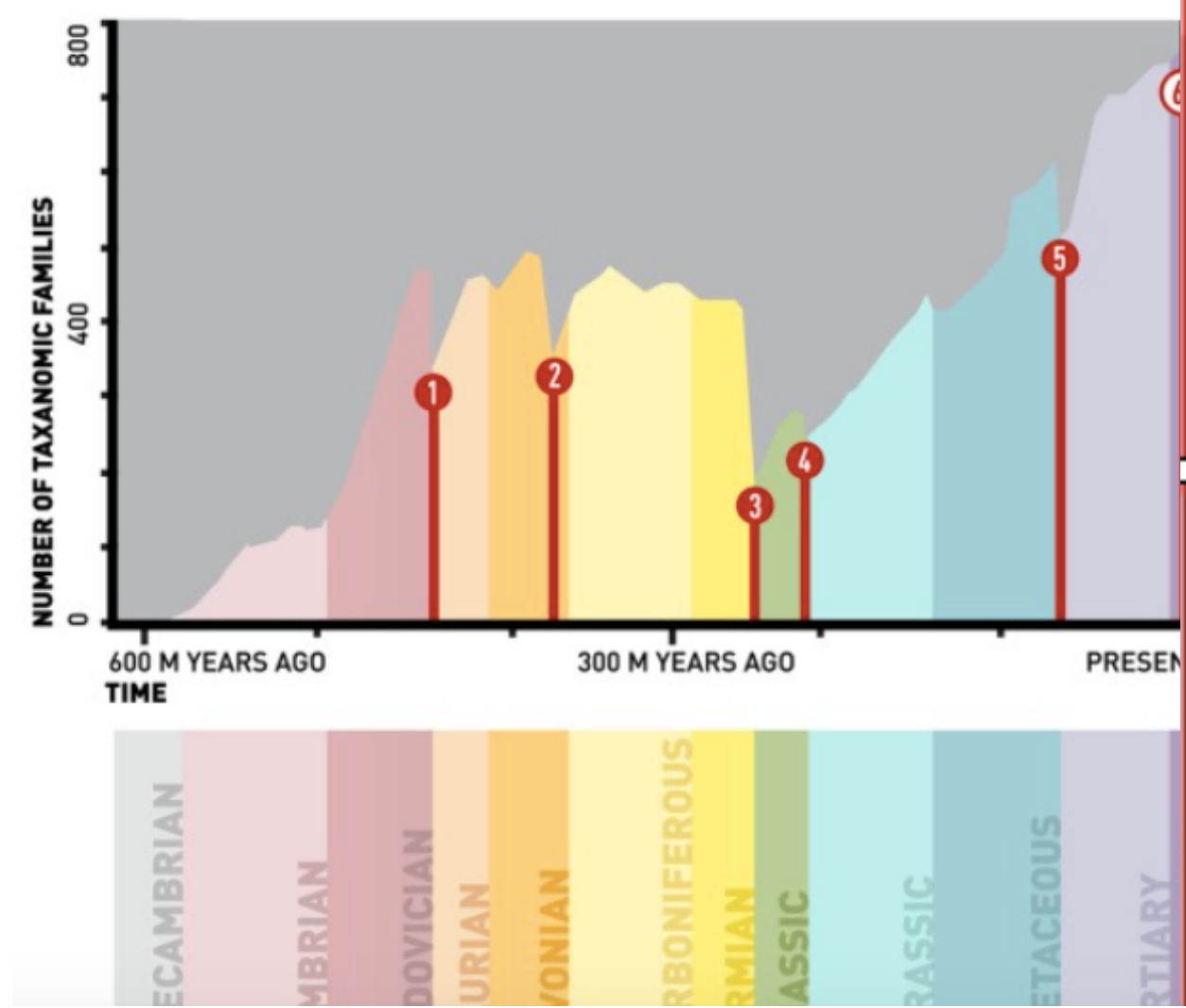


Prognosis: Journey into the Unknown

DEEP DIVE: MASS EXTINCTIONS

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1 END ORDOVICIAN

WHAT HAPPENED: Glaciation followed by a rebound of a greenhouse climate.

