Mapping & Monitoring Forest Biomass & Carbon Stock-Changes Across Complex Landscapes

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Learning Exchange Series
MSU Forest Carbon & Climate Program
12 Oct 2022

ESF State University of New York College of Environmental Science and Forestry

CAFRI Climate & Applied Forest Research Institute

NYS Forest Carbon Assessment

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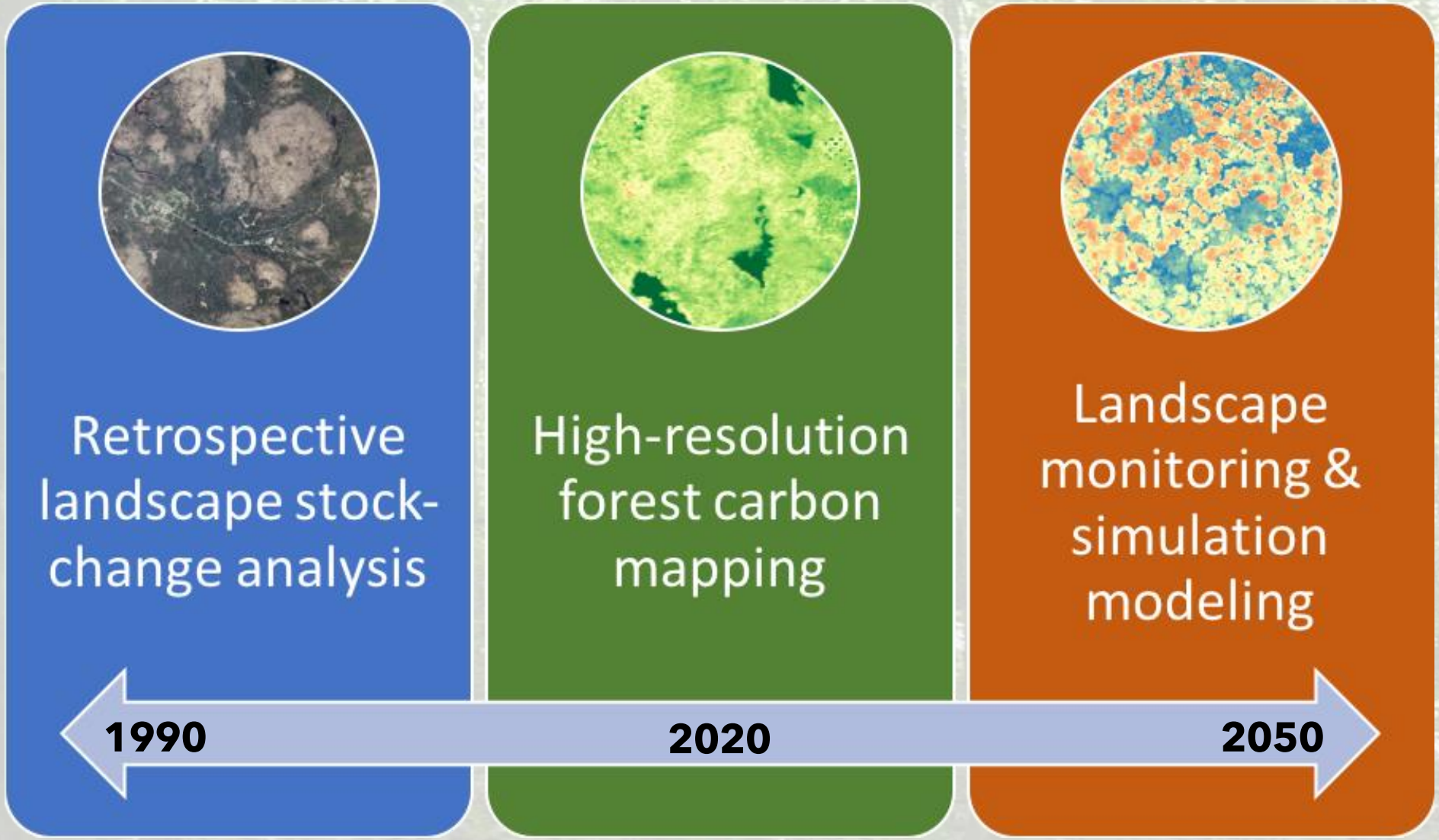
Goal: To develop a map-based carbon accounting system for 'natural and working lands' across New York State, to support policy and regulatory decisions, enhance monitoring/ reporting/verification (MRV) capabilities, and inform forest stewardship practices

US Forest Service FIA reports state-level estimates of annual forest C stocks and changes (sequestration, emissions) to the EPA, based on statistical analysis of their field plot network (over 4,400 plots across NYS)

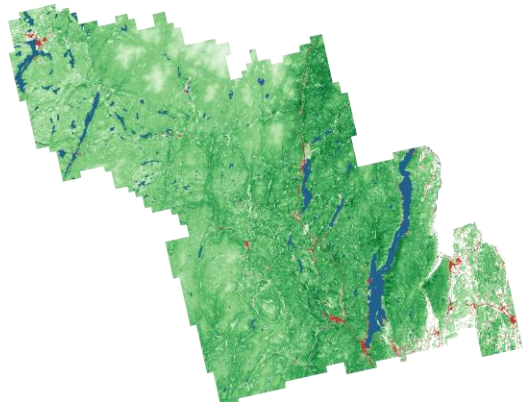
State-level stocks and trends are useful, but offer little actionable information at decision-relevant scales or insights on why, where, or how the forest C sink may be changing. So we set out to:

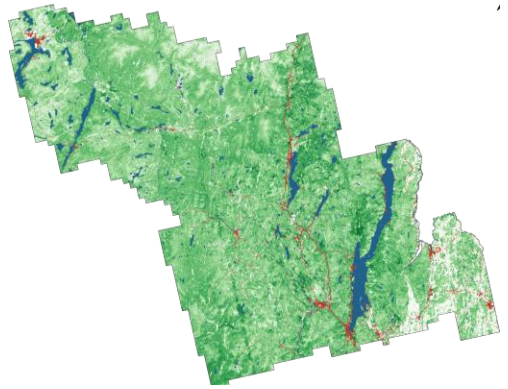
- Develop a statewide map-based inventory of forest biomass and carbon stocks
- Model and map retrospective (historical) forest biomass, carbon stocks and land use/land cover
- Apply historical forest maps/data in a stock-change framework to estimate sequestration and emissions
- Build a framework to observe future C stock-changes to support monitoring/reporting/ verification (MRV)

CAFRI is mapping **current** forest biomass & C stocks, estimating **recent patterns of changes** in C stocks, and monitoring **future patterns** in biomass and carbon, for all of New York state



Statewide annual 30m maps of forest biomass & carbon





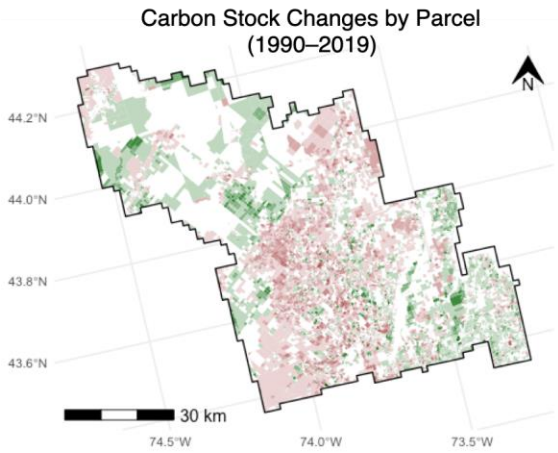
Current Forest Biomass

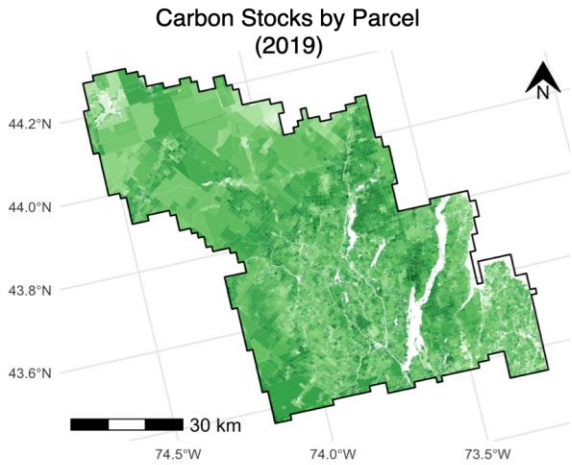
Historical Forest Biomass

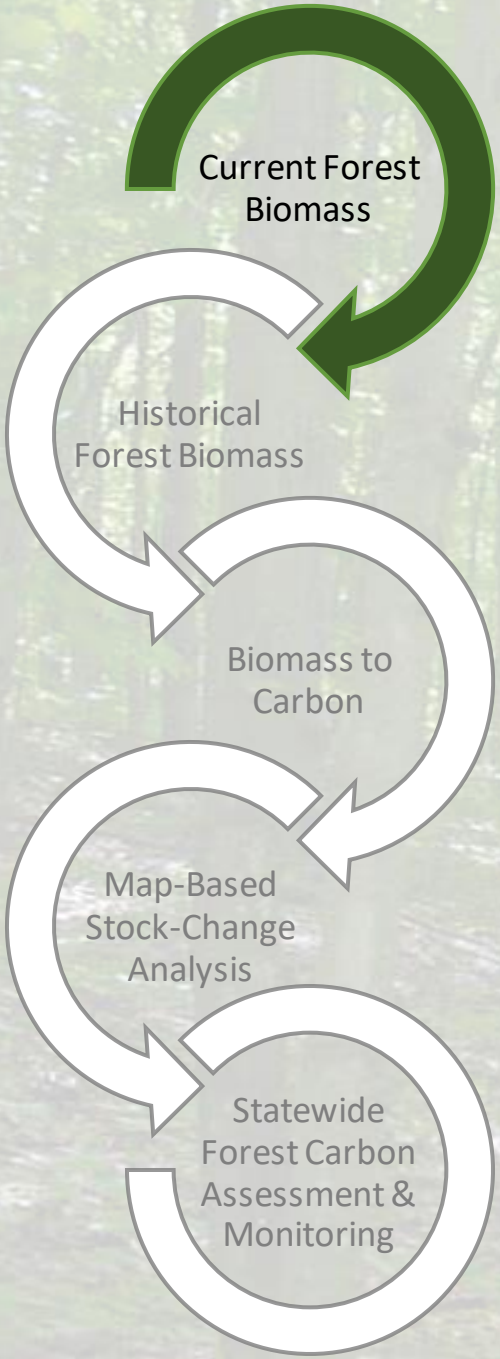
Biomass to Carbon

Map-Based Stock-Change Analysis

Statewide Forest Carbon Assessment & Monitoring





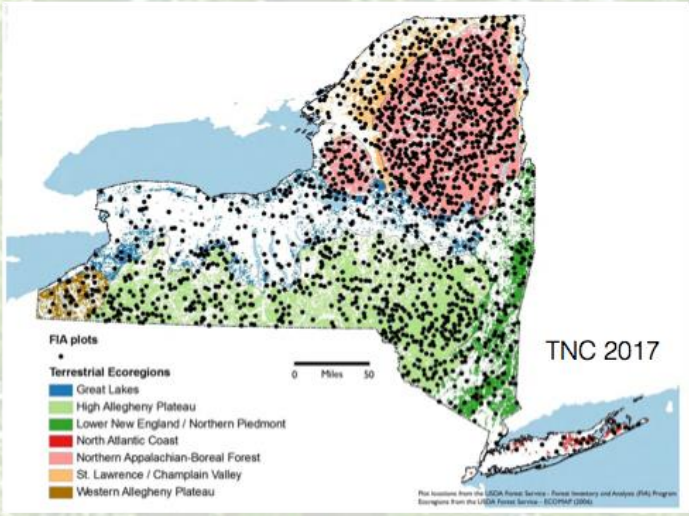


Train machine-learning models on systematic field inventory, LIDAR coverages and geospatial variables

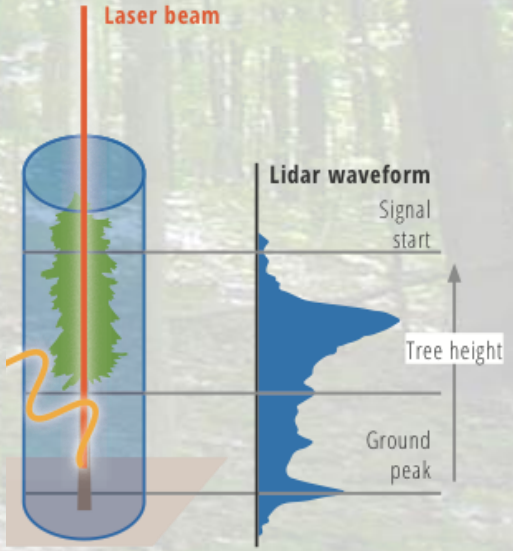
Use models to map forest aboveground biomass (AGB) for LIDAR year at 30m

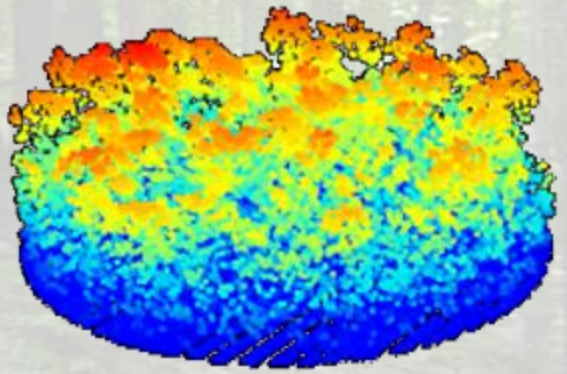
Evaluate the agreement between map predictions and FIA estimates at multiple scales

