# Impacts of Vegetation on $CO_2$ exchange, permafrost thaw depth, and NDVI in Alaskan tundra

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## Introduction

- Terrestrial vegetation plays a large role in climate change. It participates in the global climate and carbon cycle by sequestering CO2, insulating the ground, and determining the area's albedo – a measurement of surface reflectivity.
- Large scale trends like the greening of Arctic tundra and the browning of Boreal Forests have been determined. Yet, the relationship between CO2 flux, vegetation composition and distribution, and NDVI at small scales in the Arctic has yet to be fully understood.
- In the Arctic, vegetation, air temperatures, and atmospheric CO2 levels are changing on a global scale and ground temperatures are responding. Rising temperatures in the arctic are causing permafrost – frozen ground – to thaw, releasing CO2 into the atmosphere.

**Research Objective:** This study was performed to better understand the relationship between land cover type and, vegetation composition, NDVI, CO2 exchange, and permafrost thaw depth in tundra ecosystems on the Yukon Kuskokwim Delta (YKD) in southwest Alaska.

## Methods

### Study Site

- All data were collected in the Yukon Kuskokwim Delta in South Western Alaska over the course of two weeks in July of 2017.
- Sites of different land cover types ( i.e. peat plateau, tussock tundra, fen, drained lake) were chosen via GIS images and in-field scouting to gather data from distinctly different areas with varying vegetation and topography.

### Transects

- Three, 25 m transects were set up at each site to measure vegetation cover, NDVI, $CO_2$ flux, and permafrost thaw depth.
- Permafrost thaw depth, vegetation cover, and NDVI were measured at 5 m intervals along the transects for a total of six measurements along each transect and 18 in each site. $CO_2$ flux was measured at only two points along each transect, intentionally selecting areas with various specious composition within a site, for a total of six measurements at each site.

### Measurements

- NDVI was measured using an SKL 910/2 NDVI pole (MODIS) equipped with two light sensors for measuring incident and reflected light from the ground surface, accounting for varying light conditions in the field.
- Vegetation % cover was visually estimated for each species present by using a 0.25 m2 quadrat that was placed along the transect.
- Permafrost thaw depth was measured by inserting a metal probe to maximum depth and measuring to the nearest cm.
- CO2 flux was measured using a Licor 840 connected to a transparent chamber, and air temperature, soil temperature, and PAR sensors.

## Acknowledgements

Thank you to NSF, The Polaris Project team, and Fort Lewis College for their support in making this project possible. Also, special thanks to Dr. Julie Korb of Fort Lewis College for her assistance with PC-ORD analysis of plant community data.

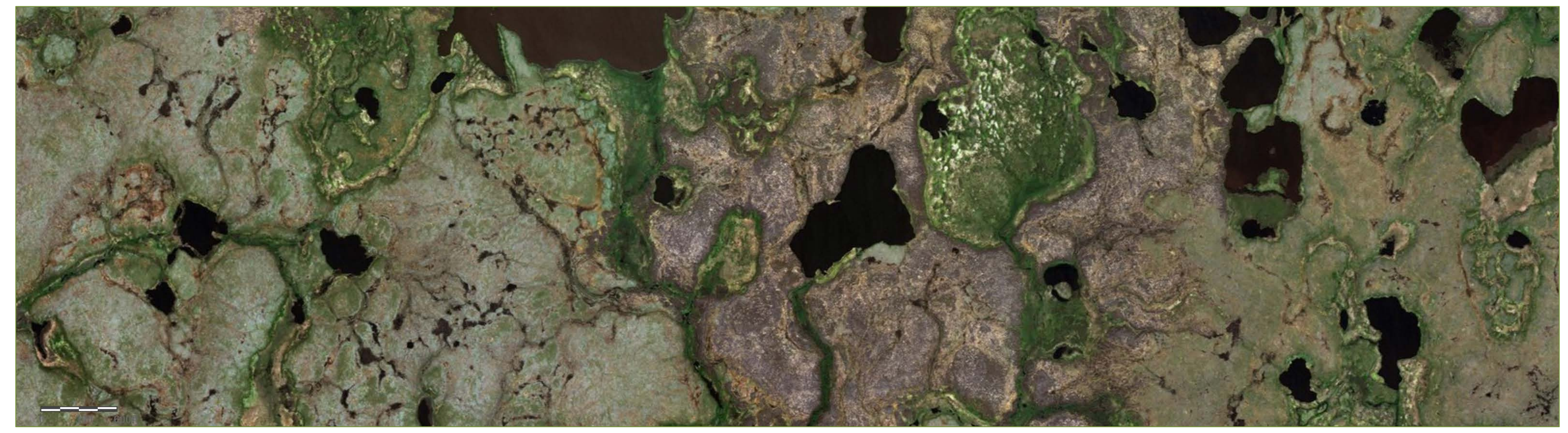


**Figure 1.** Satellite imagery of the tundra in the Yukon Kuskokwim Delta of Southwest Alaska where this study took place.

