# Assessment of Nitrogen Dynamics and Cropping System Sustainability in the Andean Region of South America with a New Tool Available for Computers and Smartphones


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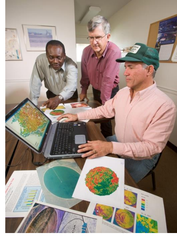

## Abstract


Implementation of best soil and water conservation practices will be key to addressing challenges we will confront in the 21st century. With challenges such as climate change and continued population growth, there is a need for tools that can help us quickly assess how to maintain sustainability of cropping systems, which will be essential for maximizing agricultural production, especially in fragile soils of the Andean region of South America.

Nitrogen (N) inputs are key for agricultural production, but because N is so mobile, high efficiency in the management and use of N input is necessary to reduce risk of N losses to the environment while maximizing production.

One of the key crops in this region is the potato (*Solanum tuberosum* L.) crop. This crop leaves a small amount of crop residue after harvest, which increases the potential for a high rate of erosion, especially in the steep soils where the crop is cultivated in this region. A new Nitrogen Index with a Sustainability Index has been calibrated and validated for this region. The tool is available in the English and Spanish languages and can be run in metric or English units. It can be run on desktop and laptop computers (using the software written in the programming language Java™), or on a smartphone that has the Android™ system (via the "app"). The tool is very user friendly and can be used by conservationists, field agronomists, technical personnel, and others. It was found that the tool can accurately assess nitrogen dynamics and evaluate the crop uptake for crops grown in this region, such as corn (*Zea mays* L.) and potato ($P<0.01$). There was high correlation between the nitrogen use efficiency (NUE) predicted by the tool and the observed NUE of the cropping systems ($P<0.01$) under different management practices. Additionally, users can quickly assess conservation practices that can contribute to the sustainability of the system. Case scenarios will be presented on how the tool has been used to help users assess the effects of management practices on the sustainability of cropping systems in their region.


## New 2013 Tool: Smartphone App

***The Environmental Problem of Reactive Nitrogen Losses to the Environment:*** Nitrogen is one of the world's most important nutrients in agriculture and was key in the Green Revolution. However, when over-applied, nitrogen losses from agricultural systems can average at about 30% of the applied N fertilizer and can contribute to significant environmental impacts. For some systems, nitrogen could be under-applied, and for these systems, the use of more nitrogen fertilizer could contribute to increased yields and economic returns. Managing nitrogen effectively continues to be a difficult and complicated endeavor, and improving nitrogen management with higher nitrogen use efficiency can contribute to increased yields and economic returns, reduced losses to the environment, and to the protection of natural resources.

***New Tools to Assess Nitrogen Management and Risk of Reactive Nitrogen Losses:*** The new 2013 Nitrogen Index (4.4.2), which is written in the programming language Java™, and the new Nitrogen Index smartphone application (4.4) that is written for Android, are new tools that can be used for assessing nitrogen management to increase nitrogen use efficiency and reduce atmospheric, surface and leaching losses of nitrogen in South American cropping systems. These are new tools and concepts that are effective in helping users assess risk of nitrogen loss across the landscape and cropping systems to conserve the environment and increase economic returns for farmers. Both tools will be upgraded in the summer of 2013 to version 4.5, a version that will allow users to assess how to use management to reduce $N_2O$ emissions.

***These New Technologies are Currently Being Used by Universities, NRCS, and Other National and International Users:*** These tools have already been transferred to U.S. agencies such as NRCS state offices. For example, in March of 2013, USDA NRCS in Kentucky released its new 590 Nutrient Management Standard, and the new Kentucky Nitrogen and Phosphorous Index is referenced in the standard as an official risk assessment tool for Kentucky. Additionally, the tools have been transferred to users from universities and national and international research centers. The tools were also developed in cooperation with Foreign Agricultural Service (FAS) and USAID programs as well as national and international universities, and have been transferred to users in Bolivia, Ecuador, and Mexico, among other locations. The Nitrogen Index can be downloaded from http://www.ars.usda.gov/npa/spnr/nitrogentools. ***The smartphone application for the Nitrogen Index is available free of cost at the Google Play website.***


**Figure 1.** Impacts of erosion in cultivated fields of the Illangama watershed located at an altitude of 3,400 m. As can be seen in the photo, a lack of conservation practices has contributed to higher erosion rates and to the loss of the more productive soil surface horizon, exposing a less fertile subsoil below (a). In Ecuador, traditional farming practices were used to prepare the land with a wood chisel plow moved by animals (horse or bulls) to kill any potential weeds and to create a furrow where the seed and fertilizers were placed (b).

