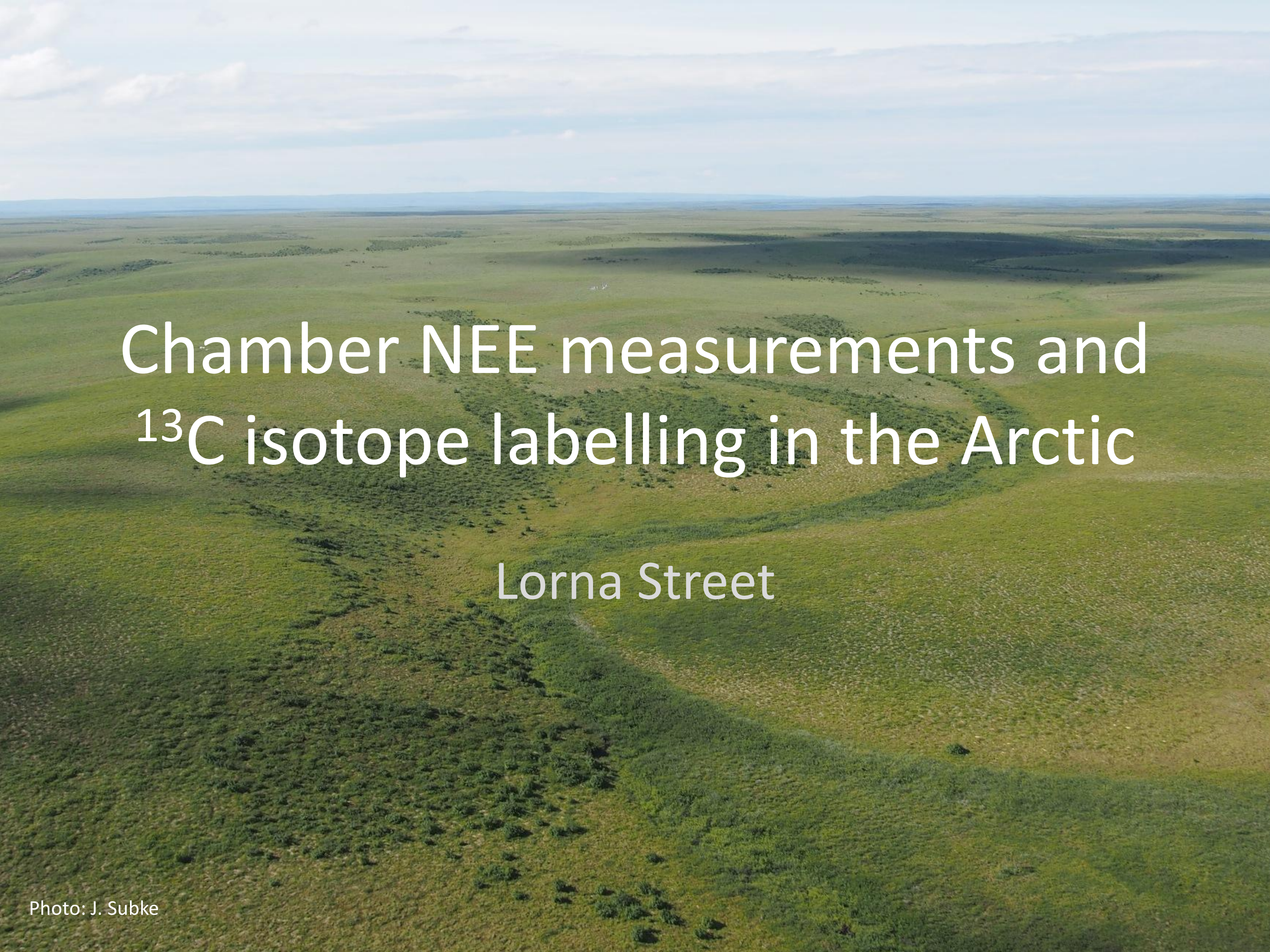


Chamber NEE measurements and ^{13}C isotope labelling in the Arctic

Lorna Street

Photo: J. Subke

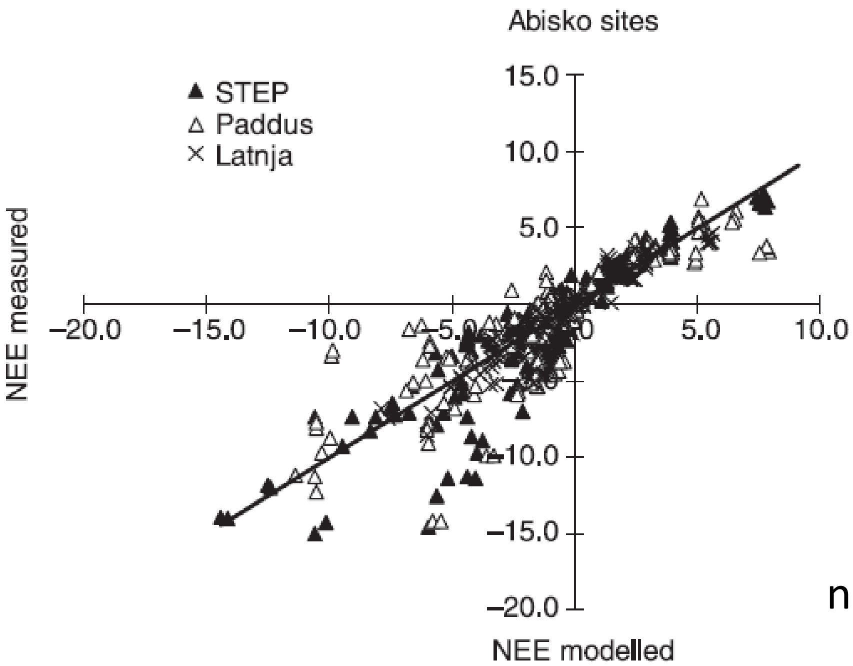
Two halves…

