Archived Soil Incubations Project

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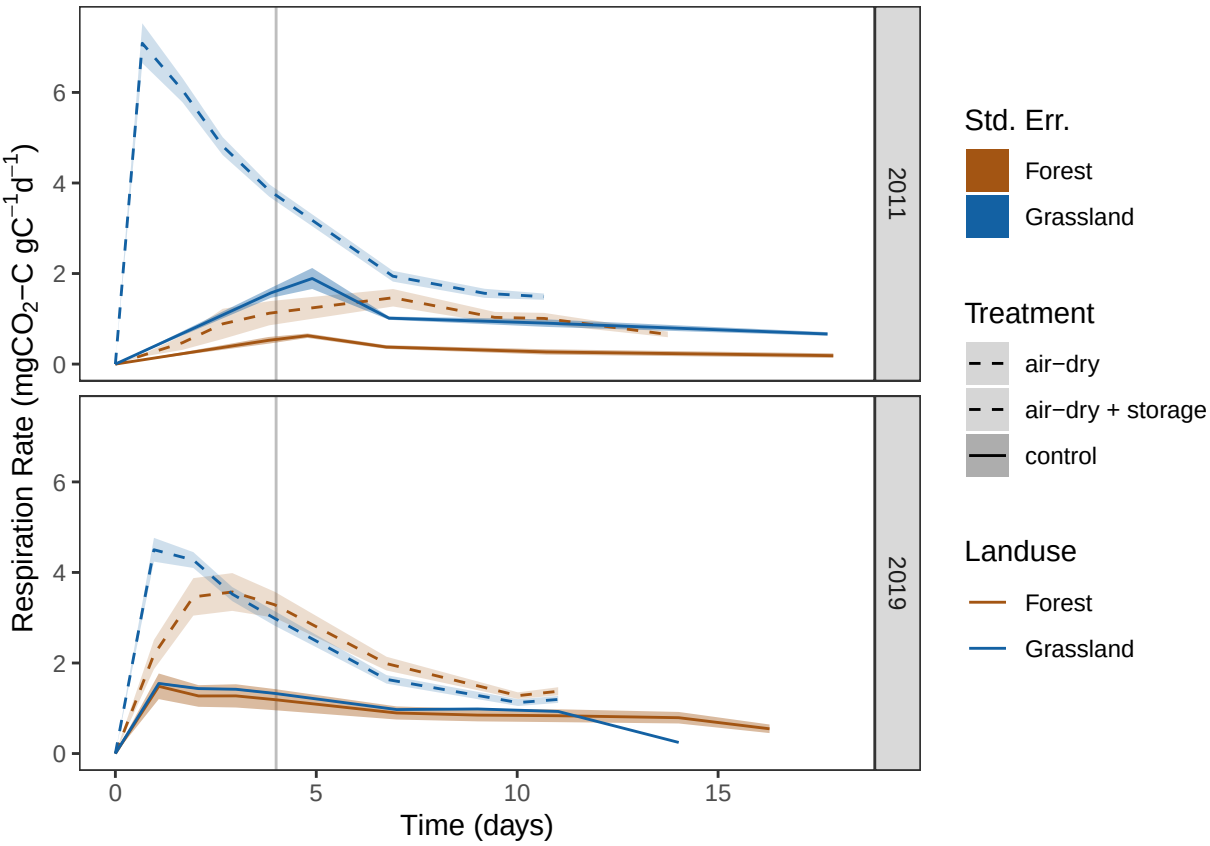
Notes:

- This workbook is intended to load and prepare the key data for analysis for the archive incubation project.
- in general, this is an updated version of script "./src/arc_inc_master.R"
- all code chunk options are set to "echo = FALSE"; see raw .Rmd file for data wrangling code.

