4-D Modeling of the Regional Carbon Cycle in & Around Urban Environments: An Interdisciplinary Study to Advance Observational & Modeling Foundations

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4-D Modeling of the Regional Carbon Cycle in & Around Urban Environments

Developing an end-to-end capability for modeling GHG dynamics in urban areas that links natural and anthropogenic drivers of GHG emissions.

1. How do land use, land cover, and land cover change in and around metropolitan areas affect carbon storage and fluxes at daily, seasonal, interannual, and decadal time scales?
2. How are anthropogenic emissions and biogenic carbon fluxes from urban and suburban ecosystems redistributed by atmospheric transport processes at regional scales where urban emissions influence GHG measurements from surface networks and satellite platforms?
3. How can inverse methods, atmospheric transport models, and remote sensing be used to better represent total atmospheric column dynamics in GHG concentrations, and by extension, determine surface fluxes in urban environments and surrounding landscapes?

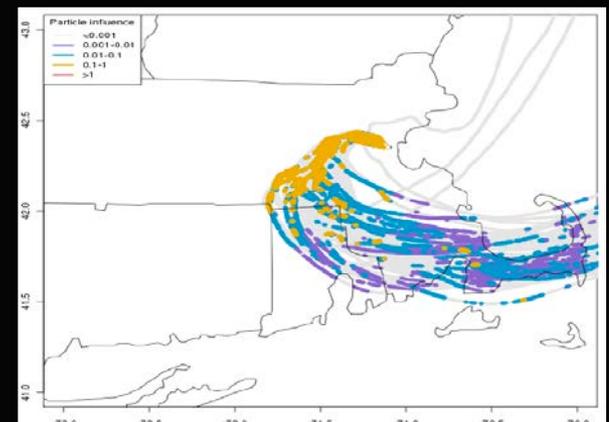# 4-D Modeling of the Regional Carbon Cycle in & Around Urban Environments

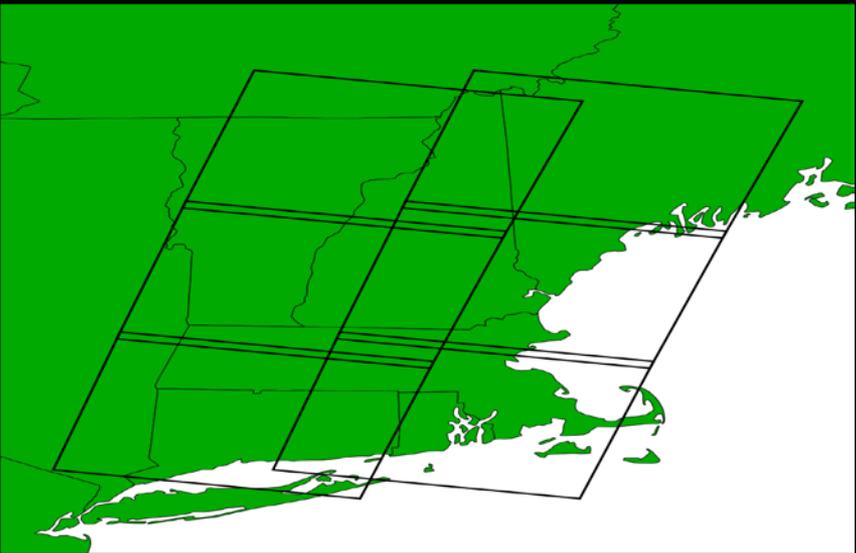## LCLUC Dynamics from Landsat Time Series

