Tree species effect on soil carbon storage and soil properties following birch-conifer conversion in Southern Central Norway

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Research Goals

This study presents soil carbon storage and soil properties from eight long-term conifer forest production experiments in Hirkjølen in comparison with neighbouring stands of natural mountain birch forest.

Overview

Converted forests have highly complex soil carbon dynamics due to changes in litter inputs, succession dynamics, soil disturbance, and microbial composition. With warming climate conditions, the dominant tree species used in forestry may switch to more heat-tolerant species, which will affect the matter in which soil carbon changes in novel ways.

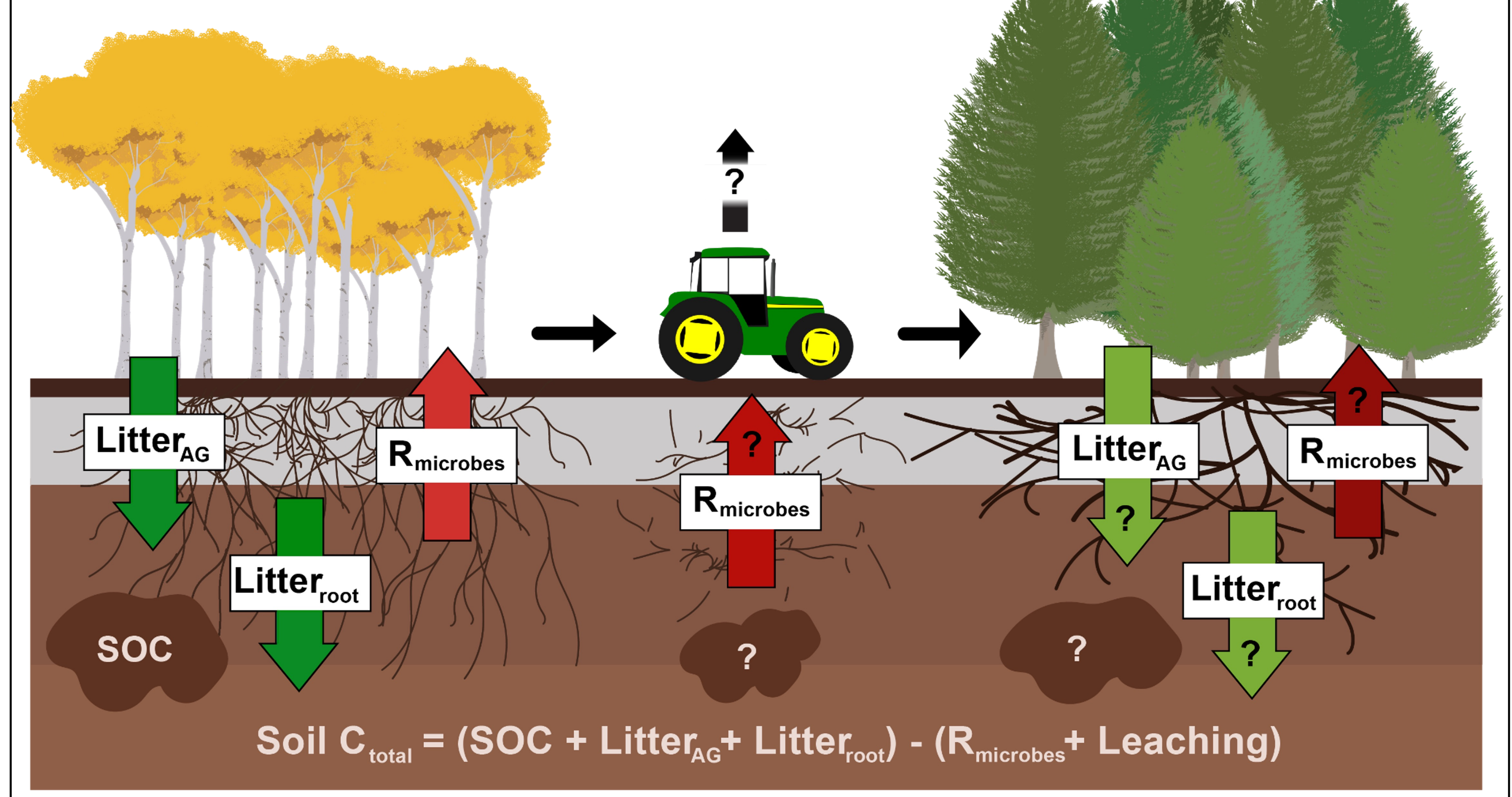
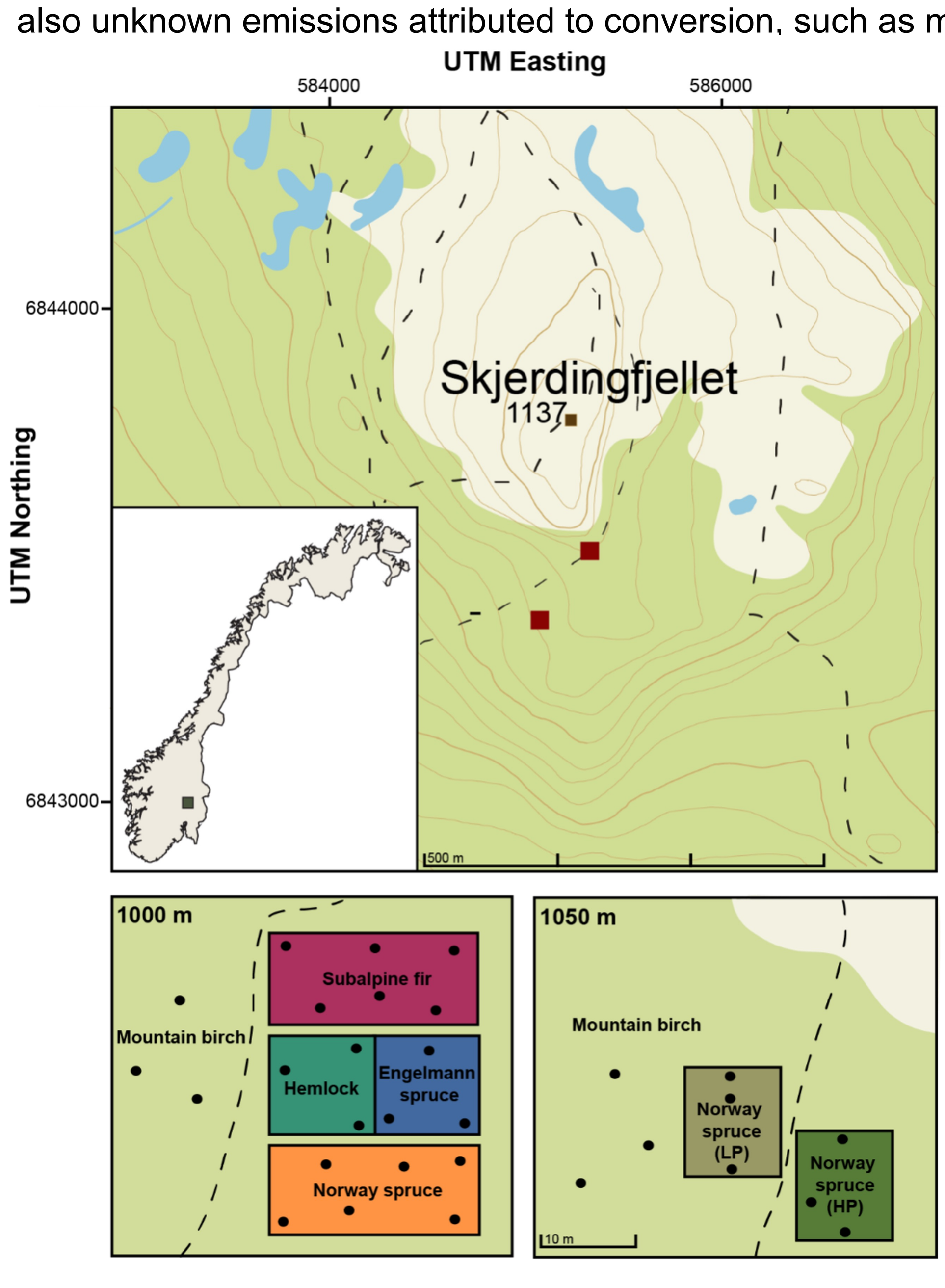


