Quantifying the Carbon Balance of a Heterogeneous Region in the Western US

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TERRA PNW
TERRESTRIAL ECOSYSTEM RESEARCH & REGIONAL ANALYSIS

OSU Oregon State University

AmeriFlux

ORCA Objectives

Objectives:

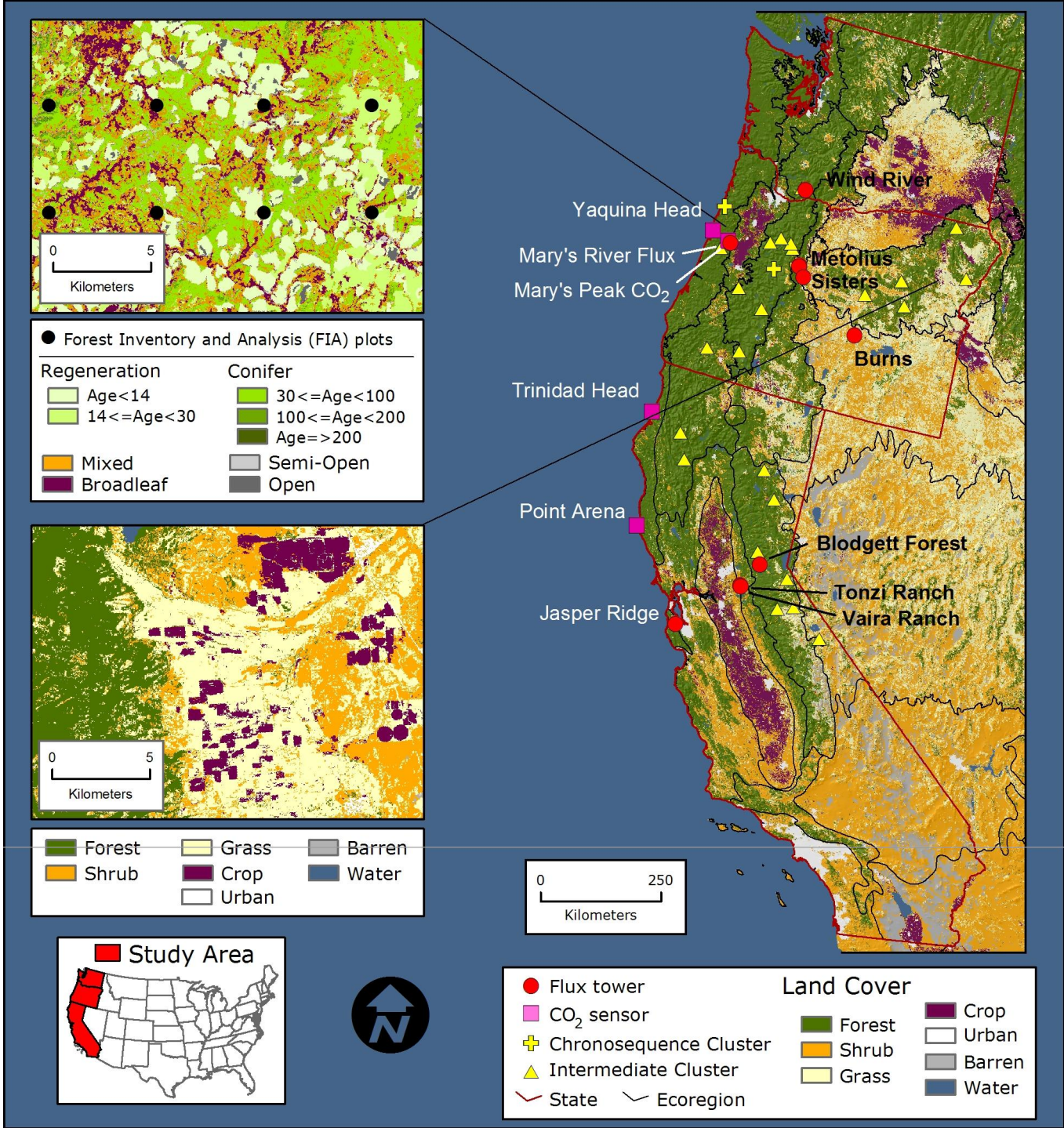
- Reduce uncertainty in C sources and sinks
- Determine effects of disturbance and variation in climate on carbon balance over past 30 years
- Study region: Oregon, California, Washington