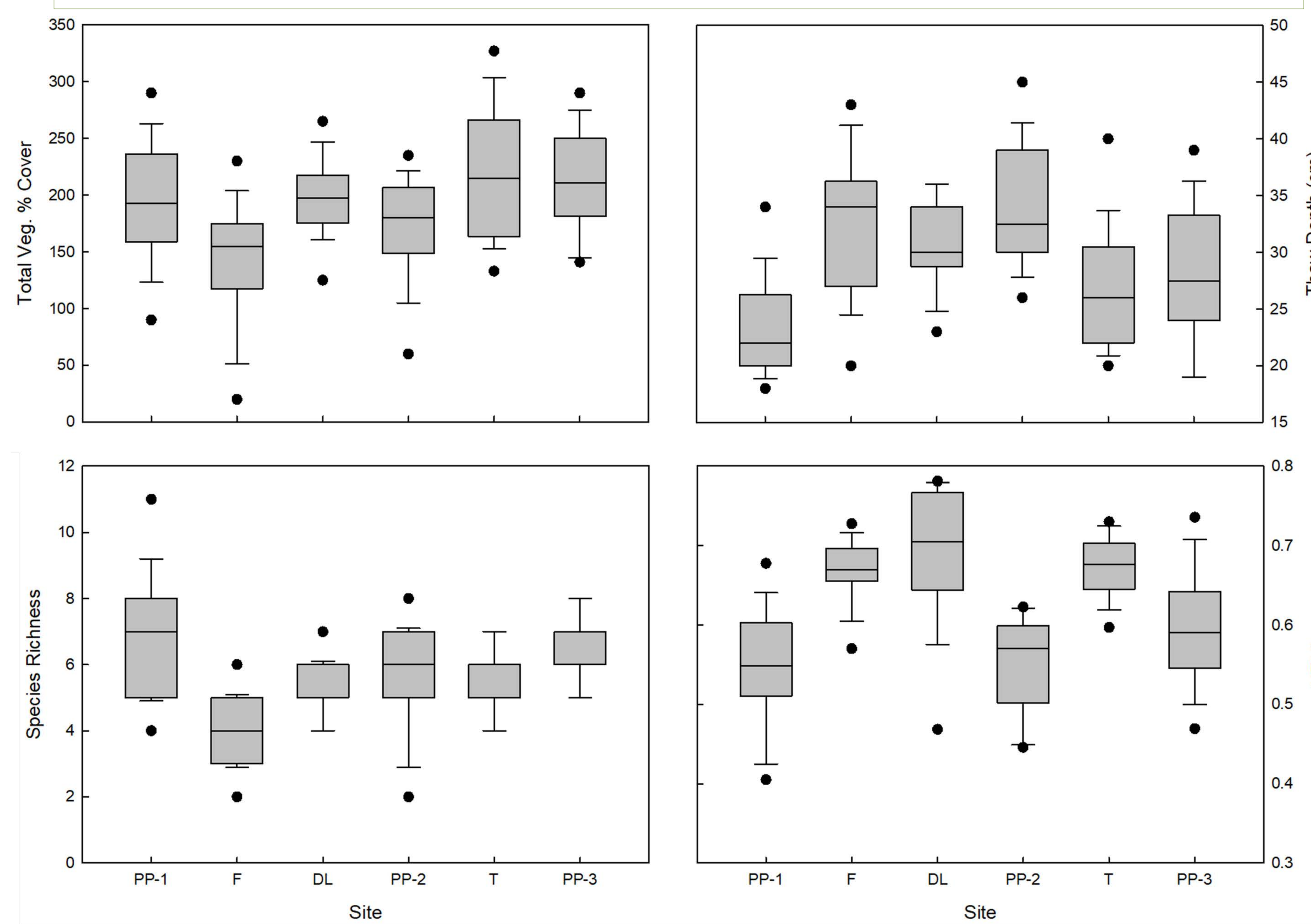



**Figure 2.** Box plots displaying statistical data (median, quartile range, 5th percentile, 95th percentile, and maximum and minimum outliers) of total vegetation % cover (vascular plants, moss and lichen), species richness, permafrost thaw depth, and NDVI for six study sites. Abbreviations PP, F, DL, and T denote peat plateau, fen, drained lake, and tussock land cover types. Numbers (such as PP-1, PP-2, etc.) denote replicate sites of the same cover type.

