

ARTICLES

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nature
sustainability

China and India lead in greening of the world through land-use management

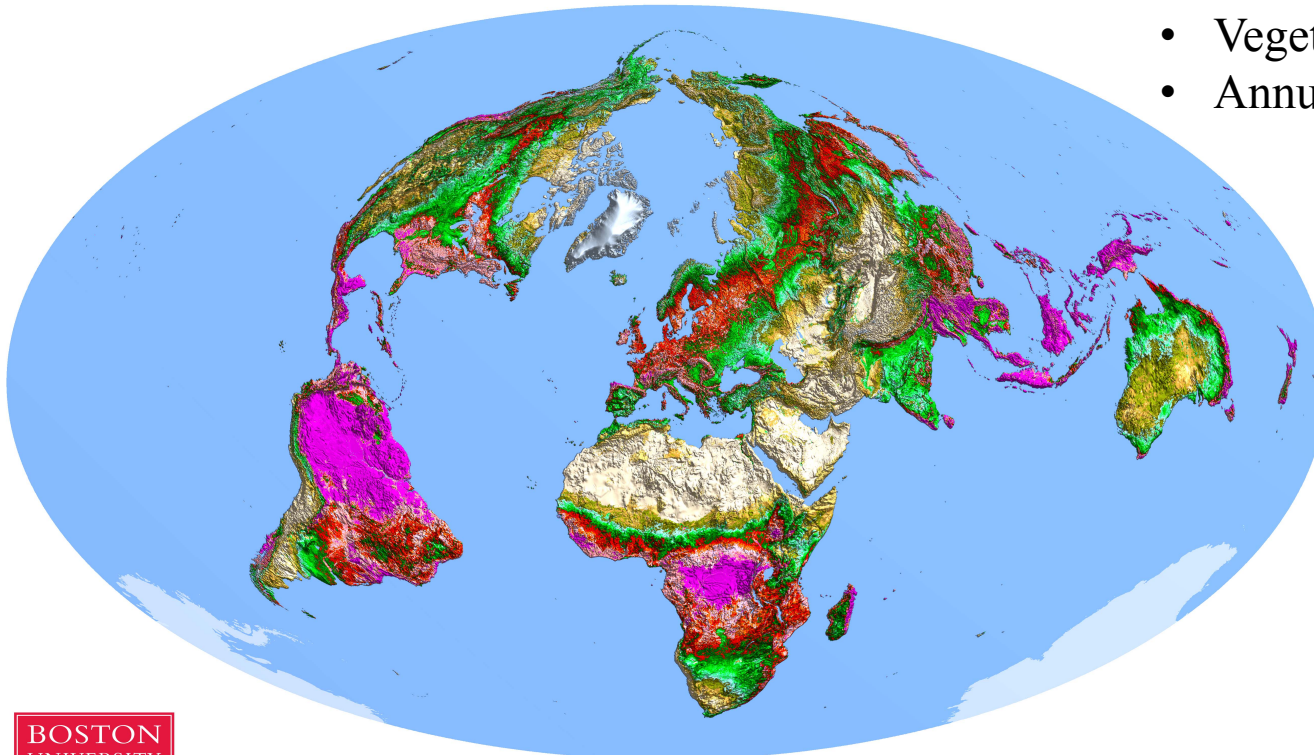
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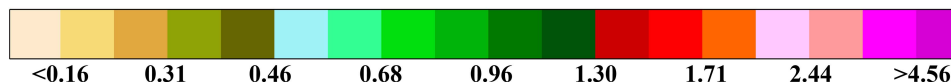
Greenness of Earth

Global (one-sided green) leaf area

- July: $231 \times 10^6 \text{ km}^2$
- January: $132 \times 10^6 \text{ km}^2$
- Yearly average: $171 \times 10^6 \text{ km}^2$
- Vegetated area: $109 \times 10^6 \text{ km}^2$
- Annual average LAI: 1.57



Annual Average Green Leaf Area Index From Terra MODIS (2001 to 2010)



Background

What is greening/browning?