Modeling Carbon Dynamics of LCLUC
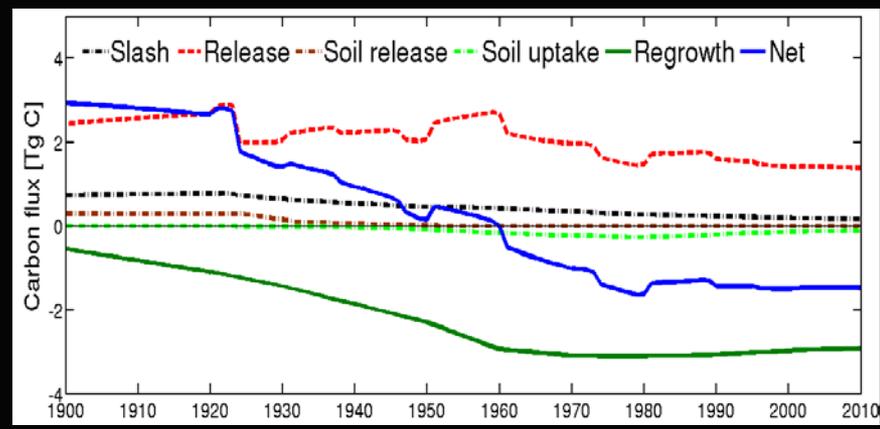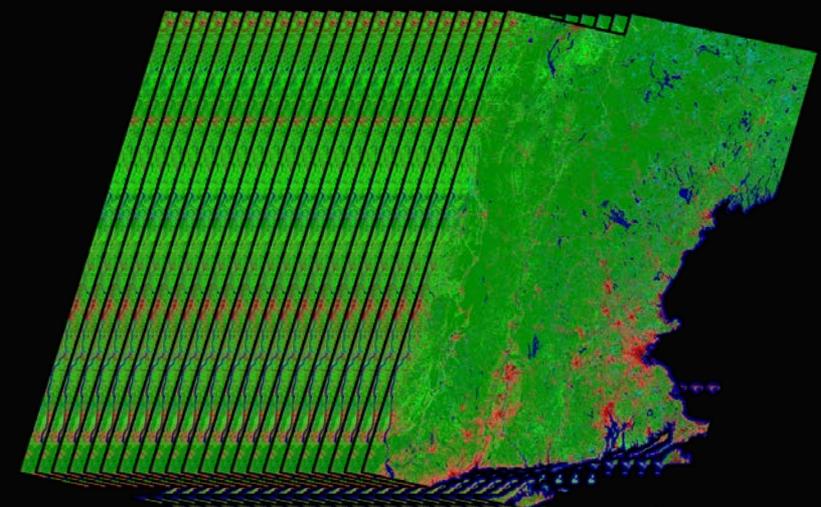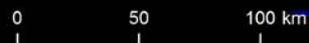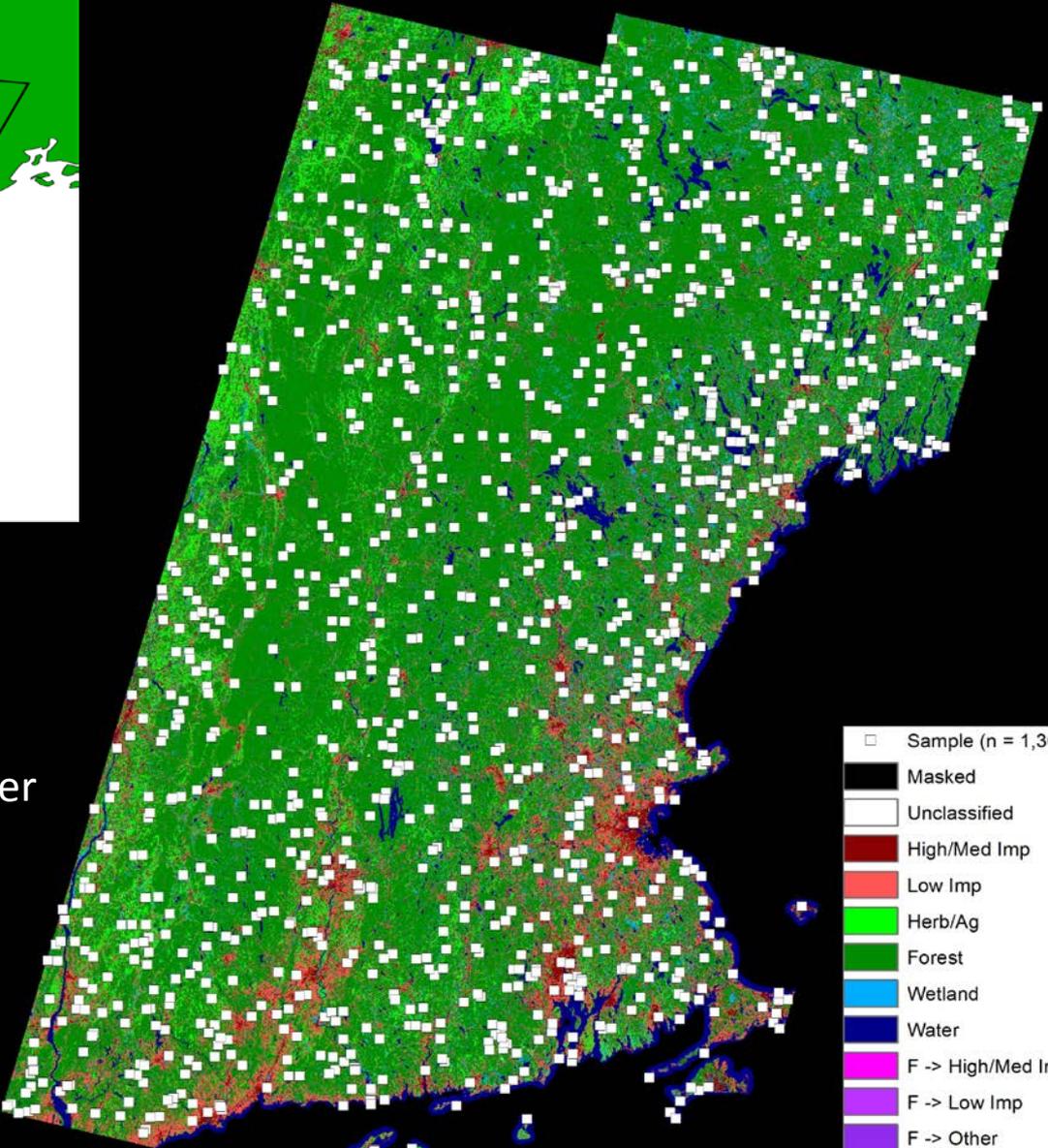