85% of living organisms lost

HARD-HIT GROUPS: TRILOBITES, BRACHIOPODS, BRIDGIANS, ECHINODERMS, GRAPTOLITES

2 LATE DEVONIAN

WHAT HAPPENED: Lack of oxygen in the oceans, rising sea levels, and global cooling.

70% of all marine species lost

HARD-HIT GROUPS: REEF ENVIRONMENTS, OSTRACODERMS & PLACODERMS, STROMATOPORIDS, RUGOSA & TABULATA, TRILOBITES

3 END PERMIAN (THE GREAT DYING)

WHAT HAPPENED: Extremely dry, hot conditions led to animal and plant decline, and a large volcanic eruption pushed carbon dioxide into the atmosphere, raising temperatures and lowering oxygen in the oceans. It took 10-20 million years for life to recover its diversity after this event.

96% of all species lost

HARD-HIT GROUPS: TRILOBITES, EURYPTERIDS, FOSSILING FORAMINIFERA, ACANTHODIANS, MONURA AND OTHER INSECTS

4 END TRIASSIC

WHAT HAPPENED: Extreme volcanic activity, which would eventually break apart the supercontinent of Pangaea, raised global temperatures and acidified the oceans. There is still a great deal of controversy surrounding the main cause of extinction during this period.

76% of all species lost

HARD-HIT GROUPS: THERAPSIDON, MASTODONTIANS, BRACHIOPODS, AMPHIBIANS, CONODONTS

6? (PROPOSED)

WHAT'S HAPPENING: Some scientists think the sixth major extinction event started 10,000 years ago when humankind began to dominate the Earth, with extinctions tied to a wide array of causes including hunting, habitat destruction, pollution, and global climate change.

??% of all species lost

WWF - LIVING PLANET REPORT 2016

WWF REPORT INT 2016

THIS REPORT HAS BEEN PRODUCED IN COLLABORATION WITH ZSL LET'S WORK FOR WILDLIFE and Global Freshwater Network

