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Carbon and oxygen isotope ratios of ecosystem respiration along an Oregon conifer transect: preliminary observations based on small-flask sampling

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Outline

- Background
- Methods
- Results
- Discussion

Background knowledge

- Stable isotope
- Isotopic fractionation
- $\delta = \frac{R_{\text{sample}}}{R_{\text{standard}}} - 1$
- $R = \frac{\text{abundance of heavier isotope}}{\text{abundance of lighter isotope}}$, $R = \frac{^{13}C}{^{12}C}$

Abstract

- Contributing to our understanding of photosynthetic and respiration processes in forest ecosystems.
- In the traditional approaches, 2-L flasks of air are collected for each isotope ratio analysis, creating a requirement for large amounts of space to accommodate the flasks and preventing such analyses from becoming routine.
- Recent advances in isotope ratio mass spectrometry allow for rapid, on-line analysis of small volumes of CO_2 in air.

Introduction

Leaf level

$$\Delta = a + (b - a)\frac{C_i}{C_a},$$

$$\Delta = \frac{\delta^{13}C_a - \delta^{13}C_p}{1+\delta^{13}C_p},$$

$$\delta^{13}C_p = \frac{R_P - R_S}{R_S} = \frac{R_P}{R_S} - 1,$$

$$\Delta = \frac{R_a}{R_p} - 1$$

$$(R = \frac{^{13}C}{^{12}C})$$

Ecosystem

$$\Delta_e = \frac{\delta^{13}C_t - \delta^{13}C_R}{1+\delta^{13}C_R},$$

Introduction

- There is fractionation events during photosynthesis.
- There is no significant fractionation events during respiration.
- $\delta^{13}C_R = \delta^{13}C_p$.