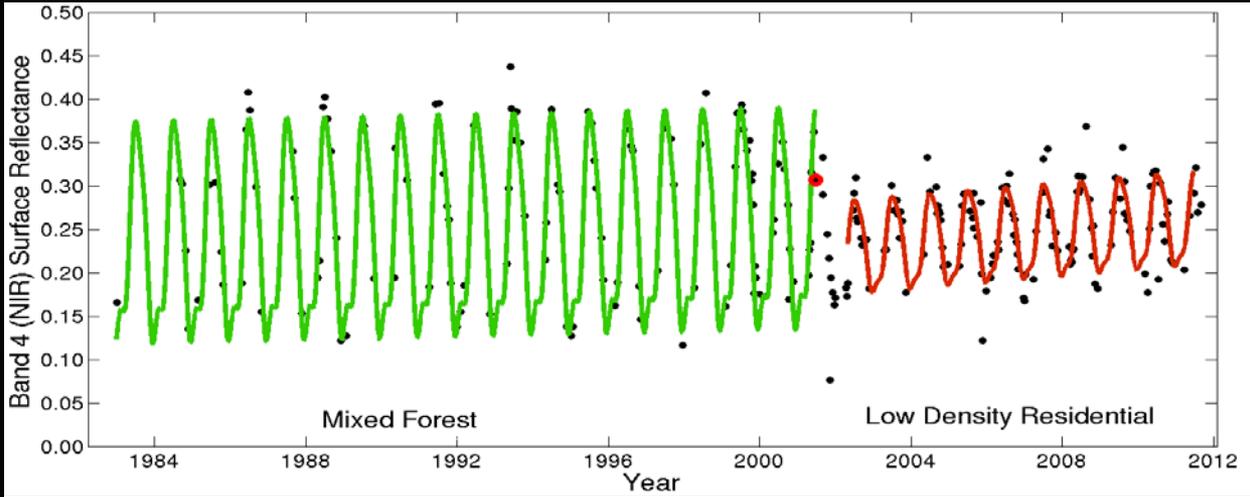## Atmospheric Measurements

Atmospheric Modeling

LCLUC Dynamics

Five Landsat scenes have processed using a Continuous Change Detection and Classification (CCDC) of Land Cover Using All Available Landsat Data

Legend:
- Sample (n = 1,300)
- Masked
- Unclassified
- High/Med Imp
- Low Imp
- Herb/Ag
- Forest
- Wetland
- Water
- F -> High/Med Imp
- F -> Low Imp
- F -> Other
- Herb/Ag -> F
- Other -> F

0   50   100 km

LCLUC Dynamics

$$\hat{\rho}(i,x)_{RIRLS} = a_{0,i} + a_{1,i}\cos\left(\frac{2\pi}{T}x\right) + b_{1,i}\sin\left(\frac{2\pi}{T}x\right) + a_{2,i}\cos\left(\frac{2\pi}{NT}x\right) + b_{2,i}\sin\left(\frac{2\pi}{NT}x\right)$$

where,

x	Julian date
I	the ith Landsat Band
T	number of days per year (T = 365)
N	number of years of Landsat data
$a_{0,i}$	coefficient for overall values for the ith Landsat Band
$a_{1,i}, b_{1,i}$	coefficients for intra-annual change for the ith Landsat Band
$a_{2,i}, b_{2,i}$	coefficients for inter-annual change for the ith Landsat Band
$\hat{\rho}(i,x)_{RIRLS}$	predicted value for the ith Landsat Band at Julian date x based on RIRLS fitting.

Zhu and Woodcock RSE 2014

LCLUC Dynamics

Urban lengthening of plant growing season by ~ 1 month!
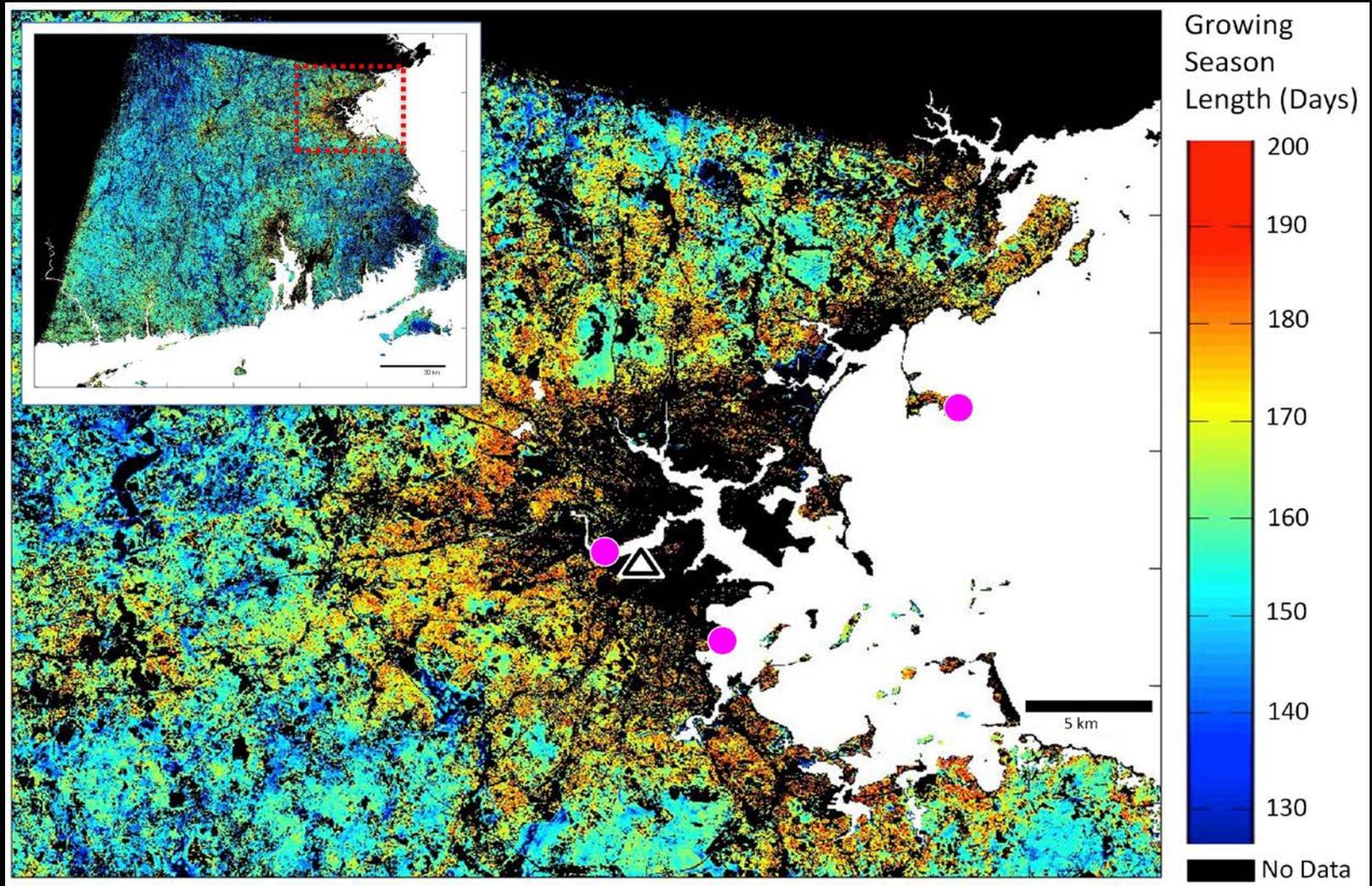
Friedl et al.

