20 years of Forest/ Atmosphere Exchange Research in New England

- Flux tower sites
- Remote sensing
- Atmospheric Chemistry
- Phenology observations
- Soil fluxes
- Modeling

See also

- Posters
- Urban-rural gradients

- Extensive areas re-growing after agriculture abandoned
- Rich historical data sets
- Steep rural-to-urban gradients

Net Carbon exchange and biomass accumulation as a function of species composition and stand age at the Harvard Forest in central Massachusetts

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Harvard Forest Overview

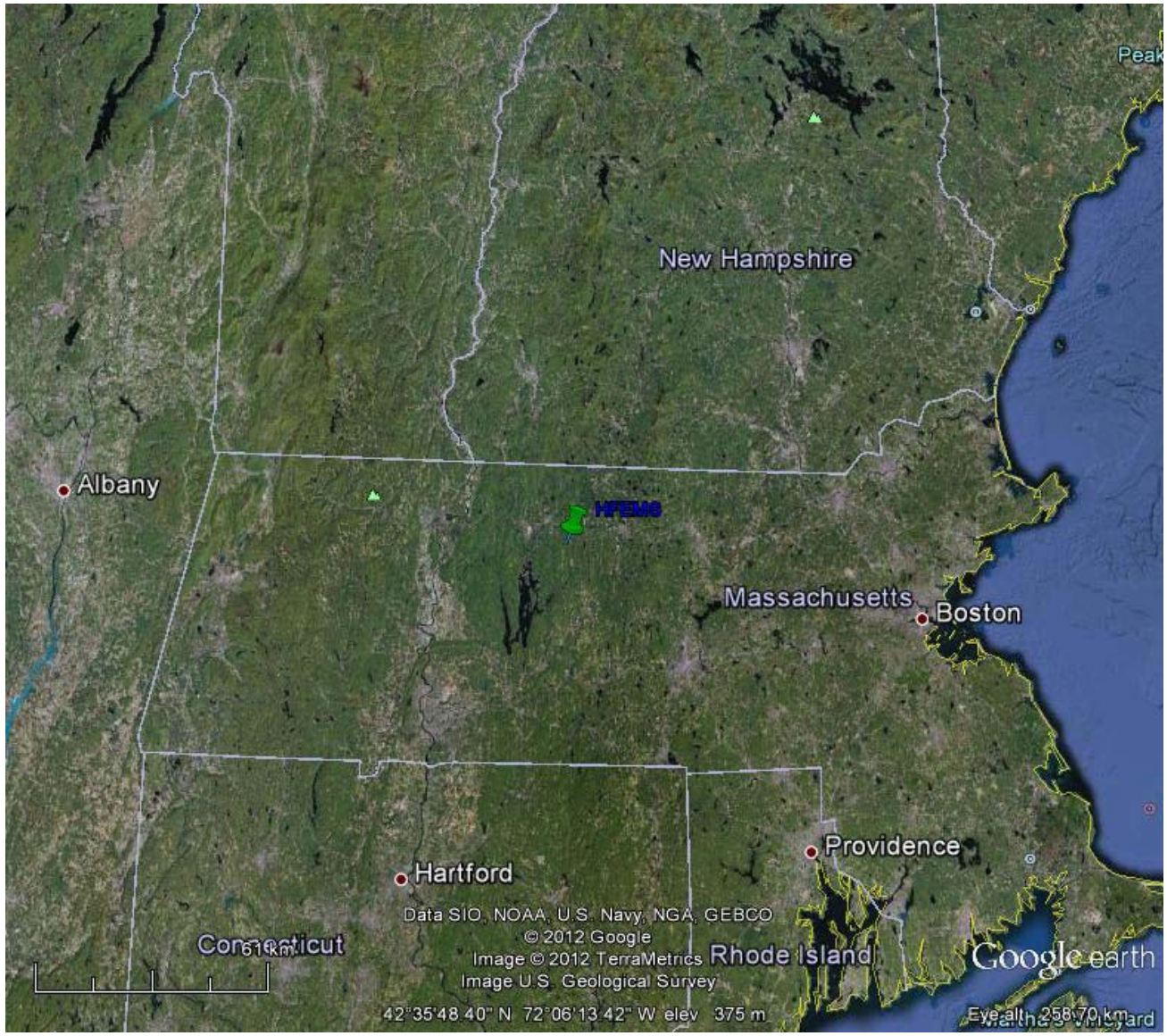
Central Massachusetts

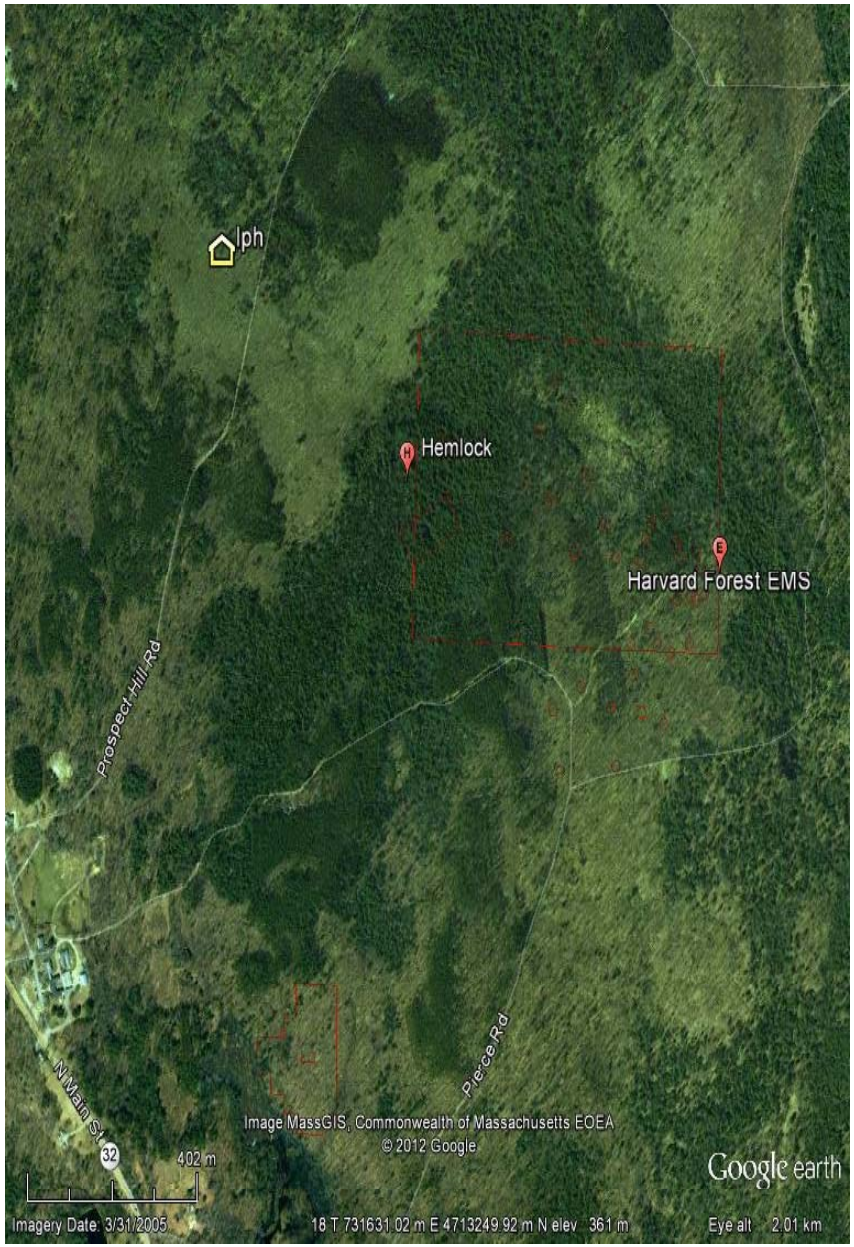
Rural area, ~100km from Boston

340 m elevation

Forest-dominated landscape for 10's of km

Low-density housing along roadways, small towns





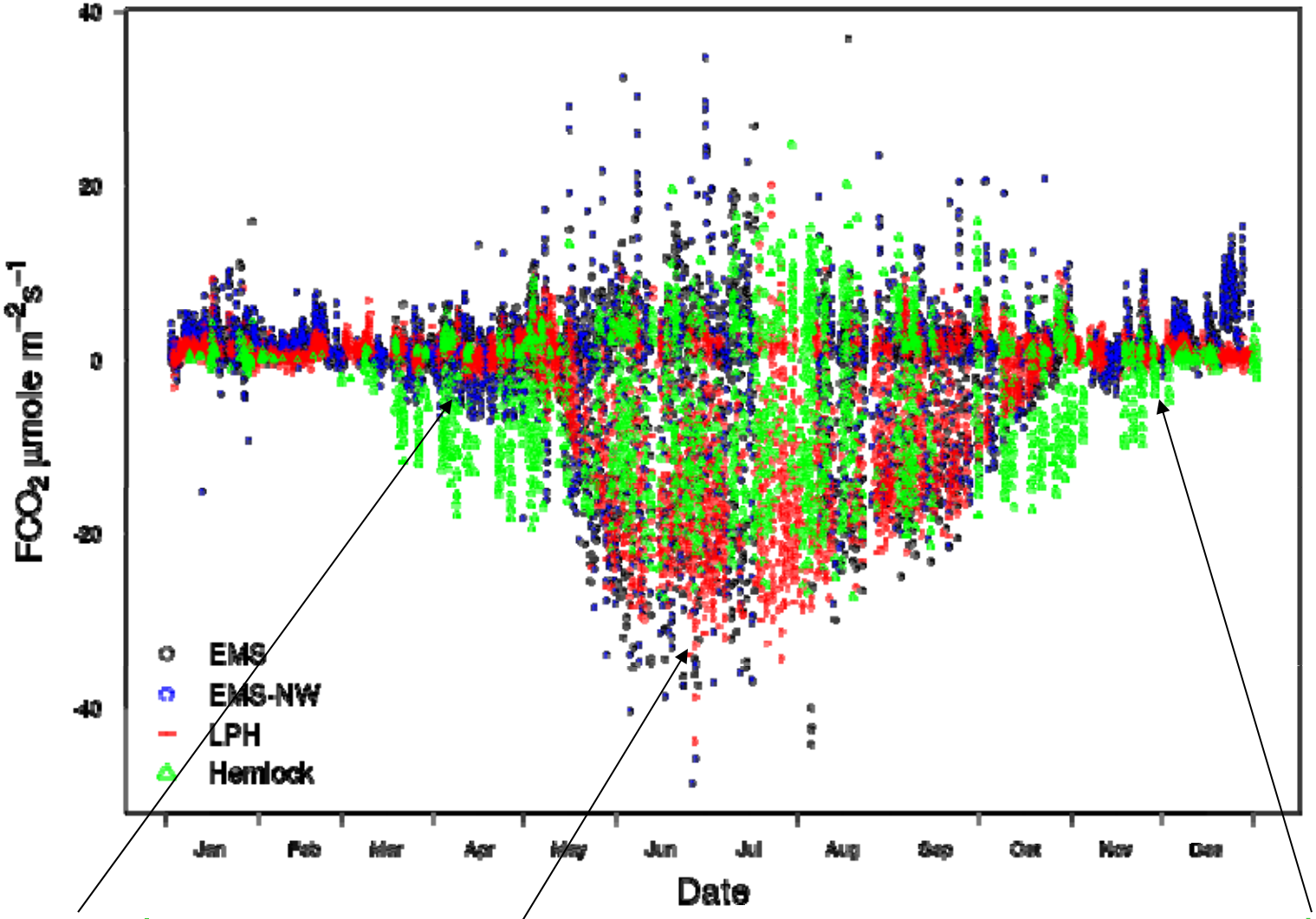
March 2005

July , 2006

Site characteristics

- **Oak-maple mixed forest (EMS and LPH)**
  - Cores show some trees established before 1900
  - LPH re-growing after 1957 fire
  - Soil carbon stock and above-ground biomass both ~ 120 Mg ha^{-1}
  - Tower operating since 1990 – consistent CO_2 fluxes since Autumn 1991
  - Biomass plots since 1993
- **Hemlock Stand**
  - 100-200 year old trees
  - Never cleared, but was used for wood products
  - ~80-125 Mg ha^{-1}above-ground biomass
  - Tower installed in 2000, consistent, continuous flux measurements since 2004