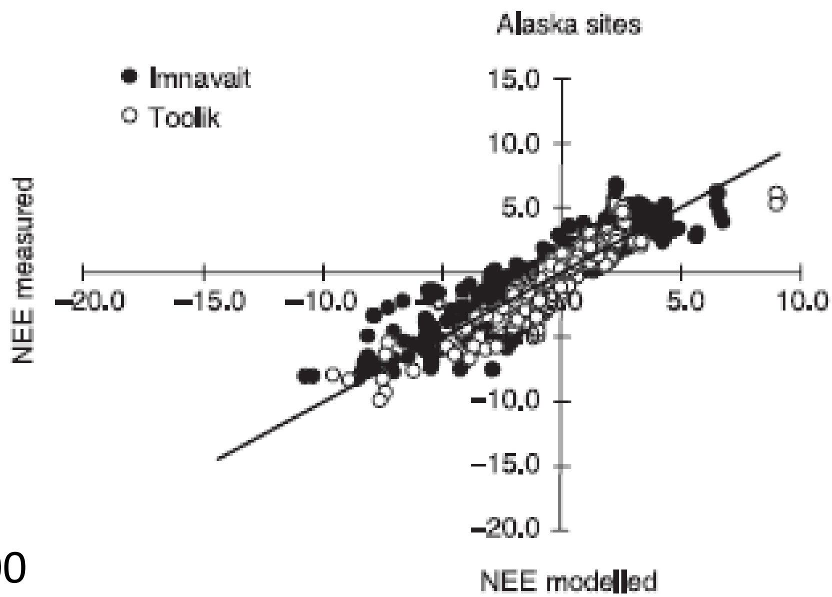
- Leaf area index and total leaf N predict Arctic NEE

- $^{13}CO_2$ pulse-chase can be used to quantify carbon use efficiency and NPP – with some caveats