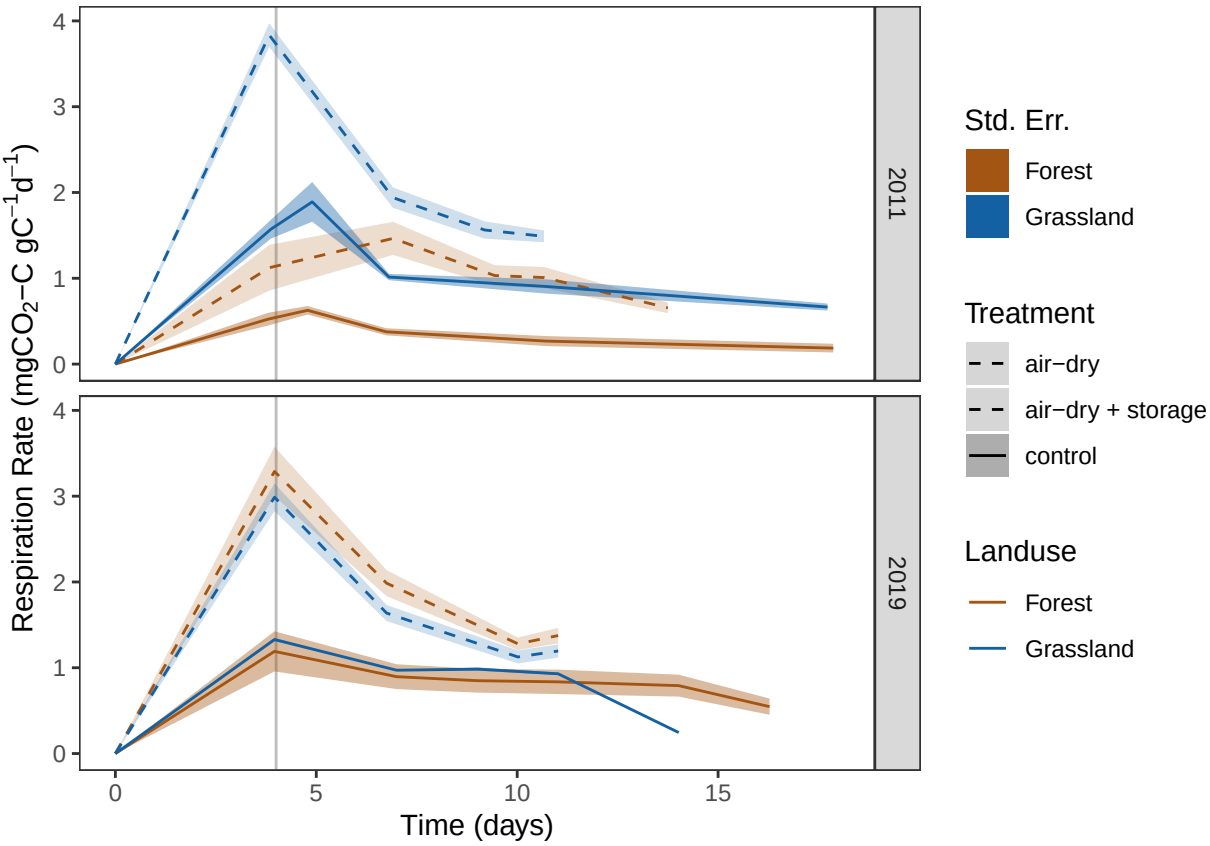
CO_2 fluxes and soil data

1. Load flux data from air-dry + storage (experiment 1) and storage duration (experiment 3) control samples, and convert from "wide" to "long" format so as to match other data.
2. Load flux data from air-dry + storage samples and from air-dry experiment (ctl & treatment), C & N data for all the Exploratories samples (measured in 2011), and soil mass and moisture data for all experiments.
3. Combine and summarize data in long format to calculate respiration rates and plot over time.
4. Plots of CO_2 fluxes over time. The final measurement points for a few samples which took >18 days to reach CO_2 targets are excluded for display reasons. Respiration rates for those samples remained flat. Notes:

- Daily measurements for the pre-incubation period were not taken for the 2011 control samples, leading to an apparent delay in the timing of the rewetting pulse (Fig 1).



- Plot pre-incubation period as average rate for the first four days for comparability (Fig. 2).



Isotope data

1. Read in isotope data from various sources. First load helper function 'read_jena_ams_results.R"
2. Next read in data from the appropriate directories in 'data/raw'.
3. Create a "tidy" style template for the data, i.e. variables in columns.