Hourly Flux data for 2010

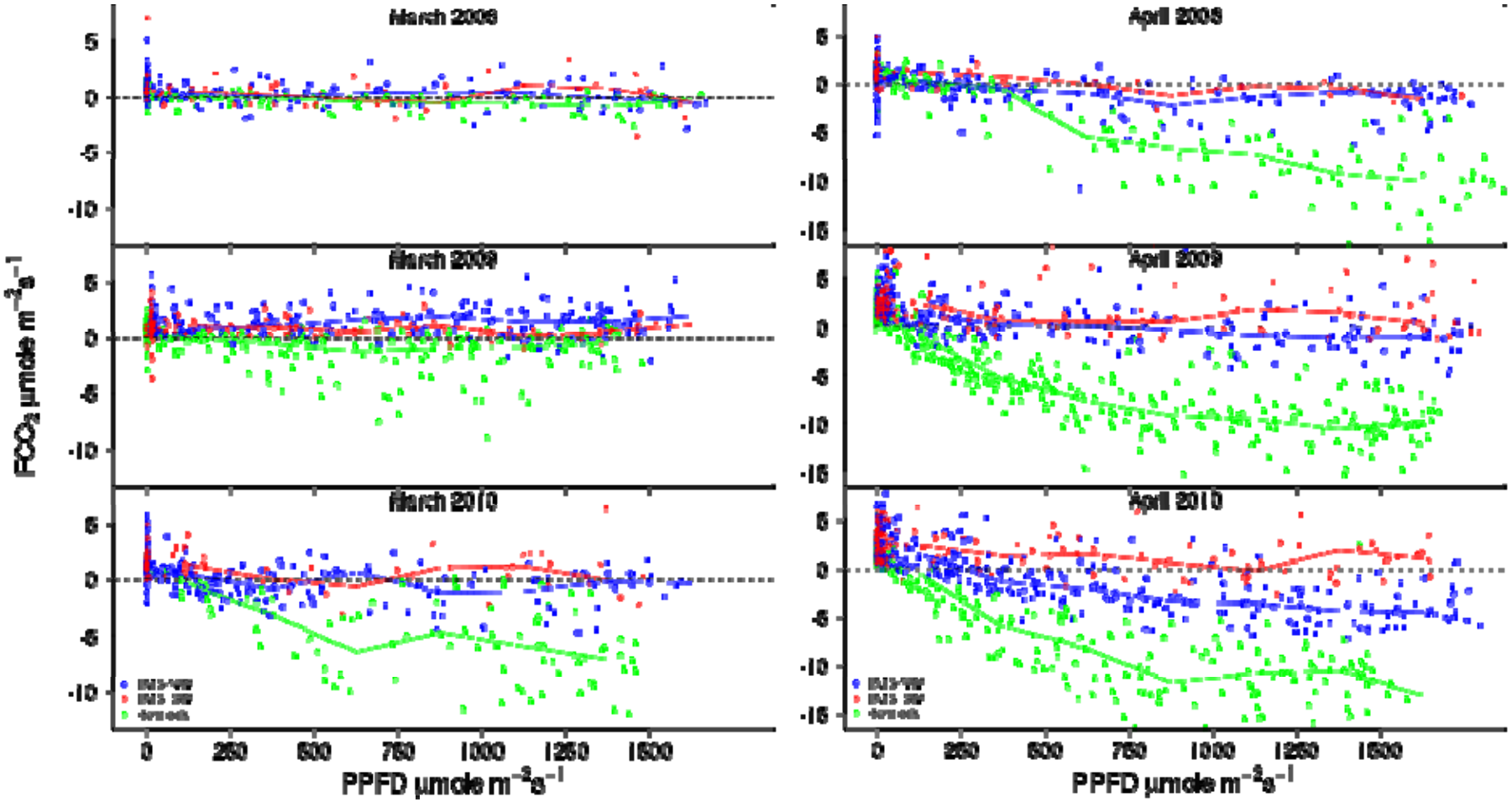


Starts early

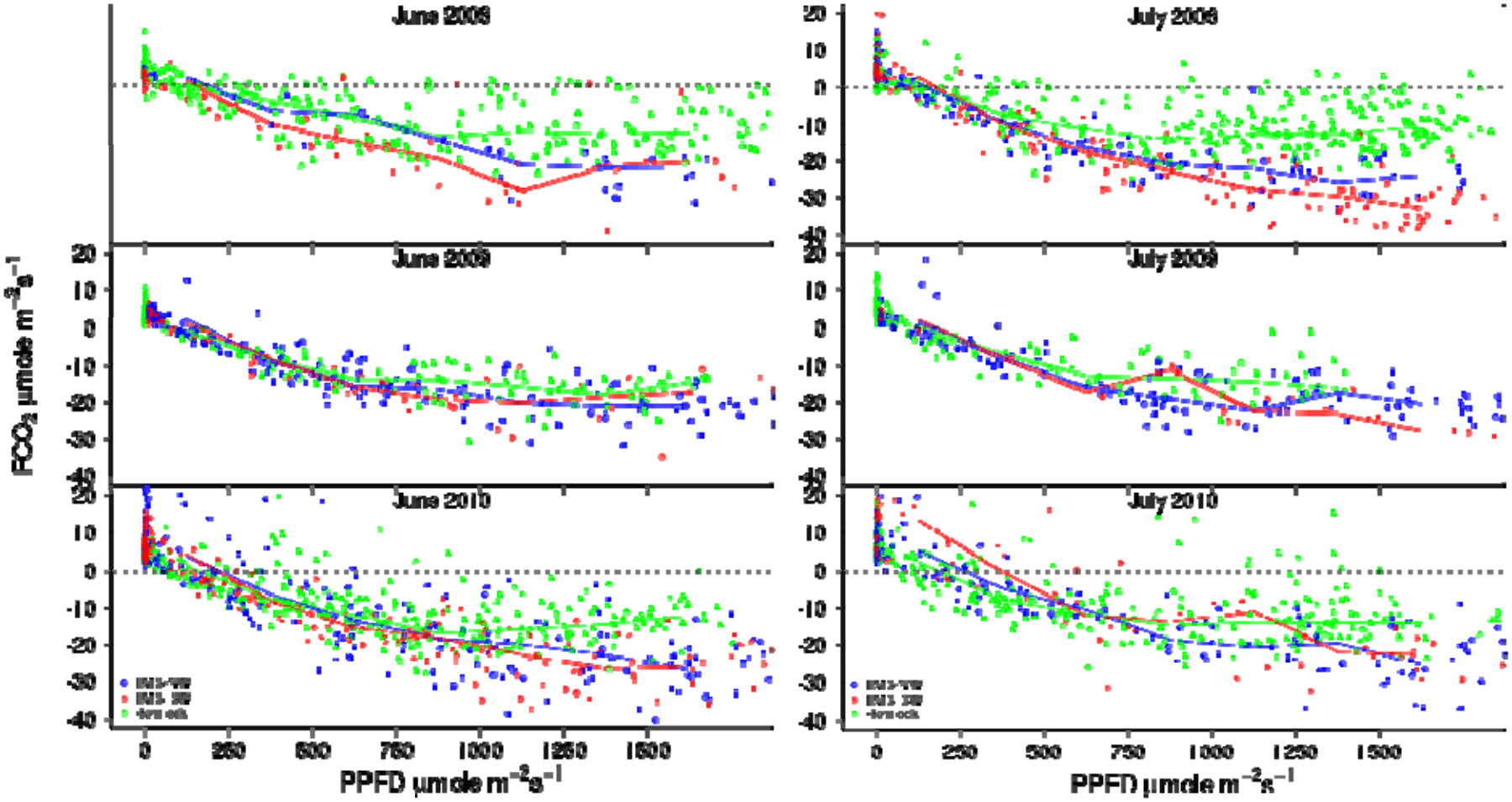