Photo: P. Wookey

Leaf area index and carbon fluxes





n=1400

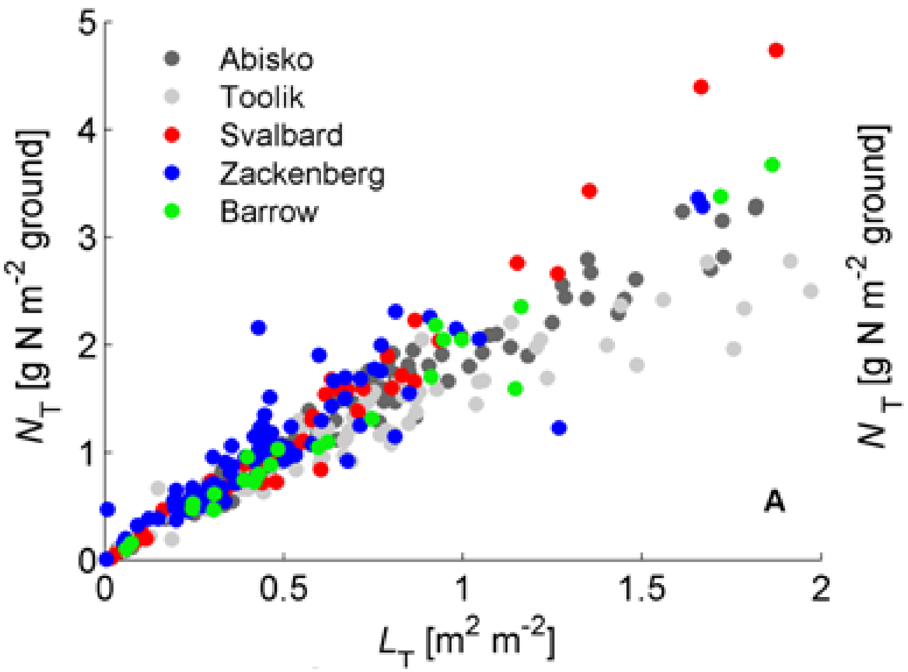
R^2=0.80

$$\text{NEE} = R_\text{E} - \text{GPP},$$
$$R_\text{E} = (R_0 \times e^{\beta T} \times \text{LAI}) + R_x$$

$$\text{GPP} = \frac{P_\text{maxL}}{k} \times \ln \frac{P_\text{maxL} + E_0 \times I}{P_\text{maxL} + E_0 \times I \times e^{(-k \times \text{LAI})}}.$$

Shaver et al. 2007, Shaver et al. 2013

LAI-Canopy N relationship is tightly constrained across most vegetation types in Alaska (Williams and Rastetter, 1999), Sweden (van Wijk et al. 2005) Svalbard and Greenland (Street et al. 2012)



Observed LAI-N relationship optimizes GPP (Williams and Rastetter 1999)

