Modeling the Impacts of Climate Change on Water Yield, Carbon Sequestration, and Biodiversity across the Lower 48 States of the United States: WaSSI-CB Model

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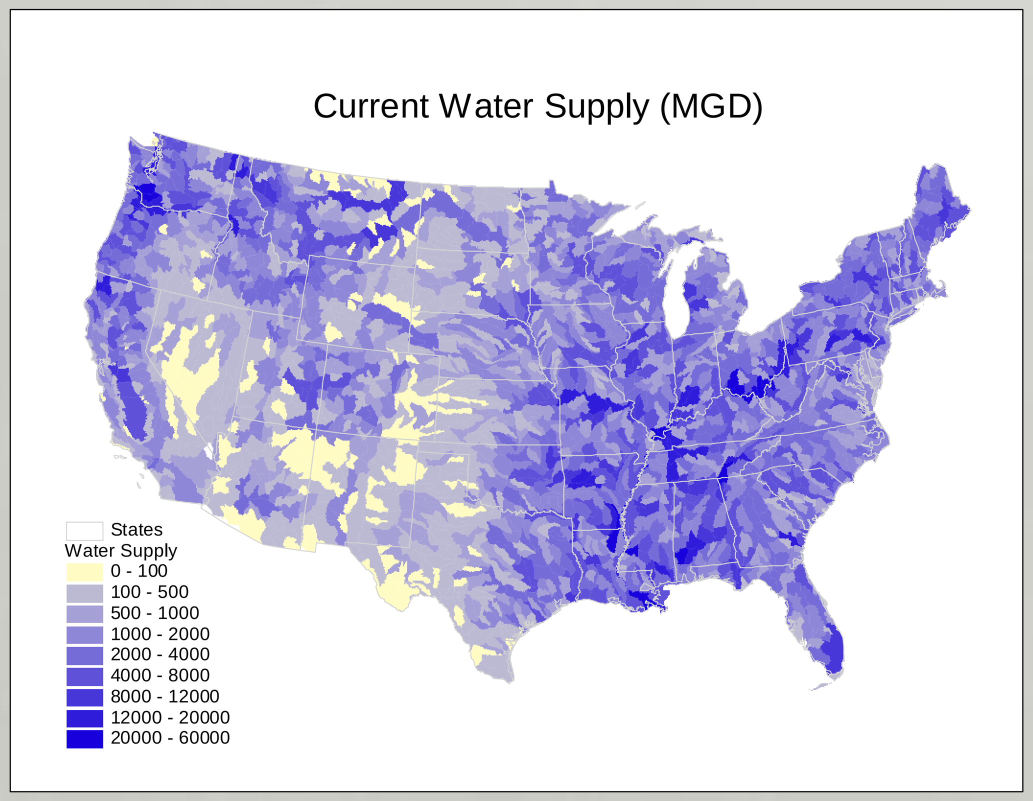
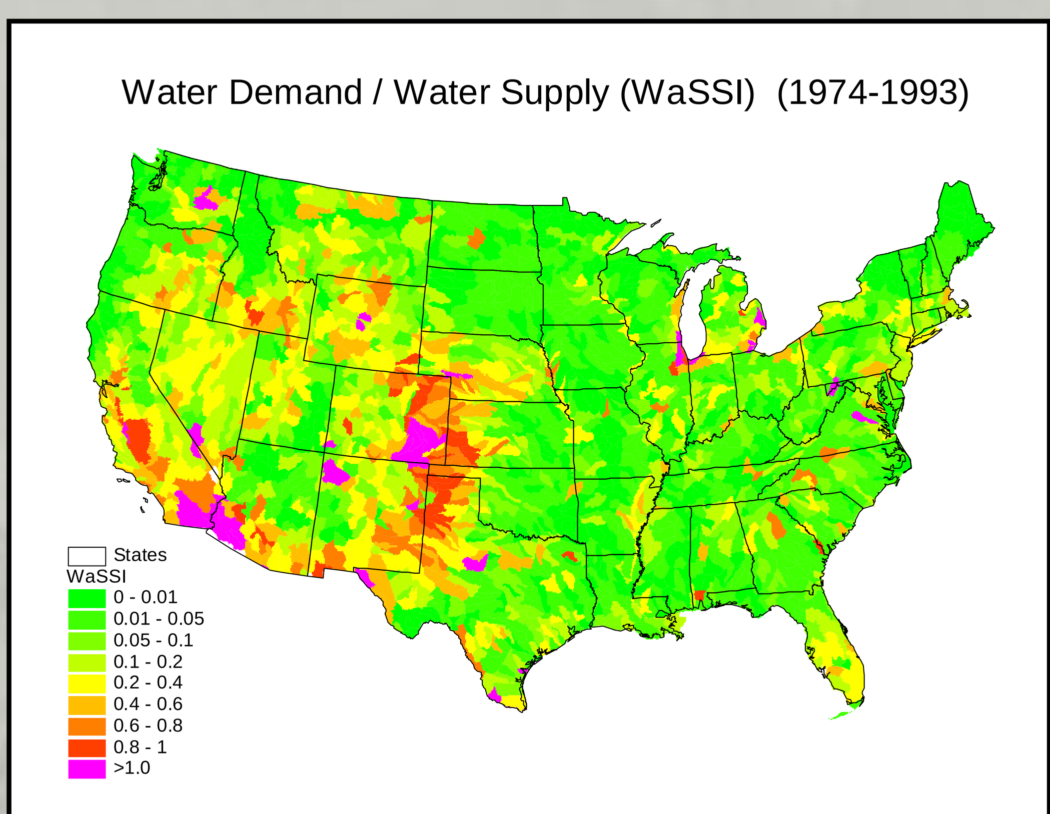
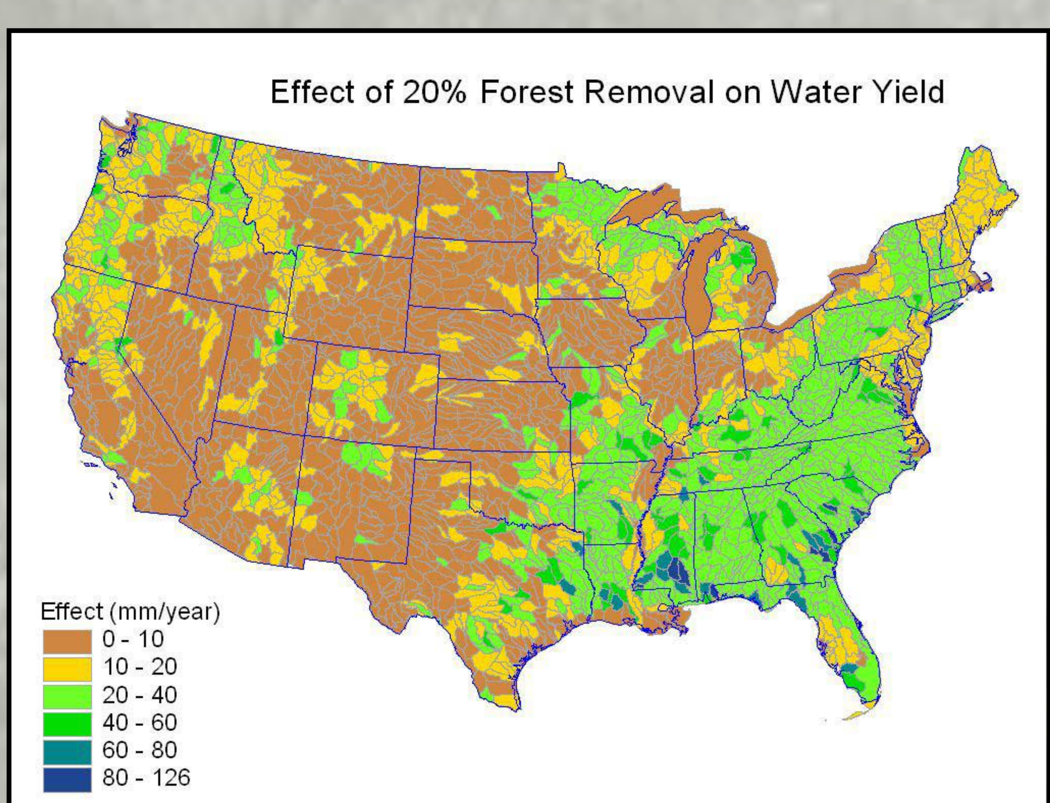






Water:
WaSSI-CB fully accounts monthly water availability for water supply (precipitation - evapotranspiration + groundwater supply + return flow) and demand from different uses and evaluate water stress conditions over time and across 8-digit HUC basins. Water drives all ecosystem processes, so the water supply stress index (WaSSI) is at the heart of WaSSI-C (carbon) B (biodiversity). Climate, landuse change, and human population predictions are integrated into examine different scenarios of water stress in the future.

