Assessing impacts of selective logging on water, energy, and carbon fluxes in Amazon forests using the Functionally Assembled Terrestrial Ecosystem Simulator (FATES)

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Motivation and Objective

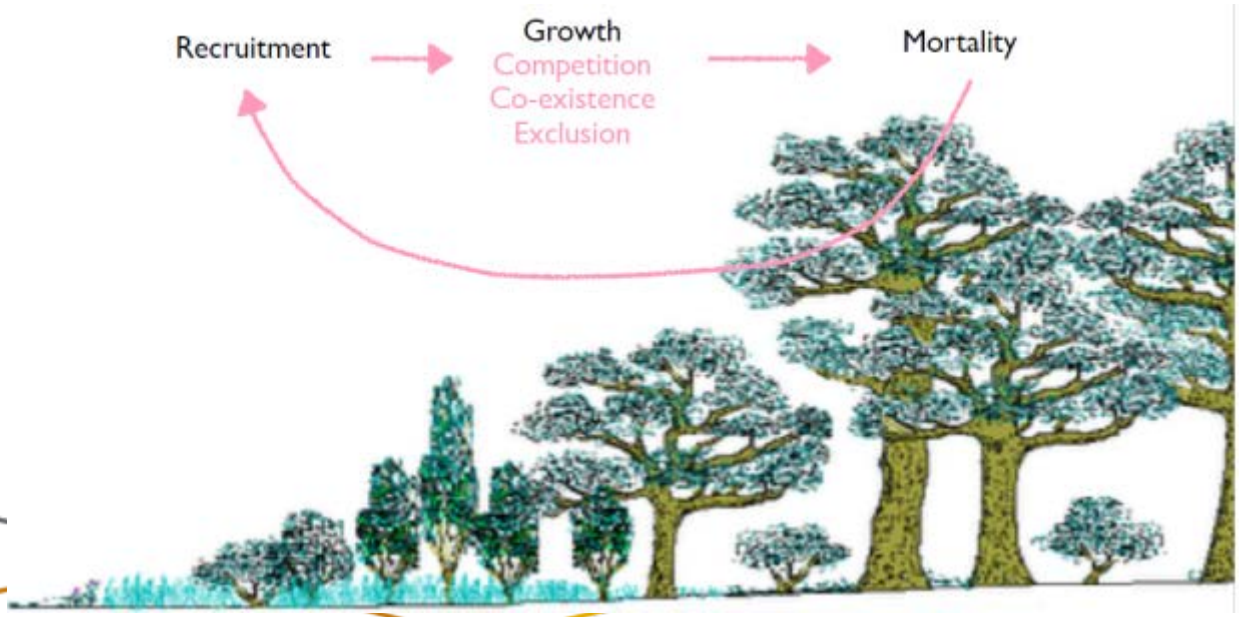
- Forest degradation as a result of logging, fire, and fragmentation not only alters carbon stocks and fluxes in tropical forests, but also impacts the exchanges of water and energy fluxes between the land and atmosphere;

- Such impacts are poorly quantified to date due to difficulties in accessing and maintaining observational infrastructures, and the lack of proper modeling tools;

- To develop a modeling tool to quantify the complex interactions among forest degradation, ecosystem recovery, climate, and environmental factors.

Functionally Assembled Terrestrial Ecosystem Simulator (FATES) in CLM

- Previously known as CLM(ED) (Fisher et al., 2015, GMD)
  - See details in presentation by C. Koven/R. Fisher
- Landscape structured according to disturbance history
- Height resolved competition between plants for light
- Plant distribution emerges from plant functional properties



A selective logging module in CLM(FATES)

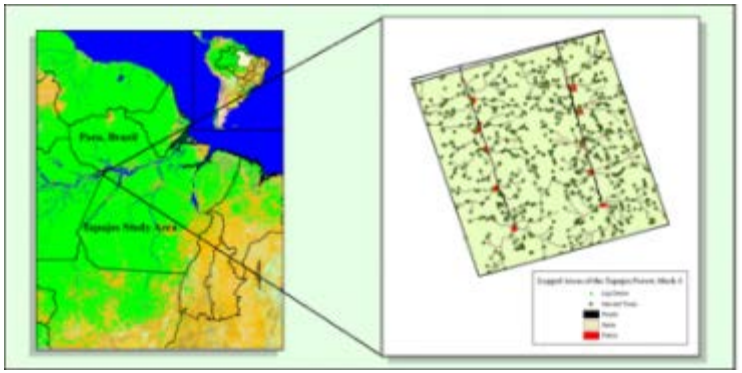
- Size-dependent mortality rates associated with selective logging
  - Mortality due to timber harvest directly
  - Mortality due to collateral damage
  - Mortality due to mechanical damage for infrastructure construction

- Removal of aboveground biomass of logged trees
  - Logs are transported off-site

- Conversion of live biomass to Coarse Woody Debris (CWD) following logging
  - CWD are updated accordingly.