- Key variables are as follows:
  - SampleName (incorporates lab rep and treatment, e.g. "HEG10-1_dry")
  - ID (plot IDs, e.g. for "HEG10" for Exploratory samples)
  - Treatment (3 treatments: air-dry, air-dry + storage, storage duration; + controls)
  - Type (2 levels: F = forest, G = grassland)
  - Period (incubation period, 2 levels: pre = preincubation, inc = equilibrium incubation)
  - Experiment (3 levels: arc = air-dry + storage, rewet = air-dry/rewet, time = storage duration)
- Observational columns include:
  - d14c (Δ^{14}C-CO_2)
  - d13c (δ^{13}C-CO_2)
  - C_g_kg (C content)
  - dw_g (dry weight)
  - mgCO2.C_gS (mg CO_2-C respired g^{-1} soil $Period^{-1}$)
  - time_d (days in incubation period prior to measurement)
  - dH2O_grav (percent change in gravimetric water content due to laboratory moisture adjustment)
  - dH2O_whc (percent change in water holding capacity due to laboratory moisture adjustment)

4. Summarize observational data from timeseries data by unique IDs (SampleName).

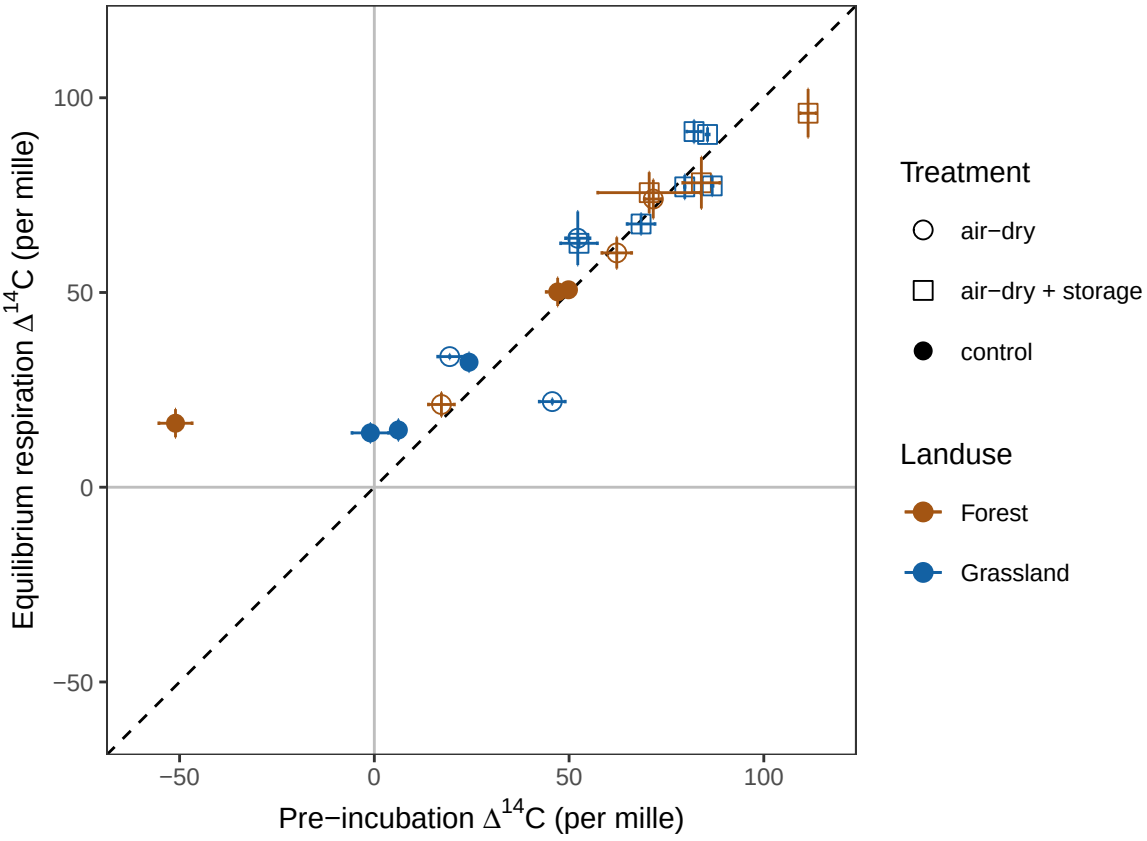
5. Create helper functions for decay correction, converting $\Delta^{14}C$ to fraction modern, and cleaning up extraneous values in raw ^{14}C data. Archived sample $\Delta^{14}C$ data should to be corrected for decay since the year of collection. (Although the correction is very small and likely insignificant, I will do it anyway).