Landuse/Landcover Data
MRLC 2001

Climate Data (Temperature & Precipitation)
IPCC AR4
SRES A1B, A2, B1

Water
Sun et al. 2010

ET

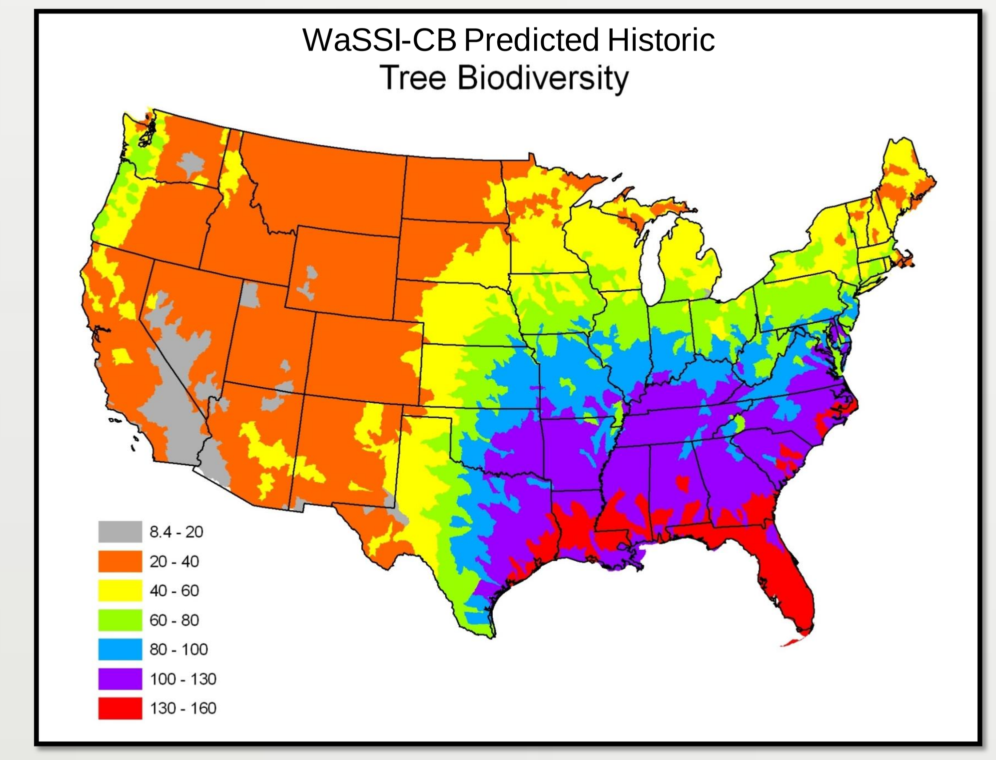
PET/AET

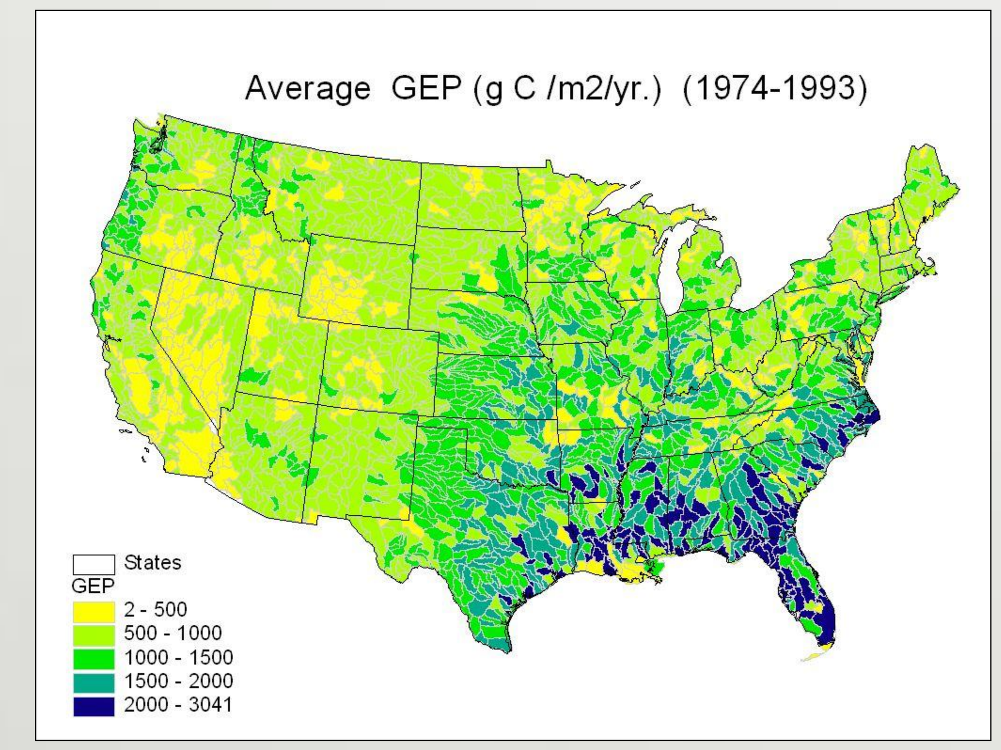
Clean water, carbon sequestration, and biodiversity are three of the most important ecosystem services that forests provide, and these ecosystem services are strongly related to one another. We have used these relationships to assess how climate, forest management, landuse, and population change will impact water availability, biodiversity, and forest growth. WaSSI-CB allows land managers and policy makers to assess how alternative future conditions will alter these important ecosystem services.

Carbon
Law et al. 2002

Biodiversity
Currie 1991,
Currie and Paquin 1987

Biodiversity:
Currie (1991) predicted bird, mammal, amphibian, reptile, and vertebrate species richness using estimates of PET. Again, PET is estimated by WaSSI-CB, allowing