Site description

- **Meteorological forcing and fluxes from eddy covariance towers at two sites located in the Tapajos National forest near Santarem:**
  - **KM67, Old-growth forest (in use), 2001-2006**
  - **KM83, Selectively logged forest, 2001-2003**



Location of logged areas in Tapajos National Forest
(adopted from Asner et al., 2004)

- **Soil texture**
  - **KM67 , 2% sand + 8% silt + 90% clay**
  - **KM83, 18% sand + 2% silt + 80% clay**

- **Plot-level measurements are available from the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA)**

Landscape components of selective logging

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Numerical experiments

- km 67 (intact site),
  - Simulation 2001-2006, 400-year spin-up
- km 83 (logged site, time of logging: 1 Sept 2001)
  - Simulation 2001-2003, 400-year spin-up

Parameters perturbed	km 67	km 83
SLA_0 ($m^2\ gC^{-1}$)	0.012	0.012
	0.018	0.018
	0.025	0.025
	0.035	0.035
V_{cmax25} ($\mu mol\ m^{-2}s^{-1}$)	45	45
	50	50
	55	55
	60	60

Mortality	km 83
Direct	15% (DBH>35cm)
Collateral	~5% (all sizes)
Mechanical	~5% (all sizes)

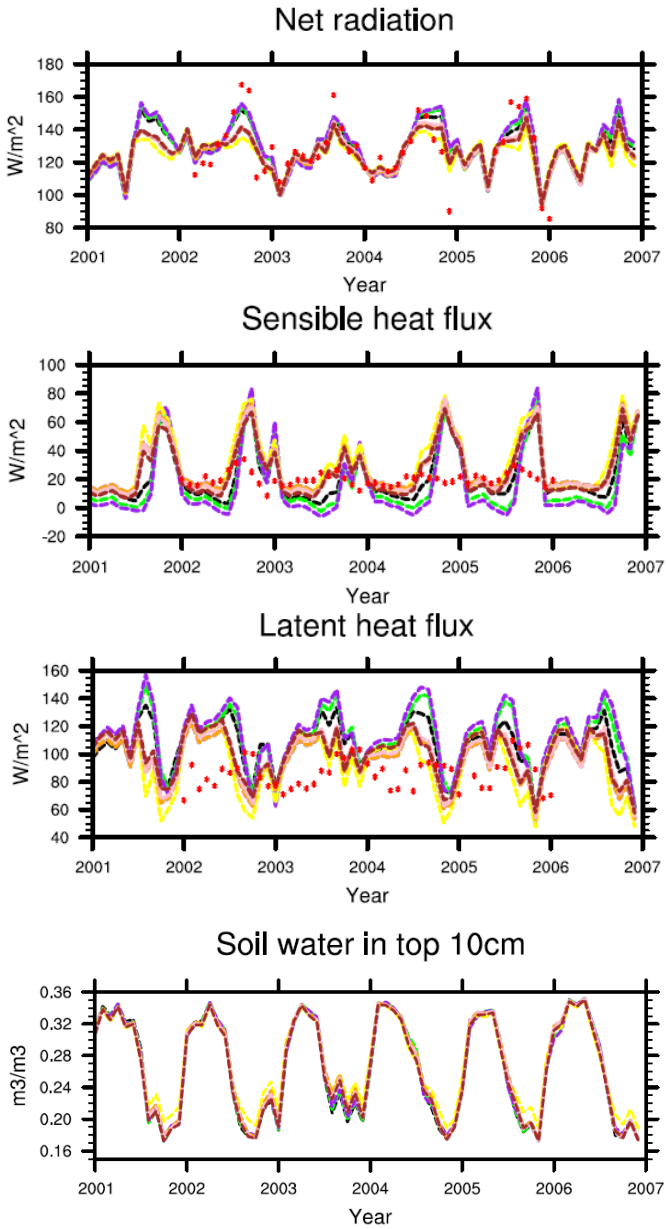
Sensitivity to logging intensities

- "Best" parameter set from previous experiment
  - SLA_0 =0.035, Vcmax=60
- Recovery following different logging intensities
  - Biomass and LAI
  - Forest structure and composition

