Appendix S2: Site Information and Sources

We calibrated the MEL model to twelve ecosystems, eleven of which are within the National Science Foundation (NSF) Long-Term Ecological Research (LTER) program. These ecosystems are from a wide variety of biomes and climatic conditions ranging from prairie to forest and from the arctic to the tropics. Although we try to compile the data for each ecosystem from a single site, those data are never complete and are typically collected in different years with different weather conditions. We therefore supplement these site data with data from other sites and even fill data gaps based on mass balance, or some assumed stoichiometric rules, or other generalized relationships (details are in Rastetter et al, 2022).

Three of the ecosystems are types of arctic tundra from the Arctic LTER (https://arc-lter.ecosystems.mbl.edu/) near Toolik Lake, on the North Slope of Alaska. The landscape is underlain by continuous permafrost, but the upper 30-200 cm of the soil thaws annually. The three arctic ecosystem types are: (1) Moist-acidic tussock tundra (ARC-t), which cover most of the hill slopes near Toolik Lake, have approximately even cover of tussock-forming sedges, deciduous dwarf shrubs, and evergreen forbs, and soils are Histosols with a 20-30 cm surface peat layer underlain by a silty mineral soil. (2) Wet-sedge tundra (ARC-w), which develops in flat areas where water collects on the surface, is dominated by sedges and moss, and soils are Histosols with a deep peat layer usually extending to permafrost; wet-sedge tundra also receives run-in water and nutrients from upland ecosystems. (3) Shrub tundra (ARC-s), which is found at the base of hillslopes and along water tracks, are dominated by shrubs, and soils are Histosols with 20-50 cm of surface peat underlain by mineral soil and gravel.

We simulate alpine dry meadow tundra (NWT) using data from the Niwot Ridge LTER (https://nwt.lternet.edu/) in the Front Range Mountains of central Colorado. Alpine dry
meadows occur at high elevation in exposed, windblown areas, are dominated by tussock-forming sedges interspersed with forbs, and soils are Inceptisols that are shallow and rocky.

We analyze two grasslands. The first is a **restored tallgrass prairie (KBS)** near the prairie-deciduous forest transition at the Kellogg Biological Station LTER (https://lter.kbs.msu.edu/) in southern Michigan. The restoration reestablished C4 prairie grasses, sub-dominant forbs and shrubs, and N-fixing red clover. Soils are Alfisols (KBS) with a clay subsoil. The second grassland is the **native tallgrass prairie (KNZ)** at the Konza Prairie LTER (http://lter.konza.ksu.edu/konza-prairie-long-term-ecological-research-lter) in the Flint Hills region of northeastern Kansas. Soils are Mollisols (KNZ) with a silt-loam texture. Tallgrass prairies are dominated by several C4, warm-season grasses with sub-dominant forbs and shrubs.

Periodic fire is an essential component of both ecosystems; for our simulations we assume an annual burn in early spring for both of these sites.

Two of the ecosystems are in the boreal forest at the Bonanza Creek LTER (https://www.lter.uaf.edu/) in central Alaska. The landscape is underlain by discontinuous permafrost. The two boreal ecosystem types are: (1) **Lowland black-spruce (BNZ-l)**, which develops in broad valleys, is dominated by black spruce and moss, and soils are Histosols with a deep peat layer; and (2) **Upland black spruce (BNZ-u)**, which develops on low-gradient north slopes, is also dominated by black spruce and moss, and soils are Histosols with a deep peat layer underlain by permafrost.

For **Northern Hardwood forest (HBR)** we use data from the Hubbard Brook LTER (https://hubbardbrook.org/hubbard-brook-long-term-ecological-research-program) in the White Mountains of central New Hampshire. This forest is dominated by maple, beech, and birch with soils that are well drained Inceptisols and overlain with a 5-7 cm organic layer.

A second hardwood forest we simulate is a **Transition Oak-Maple forest (HFR)** at the Harvard Forest LTER (https://harvardforest.fas.harvard.edu/research/LTER) in central Massachusetts. It is a mixed hardwood forest, dominated by red oak and red maple with soils that are rocky and well drained Inceptisols.

We simulate **temperate coniferous forest (AND)** at the H. J. Andrews LTER (https://andrewsforest.oregonstate.edu/) in the Cascade Range of western Oregon. This forest is
dominated by Douglas-fir with associated western hemlock and western redcedar and soils are well-drained, gravelly clay loam Andisols.

The one ecosystem we simulated that is not in the LTER program is an old-growth lowland tropical rainforest (CAX) at the Caxiuanã National Forest in the State of Para, Brazil. The vegetation consists of a high diversity of evergreen and semi-deciduous broadleaf species and soils are deep, clay rich Oxisols.

The full list of parameters, drivers, states, fluxes and the sources and calculations for all values are available on the EDI data portal (Rastetter et al, 2022). The latest version of the data set can be found by searching the EDI data portal for the data set title ‘Steady state carbon, nitrogen, phosphorus, and water budgets for twelve mature ecosystems ranging from prairie to forest and from the arctic to the tropics.’

Citations: