

# Atmospheric Nitrogen Deposition and Habitat Alteration in Terrestrial and Aquatic Ecosystems in Southern California: Implications for Threatened and Endangered Species<sup>1</sup>

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## Extended Abstract

Recent studies in the transverse ranges (including Class I Wilderness areas) of southern California have emphasized the strong linkage between levels of air pollution-related atmospheric nitrogen (N) inputs into montane watersheds and levels of nitrate in surface and subsurface drainage waters (*fig. 1*). Nitrate concentrations in streamwater in southern California are the highest in North America for wildland watersheds. High nitrate concentrations in runoff are a result of excessive ecosystem enrichment with N from atmospheric deposition. When N enrichment results in the removal of biological N limitation and the N retention capacity of the system is exceeded, the ecosystem is described as “N saturated.” Nitrogen-saturated forests are analogous to over-fertilized agricultural fields with high nitrate runoff. The primary symptom of an N-saturated ecosystem is high nitrate concentrations in the soil solution, in soil leachate, and in groundwater and streamwater (Fenn and others 1998). Vegetation in N-saturated ecosystems contains high levels of N, and excess N also builds up in litter and soil organic matter, especially under fire suppression regimes. Stand densification is likely to be exacerbated by N deposition.

Due to the interaction of N deposition with land management activities, it is possible that past, present, and future land management practices (including fire suppression, introduction of invasive species, and forestry practices) could minimize or exacerbate the adverse effects of N deposition on terrestrial and aquatic ecosystems. Hydrologic flowpaths in a watershed also influence the impact of atmospheric N deposition on aquatic ecosystems. In summary, chronic N deposition results in excess N in terrestrial, riparian, and aquatic habitats. This dramatic change in the chemical environment of these habitats has high potential to upset the normal communities of vegetation, microbes, and micro- and macro-flora and fauna either

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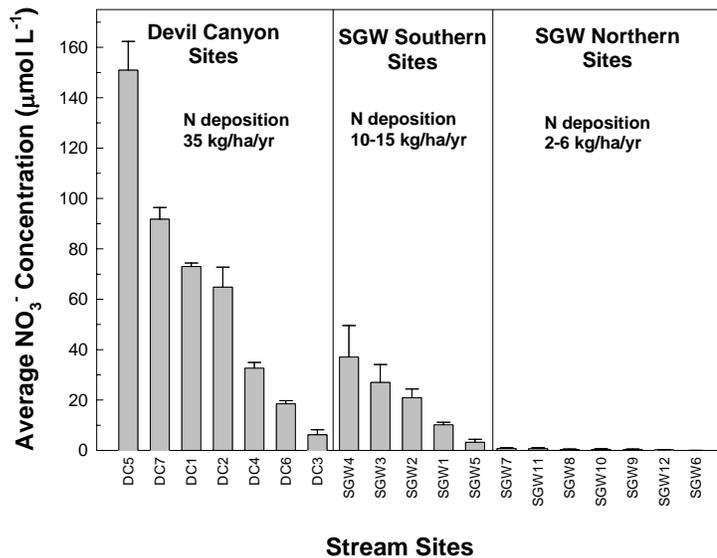
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via direct effects on sensitive organisms or via cascading effects on the food chain. As an example, evidence suggests that elevated nitrate levels in pond water may be toxic to larvae of several western frog species that are in decline (Marco and others 1999). Because of the excessively high N enrichment of many southern California ecosystems, the effect on key species is a neglected area of research that should be addressed.

Average nitrate concentrations in streams in Devil Canyon in the western San Bernardino Mountains fall within the low end of the range of concentrations that cause developmental, physical, and behavioral abnormalities in sensitive amphibian species (Rouse and others 1999). However, peak concentrations in streams in the western San Bernardino Mountains are more than twice as high as average values and may have acute effects on sensitive amphibian species. Tadpole and larval stages appear to be the most sensitive life stages. Amphibian prey and predators also can be affected by elevated nitrate, a fact that may alter predation pressure and ecological balance. However, studies on the effects of elevated streamwater nitrate on aquatic biota have not yet been done in the San Bernardino Mountains.

Recent studies suggest that chronic N deposition may be a factor in the shift from native shrub species in coastal sage scrub ecosystems to exotic annual grasses – a widespread phenomenon in the remaining coastal sage habitats in southern California (Padgett and others 1999). Changes in vegetative communities may also be occurring in the forest understory in N-saturated forests, but this has not been investigated sufficiently. In high N deposition sites in the San Bernardino Mountains,



**Figure 1**—Average streamwater nitrate concentrations in Devil Canyon (high N deposition area in the western San Bernardino Mountains), along the southern side of the San Gorgonio Wilderness (SGW) (moderate N deposition), and on the northern side of the SGW (low N deposition; Fenn and Poth 1999).

the ecosystem is highly N enriched as evidenced by high N concentrations in foliage (of understory and overstory species), litter, mineral soil, soil solution, soil leachate, and trace gas emissions from soil (Fenn and others 1996). Forested sites further away from N pollution sources (motor vehicle emissions and dairy farms) receive atmospheric N deposition loads which are at least 5-10 fold lower, and plant growth is highly N limited – which is the normal condition for these forests. Thus, the long-term ecological and environmental impacts of decades of elevated atmospheric N inputs into wildland ecosystems in southern California remains an important and sometimes under-appreciated issue for natural resource managers, especially in the face of ever-increasing human populations.

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