- decay correction formula is:

$$1000 \cdot \left((FM \cdot e^{\frac{-year_{sampled}+1950}{8267}}) - 1 \right)$$

6. Clean up ^{14}C data and add external data points (tme experiment, Xplr control samples)
7. Combine data.
8. Count number of ^{14}C observations for checking plots.
9. Plot pre-incubation period $\Delta^{14}C$ against equilibrium respiration period $\Delta^{14}C$.

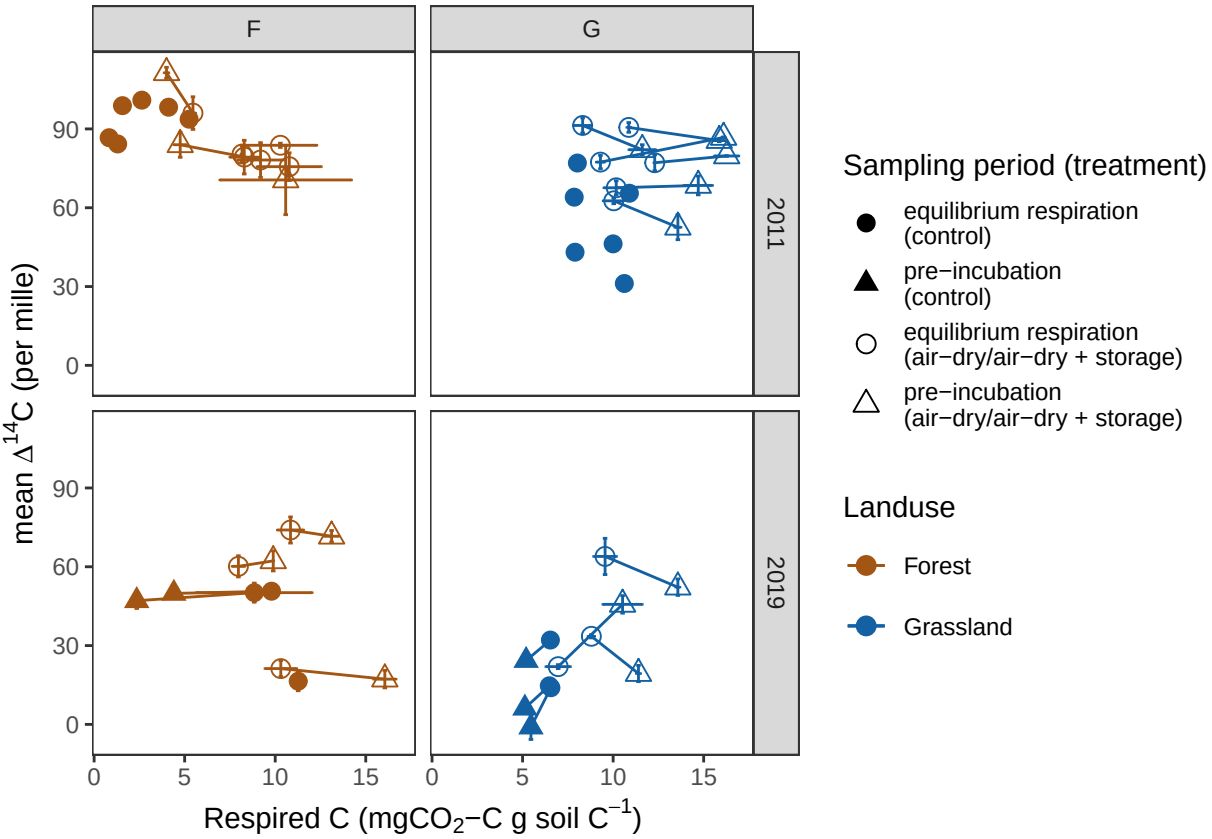
- Points are means of duplicate lab reps and error bars are min and max (except for the 2011 control samples, which were not replicated)
- Pre-incubation $\Delta^{14}C$ was not measured for the 2011 control samples.
- Relative outlier point is the very negative (mean = -51.1‰) HEW22 pre-incubation control samples from the 2019 air-dry experiment.
- Samples from three of the forest plots of the 2011 treatment samples failed to accumulate enough CO_2 to measure ^{14}C.