Approach

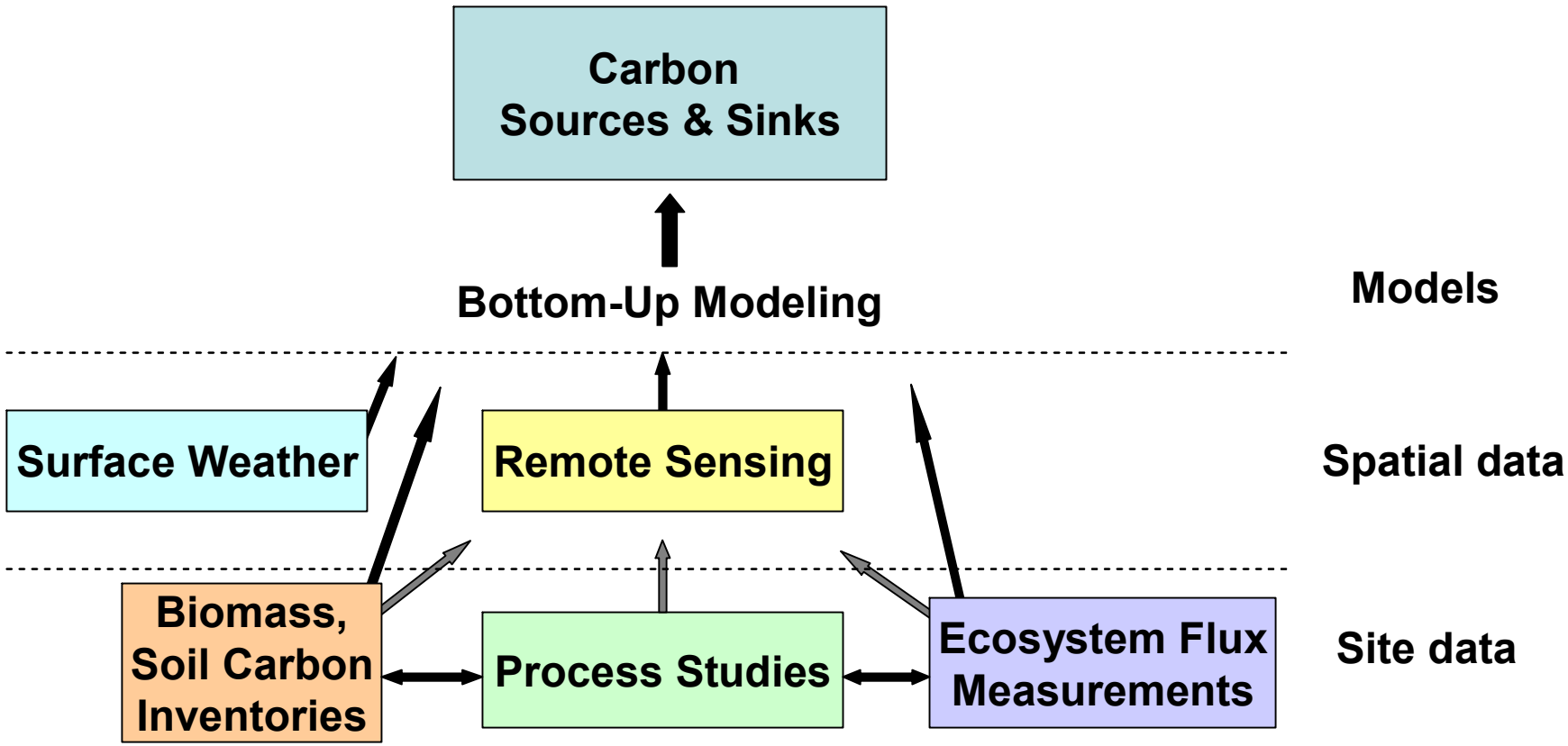
Spatially nested hierarchy of observations:

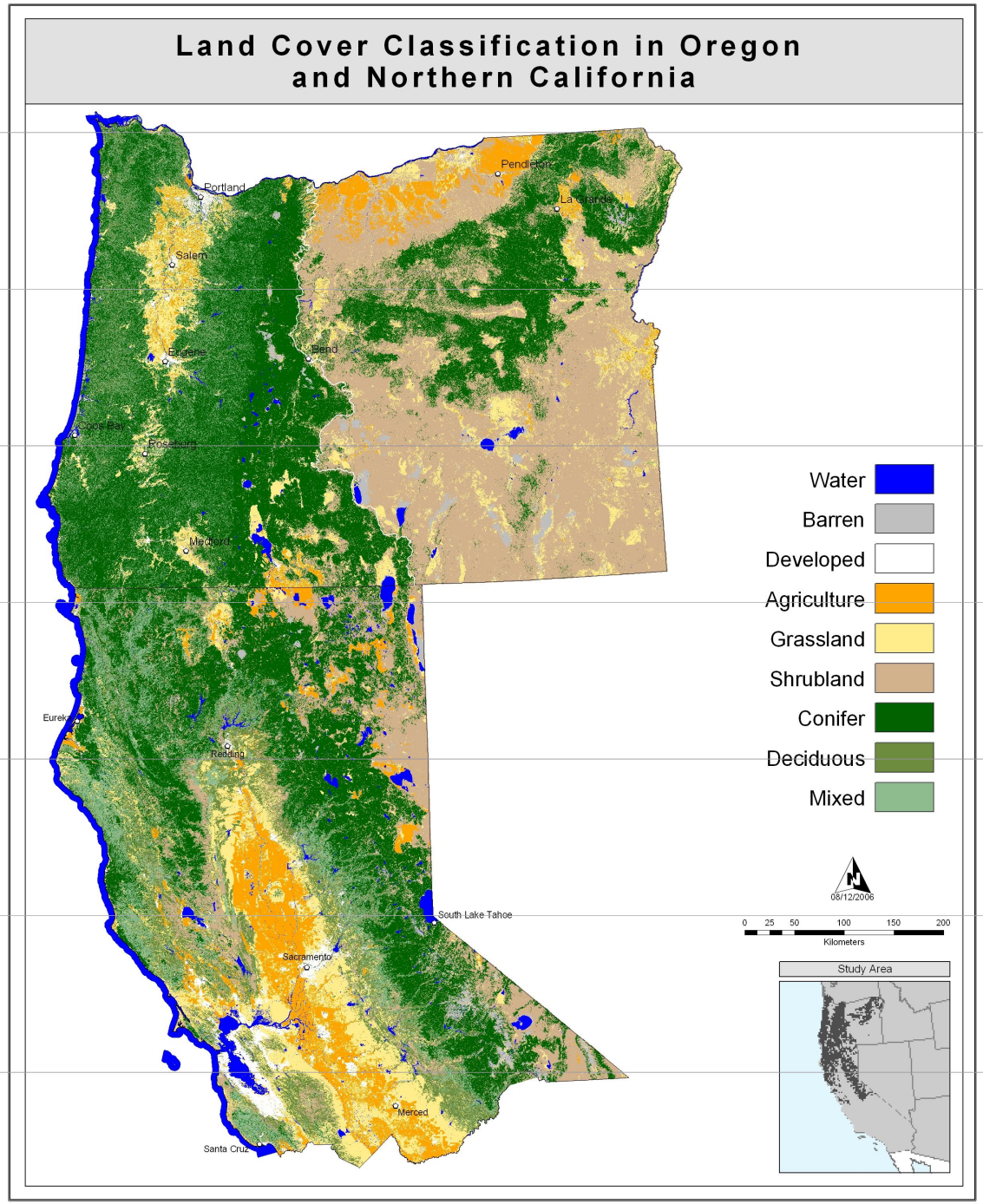
- Flux sites
- Precision CO_2 (W-E gradient)
- Intensive disturbance clusters (4)
- Extensive sites (200)
- Inventories (10,500 OR, 18,000 CA)
- Remote sensing