Figure 1. Overview of uncertainties in carbon storage following species conversion. With forest conversion, there can be significant effects on soil carbon storage due to increases in respiration and litter production. Following forest conversion, changes in aboveground and root litter inputs can cause microbial respiration changes and, ultimately, changes to soil organic carbon. There are also unknown emissions attributed to conversion, such as machinery emissions or soil albedo[1],



In the 1940's, conifer plots were planted in Hirkjølen using Norway spruce (*Picea abies*), Subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii)*, and mountain hemlock (*Tsuga mertensiana*) at different altitudes[2]. Within these sites, the biomass has been monitored every 5-8 years since 1991, but the soil has yet to be examined. These experiments offer an opportunity to compare how long-term soil carbon storage would be affected following conversion by different species.

Figure 2. Location and plots of Hirkjølen. Plots were located on the side of Skjerdingfjellet, east of Ringebu, at 1000 m and 1050 m, and number of sampling points was determined by plot size. HP = high producing, LP = low producing

Biomass

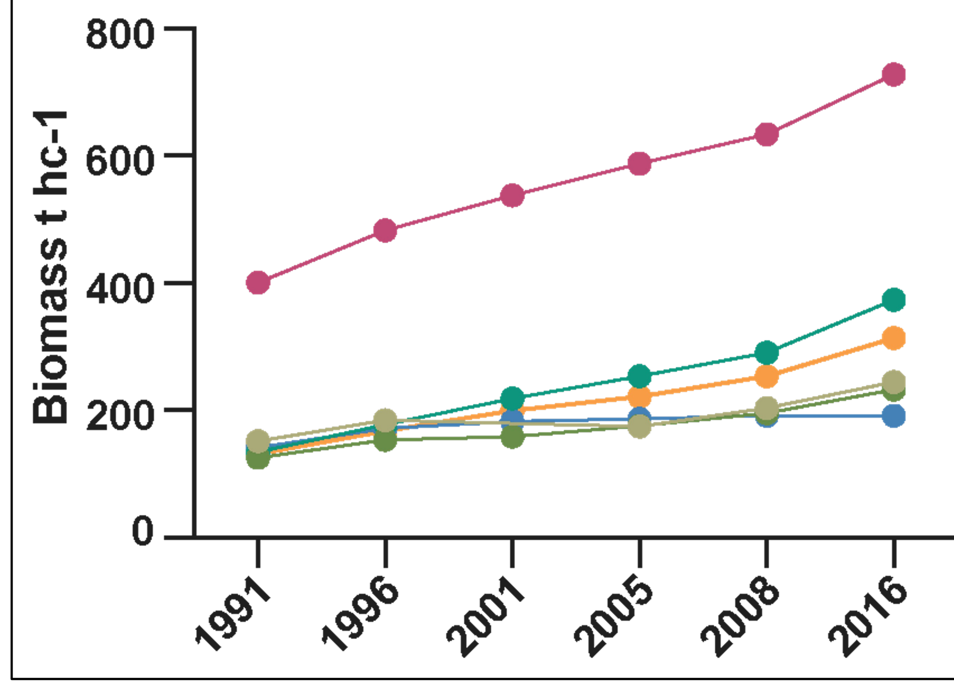


Figure 3. Long-term biomass growth of monitored Hirkjølen plots since 1991. Subalpine fir has significantly higher biomass than every other species (P< 0.005). Birch biomass is estimated to be approx. 30 t hc-1[1].

Soil Profiles

Figure 4. Soil profiles from Norway spruce, 1000 m plot (left) and natural mountain birch forest (right). All profiles were classified as podzols. There were no significant differences in horizon depths between plots, though there is evidence of mixing in certain profiles (left). There were significant differences in forest floor + L layer thickness. 3-6 soil profiles were dug within each plot. Within each profile, composite and bulk density samples were taken from the organic layer, 0-10 cm, 10-20, 20-30, and 30-40 cm.