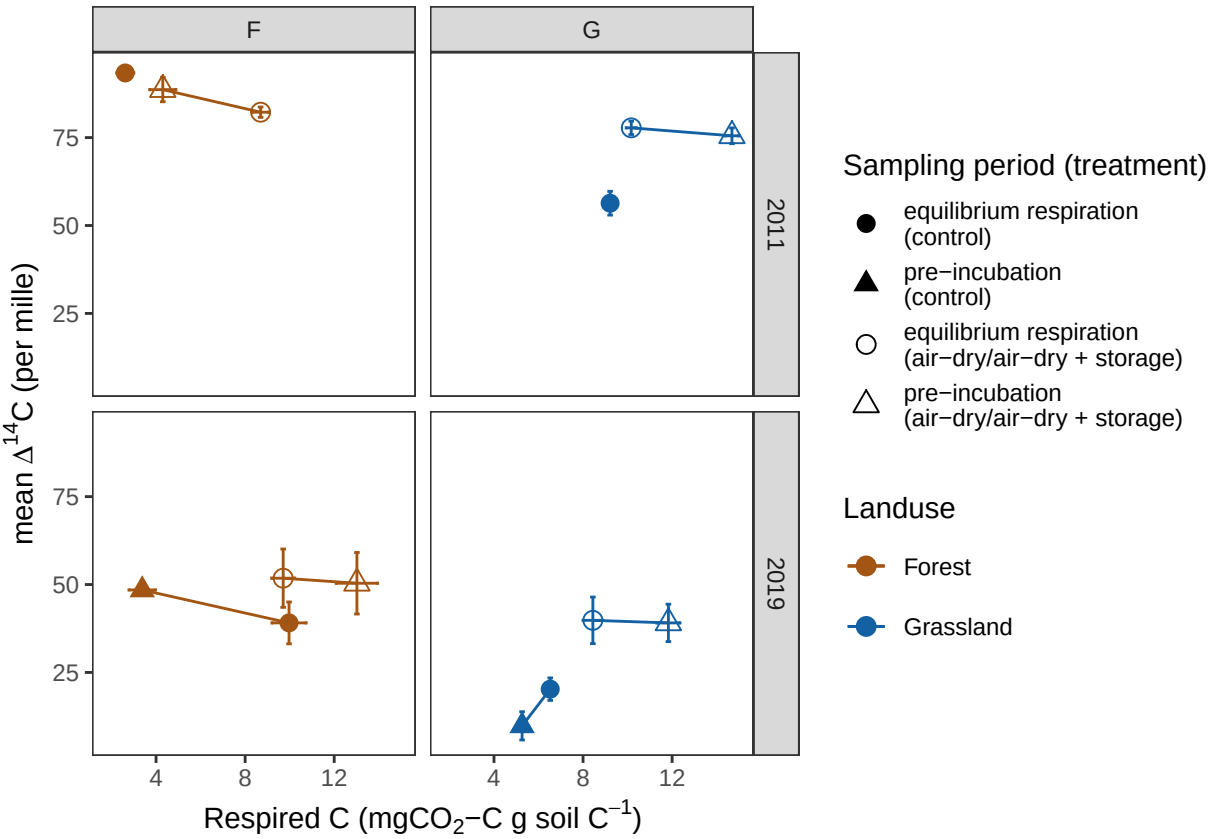


10. Plot $\Delta^{14}C$ against proportion of soil C respired by experiment, land cover, and sampling period.

- Note that data are first shown averaged by plot (Fig. 1), and then averaged by land use and treatment within sampling periods (Fig. 2)
- Pre-incubation $\Delta^{14}C$ was not measured for the 2011 control samples.