- Greening (browning) is defined as a statistically significant increase (decrease) in annual-average green leaf area at a location over a period of several years

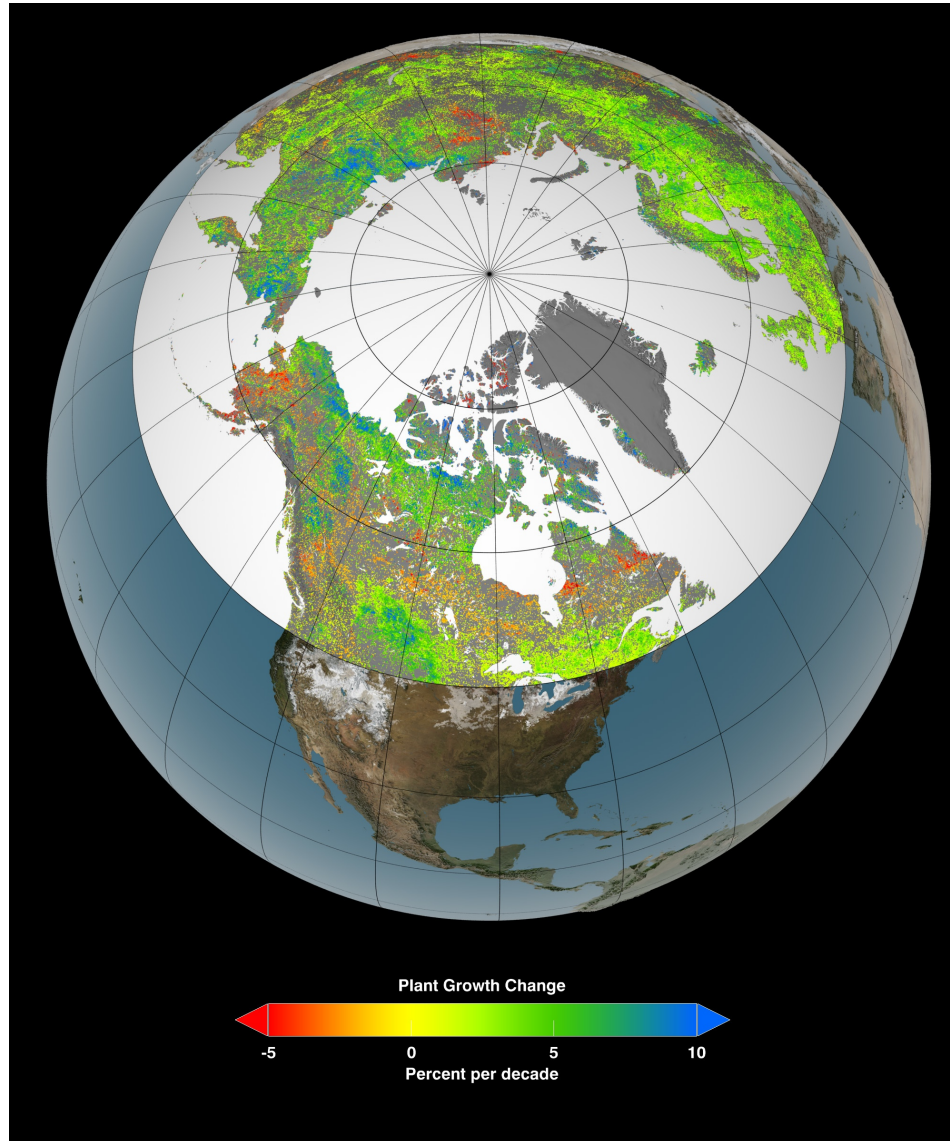
How can the land green/brown?

- It could result from changes in average leaf size, leaf number per plant, plant density, species composition, duration of green-leaf presence due to changes in growing season and multiple cropping, etc.

What causes greening/browning?

- Direct drivers: Human use of land
- Indirect drivers: Climate change, CO₂ fertilization, N deposition, Disturbances
- Hybrid drivers: Legacy effects

Greening from Warming of the Northern Lands



Finding: Warming driven greening

Data: AVHRR GIMMS NDVI 1981 to 1999

Source:

- Myneni et al., 1997
- Zhou et al., 2001

CO₂ Fertilization Greening the Earth

Finding: CO₂ fertilization -> 70% of greening Earth

Data: AVHRR GIMMS NDVI 1981 to 2011
MODIS LAI 2000 to 2010

Source:

- Zhu et al., 2016

WISSEN  WELT Titelthema

Titelthema WISSEN  WELT

Die Welt ergrünt

Satellitendaten überraschen: Auf der Erde hat sich in den vergangenen Jahrzehnten die Vegetation ausbreitet, obwohl Regenwald gerodet wurde. Ein Report über Ursachen und Folgen der zweiseitigen Entwicklung.