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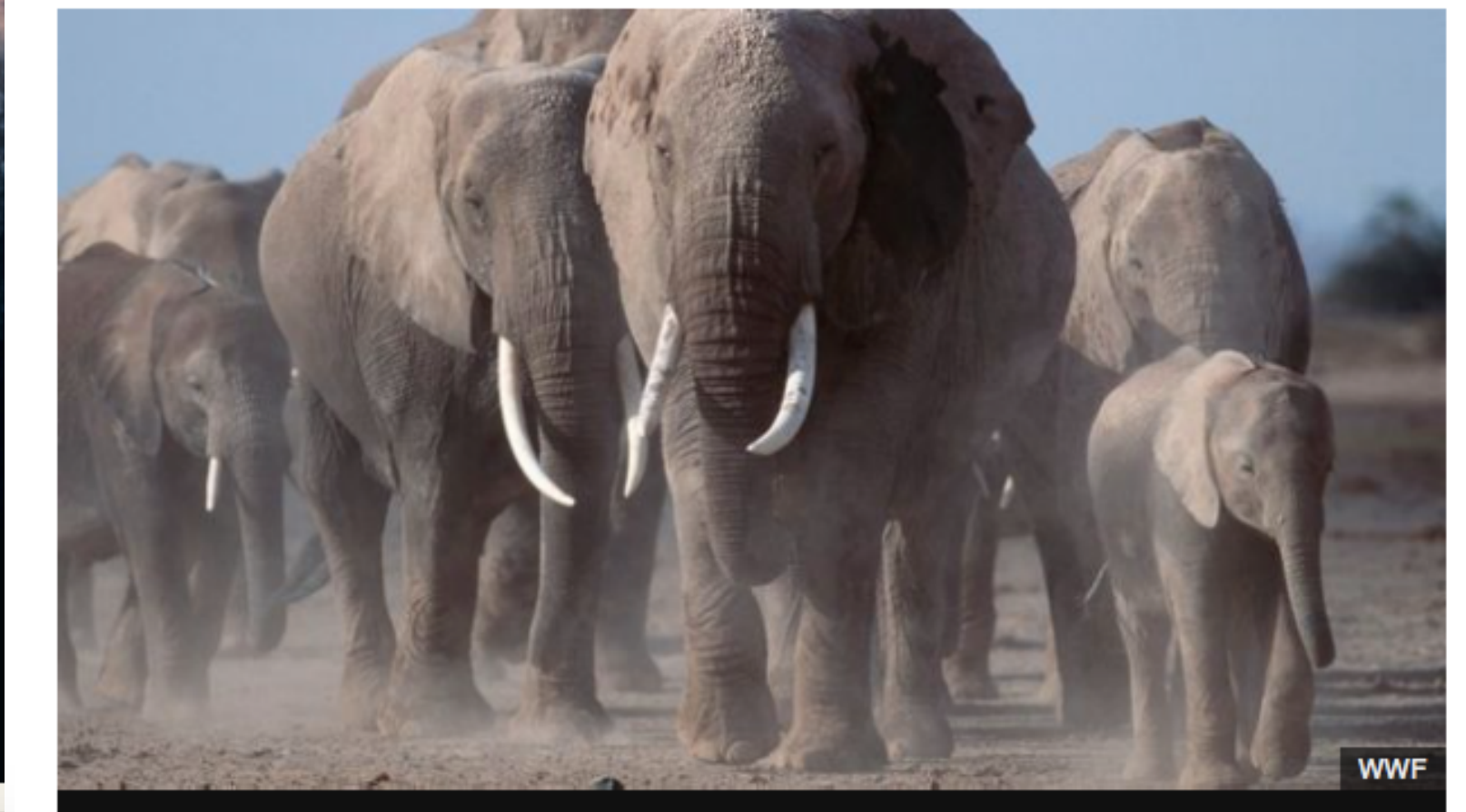
World wildlife 'fallen by 81% in 37 years'

By Rebecca Morelle
Science Correspondent, BBC

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Freshwater: 81% since 1970

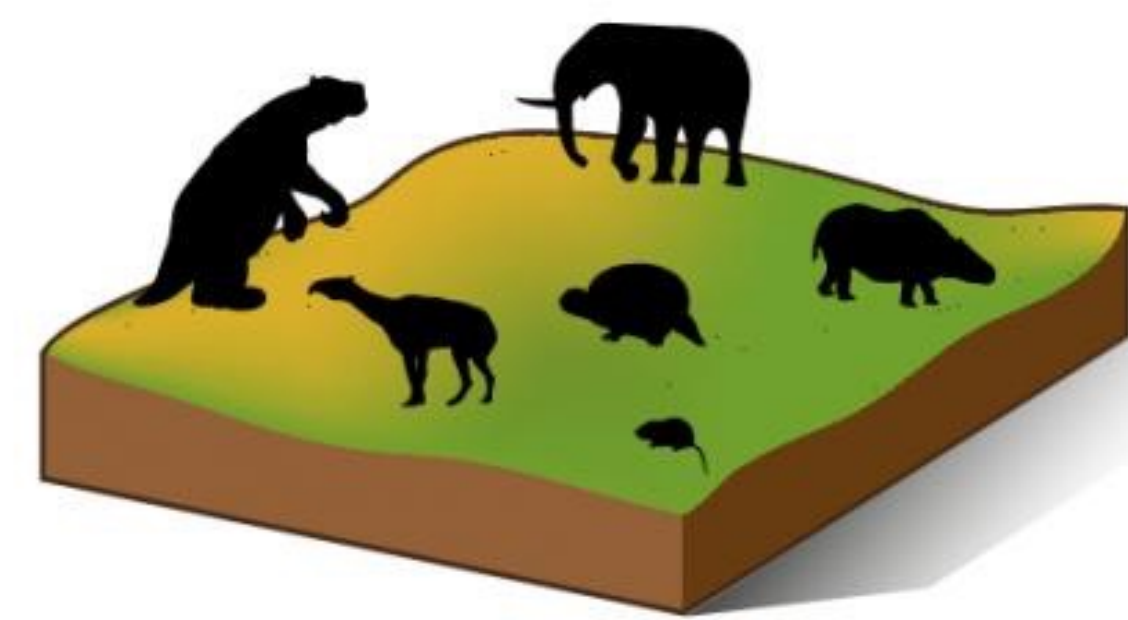
"We do see particularly strong declines in freshwater species alone, the decline stands at 81% since 1970. This is related to the way water is used and taken out of fresh water systems, and also the fragmentation of freshwater systems through dam building, for example."