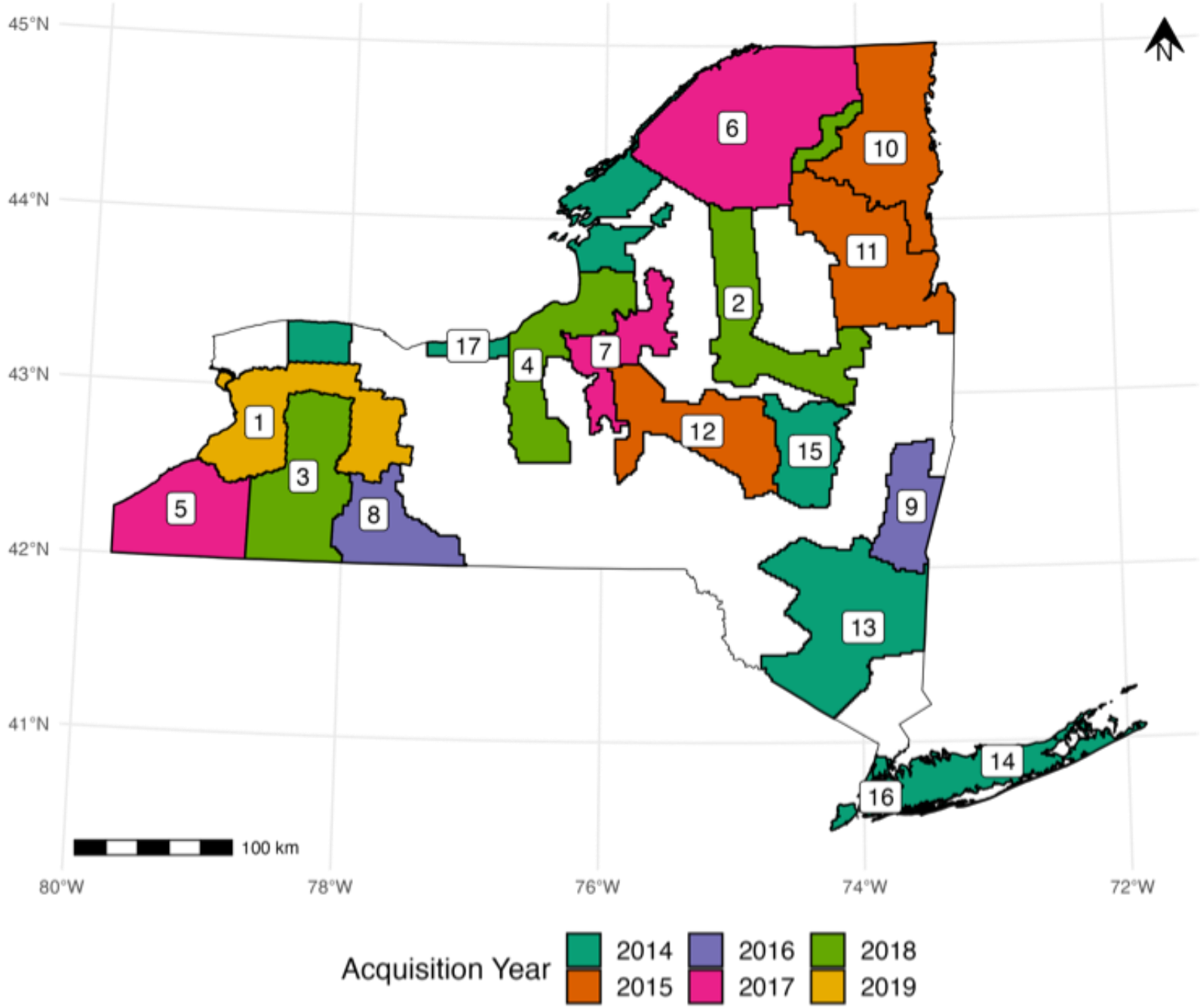
Forest Inventory & Analysis (FIA)



Large-footprint airborne LIDAR

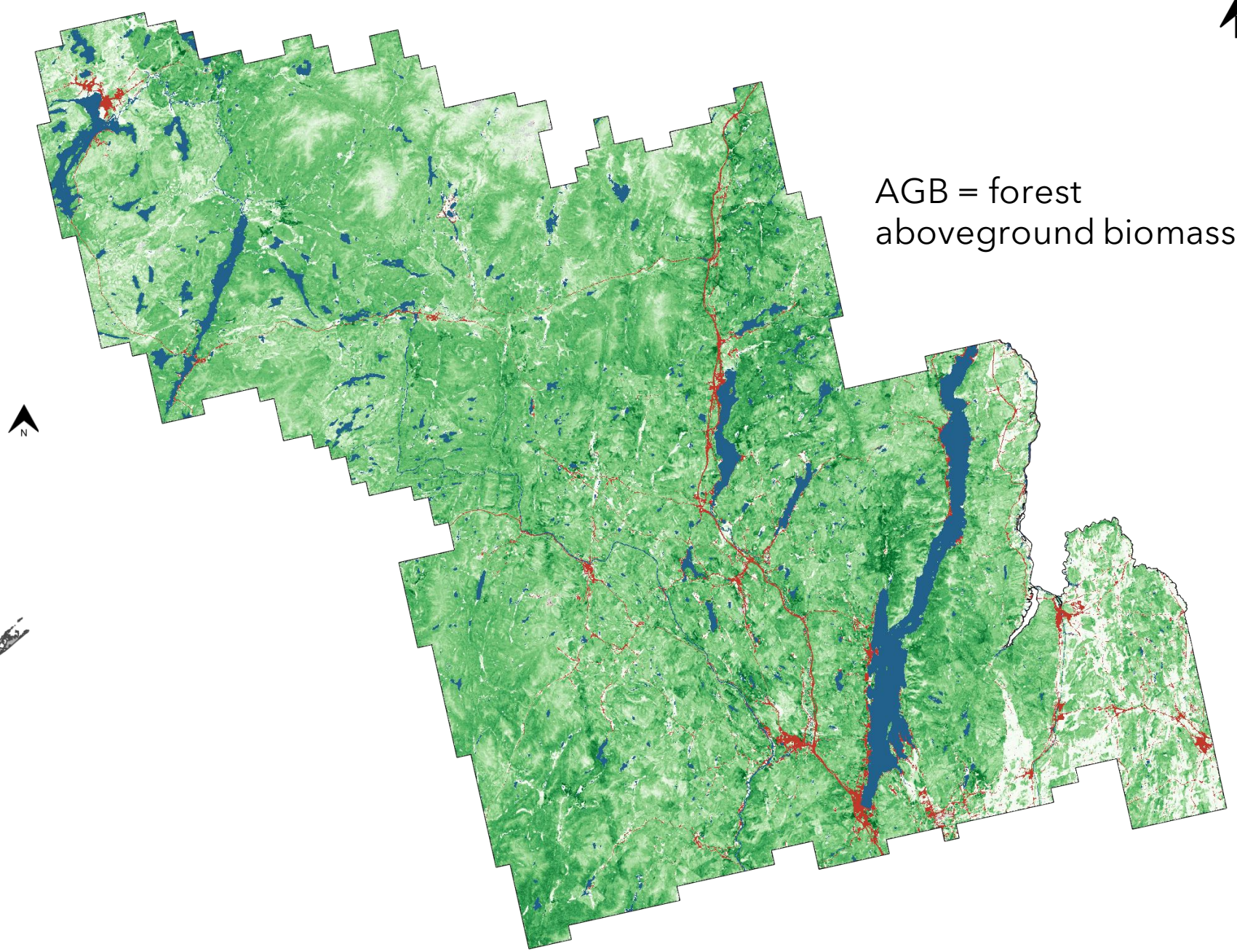





45°N
44°N
43°N
42°N
41°N
80°W
78°W
76°W
74°W
72°W
N
100 km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Acquisition Year
2014
2015
2016
2017
2018
2019

Regional 30m AGB mapping (LIDAR year)

Warren
Washington
Essex
2015



AGB = forest aboveground biomass

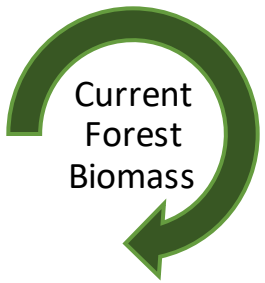
AGB (Mg/Ha)
200
100
0

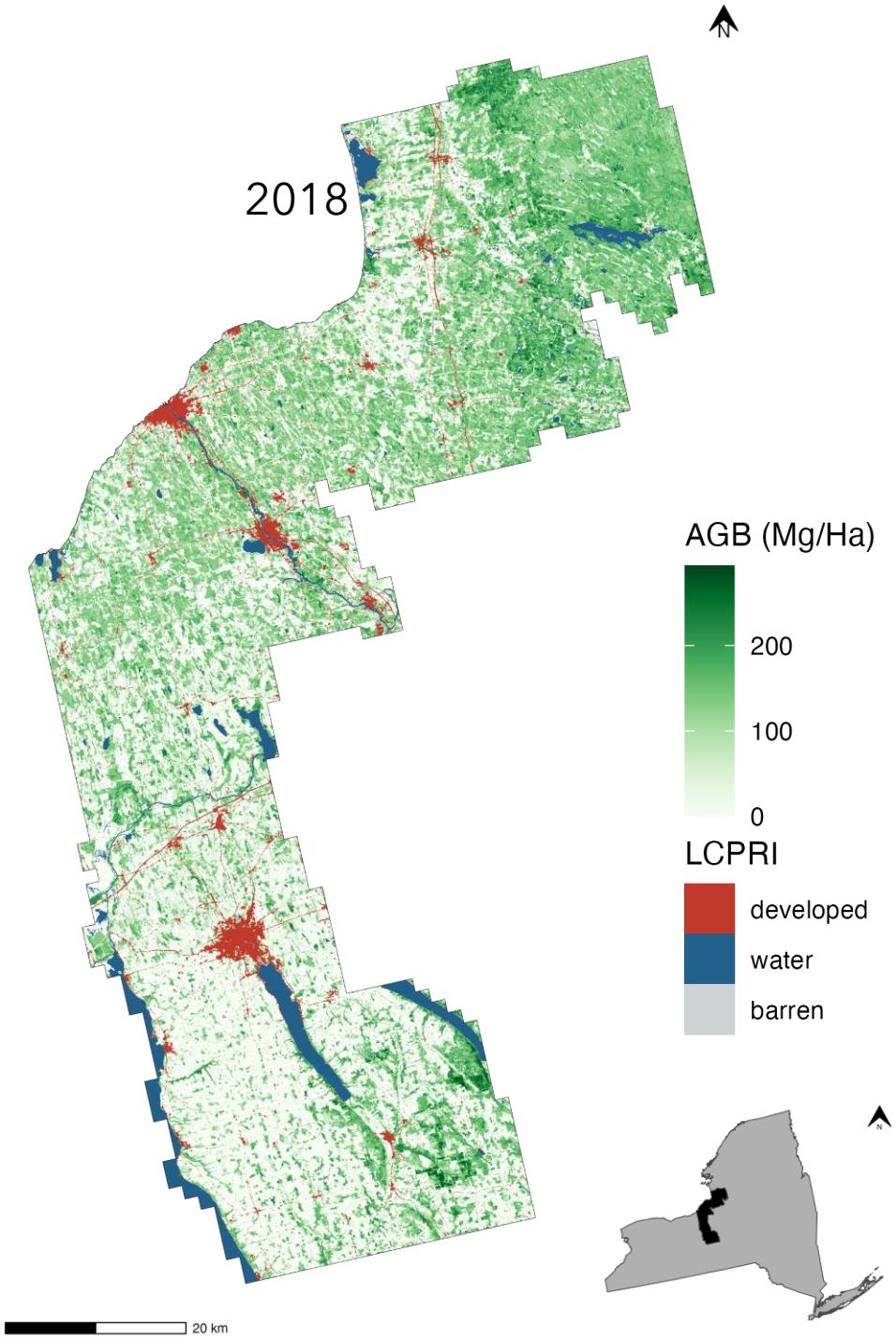
LCPRI
developed
water
barren

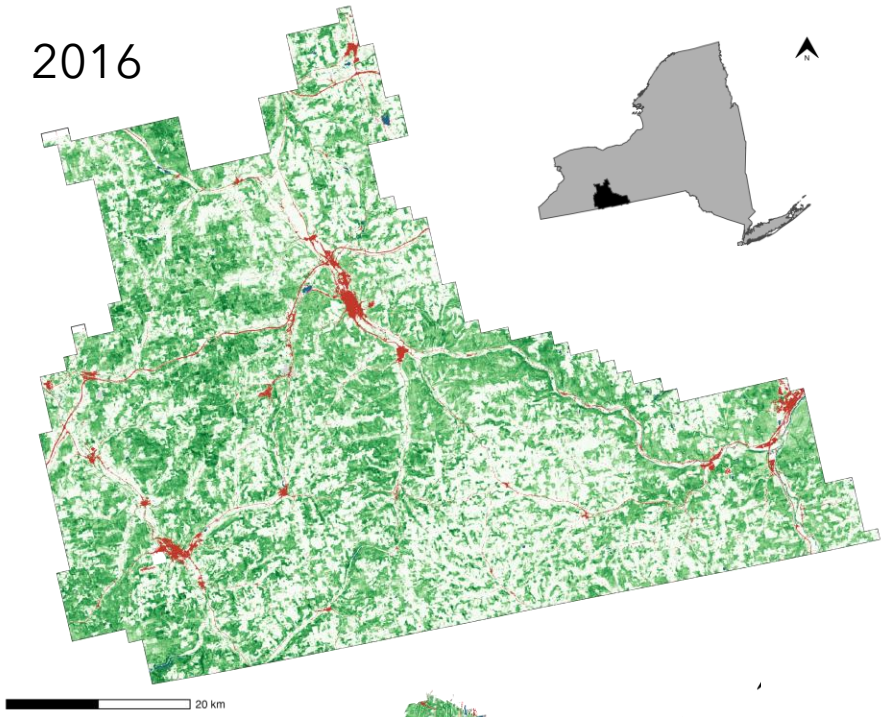
Current Forest Biomass

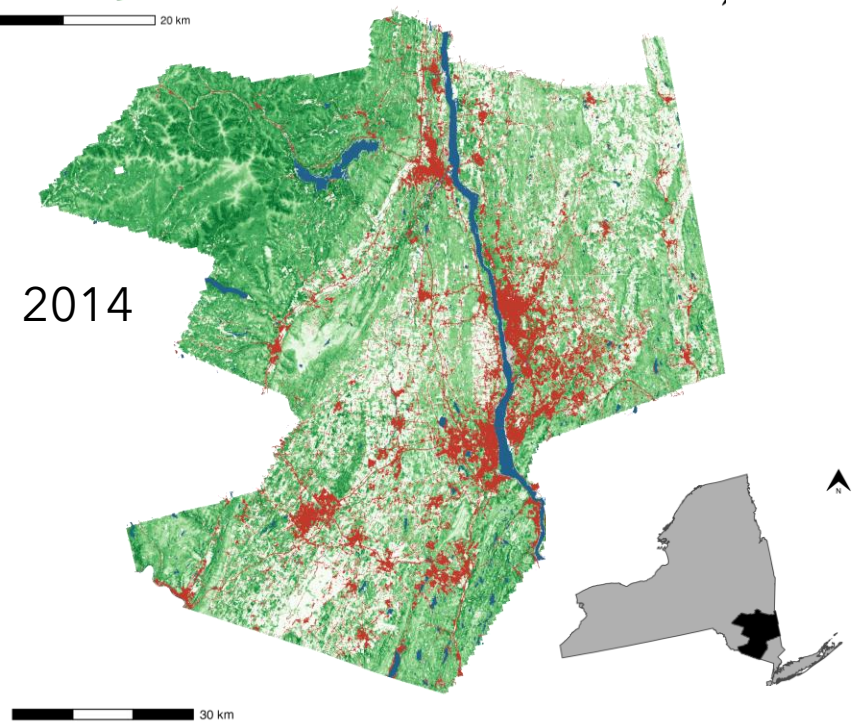
30 km

Regional 30m AGB mapping (LIDAR year)