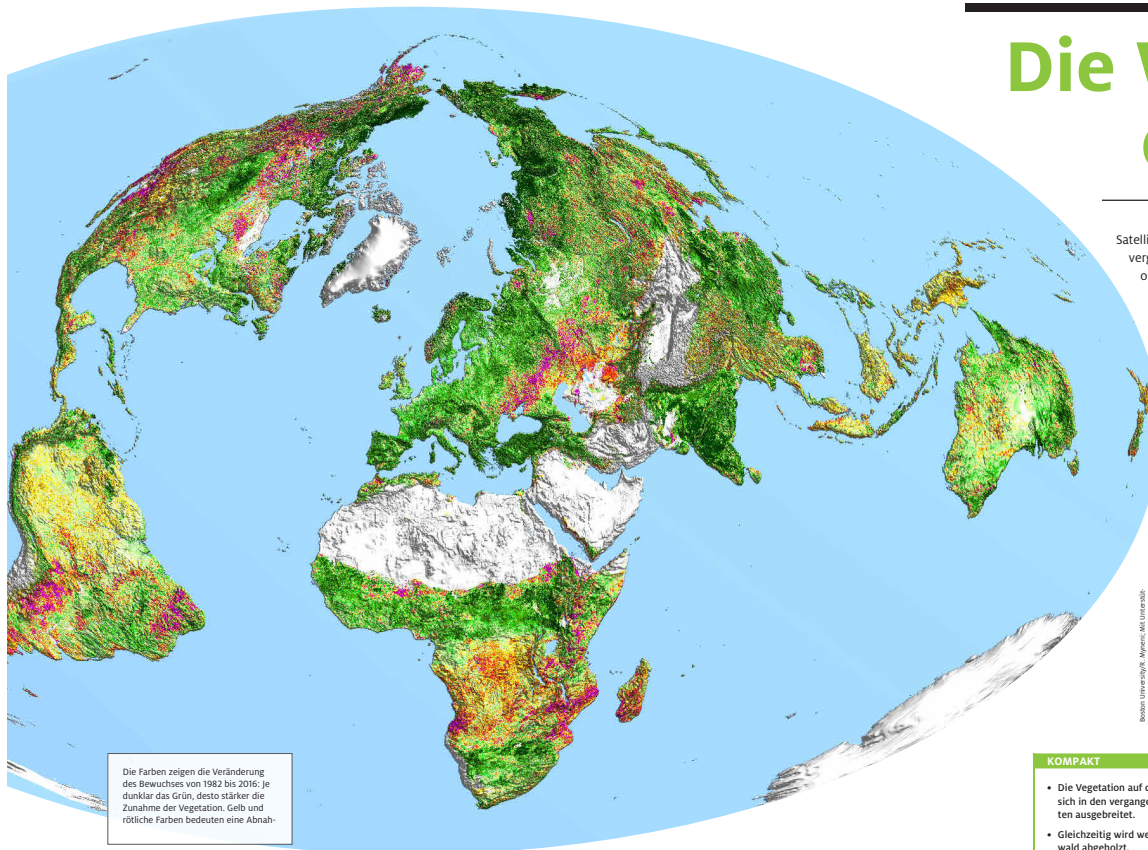
von JAN BERNDORFF

Berichte des Weltklimarats können kaum mehr überraschen, so schien es. Regelmäßig führen sie vor Augen, wie schlecht es ums Klima bestellt ist, wie dramatisch die zu erwartenden Folgen der globalen Erwärmung sein könnten. Der Abschnitt A2.3 des jüngsten Berichts aber lässt aufmerken: „Satellitenbeobachtungen haben ein Ergrünen der Vegetation über die vergangenen drei Jahrzehnte in Teilen Asiens, Europas, Südamerikas, Zentral-Nordamerikas und Südost-Australiens offenbart“, heißt es dort. Als Gründe nennt der Bericht die längere Vegetationsperiode, die Stickstoffabfagerung, die Kohlendioxid-Düngung und die Bodenbearbeitung. Es gebe zwar Regionen, die brauner würden, aber „global gesehen ist eine größere Fläche ergrünt als verbraunt“, schreibt das Klimagremium der Vereinten Nationen.

