INTERNATIONAL CLIMATE CHANGE CONFERENCE CI2C - 2025

6th Edition

CLIMATE SOLUTIONS FOR A SUSTAINABLE FUTURE

Theme: Sectorial Decarbonization and Mitigation

Methods for estimating carbon stock in forest ecosystems: From traditional approaches to advanced techniques

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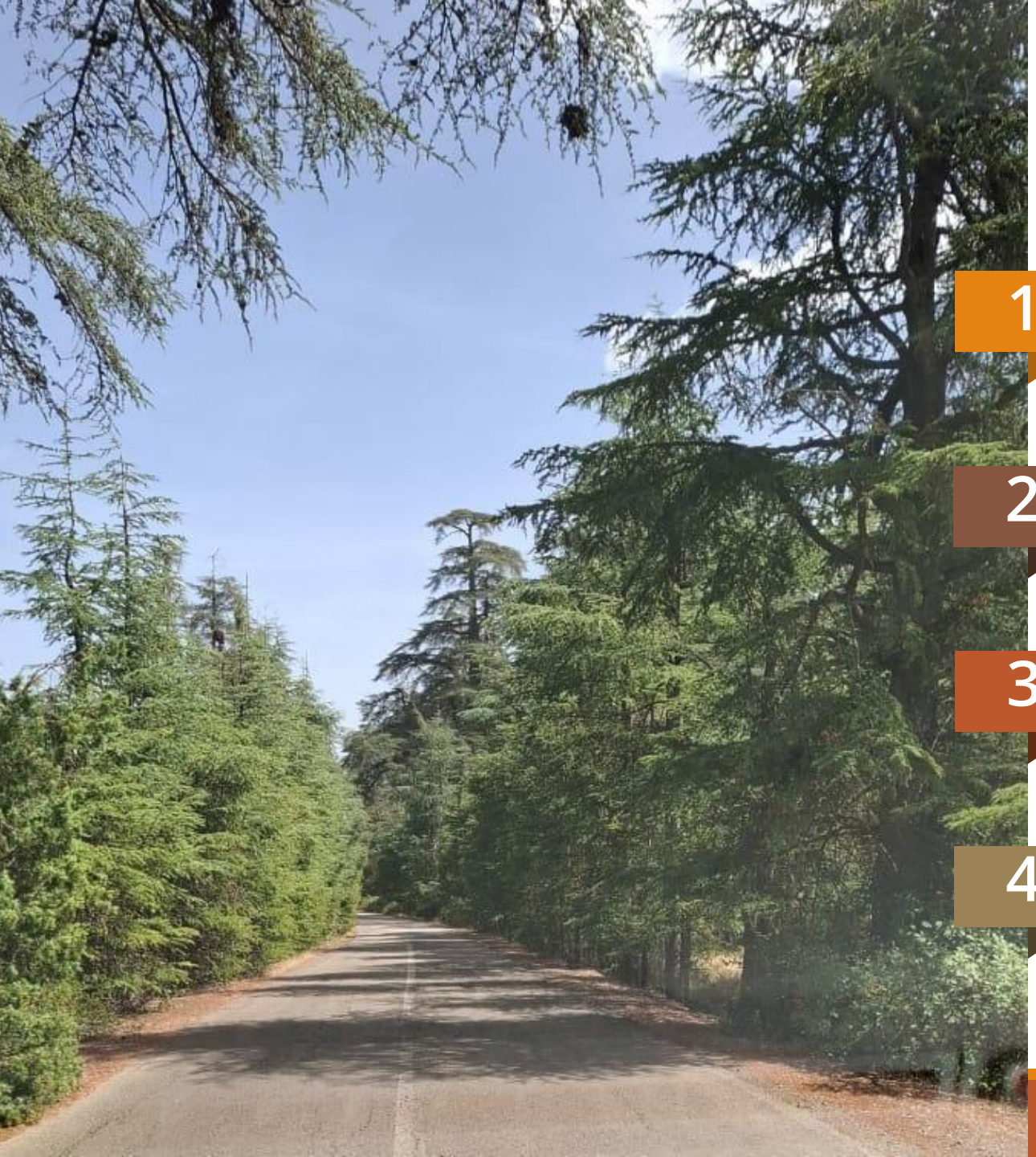


PLAN

1. Introduction & objectif
2. Methods & Data Sources
3. Results & Discussion
4. Conclusion

Introduction & Objectives :