Total C and N Stocks

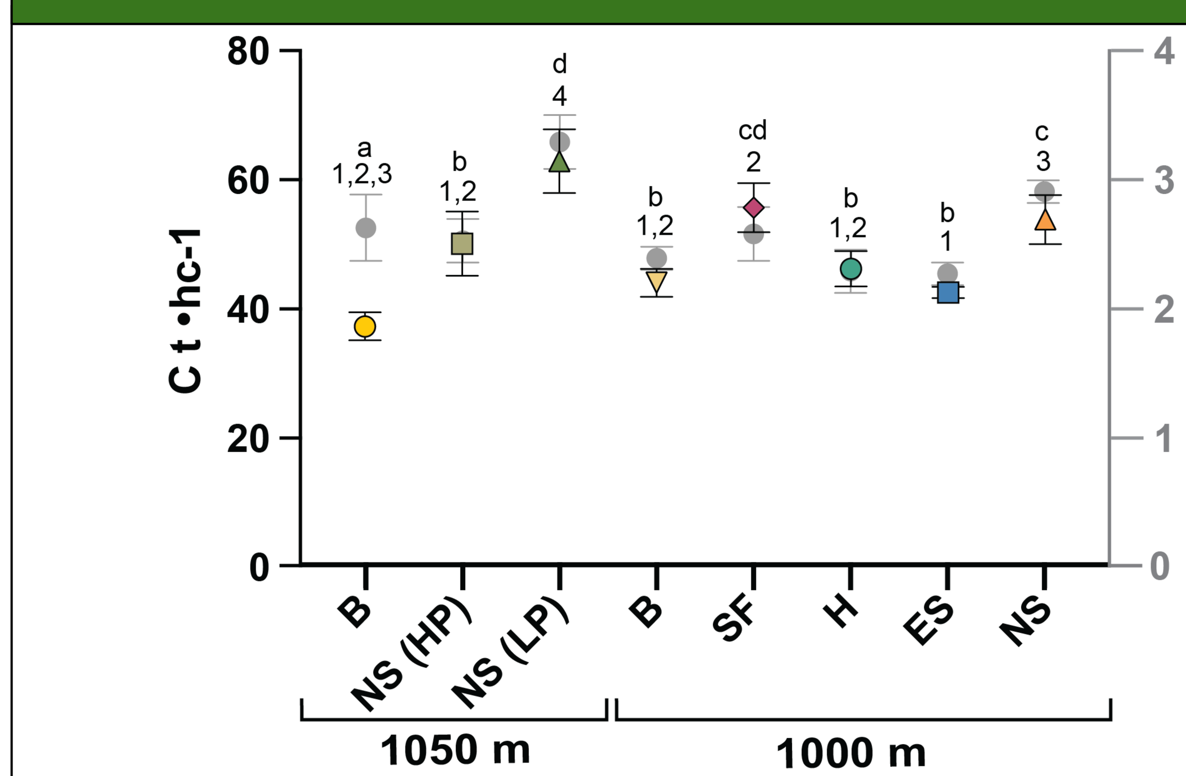


Figure 5. Total carbon (C) and nitrogen (N) stocks in converted and control plots. C stocks are shown in color (left axis) and N stocks are in grey (right axis). Significance between plots (P<0.01) for C stocks is shown in letters, and the significance for N stocks (P<0.01) is shown in numbers. Soil C and N was summed for depths to 40 cm, and added with C estimations from the forest floor, litter, and organic layer. Soil C and N stocks were calculated by depth x % C/N x BD_{FE} x CF correction.