Widerspricht die Feststellung nicht allem, was bis dato über die Vegetation der Erde verkündet wurde? Noch 2015 warnte die Welternährungsorganisation FAO in ihrem Forest Resources Assessment: „Über die letzten 25 Jahre hat die Waldfläche der Welt von 4,1 Milliarden Hektar auf knapp unter 4 Milliarden Hektar abgenommen, eine Abnahme um 3,1 Prozent.“ Hauptgrund sei die Abholzung wie

KOMPAKT

- Die Vegetation auf der Erde hat sich in den vergangenen Jahrzehnten ausbreitet.
- Gleichzeitig wird weiterhin Regenwald abgeholzt.
- Vor allem in China laufen gigantische Begrünungsprojekte.



Boston University, Myronio, Bild Universität
Jung-Li, Bild Universität von Nordost-Östling

Die Farben zeigen die Veränderung des Bewuchses von 1982 bis 2016: Je dunkler das Grün, desto stärker die Zunahme der Vegetation. Gelb und rötliche Farben bedeuten eine Abnahme.

Role of Human Use of Land?

Previous Study:

- CO₂ Fertilization 70%
- Climate change 8%
- Human land use 4%

Source:

- Zhu et al., 2016

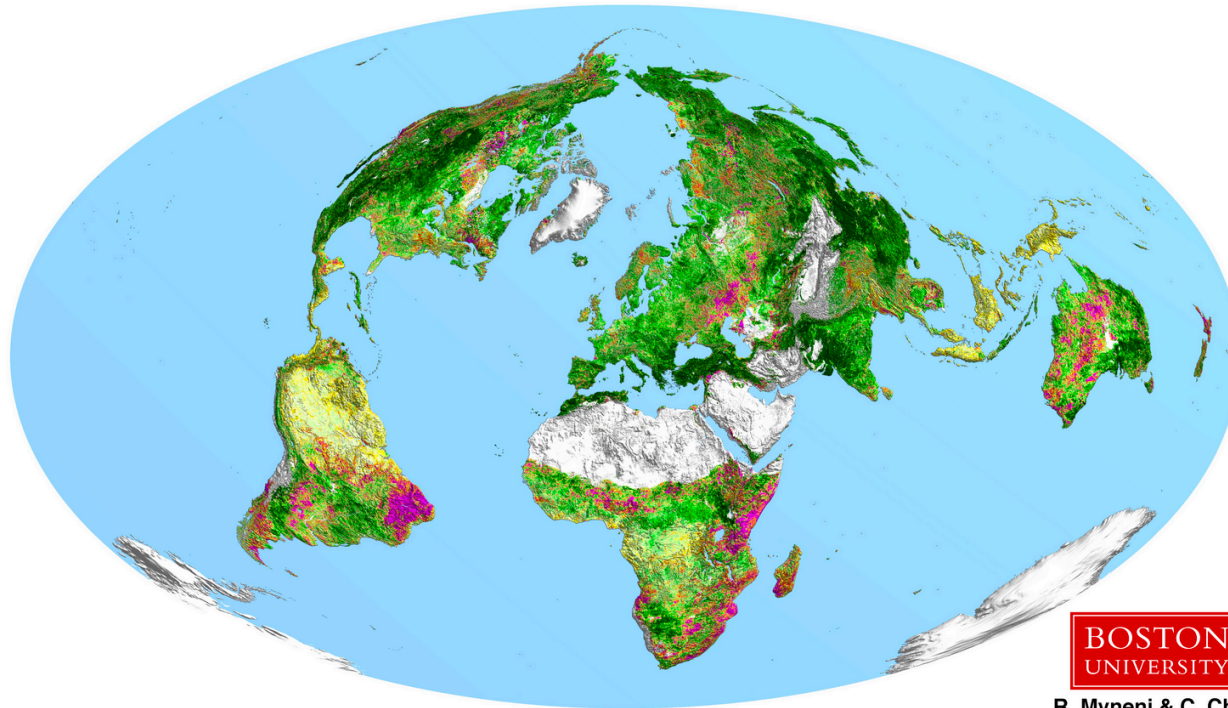
Question: What about human use of land?

Approach:

- Terra & Aqua MODIS LAI data 2000 to 2017
- Do not use models

What Does MODIS Data Show?