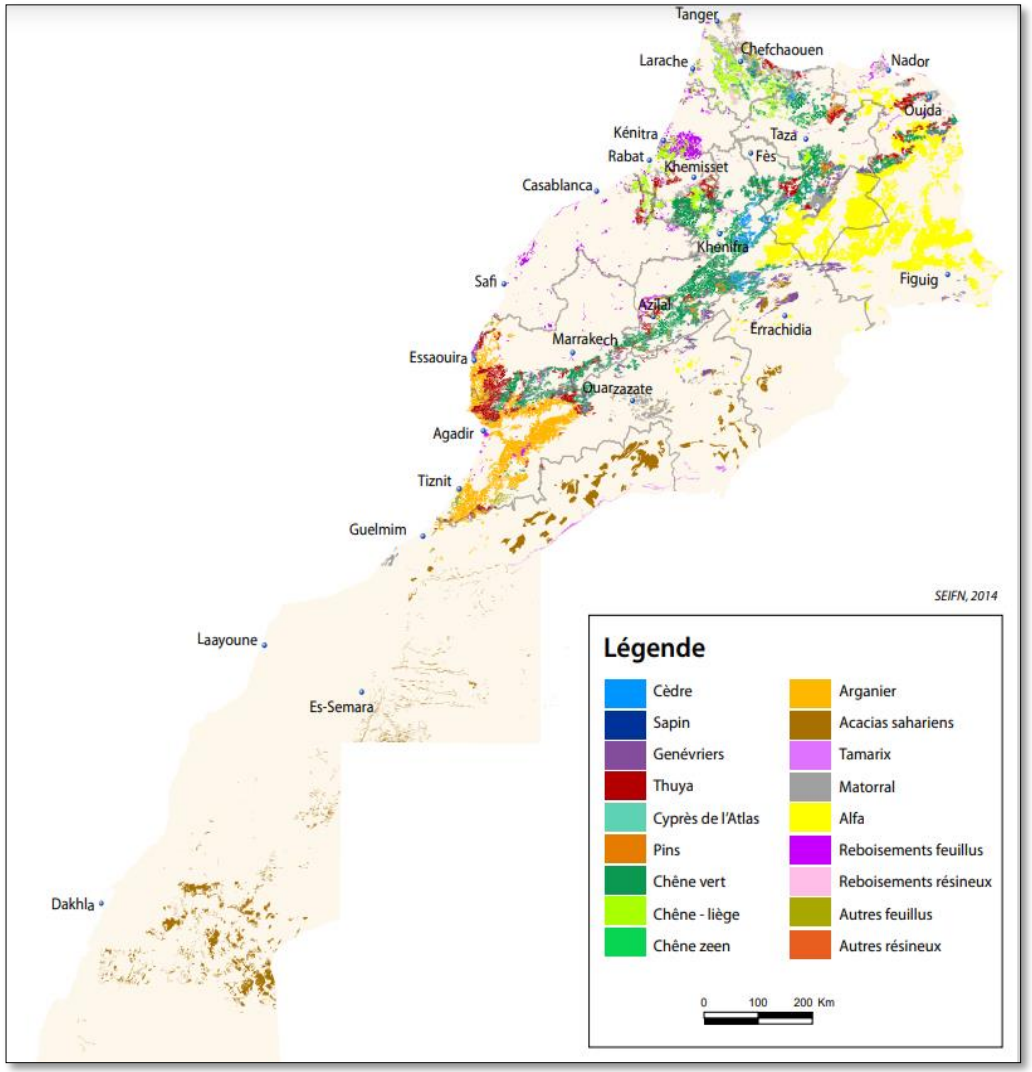
General Overview of Moroccan Forests

09 M ha: - 5,7 M ha of FS
- 3,3 M ha ES

13% of the total area

Mean afforestation rate: 9%

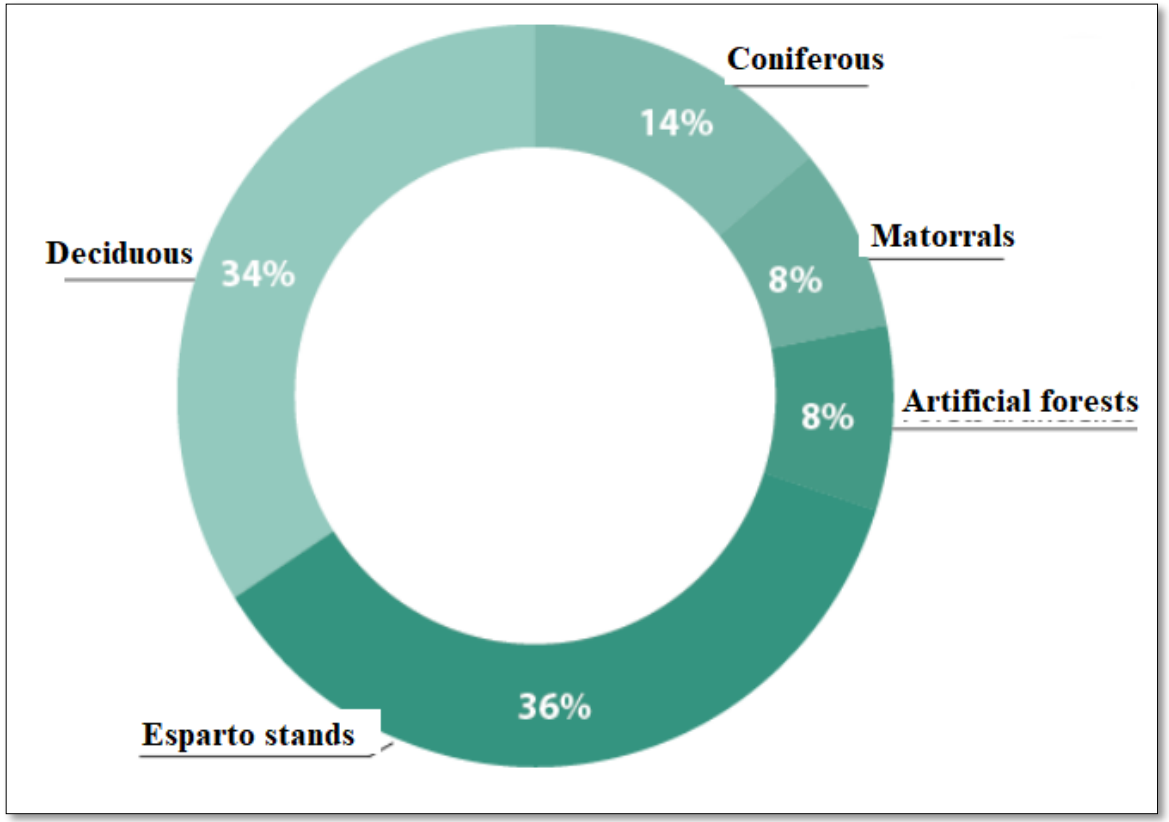
Optimal rate: 15 to 20%

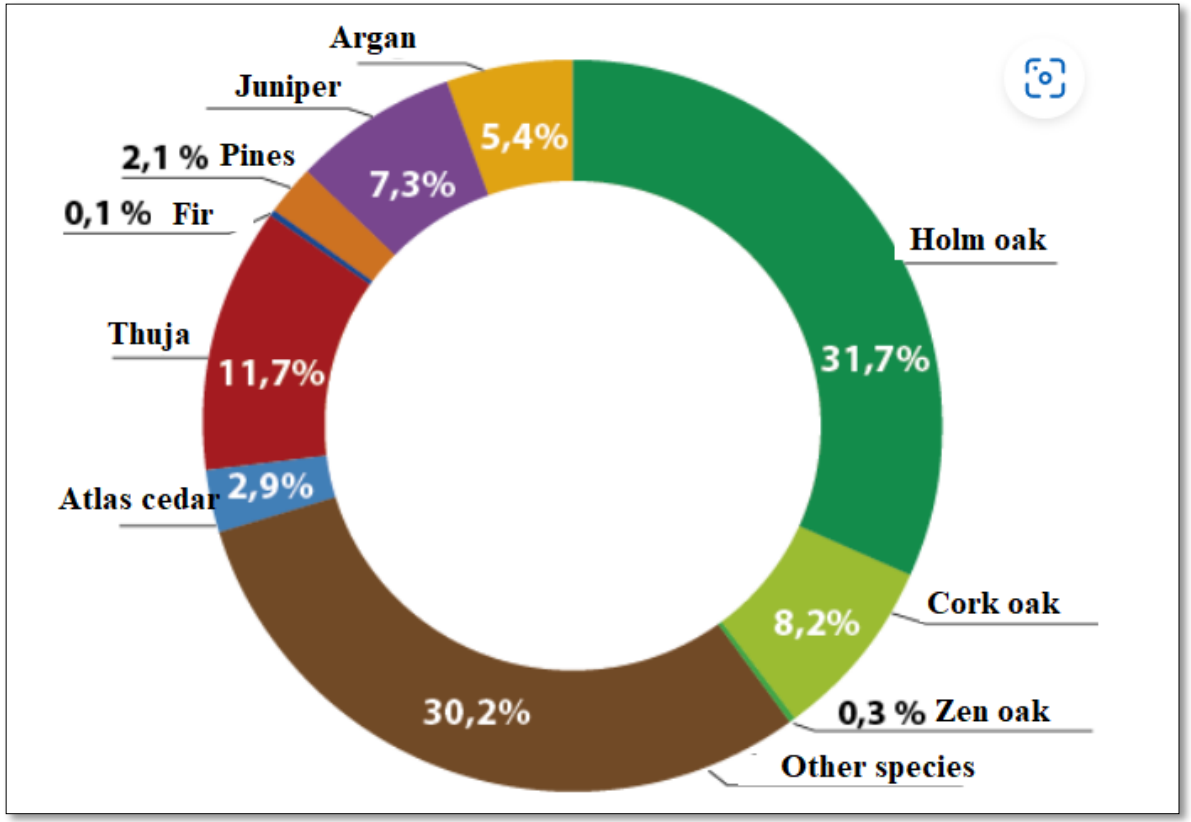


Introduction & Objectives :

General Overview of Moroccan Forests

Floristic composition





Introduction & Objectives :

