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# The use of ion-exchange resin bags for measuring nutrient availability in an arid ecosystem

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**Abstract**

An *in situ* resin bag technique was used to measure the relative availabilities of N and P along a chronosequence of soils in southern New Mexico, and was compared to two more common indices of nutrient availability. Accumulations of N and P during 10-week intervals over an 18 month period were separable into wet season (September–January) and dry season (February–August) groups, with wet season values significantly greater than dry season values. Only accumulations during the wet season showed significant differences among sites, thus stressing the role of field water regime in interpreting resin accumulation results. Total mineral N ($NO_3$ + $NH_4$) sorbed by resins was significantly correlated to laboratory N mineralization rates. Although accumulation patterns of N and P were similar to patterns of %N and %P in shrub species growing along the chronosequence, these similarities were not statistically significant. A laboratory experiment demonstrated that bicarbonate-form anion resins are preferable to hydroxyl-form resins, as long as standards are made from solutions extracted by resins to account for variable ion recovery efficiencies.

## Introduction

Recent ecological studies in deserts of the southwestern US have demonstrated that nutrients, in addition to water, may control both species distributions and the productivity of arid ecosystems (Crawford and Gosz, 1982; Ettershank *et al.* 1978; Fisher *et al.*, 1987; Wallace and Romney, 1972; Williams and Bell, 1981). In general, these studies have examined the response of desert communities to nutrient additions, usually nitrogen. However, it is difficult to study nutrient cycling processes in deserts, as the most commonly used techniques for assessing nutrient availability are not readily adaptable to arid systems. Standard laboratory methods of nutrient extraction yield static pool sizes, rather than supply rate or availability (Powers, 1980; Vitousek, 1985). Although laboratory incubations can measure mineralization and nitrification potentials, they cannot reflect changes in temperature and moisture that occur in the field, which are critical controls of nutrient availability in desert soils. *In situ* buried-bag incubations are sensitive to changes in temperature and provide an estimate of nutrient availability in mesic ecosystems (Pastor *et al.*, 1984), however, the polyethylene bags used in these studies are impermeable to water, and thus are inappropriate for use in desert soils with widely fluctuating water potentials. Foliar nutrient contents and nutrient ratios have been used to detect nutrient limitations in forest soils, but results tend to be very site-specific and somewhat inconclusive (van den Driessche, 1974; Wells *et al.*, 1986).

More recently ion-exchange resins have been used to assess both N and P availability in laboratory soil extractions (Amer *et al.*, 1955; Olsen *et al.*, 1983; Sibbesen, 1978) and N availability under field conditions (Binkley, 1984; Binkley and Matson, 1983). As exchange resins enclosed in permeable nylon mesh reflect changes in moisture as well as temperature and can be used to measure both cations and anions, their use potentially represents an improvement over may other more commonly used methods. This study was conducted to determine 1) the applicability of resin bags to desert ecosystems, 2) correlations between resin bags results and those from other techniques, and 3) the effects of ion competition and exchange counterions on the effectiveness of ion-exchange resin bags.

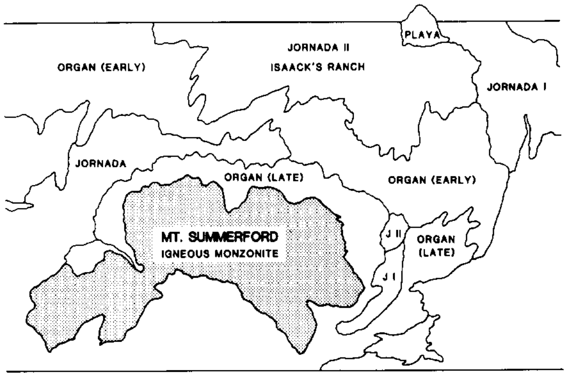


*Fig. 1.* Soil geomorphic surfaces along the piedmont slopes of Mt. Summerford. J I = Jornada I; J II = Jornada II; Jornada = undifferentiated Jornada deposition.

## Methods

### *Study site*

This study was conducted at the Long Term Ecological Research Site (LTER) of New Mexico State University in the Jornada del Muerto Basin, 40 km NNE of Las Cruces, New Mexico, an area near the northern limits of the Chihuahuan Desert. Rainfall averages 16–20 cm $yr^{-1}$, with more than half the precipitation occuring from July–September (Gile *et al.*, 1981). The chronosequence of soils studied occurs on the piedmont slope of Mt. Summerford in the Dona Ana Mountains near the western boundary of the Jornada Basin. Four geomorphic surfaces of distinct age have been identified along this slope (Fig. 1, Table 1), and have been described in detail elsewhere (Lajtha, 1986). Total P declines significantly along this chronosequence (Lajtha, 1988), and thus it was hypothesized that nutrient availability might also vary significantly. Plant communities also vary along the LTER transect that crosses this chronosequence, most probably due to past land-use history (Buffington and Herbel, 1965). However, two shrub species in the genus *Gutierrezia, G. microcephala* (DC.) Gray and *G. sarothrae* (Pursh) Britt and Rusby, grow in small washes and alluvial channels over most of the transect.

### *Field resin bags*

Four g (dry weight) of either Dowex 1-X8 anion exchange resin or Dowex 50W-X8 cation exchange resin, both 20–50 mesh, were placed in 50-$cm^2$ area resin bags sewn from undyed nylon stocking material obtained from the Kayser-Roth Corp., Burlington, NC. Anion resins were converted to the bicarbonate form by placing bags in three successive 0.5 $M$ $NaHCO_3$ rinses. Cation resins, already in the $H^+$ form, were rinsed with dilute HCl. All bags were rinsed with deionized water and spun

*Table 1.* Classification and estimated ages of soils from the Jornada chronosequence

| Soil | Classification | Estimated age (Gile *et al.* 1981) | |
|---|---|---|---|
| late Organ (Organ II) | Ustollic Haplargid | 1,100–7,000 ybp | (late Holocene |
| early Organ (Organ I) | Typic Haplargid | 2,200–7,000 | (early Holocene) |
| Isaack's Ranch | Typic Haplargid | 8,000–1500 | (Holocene/Pleistocene) |
| Jornada II | Typic Haplargid | 25,000–75,000 | (mid-Pleistocene) |