us to extend the model predictions to include biodiversity. We incorporated a tree species richness and ET relationship developed by Currie and Paquin (1987). The resulting set of water, carbon, and biodiversity estimates allow us to compare the impacts that managing for one might have upon the others.





Carbon:
The WaSSI-CB model predicts ET as a function of potential ET, precipitation, and leaf area index (LAI) and as part of its water supply calculations. Law et al. (2002) developed relationships between gross ecosystem productivity and ET for evergreen and deciduous forests, croplands, and grasslands. Using these models and WaSSI model's regional ET estimates, we simulate monthly GEP and net ecosystem exchange (NEP) as estimation of ecosystem carbon sequestration, at basin scale for current and future climate conditions.

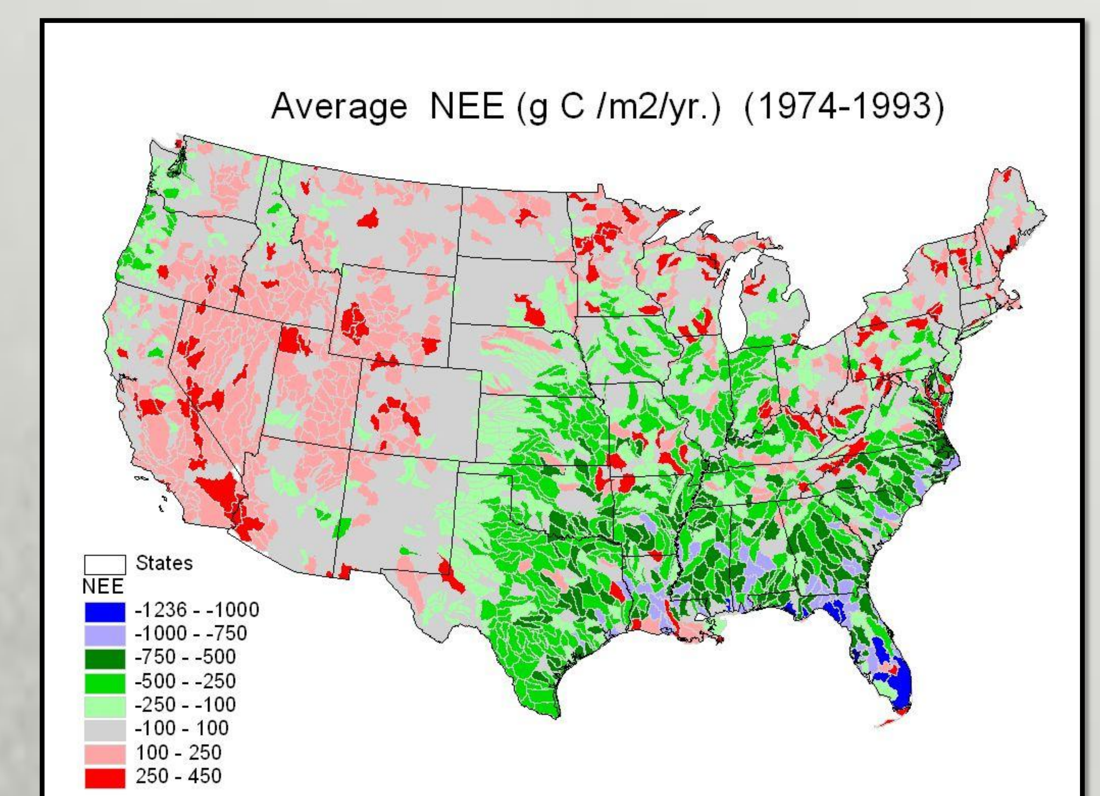
FLUXnet Data
Point based validation using 263 flux sites representing over 1200 site-years