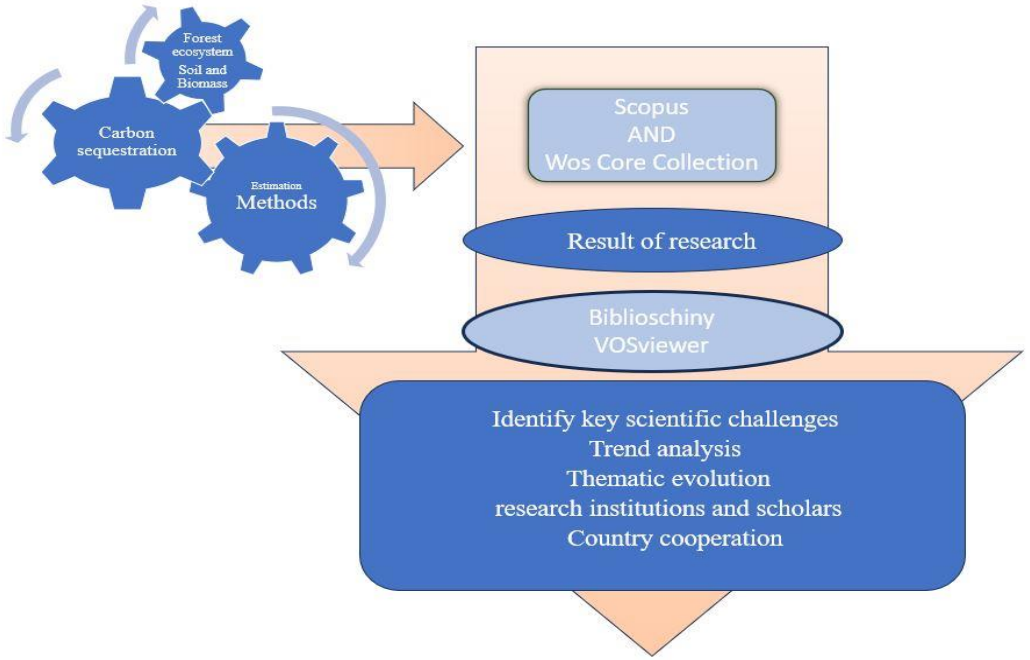
	Main functions
Social	wood for energy; forage for livestock
Economic	Provide wood to the industrial sectors
	Produce non-timber resources
Environmental	Developing ecotourism and entertainment activities
	Protecting the environment (soil conservation, carbon sequestration, fighting desertification, water filtration,.)

- Forests are key terrestrial carbon sinks, essential in mitigating global climate change;
- Accurate carbon estimation supports ecosystem management and climate policies;
- This study offers a bibliometric analysis (2014–2024) of carbon storage estimation methods;
- Objectives:
  - Identify main trends and methods
  - Map international collaborations
  - Support effective climate adaptation strategies

Methods & Data Sources:

Bibliometric Approach

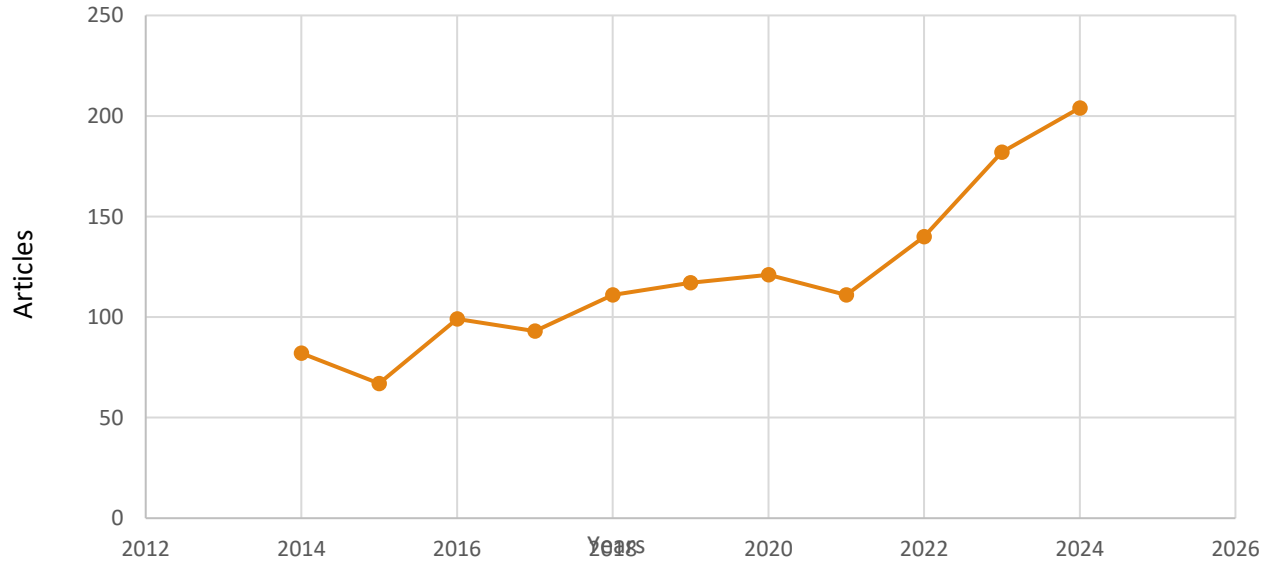
- Tools used: VOSviewer, Biblioshiny (R Studio).
- Data sources: Scopus, Web of Science.
- Research period: 2014–2024; focused on articles only.



Results & Discussion:

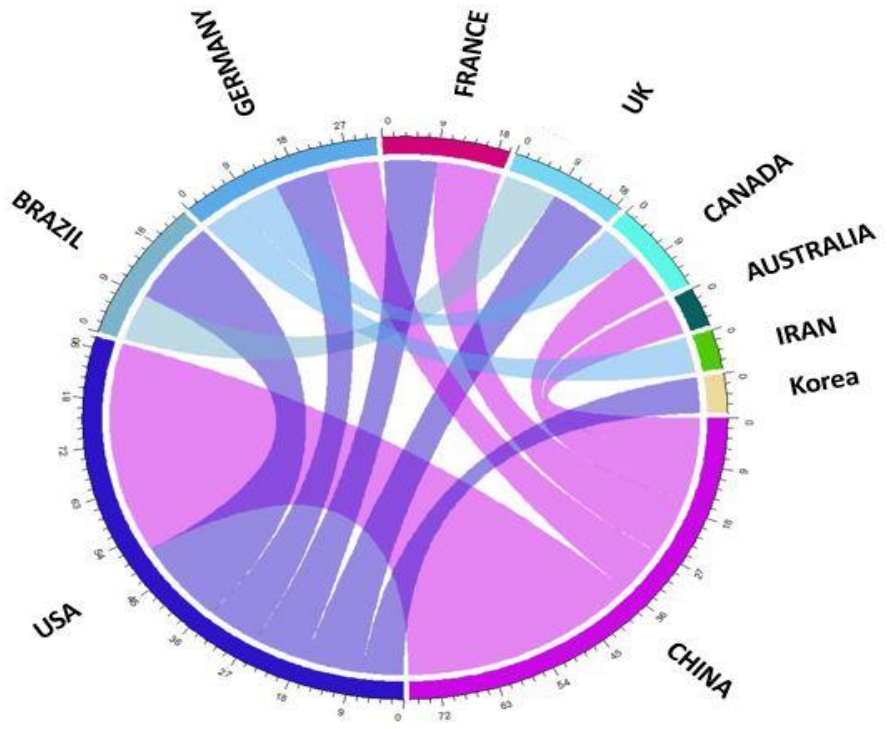
Scientific Publication Trends

- Rising volume of forest carbon research since 2014.
- Major drivers: international climate initiatives (e.g., REDD+), technological innovation.
- Shift towards scalable, effective, and data-driven methods.



