What the Nitrogen Balance “Safe Zone” Indicates

The “safe zone” provides valuable context for understanding nitrogen balance, or N balance, scores. Scores that fall within the safe zone range indicate that a farmer is optimizing yields, using N additions efficiently, minimizing N losses to the environment and protecting long-term soil health.
How EDF scientists determined the safe zone range

The safe zone includes N balance scores\(^1\) of 25-75 lbs. N/acre (Figure 1).

When N balance scores exceed 75 lbs. N/acre, N losses to the water as nitrate (NO\(_3\)) and to the air as nitrous oxide (N\(_2\)O) increase dramatically. Beyond this upper threshold, the crop does not need or use the extra N added.\(^2\) Therefore, staying below the upper limit keeps N losses to the environment as low as possible, while making the most efficient use of N added to the system.

Alternatively, when N balance scores fall below 25 lbs. N/acre, the N provided from outside sources is insufficient to replace N mineralized from the soil during the growing season and used by the crop. If plants must rely on N mineralized from organic matter in the soil that is not replenished, long-term productivity and soil health may suffer.\(^3\)

EDF defined this range with the best available peer-reviewed science. We may continue to refine the safe zone bounds as additional data advances our understanding of the relationship between N balance and specific agro-ecological regions and production systems.

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\(^1\) See How to Calculate Nitrogen Balance on edf.org/n-balance for more information.

\(^2\) McClellan et al., 2018.

\(^3\) Campbell and Zentner, 1993; van der Pol and Traore, 1993.
Additional research on the safe zone

Non-EDF scientists researching the safe zone concept at both global and farm scales have identified some variations on the upper and lower bounds, but their published ranges remain comparable to that used in EDF’s N balance framework.

**U.S. land-grant universities**

A team of researchers connected with Princeton University and the University of Maryland translated the “safe” planetary boundary for N into a comparable global average N balance of 35-70 lbs. N/acre of harvested cropland per year. They propose that these targets will allow global agriculture to meet 2050 food demand and also meet United Nations Sustainable Development goals.

Researchers from Cornell University established the concept of a whole-farm safe zone of N balance for dairy operations. The “optimal operational zone” was designed to “allow dairy farms to be economically profitable and environmentally sustainable while promoting flexibility in management practices.” The high end of the zone was determined to be 105 lbs. N/acre, the point below which 75% of studied dairies were operating. Dairies operating within this zone are given some regulatory relief under New York state nutrient management rules. This high-end value is slightly higher than EDF’s recommended upper threshold of 75 lbs. N/acre, but most dairies must account for additional nutrient imports and exports compared to standard row crop operations.

**European Union**

The European Union Nitrogen Expert Panel also applied the safe zone concept to N balance along with N output — productivity from crop yield and other N removal sources.

The panel recommends a target maximum N balance of 68 kg N/hectare/year, which is comparable to 75 lbs. N/acre, the upper threshold of EDF’s N balance safe zone.

They advise that farmers operate in the safe zone, noting that this can be achieved through intensification or efficiency gains, depending on the situation. The panel also proposes a whole-farm approach with a standardized set of input and output data to ensure uniformity for benchmarking and peer-to-peer comparisons.

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4 Bodirsky et al., 2014; de Vries et al., 2013; Steffen et al., 2015.
5 Zhang et al., 2015.
6 Cela et al., 2014.
7 Quemada et al., 2020.
References