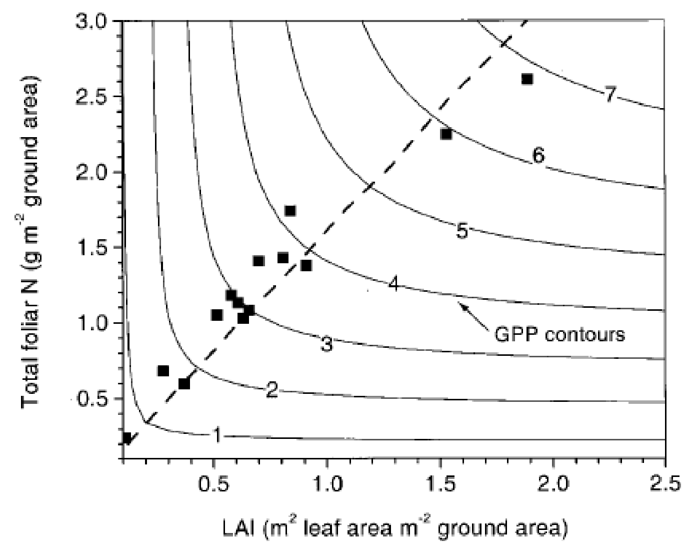
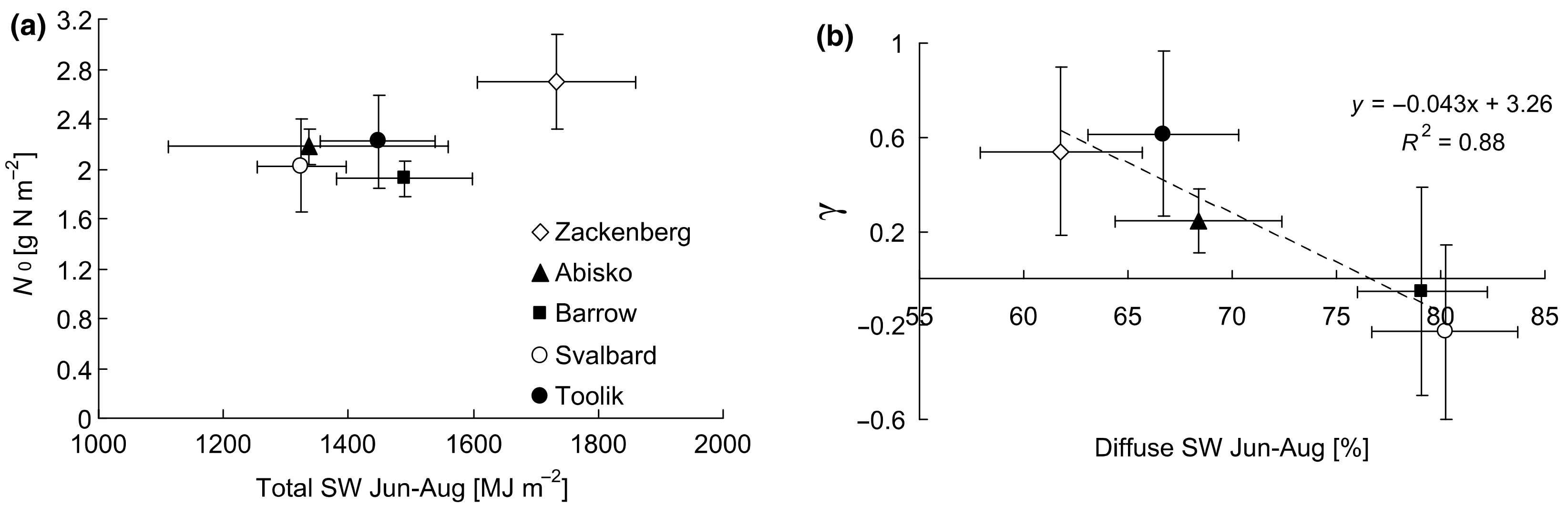


Fig. 6 The modelled response surface of GPP of vascular plants (contour lines, g C m^{-2} day^{-1}) to combined variations in LAI (L; m^2 leaf area m^{-2} ground area) and total foliar N (N; g N m^{-2} ground area). Also shown (symbols) are the LAI–N relationships for the sites along the transect, and the line that connects points on the surface where $\partial P/\partial L = 1.48\ \partial P/\partial N$, where P = GPP.

$$N_L = \frac{N_0}{\gamma}(1 - e^{-\gamma L_T})$$

N_L : [N] in leaves (g N m^{-2} ground)
N_0 : [N] in upper leaves (g N m^{-2} ground)
γ : extinction coefficient
L_T: total LAI



Street et al. 2012

First half…

- Strong relationship between (apparent) plant N availability and instantaneous carbon fluxes
- Extrapolation in time and space ≈ NEP

- But what about NPP?

