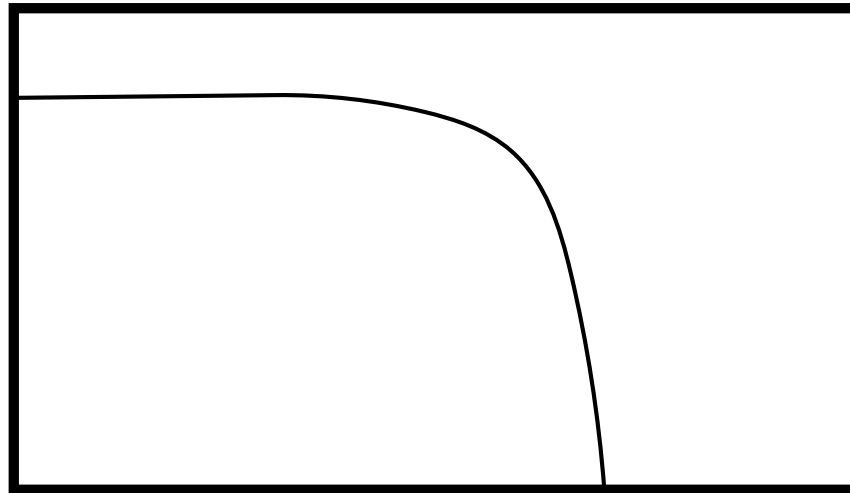


# Human Population 2018

Lecture 12  
Limits  
Carrying capacity

We're  
using  
stuff  
up !

**Stuff vs time** when stuff does not grow but is used by a growing population



**Extrinsic decline**

# Carrying capacity

## definition

- maximum sustainable population
- human c.c. depends on...
  - affluence -- resource needs
  - technology -- amplifier or silencer of affluence
  - impact -- activities that degrade the biocapacity

Defined by Daly's Criterea

# Carrying capacity

many components

( go to the board and list them )



# Energy

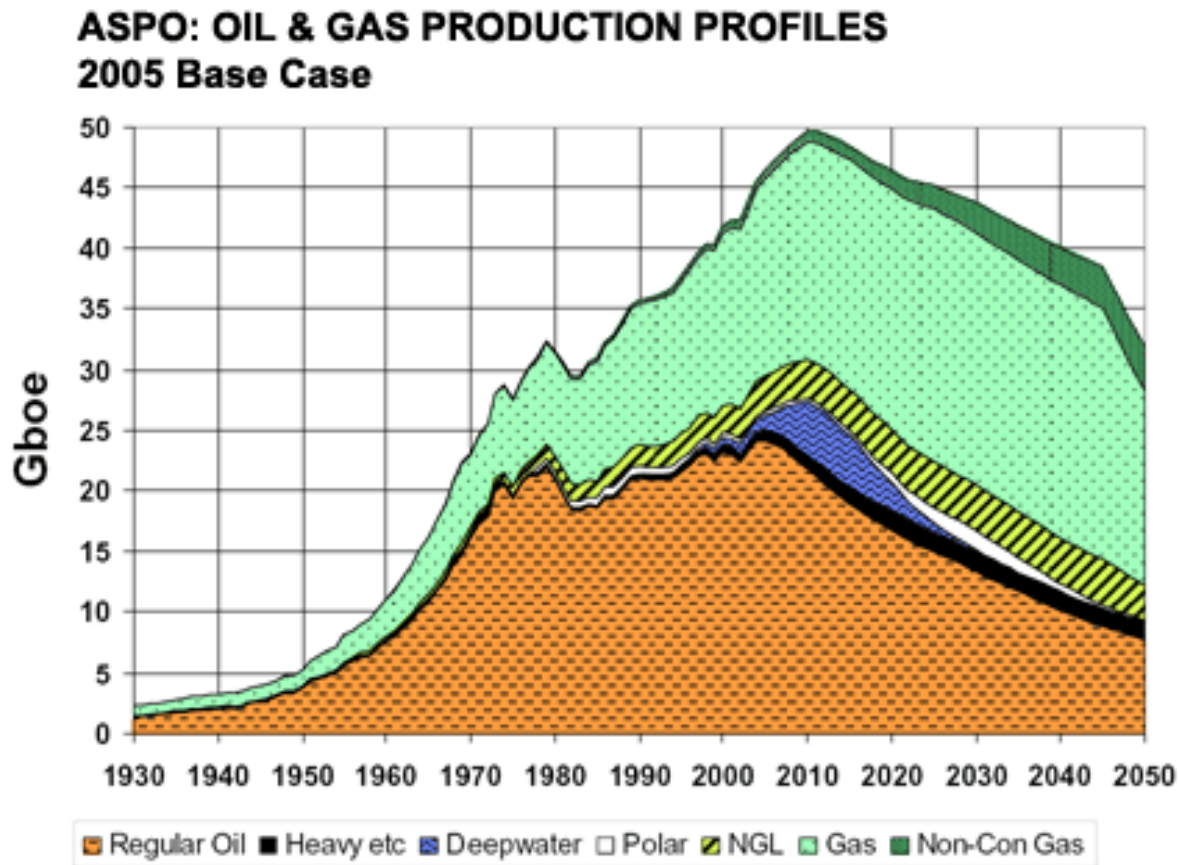
how does it relate to c.c.?

How does energy input into (the land, water, manufacturing, health, education) affect that resource?

( go back to the board )

Increasing carrying capacity, temporarily.

# Oil is not renewable



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

Food production, heat, transportation all depend largely on oil, a non-renewable resource. *Are we spending our savings?*