Current extinction rates:
300 times background rate for birds
80,000 times background rate for mammals

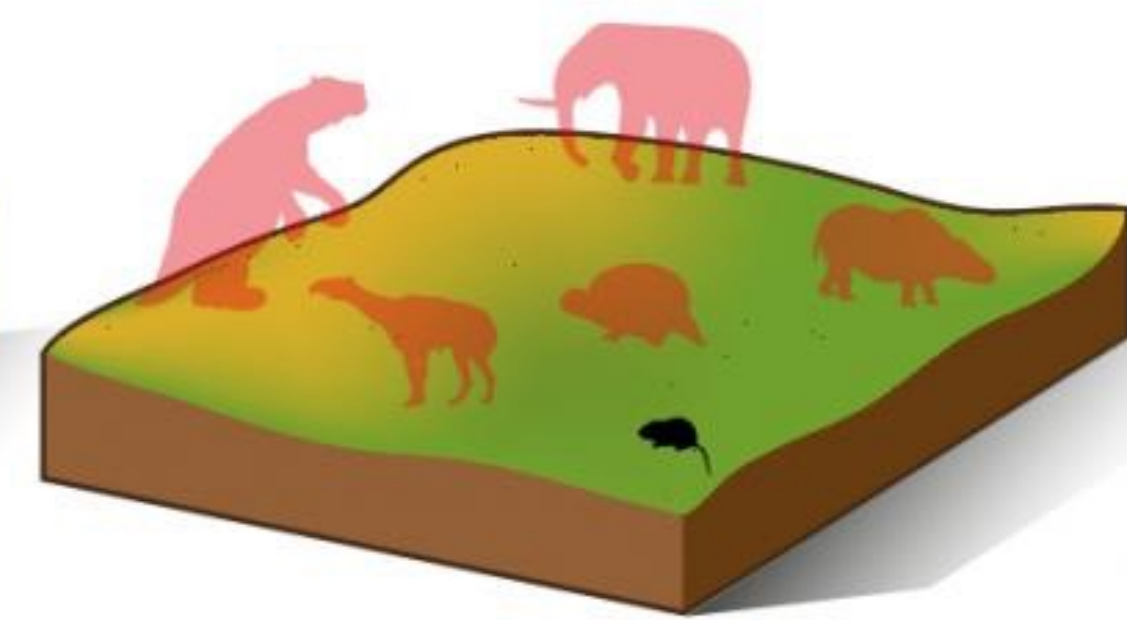
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The Ice Age