Bottom-up and top-down modeling



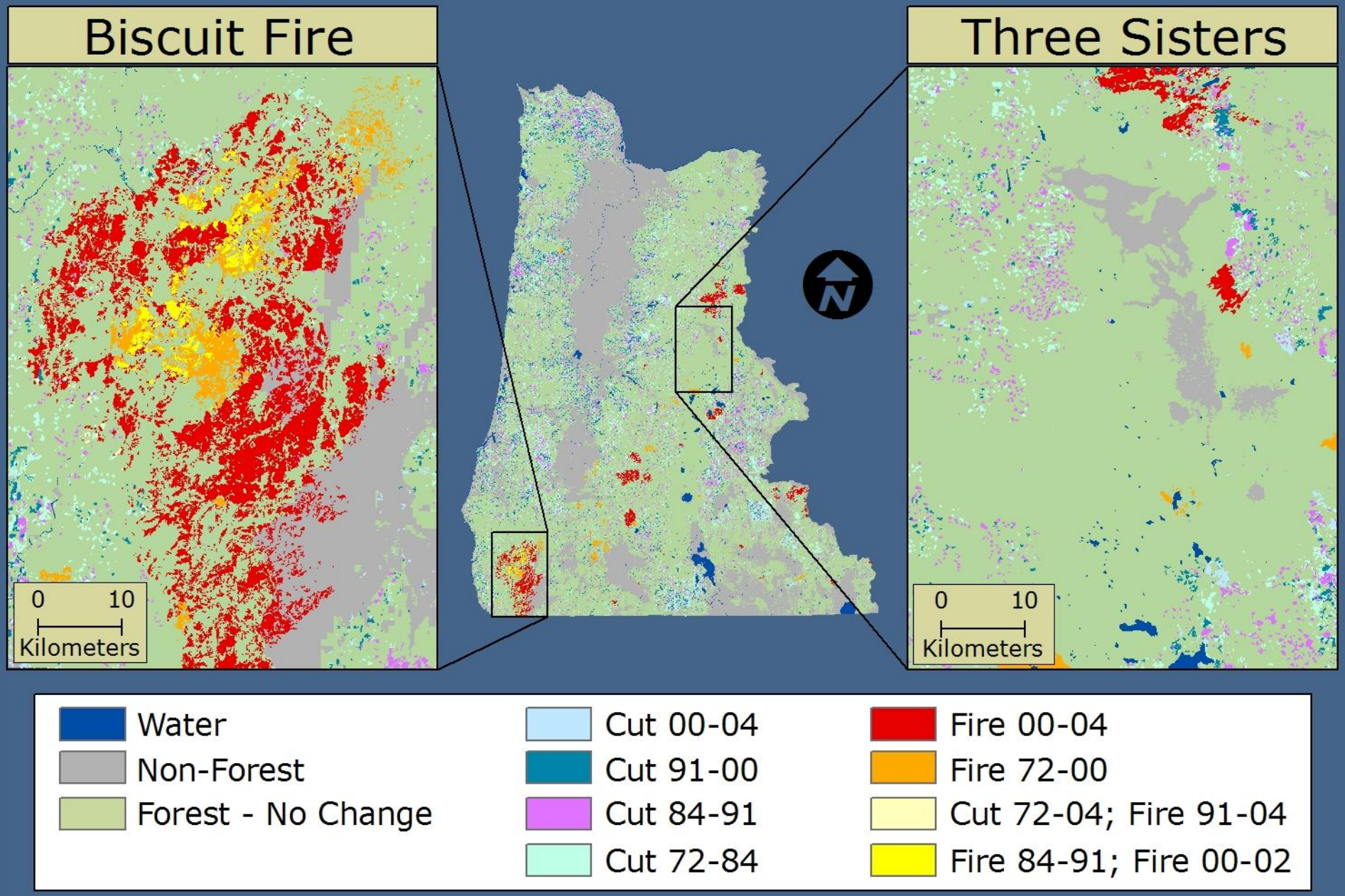
Bottom-up Approach – Biome-BGC





Area = 45M ha
~50% forested

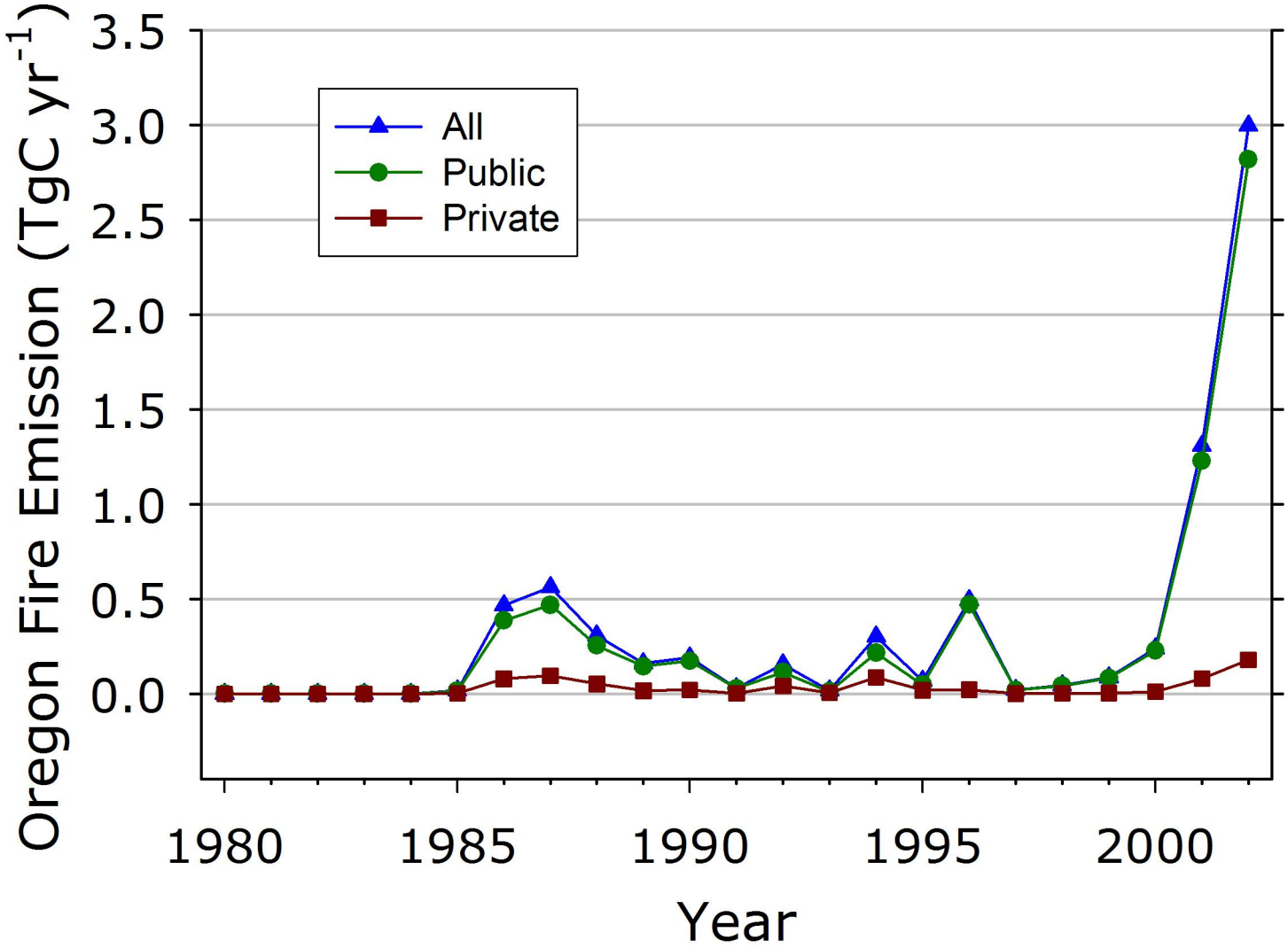
Western Oregon Change Detection



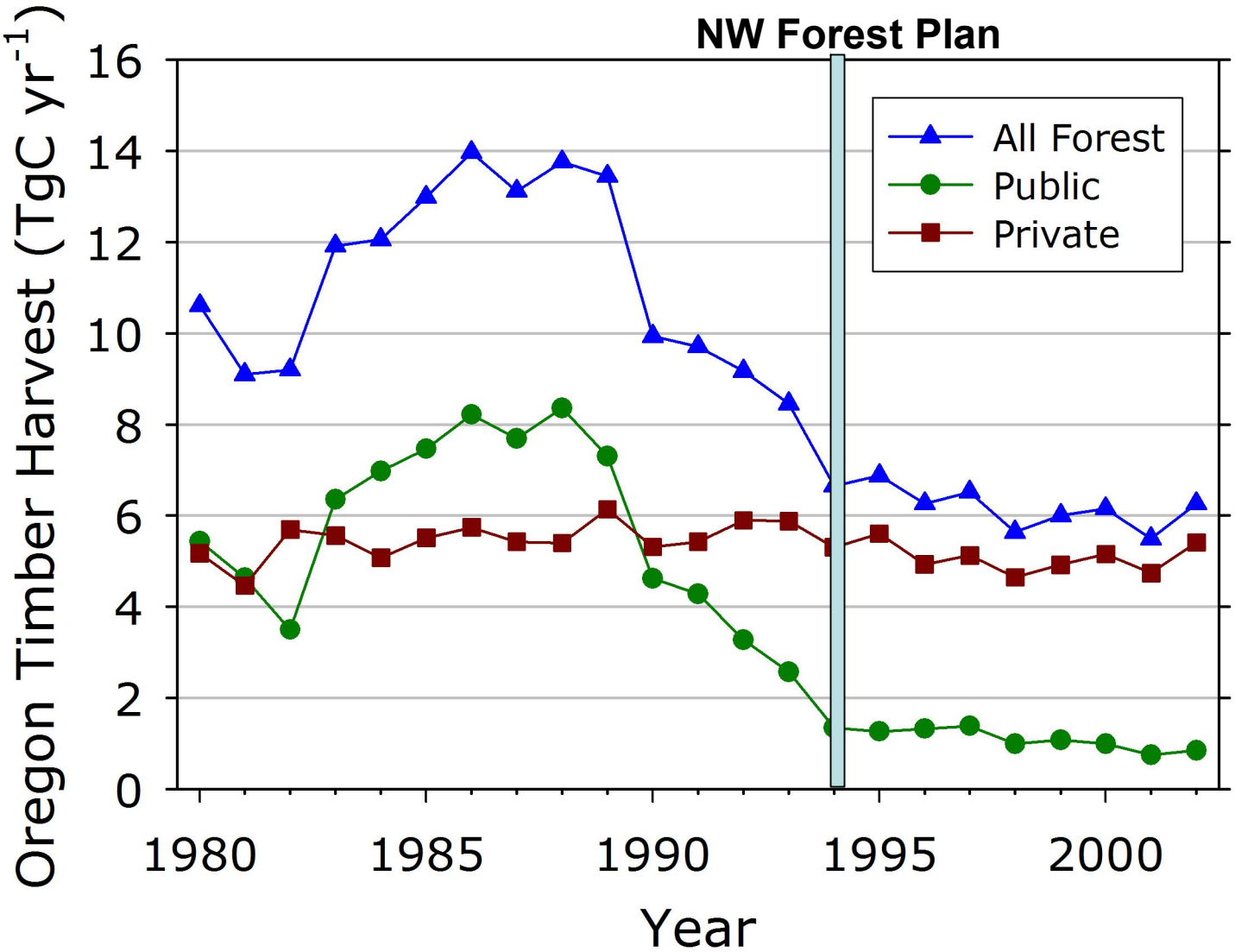
Limitations to BGC Approach

- Land cover is held constant over the duration of the simulation