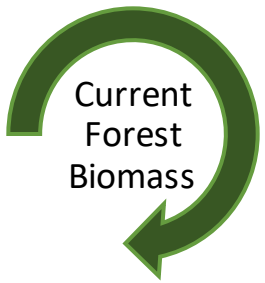


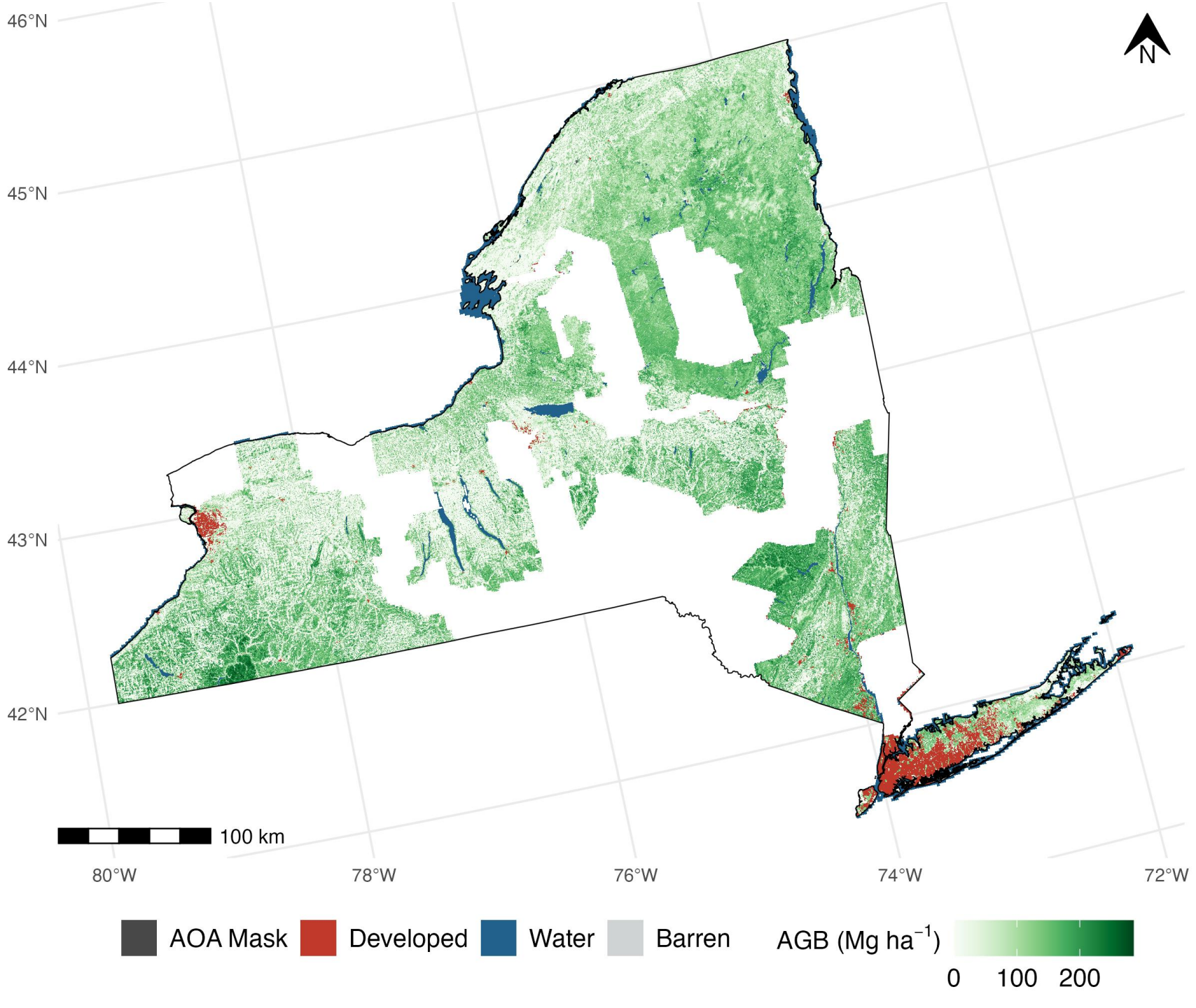




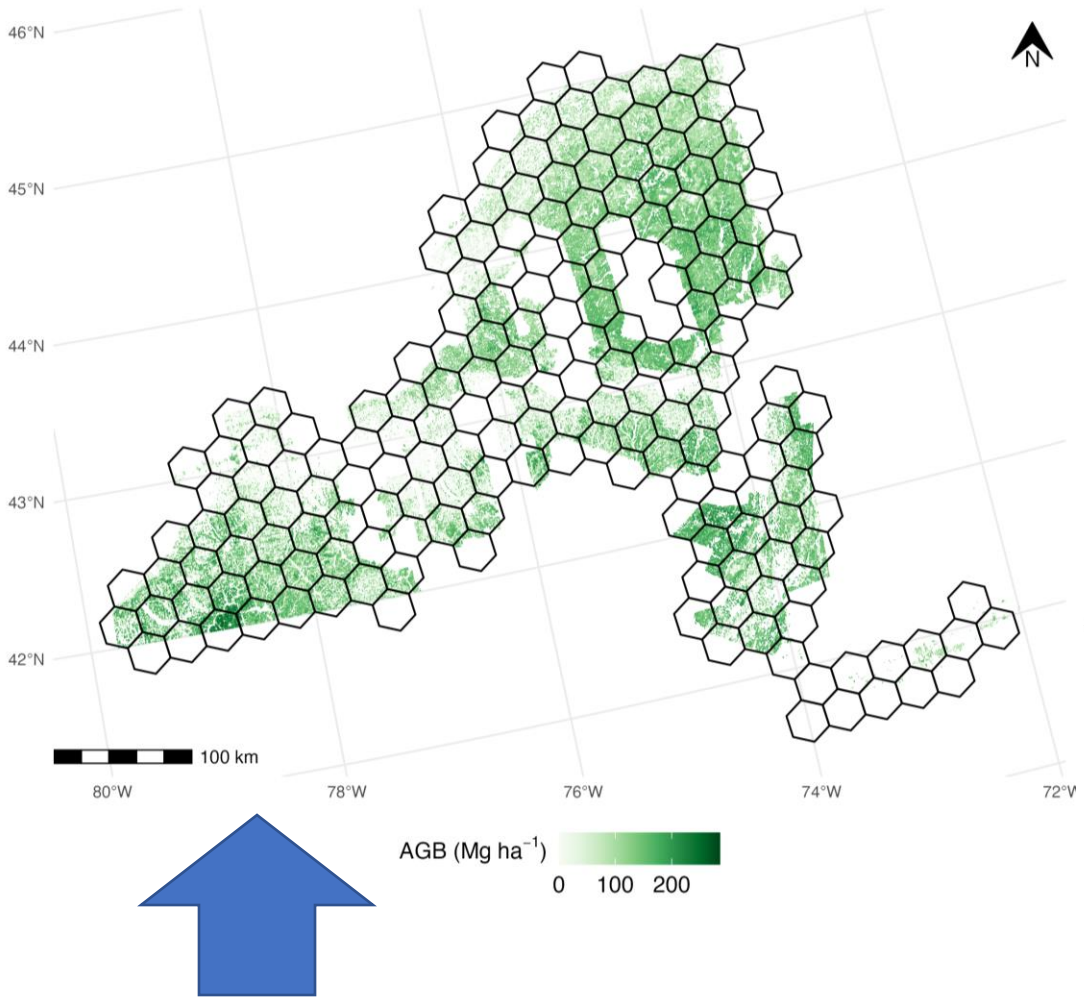
Current ‘patchwork’ of LIDAR-AGB maps

Updated to reflect 2019 land cover (based on LCMAP)



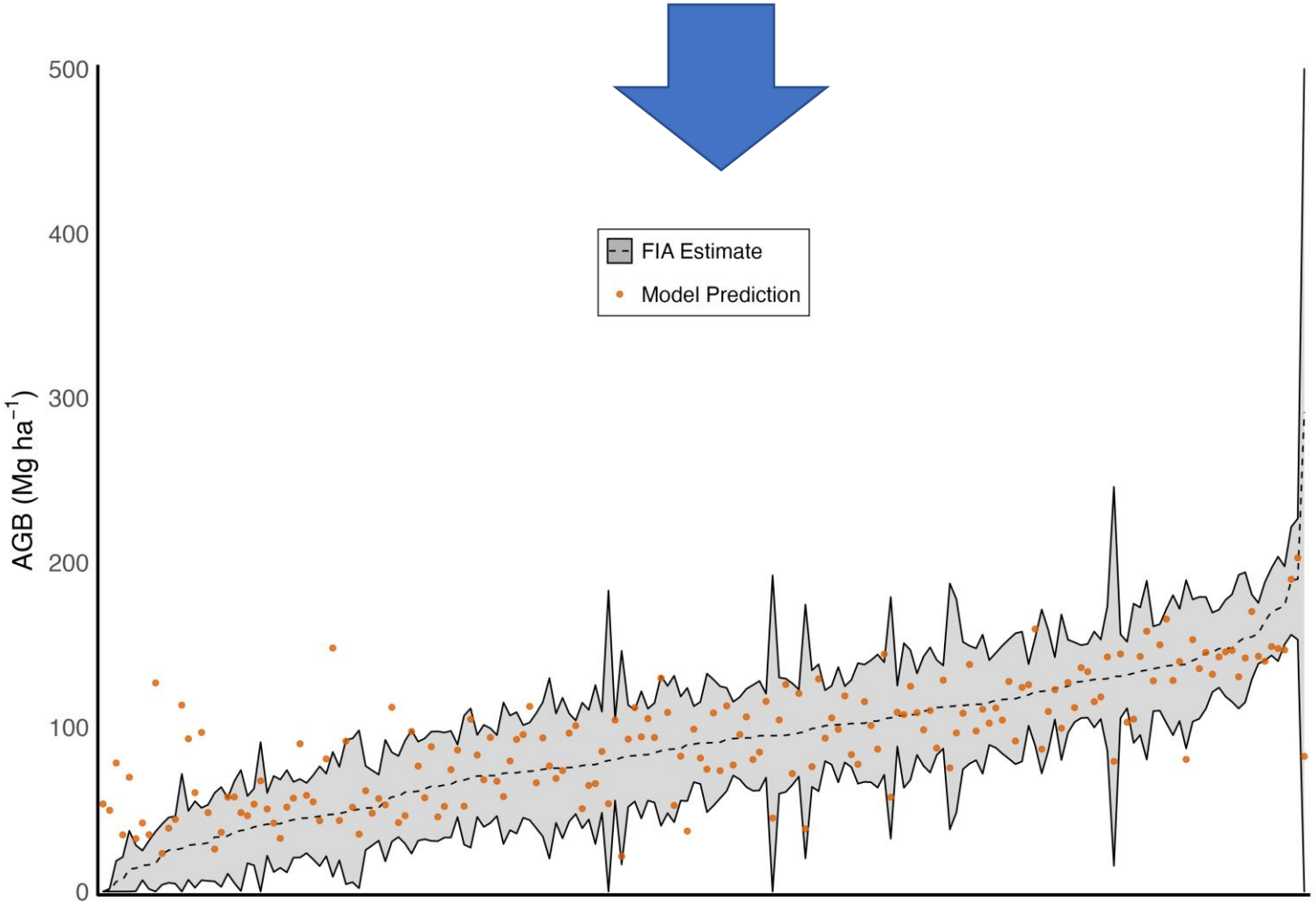


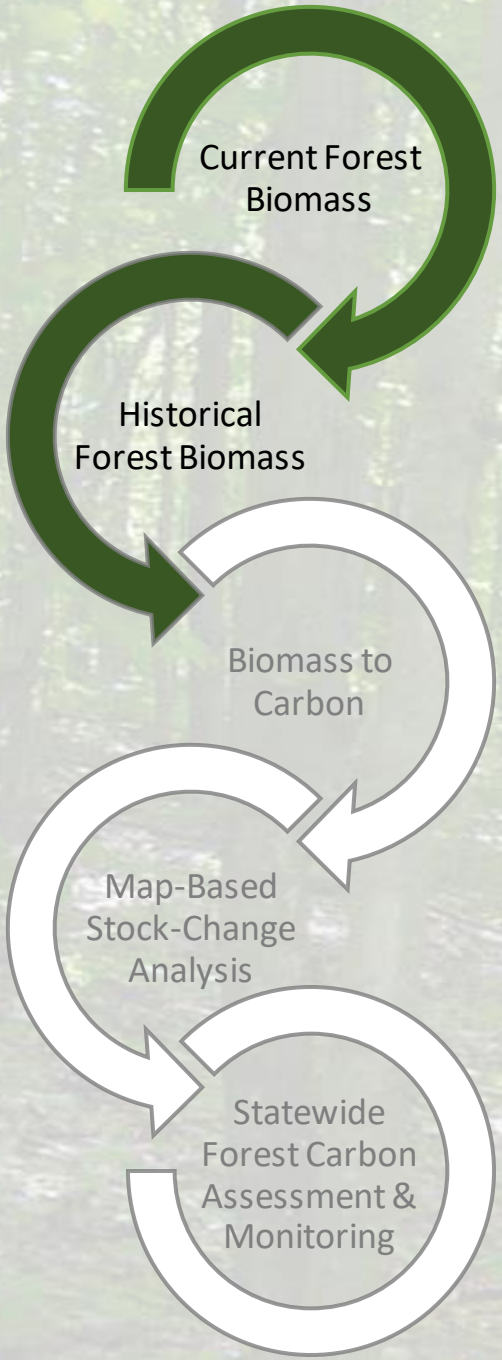
Map agreement with FIA small-area estimates



We compared our maps to FIA estimates of AGB for 'small-area' hexagons, which incorporate corrections for land cover (Menlove & Healey 2021)

We found that 89% of our AGB map predictions agreed with FIA design-based estimates, falling within their 95% confidence intervals for small area hexagonal estimates.