# Sinks

**What are they?**

**What do they absorb?**

# Overshoot

**Are we already there, according to Daly?**

**Fresh water**

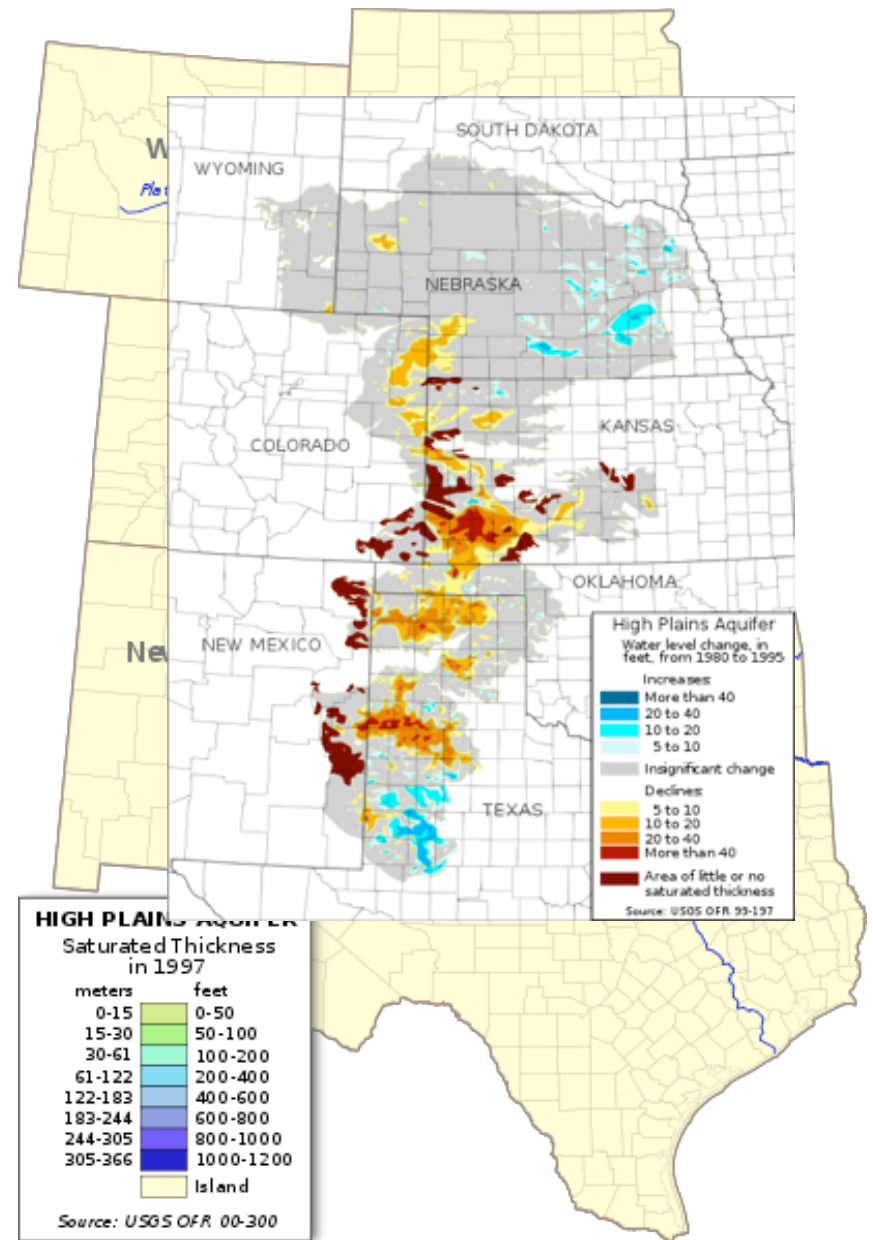
**Forests**

**Ice**

# Overshooting carrying capacity by using non-renewable water



NASA [ASTER](#) image of an approx. 557 mi<sup>2</sup> area of fields (1443 km<sup>2</sup>) in [Kansas](#) which are watered from the Ogallala aquifer with [center pivot irrigation](#) systems.



The Ogallala aquifer is being depleted due to irrigation.



# Map of US Aquifers





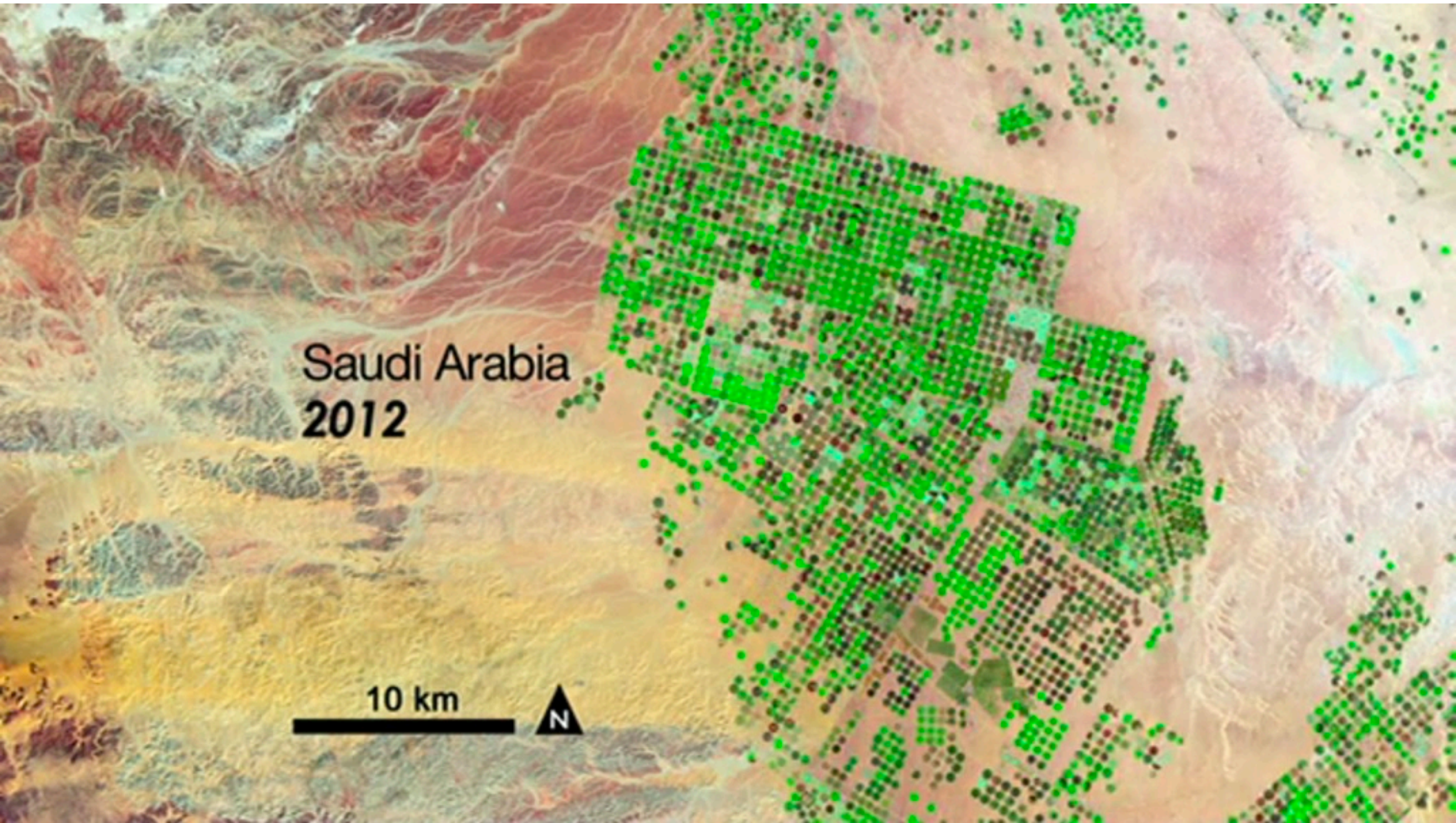
# alfalfa culture in the AZ desert



How can this be economical?