Trend in annual average leaf area (% per decade, 2000 to 2017)

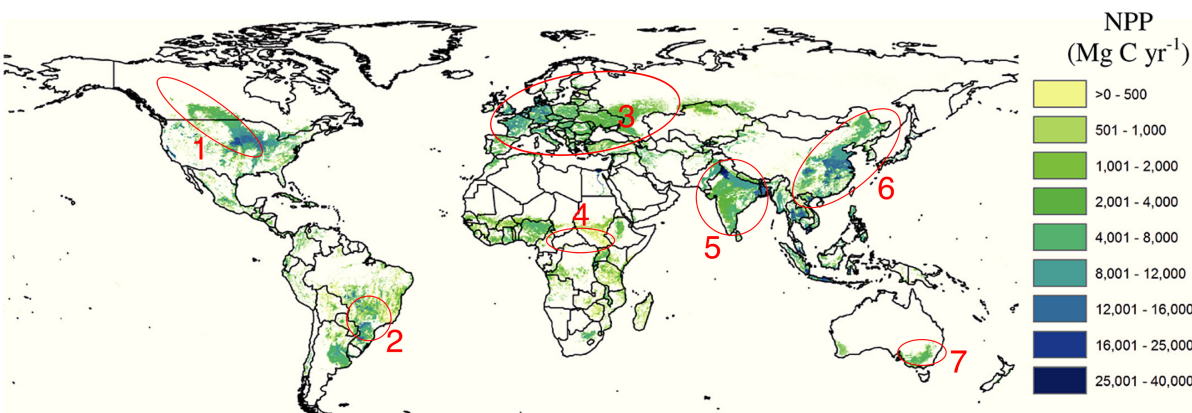
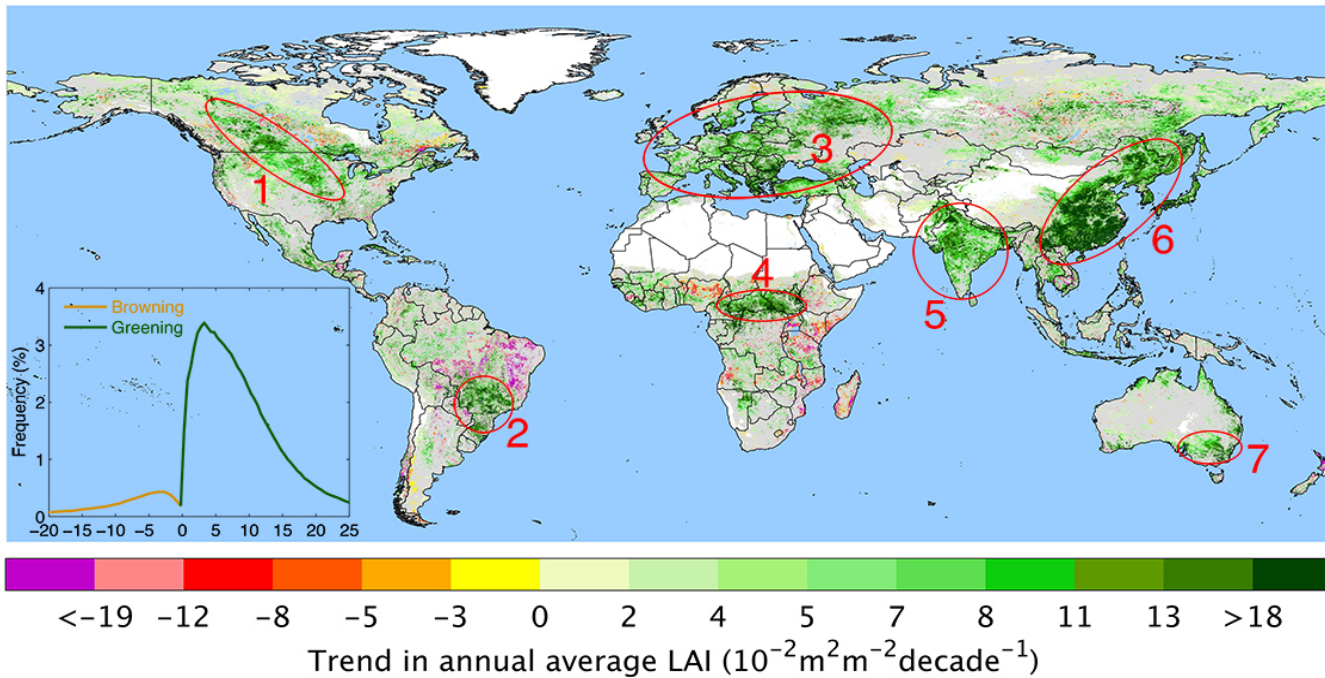