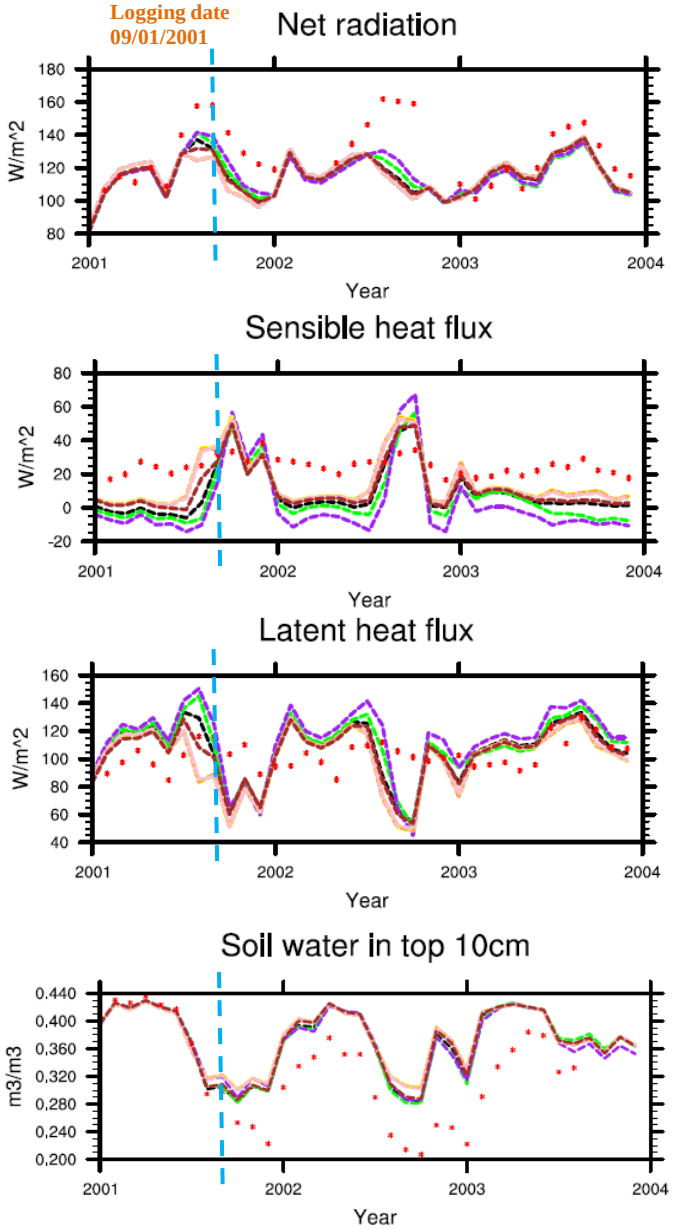
Mortality	KM 83			
Direct	10% (DBH>35cm)	15% (DBH>35cm)	20% (DBH>35cm)	25% (DBH>35cm)
Mechanical	3.3%	5%	6.7%	8.3%
Collateral	3.3%	5%	6.7%	8.3%