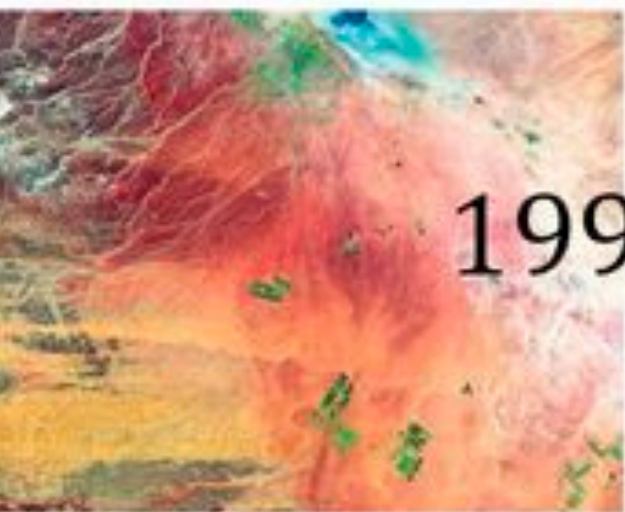
# Fossil water







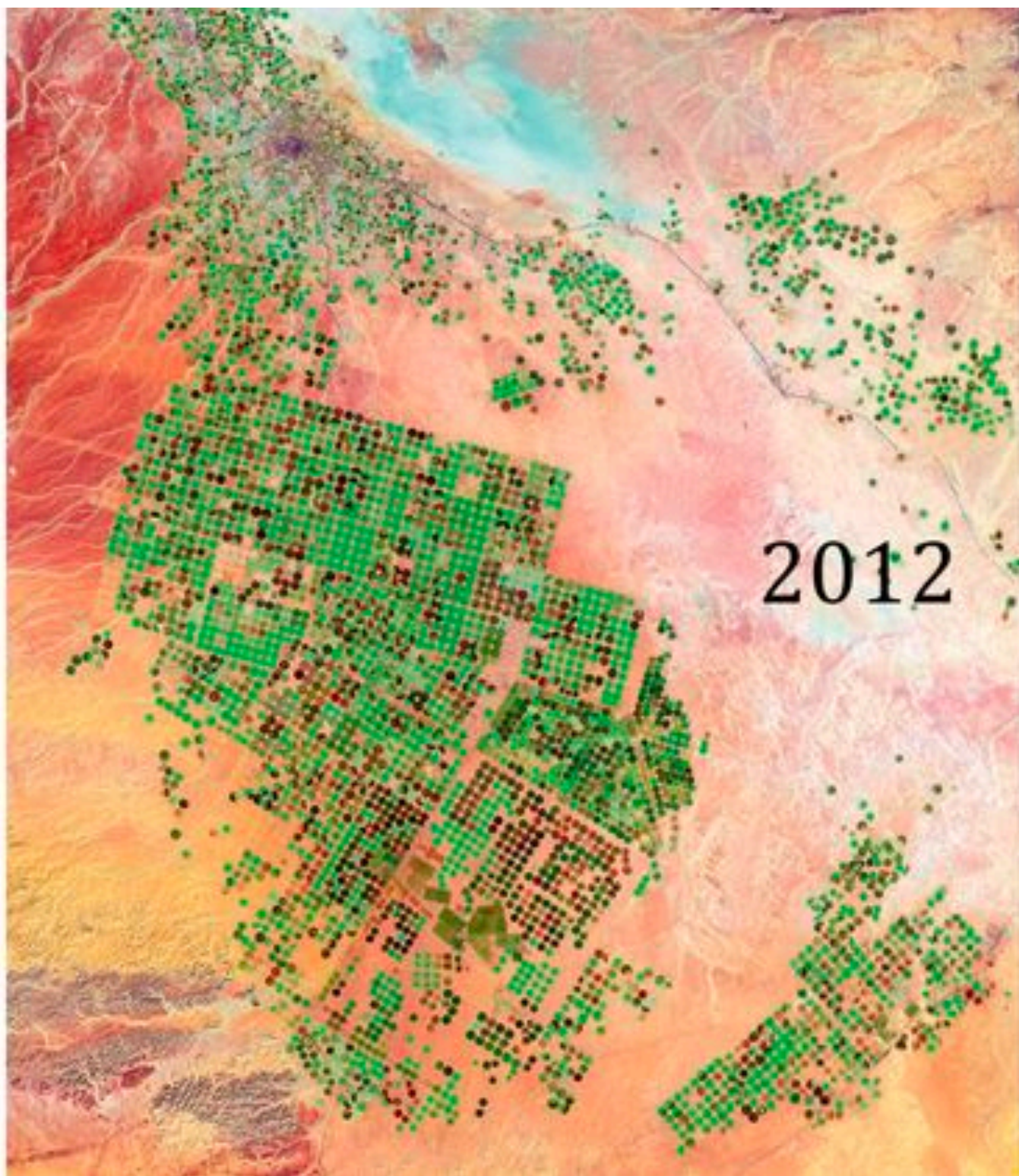
1987



1991



2000



2012





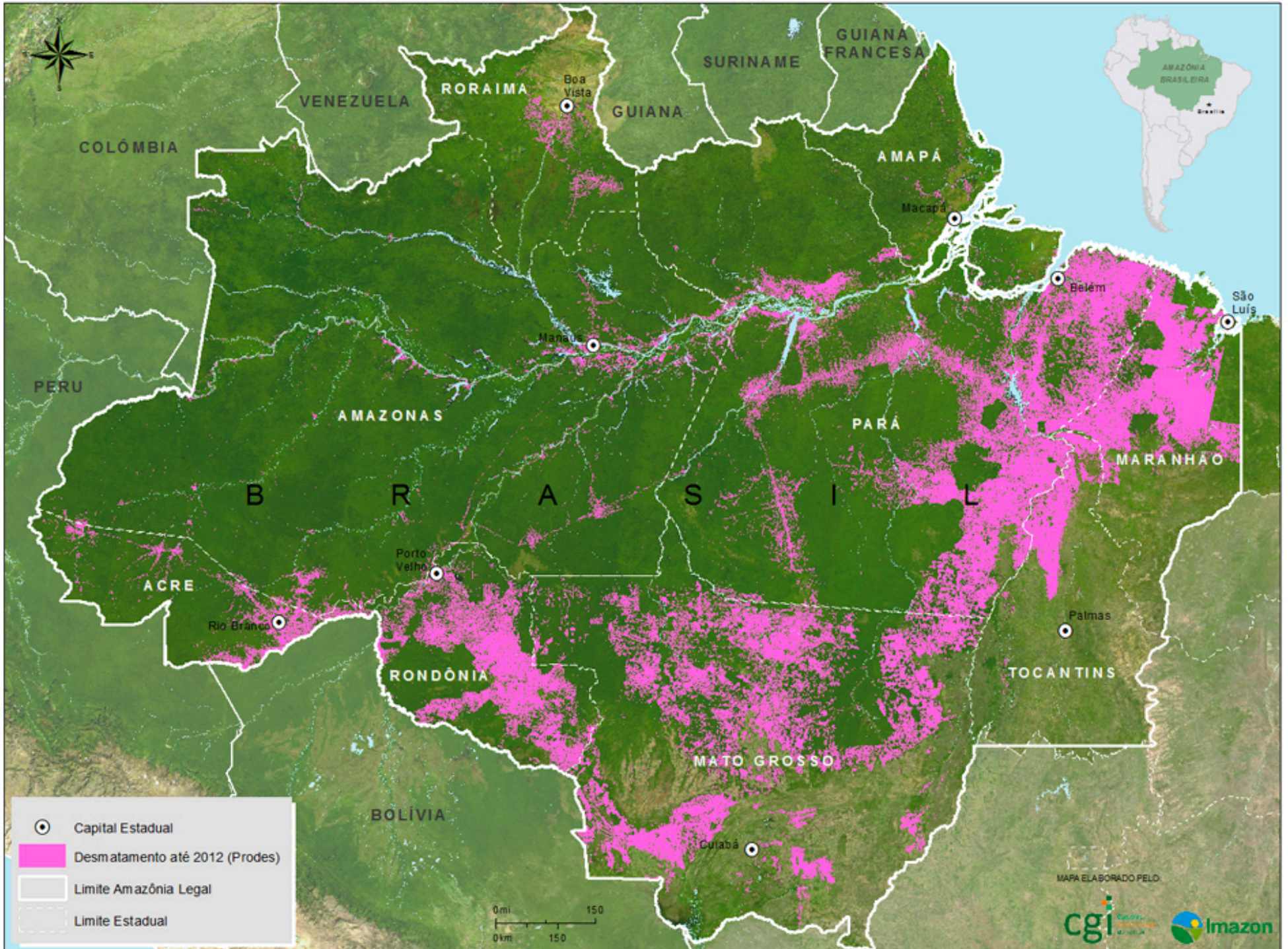




# Center-pivot irrigation.





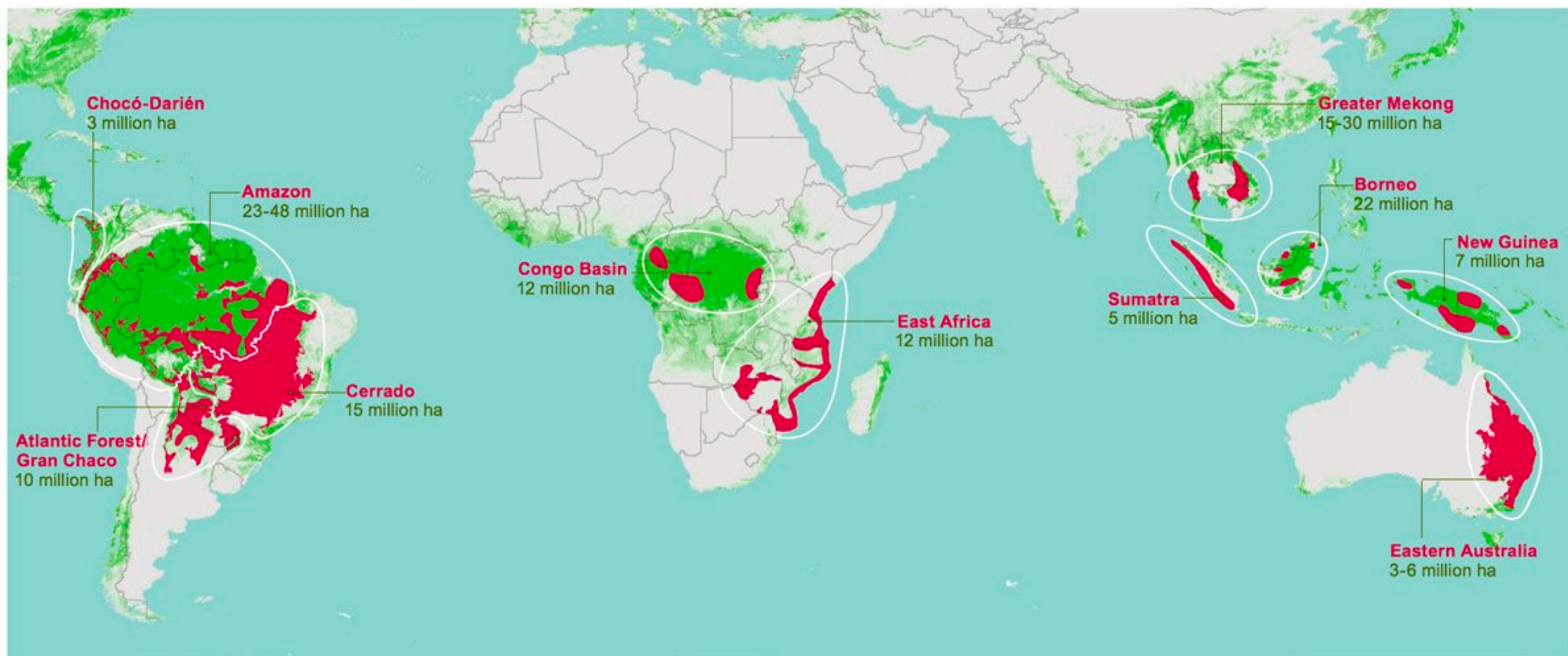






