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Estimated losses of plant biodiversity in the United States from historical N deposition (1985–2010)

Christopher M. Clark,[1,4] Philip E. Morefield,[1] Frank S. Gilliam,[2] and Linda H. Pardo[3]

[1]*National Center for Environmental Assessment, U.S. EPA, Office of Research and Development, 1200 Pennsylvania Avenue, N.W., Mail Code 8601-P, Washington, D.C. 20460 USA*
[2]*Department of Biological Sciences, Marshall University, Huntington, West Virginia 25755-2510 USA*
[3]*USDA Forest Service, Northern Research Station, 81 Carrigan Drive, Burlington, Vermont 05405 USA*

Abstract. Although nitrogen (N) deposition is a significant threat to herbaceous plant biodiversity worldwide, it is not a new stressor for many developed regions. Only recently has it become possible to estimate historical impacts nationally for the United States. We used 26 years (1985–2010) of deposition data, with ecosystem-specific functional responses from local field experiments and a national critical loads (CL) database, to generate scenario-based estimates of herbaceous species loss. Here we show that, in scenarios using the low end of the CL range, N deposition exceeded critical loads over 0.38, 6.5, 13.1, 88.6, and 222.1 million ha for the Mediterranean California, North American Desert, Northwestern Forested Mountains, Great Plains, and Eastern Forest ecoregions, respectively, with corresponding species losses ranging from <1% to 30%. When we ran scenarios assuming ecosystems were less sensitive (using a common CL of 10 $kg \cdot ha^{-1} \cdot yr^{-1}$, and the high end of the CL range) minimal losses were estimated. The large range in projected impacts among scenarios implies uncertainty as to whether current critical loads provide protection to terrestrial plant biodiversity nationally and urge greater research in refining critical loads for U.S. ecosystems.

Key words: biodiversity; critical loads; ecoregion; herbaceous; nitrogen deposition.

Introduction

The global threat of nitrogen (N) deposition to terrestrial plant biodiversity is increasingly recognized (Sala et al. 2000, Bobbink et al. 2010, Pardo et al. 2011*a*). Human activities have increased deposition of this key limiting nutrient in many areas by nearly an order of magnitude over historical levels (Galloway et al. 2004). For vascular plants, it is increasingly realized that impacts on biodiversity may be particularly pronounced for herbaceous species, evidenced from large-scale sampling studies across deposition gradients in Europe (Maskell et al. 2010, Stevens et al. 2010), resampling studies comparing past with present community composition (Dupre et al. 2010), and long-term field experiments with low levels of N input in North America, Europe, and Asia (Bowman et al. 2006, Clark and Tilman 2008, Bai et al. 2010). Nonvascular species, lacking a protective cuticle and experiencing the passive absorption of water over their entire surface, are expected to be even more sensitive (Fenn et al. 2010). Impacts to vascular species are unlikely restricted to grasslands alone, as forest studies indicate that changes in understory and tree species composition may occur as well (Gilliam 2006, Thomas et al. 2010).

Atmospheric deposition of N, however, is not a recent stressor for most of the industrialized world. The activities leading to elevated N deposition such as fossil fuel combustion and fertilizer application for modern agriculture date back to the late 19th century. Networks to monitor N deposition, however, only date back a few decades for the United States and Europe (Galloway et al. 2004). Recently, N deposition has actually been declining over much of northeastern United States, mostly from reductions in oxidized N (Burns et al. 2011, Suddick and Davidson 2012). However, these levels remain high and have been elevated for decades. N deposition from agricultural activities remains high, and total N deposition over much of the rest of the country is actually increasing (Suddick and Davidson 2012).

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[4] E-mail: clark.christopher@epa.gov