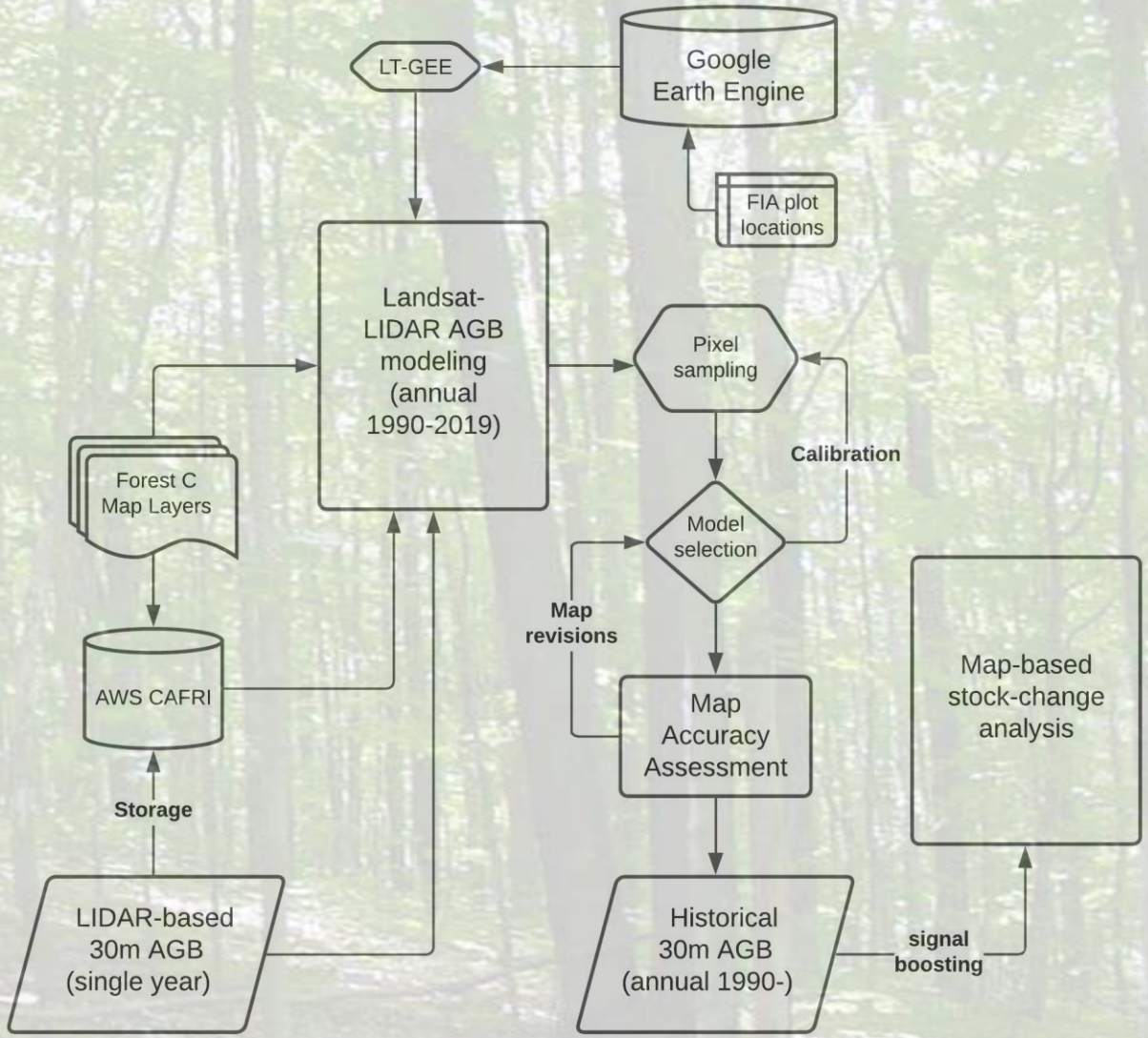




Use LIDAR-based maps of biomass (AGB) to train a second set of AGB models based on Landsat imagery

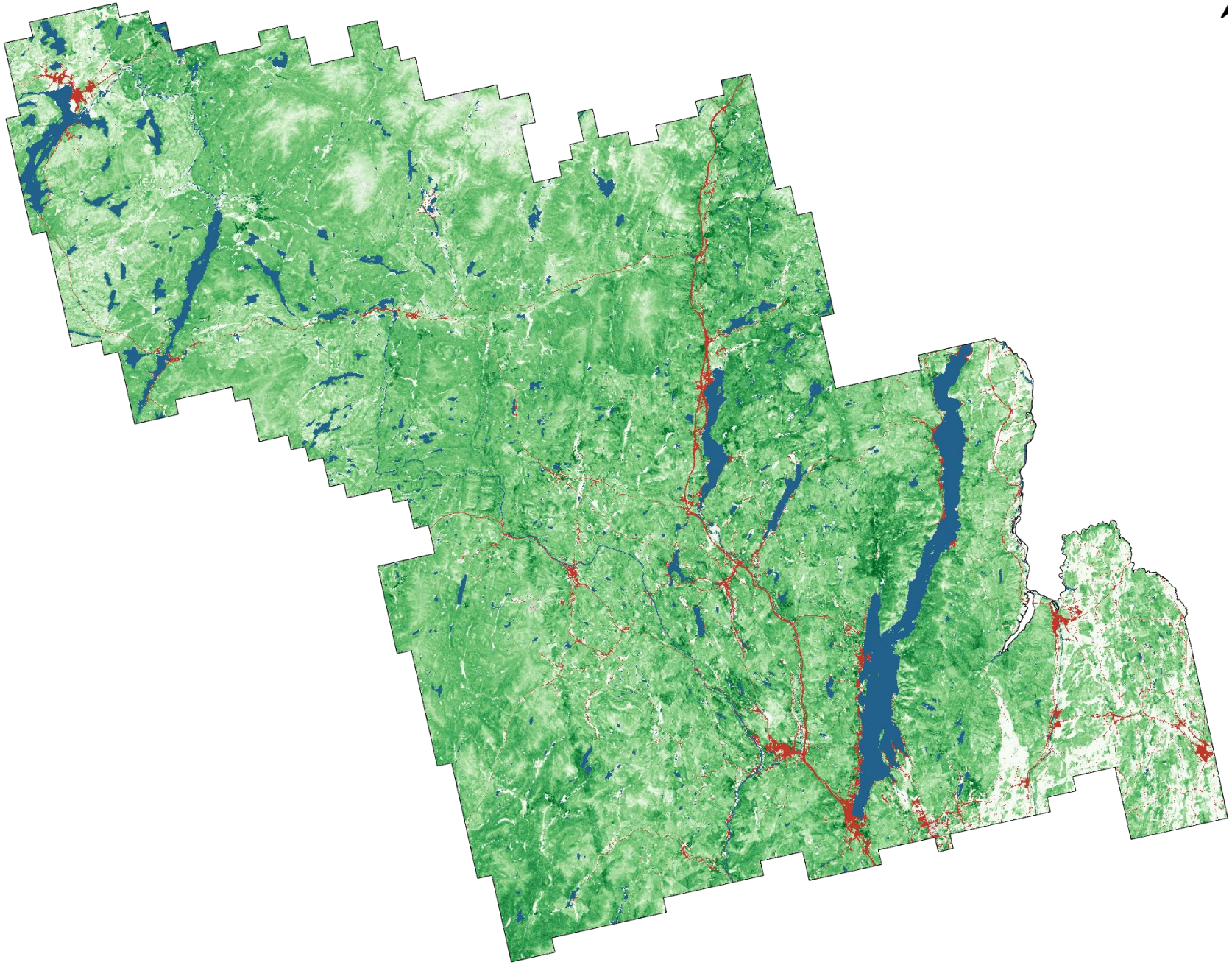
Use models and historical Landsat imagery to produce annual 30m AGB maps from 1990-2019

Evaluate the agreement between map predictions and FIA estimates at multiple scales