Methods

PreCon → To separate CO_2 and N_2O from the other gases

↓

GC → To separate CO_2 and N_2O

↓

MS(CF mode) → Isotope ratio analysis

Results

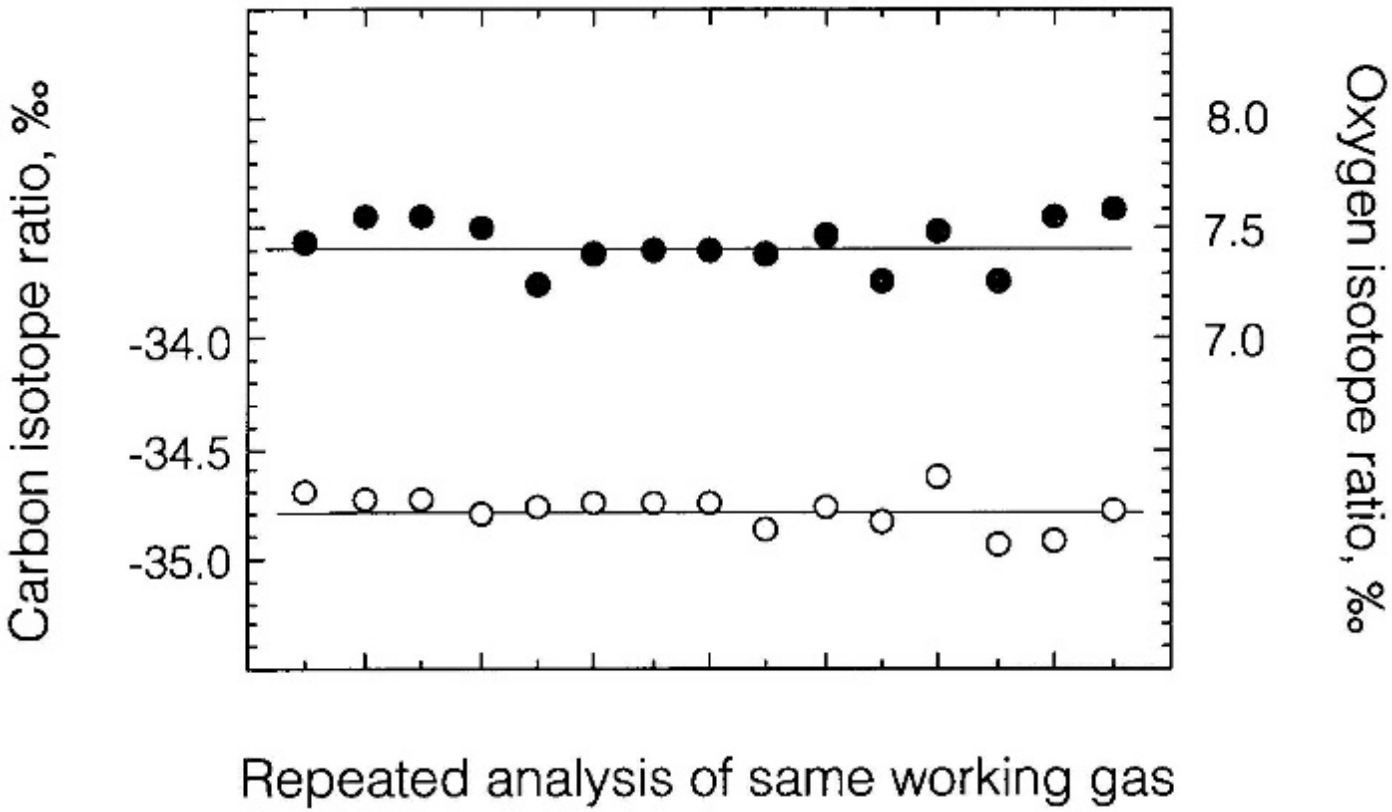


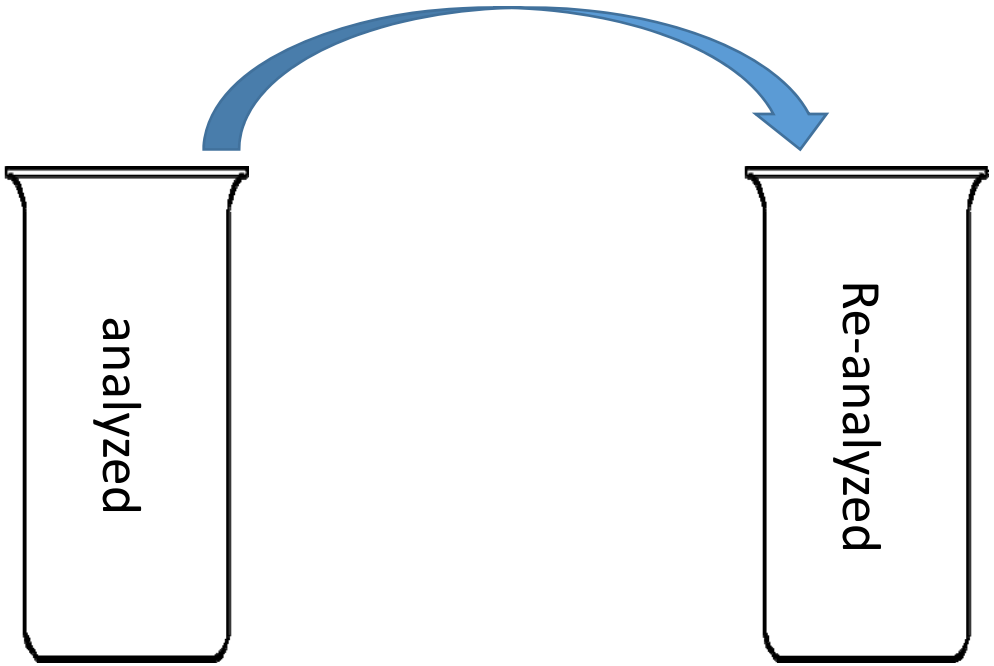
Figure 1. Sequential measurements of the carbon and oxygen isotope ratios of CO_2 from 300-µl atmospheric air samples (at ~350 ppmv CO_2) using the online PreCon-GC-MS in continuous flow mode.