Greater uptake at peak

Ends later

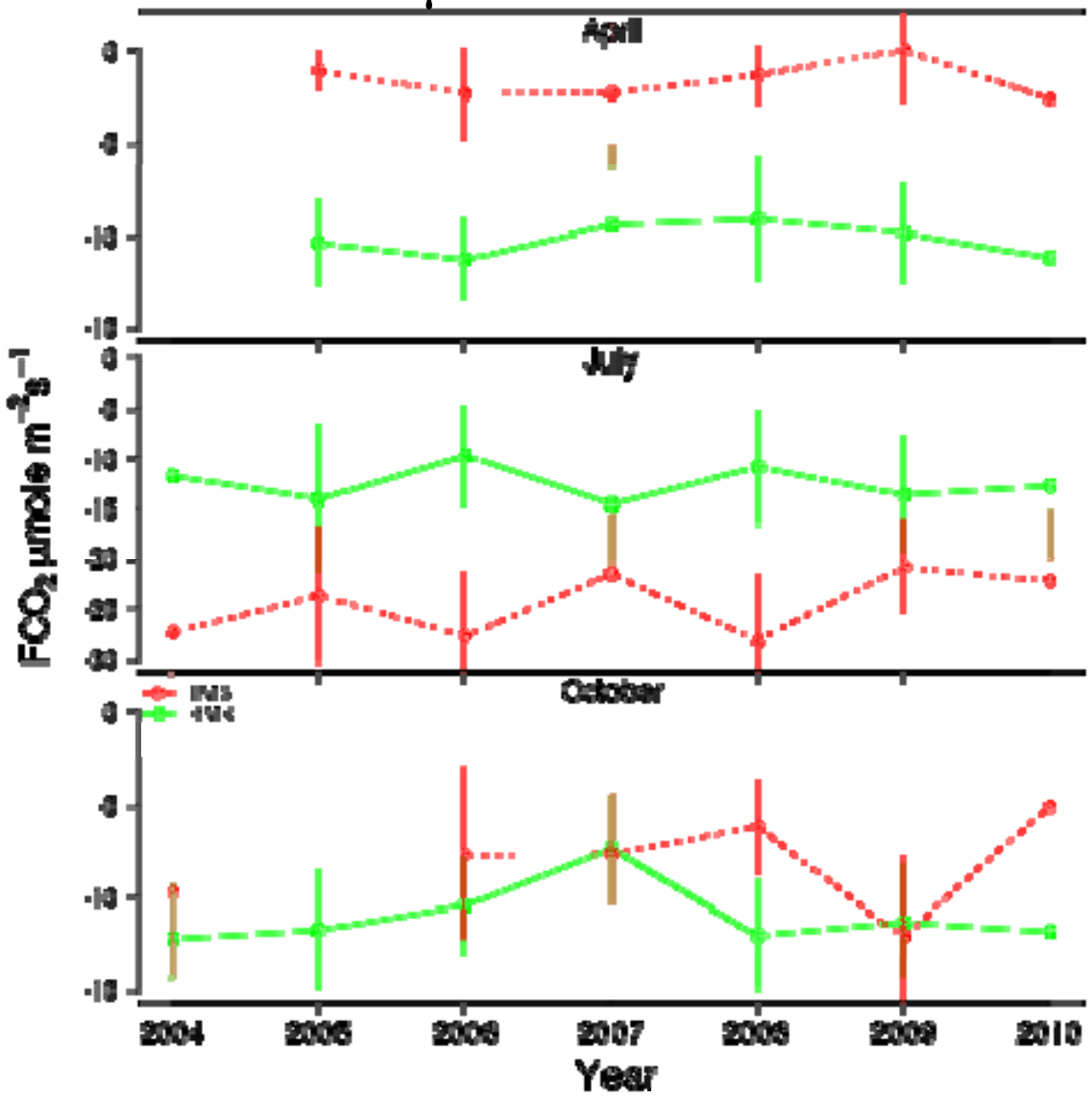
Light curves for early spring clearly show active CO_2 uptake in the Hemlock Stand, with some years having some CO_2 uptake in the NW sector of mixed forest tower where there are more conifers