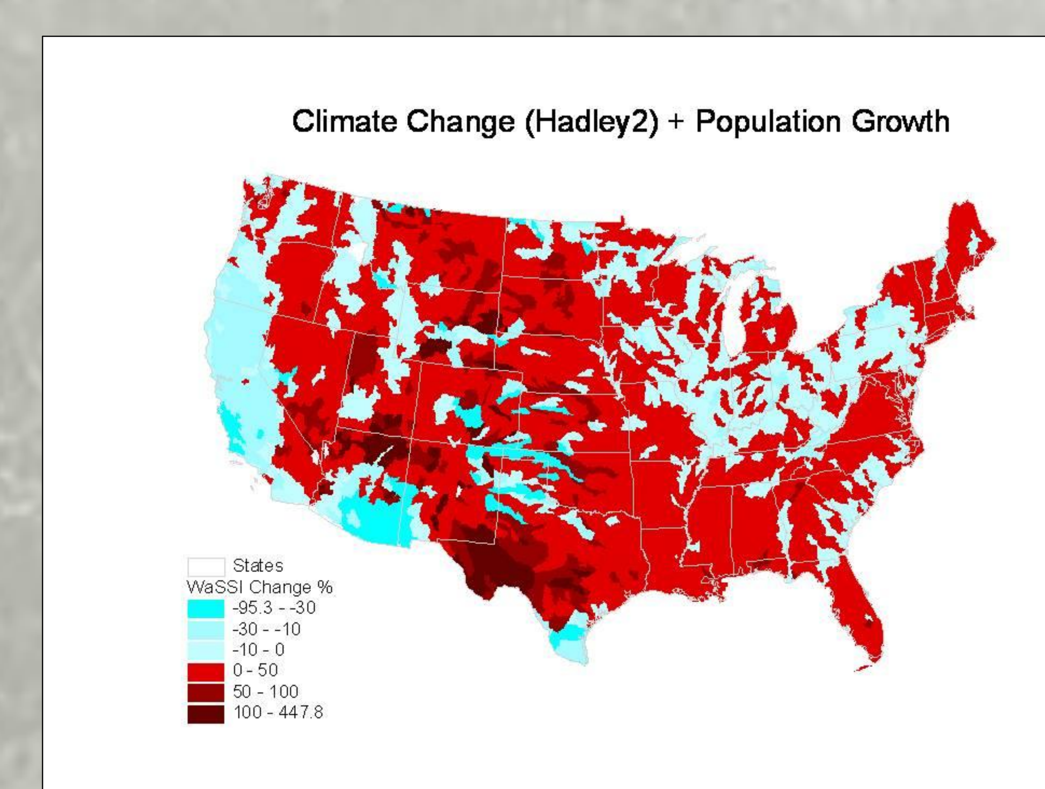
Ameriflux tower in a loblolly pine plantation on the coastal plain of North Carolina