Results

$\delta^{13}C$ =-8.49‰	-16.85‰< δ^{13} C <-8.49‰	$\delta^{13}C$ =-16.85‰
$\delta^{18}O$ =-23.39‰	-41.71‰< δ^{18} O <-23.31‰	$\delta^{18}O$ =-23.39‰

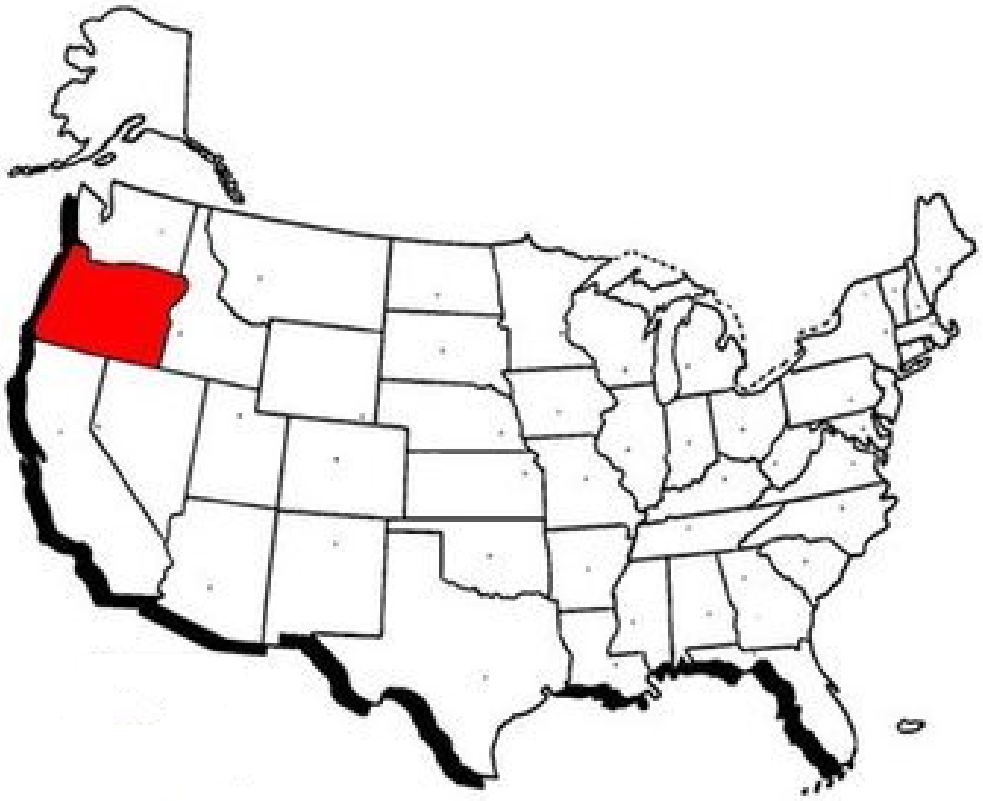
- There were no memory effects between sequential gas samples of high to low isotope ratio.
- There were no statistically significant differences between the two measurement approaches.

Results



There were no significant time-dependent changes in either $\delta^{13}C$ or $\delta\ ^{18}O$ values between the initial and second measurements ($r^2 < 0.03$, not significant).