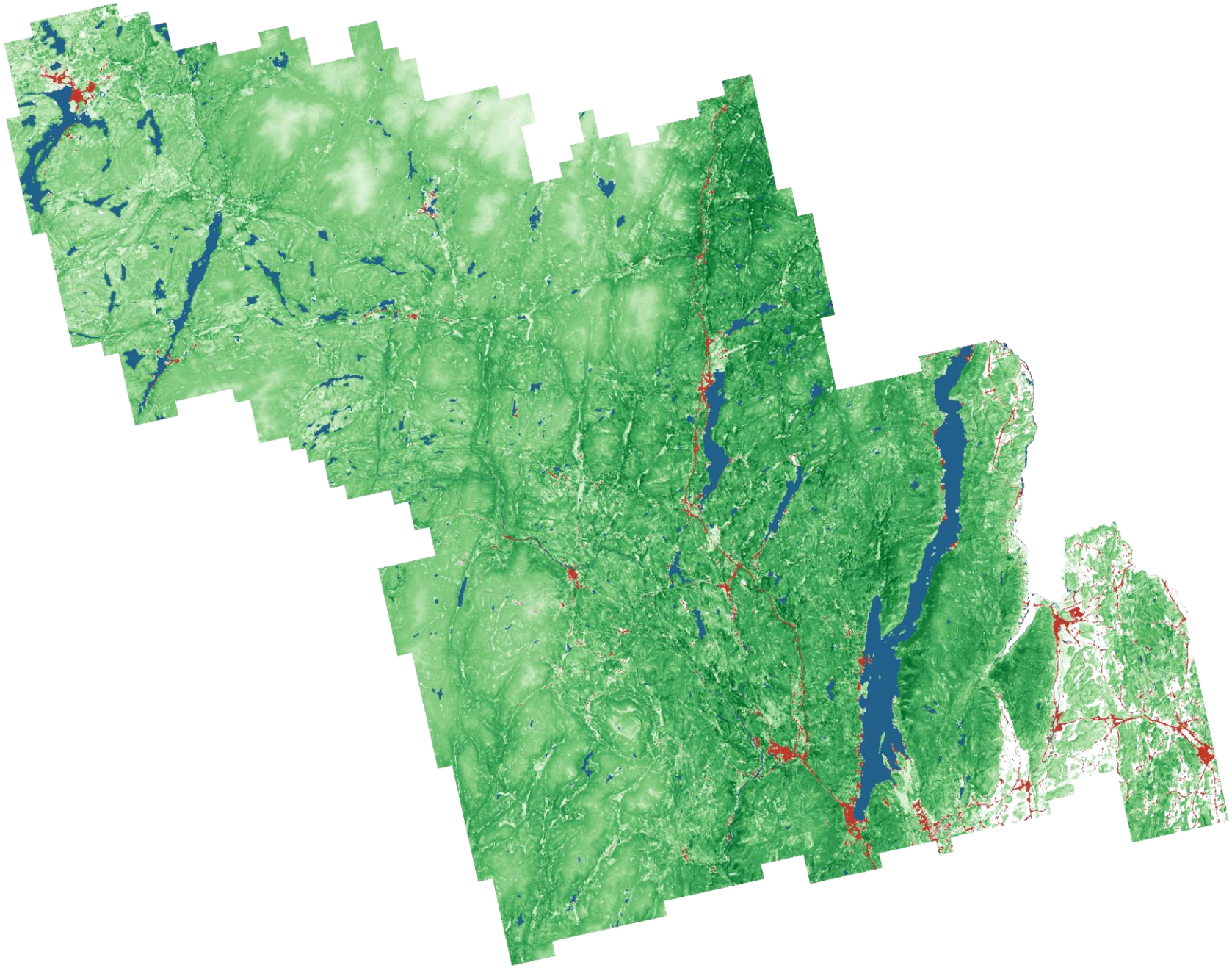
Historical AGB Mapping workflow

LiDAR AGB 2015



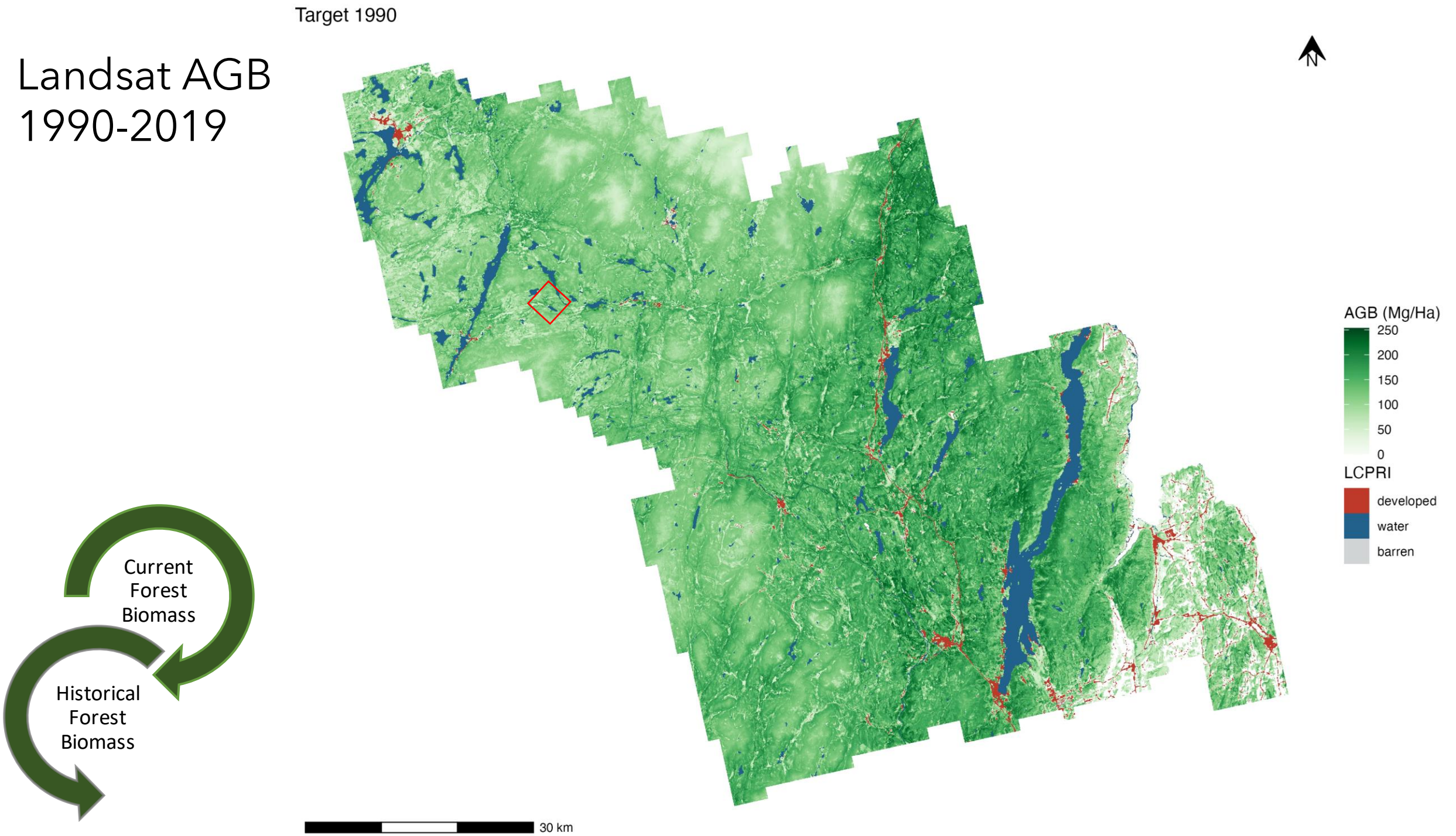
Current Forest Biomass

Landsat AGB 2015



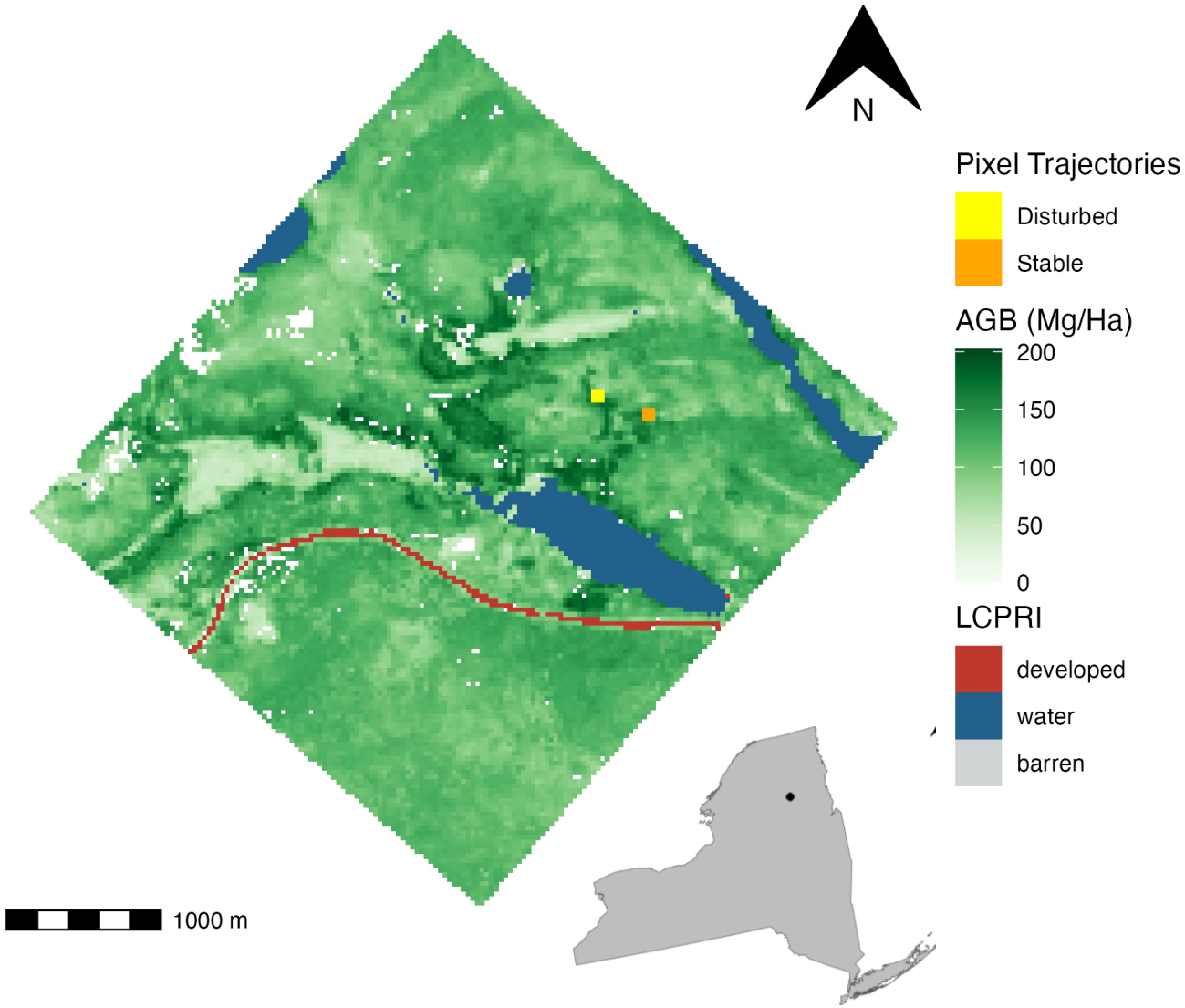
Current Forest Biomass

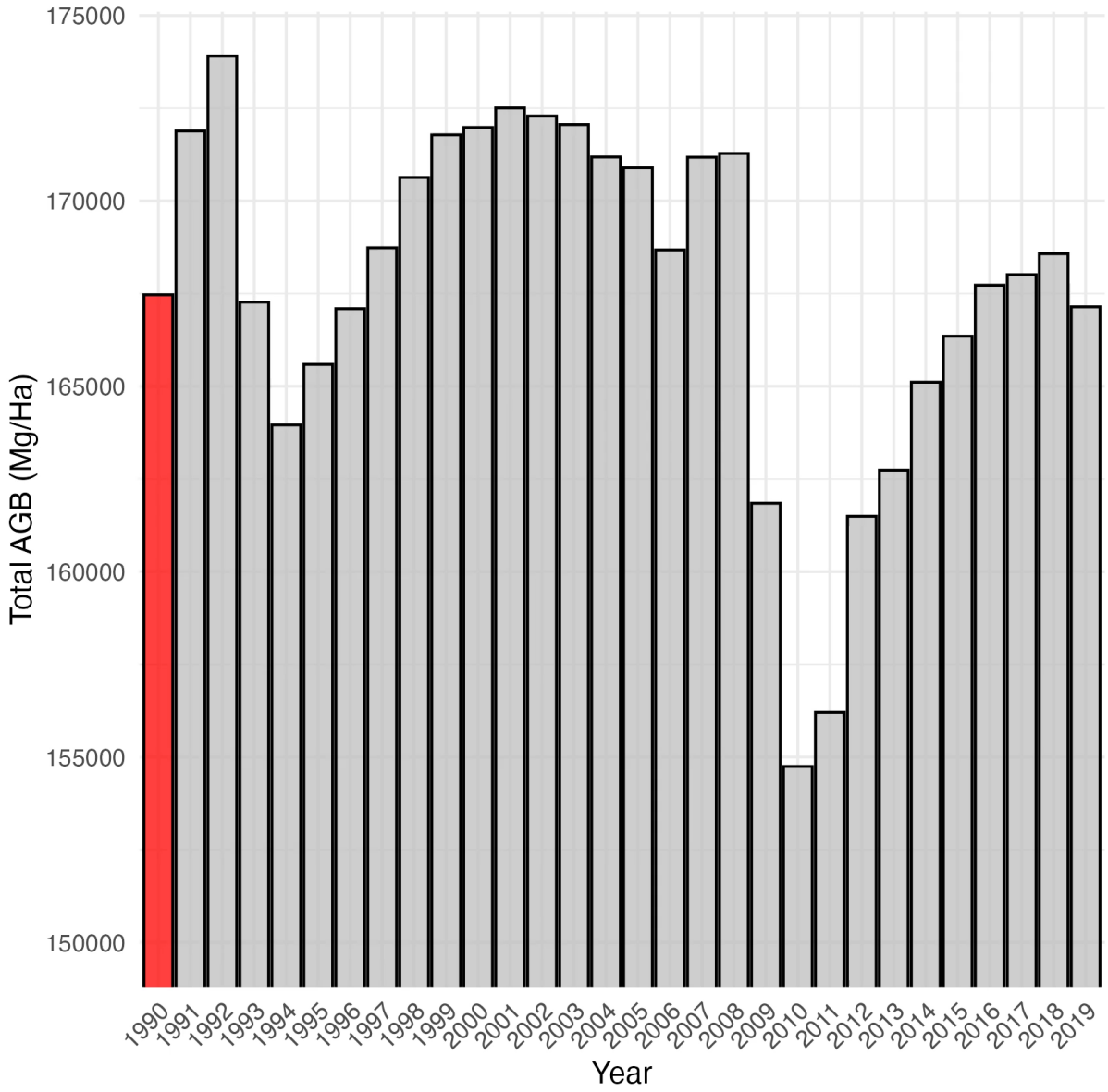
Landsat AGB 1990-2019

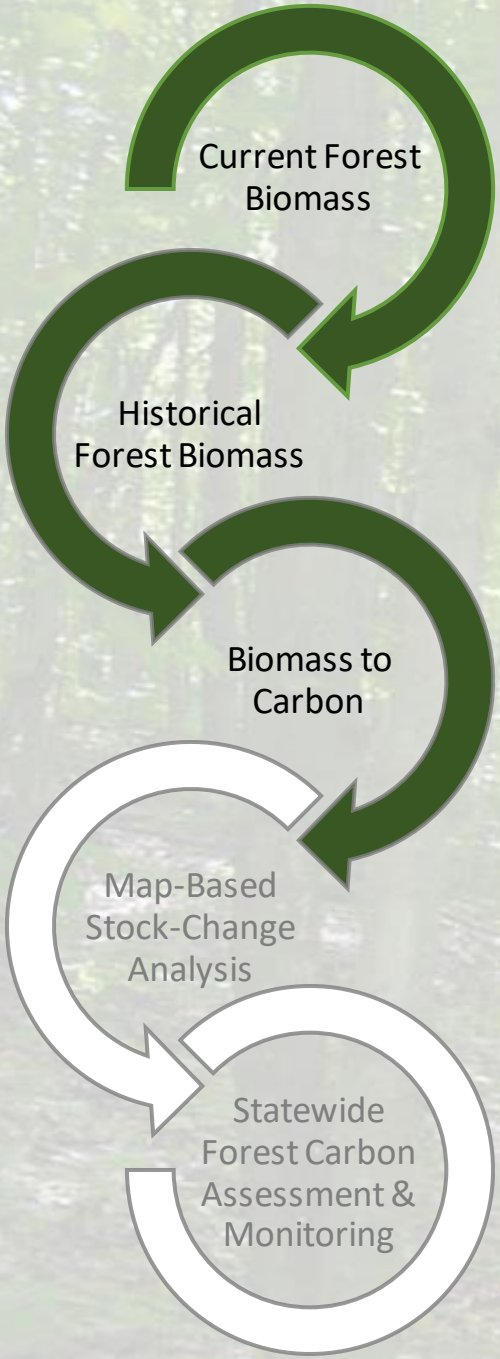


Zooming in…to a working forest

target_1990





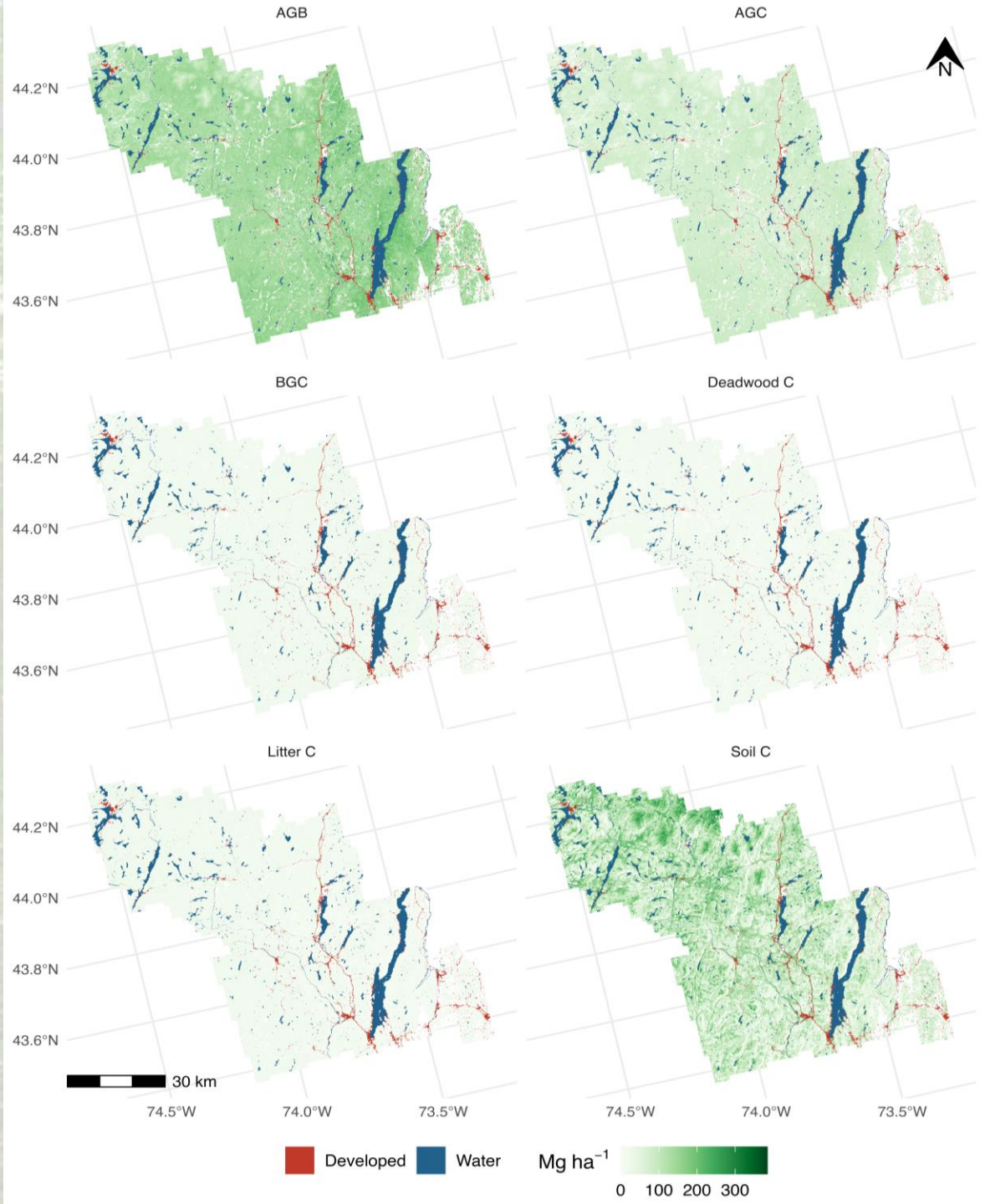


Model relationships between biomass and carbon pools using FIA plot-level measurements