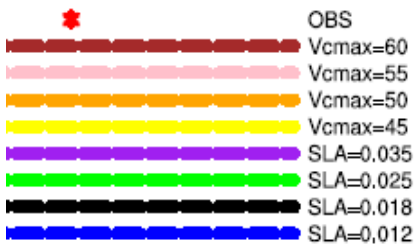
Energy and water budgets

KM 67



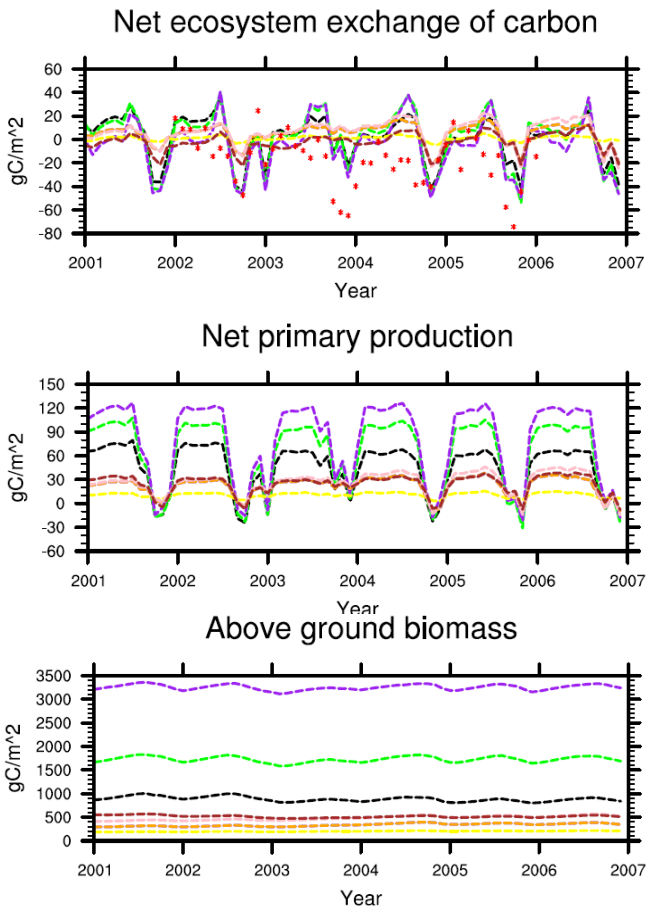
KM 83



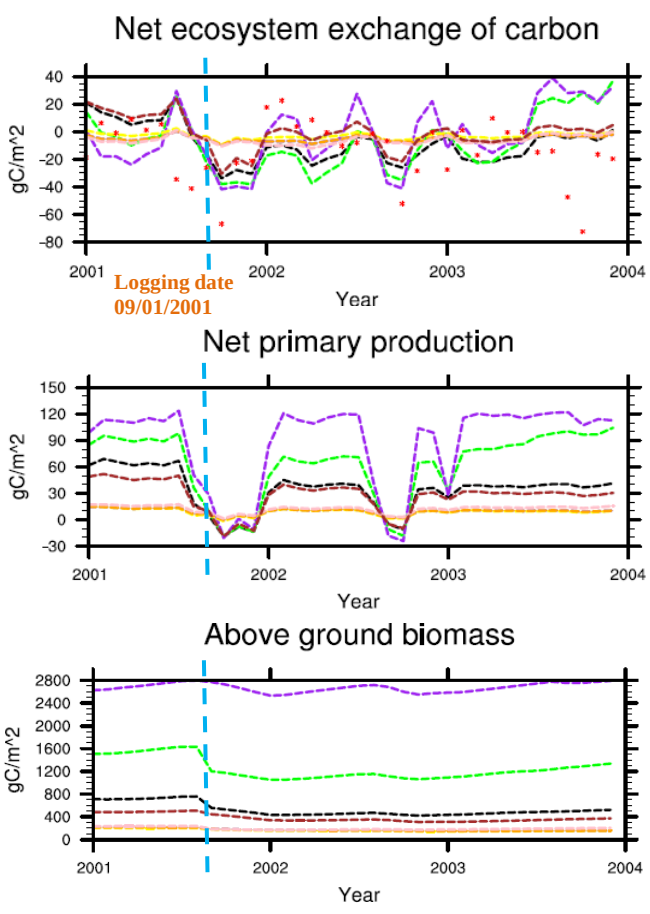


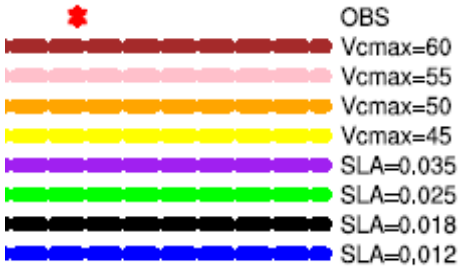
Carbon Budget

KM 67

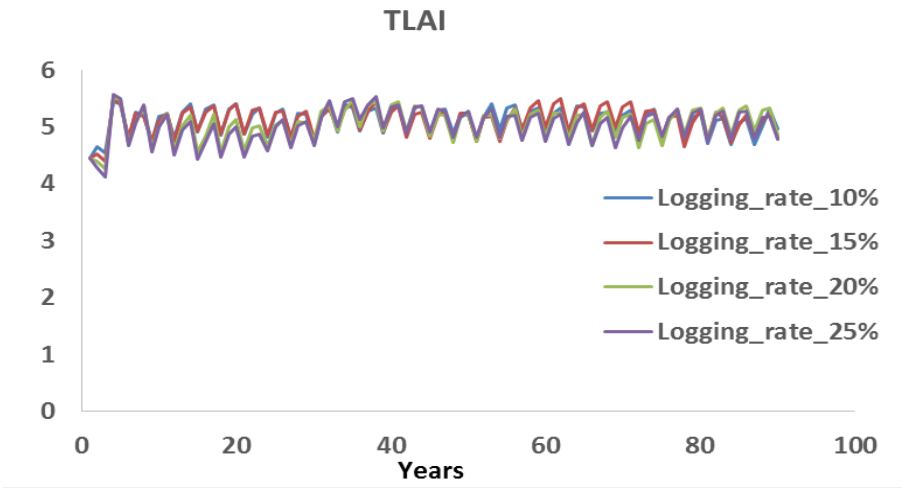


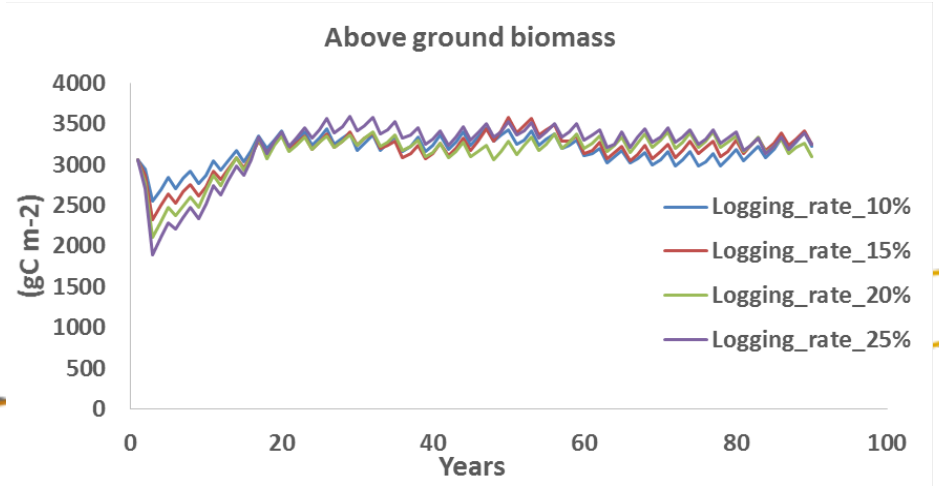
KM 83



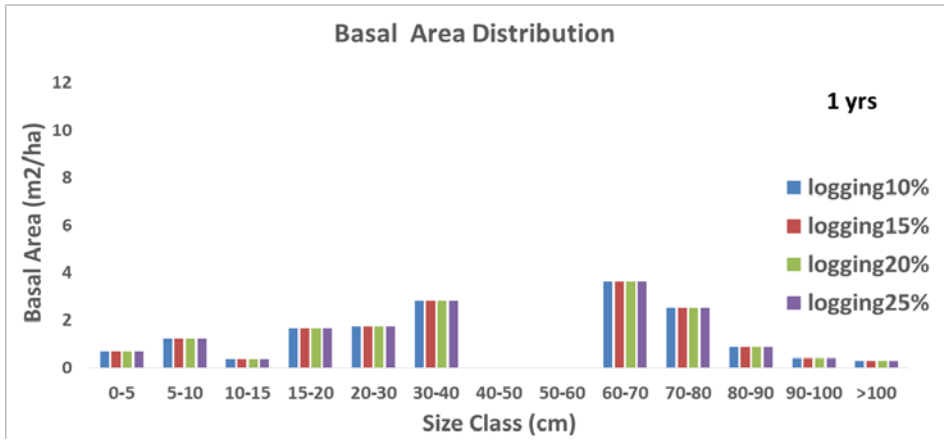


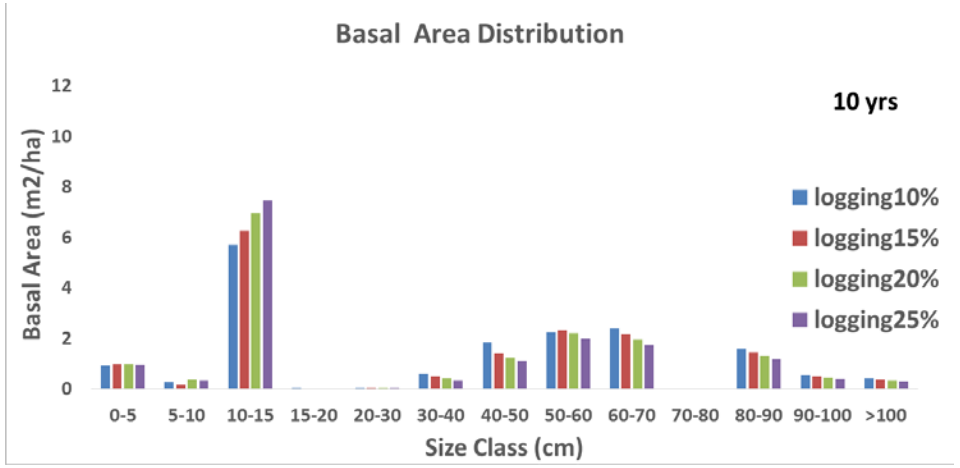
Recovery of biomass and LAI following logging