Results



Map of the USA and the red region is Oregon

Results

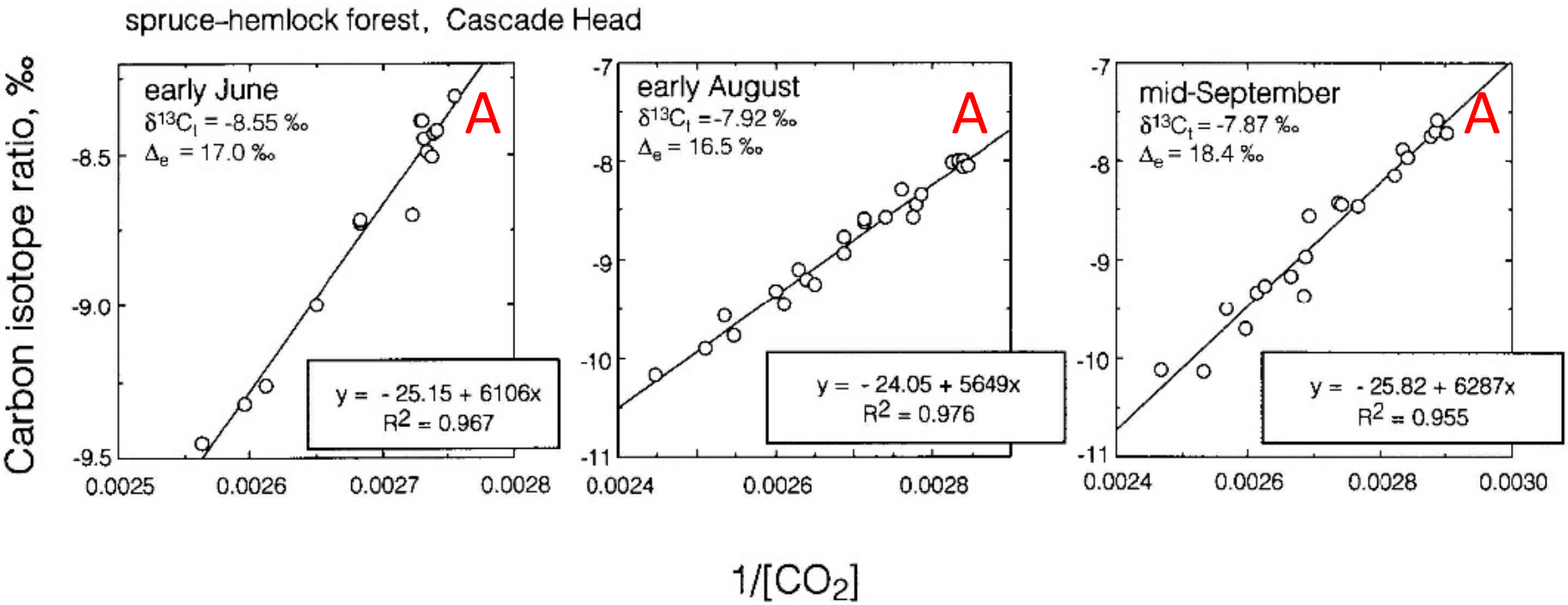


Figure 2. Carbon isotope ratio of ecosystem respiration ($\delta^{13}C_R$) in a spruce-hemlock forest ecosystem at Cascade Head, Oregon during the 1996 growing season. Shown below the months are the isotope ratio of tropospheric CO_2 ($\delta^{13}C_t$) (measured on the coast at Cascade Head) and the calculated ecosystem carbon isotope discrimination during the 1996 growing season.