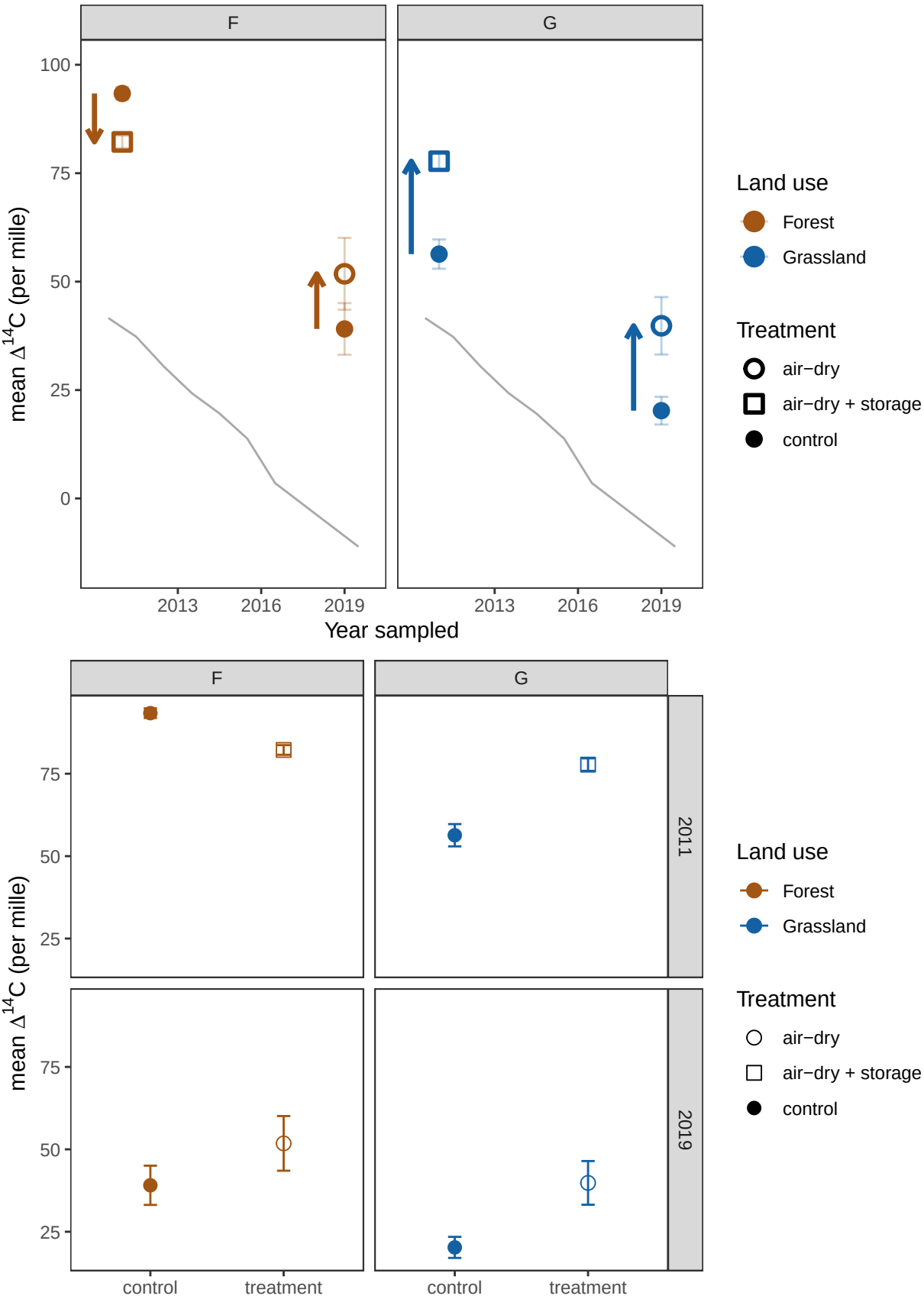
- Limits exclude outlier point (HEW22 control pre-incubation) for improved legibility
- Code for plot with outlier data is in second code chunk below, but not is currently included in report