Soil Properties

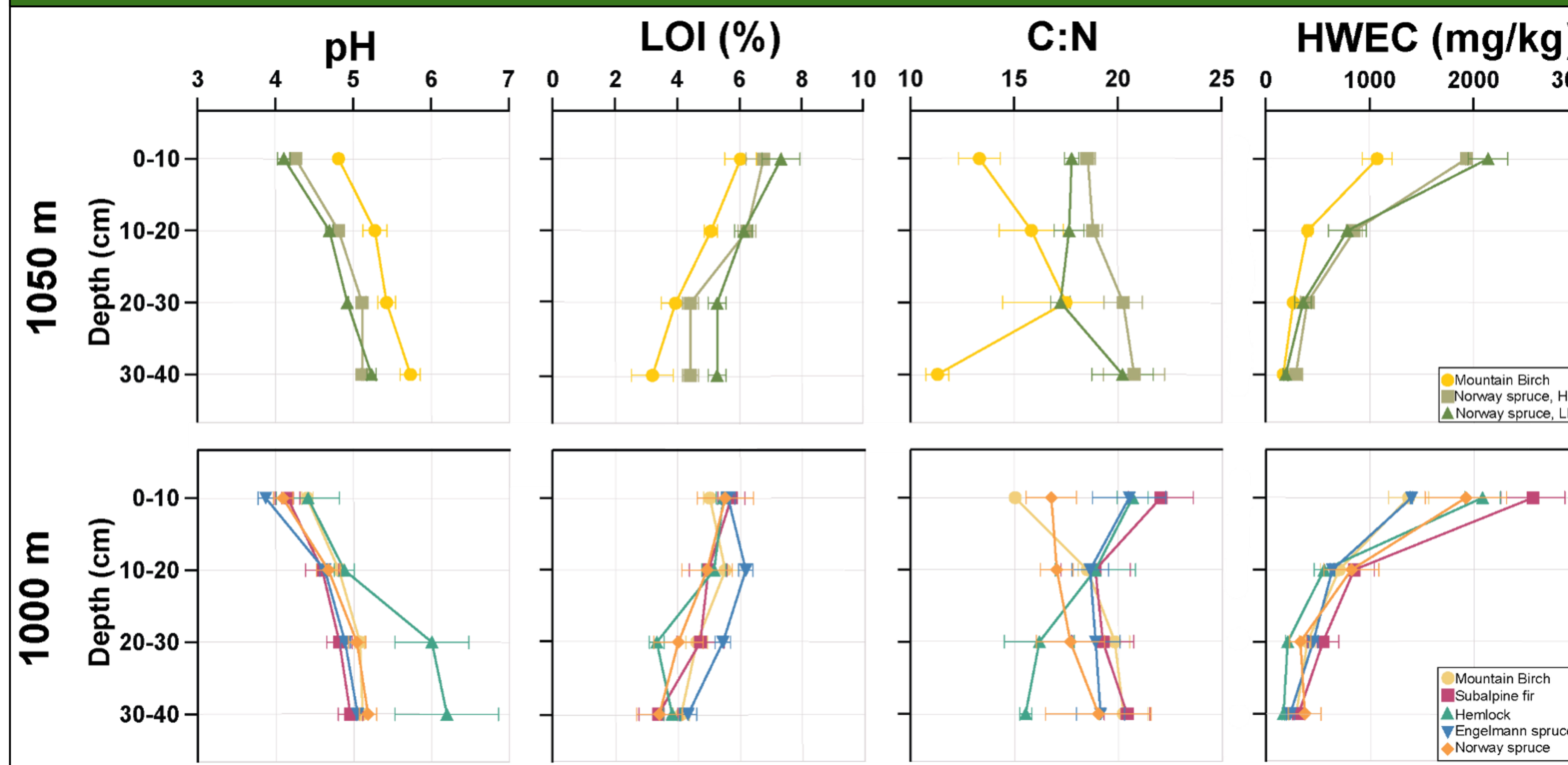


Figure 6. Soil property comparisons at 1000m and 1050 m for all species. **Left-most panel** is pH, measured in a 1:1 soil to water combination at each depth. **Left-middle panel** is the weight percentage of organic matter lost at 550 °C. **Left-right panel** is C:N ratio, and the **right-most panel** is hot water extractable carbon from 1:5 soil to water combination. Plots are organized by altitude (noted on left), and plot species (see bottom right corners).