Light curves during summer months June-July show tendency for greater uptake by the deciduous-dominated forest stand at EMS tower



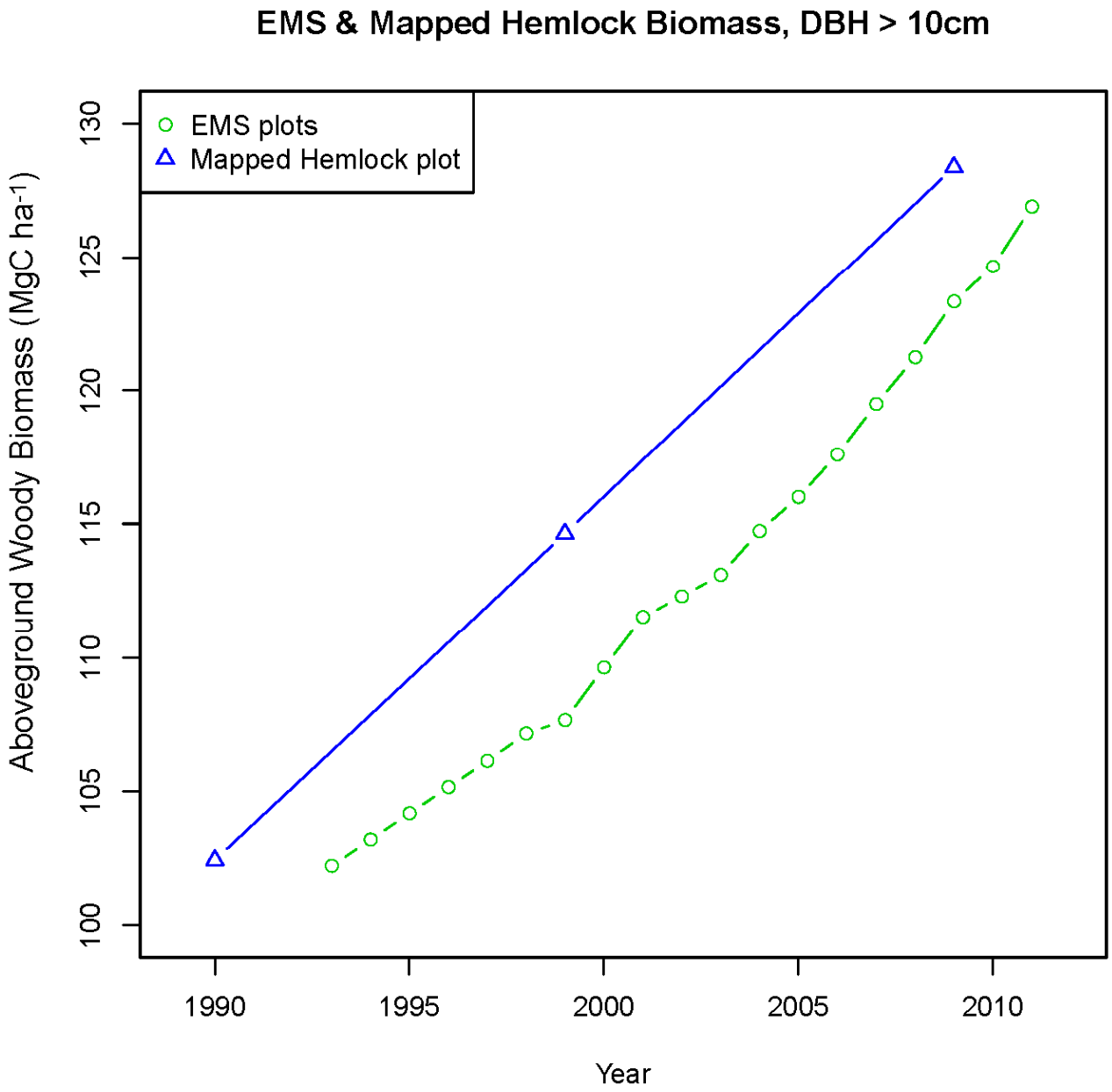
Mean CO_2 flux for PPFD > 1000 µmole m^{-2} s^{-1}