Use models to estimate all 5 forest C pools based on AGB predictions and environmental variables

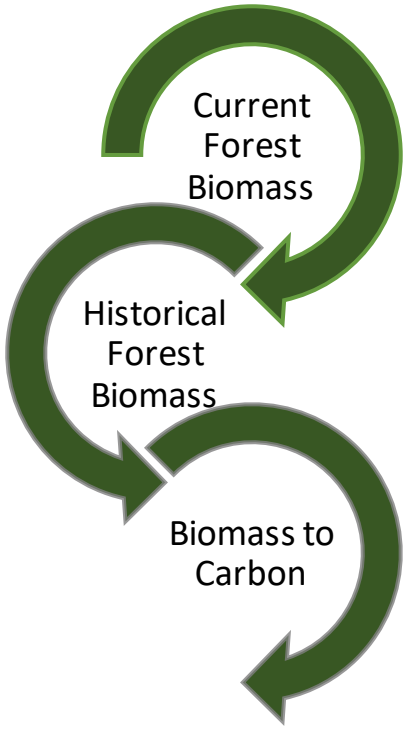
Map forest C pools at 30m for 1990-2019

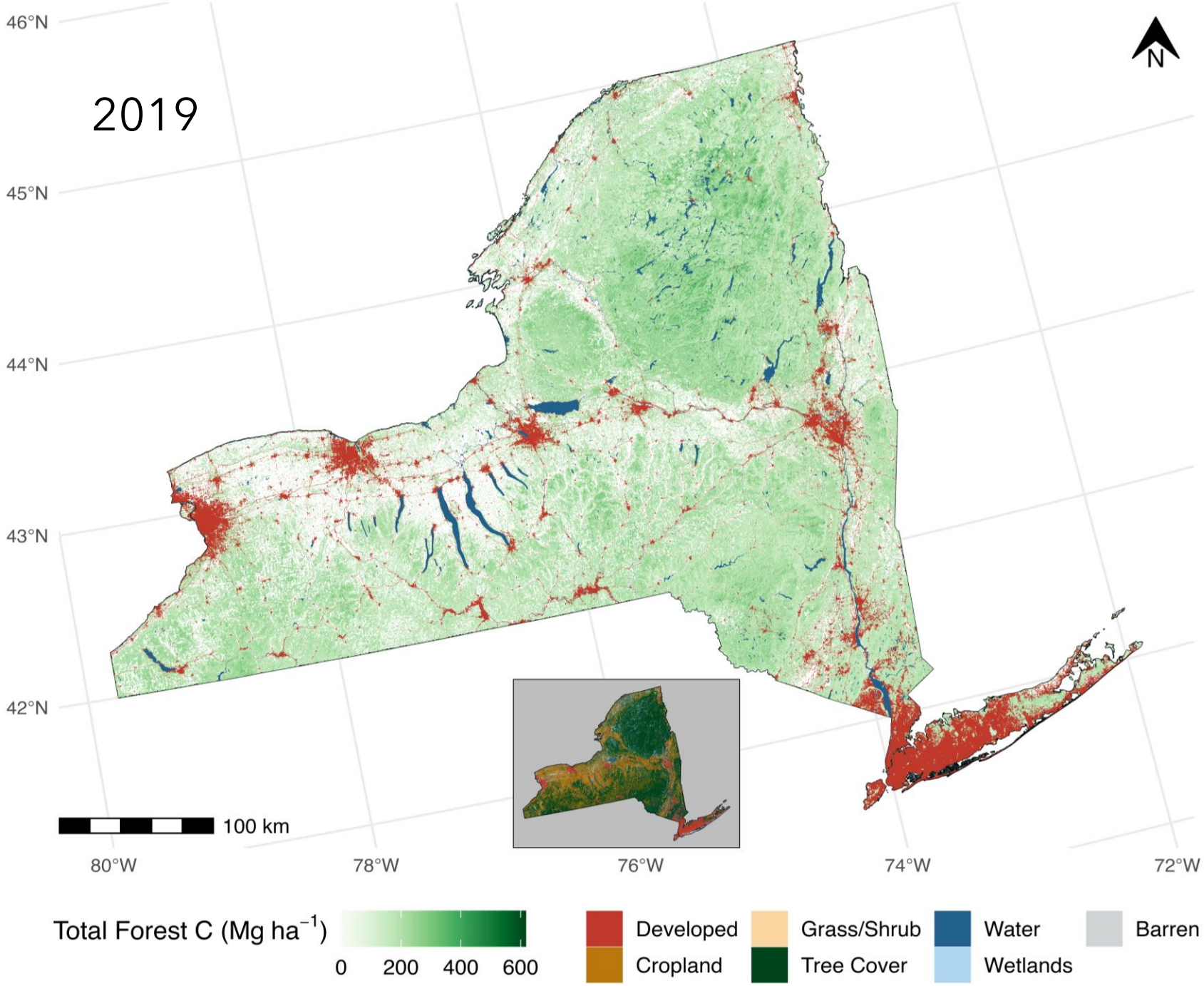
Evaluate the agreement between map predictions and FIA estimates at multiple scales



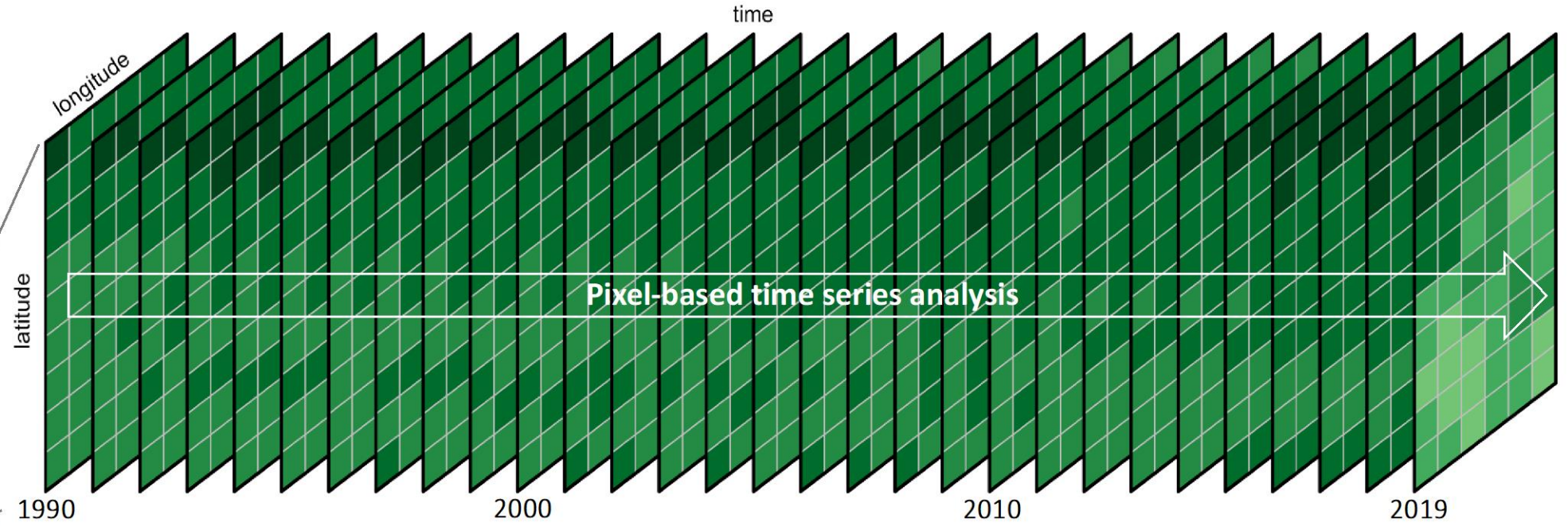
Statewide total forest carbon stock estimates