Results

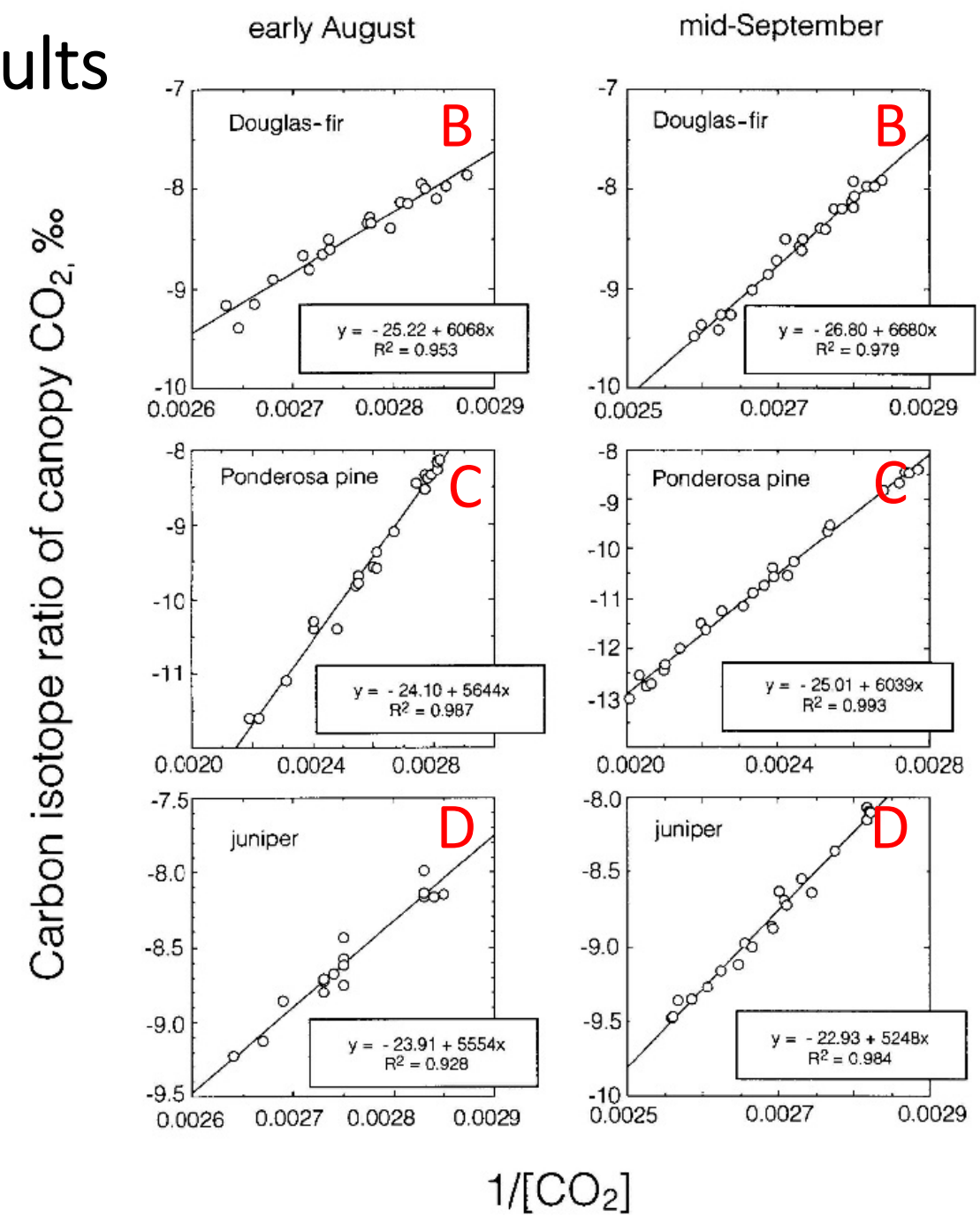


Figure 3. Carbon isotope ratio of ecosystem respiration ($\delta^{13}C_R$) in three forest ecosystems along the Oregon transect (OTTER) in early August and mid-September 1996. The Douglas-fir stand was at Corvallis, the ponderosa pine stand was at Metolius, and the juniper stand was east of Sisters. All sites are geographically similar to those originally used in the OTTER study.