Modeling of Carbon Dynamics of LCLUC
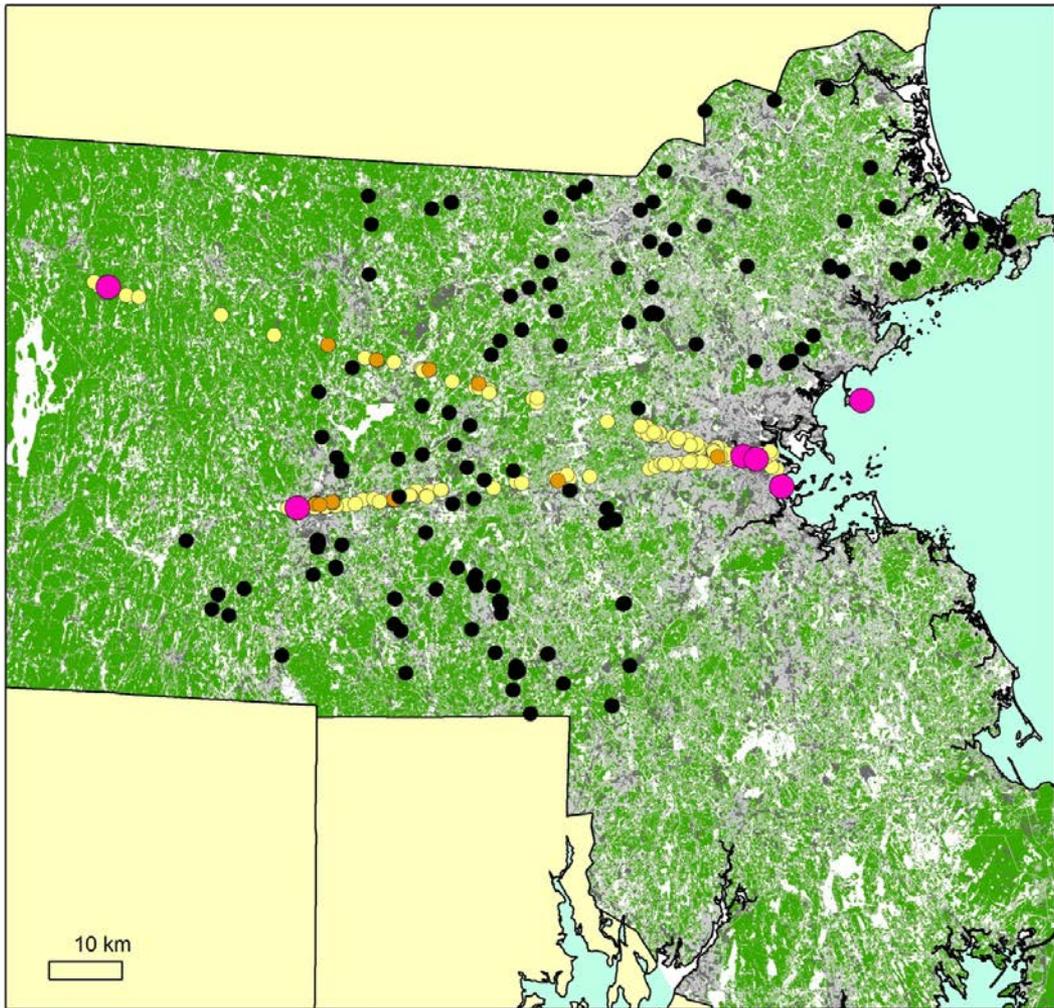
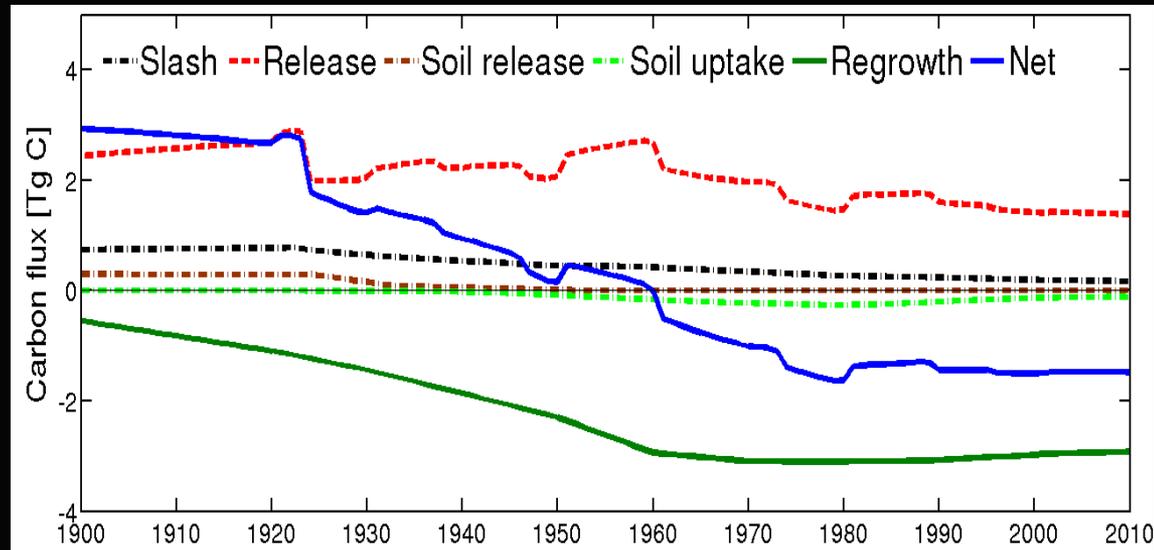# Modeling of Carbon Dynamics of LCLUC