# Deforestation

## MAP OF DEFORESTATION FRONTS



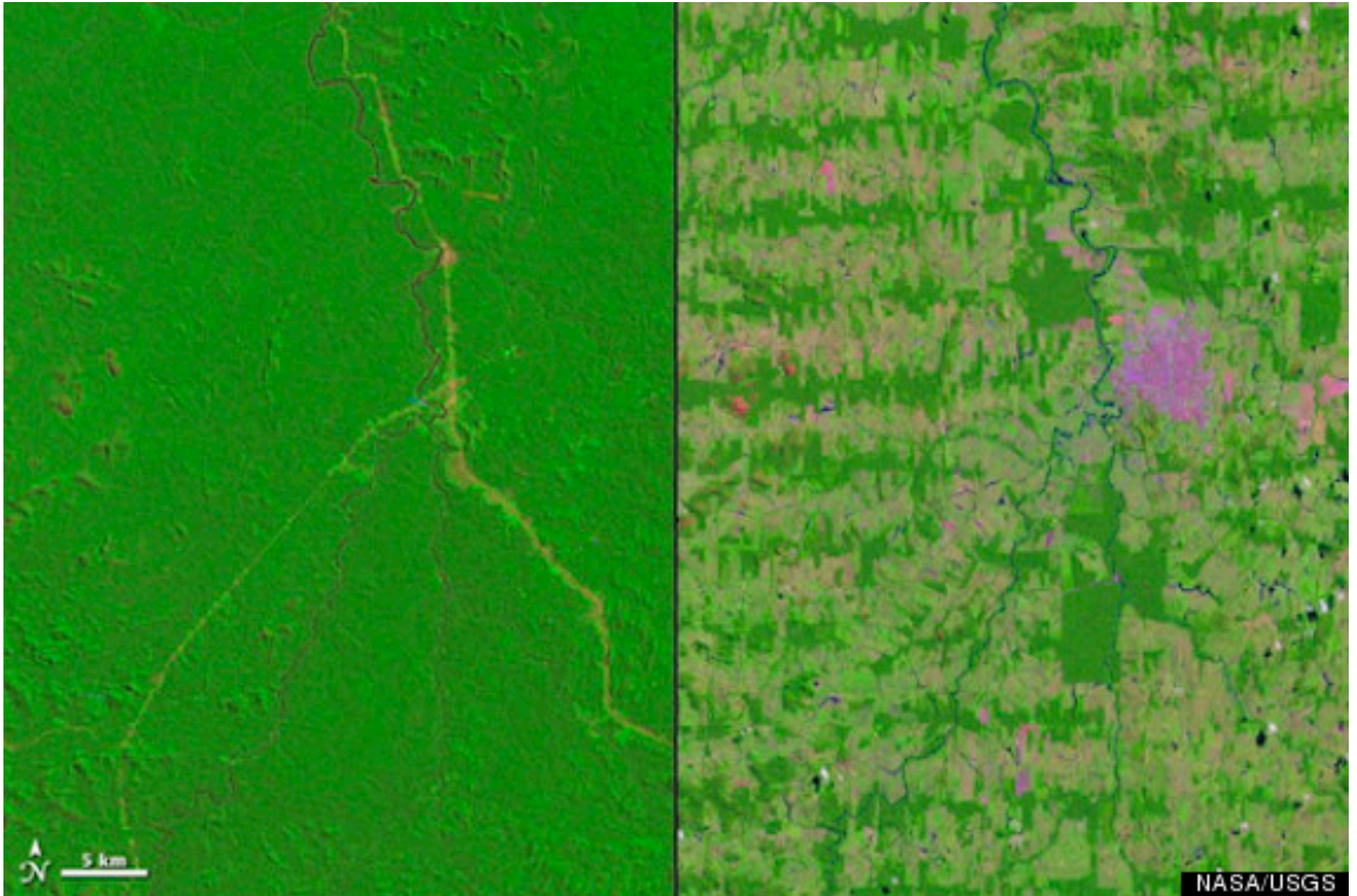
Forest

Deforestation fronts + projected deforestation, 2010-2030

<https://www.businessinsider.com.au/these-forests-are-about-to-start-disappearing-2015-5>