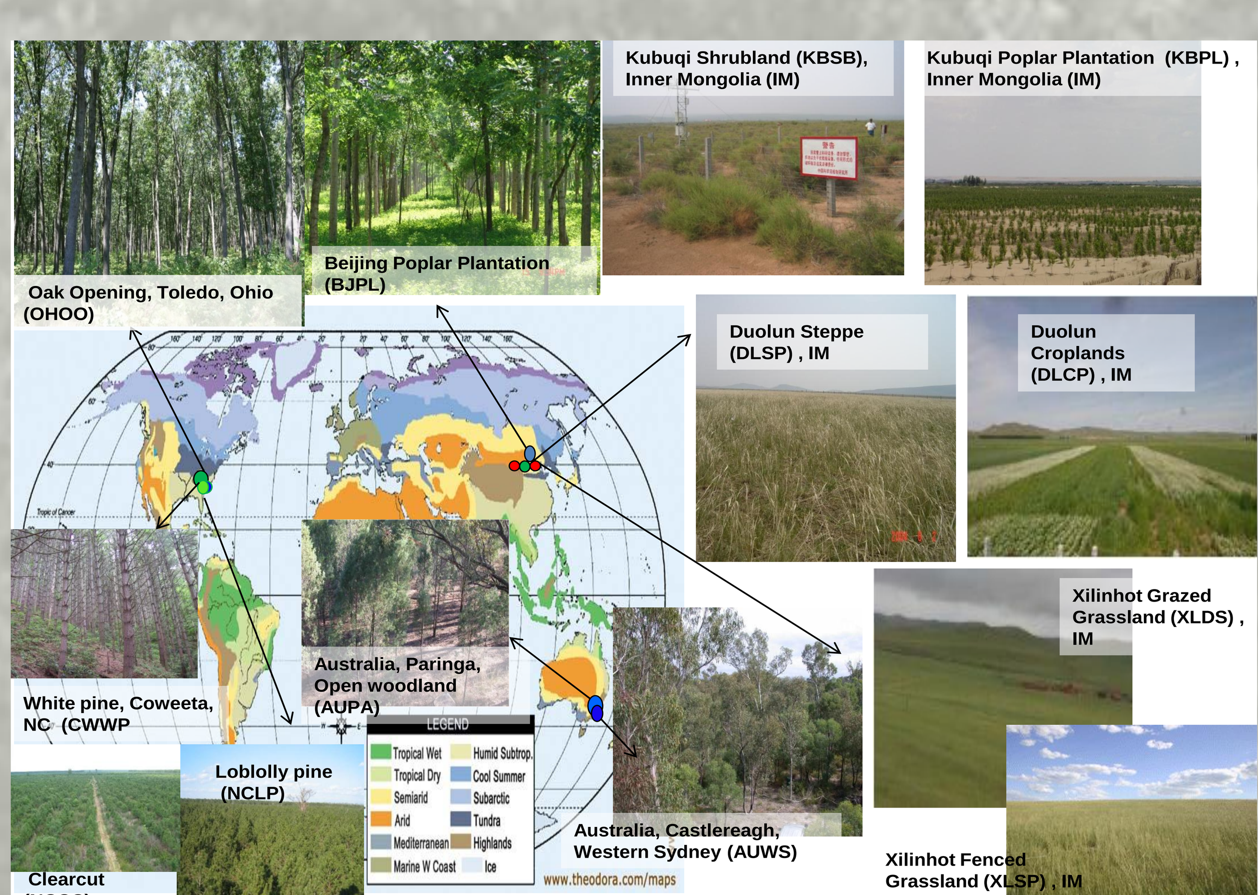
Summary
WaSSI-CB estimates of long term mean gross ecosystem productivity (GEP) at 7.6 Pg C/year. This compared favorably with estimated at 6.2 to 7.3 Pg C based on other models and satellite estimates (Xiao et al., 2008).

The long-term mean net ecosystem exchange (NEP) was estimated as -0.79 Pg C/year, compared to -0.63 Pg C/year by an independent study (Xiao et al. 2008).

Population rise will cause increase of water stress even under wet climate change scenarios.







A General Monthly Evapotranspiration Model
(Sun et al., Ecohydrology 2010)

ET = 11.9 +4.76 LAI + PET(0.032LAI+0.0026P+0.15)

Future Research
We are using the FLUXNET global carbon and evapotranspiration data to refine algorithms at finer time scales and for specific landuse / landcover types. Validations will be completed using MODIS products.

Currently, we are collaborating with government, university, and NGO partners in Brazil, China, and Mexico to develop country-specific equations and implement the WaSSI-CB framework to address regional and national ecosystem management questions.

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