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# Contribution of actinorhizal shrubs to site fertility in a Northern California mixed pine forest

Matt D. Busse [a,*], Martin F. Jurgensen [b], Deborah S. Page-Dumroese [c], Robert F. Powers [a]

[a] Pacific Southwest Research Station, USDA Forest Service, 3644 Avtech Parkway, Redding, CA 96002, United States
[b] School of Forest Resources and Environmental Science, Michigan Technological University, 1400 Townsend Dr., Houghton, MI 49931, United States
[c] Rocky Mountain Research Station, USDA Forest Service, 1221 South Main, Moscow, ID 83843, United States

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## Abstract

Bitterbrush (Purshia tridentata) and mahala mat (Ceanothus prostratus) are common N-fixing shrubs in interior forests of the western United States, yet their contribution to ecosystem N pools is poorly characterized. We compared N fixation and soil N accretion by these shrubs in old-growth ponderosa pine (Pinusponderosa)–Jeffrey pine (Pinusjeffreyi) stands versus stands that had been harvested 50 years earlier. No differences ($a = 0.10$) in cover, biomass, or percent N derived from fixation by bitterbrush or mahala mat were found between harvested and uncut stands. Approximately 46% of bitterbrush N was derived from symbiotic N fixation as measured by the $15_N$ natural abundance method. No accurate measure of percent N derived from fixation was attained for mahala mat using this technique due to the absence of a well-matched reference plant. Estimates of total N fixation rates in both stand types were 0.2 kg ha$^{-1}$ year$^{-1}$ for bitterbrush and 0.3 kg ha$^{-1}$ year$^{-1}$ or less for mahala mat. No appreciable soil N accretion resulted due to the presence of bitterbrush or mahala mat in either stand type. Nitrogen addition by these shrubs, although small, accounts for 10–60% of annual N input in these dry forest ecosystems.


Keywords: Symbiotic nitrogen fixation; Bitterbrush; Mahala mat; Purshia tridentata; Ceanothus prostratus; Natural $^{15}N$ abundance; Old-growth; Timber harvesting

## 1. Introduction

Maintaining site nutrient capital is a tenet of sustainable forestry. This holds particular relevance in many ponderosa pine forests on the east side of the Cascade Range and the Sierra Nevada Mountains in California (hereafter, eastside pine forests), where vegetation growth is limited by low annual precipitation. Nutrient pools in these forests are considerably lower than in more mesic forests of the western United States (e.g. Little and Shainsky, 1995; Page-Dumroese and Jurgensen, 2006). Thus, nutrient losses during logging or fire result in proportionally larger reductions to the total pool size of these infertile ecosystems. As an example, volatilization loss of N during wildfire can exceed 800 kg ha$^{-1}$ in eastside forests (Grier, 1975), or approximately 25% of the total ecosystem N in some stands (Little and Shainsky, 1995). Even the popular management practice of prescribed burning to reduce unwanted fuel buildup and overstocking can release 50–400 kg N ha$^{-1}$ in eastside pine forests (Shea, 1993; Caldwell et al., 2002). Nitrogen loss associated with logging varies considerably depending on harvest intensity. For example, clear-cut harvesting and removal of whole trees may remove between 100 and 200 kg N ha$^{-1}$ from these forests (Little and Shainsky, 1995).

Symbiotic N fixation by actinorhizal shrubs is an important mechanism to offset N losses from logging and fire disturbances (Jurgensen et al., 1997; Johnson and Curtis, 2001). For example, snowbrush (Ceanothus velutinus) fixes between 4 and 75 kg N ha$^{-1}$ annually in eastside pine and mixed-conifer forests (Youngberg and Wollum, 1976; Busse, 2000). Site factors, such as overstory density, shrub cover, shrub age, length of growing season, and annual precipitation, contribute to the large range of reported N fixation rates. However, even at its lowest N fixation rate of 4 kg ha$^{-1}$ year$^{-1}$, snowbrush can replace most disturbance-caused N losses within a 100-year rotation.

* Corresponding author. Tel.: +1 530 226 2530; fax: +1 530 226 5091.
E-mail address: mbusse@fs.fed.us (M.D. Busse).

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