Explanations for nitrogen decline
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New treaty must address ghost fishing gear

In his News story “World’s nations start to hammer out first global treaty on plastic pollution” (23 February, https://scim.ag/unplastic treaty), E. Stokstad discusses the issues that may be addressed by a new plastic treaty (1), including pollution resulting from fishing activities. Because fishing gear is often made from long-lasting synthetic polymers, such as nylon (2), lost and abandoned gear is a long-term problem. This type of pollution, known as ghost gear, is a serious and pervasive threat to marine and aquatic ecosystems (3). The first plastic treaty must address ghost gear in marine (3) and freshwater environments.

Ghost gear affects aquatic ecosystems on every continent. Abandoned or lost nets, for example, trap and often kill large fish (e.g., elasmobranchs), crustaceans (decapods), turtles, mammals (including cetaceans), and other organisms (4–7). Although reports are more frequent from marine ecosystems, damage has occurred in inland water ecosystems as well (2, 7). Other animals, such as birds, are attracted to potential prey trapped in the ghost gear and can become entangled themselves (5, 8), generating a negative cascade effect (5). As Stokstad notes, the problem is exacerbated by the lack of reliable data on the frequency and degree of impact of ghost gear in aquatic ecosystems around the world.

Given the increasing demand for resources to feed the world’s growing population, fishing will intensify in coming years (3, 9), and the amount of ghost gear in aquatic ecosystems will almost certainly increase as a result. To address this problem, the plastic treaty should aim to reduce the risk fishing gear poses to the environment. Possible strategies include replacing synthetic fishing gear with biodegradable alternatives, which are already available (10); limiting the sales of nylon nets; providing educational opportunities; and removing lost and abandoned fishing gear from ecosystems (2). In addition to drafting the plastic treaty, all countries must take urgent and comprehensive action to combat the harm caused by fishing activities.

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1. UN Environment Assembly of the UN Environment Programme, “End plastic pollution: Towards an international legally binding instrument” (2022); https://wedocs.unep.org/bitstream/handle/20.500.11822/38522/
Response

Off et al. select only a subset of the evidence for declining nitrogen availability and assign unlikely mechanisms to reach the conclusion that nitrogen availability is not declining over large areas of Earth. We disagree that the evidence can be grouped into the categories that Off et al. describe; the complete set of observations is wider in scope and cannot be explained by the mechanisms that the authors propose.

Off et al. claim that declines in nitrogen emissions since 1990 can explain declining nitrogen availability. Our Review acknowledges reduced emissions, and the resulting reduction in atmospheric deposition of nitrogen onto ecosystems, as a likely contributing factor. However, we also present long-term records of declining nitrogen availability, including declining nitrogen concentrations in plant leaves since around 1930 (1, 2) and in plant pollen since the early 1900s (3), as well as declines in a broad suite of soil nitrogen availability indicators and stream water NO₃⁻ at Hubbard Brook in New Hampshire, United States, that date back to the 1960s and 1970s (4, 5). These observations predate reductions in nitrogen deposition. Moreover, as we explain in the Review, declines in nitrogen availability indicators have occurred in places that have never experienced substantially elevated nitrogen deposition (1) and alongside declines in concentrations of other elements in plants (6–8).

Off et al. then propose that large-scale declines in natural abundance nitrogen isotope ratio (δ¹⁵N) values in sediment and plants can be explained by a change over time in the isotopic signature of anthropogenic nitrogen emissions toward isotopically lighter, reduced forms of nitrogen. However, the evidence they cite of possible effects of this shift on plant δ¹⁵N refers only to a handful of case studies in atypical environments (9–11). The isotopic ratio of deposited nitrogen is elevated by processes in soil that discriminate against δ¹⁵N; the effects of such processes increase with increasing nitrogen supply (2, 12). Models show that the isotopic signature of deposited nitrogen would have to be implausibly low to cause plant δ¹⁵N to decline at the observed rate (2).

There is little doubt that massive and poorly managed anthropogenic nitrogen inputs have led to eutrophication and biodiversity loss in many locations. However, rising atmospheric CO₂ warming, and several other global changes are concurrently driving a reduction in nitrogen availability (i.e., nitrogen supply relative to nitrogen demand). The well-documented increases in anthropogenic nitrogen supply noted by Off et al. have not affected global ecosystems uniformly and are unlikely to be the overriding driver of changes in nitrogen availability across all terrestrial ecosystems.