  - Might be ok in short term, but should introduce land cover change as a type of disturbance
  - Importance of juniper woodland encroachment
- Age classes > 30 not as clear in some ecoregions
  - Occurs in open canopies with mixed age classes
  - Need age classes to test hypotheses about management effects on carbon uptake
- Partial disturbances need to be considered
  - Neglecting management interventions e.g. thinning
  - Mixed and moderate severity fire impacts on carbon balance, emissions
- Uncertainty assessment should include remote sensing inputs to model
  - Effect of aggregation of land cover and age
  - Non-stand replacing disturbance
  - Static land cover

Oregon Fire Emissions



Timber Harvest Trends in Oregon



Top-Down Modeling - Integrated

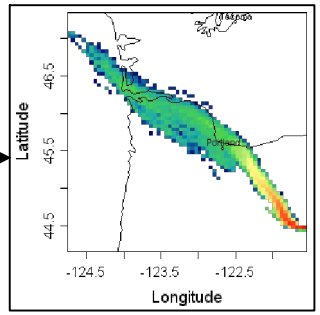
Footprint model

STILT

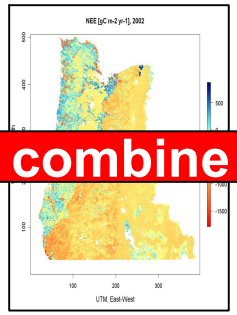
Stochastic Time Inverted Lagrangian Transport Model

output

Source weight function

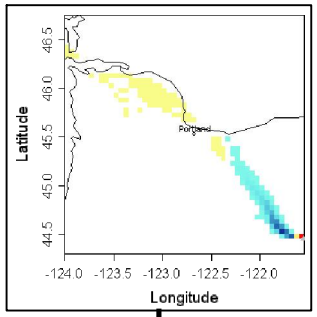


Regional NEE maps



combine

Footprint weighted ΔCO_2



integrate

Modeled CO_2 concentration

input

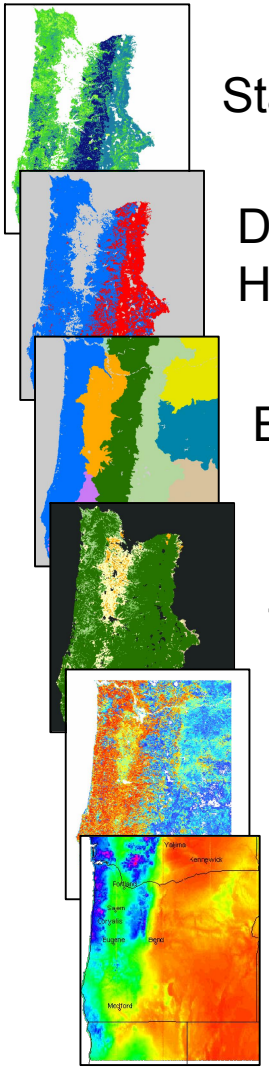
EDAS
(coarse met fields, 40km grid)