**Figure 3.** 25 m transect along which NDVI, $CO_2$ flux, thaw depth, and vegetation % cover were measured.

**Figure 2.** SKL 910/2 NDVI pole from Skye Instruments with dual sensors for measuring ground NDVI.

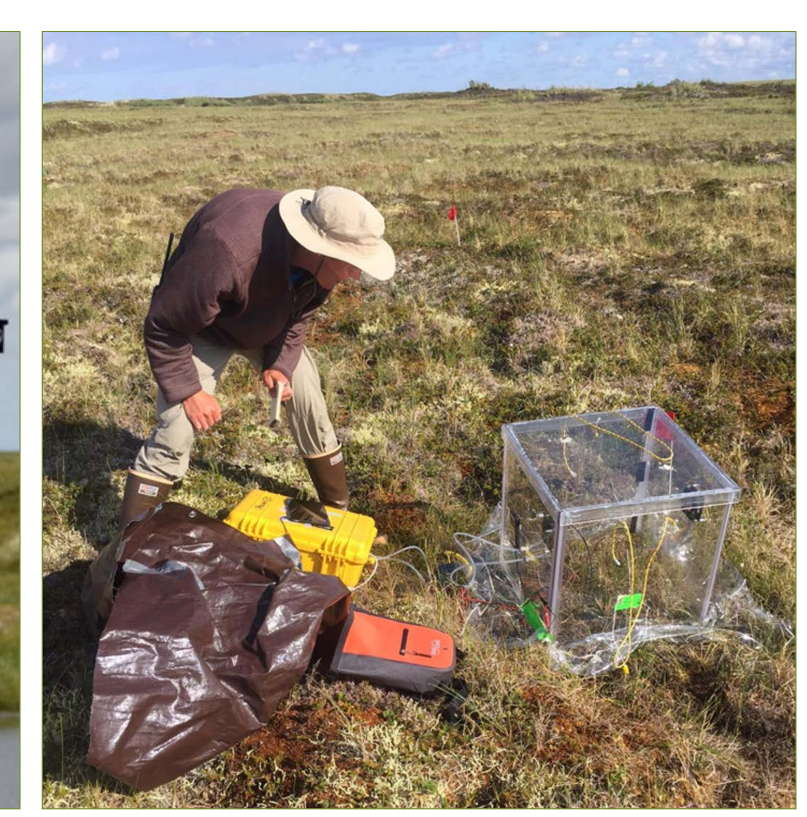


**Figure 5.** Licor $CO_2$ flux system and transparent chamber with PAR sensor, thermometer, and cover for measuring resp.

## Results & Discussion

### Variation Across Land Cover Types

- Across land cover types, thaw depth and NDVI varied with the deepest thaw depths in the fen & the highest NDVI in the fen and drained lake.
- While land cover types had different prominent species, mean species richness and total % cover did not vary greatly across all types.
- In all study sites, average respiration rate was higher than average GPP, especially the tussock site. This land cover type also had the highest GPP of all sites, possibly due to its abundance of relatively large vascular plants (tussocks).

### Correlation Between Variables

- NDVI showed a linear correlation with an $r^2$ value of 0.2112. with GPP.
- According to the PC-ORD analysis, all sites had similar plant communities except for the drained lake and fen site, which had higher average NDVI than the rest.
- These two sites likely had the highest soil moisture and were lower in elevation than the others. This suggests that soil moisture and/or low elevation are driving factors in producing distinct plant communities.

