Comment on "A Reservoir of Nitrate Beneath Desert Soils"

Walvoord *et al.* (*1*) reported a large nitrate pool located deep (>1 m) beneath desert soils. Two aspects of this work were particularly surprising: the large pool size, estimated to be up to ~10^4 kilograms of nitrogen per hectare, as nitrate (kg N ha^{-1}); and the shape of the nitrate profiles, which resembled the conservative solute-accumulation profiles of Cl^- more than typical nutrient depletion profiles. In view of independent data and additional issues discussed below, however, we question the generality of these results.

Soil nitrate values can vary greatly over short temporal and spatial scales. We recently investigated 16 desert soil profiles to 10 m depth in paired grassland and woody sites at the Jornada and Sevilleta long-term ecological research stations (*2*). Analyses of eight Chihuahuan Desert cores at Jornada showed nitrate values that ranged from ~4 μg N g^{-1} of soil near the surface to ~0.1 μg N g^{-1} in subsurface soils (Fig. 1). The observed values were consistent with data from surface soils in other desert studies [e.g., (*3*–*8*)] and were an order of magnitude lower than the Chihuahuan Desert values reported in (*1*). Our total pool estimates to 10 m depth, at 50 to 100 kg N ha^{-1}, were also substantially lower.

The shape of the nitrate profiles was the second surprising result in (*1*). Our Jornada nitrate data followed the pattern of nutrient depletion profiles (*9*) and bore no resemblance to Cl^- profiles at the site (Fig. 1). The one clear difference between the two nitrate profiles we studied—the smaller nitrate pool in the top meter of soil in the grassland compared to the shrubland, which is dominated by the nitrogen-fixing honey mesquite, *Prosopis glandulosa* (Fig. 1)—was most likely biological.

Soil nitrate concentrations from Sevilleta were of similar magnitude and profile shape to those at Jornada (Fig. 2). The nitrate concentrations for Sevilleta soils were also an order of magnitude lower than values in (*1*), with total pool estimates of only 60 to 90 kg N ha^{-1} to 10 m depth. A lack of correspondence between the shape of the NO_3^- curve and the Cl^- peak at ~2 to 3 m depth was particularly clear at Sevilleta (Fig. 2).

Vegetation and the timing of precipitation—whether rainfall occurs primarily in the growing season—may play important roles in determining the variability of nitrate at depth. In the Chihuahuan desert, *P. glandulosa* often grows roots to 5 or 10 m (*2*, *10*), as deep as or deeper than the NO_3^- and Cl^- peaks observed in the Chihuahuan data of (*1*). Direct evidence of nutrient uptake from at least 3 to 4 m depth by *P. glandulosa* and the grass *Bouteloua eriopoda* has been shown at Jornada (*2*). We speculate that the large variability in nitrate concentrations and profile shapes in the soil cores studied in (*1*) may be partly caused by plant activity. We further speculate that the possible uptake of nitrate in such deep pools could aid the success of invasive woody shrubs in deserts, a mechanism that to our knowledge has not been considered previously.