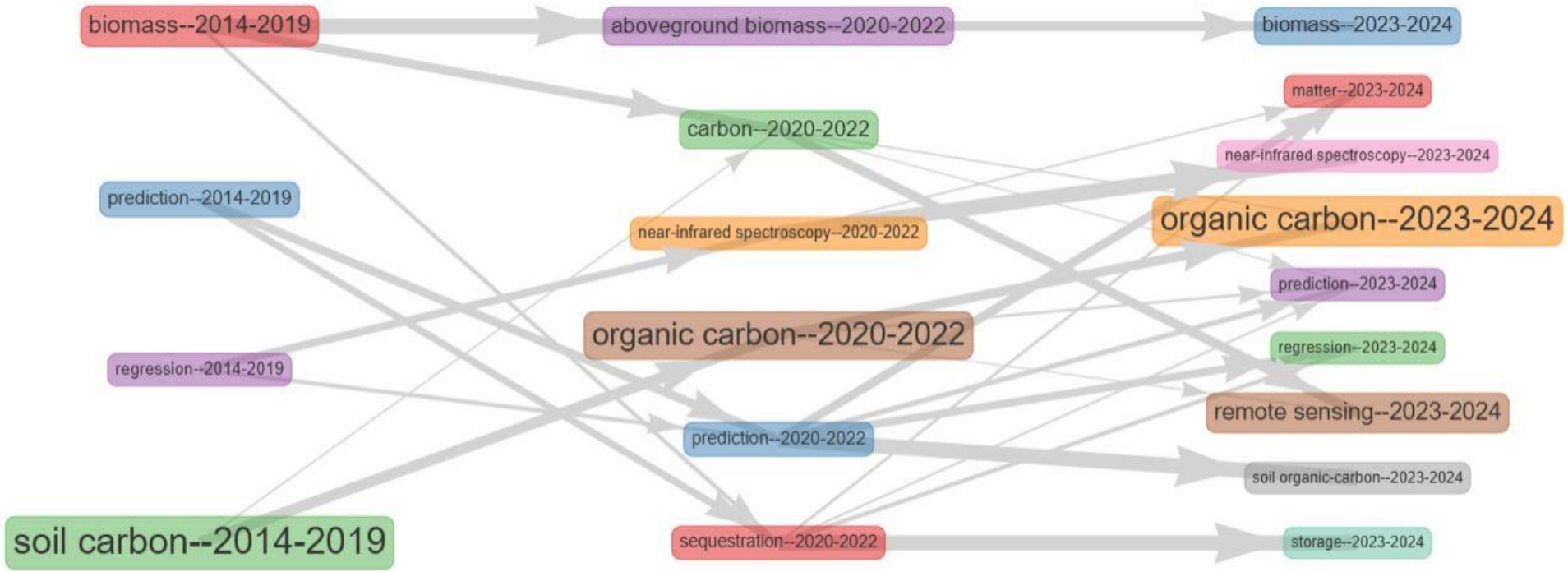
International Publication and Collaboration:

- China leads with 3,072 papers (28.8%), USA with 2,657 (24.9%), Germany with 974 (9.1%).
- High collaboration: China, North America, Europe (especially Germany).
- International partnerships continue to grow and diversify.



Thematic Evolution & Keywords:

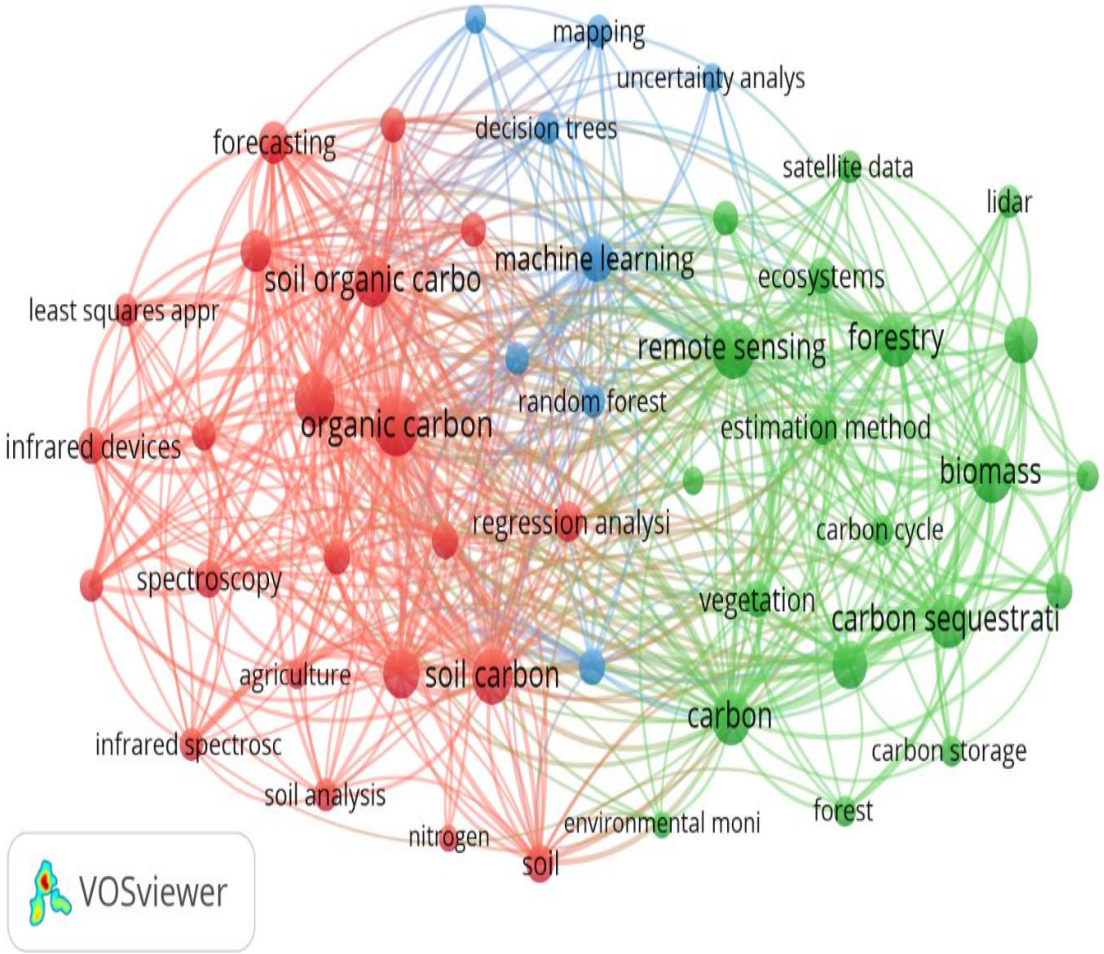
- 2014-2019: Focus on statistical models, soil carbon, traditional inventories;
- 2020-2022: Integration of advanced methods (spectroscopy, multisource data);
- 2023-2024: Machine learning, remote sensing, uncertainty analysis become central.



Keyword Clusters:

- Three main research clusters:
  - Soil organic carbon and spectroscopy
  - Remote sensing, forest biomass
  - Advanced analysis methods and machine learning

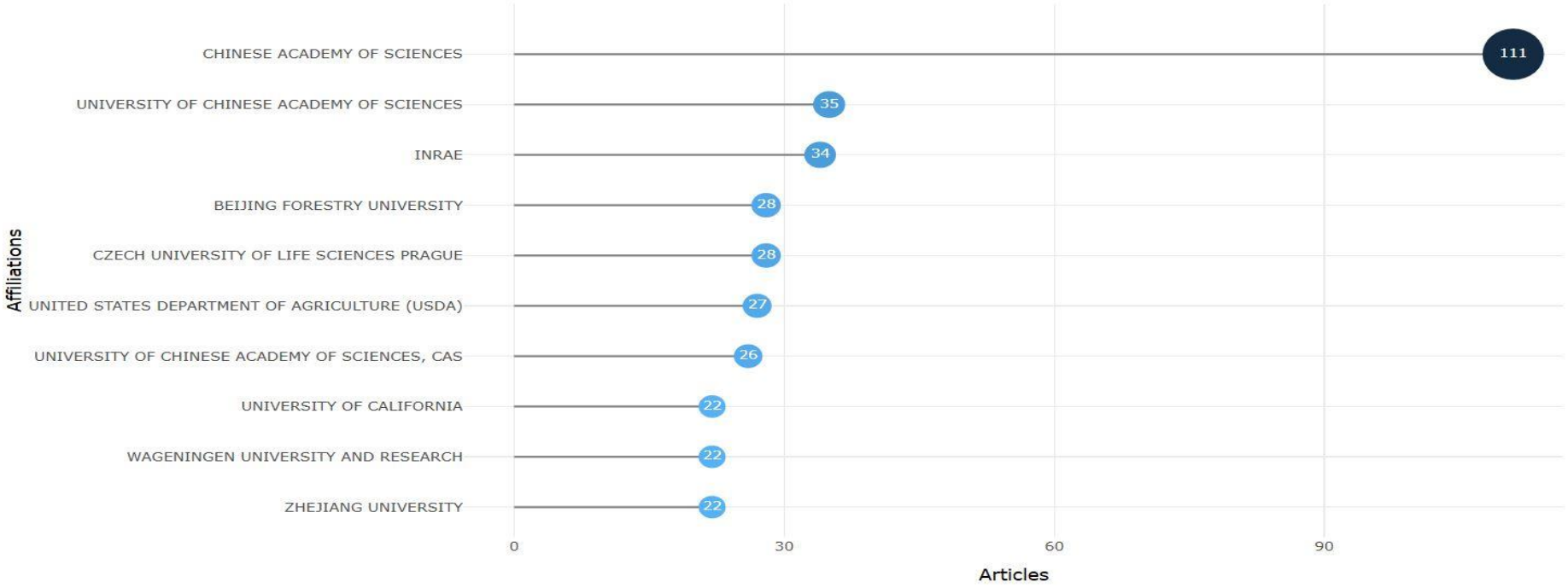
- Central keywords: SOC, machine learning, remote sensing.