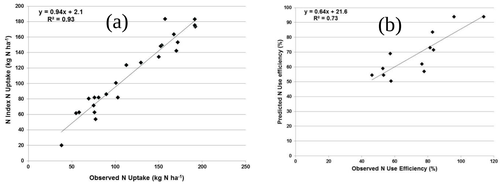


**Figure 2.** Aboveground crop nitrogen uptake predicted by the Nitrogen Index versus observed aboveground nitrogen uptake at harvest for corn (*Zea mays* L.) grown in Ecuador (a). Cropping system nitrogen use efficiency predicted by the Nitrogen Index versus observed nitrogen use efficiency for the fertilizer nitrogen rates of 120 and 140 kg urea N $ha^{-1}$ in Ecuador fertilizer studies (b).

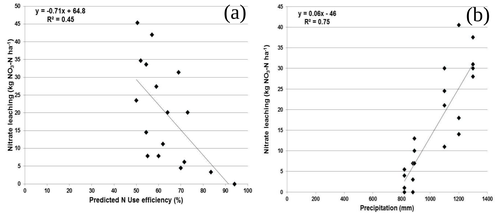


**Figure 3.** Nitrogen leaching versus system nitrogen use efficiency, both estimated with the Nitrogen Index in Ecuador (a). Nitrogen leaching estimated by the Nitrogen Index versus precipitation in Ecuador (b).

**Figure 4.** Dr. Delgado conducting a one-day training in the use of the Ecuador Nitrogen Index with a Sustainability Index. Training attendees included individuals from the USAID project, INIAP, and Universidad Estatal de Bolivar. Participants of the training brought their own laptop computers. Using their laptops they were able to download the Nitrogen Index from the USDA-ARS server located in Fort Collins, Colorado, and the students were able to participate in the training.

**Figure 5.** An example of the traditional low-input systems found in the Andean region of Bolivia.

**Figure 6.** Harvesting potato varieties in an Andean field site at low altitude (area of Tiraque, near the site of Cochabamba, Bolivia).

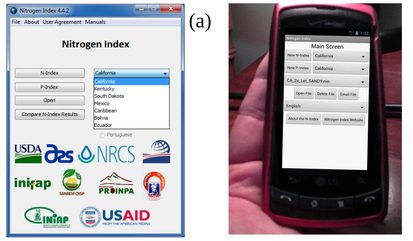


**Figure 7.** Nitrogen Index 4.4.2 (2013 version; written in the programming language Java™) is available in the English and Spanish languages (a). The Nitrogen Index can be run on a small mobile device that can fit in your hand or your pocket (b).

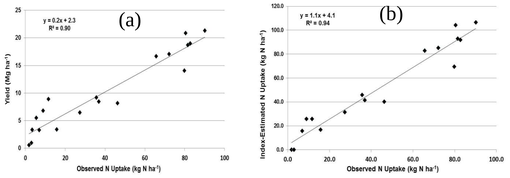


**Figure 8.** Mean fresh potato tuber yields at harvest versus observed nitrogen uptake of the cropping system used for assessing nitrogen dynamics in low input systems of Cochabamba and Patacamaya, Bolivia (a). Potato crop nitrogen uptake estimated by the Nitrogen Index versus observed total nitrogen uptake at harvest (b).

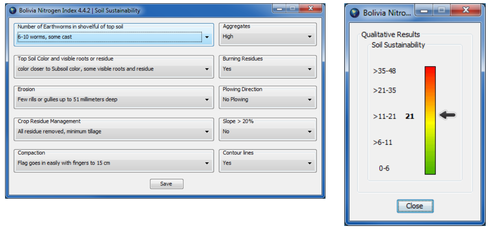


**Figure 9.** Sustainability Index for South American cropping systems.

## Summary

- In Ecuador, the Nitrogen Index was able to quickly assess the effects of nitrogen management practices on nitrogen uptake, nitrogen use efficiency, and risk of nitrogen losses to the environment ($P < 0.001$).
- This index can potentially be used in extension programs, and as an aid to engage local farmers and increase use of best management practices in these high-altitude mountain systems.
- In Bolivia, observed nitrogen uptake was correlated with observed yields from the studies. Mean potato tuber fresh yields in the system were correlated with the nitrogen in the system as estimated by the Nitrogen Index.
- In Bolivia, the Nitrogen Index demonstrated that improved nitrogen management and an increase of nitrogen inputs into potato production systems, will significantly increase yields and improve the standard of living of families across rural Bolivia.
- The results suggest that the Bolivia and Ecuador Nitrogen Indexes can accurately assess nitrogen dynamics and uptake in vulnerable, high-elevation Andean potato and corn cropping systems. As a result, they can potentially be used as a technology transfer tool to assess nitrogen management practices in such systems.
- The Nitrogen Index can be used to quickly conduct an analysis across the soils of this region and help users determine how nitrogen needs to be applied to optimize yields. The tool is also available as a mobile application for smartphones.

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**** For additional information, a complete list of references, questions, reprints, or requests for new tools, please email Dr. Jorge A. Delgado at jorge.delgado@ars.usda.gov, or Dr. Jeff Alwang at alwangj@vt.edu.***