



## **Climatic Controls of Soil Carbon Cycling Across a Gradient of Sonoran Desert Ecosystems**

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Arid and semiarid lands cover roughly 36% to 40% of global land area, highlighting the importance these ecosystems play in the global carbon cycle. The controls of arid and semiarid ecosystem carbon cycle processes, such as soil organic matter turnover and mineral weathering, remain poorly understood. To address this knowledge gap, we established a set of long-term soil monitoring sites across a gradient of semiarid ecosystems in the Sonoran Desert of the Southwestern USA. These sites were established as part of the Critical Zone Exploration Network (CZEN), sponsored by the US National Science Foundation. The primary objectives of the Sonoran Desert Environmental Gradient (SDEG) include: (i) characterizing climate forcing controls of soil physical, chemical and biological processes, and the flux of chemical species from soils to surface waters; and (ii) developing predictive models of carbon cycle response to climate and climate change. Particular attention is given to the bimodal precipitation regime characteristic of the SDEG ecosystems and the relative impact of warm versus cold precipitation on biogeochemical processes. The SDEG spans a steep elevation and environmental gradient on granitic parent materials near Tucson, Arizona, USA. Elevation ranges from 800-2650 m a.s.l. with concurrent shifts in climatic regime. Specifically, mean annual air temperature decreases (20-10 °C) and mean annual precipitation increases (30-85 cm) with elevation, with concomitant changes in vegetation from mixed desert-scrub (<1200m) to grass and oak woodlands (1200-1700 m) to pinyon-juniper woodland (1700-2000 m) and ponderosa pine and fir forest (>2000 m). We sampled soil and regolith material from each of vegetation community across the SDEG and established a long-term soil-moisture and temperature monitoring network. Pedon physicochemical data, coupled with elemental mass balance, radiocarbon analyses of soil organic matter, and terrestrial cosmogenic nuclide ( $^{10}\text{Be}$ ) analyses indicate substantial variation in carbon cycling across the SDEG. Soil morphology suggests the dominant pedogenic process is the accumulation and cycling of soil organic matter, with an increase from 0.5 to 5.0 kg C per square meter with increasing elevation. Furthermore, radiocarbon data suggest rapid turnover of soil carbon, with carbon pools dominated by fast-cycling carbon that has a mean residence time of less than 15 years. X-ray diffraction data indicate mineral weathering is dominated by transformation of feldspar to kaolinite. A coupled mass balance-denudation rate analysis indicates the total mass flux and rate of silica and cation loss varies by an order of magnitude across the SDEG, e.g., total Si mass flux ranged from 25-150 kg Si per square meter and rates of Si loss ranged from 4-20 g Si per square meter per year, respectively. Mass flux and weathering rate scales directly with precipitation and integrated soil-moisture content. The combined data demonstrate significant variation in the relative importance of organic and inorganic carbon cycle processes across the SDEG that may be linked quantitatively to climate and soil-water dynamics.