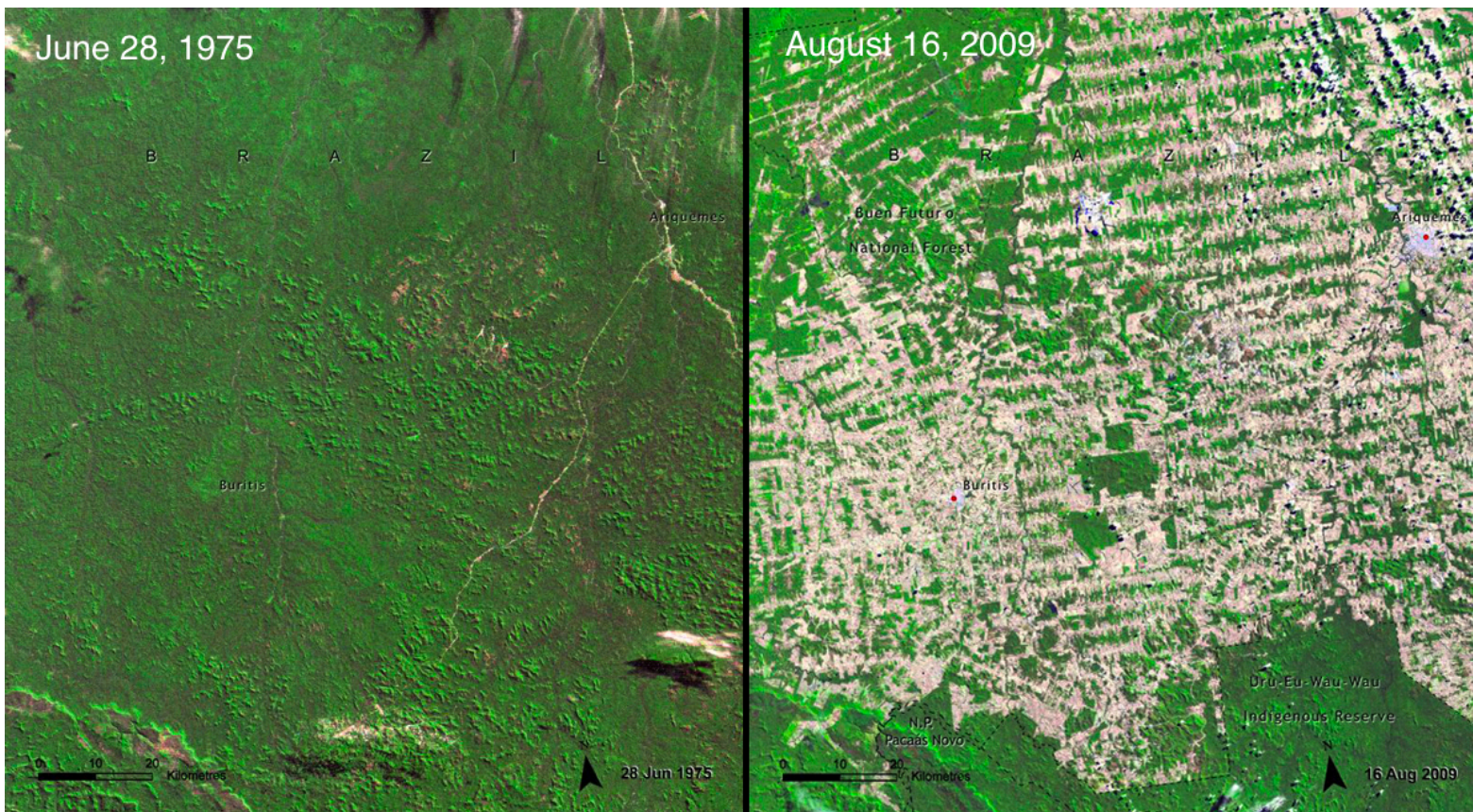
## Western Brazil



MISSING THE FOREST FOR THE TREES: NASA reveals 37 years of Amazon deforestation by juxtaposing satellite photos of western Brazil taken in 1975 and 2012.