Key Papers & Institutions:

- Most cited works shaping the field:
  - Remote sensing of the terrestrial carbon cycle
  - Soil organic matter studies

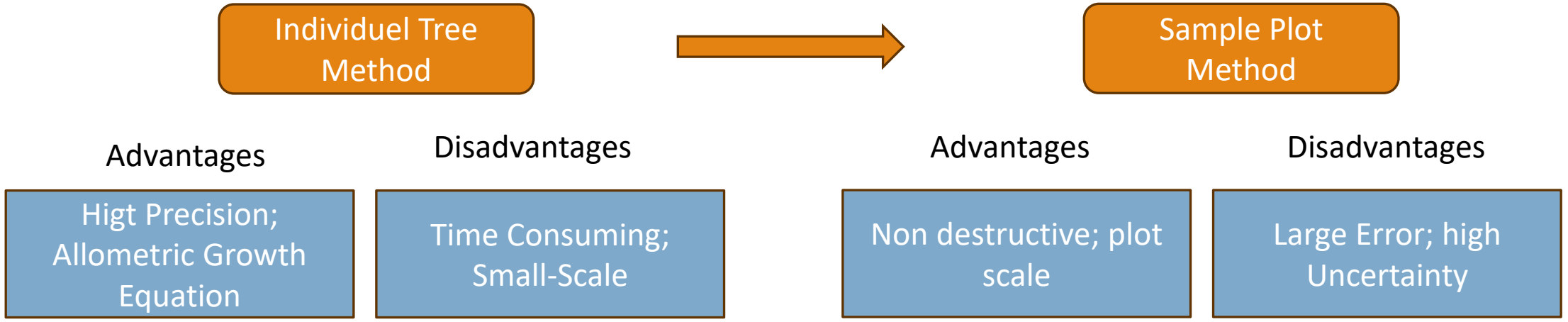
- Leading research institutions: Chinese Academy of Sciences, INRAE, Wageningen, USDA, University of California.



Methods for Carbon Estimation:

- **Classical methods based on forest inventory and allometry :**

- Allometry: Use of allometric equations (linking diameter to height/biomass) to estimate biomass from field measurements
- Forest inventories: Collection of data on species, density, structure, etc



Methods for Carbon Estimation:

- **Advanced methods integrating remote sensing :**

- Optical remote sensing (satellites) and vegetation indications, calculation of indicators such as NDVI, SAVI, ARVI from imaging (Sentinel-2, Landsat, MODIS, WorldView-2;
- Terrestrial and airborne LIDAR: Acquisition of 3D structural data (canopy height, vertical profile) used to estimate the total biomass and its compartments;
- Radar and SAR (Polarimetric): Gives information on the forest structure, useful for estimating biomass and carbon in difficult environments.

Machine Learning and Advanced Data Fusion Methods

ML Approach	Application & Variables	Main Data Sources	Key References
Random Forest	Predict biomass from LiDAR/optical indices	LiDAR metrics, vegetation indices	Li et al., 2014; Zhang et al., 2019
Boosted Regression Trees (BRT)	Analyze relative variable importance; minimize deviations	Inventory, remote sensing, stand variables	Qiu et al., 2018; Li et al., 2014
Deep Learning (SSAE, Autoencoders)	Fuse LiDAR & optical for biomass estimation	LandSat, airborne LiDAR, combined indices	Zhang et al., 2019
K-Nearest Neighbor, SVR, Cubist, Bagging, GAM	Various regression/classification approaches	Mainly LiDAR but also optical RS	Li et al., 2014; Nguyen et al., 2015
Geostatistics (Kriging)	Spatial interpolation of biomass/carbon	RS indices + ancillary variables	Ahmad et al., 2023

Conclusion

- Remote sensing and machine learning are now pivotal for accurate, large-scale carbon estimation.
- Bridging geographical and linguistic gaps in research remains imperative.
- Interdisciplinary and international cooperation is key to advancing sustainable forest management and climate mitigation.
- Advances in AI and spatial technologies promise further progress in the field

THANK YOU FOR YOUR ATTENTION