Results

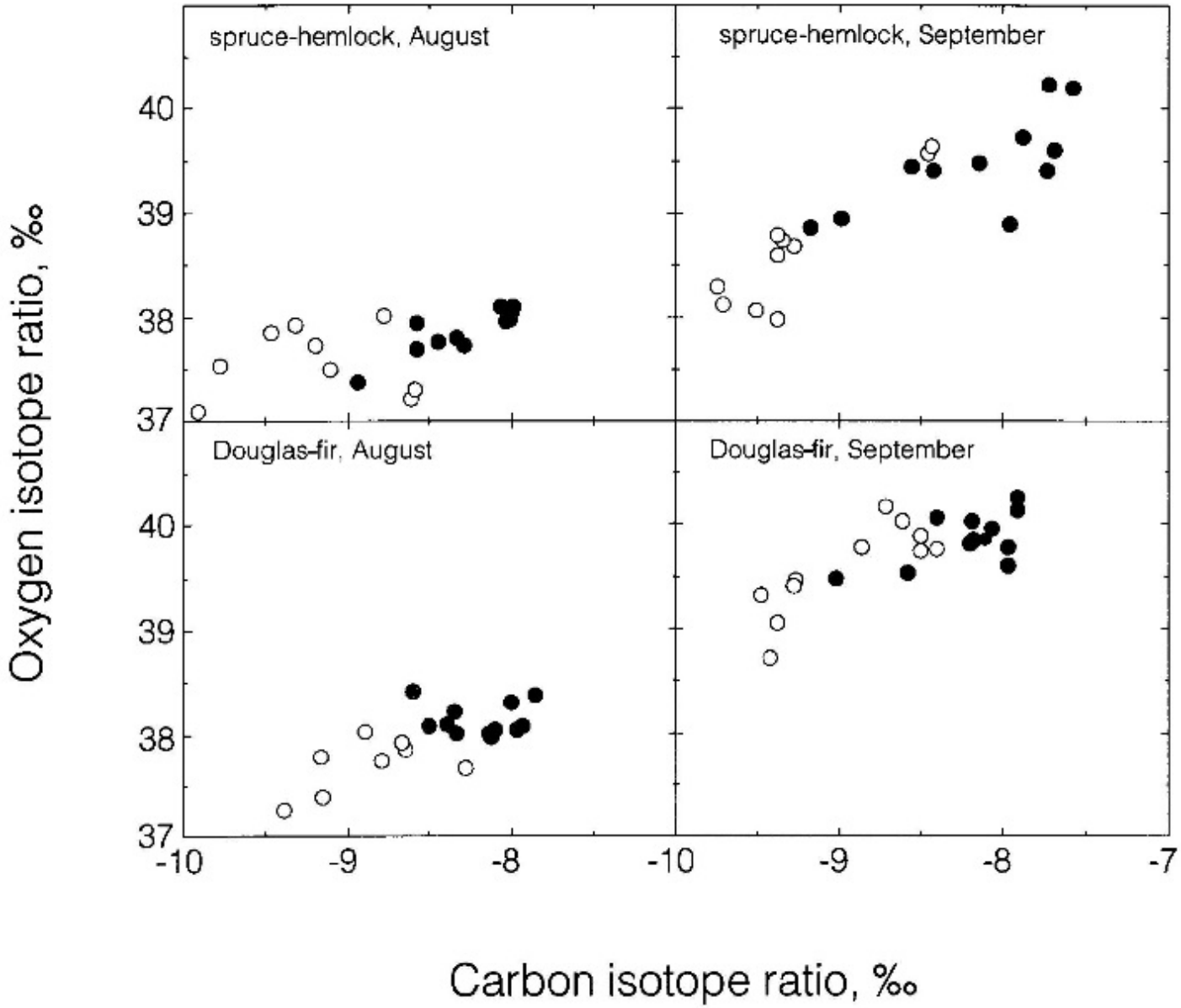


Figure 4. Correlation between the carbon and oxygen isotope ratios of canopy CO_2 at the spruce-hemlock (Cascade Head) and Douglas-fir (Corvallis) Forests, during a single day in August or September 1996. Symbols: ● = air samples collected in the upper portions of the canopy; ○ = samples collected in the lower portions of the canopy.