~50% less biomass in urban areas, but we observe an ~50% increase in per tree productivity
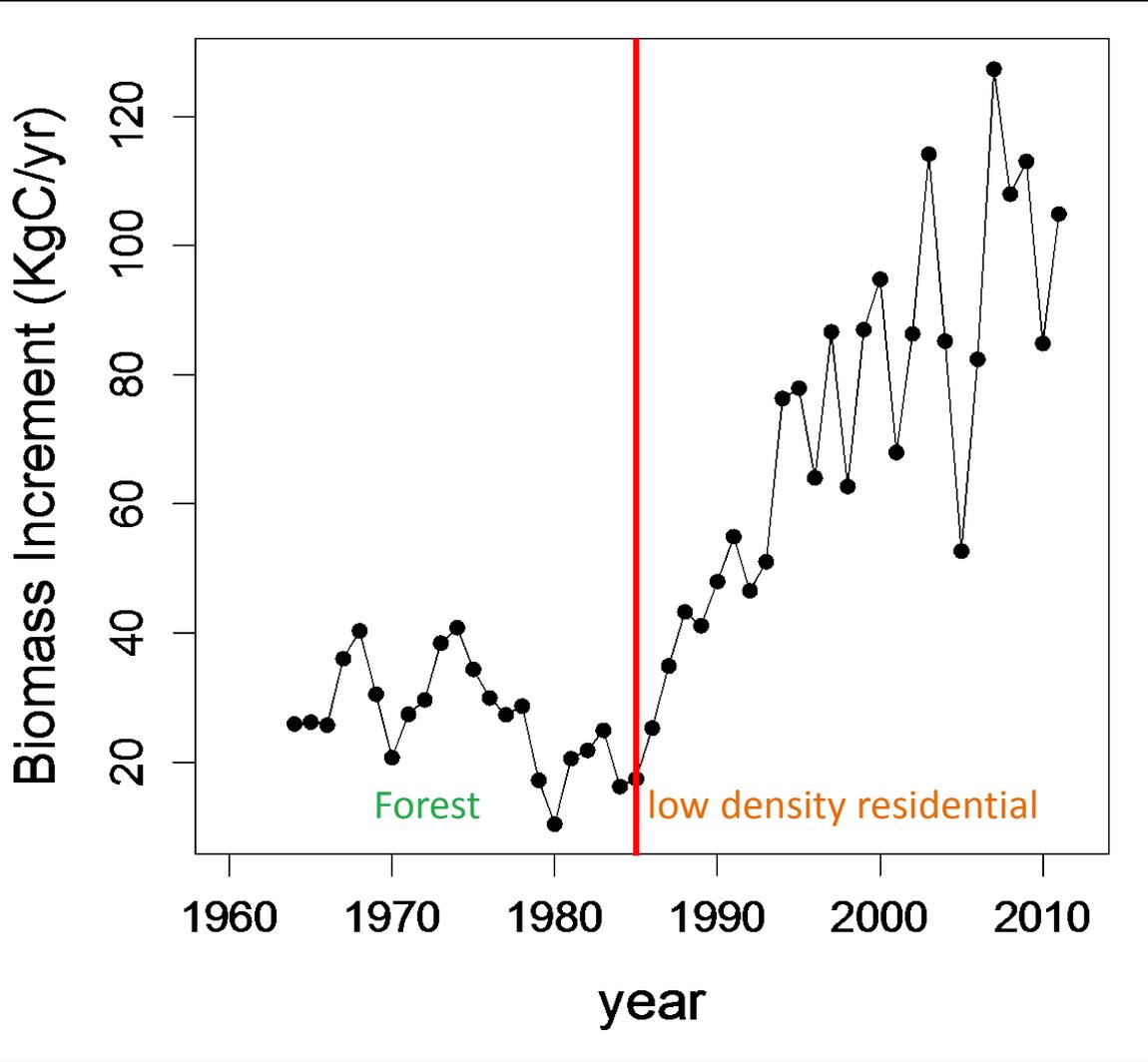