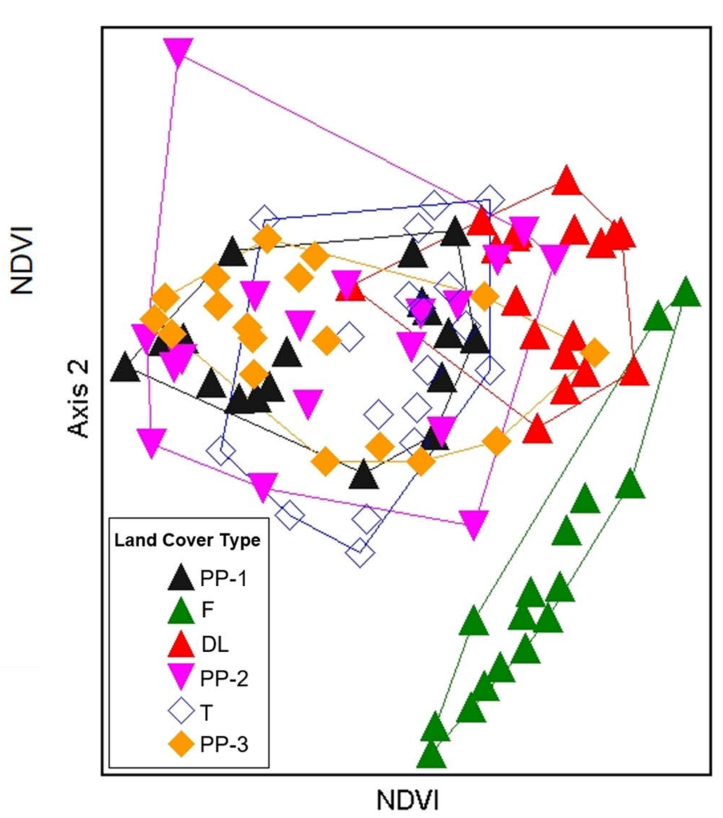



**Figure 6.** Graphical representation of PC-ORD multivariate analysis on plant community data. Axis 1 (x-axis) groups data points by NDVI and axis 2 (y-axis) groups data by similarity in plant species composition.

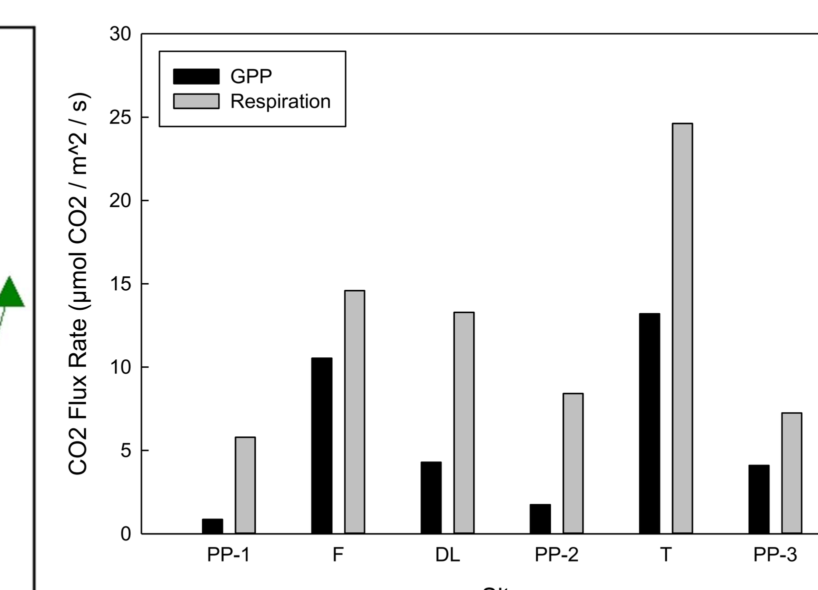
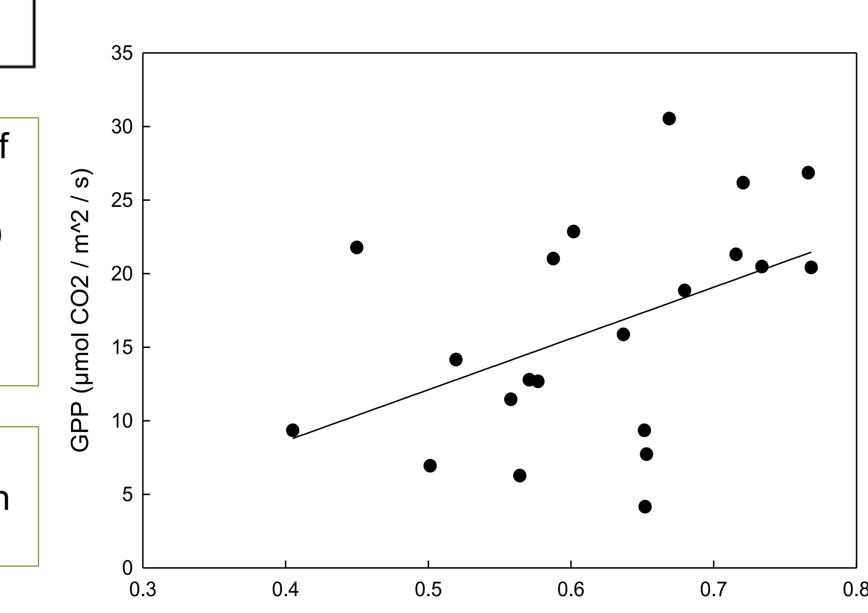



**Figure 8.** Absolute value of the average GPP and respiration at each site.

**Figure 7.** NDVI vs. GPP across all sites fitted with a linear trend line with $r^2$ value of 0.2112

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