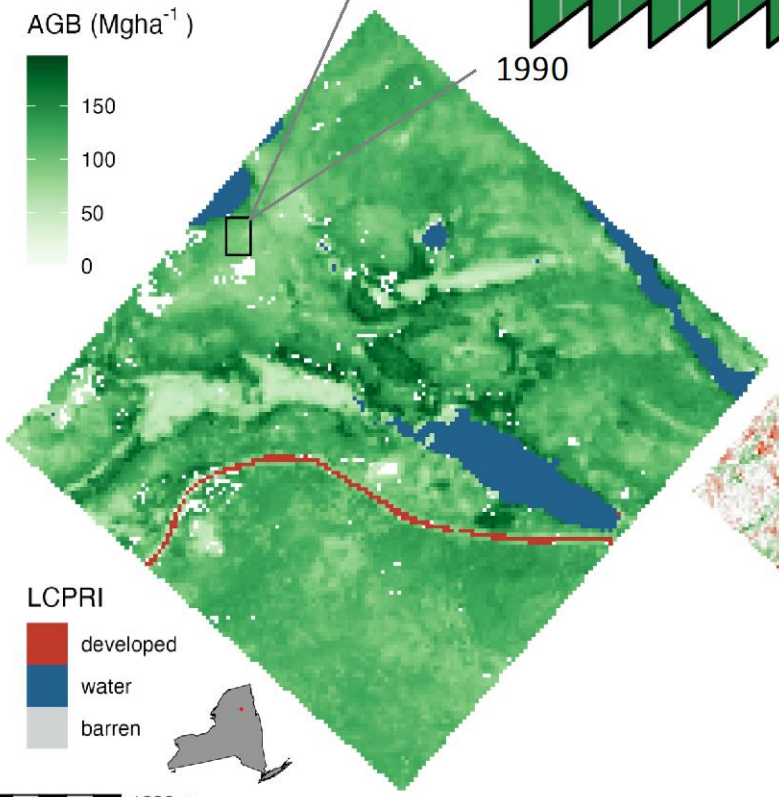
30m
Yearly
1990-2019

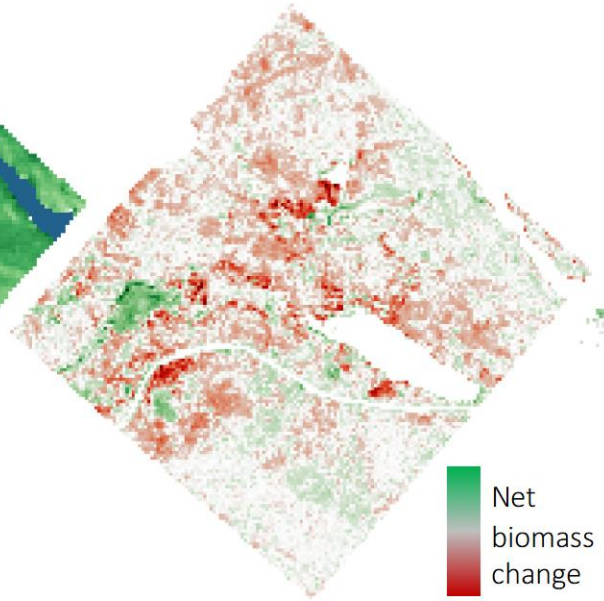




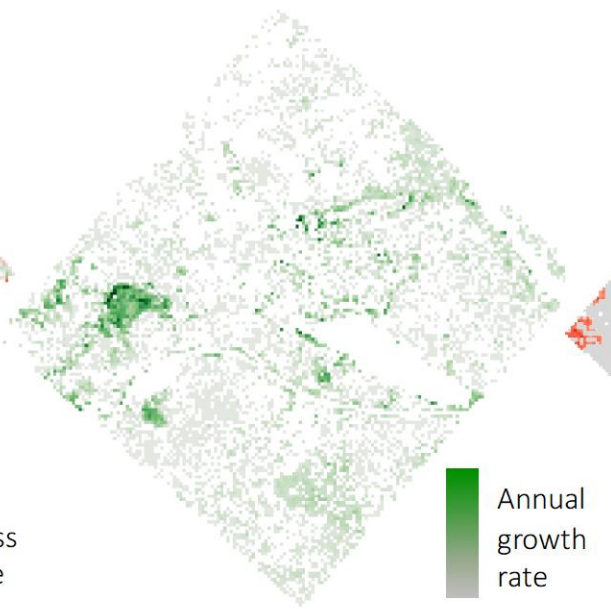
Map-based stock-change analysis



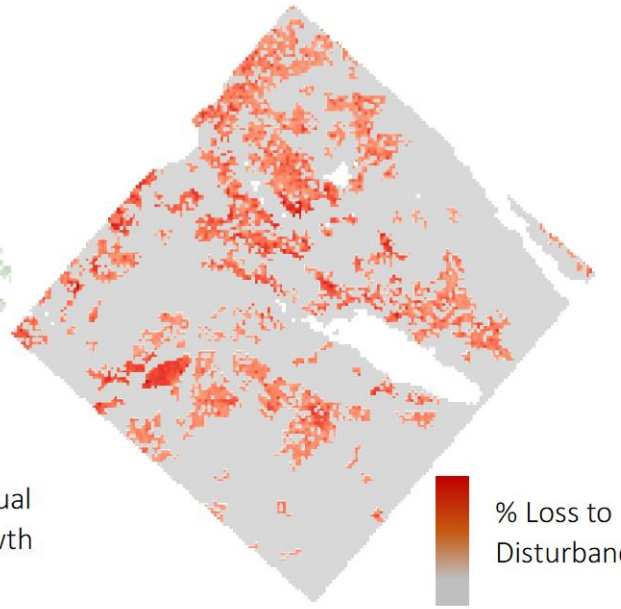




Raster subtraction



Trend analysis



Temporal segmentation

Current Forest Biomass

Historical Forest Biomass

Biomass to Carbon

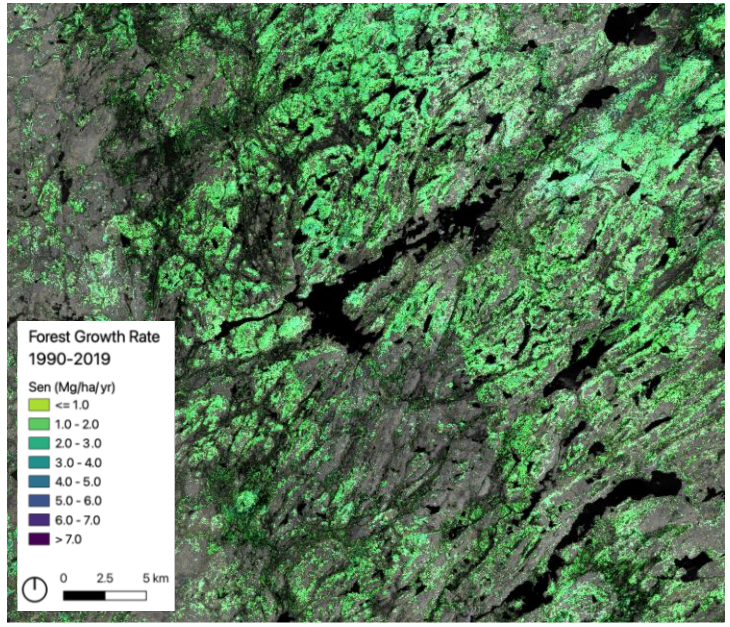
Map-Based Stock-Change Analysis

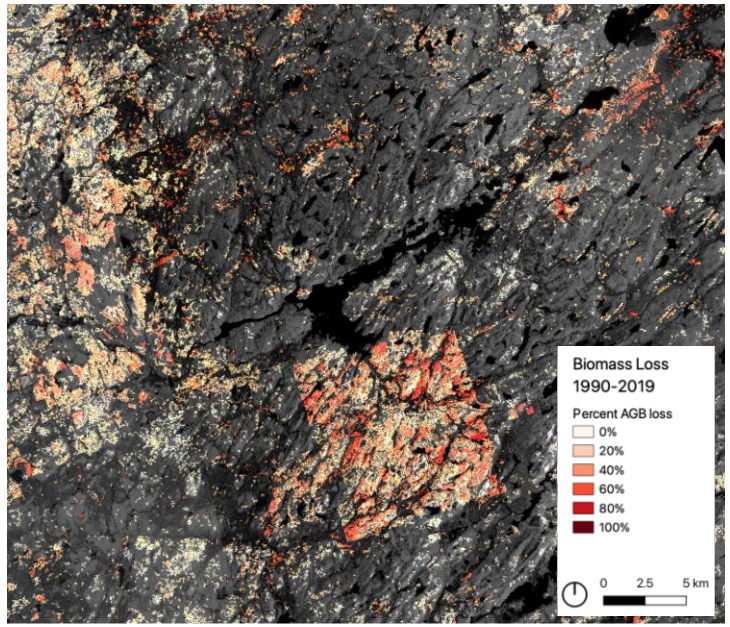
Statewide Forest Carbon Assessment & Monitoring

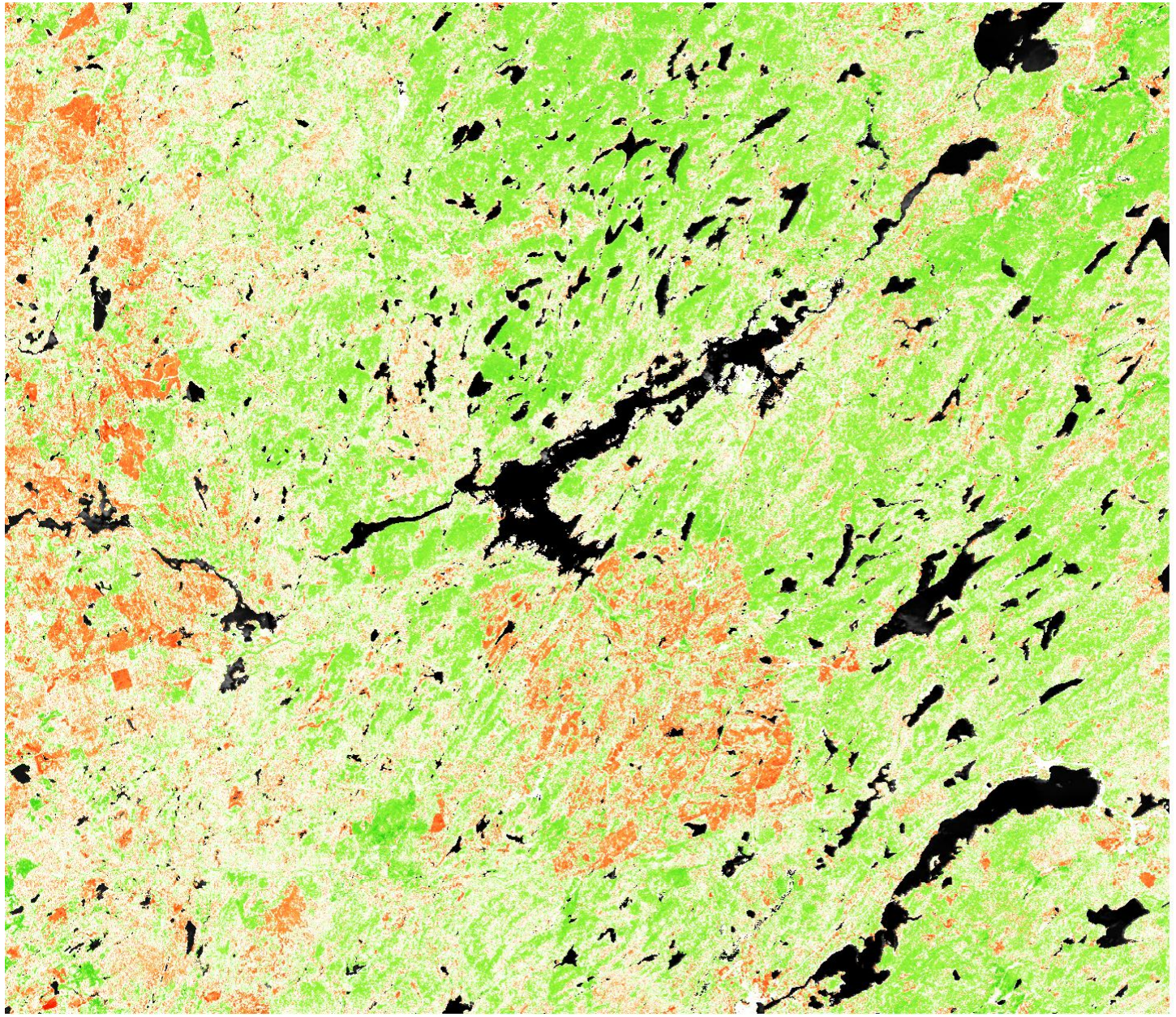
Aboveground biomass (AGB) change

1990-2019

Mapping forest biomass change, growth rates and mortality / removals







Estimate change in aboveground biomass (1990-2019)