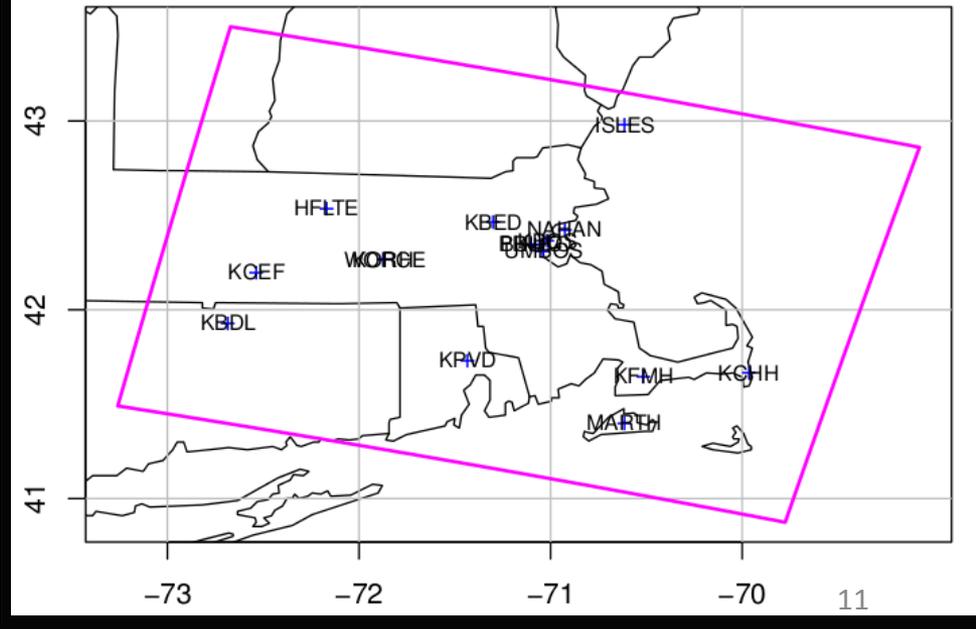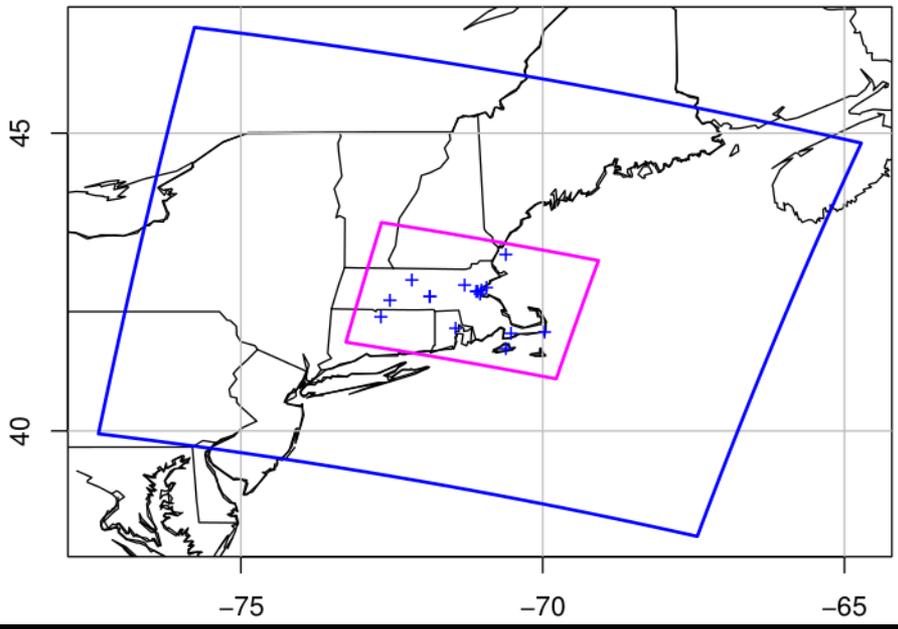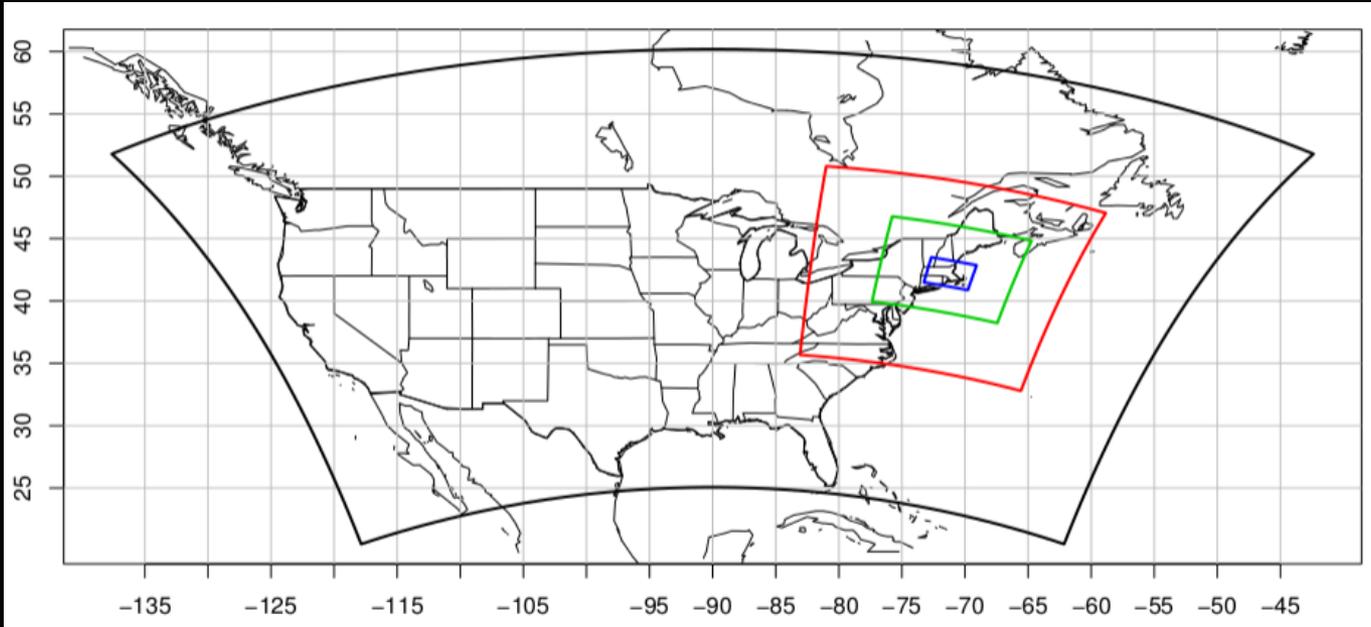# Modeling of Carbon Dynamics of LCLUC