**BOSTON
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R. Myneni & C. Chen

- One-third of the global vegetated area is greening and only 5% is browning
- Net increase in leaf area of 2.3% per decade
- Equivalent to adding 5.4×10^6 km² of new leaf area over the 18-yr period of the record
- Two-thirds of this greening is from croplands and forests in about equal measure

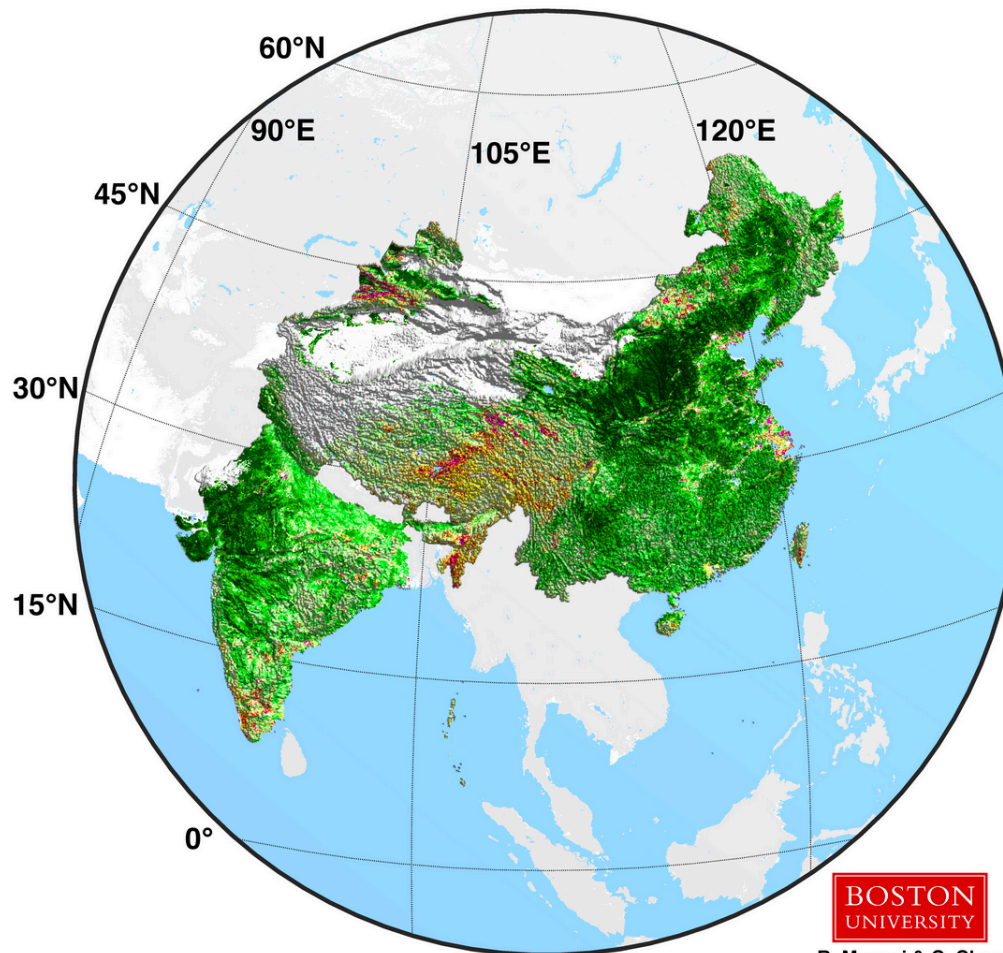
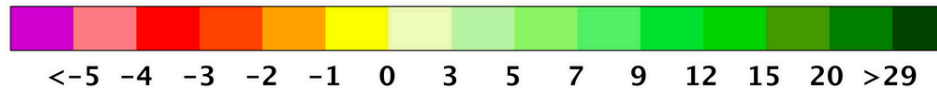
Human Managed Lands Exhibit Most Greening