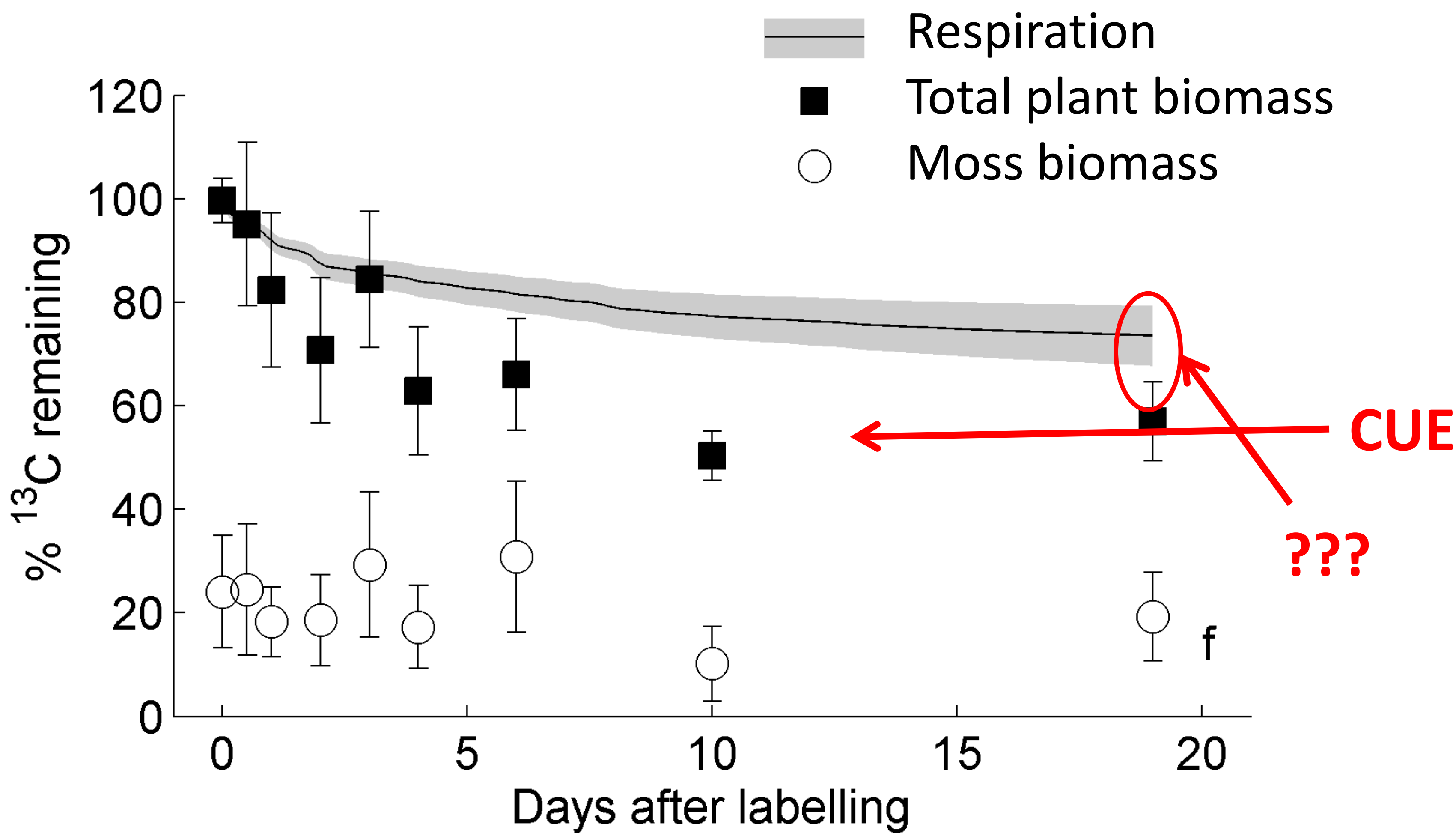
Using $^{13}CO_2$ to quantify CUE & NPP

- Plant communities exposed to $^{13}CO_2$
- Can (in theory) quantify:
  - total ^{13}C fixed (GPP)
  - ^{13}C incorporated into plant pools ("NPP")
  - ^{13}C in respired CO_2 ($R_A + R_H$)
- ^{13}C incorporated into tissues per unit ^{13}C fixed
  - carbon use efficiency

Exposing plants to $^{13}CO_2$…

Photo: P. Wookey

An example from Finland



Street et al. 2012

Challenges:

- How much ^{13}C is fixed?
- How much ^{13}C is respired?
  - The problem of diffusion
- How much ^{13}C is in plant tissues?
  - Aboveground biomass is straightforward
  - Belowground biomass not so straightforward…fine roots/fungal hyphae?