We are parameterizing a model for long-term carbon dynamics following land cover change wherein we track changes in carbon pools follow forest harvests and urban development. Model utilizes the Houghton bookkeeping framework, FIA data, and direct urban field observations.
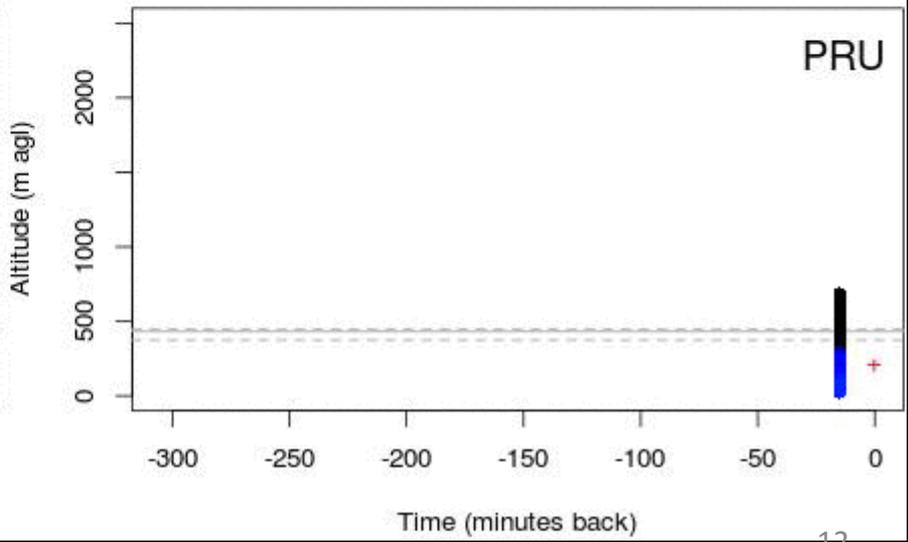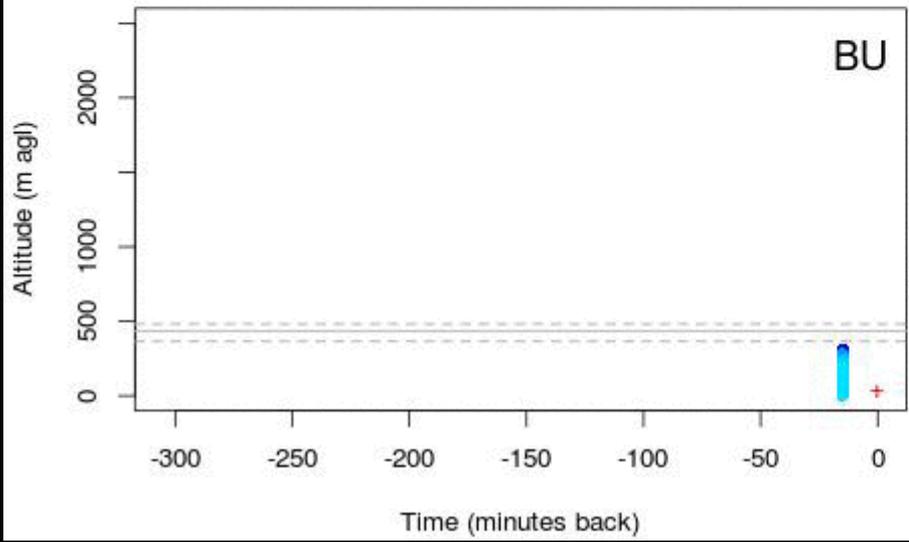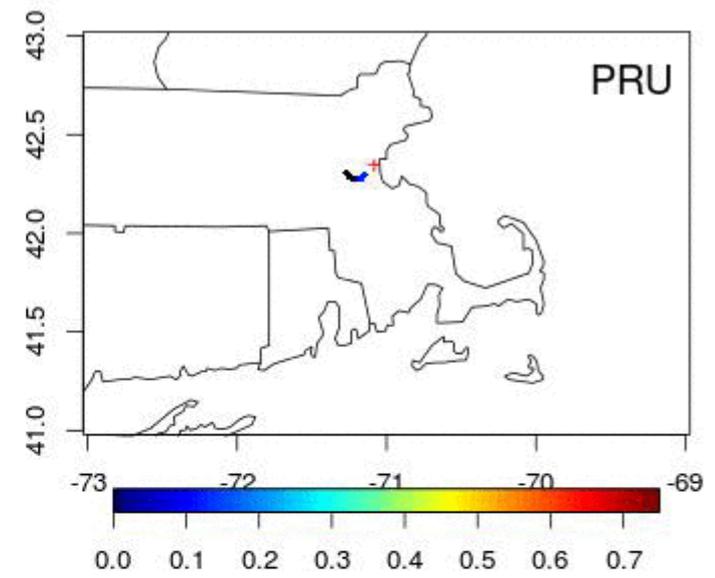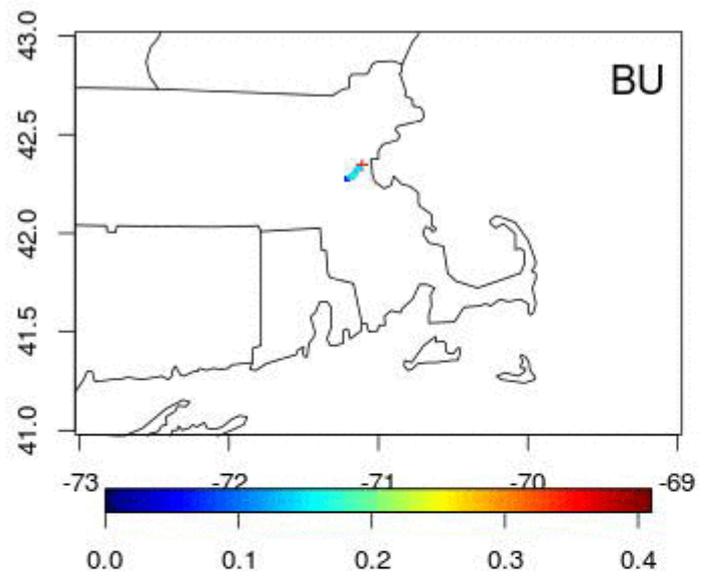
Atmospheric Measurements

