# A large but transient carbon sink from urbanization and rural depopulation in China

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## Background & Aim

- China has experienced unprecedented urbanization and associated rural depopulation during recent decades alongside a massive increase in total population. We hypothesis that urbanization causes rural outmigration which leads to a large carbon sink.

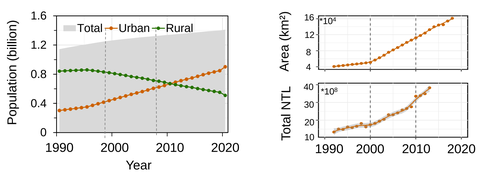
**Aim:**

- The study tests the hypothesis that urbanization and carbon neutrality are not mutually exclusive and that sustainably-managed urbanization could increase carbon sequestration, especially in rural areas.

## Datasets

- WorldPop population density (2000,2020) with 1km resolution used to estimate population change in 1km for 2000-2020.
- Annual ESA-CCI land use maps and Nighttime lights derived from DMSP/OLS v4 are used to study urban expansion.
- GlobaLand30 land cover maps in 2000 and 2020 are used to define urban areas and agricultural land.
- Aboveground carbon density based on MODIS from *Tong et.al 2020* expanded to all China estimates the aboveground carbon density change during 2002-2019.
- Mobile phone location data from the Tencent location service platform was used to generate daily population movement maps for 8 provinces of southern China.
- Demographic data from the national census shows rural and urban residents.
- Global Urban footprint (GUF) dataset provides human settlement map with ~12 m spatial resolution.
- Fossil $CO_2$ emission data derived from Global Carbon Project is used to evaluate fossil $CO_2$ emission at national scale for 2000-2019.

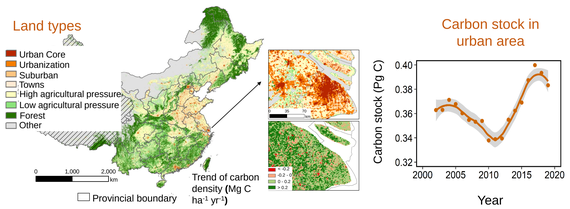
## Urbanization and rural outmigration

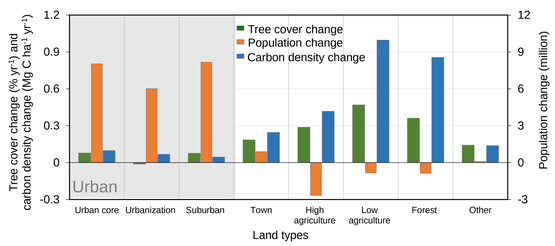



- China's population increased from 1.13 billion to 1.40 billion (+24%) during 1990-2020, while **rural population dramatically decreased (-28%)** with the mean speed of -14 million people $yr^{-1}$.
- Annual land cover map and nighttime lights show the rapid urbanization after 2000.

## Greening of urban areas

- Although urban expansion caused an initial aboveground carbon loss of -0.02 Pg C during 2002-2010, **urban greening compensates these original losses with an overall balance** of +0.03 Pg C in urban areas during 2002-2019.

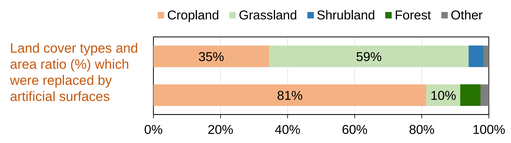


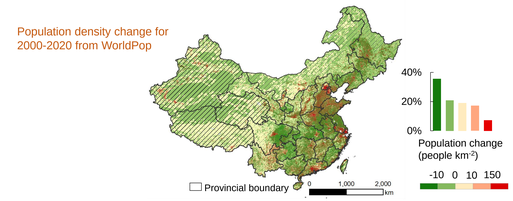

- **Agricultural land with low pressure has by far the strongest increase in biomass**, followed by "forests" and agricultural land with high pressure.

## Marginal decline of croplands

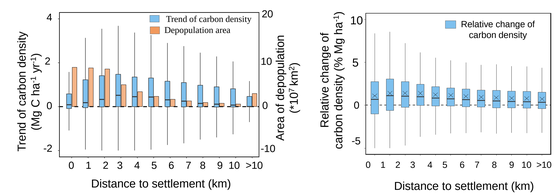
- New artificial surfaces replaced mainly croplands, followed by grasslands and forests, which causes a slight decline in cropland areas (4%).
- **The relatively low aboveground biomass of croplands helps explaining the overall increase of biomass in urbanization areas** shown in upper section.



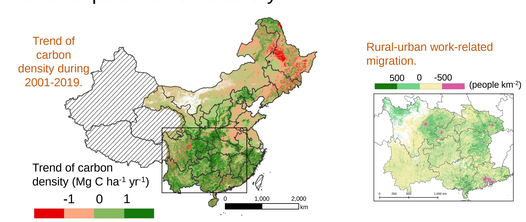

## Carbon stocks in rural outmigration areas



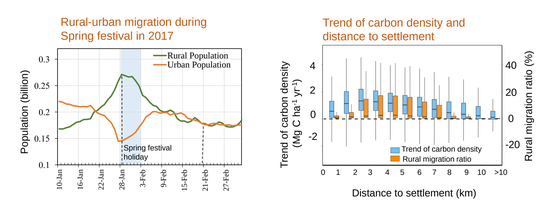

- The **distance to settlements** are explored to reflect different intensity levels of human pressure.




- A **maximum increase** in aboveground carbon stocks at **intermediate distances to rural settlements (2-4 km)** reflects the decreased pressure on natural resources. At longer distances, the smallest amount of regrowth was observed, as these more remote forest areas likely experienced less past disturbance, thereby showing a smaller potential for recovery.

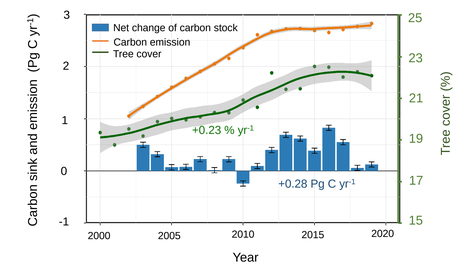



- **Rural-urban work-related migration is** derived from Mobile Phone location dataset during Spring Festival holiday in south 8 provinces in China.




## Carbon sink and $CO_2$ emissions trends

- **Tree cover strongly increased over 2000-2011, the increase slowed down** in recent years.
- An extensive aboveground carbon sink of 0.28 ± 0.05 Pg C $yr^{-1}$ is observed in national level during 2002 - 2019.
- The increase of fossil $CO_2$ emissions also slowed down in 2011, with only a small growth rate in the last years.




## Highlights

- **Urban greening compensates original aboveground carbon losses with an overall positive balance in urban areas during 2002-2019 for China.**
- **Aboveground carbon stocks increase strongly in rural outmigration areas. Young forests around rural settlements with a shrinking population recover faster than older forests** in distance to those settlements which did not experience the same level of pressure in the past.
- Urbanization and carbon neutrality are not mutually exclusive. **Sustainably managed urbanization may even be an integral part of the pathway to reduce atmospheric $CO_2$.**
- Tree cover growth saturation limits the carbon removal capacity of forests, and only a strong decrease in $CO_2$ emissions from fossil fuel burning will make the aim of carbon neutrality achievable for China.

*Reference:*
*Tong, Xiaowei, et al. "Forest management in southern China generates short term extensive carbon sequestration." Nature communications 11.1 (2020): 1-10.*

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