Results

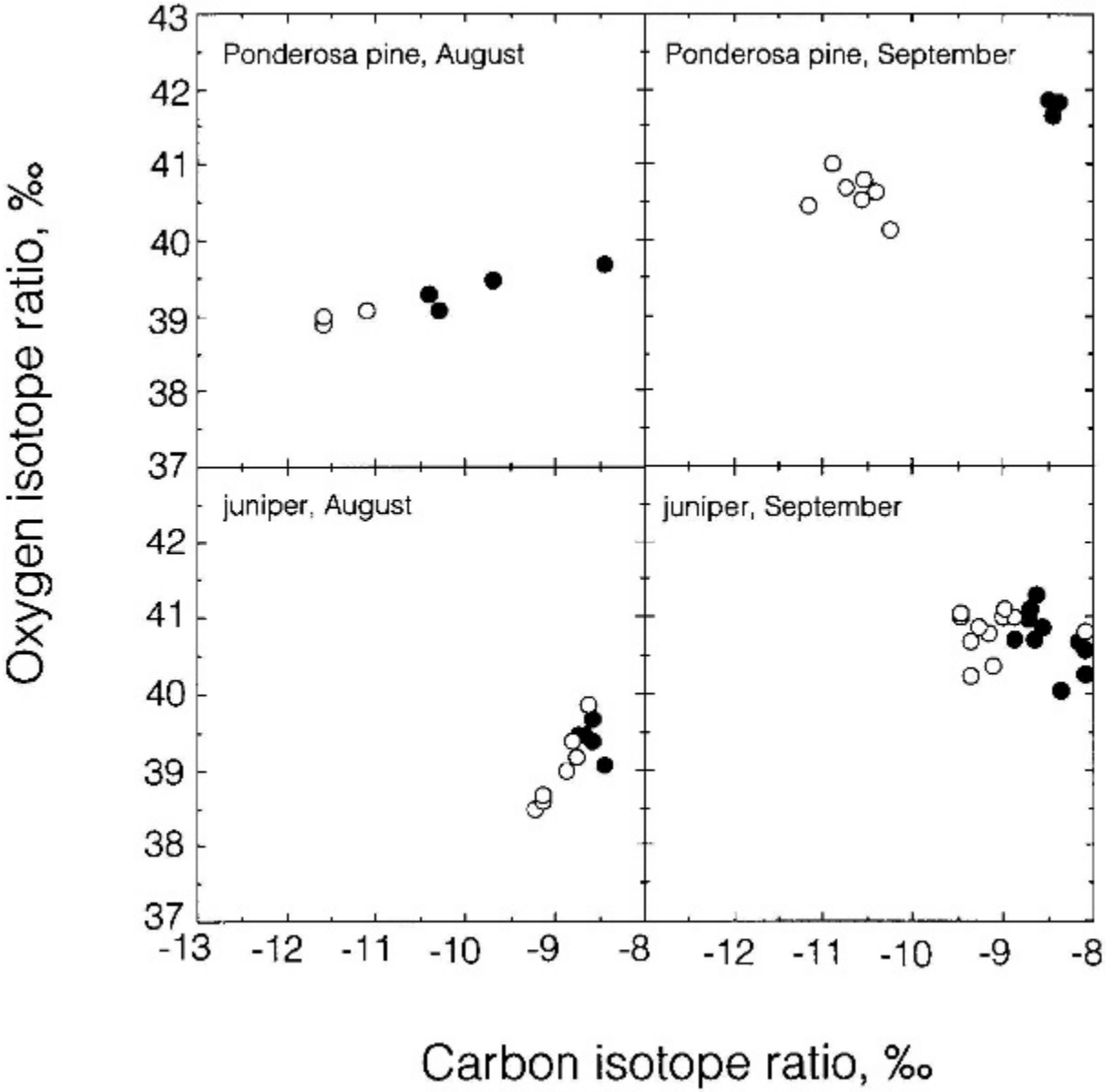


Figure 5. Correlation between the carbon and oxygen isotope ratios of canopy CO_2 at the ponderosa pine (Metolius) and juniper (Sisters) forests, during a single day in August or September 1996. Symbols: ● = air samples collected in the upper portions of the canopy; ○ = samples collected in the lower portions of the canopy.