Harvard Forest

Nahant

Harbor Islands

BU

Prudential

WRF Domains
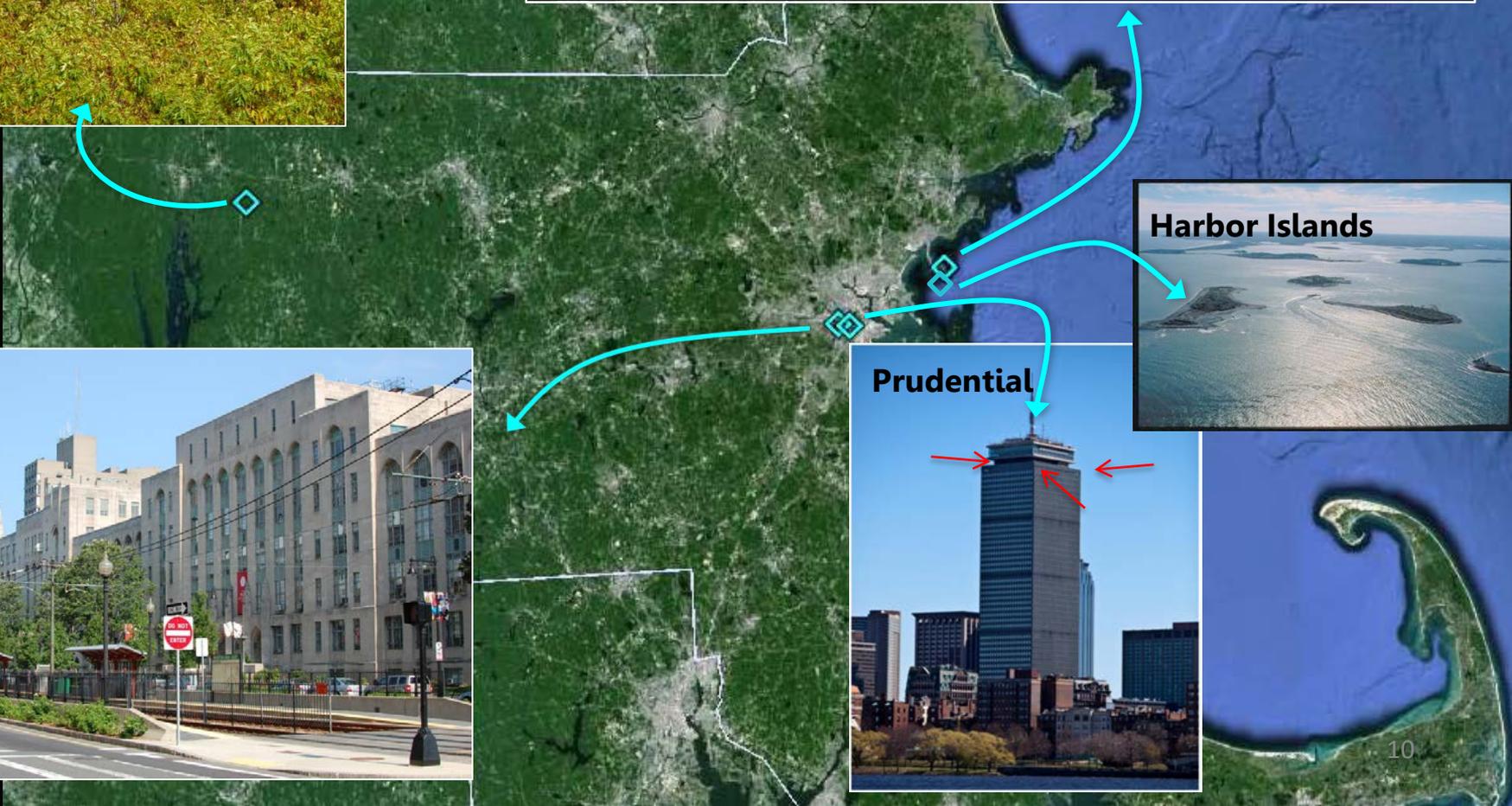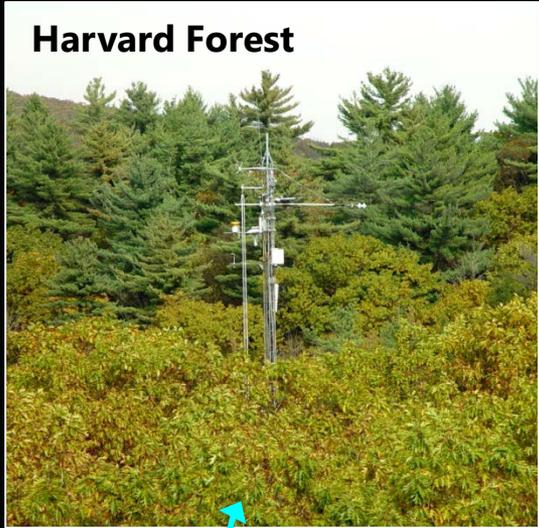
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Link

Summary

We are implementing an interdisciplinary measurement and modeling framework that combines explicit treatment of urban emission sources, urban ecology, atmospheric transport of GHGs, and land cover change dynamics in a comprehensive treatment of carbon flows in and around densely populated regions.

- Measurement systems in place

- Field measurements complete

- Remote sensing imagery processed

- Model parameterization and simulation in progress.

- Synthesis is in progress.

Lucy Hutyra   Steve Wofsy   Curtis Woodcock   Mark Friedl   Steve Raciti   Conor Gately   Britt Briber   Kathryn McKain