Multivariable Analysis

	Altitude	Biomass	LOI	C stock (d)	N stock (d)	HWEC	pH	C stock (t)	Organic Layer (d)	C stock O
Altitude	1.00	-0.37	0.27	0.12	0.19	-0.05	0.11	0.10	-0.01	-0.16
Biomass	-0.37	1.00	-0.09	-0.05	-0.18	0.21	-0.16	0.54	0.53	0.80
LOI	0.27	-0.09	1.00	0.83	0.78	0.68	-0.73	0.24	-0.05	0.05
C stock (d)	0.12	-0.05	0.83	1.00	0.94	0.81	-0.71	0.17	0.002	0.02
N stock (d)	0.19	-0.18	0.78	0.94	1.00	0.72	-0.61	0.04	-0.01	-0.09
HWEC	-0.05	0.21	0.68	0.81	0.72	1.00	-0.81	0.20	0.16	0.22
pH	0.11	-0.16	-0.73	-0.71	-0.61	-0.81	1.00	-0.28	-0.21	-0.31
C stock (t)	0.10	0.54	0.24	0.17	0.04	0.20	-0.28	1.00	0.69	0.84
Organic Layer (d)	-0.01	0.53	-0.05	0.002	-0.01	0.16	-0.21	0.69	1.00	0.87
C stock O	-0.16	0.80	0.05	0.02	-0.09	0.22	-0.31	0.84	0.87	1.00

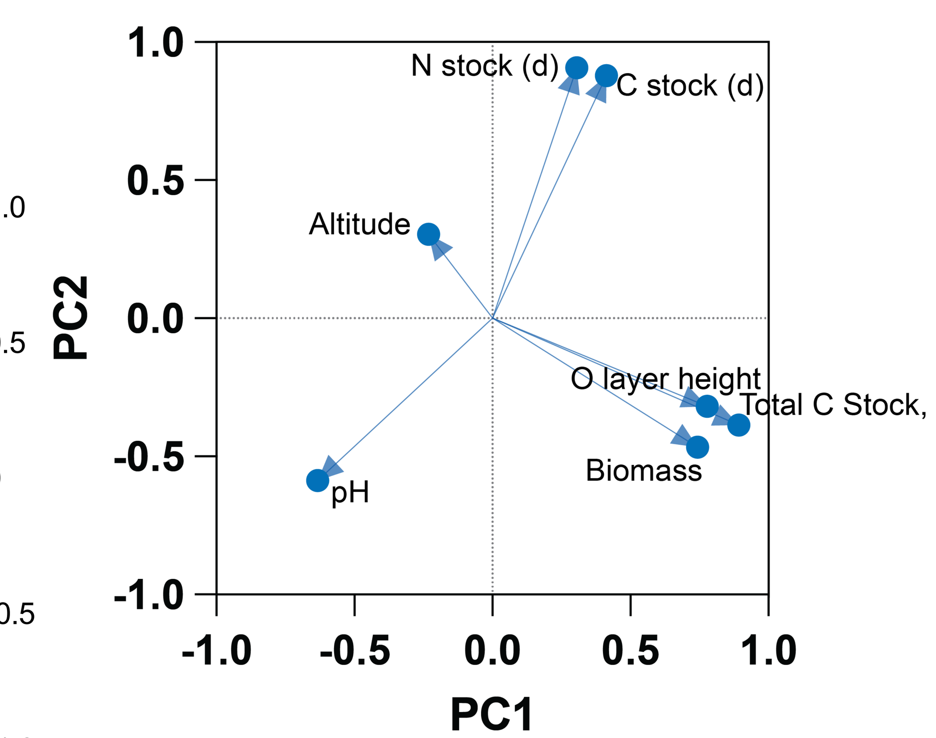


Figure 7. Multivariate analyses for all plots. Pearson correlation matrix (left) of continuous variables of each plot was determined using approximate p values. Bar on right demonstrates various degrees of correlation, with blue (1.0) being the highest and red (-1.0) being the lowest. Principle component regression (right) of variable on total C stocks accounted for 73.87% of total variation, with PC1 accounting for 38.51% of variation, and PC2 accounting for 35.72% of variation.

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