- Before leafout, consistently higher photosynthesis rates in the Hemlock stands
- In peak of summer photosynthesis rates for deciduous dominated stand nearly twice that of the hemlock stand
- Photosynthesis rates are comparable for the two stands, but dependent on timing of senescence and leaf color at deciduous stand

Stand Biomass as an indicator of long-term carbon uptake

- 34 (10m radius) plots within 500 m of EMS tower along dominant wind direction observed annually since 1998
  - Trees > 10cm dbh
- Mapped Hemlock plot established in 1990, re-sampled about every 10 years
  - Trees > 5cm dbh
- Reporting biomass increment, recruitment, mortality


EMS & Mapped Hemlock Biomass, DBH > 10cm
EMS plots
Mapped Hemlock plot
Aboveground Woody Biomass (MgC ha-1)
100
105
110
115
120
125
130
1990
1995
2000
2005
2010
Year

Conclusions

Physiological Comparison

- Earlier onset and later persistence to growing season at Hemlock
  - Hemlock spring activity clearly evident in March and April light curves
    - Photosynthesis can start as soon as temperature above freezing
  - April light curves at EMS vary from year to year,
    - Conifers in the NW sector at EMS and young hemlocks that comprise less than 10% of total biomass, which receive direct sunlight in the spring before the deciduous canopy emerges, contribute to CO_2 uptake rates that are about 30% of the corresponding rates in the hemlock stand

Conclusions, continued

- At growing season peak, oak-dominated EMS stand has higher CO_2 uptake rates for a given light level.
  - The peak rate of hourly CO_2 uptake in July for the deciduous stand 1.5 -2 times higher than the peak rate for hemlock-dominated stand
- The reduced magnitude of CO_2 uptake during summer months by hemlock is partly offset by the 1.5 – 2 month longer growing season that starts earlier and ends later compared to the active season for deciduous stands.

Conclusions, continued

Biomass accumulation in above-ground wood has been remarkably similar for hemlock and deciduous-dominated stands over the last 2 decades.

Different strategies achieve the same carbon outcome

Even though the hemlock stands is older, it is still actively accumulating carbon!

However, prognosis for hemlocks in the region is grim; recent warmer winters have allowed Hemlock Wooly Adelgid to spread northward.

- Invasive insect pest that is spreading through eastern U.S.
- Infected trees invariably die within 5-10 years

Ongoing research will quantify the changes in carbon, water, and energy exchange as hemlock canopy dies and new species emerge

Thank you

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