Regional carbon cycle responses to 25 years of variation in climate and disturbance in the Pacific Northwest

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Objectives:

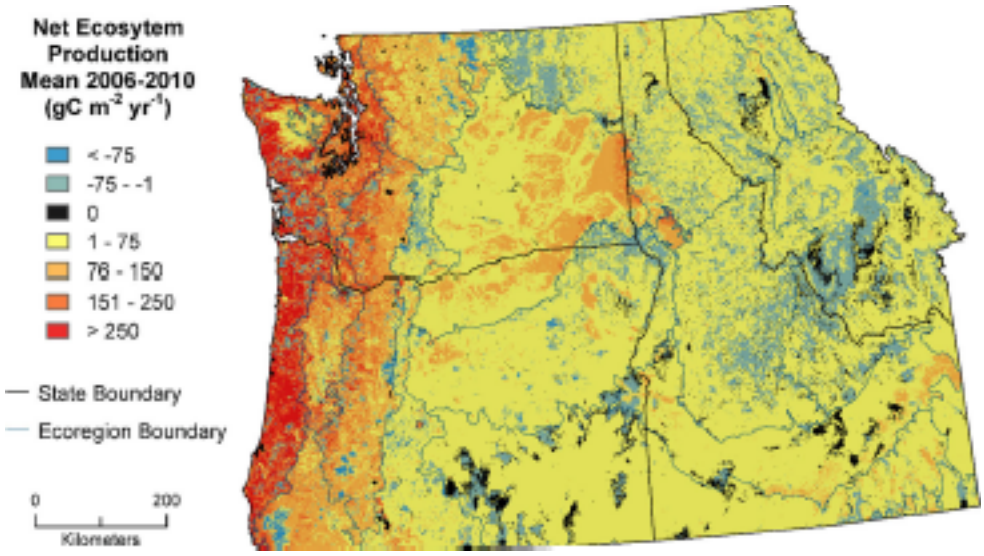
- Spatial and temporal heterogeneity in climate and ecosystem disturbance regimes have strong effects on the carbon cycle and make it challenging to monitor and evaluate regional carbon stocks and fluxes.
- Spatially distributed, process-based, carbon cycle simulation models provide a means to integrate information on these various influences to estimate carbon pools and flux over large domains.
- In this study, authors apply the Biome-BGC model, over the four-state (Oregon, Washington, Idaho and Western Montana) Northwest US region for the interval from 1986 to 2010 with the goal of improving our understanding of spatial and temporal heterogeneity in regional and ecoregional- scale carbon stocks and fluxes.
- Inputs to the Biome-BGC model included:
    - Satellite remote sensing (Landsat) to characterize the land cover and disturbance regime.
    - Distributed meteorological station data for algorithms to calculate photosynthesis, autotrophic respiration, heterotrophic respiration, and evapotranspiration.
    - USDA Forest Service Forest Inventory and Analysis (FIA) plots to calibrate and evaluate the carbon stocks and flux estimates.

New Science:

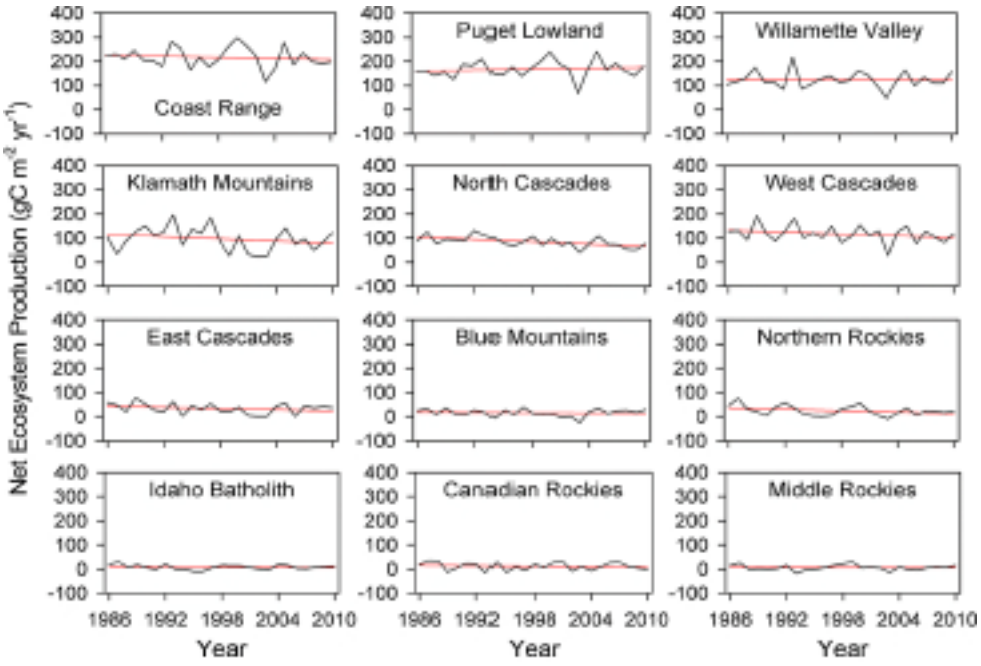
- The overall disturbance rate on forest land across the region was 0.8 % year^{-1}, with 49% as harvest, 28% as fire, and 23% as pest/pathogen.
- Net ecosystem production (NEP) was predominantly positive (a carbon sink) throughout the region, with maximum values in the Coast Range, intermediate values in the Cascade mountains, and relatively low values in the Inland Rocky Mountain ecoregions.
- The net ecosystem carbon balance (NECB) was positive for the region (14.4 TgC year^{-1}).
- There was large interannual variation in regional NEP, with notably low values across the region in 2003, which was also the warmest year in the interval and localized negative NEPs were mostly associated with recent disturbances.
- A large proportion of the harvested area was on private forestland (62%).
- A large proportion of total burned area was on public forestland (89 %) and tended to increase over time.
- Pest/pathogen disturbances tended to be distributed over both public and private areas and there was not a strong temporal pattern across the region in the area disturbed by pests/pathogens.
- The largest NECB gains were in the ecoregions which have some of the most productive forests in the region and mean tree biomass is rising.
- Uncertainty in the simulated carbon stocks and flux estimates arises from errors in the spatially distributed inputs to the model, as well as from Biome-BGC model structure and parameter uncertainty.

Significance:

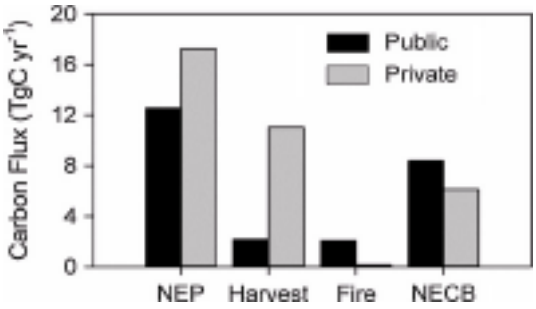
- Evaluating the carbon flux is difficult and uncertain at the intermediate scales of landscape, ecoregion, and region, due to spatial heterogeneity in climate, soils, disturbance regime, and forest management, as well as temporal variation in weather all of which contribute to variability in carbon sources and sinks.
- Application of a spatially distributed carbon cycle process model, which integrates observations from meteorological stations, satellite-borne sensors, and forest inventory plots is a viable approach to addressing this challenge.
- The complexity of the multiple influences on the regional carbon budget support development of regional scenarios based on landscape simulation models that account for changing disturbance regimes and ecophysiology-based influences on ecosystem carbon cycle dynamics.
- Aggregated forest inventory data and inversion modeling are beginning to provide opportunities for evaluating model-stimulated regional carbon stocks and fluxes.
- Improvements in remote sensing-based observations, including airborne lidar for tree biomass and satellite-borne spectrometers for atmospheric CO_2 concentration, are expanding the options for validation of simulated carbon fluxes.
- NECB, calculated in this study, is a carbon cycle metric of high interest to climate change policy makers because it represents the actual carbon sequestration of the land base.
- Because the ecoregions of the Pacific Northwest are distinct with respect to climate, soil, and vegetation this effort to differentiate them in relation to recent carbon cycle changes is warranted and useful.



The distribution of net ecosystem production (mean for 2006-2010).



Mean net ecosystem production time series by ecoregion (1986 – 2010).



Net ecosystem production, fire emissions, harvest removals, and net ecosystem carbon balance (2006-2010) for a. private forestland b. public forestland.

DATA PRODUCT CITATION:

Turner, D.P., W.D. Ritts, R.E. Kennedy, A.N. Gray, and Z. Yang. 2016. NACP Biome-BGC Modeled Ecosystem Carbon Balance, Pacific Northwest, USA, 1986-2010. ORNL DAAC, Oak Ridge, Tennessee, USA. http://dx.doi.org/10.3334/ORNLDAAC/1317