

Evidence essay · Land and freshwater

A carbon store is not an annual emission

Priyanka Das · 26 August 2026

Fictional author and institute · Editorial demonstration, not peer reviewed

ABSTRACT

Northern soil carbon stocks and annual exchanges are separated by units, geography, time, and the direction of transfer. Drawing on NOAA's terrestrial carbon assessment, the essay explains why stored organic matter does not specify when it will thaw, decompose, or reach the atmosphere. Temperature, oxygen, water, methane oxidation, plant uptake, and aquatic transport shape distinct pathways. Summer growth is considered alongside winter respiration and wildfire, allowing a locally observed sink and a regional source to coexist without contradiction when their boundaries differ. Flux towers, chambers, and regional analyses also represent different footprints. The account rejects both immediate release of the whole store and reassurance based on one green season, arguing instead for sustained, year-round observations with explicit budget components and uncertainty.

Keywords: carbon stocks · carbon fluxes · winter respiration · methane · wildfire accounting

Adapted from the Still North field journal. Original article. A source-based editorial text, not a report of original Still North research. Examples and imagery are illustrative.

A figure for carbon held in northern soils can be enormous without being a figure for carbon released this year. The store describes accumulated material. An emission describes a transfer over time. Reading one as the other turns a serious, long-lived climate feedback into a false countdown, and makes it harder to understand what monitoring can tell us.

The useful questions are more specific. How much carbon becomes available for decomposition? Under what temperature and moisture conditions? How much do plants take up? Which gases leave the ecosystem, and when? Those questions connect the underground store to the atmosphere without pretending that all of it behaves alike.

Keep the units attached

The NOAA Arctic Report Card 2024 assessment describes at least 1.4 to 1.6 trillion tonnes of carbon accumulated in terrestrial soils and permafrost across its northern study region. That is a stock, not an annual loss, and its geography includes tundra and boreal lands within the northern permafrost region. It should not be relabelled as carbon beneath every square metre of tundra or as a quantity already entering the air.

An annual flux might instead be reported as grams of carbon per square metre per year, or tonnes of carbon per year across a defined region. Carbon mass and carbon-dioxide mass also differ because a carbon-dioxide molecule contains oxygen as well as carbon. Before comparing two large numbers, check whether they describe the same substance, area, period, and direction of transfer.

A hypothetical soil profile makes the distinction tangible. Finding organic carbon below the present thaw boundary shows material that may become vulnerable under changing conditions. It does not show the date it will thaw, the fraction microbes will decompose, or the

annual balance between losses and new plant inputs. Those require additional evidence.

Thaw opens possibilities, not one fixed pathway

Once frozen organic matter thaws, microbes can process it. Temperature, oxygen availability, water, and the character of the material influence that processing. Water-logged, oxygen-poor environments can favour methane production, while carbon dioxide is also released through respiration. Methane may be oxidised before reaching the atmosphere, so production below ground and emission above ground are not interchangeable measurements.

Water can also carry carbon sideways into streams and lakes. Some may be processed there, some transported onward, and some stored in sediments. This matters when drawing a boundary around an ecosystem budget: a carbon loss from one patch of soil is not automatically a simultaneous atmospheric emission at that patch. Our Permafrost and freshwater overview introduces the connected water pathways.

A green summer is not the whole year's balance

Plants remove carbon dioxide through photosynthesis, while plants and microbes release it through respiration. More summer growth can increase uptake without guaranteeing a larger annual net sink. The NOAA assessment describes growing-season uptake being offset by non-growing-season respiration across the region. A short, bright measurement window can therefore tell a different story from a full annual record.

Fire introduces another boundary choice. NOAA reports that the tundra region has shifted to a small carbon-dioxide source when wildfire emissions are included. The chapter also presents monitoring sites that take up carbon dioxide over their assessed year, and explicitly warns that

those sites are not direct averages for entire biomes. These findings are compatible: a local footprint without a fire and a regional budget including disturbance are different accounts.

What would establish an emission trend?

Measurements must follow exchange over enough of the year and across enough landscape types to represent the claim. Flux towers observe a footprint that changes with wind and atmospheric conditions. Chambers investigate smaller patches. Regional estimates combine observations and models, with gaps and assumptions that should remain visible. A growing body of evidence is stronger than treating one instrument as a verdict on the whole Arctic.

Ask whether the budget includes winter, fire, aquatic transfers, and both carbon dioxide and methane. Check whether a positive sign means a source or a sink in that particular dataset. Look for uncertainty intervals and the years averaged. A near-neutral carbon-dioxide budget does not imply no methane emissions, and uncertainty around a net balance does not mean the much larger underlying exchanges have stopped.

Our [Why the Arctic matters](#) guide places these feedbacks in the wider climate system. The practical conclusion is neither that the whole store will escape immediately nor that its gradual release is harmless. It is that warming changes the conditions controlling a large store, while sustained, year-round evidence tells us how that vulnerability becomes actual exchange.

References

1. NOAA Arctic Report Card 2024 assessment (arctic.noaa.gov)