# Rondônia

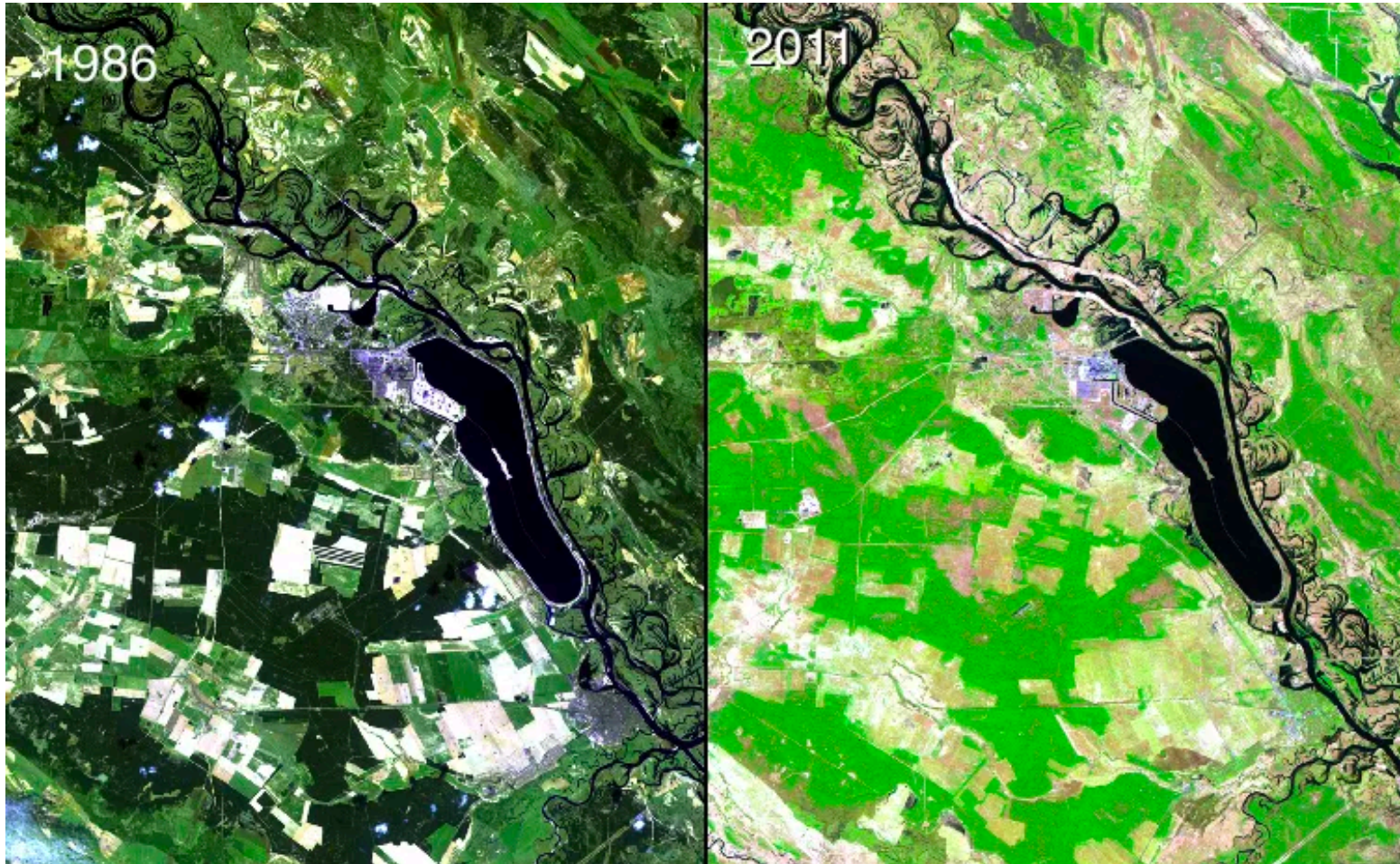


| Year | Area cleared           |
|------|------------------------|
| 1978 | 4,200 km <sup>2</sup>  |
| 1988 | 30,000 km <sup>2</sup> |
| 1998 | 53,300 km <sup>2</sup> |
| 2003 | 67,764 km <sup>2</sup> |

Satellite images of Rondônia in western Brazil, taken in 1975 (left) and 2009 (right). (NASA, Images of Change)



# Chernobyl



Chernobyl Nuclear Power Plant, seen in 1986 and 2011. (NASA, Images of Change)