CO_2 drawdowns – difference between model runs in morning and evening

Results are completely based on remote sensing input

Comparison with local CO_2 measurements for optimization

Top-Down Modeling – flux model



Stand Age

Disturbance History

Ecoregion

Land cover type

MODIS fPAR

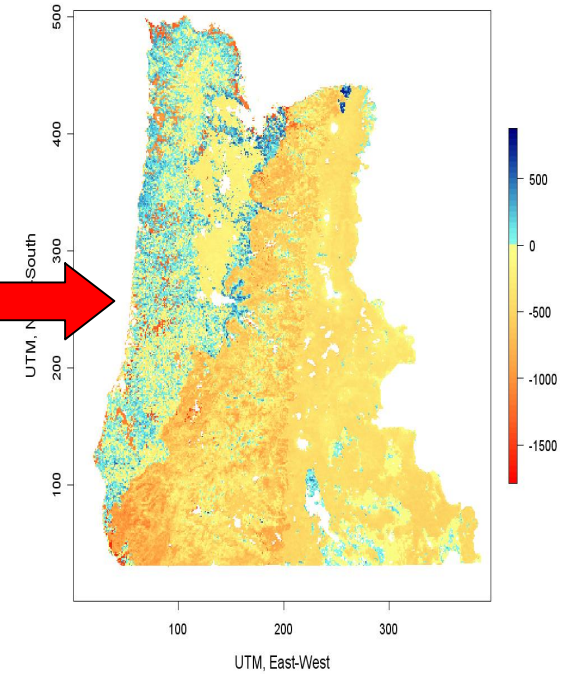
DayMet (precip, T, srad,VPD)

Process model for GPP, R_A, R_H

considers

- Stand Age
- Disturbance History
- GPP-effect on R_A
- Soil moisture

Regional Fluxes at sub-daily timesteps



Summary

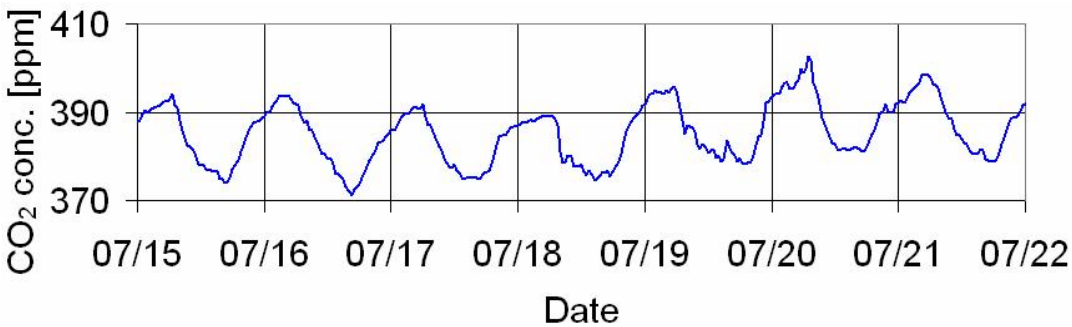
- Land-use: Land-use change needed as a disturbance
- Disturbance: Major issue driving C balance, with important secondary effects from climate
  - Disturbances at 1-2 yr frequency needed (harvest is largest effect on NBP)
  - Partial disturbances needed (mixed/mod severity fire, thinning), e.g. for fire emissions estimates -> NBP

Extras

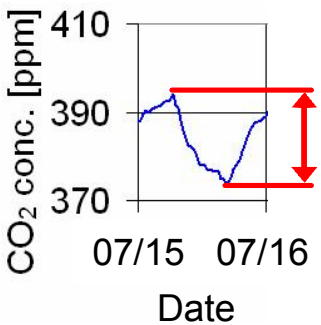
Top-Down Modeling

OBJECTIVE: Develop and validate a regional flux model based on atmospheric measurements

STARTING POINT
Measured CO_2 concentration time series



APPROACH
Simulate CO_2 dynamics with a modeling approach



Work on daily timestep, use CO_2 drawdown as measure

OPTIMIZATION
Tune model baserates to fit modeled to measured drawdowns

Top-Down Modeling

- Combination of process model and atmospheric transport model provides dynamics of CO_2 concentration independent of local measurements
- No spin-up, ideal for modeling interannual variability due to use of remote-sensing information provided for *each year*
- Simple CO_2 concentration time series needed for validation. Due to large footprints, [CO_2] is regionally representative
- Model approach allows validation of process model parameters for regions with significant footprint coverage. For regional coverage a network of sites has to be designed according to the local wind climatology
- For regions not covered by footprints, model parameters have to be fit to single point runs of a bottom-up model (Biome-BCG)