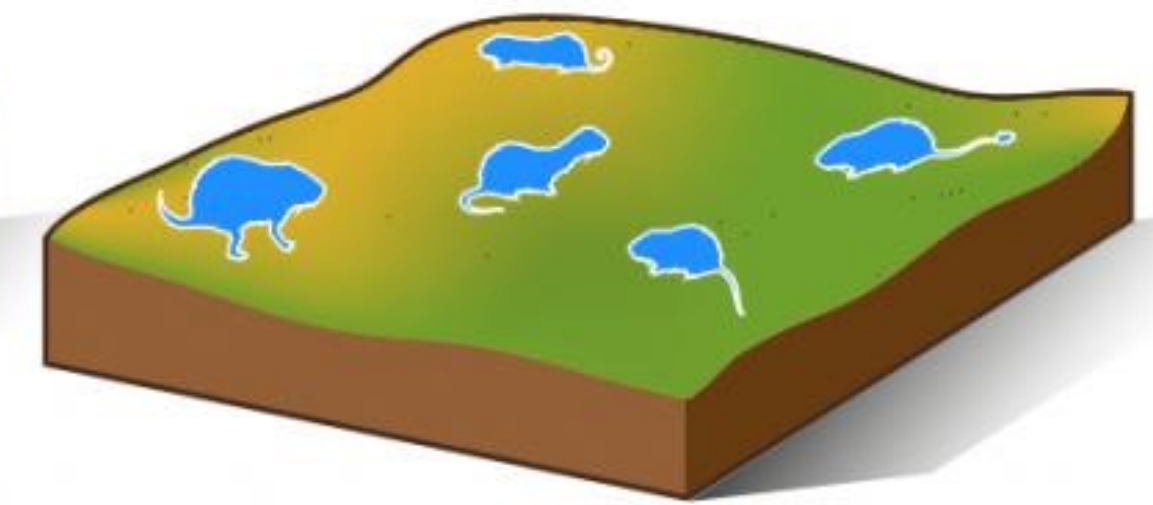
During the Ice Age, many large mammals roamed the earth, filling out deep branches on the mammal Tree of Life

The Present

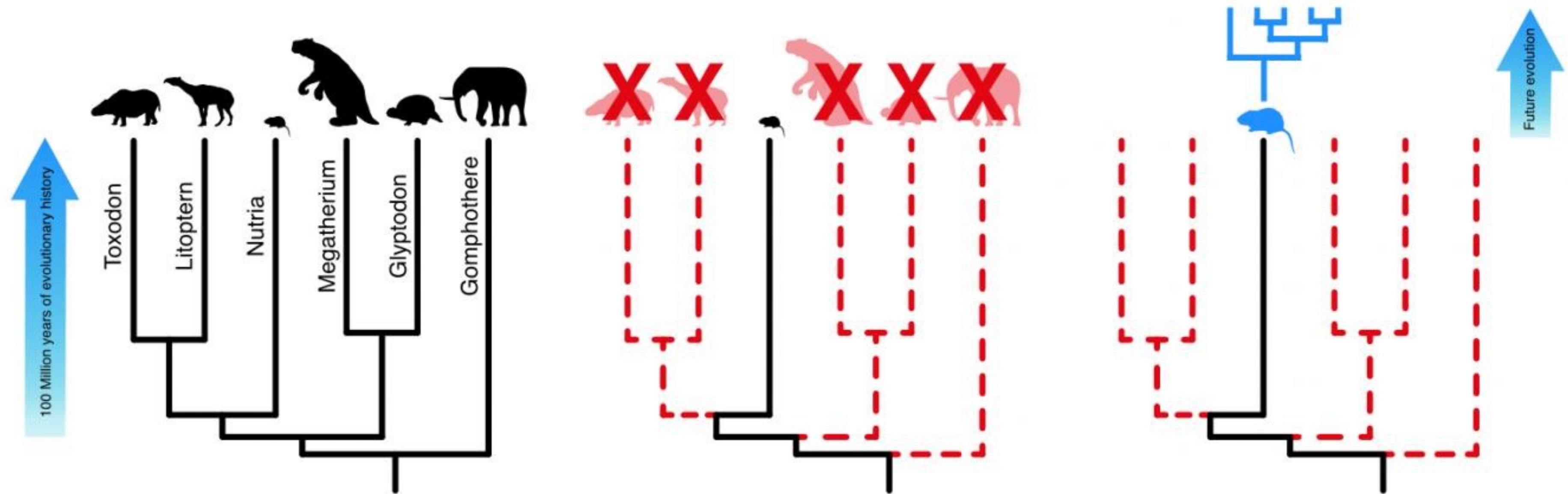


Since then, all the largest species have been chopped off the mammal Tree by extinctions

The Future?