<http://world.time.com/timelapse/>



# Arctic Ice Loss

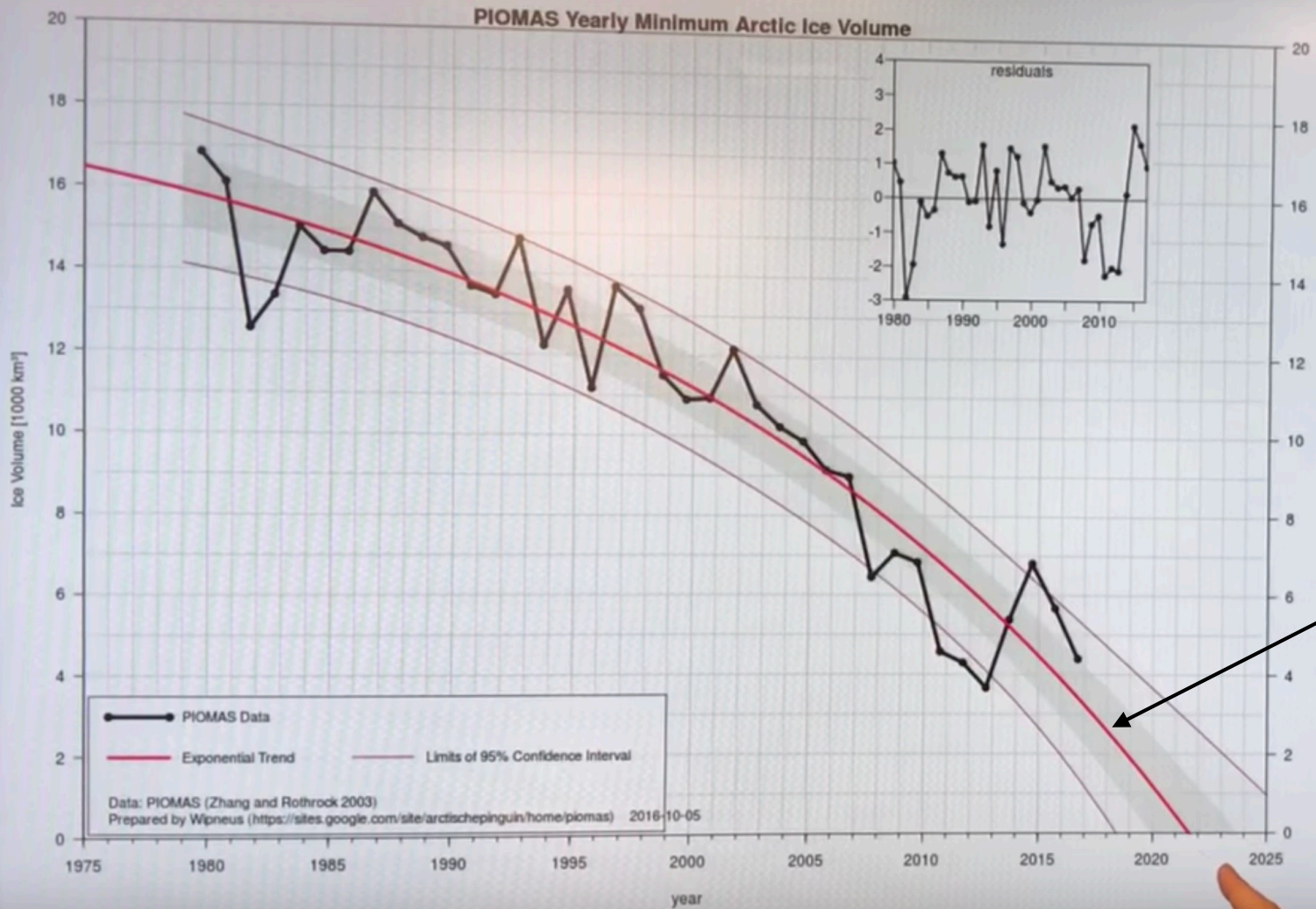
Sep 1984

Sep 2016



**NASA VIDEO SHOWS HOW THE ARCTIC SEA ICE HAS CHANGED SINCE THE 1980S**

# All arctic sea ice could be gone by 2020



Exponential fit!

<https://www.youtube.com/watch?v=eZdiqPEDXKE>

Let's talk about  
solutions!

**Table 1.** Summary of geoengineering options

| Geoengineering option      | Description  | Advantages   | Disadvantages   |
|----------------------------|--|--|---|
| Sulfur injection[7, 8]     | Injection of sulfur aerosols into the stratosphere by aircraft   | Concept demonstrated by volcanic eruptions; delivery technology in the form of tanker aircraft is proven                       | Does not reduce the actual atmospheric greenhouse gas concentration, so must be constantly deployed   |
| Sea spray injection[9, 10] | Injection of sea water droplets into the air to thicken low-level maritime clouds, thereby increasing albedo             | Enhances an existing natural process; does not introduce any chemicals into the environment                                    | Does not reduce the actual atmospheric greenhouse gas concentration, so must be constantly deployed; unproven delivery technology; geographically limited |
| Ocean fertilization[11-14] | Addition of nutrients (such as iron, nitrogen, or phosphorus) to the ocean to enhance the natural biological carbon pump | Enhances an existing natural process; actually removes CO <sub>2</sub> from the atmosphere; easily deployed using tanker ships | Potential adverse impacts to marine environments  |
| Tree planting              | Planting trees to absorb CO <sub>2</sub>   | No special technology required; additional economic and environmental benefits, such as lumber and erosion protection          | Net CO <sub>2</sub> absorption stops once trees mature; significant land area required which could compete with other uses                                |



# Algal blooms



Public Domain, <https://commons.wikimedia.org/w/index.php?curid=208541>

Published online 29 October 2010 | Nature | doi:10.1038/news.2010.572

News

## Sparks fly over theory that volcano caused salmon boom

### Could volcanic ash feed ailing fish populations?

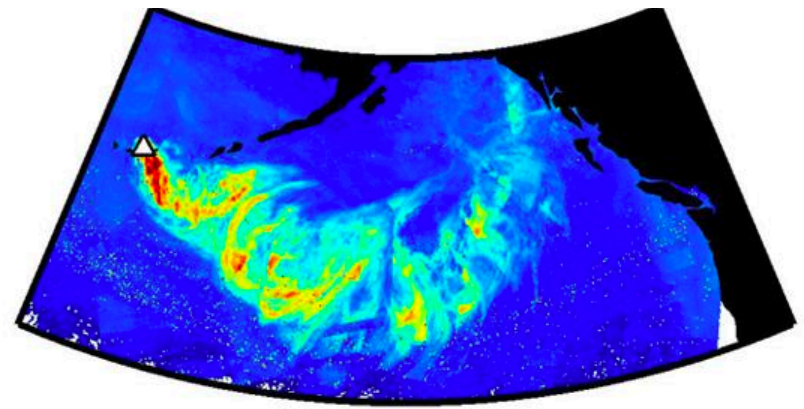
Nicola Jones

Speculation has been flying this week that a 2008 volcanic eruption on an Alaskan island was responsible for this year's glut of salmon in rivers in British Columbia, Canada. If confirmed, the idea will improve biologist's understanding of the notoriously unpredictable size of salmon runs, and add fuel to the controversial idea of intentionally seeding the ocean with iron to boost diminishing fish stocks. But some researchers contacted

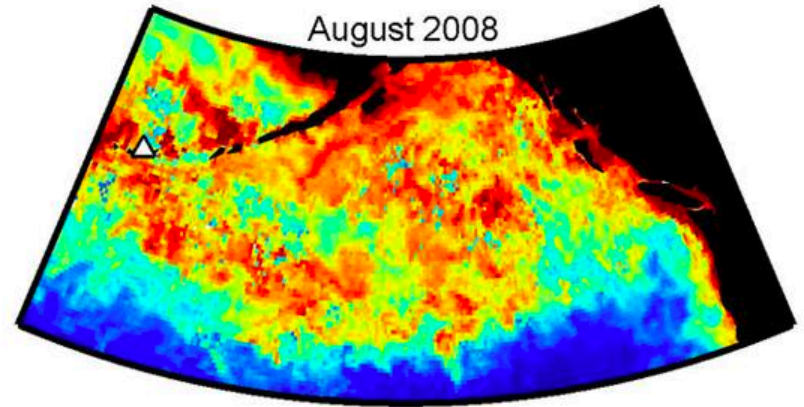


The eruption of the Kasatochi volcano in 2008 has been linked to an unexpected boom in the numbers of salmon in Canadian rivers this year.