Landsat-AGB v1.0

Stillwater Reservoir

Five Ponds Wilderness

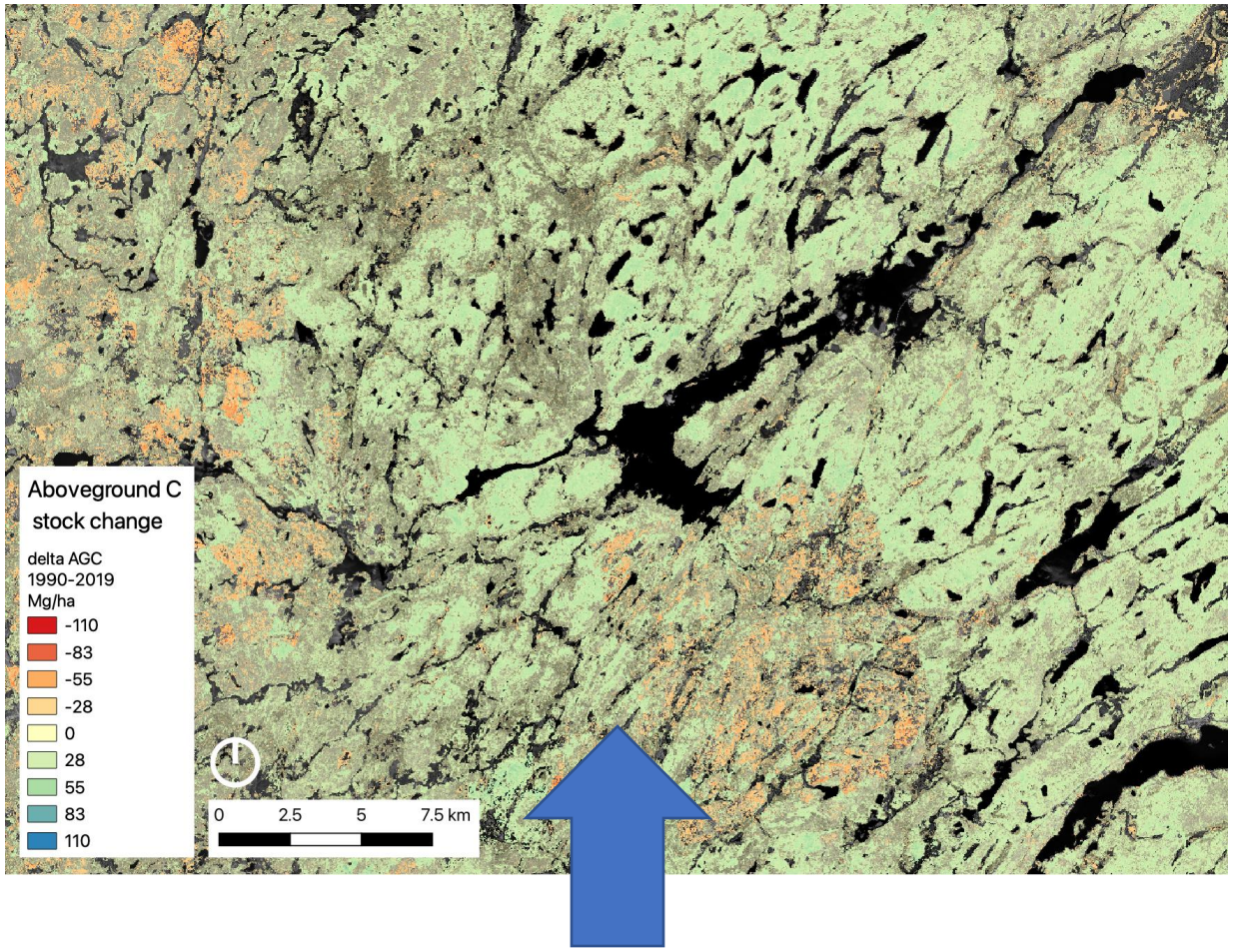
Independence River Wild Forest

AGB Change 1990-2019

Mg/ha
-215
-30
0
30
215

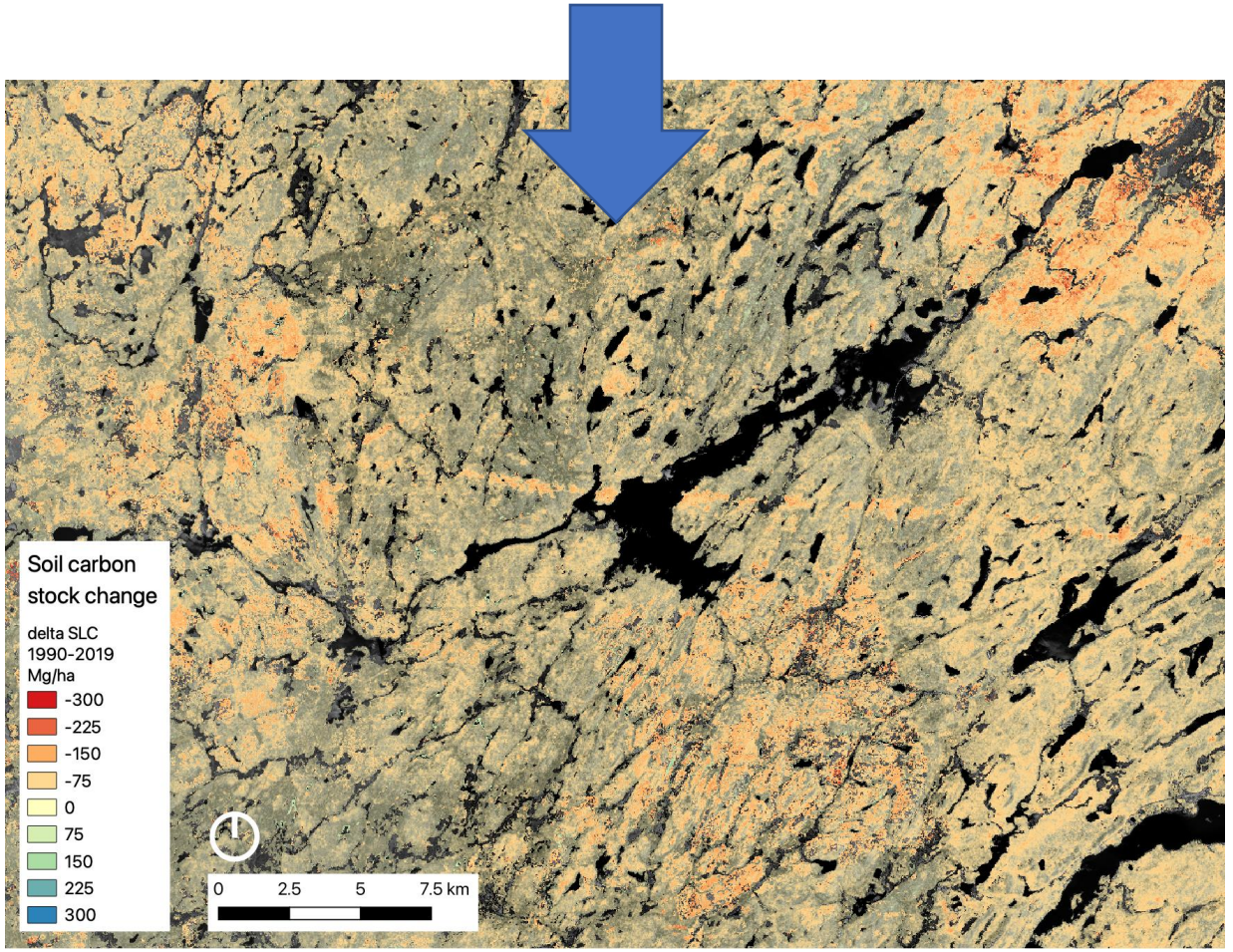
0 2.5 5 km

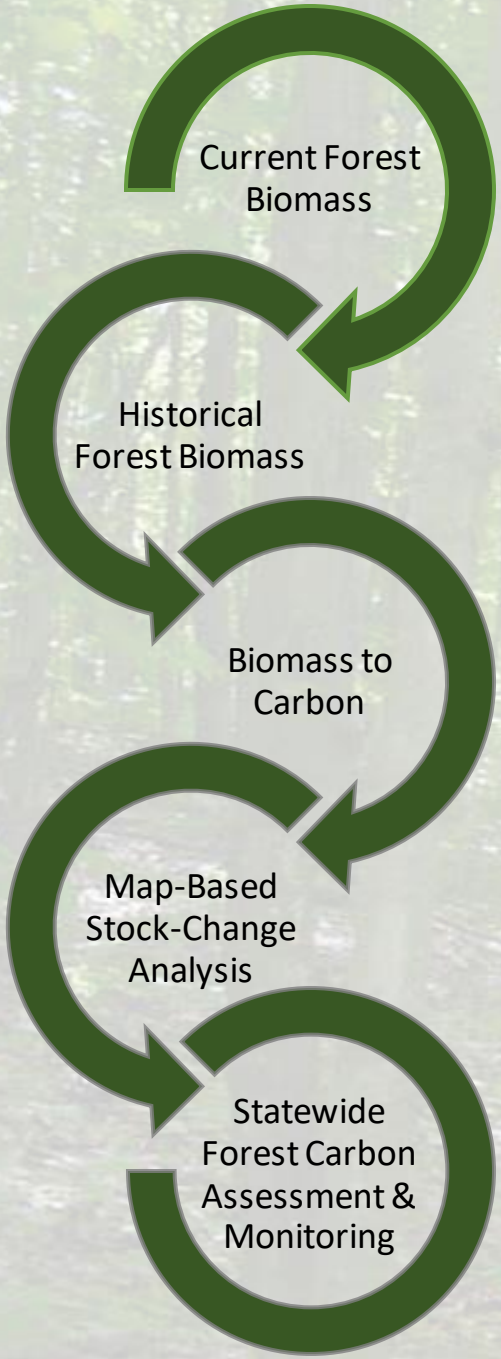
Mapping net carbon removals (sequestration) and additions (emissions)



Aboveground vegetation C stock-change maps track closely with biomass (AGB) maps and show areas of net sequestration (green) and emissions (orange) that align with known parcels and land use history

Soil C stock-change maps consistently show declines that are likely due to model error and uncertainty. Our models do not represent the processes by which soil C pools would decrease over time in reserved forests.



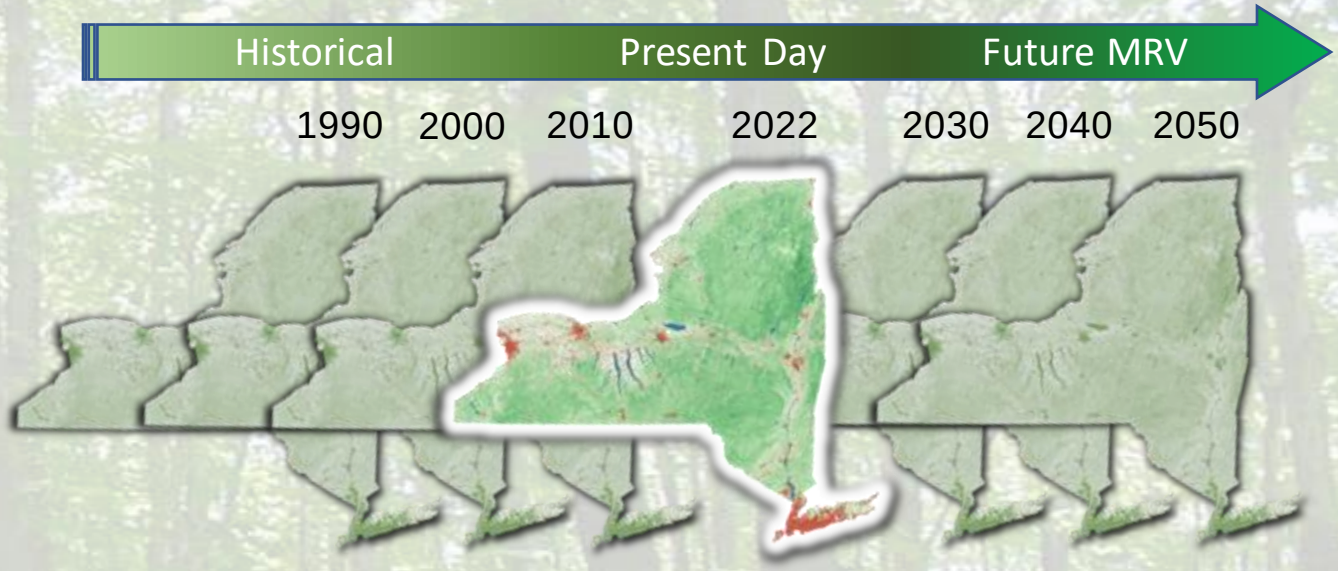


Build a system for statewide carbon monitoring, reporting and verification (MRV)

- Accuracy
- Cost-Efficiency
- Versatility

Version 1.0 based <u>only</u> on Landsat, FIA and suite of open-source data & tools

Parcel-level, statewide forest C accounting and MRV applications



USDA FOREST SERVICE DEPARTMENT OF AGRICULTURE

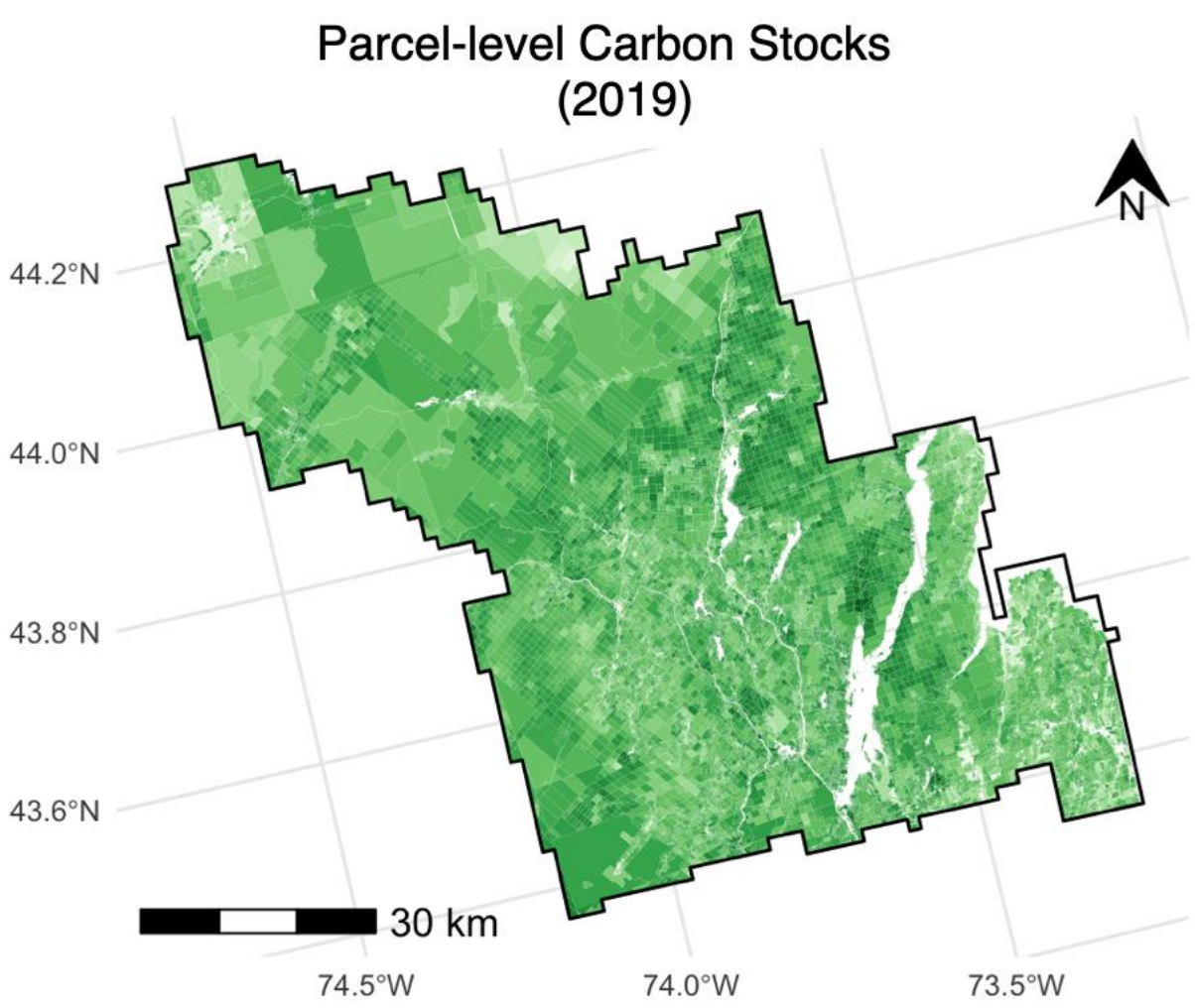
FIA

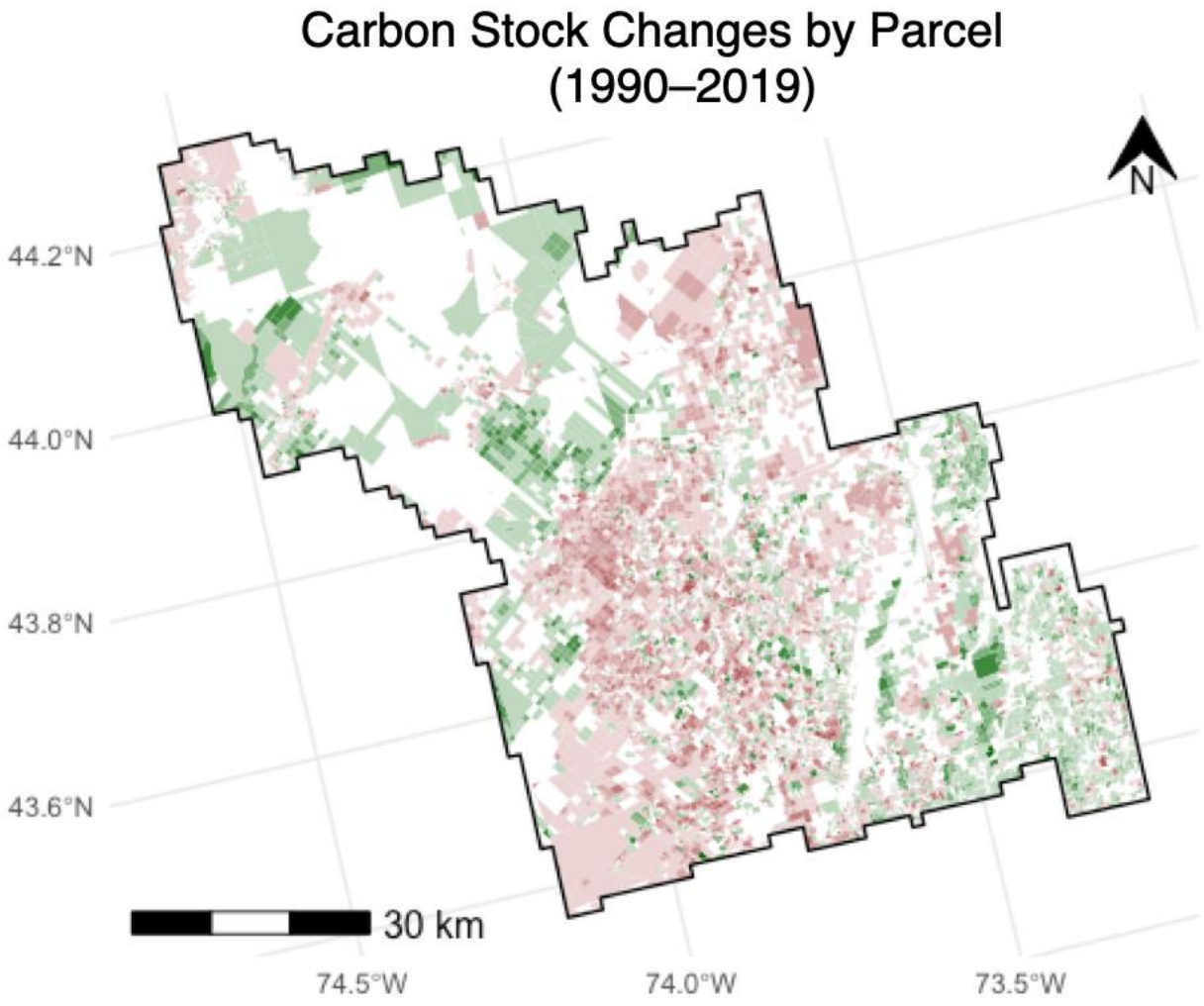
R

PostgreSQL

Google Earth Engine

Parcel-level carbon accounting & monitoring/reporting/verification





Thank you. Questions?

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College of Environmental Science and Forestry

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