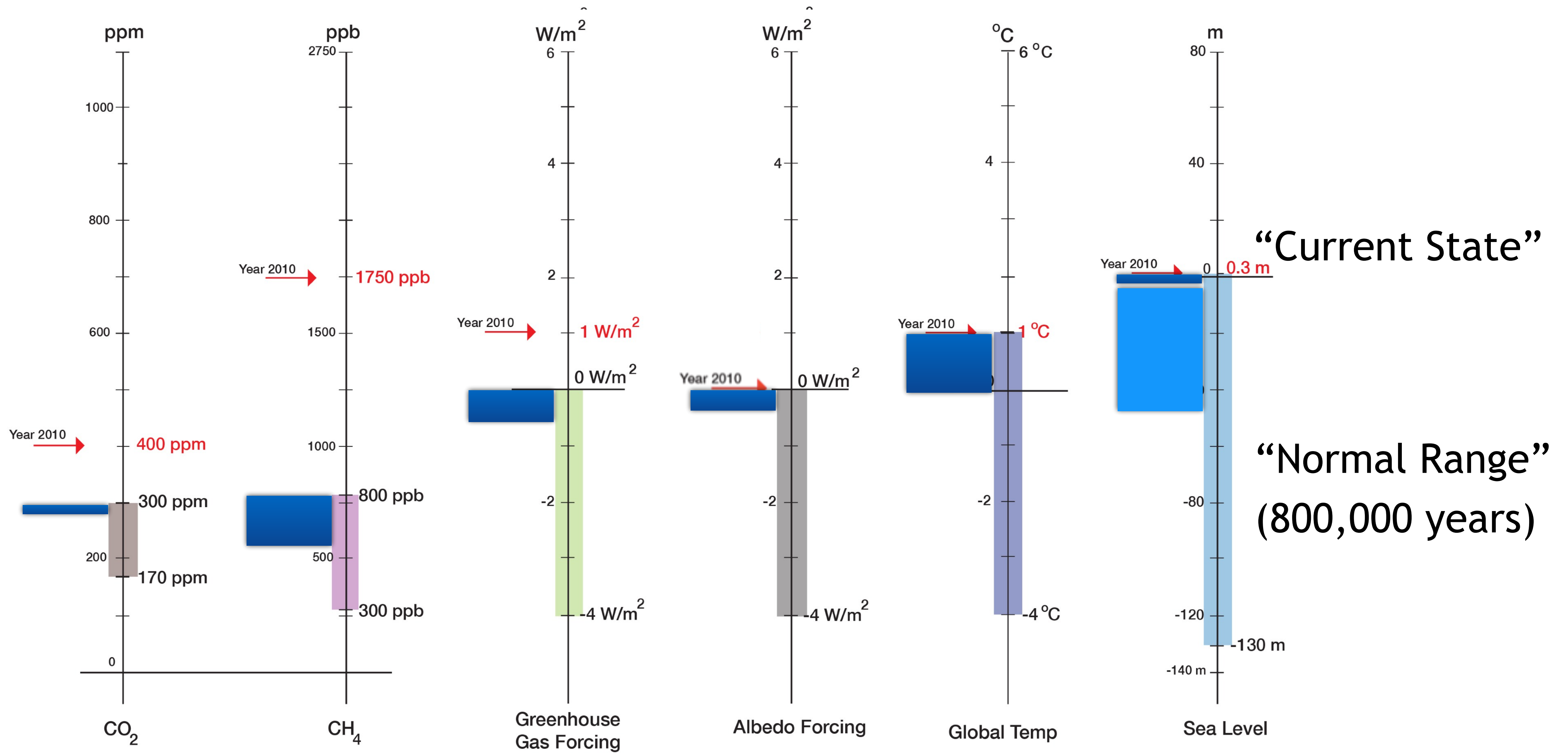


Surviving species will have to diversify for millions of years to restore this missing evolutionary history and regrow the Tree of Life



Cases Changes

Holocene and Post-Holocene: Leaving the Safe-Operating Space for Humanity



Cases Changes

Holocene and Post-Holocene: Leaving the Safe-Operating Space for Humanity