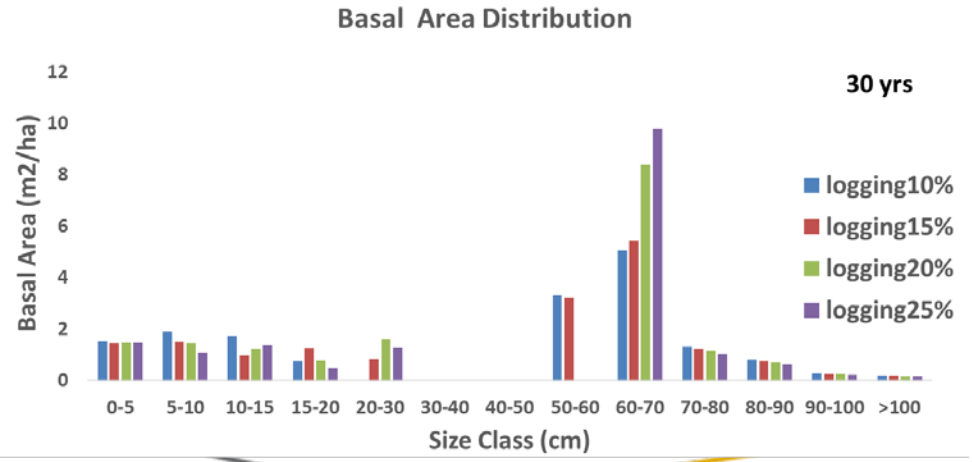


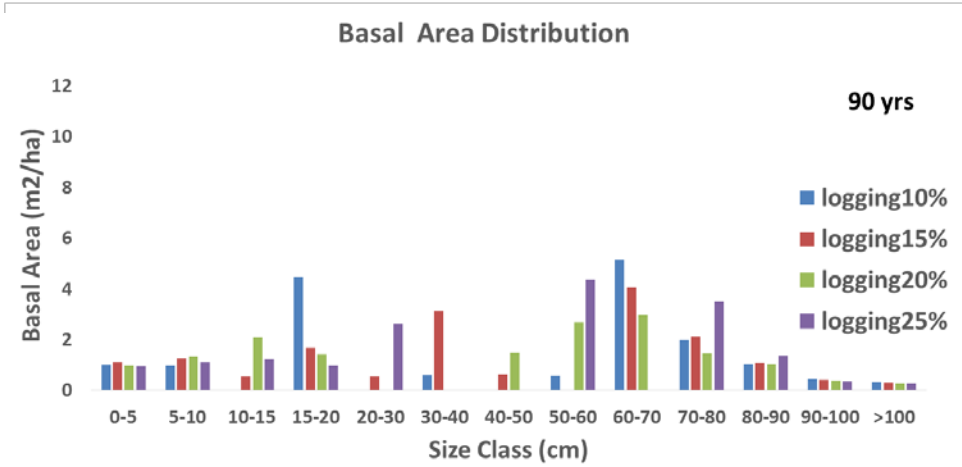


Sensitivity of ecosystem demography to logging intensities at km83









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Summary and future work

- CLM(FATES) is able to reproduce latent heat and net ecosystem exchange reasonably well, although sensible heat is significantly overestimated.

- A selective logging module has been implemented into FATES and can be used for site-level applications, but further developments are needed for applications at larger scales.

- Model simulations are highly sensitive to parameter values. A global sensitivity analysis on key parameters in FATES will be conducted.

- The degraded forest is able to recovery its biomass in 20 years, but the recovery of forest structure and composition takes much longer based on the numerical experiments.

Acknowledgement

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