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National Aeronautics and Space Administration

FUN
FIXATION & UPTAKE OF NITROGEN

PLANT N IMPACTS ON THE C CYCLE

JOSHUA B. FISHER
S. SITCH | Y. MALHI | R.A. FISHER | C. HUNTINGFORD | S.-Y. TAN

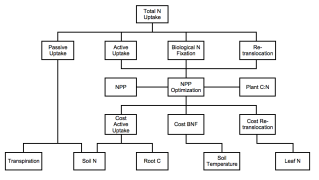
ABSTRACT

We introduce a new mathematical model of plant N acquisition (FUN), based on active and passive soil N uptake, retranslocation of leaf N, and N fixation. This model is unified under the theoretical framework of carbon (C) cost economics, or resource optimization. FUN specifies C allocated to N acquisition as well as remaining C for growth, or N-limitation to growth.

BACKGROUND

- Nitrogen generally limits plant growth and controls biosphere responses to climate change [1].
- Most of the models in the IPCC lack a mechanistic approach for plant N uptake; these models likely over-estimate CO_2 sequestration than if N-cycle feedbacks were included [2].
- N uptake requires carbon expenditure, which changes depending on factors still being studied [3].

METHODS



$$N_{demand} = \frac{C_{NPP}}{r_{C:N}}$$

$$N_{passive} = N_{soil}\frac{E_T}{S_T}$$

$$C_{growth} = C_{NPP} - C_{acq}$$

$$N_{acq} = \frac{C_{acq}}{Cost_{acq}}$$

$$r_{C:N} = \frac{C_{growth}}{N_{passive} + N_{acq}}$$

$$Cost_{fix} = s\left(\exp\left(a + b \cdot T_{soil}\left(1 - 0.5\frac{T_{soil}}{c}\right)\right) - 2\right)$$

$$Cost_{active} = \left(\frac{k_N}{N_{soil}}\right)\left(\frac{k_C}{C_{root}}\right)$$

$$Cost_{resorb} = \frac{k_R}{N_{leaf}}$$

$$Cost_{acq} = \min(Cost_{resorb}, Cost_{active}, Cost_{fix})$$

[1] Vitousek & Howarth 1991; [2] Hungate et al 2003; [3] Vitousek et al 2002; [4] Houlton et al 2008; [5] Finzi et al 2007; [6] McVoy et al 2005; [7] Tan 2008

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
www.nasa.gov

RESULTS

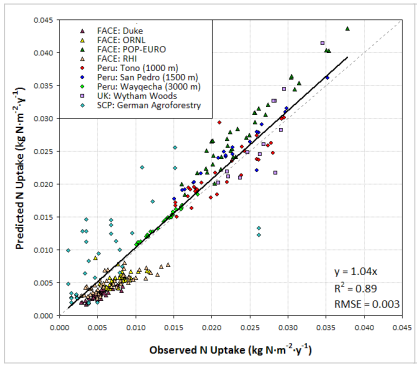

Fig 1. Scatterplot of observed versus predicted N uptake [5, 6, 7].

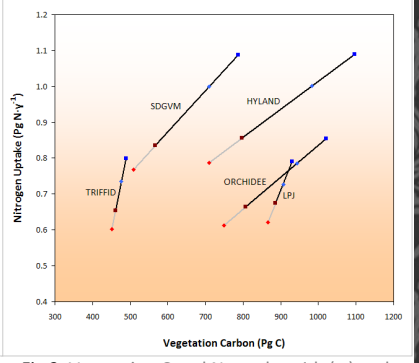

Fig 2. Vegetation C and N uptake with (■) and without (♦) FUN from 2000 to 2100.

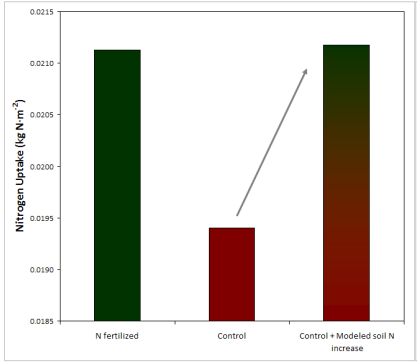

Fig 3. Modeled N fertilization versus measurements from a N fertilization experiment.

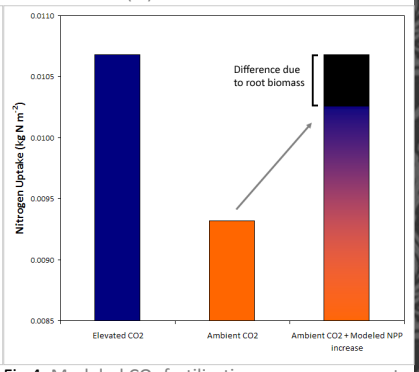

Fig 4. Modeled CO_2 fertilization vs. measurements from a CO_2 fertilization experiment [5].

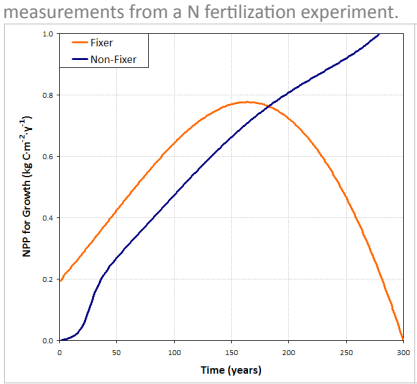

Fig 5. Scenario of primary succession between fixer and non-fixer.

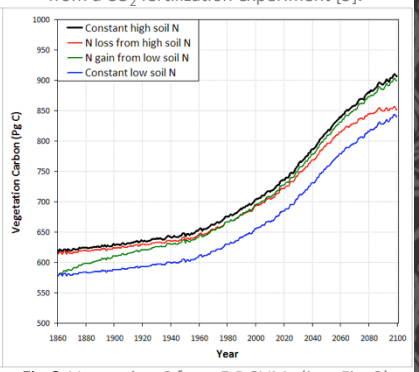

Fig 6. Vegetation C from 5 DGVMs (i.e., Fig. 2) with FUN averaged for the IPCC A1 scenario.

jbfisher@jpl.nasa.gov