Six of the seven greening clusters overlap with the areal pattern of agricultural primary productivity derived independently by Wolf et al. (2015)

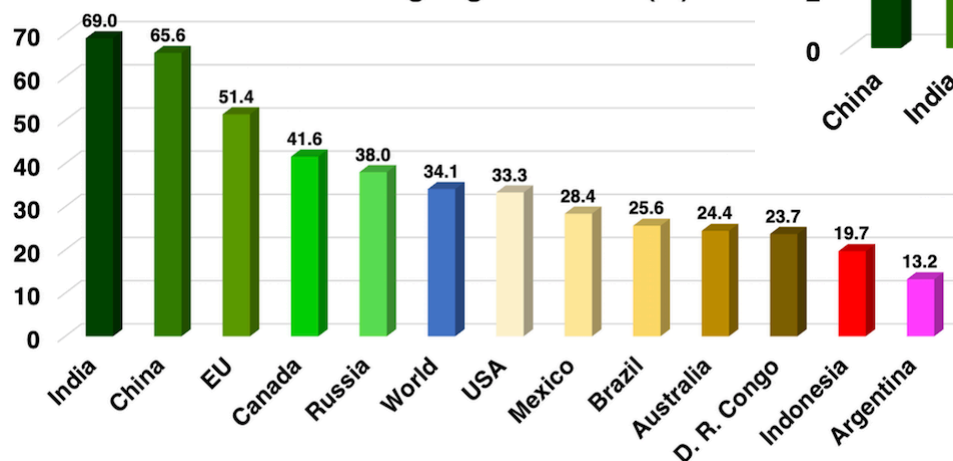
China and India Stand Out !

Trend in annual average leaf area (% per decade, 2000 to 2017)

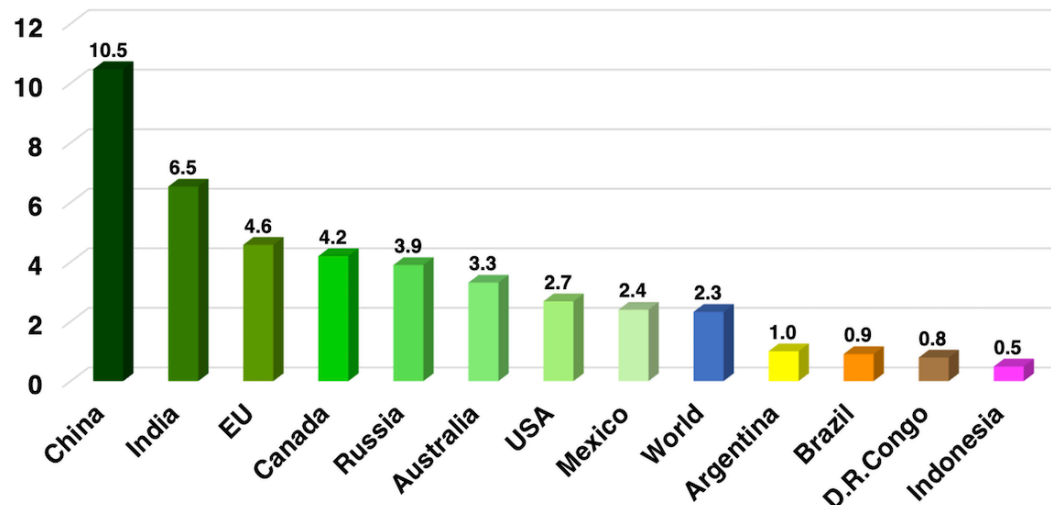


China and India Stand Out !

Greening vegetated area (%)



Change in leaf area (% per decade)