The nitrate values we observed and the questions raised above do not

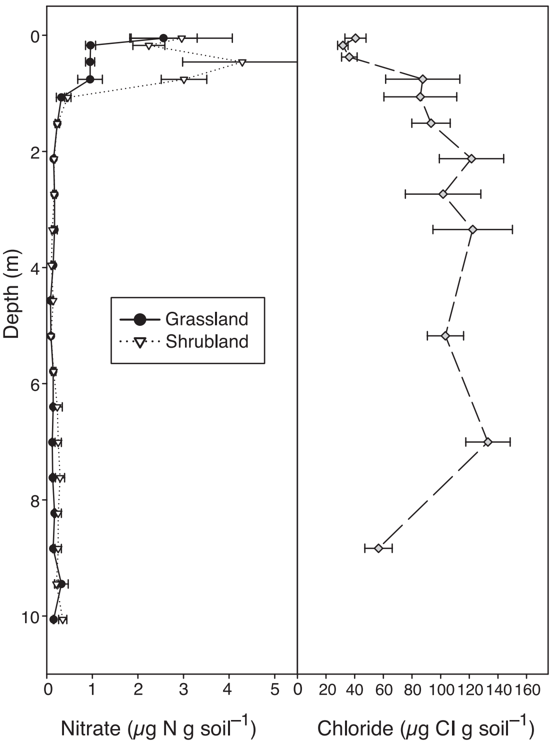

Fig. 1. Soil NO_3^- and Cl^- values to 10 m depth for adjacent Jornada grassland and shrubland sites (mean plus standard error). In each of the two communities per site, four cores of 6 cm diameter were taken with an environmental drilling rig to 10 m depth in 61 cm increments, with additional sampling at smaller intervals in the top 50 cm of soil. Soils were analyzed for exchangeable Cl^- and extractable NO_3^- using standard soil protocols (*12*, *13*), including distilled-water extracts for Cl^- and 2 M KCl extracts for NO_3^-. Exchangeable Cl^- was determined colorimetrically at the Utah State University Analytical Soil Laboratory on a Lachat Quickchem FIA+8000; extractable NO_3^- was determined at Duke University on a Bran and Luebbe TRAACS800. The Jornada site (32°36'16.6" N, 106°56'46.3" W) compared adjacent grassland (*Bouteloua eriopoda*) and shrubland (*Prosopis glandulosa*) communities where management practices contributed to woody plant encroachment into the native grassland (*2*). The Cl^- data for the grassland and shrubland sites were pooled for clarity; values were similar in both sites. Detailed descriptions of the study sites and sampling protocols are available in (*2*).

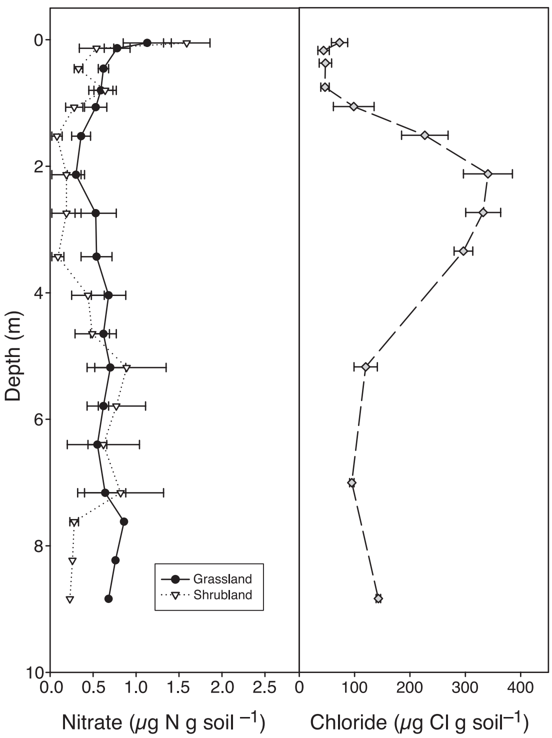

Fig. 2. Soil NO_3^- and Cl^- values to 10 m depth for adjacent Sevilleta grassland and shrubland sites (mean plus standard error). The Sevilleta site (34°20'05.7" N, 106°41'59.9" W) compared adjacent grassland (*Bouteloua eriopoda*) and shrubland (*Larrea tridentata*) communities, where *L. tridentata* was expanding into the native grassland. Additional information on methods can be found in (*2*) and in the caption for Fig. 1; note difference in scales on *x*-axis compared with Fig. 1.

negate the results of (*1*). However, the nitrate reservoir proposed for desert soils is large—up to 13,600 kg N ha^{-1}, far larger than values in agricultural soils (*11*). The extrapolation of these results to 16% of global vadose-zone nitrate and 71% of warm desert nitrate is questionable. Until confirmation of a large deep-soil nitrate pool exists generally, such regional and global extrapolations must be treated with caution.

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