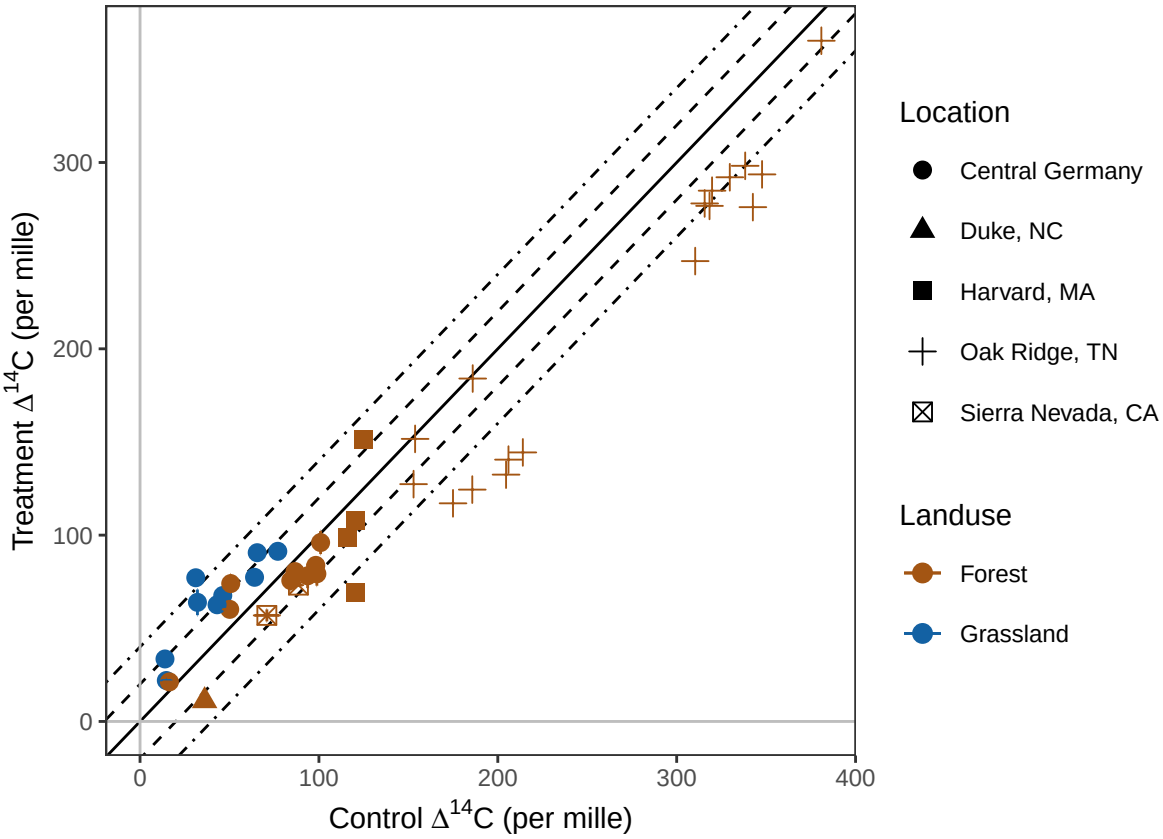
12. Show treatment effects on observed equilibrium period ^{14}C.

- Fig. 1 shows the direction of mean treatment effects over time in reference to the atmosphere (gray line). Points are means (n = 12 for 2011 treatment points, n = 9 for 2011 control points; n = 6 for all 2019 points); error bars = 2x std. err. of the mean.
- Fig. 2 shows treatment effects as means with inferential error bars (2x SE) [Sue and Alison suggest to display this info in tabular form]


F
G
100
75
50
25
0
mean Δ14C (per mille)
2013
2016
2019
Year sampled
Land use
Forest
Grassland
Treatment
air−dry
air−dry + storage
control
2011
2019
control
treatment

15. Show overall effect of treatment on whole data set.

- Control data shown on x-axis, treatment data shown on y-axis
- Solid line is 1:1, dashed line is a 20 per mille offset, and dot-dash line is a 40 per mille offset (roughly equivalent to the atmospheric decline over five and 10 years respectively for the period 2000 to 2020)
- Note that the difference between control and treatment points is within a 5 year range for the majority of points
- Data from all three experiments conducted in this study are shown, as well as a handful of additional data points for which both control and treatment (i.e. after air-drying + storage) incubations were conducted in another laboratory (Harvard points)
- Only A horizon data are shown here, as only three samples were analyzed for organic and B horizons (respectively) owing to sample availability



16. Show the effect of storage duration by plotting the difference between control and treatment ^{14}C as a function of storage duration.