Thanks

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$$N_L = N_0 e^{-\gamma L_c}$$

N_L : [N] in leaves (g N m^{-2})
N_0 : [N] in upper leaves (g N m^{-2})
γ : extinction coefficient
L_c : cumulative LAI above leaf
L_T: total LAI

$$N_L = \int_0^{L_T} N\,dl = \frac{N_0}{\gamma}\left(1 - e^{-\gamma L_T}\right)$$

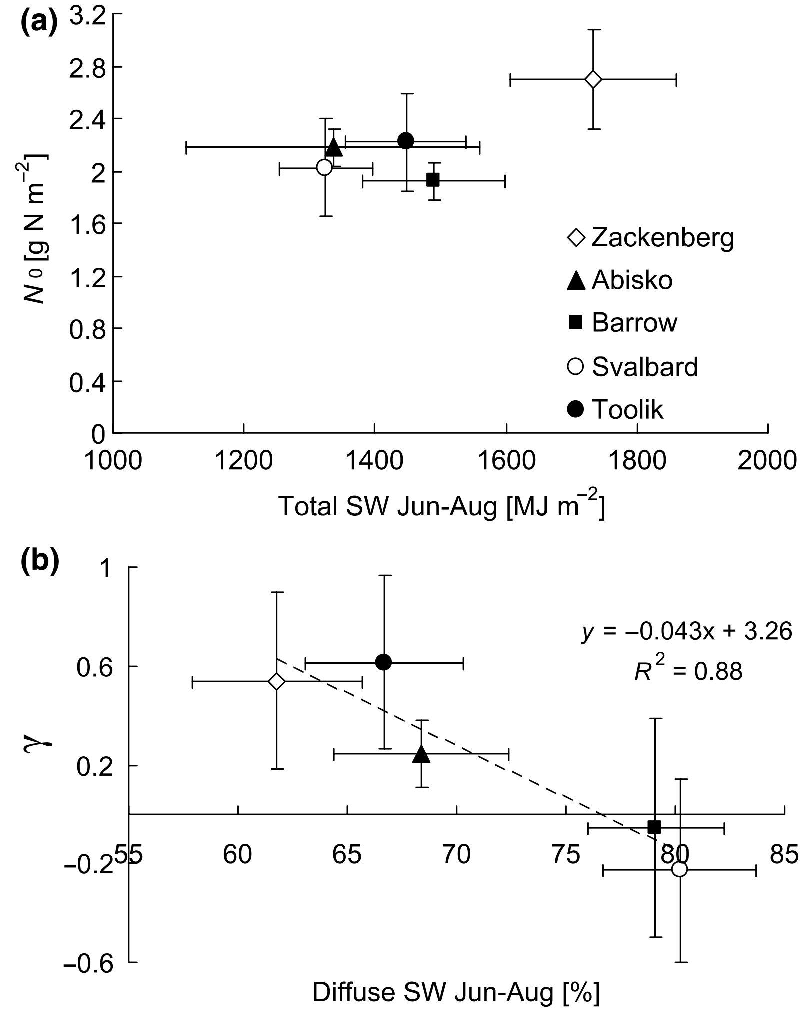

Fig. 4 Site-specific fitted values of (a) N_0 vs. total growing season short-wave radiation and (b) γ vs. diffuse radiation fraction for Abisko, Barrow, Toolik, Svalbard and Zackenberg. Horizontal error bars are standard deviation for 5 years of radiation data. Vertical error bars are 90% confidence interval for fitted parameters.