*J. Morris/AVO/USGS*

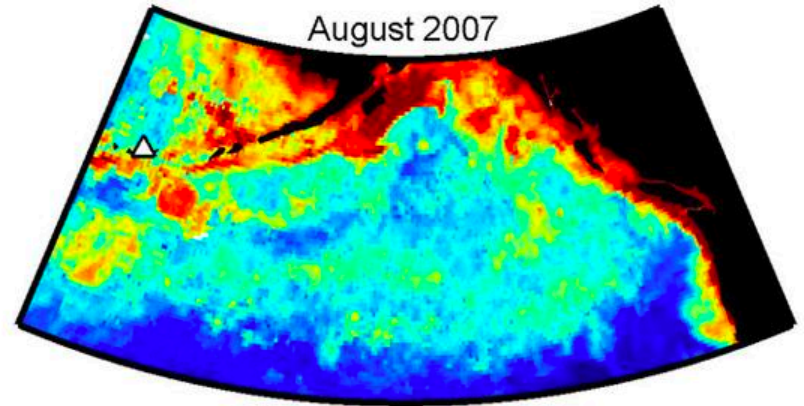


Satellite image of airborne volcanic ash, August 2008



Lowest  Highest

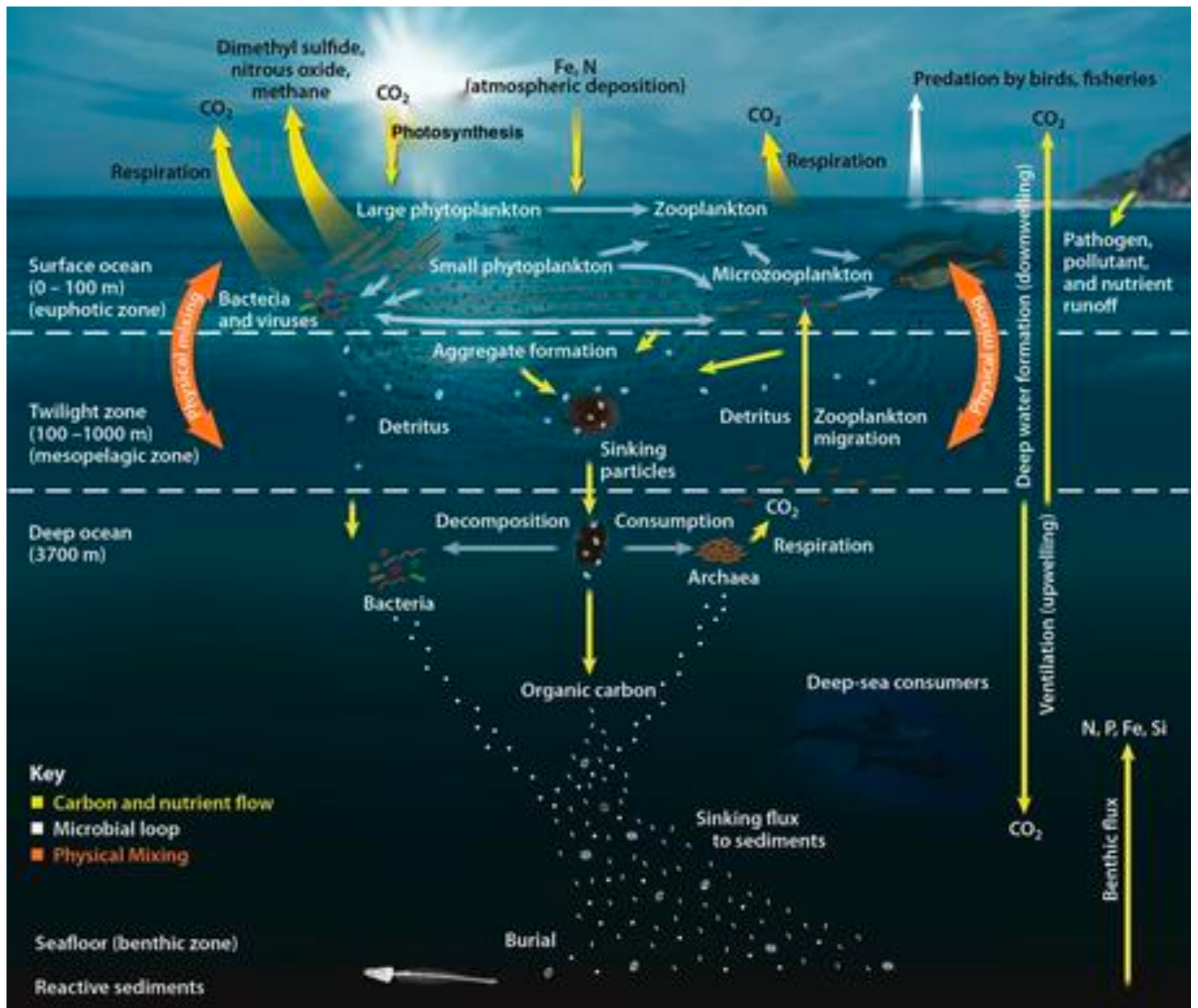
Satellite image of phytoplankton in North Pacific



Lowest  Highest

Satellite image of phytoplankton in North Pacific





## Opinions about ocean fertilization

ters carbon is uncertain. A study<sup>1</sup> by Smetacek published in July — based on analysis of an experiment in 2004 — found that at least half of the carbon taken up by the iron-fertilized plankton was buried after they sank to the bottom of the sea. But other studies<sup>2</sup> have found that carbon in the blooms remains in the active biological cycle and is not sequestered at all.

Smetacek, V. et al. Nature 487, 313–319 (2012).

. Boyd, P. W. et al. Nature 407, 695–702 (2000)

It is unclear whether the project will restore the salmon. A bumper run of sockeye salmon (*Oncorhynchus nerka*) in 2010 came two years after a volcanic eruption in Alaska sent a layer of iron-rich ash over the ocean, fertilizing a plankton bloom<sup>3</sup>. But many scientists remain sceptical.

Jones, N. Nature <http://dx.doi.org/10.1038/>

# Clear.

- Fertilizing the ocean absorbs CO<sub>2</sub>
- Fertilizing the ocean via volcanic eruption creates algal blooms.
- Algal blooms in the deep ocean create trophic cascades leading to more fish.

# Not clear, yet.

- Fertilizing the ocean with iron sulfate always creates algal blooms. There are other nutrients in volcanic ash.
- Percentage of carbon absorbed into the marine ecosystem remains trapped.

# Debate 3 topic

**Is geoengineering stupid?**

## **Affirmative**

Chisholm, S.W., Falkowski, P.G. and Cullen, J.J., 2001. Discrediting ocean fertilization.

## **Negative**

Buesseler, K.O. and Boyd, P.W., 2003. Will ocean fertilization work?. *Science*, 300(5616), pp.67-68.