Results

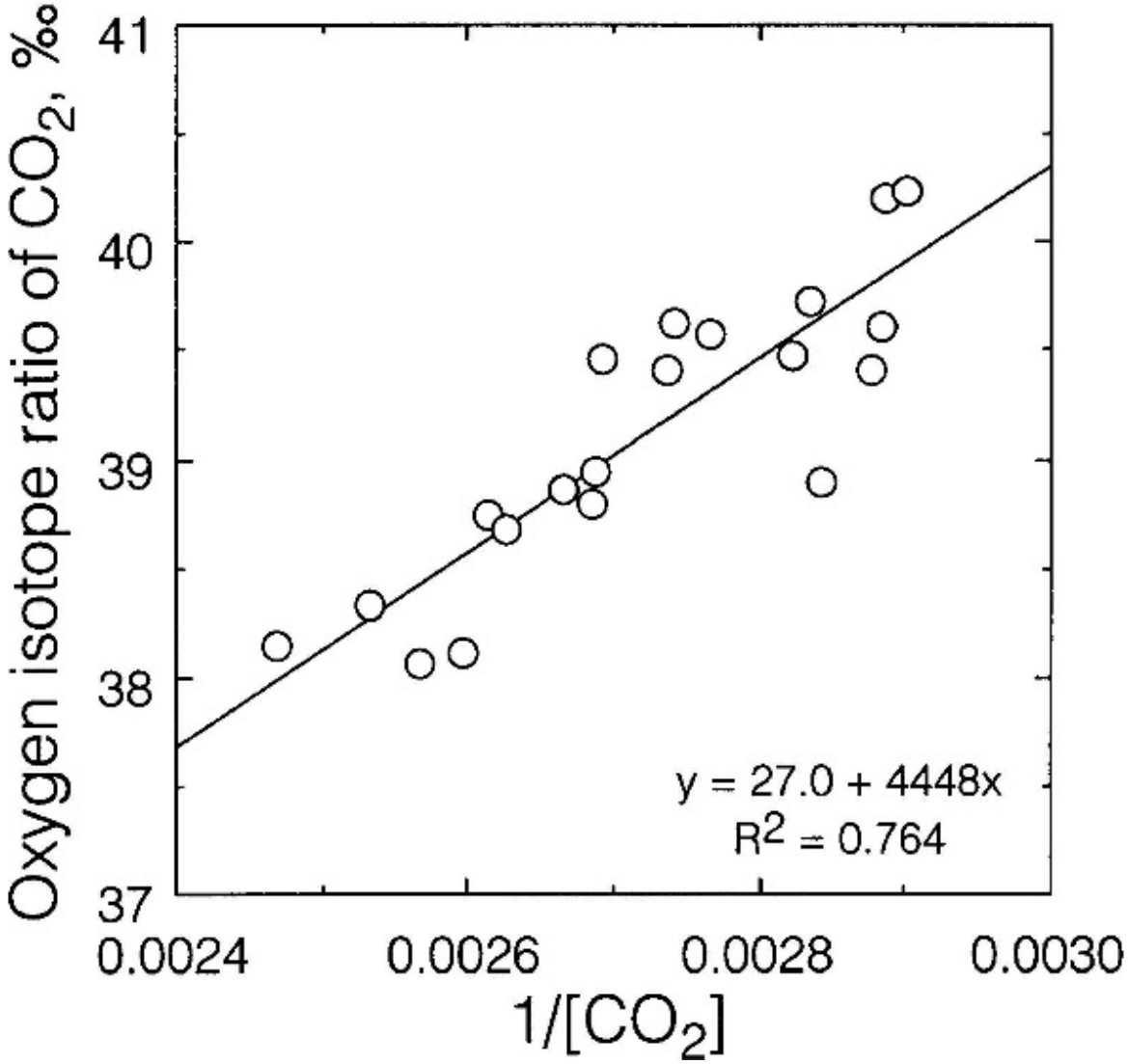


Figure 6. A Keeling-plot analysis of the oxygen isotope ratio of canopy CO_2 versus the inverse of the canopy CO_2 concentration ($ppmv^{-1}$) at the spruce-hemlock (Cascade Head) forest during September 1996.

Discussion

- We conclude that small-flask sampling offers the potential for rapid acquisition of a large number of field samples for Keeling-plot analyses of ecosystem respiration.
- Because stomata tend to restrict gas exchange under drier atmospheric or soil-drought conditions ,$\delta^{13}C_R$ values might be expected to increase under conditions of low water availability or high evaporative demand.

Thank you

Any suggestions and questions are welcomed