China and India (& EU) –

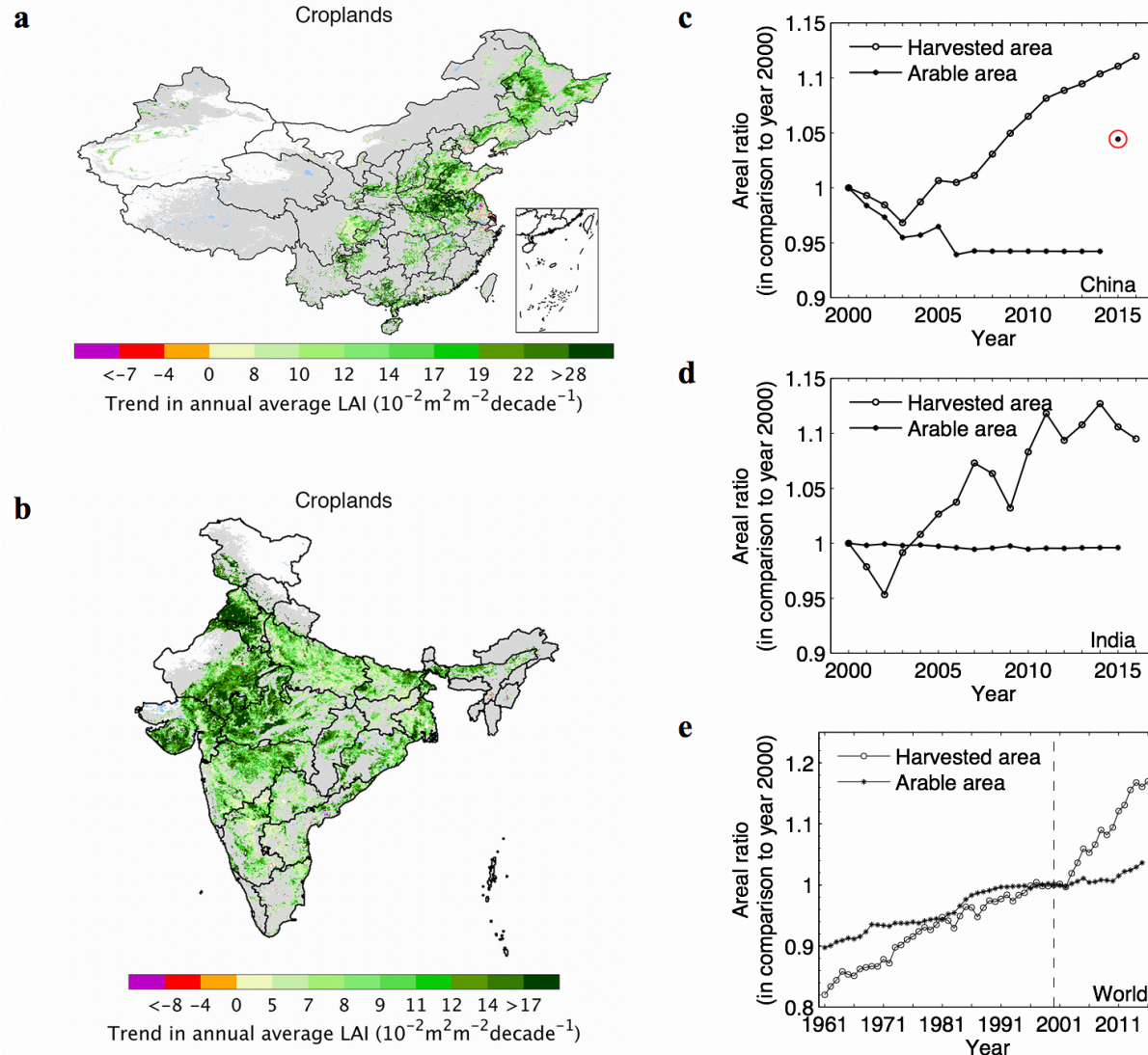
- Middle ranks in terms of vegetated area and average leaf area
- Top ranks in terms of greening land proportions and net change in leaf area

Why?

- China is implementing several ambitious programs to conserve and expand forests with the goal of mitigating soil erosion, air pollution and climate change
- Already a third of the 2.08×10^6 km² of current forests are plantations with rapidly growing young trees less than 40 years old



Why?



- Comparable and stable land area under crop cultivation since 2000 (1.92 and $2.11 \times 10^6 \text{ km}^2$)
- Total food production (grains, fruits, vegetables, etc.) has increased 35 to 40%

Croplands in China and India

- Increasing harvested area through multiple cropping
- Facilitated by heavy fertilizer use and surface/ground-water irrigation
- The two countries currently rank at the top for the amount of fertilizer use
- The observed large-scale greening is a harbinger of food self-sufficiency for 2.7 billion people in the two top ranked countries in terms of agricultural output (nominal GDP of 1.1 and 0.41 trillion in 2015 US dollars from the agricultural sector in 2015)

Acknowledgement

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